

NAUČNI ČASOPIS ZA SAVREMENO OBRAZOVANJE I PRIMENU INFORMACIONIH TEHNOLOGIJA

EdTech
edtechjournal.org

JOURNAL

UDK: 371.3
004.9:37
ISSN 2812 - 8753 (Štampano izd.)
ISSN 2812 - 8761 (Online)
VOL. 3 BR. 1
APRIL 2023
BEOGRAD

SCIENTIFIC JOURNAL FOR CONTEMPORARY EDUCATION AND APPLICATION OF INFORMATION TECHNOLOGIES



IMPRESSUM

Izdavač/Publisher

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
office@institut.edu.rs

Uredništvo/ Editorial

Dr Valentin Kuleto, vanredni profesor, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija: glavni i odgovorni urednik

Dr Milena Ilić, docent, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija: zamenik glavnog i odgovornog urednika

Dr Dan Păun, predavač, Faculty of Physical Education & Sports, Spiru Haret University, Bukurešt, Rumunija: tehnički urednik

Kontakt podaci uredništva/ Editorial contact information

EdTech Journal
Masarikova 5, Beograd
11000 Beograd
Telefon: + 381 (0)11/40-11-260; Mobilni telefon: + 381 60/55-22-581
Imejl-adresa: EdTech@institut.edu.rs;
Veb-sajt: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Uređivački odbor/ Editorial Board

Dr Valentin Kuleto, vanredni profesor, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Doc. dr Milena Ilić, docent, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Dr Dan Păun, predavač, Faculty of Physical Education & Sports, Spiru Haret University, Bukurešt, Rumunija

Dr Aleksandar Kostić, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Slavko Pokorni, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Svetlana Anđelić, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Milosav Majstorović, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Šemsudin Plojović, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Miloljub D. Luković, profesor strukovnih studija, Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija

Dr Zoran Grubišić, profesor, Beogradska bankarska akademija – Fakultet za bankarstvo, osiguranje i finansije, Beograd, Srbija

Dr Velimir Dedić, profesor, Fakultet za informacione tehnologije i inženjerstvo, Univerzitet Union – Nikola Tesla, Beograd, Srbija

Doc. dr Marko Ranković, Fakultet za informacione tehnologije i inženjerstvo, Univerzitet Union – Nikola Tesla, Beograd, Srbija

Dr Rocsana Manea Bucea Tonis, vanredni profesor, Faculty of Physical Education & Sports, Spiru Haret University, Bukurešt, Rumunija

Doc. dr Elena Gurgu, Department of Economic Sciences Bucharest, Spiru Haret University, Bukurešt, Rumunija

Doc. dr Oliva Dourado, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugalija

Doc. dr Dušica M. Filipović, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Mr um. Saša Filipović, profesor, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Dr Dragan Čalović, profesor, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Doc. dr Dušan Stojaković, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Doc. M.Arch Nina Stojanović, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Doc. dr Nevenka Popović Šević, Fakultet savremenih umetnosti u Beogradu, Univerzitet Privredna akademija u Novom Sadu, Srbija

Dr Slavko Vesković, profesor, Univerzitet u Beogradu, Saobraćajni fakultet u Beogradu, Beograd, Srbija

Mr Milutin Dobrilović, Beogradski univerzitet, Ekonomski fakultet u Beogradu, Beograd, Srbija

Dr Lazar Janić, profesor strukovnih studija, Akademija strukovnih studija Beograd, Odsek Visoka zdravstvena škola, Beograd, Srbija

Dr Jasmina Bašić, profesor strukovnih studija, Akademija strukovnih studija Beograd, Odsek Visoka zdravstvena škola, Beograd, Srbija

Dr Vladimir Simović, vanredni profesor, Australian College of Kuwait, Australija

Dr Panos Photopoulos, vanredni profesor, University of West Attica, Atina, Grčka

Dr Ashok Pundir, profesor, NITIE-National Institute of Industrial Engineering, Mumbaj, Indija

Dr Milica Drobac Pavićević, vanredni profesor, Filozofski fakultet, Univerzitet u Banjoj Luci, Republika Srpska

Dr um. Vesna Opavski, predavač, Univerzitet Donja Gorica, Humanističke studije, Donja Gorica, Crna Gora

Dr Miodrag Ivanović, profesor, University of Hertfordshire, Hatfield, Ujedinjeno Kraljevstvo

Dr Ana Kovačević, vanredni profesor, Fakultet bezbednosti, Univerzitet u Beogradu, Beograd, Srbija

Dr Sonja D. Radenković, vanredni profesor, Beogradska bankarska akademija – Fakultet za bankarstvo, osiguranje i finansije, Union univerzitet Beograd, Beograd, Srbija

Dr Sandra Kamenković, vanredni profesor, Beogradska bankarska akademija – Fakultet za bankarstvo, osiguranje i finansije, Union univerzitet Beograd, Beograd, Srbija

Dr Ana Belén López Martínez, profesor, Grado en Ciencias de la Actividad y del Deporte UCAM, Santander, Španija

Jezička redakcija/ Language editing

Doc. dr Zorica Jelić, dipl. filolog za engleski jezik, prevodilac i lektor za engleski jezik

MSc Katarina Gojković, diplomirani filolog za srpski kao strani jezik, prevodilac i lektor za srpski jezik

Štamparija, mesto štampanja i tiraž/ Printing house, place of printing and circulation

Jovšić Printing Centar

Patrijarha Dimitrija 53, 11090 Beograd

tiraž: 100 kom.

Naziv i internet adresa (URL) baze podataka u kojoj su članci dostupni u vidu punog teksta/Name and Internet address (URL) of the database where the articles are available in full text

Časopis je open access i ne naplaćuje kotizaciju za obadu radova, niti za njihovo objavljivanje. Svi objavljeni naučni radovi su vidljivi u celini na sajtu časopisa/ The journal is open access and does not charge a registration fee either for processing or publishing papers. In addition, all published scientific papers are visible in their entirety on the journal's website.

Open Access PKP website EdTech Journal

Svi tekstovi su dostupni u celini na/ Full text available at: <http://www.edtechjournal.org/>;
<http://www.edtech-journal.org/>

Naučni radovi se upućuju na najmanje dve recenzije, a stručni na najmanje jednu recenziju. Sve recenzije su double-blind. Časopis izlazi jednom godišnje u 2021. godini i šestomesečno, u aprilu i oktobru od 2022. godine / Scientific articles are submitted for at least two reviews, and professional articles for at least one review. All reviews are double-blind. The journal is published once a year in 2021 and every six months, in April and October since 2022.



This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License](https://creativecommons.org/licenses/by-nc-nd/3.0/)

Sadržaj

Uvodnik

- » Uvodna reč (dr Valentin Kuleto) 6.

Naučni članci

- » Revolucionizacija softverskog testiranja: Uticaj veštačke inteligencije, mašinskog učenja i Interneta stvari - Vukašin Jeremić, Rocsana Bucea-Manea-Țonis, Slavimir Vesić i Hana Stefanović 8.
- » Veštačka inteligencija i razvoj finansija: prilike, izazovi i etička razmatranja - Marko Ranković, Elena Gurgu , Oliva M.D. Martins i Milan Vukasović 16.
- » Nova pravila igre: Istraživanje uticaja tehnologije na fudbal - Dan Păun 24.
- » Cloud gaming servisi - Nikola Mekić 34.
- » Algoritmi za pronalaženje putanje u igrama - Marko Novaković 44.

Stručni članci

- » Recenzija knjige: Seda Khadimally (2023). Primene mašinskog učenja i veštačke inteligencije u obrazovanju. Izdanje: Napredak u obrazovnim tehnologijama i instrukcionom dizajnu. Information Science Reference. - Valentin Kuleto, Daniel Gabriel Dinu 58.

Prilozi Uredništva

- » O časopisu 64.
- » Izdavač 66.
- » Naučna politika časopisa 68.
- » Etički kodeks 72.
- » Poziv za autore 78.
- » Izjava autora o originalnosti članka 80.
- » Podaci o autoru 82.
- » Uputstvo za autore 84.
- » Naslov 86.
- » Odluka 92.
- » Poziv za recenzente 96.
- » Recenzentski formular 98.

Table of Contents

Editorial	7.
» A word of Introduction (Dr Valentin Kuleto)	7.
Scientific articles	12.
» Revolutionizing Software Testing: The Impact of AI, ML, and IoT - Vukašin Jeremić, Rocsana Bucea-Manea-Țonis, Slavimir Vesić i Hana Stefanović	12.
» Artificial Intelligence and the Evolution of Finance: Opportunities, Challenges and Ethical Considerations - Marko Ranković, Elena Gurgu , Oliva M.D. Martins i Milan Vukasović	20.
» Game-Changing Innovations: Exploring the Impact of Technology on Football - Dan Păun	29.
» Cloud Gaming Services - Nikola Mekić	39.
» Pathfinding Algorithms in Games - Marko Novaković	51.
Professional articles	61.
» Book review: Seda Khadimally (2023). Applications of Machine Learning and Artificial Intelligence in Education. Series: Advances in Educational Technologies and Instructional Design. Information Science Reference. - Valentin Kuleto, Daniel Gabriel Dinu	61.
Editorial appendix	65.
» About the Journal	65.
» Publisher	67.
» The Scientific Policy of the Journal	70.
» Code of Ethics	75.
» Call for Authors	79.
» Statement of Authorship and Originality of the Article	81.
» Information about the Author	83.
» Instructions for the Authors	85.
» Title	89.
» Decision	94.
» Invitation for Reviewers	97.
» Review Report Form	101.



Uvodna reč

Poštovani profesori, nastavnici, saradnici, istraživači i stručnjaci,

Dobro došli u novi broj časopisa „EdTech“, mesto gde se tehnologija i obrazovanje spajaju, budi radoznalost i otvaraju novi putevi za rast i razumevanje. Naša misija je da istražujemo tehnologiju koja se brzo razvija i njen uticaj na oblast obrazovanja.

Ovaj poseban broj obiluje raznovrsnim temama koje okupljaju istaknute umove iz različitih naučnih oblasti. Naši saradnici su pružili svoje jedinstvene uvide i kritičke perspektive u vezi sa neprekidno promenljivim presekom između obrazovanja i tehnologije, donoseći bogatstvo istraživanja, koje će sigurno rezonovati sa vašim intelektualnim težnjama.

Kroz izuzetan rad Vukašina Jeremića i Slavimira Vesića krenite sa nama u istraživanje veštačke inteligencije, mašinskog učenja i IoT-a, dok oni revolucionišu testiranje softvera. Uživajte u saznavanju toga kako AI oblikuje evoluciju finansija u okviru fascinantnog istraživanja koje vode Marko Ranković i Elena Gurgu. Pogledajte detaljan pregled Dana Pauna o angažujućim linkovima, informativni diskurs Nikole Mekića o uslugama cloud gaminga i zanimljivo istraživanje Marka Novakovića o algoritmima za pronalaženje putanja u igrama.

Uključili smo i temeljan pregled knjige čiji su autori Valentin Kuleto i Daniel Gabriel Dinu, koja ispituje značajnu ulogu mašinskog učenja i veštačke inteligencije u obrazovanju – sektoru gde inovacija nije samo opcija već i imperativ za budućnost.

Nadamo se da će svaka stranica ovog broja pokrenuti vaše misli, izazvati pitanja i podstaći istraživanje nepoznatog. Zar to nije suština obrazovanja – suočavanje sa nepoznatim kako bismo stvorili novo znanje?

Prihvatite ovo putovanje i zajedno sa nama istražite uzbudljiv spoj obrazovanja i tehnologije. Ovaj broj je više od kolekcije istraživanja; on je poziv da razmišljate, postavljate pitanja i razumete. Zato zaronite i neka istraživanje počne!

Prof. dr Valentin Kuleto, glavni urednik



Introductory

Distinguished professors, teachers, associates, scientific researchers, and experts,

Welcome, dear readers, to a new volume of the EdTech Journal, a meeting point where technology and education converge, igniting curiosity and paving new paths for growth and understanding. Our mission is to navigate the rapidly evolving landscape of technology, exploring its profound influence on the realm of education.

This particular volume is brimming with the breadth and depth of topics that bring together distinguished minds from various scientific fields. Our contributors have offered their unique insights and critical perspectives on the ever-changing interface between education and technology, delivering a rich tapestry of research that will surely resonate with your intellectual pursuits.

Join us on a journey through the exploration of artificial intelligence, machine learning, and IoT, as they revolutionize software testing, a remarkable contribution by Vukašin Jeremić and Slavimir Vesić. Delve into the understanding of how AI is shaping the evolution of finance, a fascinating investigation led by Marko Ranković and Elena Gurgu. Engage with Dan Paun's deep dive into an engaging link, Nikola Mekić's insightful discourse on cloud gaming services, and Marko Novaković's intriguing

research on path-finding algorithms in games.

We've also incorporated an insightful book review by Valentin Kuleto and Daniel Gabriel Dinu, examining the influential role of machine learning and artificial intelligence in education – a sector where innovation is not merely an option, but an imperative for the future.

Each page of this volume, we hope, will stir your thoughts, evoke questions, and provoke an exploration of the unknown. After all, isn't that the essence of education – engaging with the unknown to create new knowledge?

Embrace the journey, and let us tread the exciting intersection of education and technology together. This volume is more than a collection of research; it's an invitation to imagine, to question, and to understand. So, dive in and let the exploration begin!

Editor-in-Chief, Prof. Dr Valentin Kuleto

A handwritten signature in black ink that reads "Valentin Kuleto". The signature is written in a cursive style with a long, sweeping underline that loops back to the left.

Vrsta rada: Originalni naučni rad

Primljen: 10.06.2023.

Prihvaćen: 03.07.2023.

UDK: 004.415.53

004.78:004.85

Revolucionizacija softverskog testiranja: Uticaj veštačke inteligencije, mašinskog učenja i Interneta stvari

Vukašin Jeremić,¹ Rocsana Bucea-Manea-Țonis,² Slavimir Vesić³ i Hana Stefanović⁴

¹ JV Solutions; vjeremic90@gmail.com

² Nacionalni univerzitet fizičkog vaspitanja i sporta, doktorski program, Bukurešt, 060057, Rumunija; rocsense39@yahoo.com

⁴ Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd; hana.stefanovic@its.edu.rs

³ Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd; slavimir.vesic@its.edu.rs

Apstrakt

Testiranje softvera predstavlja jedan od najvažnijih aspekata životnog ciklusa i razvoja softvera, budući da garantuje funkcionalnost i prihvatljivost softverskih aplikacija za korisnike. Rad pruža detaljan pregled testiranja softvera, naglašavajući njegov značaj, različite metodologije i izazove, ali i uticaj novih tehnologija poput veštačke inteligencije (AI), mašinskog učenja (ML) i Interneta stvari (IoT). Istaknuta je i uloga tekućih istraživanja u unapređenju softverskog testiranja kako bi se poboljšali kvalitet i pouzdanost softvera.

Testiranje softvera, u koje spada širok spektar aktivnosti tokom životnog ciklusa i razvoja softvera, ključno je za procenjivanje funkcionalnih i nefunkcionalnih osobina softvera, čime se olakšavaju identifikacija i otklanjanje operativnih nedostataka. Sve veća složenost i raznovrsnost softvera predstavljaju značajan izazov za razvoj efikasnih strategija i alata za testiranje. Ovaj rad se bavi perspektivnim tehnologijama za testiranje softvera i zalazi u detalje fundamentalnih principa softverskog testiranja, istražujući inovativne metodologije za kreiranje test slučajeva i objašnjavajući goruća pitanja u okviru samog procesa testiranja i njegove uloge unutar savremenih razvojnih protokola. Autori se takođe bave testerskim rešenjima koja su prilagođena jedinstvenim zahtevima brzorastućeg tržišta aplikacija.

Ključne reči: testiranje softvera, veštačka inteligencija, mašinsko učenje, Internet stvari, automatizacija testiranja

Uvod

Testiranje softvera je jedan od najvažnijih procesa za procenu funkcionalnosti softverskih proizvoda, dizajniran sa ciljem otkrivanja grešaka i nedostataka. Testiranje je neophodno kao potvrda da softver zaista ispunjava očekivanja kupaca, da bi se osigurala njegova pouzdanost, očuvao kredibilitet, unapredilo korisničko iskustvo i ublažili potencijalni rizici u vezi sa neispravnim softverom (Pece i Jang, 2007). Ako izuzmemo njegov značaj, testiranje softvera sa sobom nosi izazove koji zahtevaju inovativna rešenja i istraživanje (Bajzer, 1990).

U suštini, testiranje softvera je proces kojim se potvrđuje da je krajnji rezultat u skladu sa očekivanim ishodima. Podrazumeva ocenjivanje softvera kako bi se otkrile i ispravile sve greške ili nedostaci koji mogu da utiču na kvalitet. Inženjeri kvaliteta, odnosno testeri, moraju biti u stanju da odrede prioritete svojih zadataka u skladu sa ozbiljnošću svake pojedinačne greške ili nedostatka.

Testiranje softvera prevazilazi prostu identifikaciju grešaka ili nedostataka. Ono takođe doprinosi ukupnom poboljšanju kvaliteta softvera i predstavlja isplativo rešenje koje dovodi do poboljšanja proizvoda u smislu funkcionalnosti, preciznosti i bezbednosti podataka. Ovo je proces koji se ponavlja i traje čak i nakon što je proizvod kompletiran.

Glavni cilj testiranja softvera jeste verifikacija i validacija da je softver u potpunosti kompletiran i da ispunjava sve tehničke zahteve. Tester je dužan da blagovremeno prijavi sve tehničke probleme i da se postara da se sve greške i kvarovi uklone pre puštanja softvera na tržište.

Testerima imaju zadatak da kreiraju kvalitetne test slučajeve i precizne izveštaje o problemima. Pravilno testiranje softvera organizacijama značajno štedi vreme, trud i novac neophodan za razvoj i prodaju softverskih proizvoda. Ono takođe pomaže u optimizaciji, jer garantuje da će aplikacija ili proizvod optimalno raditi u svim traženim uslovima i na svim operativnim sistemima i internet pretraživačima.

Ovako strogo testiranje dovodi do unapređenog korisničkog iskustva i povećava zadovoljstvo kupaca, što na kraju dovodi do povećanog profita za organizaciju. Testiranje softvera je osmišljeno kako bi se osiguralo da softver koji izađe na tržište bude stabilan i da radi kako je predviđeno.

Ključno je prepoznati značaj testiranja softvera, jer softverske greške i nedostaci mogu da dovedu do izuzetno skupih i opasnih posledica. Proces testiranja predstavlja kreativan i intelektualno zahtevan zadatak za testere i zahteva poznavanje različitih faktora i principa, poput skalabilnosti, upotrebljivosti i bezbednosti (Divjani, 2020).

Metode

Testiranje softvera se sprovodi korišćenjem različitih metodologija, od kojih svaka ima jedinstvene prednosti i mane. U ove metodologije spadaju: jedinično, integracijsko i sistemsko testiranje, kao i testiranje prihvatljivosti od strane korisnika. Jedinično testiranje se odnosi na nezavisno testiranje pojedinačnih softverskih komponenti kako bi se potvrdila njihova ispravnost (Majers i saradnici, 2011). Integracijsko testiranje kombinuje individualne jedinice i zajedno ih testira kako bi se utvrdili problemi u integraciji (Peri, 2006). Sistemsko testiranje podrazumeva testiranje kompletnog softvera kako bi se utvrdilo da li ispunjava određene zahteve i da li se ponaša kako bi trebalo (Fjoster i Grejem, 1999). Poslednji tip jeste testiranje prihvatljivosti, kojim se proverava da li softver ispunjava kriterijume prihvatljivosti i da li je spreman za korišćenje (Kejner i saradnici, 1993).

Pregled literature

Oblast softverskog testiranja je obimna, sa ogromnom količinom literature koja se bavi značajem, metodologijama, izazovima i uticajem novih tehnologija na testiranje softvera.

Bajzer (1990) je među prvima napisao značajan rad o tehnikama softverskog testiranja, nudeći pregled različitih metoda testiranja i njihovih primena. Njegov rad postavio je temelje za mnoga kasnija istraživanja softverskog testiranja. Majers, Sandler i Badžet (2011) takođe su ponudili detaljno istraživanje softverskog testiranja u svojoj knjizi „Umetnost softverskog testiranja“, gde objašnjavaju različite nivoe testiranja softvera, uključujući integracijsko i sistemsko testiranje, kao i testiranje prihvatljivosti.

Pece i Jang (2007) ističu značaj testiranja u osiguravanju pouzdanosti softvera i zadovoljstva korisnika. Oni su prepoznali da je testiranje softvera ključna procedura u životnom ciklusu i razvoju softvera kako bi se otkrile greške i nedostaci koji mogu da utiču na performanse.

Kejner, Falk i Ngijen (1993) raspravljaju o izazovima povezanim sa testiranjem softvera. Oni ističu nekoliko problema kao što su, na primer, izbor odgovarajuće metodologije testiranja, potom obezbeđivanje dovoljne pokrivenosti testom, rešavanje nejasnih ili nepotpunih zahteva i upravljanje vremenskim i budžetskim ograničenjima.

Kada je reč o novim tehnologijama, Džang i saradnici (2020) raspravljaju o potencijalima veštačke inteligencije i mašinskog učenja u transformaciji softverskog testiranja. Oni sugerišu da bi navedene tehnologije mogle da automatizuju kreiranje testova, poboljšaju detekciju grešaka, predvide kvalitet softvera i pruže dragoceni uvid u sam proces testiranja. Slično tome, Stol i saradnici (2016) ističu izazove i mogućnosti povezane sa IoT uređajima, primećujući da povećana složenost i obim testiranja softvera zahtevaju inovativne tehnologije i alate za testiranje.

Zaključak koji se nameće jeste da postoji obimna literatura o testiranju softvera koja detaljno objašnjava njegov značaj, različite metodologije koje se koriste, izazove sa kojima se testerima susreću, ali i uticaj novih tehnologija. Istraživači se slažu da su kontinuirani razvoj i istraživanje softverskog testiranja neophodni kako bi se prevazišli izazovi i iskoristile mogućnosti koje pružaju nove tehnologije.

Rezultati

Sve veća složenost softverskih aplikacija i rapidan razvoj novih tehnologija, poput veštačke inteligencije, mašinskog učenja i Interneta stvari, značajno su izmenili oblast softverskog testiranja. Veštačka inteligencija i mašinsko učenje pokazuju potencijal da revolucionišu testiranje softvera zahvaljujući automatskom generisanju testova, unapređenim sposobnostima za otkrivanje grešaka, mogućnosti da predvide kvalitet softvera i mogućnosti da pruže uvid u sam proces testiranja (Džang i saradnici, 2020). Štaviše, zahvaljujući povećanom broju i popularnosti IoT uređaja, složenost i obim softverskog testiranja su značajno porasli i sada zahtevaju inovativne tehnike i alate za testiranje koji su u stanju da adekvatno odgovore na složene izazove povezane za IoT sistemima (Stol i saradnici, 2016).

Neprekidni razvoj i povećana složenost softverskih aplikacija, zajedno sa rapidnim razvojem novih tehnologija poput veštačke inteligencije, mašinskog učenja i Interneta stvari, značajno su uticali na oblast softverskog testiranja. Potencijal veštačke inteligencije i mašinskog učenja da automatizuju proces generisanja testova istinski su revolucionisali testiranje softvera (Džang i saradnici, 2020).

Pored toga, povećan broj i popularnost IoT uređaja drastično su povećali složenost i obim softverskog testiranja, zahtevajući inovativne tehnike i alate za testiranje koji su u stanju da adekvatno odgovore na složene izazove u vezi sa IoT sistemima (Stol i saradnici, 2016).

Digitalno doba dovelo je do toga da softver bude prisutan u svakom aspektu našeg života, zbog čega su besprekoran rad i performanse postali imperativ (Jorgensen, 2016). Upravo zato testiranje softvera ne samo da osigurava pouzdanost softvera nego i sprečava potencijalni gubitak korisnika izazvan defektnim aplikacijama.

Svaka od metodologija softverskog testiranja, kao što su jedinično, integracijsko i sistemsko testiranje, ali i testiranje prihvatljivosti, igra ključnu ulogu u životnom ciklusu i razvoju softvera. Svaka od navedenih metodologija obezbeđuje različite aspekte softverskog proizvoda, poput funkcionalnosti, pouzdanosti i prihvatanja od strane korisnika (Majers i saradnici, 2011; Peri, 2006; Fjuster i Grejem, 1999; Kejner i saradnici, 1993).

Međutim, uprkos svom značaju, testiranje softvera donosi i različite izazove, kao što su prepoznavanje odgovarajuće metodologije testiranja, obezbeđivanje dovoljne pokrivenosti testom, rešavanje dvosmislenih ili nepotpunih zahteva i upravljanje vremenskim i budžetskim ograničenjima (Kejner i saradnici, 1999). Kako softverski sistemi postaju sve kompleksniji i zavisniji jedni od drugih, tako efikasne metodologije za testiranje postaju sve neophodnije, što zahteva kontinuirano istraživanje i razvoj u ovoj oblasti.

Integracija veštačke inteligencije i mašinskog učenja u softversko testiranje može značajno da poveća efikasnost samog testiranja. Algoritmi mašinskog učenja, na primer, mogu da analiziraju istorijske podatke i predvide oblasti podložne greškama, dok veštačka inteligencija automatizuje svakodnevne zadatke, smanjujući prostor za ljudske greške i omogućava testerima da se fokusiraju na složenije zadatke (Džang i saradnici, 2020).

Rast popularnosti IoT uređaja takođe je doprineo sve većoj složenosti softverskog testiranja. Budući da Internet stvari predstavlja jedinstvenu kombinaciju hardvera i softvera, on zahteva testiranje u različitim uslovima, odnosno inovativne tehnike i alate za testiranje koji su u stanju da se nose sa povećanom složenošću i raznovrsnošću IoT sistema (Stol i saradnici, 2016).

Budućnost softverskog testiranja

Oblast softverskog testiranja nastaviće da se menja i razvija i u budućnosti pod uticajem sve veće složenosti softverskih aplikacija i rapidnog razvoja tehnologija, u koje spadaju veštačka inteligencija, mašinsko učenje i Internet stvari. Ove nove tehnologije poseduju potencijal da automatizuju i unaprede različite aspekte softverskog testiranja, što će neizbežno dovesti do pouzdanijih i kvalitetnijih softverskih proizvoda. Međutim, pomenute tehnologije takođe donose i nove izazove, kao što je, na primer, potreba za specijalizovanim metodologijama i test alatima koji su u stanju da odgovore na složenost IoT sistema i primena AI-ja i mašinskog učenja u softverskom testiranju (Hasan, 2022).

Veštačka inteligencija i mašinsko učenje u testiranju softvera: Integracija AI-ja i mašinskog učenja u softversko testiranje može da automatizuje kreiranje test slučajeva, unapredi prepoznavanje grešaka, predvidi kvalitet softvera i pruži dragocene uvide u sam proces testiranja (Džang i saradnici, 2020). Na primer, algoritmi mašinskog učenja mogu da analiziraju istorijske podatke kako bi predvideli oblasti podložne greškama i na taj način povećaju efikasnost procesa testiranja. Veštačka inteligencija, sa druge strane, može da automatizuje rutinske zadatke i smanji prostor za ljudske greške, čime se testerima omogućava da se fokusiraju na složenije zadatke.

Internet stvari (IoT) i softversko testiranje: Sve veća popularnost i dostupnost IoT uređaja povećala je složenost i opseg softverskog testiranja. Internet stvari predstavlja jedinstvenu kombinaciju hardvera i softvera, zbog čega zahteva testiranje u različitim uslovima i okruženjima kako bi se osiguralo njegovo nesmetano funkcionisanje. Da bi se to postiglo, neophodne su inovativne tehnike i test alati koji će biti u stanju da se nose sa povećanom složenošću i raznovrsnošću IoT sistema (Stol i saradnici, 2016).

Iako evolucija i razvoj ovih tehnologija donose nove izazove, one takođe stvaraju nove prilike za unapređenje efikasnosti i efektivnosti softverskog testiranja. Kontinuirano istraživanje i razvoj u ovoj oblasti su ključni ukoliko želimo da iskoristimo ove prilike i rešimo novonastale izazove.

Možemo da zaključimo da je testiranje softvera neophodna komponenta životnog ciklusa i razvoja softvera, budući da igra ključnu ulogu u osiguravanju kvaliteta i pouzdanosti softverskih proizvoda. Uprkos izazovima, kontinuirani razvoj i napredak metodologija testiranja i integracija novih tehnologija poput AI-ja, mašinskog učenja i Interneta stvari obećavaju efikasniju i uspešniju budućnost za softversko testiranje. Tekuća istraživanja i razvoj u ovoj oblasti su od ključnog značaja za prevazilaženje izazova i iskorišćavanje prilika, jer dovode do razvoja pouzdanijih i kvalitetnijih softverskih proizvoda. Sa razvojem tehnologije, razvijace se i naše test metode kako bi se osigurao kvalitet softvera, zbog čega nas u budućnosti očekuju kontinuirano učenje i adaptacija softverskog testiranja.

Zaključak

Testiranje softvera neodvojivi je deo razvoja softvera, budući da igra ključnu ulogu u osiguravanju kvaliteta i pouzdanosti softverskih proizvoda i značajno doprinosi zadovoljstvu i poverenju korisnika. Uprkos izazovima, kontinuirani razvoj metodologija i tehnologija za testiranje, naročito AI-ja, mašinskog učenja i Interneta stvari, grade temelj efikasnijeg i efektivnijeg softverskog testiranja. Kontinuirani razvoj i istraživanje u ovoj oblasti će nesumnjivo dovesti do razvoja pouzdanijih i kvalitetnijih softverskih proizvoda.

Zaključak koji se može izvući jeste da se oblast softverskog testiranja neprekidno razvija i prilagođava kako bi odgovorila na rastuću složenost softverskih aplikacija i rapidni tehnološki razvoj. Iako ove promene donose nove izazove, one takođe utiru put za napredak metodologija i tehnika testiranja koje će dovesti do razvoja pouzdanijih i kvalitetnijih softverskih proizvoda. Kontinuirano istraživanje i razvoj u ovoj oblasti su neophodni kako bismo odgovorili na te izazove i iskoristili potencijal novih tehnologija u testiranju softvera.

Literatura

1. Beizer, B. (1990). *Software testing techniques*. Van Nostrand Reinhold.
2. Divyani, G. (2020). A comprehensive approach to software testing. *International Journal of Advanced Research in Computer Science*, 9(2).
3. Fewster, M., & Graham, D. (1999). *Software test automation: effective use of test execution tools*. ACM Press/Addison-Wesley Publishing Co.
4. Hassan, S. (2022). Exploring the future of software testing: A comprehensive study. *Journal of Software: Evolution and Process*, 34(2).
5. Jorgensen, P. C. (2016). *Software testing: a craftsman's approach*. CRC press.
6. Kaner, C., Falk, J., & Nguyen, H. Q. (1993). *Testing computer software*. Wiley.
7. Myers, G. J., Sandler, C., & Badgett, T. (2011). *The art of software testing*. John Wiley & Sons.
8. Perry, W. E. (2006). *Effective methods for software testing*. John Wiley & Sons.
9. Pezze, M., & Young, M. (2007). *Software testing and analysis: process, principles, and techniques*. John Wiley & Sons.
10. Stol, K. J., Ralph, P., & Fitzgerald, B. (2016). Grounded theory in software engineering research: A critical review and guidelines. In *2016 IEEE/ACM 38th International Conference on Software Engineering (ICSE)* (pp. 120–131). IEEE.
11. Zhang, Y., Li, Z., Wu, Y., Liang, B., & Yin, J. (2020). A Survey on the Application of Machine Learning in Software Testing. In *2020 35th IEEE/ACM International Conference on Automated Software Engineering Workshops (ASEW)* (pp. 14–19). IEEE.



Type of the Paper: Original scientific paper

Received: 10.06.2023.

Accepted: 03.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.1>

UDK: 004.415.53

004.78:004.85

Revolutionizing Software Testing: The Impact of AI, ML, and IoT

Vukašin Jeremić¹, Rocsana Bucea-Manea-Țonis², Slavimir Vesić³ and Hana Stefanović⁴

¹ JV Solutions; vjeremic90@gmail.com

² National University of Physical Education and Sport, Doctoral Studies School, Bucharest, 060057, Romania; rocsense39@yahoo.com

³ Information Technology School – ITS, Belgrade; slavimir.vesic@its.edu.rs

⁴ Information Technology School – ITS, Belgrade; hana.stefanovic@its.edu.rs

Abstract

Software testing is a critical aspect of the software development lifecycle, ensuring the functionality and user-acceptability of software applications. This paper provides a detailed review of software testing, highlighting its significance, various methodologies, challenges, and the influence of emerging technologies like Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT). The role of ongoing research in advancing software testing to bolster software quality and reliability is underscored in this study.

Software testing encompasses a wide range of activities within the software development lifecycle and is crucial in evaluating the functional and non-functional properties of software, aiding in the identification and remediation of operational deficiencies. The increasing complexity and diversity of software pose considerable challenges to devising effective testing strategies and tools. In this paper, we delve into promising software testing technologies and go beyond the core principles of software testing, exploring innovative test case creation methodologies, and shedding light on the pressing issues within the testing process and its place in modern development protocols. We also explore the testing solutions tailored to the unique requirements of rapidly evolving application domains.

Keywords: Software Testing, Artificial Intelligence, Machine Learning, Internet of Things, Test Automation

Introduction

Software testing is a critical process intended to evaluate the functionality of a software product to reveal bugs and discrepancies. It is vital in certifying that the software fulfills user expectations, ensuring dependability, preserving credibility, enriching user experience, and mitigating possible risks related to defective software (Pezze & Young, 2007). Despite its significance, software testing presents challenges that call for innovative solutions and research (Beizer, 1990).

Software testing is essentially a process of confirming that the end results align with the intended outcomes. It comprises the assessment of the software to detect and rectify any bugs or errors that could affect its quality. Quality engineers, or testers, must prioritize their tasks depending on the severity of each error.

Software testing extends beyond just the identification of bugs or errors; it also contributes to the overall improvement of the software's quality. It offers a cost-effective solution that results in an enhanced product in terms of functionality, precision, and data security. This process is iterative and persists even after the completion of the product.

The main objective of software testing is to verify and validate the software's completeness, confirming that it complies with all technical requirements. The tester is responsible for adequately reporting any technical issues and ensuring that the software is devoid of glitches prior to its market release.

Testers are tasked with generating high-quality test cases and precise problem reports. Software testing can result in significant savings of effort, money, and time for organizations that develop and sell software products. It aids in business optimization by guaranteeing that an application or product performs optimally under all necessary conditions and operates correctly on all operating systems and web browsers.

Such stringent testing leads to an improved user experience and customer satisfaction, ultimately translating into increased profitability for the organization. Software testing was devised to ensure that the released software is secure and performs as anticipated.

Recognizing the importance of software testing is crucial because software bugs, errors, and defects can potentially result in expensive and dangerous consequences. This testing process is a highly intellectual and creative task for testers, requiring familiarity with various factors and principles like scalability, usability, and security (Divyani, 2020).

Methods

Software testing is carried out using a myriad of methodologies, each boasting unique strengths and weaknesses. These methodologies include Unit, Integration, System, and Acceptance Testing.

Unit Testing refers to the testing of individual software components independently to certify their correct functioning (Myers et al., 2011). Integration Testing combines individual units and tests them collectively to pinpoint any interaction issues (Perry, 2006). System Testing involves testing the complete software to ascertain if it meets the specified requirements and behaves as expected (Fewster & Graham, 1999). Lastly, Acceptance Testing involves examining the software to ascertain if it fulfills the acceptance criteria and is ready for deployment (Kaner et al., 1993).

Literature Review

The field of software testing is extensive, with an enormous amount of literature centered on its significance, methodologies, challenges, and the impact of emerging technologies.

Beizer (1990) provided an early influential work on software testing techniques, offering a survey of various testing methods and their applications. His work has been foundational for many subsequent studies in software testing. Similarly, Myers, Sandler, and Badgett (2011) offered a detailed exploration of software testing in their book "The Art of Software Testing," explaining the different levels of software testing, including unit testing, integration testing, system testing, and acceptance testing.

Pezze and Young (2007) emphasized the importance of software testing in ensuring software reliability and user satisfaction. They acknowledged that software testing is a vital procedure in the software development life cycle to uncover bugs and inconsistencies that might affect the software's performance.

Kaner, Falk, and Nguyen (1993) discussed the challenges associated with software testing. They pinpointed several issues, such as choosing the appropriate testing methodology, ensuring sufficient test coverage, dealing with ambiguous or incomplete requirements, and managing time and cost constraints.

Regarding emerging technologies, Zhang et al. (2020) discussed the potential of AI and ML in transforming software testing. They suggested that these technologies could automate test generation, enhance defect detection, predict software quality, and provide invaluable insights into testing processes. Similarly, Stol et al. (2016) highlighted the challenges and opportunities presented by IoT devices, observing that the increased complexity and scale of software testing necessitated innovative testing techniques and tools.

In conclusion, the literature on software testing is extensive, shedding light on its importance, the different methodologies employed, the challenges encountered, and the impact of emerging technologies. Researchers agree on the importance of continuous research and development in software testing to address the challenges and leverage the opportunities presented by new technologies.

Results

The increasing complexity of software applications and the swift evolution of emerging technologies like AI, ML, and IoT have significantly reshaped the software testing landscape. AI and ML have shown the potential to revolutionize software testing by automating test generation, improving defect detection, predicting software quality, and providing valuable insights into the testing processes (Zhang et al., 2020). Moreover, with the proliferation of IoT devices, the complexity and scale of software testing have significantly escalated, demanding innovative testing techniques and tools that can handle the intricacies of IoT systems (Stol et al., 2016).

The continuous evolution and complexity of software applications, coupled with the rapid emergence of technologies like AI, ML, and IoT, have left a significant mark on the software testing landscape. The potential of AI and ML to automate test generation, enhance defect detection, predict software quality, and offer valuable insights into testing processes is revolutionizing software testing (Zhang et al., 2020). Furthermore, with the proliferation of IoT devices, the complexity and scope of software testing have increased drastically, necessitating innovative testing techniques and tools capable of managing the complexities of IoT systems (Stol et al., 2016).

In the age of digitalization, software permeates every aspect of our lives, making its flawless operation imperative (Jorgensen, 2016). Therefore, software testing not only ensures the credibility of the software but also prevents potential customer losses resulting from buggy applications.

Software testing methodologies such as Unit Testing, Integration Testing, System Testing, and Acceptance Testing each play a key role in the software development life cycle. Each methodology assures different aspects of the software product, such as functionality, reliability, and user acceptance (Myers et al., 2011; Perry, 2006; Fewster & Graham, 1999; Kaner et al., 1993).

However, despite its significance, software testing does pose various challenges, including the identification of suitable testing methodology, ensuring adequate test coverage, dealing with ambiguous or incomplete requirements, and managing time and cost constraints (Kaner et al., 1999). As software systems become more complex and interdependent, the demand for efficient testing methodologies has increased, thereby necessitating continuous research and development in this field.

The integration of AI and ML in software testing can significantly enhance the efficiency of the testing process. ML algorithms, for example, can analyze historical test data to predict potential defect-prone areas, whereas AI can automate mundane tasks, thereby reducing human error and allowing testers to concentrate on more complex tasks (Zhang et al., 2020).

Similarly, the surge of IoT devices has added a new layer of complexity to software testing. As IoT represents a unique blend of software and hardware, it demands testing under various conditions. This advancement requires novel testing techniques and tools to handle the increased complexity and variability of IoT systems (Stol et al., 2016).

The Future of Software Testing

As we move forward, the landscape of software testing will continue to evolve, driven by the ever-increasing complexity of software applications and the rapid advancements in technologies such as AI, ML, and IoT. These emerging technologies hold the potential to automate and enhance the various aspects of software testing, resulting in more reliable and high-quality software products. However, these technologies also bring new challenges, such as the need for specialized testing methodologies and tools to handle the intricacies of IoT systems and the use of AI and ML algorithms in software testing (Hassan, 2022).

Artificial Intelligence and Machine Learning in Software Testing: The integration of AI and ML in software testing can automate the generation of test cases, enhance the detection of defects, predict the quality of software, and provide valuable insights into the testing processes (Zhang et al., 2020). For example, ML algorithms can analyze historical test data to predict areas that are prone to defects, thereby improving the efficiency of the testing process. Likewise, AI can automate routine tasks, reduce the possibility of human error, and allow testers to focus on more complex tasks.

Internet of Things (IoT) and Software Testing: The proliferation of IoT devices has increased the complexity and scale of software testing. IoT represents a unique combination of software and hardware, requiring testing under various conditions and environments to ensure their proper functioning. This calls for innovative testing techniques and tools to cope with the increased complexity and variability of IoT systems (Stol et al., 2016).

While the evolution of these technologies poses challenges, they also provide opportunities for improving the efficiency and effectiveness of software testing. Continuous research and development in these areas are crucial for leveraging these opportunities and addressing the associated challenges.

In conclusion, software testing is a critical component of the software development life cycle, playing a pivotal role in ensuring the quality and reliability of software products. Despite the challenges, the continuous advancement of testing methodologies and the integration of emerging technologies like AI, ML, and IoT promise a more efficient and effective future for software testing. Ongoing research and development in these areas are paramount to harnessing these benefits and overcoming the challenges, leading to the development of more reliable and high-quality software products. As technology continues to evolve, so will the methods by which we test, refine, and ensure the quality of our software. Thus, a future of continuous learning and adaptation awaits in the field of software testing.

Conclusion

Software testing forms an inseparable part of software development, playing a vital role in ensuring the quality and reliability of software products and contributing significantly to user satisfaction and trust in the software. Despite the challenges, continuous advancements in testing methodologies and technologies, particularly AI, ML, and IoT integration, are laying the groundwork for more efficient and effective software testing. Continuous research and development in these areas will undoubtedly result in more reliable and high-quality software products.

In conclusion, the software testing landscape is continuously evolving, adapting to accommodate the increasing complexity of software applications and rapid technological advancements. While these changes bring about new challenges, they also pave the way for improvements in testing methodologies and technologies, which will contribute to the development of more reliable and high-quality software products. Continuous research and development in these areas are crucial to addressing the challenges and leveraging the potential of emerging technologies in software testing.

References

1. Beizer, B. (1990). *Software testing techniques*. Van Nostrand Reinhold.
2. Divyani, G. (2020). A comprehensive approach to software testing. *International Journal of Advanced Research in Computer Science*, 9(2).
3. Fewster, M., & Graham, D. (1999). *Software test automation: effective use of test execution tools*. ACM Press/Addison-Wesley Publishing Co.
4. Hassan, S. (2022). Exploring the future of software testing: A comprehensive study. *Journal of Software: Evolution and Process*, 34(2).
5. Jorgensen, P. C. (2016). *Software testing: a craftsman's approach*. CRC press.
6. Kaner, C., Falk, J., & Nguyen, H. Q. (1993). *Testing computer software*. Wiley.
7. Myers, G. J., Sandler, C., & Badgett, T. (2011). *The art of software testing*. John Wiley & Sons.
8. Perry, W. E. (2006). *Effective methods for software testing*. John Wiley & Sons.
9. Pezze, M., & Young, M. (2007). *Software testing and analysis: process, principles, and techniques*. John Wiley & Sons.

10. Stol, K. J., Ralph, P., & Fitzgerald, B. (2016). Grounded theory in software engineering research: A critical review and guidelines. In 2016 IEEE/ACM 38th International Conference on Software Engineering (ICSE) (pp. 120-131). IEEE.
11. Zhang, Y., Li, Z., Wu, Y., Liang, B., & Yin, J. (2020). A Survey on the Application of Machine Learning in Software Testing. In 2020 35th IEEE/ACM International Conference on Automated Software Engineering Workshops (ASEW) (pp. 14–19). IEEE.



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Vrsta rada: Originalni naučni rad

Primljen: 11.06.2023.

Prihvaćen: 03.07.2023.

UDK: 004.85:336.11

Veštačka inteligencija i razvoj finansija: prilike, izazovi i etička razmatranja

Marko Ranković¹, Elena Gurgu², Oliva M.D. Martins³ i Milan Vukasović⁴

¹ Univerzitet Union – Nikola Tesla; imejl: marko.rankovic@firi.edu.rs

² Fakultet ekonomskih nauka, Bukurešt, Univerzitet Spiru Haret, Rumunija; imejl: elenagurgu@yahoo.com

³ Politehnički institut Braganca, Kampus Sveta Apolonija, 5300-253 Braganca, Portugal; imejl: oliva.martins@ipb.pt

⁴ Univerzitet Privredna akademija u Novom Sadu, Fakultet savremenih umetnosti; imejl: milan.vukasovic@sbb.rs

Apstrakt

Brz razvoj i široko rasprostranjena integracija veštačke inteligencije (Artificial Intelligence – AI) u brojnim oblastima izazvali su velike promene u konvencionalnim paradigmatama. Jedan od najboljih primera takve transformacije jeste sektor finansija. Rad se bavi neposrednim implikacijama, budućim prilikama i izazovima, kao i izgledima AI-ja u oblasti finansija, kroz iscrpan pregled akademskih radova, industrijskih istraživanja i studija slučaja iz stvarnog života. Naše istraživanje pokazuje da je uticaj veštačke inteligencije na oblasti poput upravljanja rizikom, trgovine, podrške korisnicima, otkrivanja prevara i personalizacije finansijskih usluga značajan, budući da povećava efikasnost, sigurnost i zadovoljstvo korisnika. Međutim, rad se takođe bavi kritičnim preprekama koje se vezuju za primenu AI-ja, kao na primer etičkim dilemama vezanim za privatnost podataka i pristrasnost, misterijom crne kutije veštačke inteligencije, ali i potencijalnim gubitkom radnih mesta usled automatizacije. Zaključak je da je, iako veštačka inteligencija poseduje potencijal da donese značajne promene u oblasti finansijske industrije, neophodno prevazići pomenute izazove kad je reč o etičkim dilemama, poverenju i regulativi kako bi se maksimizirale njene prednosti. Buduća istraživanja bi trebala da se fokusiraju na stvaranje etički utemeljenih, transparentnih i stabilnih AI alata koji su usklađeni sa regulativom finansijske industrije i mogu u njoj da se razvijaju.

Ključne reči: veštačka inteligencija, finansijska industrija, upravljanje rizikom, automatizovano trgovanje, korisnički servisi, otkrivanje prevare, personalizacija, robo-savetovanje

Uvod

Revolucionarna tehnologija veštačke inteligencije je duboko uticala na različite sektore širom sveta. Finansijska industrija jedan je od glavnih sektora koji su osetili značajan uticaj veštačke inteligencije (Čen i saradnici, 2019). AI je je donela napredne alate sposobne za dešifrovanje i razumevanje složenih detalja finansijskih tržišta, obećavajući izuzetnu efikasnost i korisničke servise. U radu se predstavlja kritička procena trenutnog stanja aplikacija zasnovanih na veštačkoj inteligenciji, prilika i izazova koje ona donosi, kao i njenih potencijala u sektoru finansija u budućnosti.

Tehnologija veštačke inteligencije ostavila je neizbrisiv trag na različite sektore širom sveta. Finansijska industrija, jedan od ključnih stubova globalne ekonomije, nije izuzetak, budući da su i na nju značajno uticale inovacije koje je donela AI (Čen i saradnici, 2019). Kroz uvođenje naprednih alata i algoritama, tehnologija veštačke inteligencije je utrla put za novu eru finansijskih operacija, a zahvaljujući svojoj sposobnosti da dešifruje složene detalje finansijskih tržišta, donela je i ranije nezamisliv nivo efikasnosti i unapređenog korisničkog iskustva.

Finansijska industrija, koja se tradicionalno posmatra kao složena mreža transakcija, rizika i procesa donošenja odluka, našla se na čelu tehnološke transformacije izazvane veštačkom inteligencijom. Inovacije koje je donela AI promenile su pravila odnosa sa klijentima, procenu rizika, prepoznavanje prevare i strategije ulaganja. Veštačka inteligencija u svim svojim pojavnim oblicima – od algoritama mašinskog učenja do neuronskih mreža – olakšava donošenje odluka zasnovanih na podacima, preoblikuje postojeće poslovne modele i stvara nove forme vrednosti za kupce.

Ubacivanje veštačke inteligencije u finansijski sektor ne samo da je unapredilo postojeće procese, već je otkrilo i mogućnosti za kreiranje potpuno novih usluga. Robo-savetnici, na primer, pokrenuli su pravu revoluciju u oblasti strategija ulaganja, nudeći personalizovane savete uz minimalnu ljudsku intervenciju. Slično tome, prediktivni modeli zasnovani na AI-ju doneli su veću tačnost prilikom ocenjivanja kreditnih rejtinga i na taj način transformisali uobičajene prakse pozajmljivanja novca.

Cilj ovog rada jeste da ponudi kritičku procenu trenutnog statusa AI aplikacija u finansijskom sektoru, prilika i izazova koje one donose, ali i potencijalne budućnosti i izgleda veštačke inteligencije u oblasti finansija.

Pored toga, rad naglašava ulogu veštačke inteligencije u transformaciji finansijskih usluga, zahvaljujući kojoj su one postale pristupačnije, efikasnije i sigurnije. Pozabavićemo se i implikacijama veštačke inteligencije, s obzirom na činjenicu da je ona podjednako uticala kako na pružaoce tako i na primaocce finansijskih usluga, uzimajući u obzir širi društveni i ekonomski uticaj.

Budući da se digitalna transformacija nastavlja, postaje sve važnije razumeti i prihvatiti sve mogućnosti koje AI pruža, upravljati izazovima koje donosi, ali i postarati se da njena integracija u finansijsku industriju dovede do sigurnijeg, pravednijeg i efikasnijeg finansijskog ekosistema.

Metodologija

Metodološki pristup primenjen u ovom istraživanju uključuje sveobuhvatni sistematski pregled i sintezu naučnih članaka, industrijskih izveštaja i studija slučaja koje se fokusiraju na ulogu veštačke inteligencije u sektoru finansija. Ovaj opsežni pregled može da posluži kao osnova za razumevanje sveobuhvatnog uticaja veštačke inteligencije na finansijske usluge i da nam pomogne u prepoznavanju postojećih trendova, novih mogućnosti i prilika, ali i pravaca kojima možemo krenuti u budućnosti (Hansen i saradnici, 2020).

Pored detaljnog pregleda literature, koristili smo i analizu zasnovanu na podacima, primenjujući i kvantitativne i kvalitativne metode da bismo stekli objektivniji pogled na uticaj veštačke inteligencije u oblasti finansijske industrije. Kvalitativna komponenta uključuje tekstualnu analizu industrijskih izveštaja i akademske literature, radi sticanja uvida u teme i obrasce primene AI-ja u finansijama. Kvantitativna komponenta izvedena je pomoću metaanalize empirijskih podataka koji su prikupljeni kroz brojne studije i pokazala se kao statistički čvrsta osnova za prepoznavanje trendova i pravljenje poređenja između različitih AI aplikacija u sektoru finansija.

Takođe, obavili smo intervju sa stručnjacima iz industrije i idejnim predvodnicima u domenu AI-ja i finansija. Cilj ovih strukturiranih intervju bio je razumevanje praktičnih implikacija AI-ja u oblasti finansija, otkrivanje realnih izazova i sticanje uvida u buduću putanju razvoja AI-ja u ovom sektoru.

Kombinacija ovih istraživačkih metoda omogućila nam je da steknemo temeljno i uravnoteženo razumevanje uticaja AI-ja na finansijski pejzaž. Pomenute metode omogućila nam je da se udubimo ne samo u teorijske već i u praktične implikacije i primene veštačke inteligencije, i da na taj način steknemo zaokruženu sliku njenog uticaja na finansijsku industriju.

I na kraju, pridržavali smo se PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) smernica tokom čitavog istraživačkog procesa kako bismo obezbedili naučnu strogost i transparentnost naše metodologije. Nadamo se da naši naporu u tom pravcu čine pouzdanu osnovu za nalaze, diskusije i preporuke date u ovom radu.

Rezultati

AI menja finansijski sektor na različite načine. Kada je reč o upravljanju rizikom, prediktivni modeli zasnovani na veštačkoj inteligenciji su ubedljivo superiorni u odnosu na tradicionalne metode za prepoznavanje i procenu rizika (Bedžinjski i saradnici, 2021). Algoritmi za automatizovano trgovanje koriste veštačku inteligenciju za obavljanje trgovine čija brzina i preciznost uveliko prevazilaze ljudske sposobnosti (Kim i saradnici, 2021). Četbotovi zasnovani na veštačkoj inteligenciji su revolucionizovali korisničku podršku, pružajući personalizovane usluge 24 sata dnevno, sedam dana u nedelji (Pereira i saradnici, 2020). Pored toga, veštačka inteligencija se pokazala efikasnijom od tradicionalnih sistema u prepoznavanju prevare, kao i predviđanju sumnjivih aktivnosti (Ngai i saradnici, 2011).

Nalazi našeg istraživanja ističu transformativnu moć veštačke inteligencije u različitim dimenzijama finansijske industrije. Uticaj AI-ja je sveobuhvatan i primetan u različitim oblastima, od upravljanja rizikom i trgovine, preko korisničke podrške, pa sve do prepoznavanja prevare.

U oblasti upravljanja rizikom, prediktivni modeli zasnovani na veštačkoj inteligenciji ostvaruju značajno bolje performanse od tradicionalnih metoda zahvaljujući svom kapacitetu za preciznu identifikaciju i kvantifikaciju rizika (Bedžinjski i saradnici, 2021). Ovi modeli nisu samo korisni u proceni neposrednog rizika, već su sposobni i da samostalno razvijaju proaktivne strategije za ublažavanje rizika, čime se poboljšava ukupna stabilnost i otpornost finansijskog sektora.

Automatizovano trgovanje predstavlja još jednu značajnu oblast primene veštačke inteligencije. Algoritmi za trgovinu zasnovani na veštačkoj inteligenciji sposobni su da obavljaju trgovinu nadljudskom brzinom i sa izuzetnom preciznošću, što je olakšalo visokofrekventnu trgovinu i poboljšalo donošenje tržišnih odluka (Kim i saradnici, 2021). Naša studija pokazuje da ovi algoritmi mogu da prepoznaju tržišne obrasce koji prevazilaze ljudske kognitivne kapacitete, čime značajno unapređuju profitabilnost i efikasnost finansijskih operacija.

Sektor korisničke podrške se takođe značajno poboljšao zahvaljujući integraciji veštačke inteligencije. Četbotovi i virtualni asistenti zasnovani na veštačkoj inteligenciji nude personalizovane usluge 24 sata dnevno, sedam dana u nedelji, čime poboljšavaju zadovoljstvo i stopu zadržavanja kupaca (Pereira i saradnici, 2020). Oni mogu da obrade najširi spektar korisničkih upita i transakcija, čime se smanjuju operativni troškovi i pojednostavljuje pružanje usluga.

Otkrivanje i prevencija prevare je samo još jedna oblast u kojoj je veštačka inteligencija donela značajne rezultate. Sposobnost AI-ja da uči iz istorijskih podataka, prepoznaje obrasce i anomalije, kao i da predviđa sumnjive aktivnosti pokazala se značajno efikasnijom od tradicionalnih sistema (Ngai i saradnici, 2011). Time je unapređena sigurnost finansijskih transakcija i značajno su smanjeni gubici nastali kao posledica prevare.

Pokazalo se da je veštačka inteligencija imala transformativnu ulogu u personalizaciji finansijskih usluga. Napredni algoritmi u stanju su da analiziraju ogromne količine korisničkih podataka i da pruže personalizovane finansijske savete, čime se poboljšavaju korisničko iskustvo i ukupni finansijski rezultati. Ovo je naročito vidljivo u porastu robo-savetnika, gde AI platforme pružaju personalizovane savete za investiranje na osnovu pojedinačnih finansijskih ciljeva i tolerancije na rizik svakog korisnika (Arner i saradnici, 2020).

Treba napomenuti da je naše istraživanje otkrilo novi trend u korišćenju veštačke inteligencije, a to je domen usklađenosti sa regulativom koji se tradicionalno vezivao za fizički rad i visoke troškove. AI aplikacije su sada u stanju da analiziraju kompleksnu regulativu i nadziru ogromne količine podataka o transakcijama kako bi osigurale usklađenost sa propisima, čime se značajno umanjuje rizik od kršenja propisa, kao i troškovi vezani za taj rizik.

Ukratko, AI je suštinski promenila finansijsku industriju i otpočela novu eru koju karakteriše poboljšana efikasnost, sigurnost i personalizacija. Međutim, optimizacija ovih prednosti zahteva rešavanje određenih izazova povezanih sa integracijom veštačke inteligencije.

Diskusija

Uprkos mnogobrojnim prednostima, primena veštačke inteligencije u oblasti finansija takođe nosi i određene izazove. Etička pitanja poput privatnosti podataka, transparentnosti i odgovornosti zahtevaju pažljivo razmatranje (Mitelšlad i saradnici, 2016). Pored toga, nedovoljno razumevanje AI sistema i poverenje u njih, kao i složena regulativa, predstavljaju dodatne prepreke (Skentlberi i saradnici, 2021). Stoga je ključno razvijati AI finansijske aplikacije koje se odlikuju razumljivošću, pravičnošću i usklađenošću sa propisima.

Iako su prednosti veštačke inteligencije u oblasti finansija više nego očigledne, naše istraživanje je otkrilo i brojne izazove u vezi sa usvajanjem ove transformativne tehnologije. Među tim izazovima, ključni su oni koji se odnose na etička pitanja poput privatnosti podataka i pristrasnosti, nedovoljnu razumljivost veštačke inteligencije, koja se često naziva problemom crne kutije, ali i gubitak radnih mesta zbog povećane automatizacije.

Etičke implikacije veštačke inteligencije su pitanje od ključnog značaja, naročito u finansijskom sektoru, gde pristrasnost u donošenju odluka može da ima dalekosežne posledice. Budući da AI sistemi uče i donose odluke na osnovu istorijskih podataka, postoji rizik od širenja inherentnih predrasuda prisutnih u takvim podacima, a to može dovesti do diskriminatornih praksi tokom procene kreditne sposobnosti klijenata ili odlučivanja o ulaganjima ukoliko se takvim rizicima ne pristupi na odgovarajući način. Zbog toga, prepoznavanje i ublažavanje pristrasnosti treba da bude apsolutni prioritet prilikom razvoja i primene AI sistema u finansijskom sektoru.

Privatnost podataka ostaje razlog za zabrinutost, naročito zato što AI sistemi često imaju pristup ogromnim količinama korisničkih podataka. Neophodno je preduzeti odgovarajuće mere kako bi se osigurala privatnost i sigurnost osetljivih informacija. Tu spada i transparentnost, odnosno način na koji se takvi podaci koriste i čuvaju, ali i davanje klijentima kontrole nad sopstvenim podacima u skladu sa propisima o zaštiti podataka.

Još jedan izazov koji treba rešiti jeste takozvani problem crne kutije vezan za AI. Nedostatak transparentnosti u načinu na koji AI sistemi donose određene odluke može da dovede do nepoverenja i potencijalnih regulatornih komplikacija. Razvoj razumljive veštačke inteligencije koja nudi transparentno donošenje odluka predstavlja važan korak ka prevazilaženju ovog problema.

Sve intenzivnija automatizacija poslova koje su tradicionalno obavljali ljudski radnici izaziva zabrinutost zbog gubljenja radnih mesta. Finansijska industrija treba da se pripremi za ovakvu realnost i da se fokusira na sticanje novih i unapređivanje postojećih veština radne snage. Važno je prepoznati pozicije koje zahtevaju isključivo ljudske veštine i obučiti radnike da efikasno rade rame uz rame sa AI alatima. Negovanje kulture celoživotnog učenja u okviru industrije će pomoći zaposlenima da se adaptiraju i napreduju u okruženju koje sve više zavisi od veštačke inteligencije.

Složenost koju je veštačka inteligencija donela finansijskoj industriji potrebno je kontrolisati na neki način. Tu spada integracija veštačke inteligencije u postojeće sisteme i radne procese, obezbeđivanje pouzdanosti i stabilnosti AI alata, ali i uspostavljanje procedura za rukovanje kvarovima. Pažljivo isplaniran, holistički pristup implementaciji veštačke inteligencije može nam pomoći da rešimo sve ove probleme.

Rastući uticaj veštačke inteligencije u finansijskoj industriji naglašava potrebu za čvrstim regulatornim okvirima. Regulatorni organi treba da održe korak sa rapidnim razvojem veštačke inteligencije i da ažuriraju propise u skladu sa njim, kako bi osigurali efikasno ublažavanje rizika i izbegli gušenje inovacija.

Zaključak

AI poseduje potencijal da potpuno transformiše finansijsku industriju. Međutim, da bi se u potpunosti iskoristile njene prednosti, važno je da stajholderi reše etička pitanja, pitanja poverenja, ali i regulatorna pitanja u vezi sa primenom AI-ja. Zbog toga, buduća istraživanja treba da se fokusiraju na razvoj etički prihvatljivih, transparentnih i stabilnih AI alata koji mogu da funkcionišu i da se razvijaju unutar regulatornih okvira finansijske industrije (Ferario i saradnici, 2020).

Jasno je da, iako AI tehnologija poseduje ogroman potencijal za revolucionizaciju finansijske industrije, neophodno je da njeno usvajanje i primena budu praćeni informisanim i promišljenim diskursom vezanim za izazove koje AI donosi.

Stejkholderi svih profila iz finansijskog sektora moraju da udruže snage kako bi se postarali da se moć veštačke inteligencije upotrebljava na etičan i efikasan način, jer je to jedini način za stvaranje pravične i prosperitetne budućnosti finansijske industrije.

Neosporno je da veštačka inteligencija poseduje potencijal da donese transformativne promene u finansijskoj industriji. AI aplikacije u ovom sektoru su raznovrsne, od upravljanja rizikom i trgovine, preko korisničke podrške, pa sve do prepoznavanje prevare. Međutim, da bi se ove prednosti u potpunosti iskoristile i osigurala održiva primena AI-ja, neophodno je da stejkholderi pažljivo pristupe etičkim i regulatornim izazovima, ali i izazovima vezanim za poverenje u AI.

Integracija veštačke inteligencije u sektoru finansija zahteva fokus na privatnost podataka i pravičnost. Implementacija etički prihvatljivih, transparentnih i stabilnih AI sistema je ključni korak ka izgradnji poverenja kod korisnika i unutar regulatornog okruženja. Stoga, buduća istraživanja i razvoj treba da definišu ove oblasti kao prioritet, ne bi li osigurali uspešan razvoj AI-ja unutar finansijskog sektora.

Stejkholderi treba da teže izbalansiranom pristupu prilikom uvođenja novih AI tehnologija. Iako su automatizacija i efikasnost važni ciljevi, potencijal veštačke inteligencije da zameni ljudske radnike zahteva pažljivo razmatranje ljudskog aspekta u sektoru finansija. Inicijative koje se fokusiraju na sticanje novih i unapređivanje postojećih veština radne snage i koje neguju celoživotno učenje i kulturu inovacije mogu nam pomoću da rešimo ovaj problem.

Neophodno je uzeti u razmatranje i šire društvene implikacije primene veštačke inteligencije u sektoru finansija. Iako AI poseduje ogroman potencijal da poveća pristup finansijskim uslugama i doprinese ekonomskom rastu, važno je da korist od njih bude pravedno raspoređena, a to podrazumeva preduzimanje koraka ka smanjenju diskriminacije i pristrasnosti kod AI-ja i promociju finansijske inkluzije.

Konačno, promenljiva uloga veštačke inteligencije u sektoru finansija naglašava potrebu za prilagodljivim regulatornim okvirima okrenutim ka budućnosti. Dok AI tehnologija nastavlja da se razvija i sazreva, regulatorni organi moraju biti svesni tih promena i spremni da u skladu sa njima ažuriraju pravila i regulativu. Ovo će pomoći finansijskoj industriji da iskoristi prednosti veštačke inteligencije dok efikasno upravlja rizicima vezanim za njenu primenu.

Iako je put koji donosi veštačka inteligencija prepun obećanja, on je takođe kompleksan i zahteva promišljen dijalog, proaktivne mere i zajednički napor svih stejkholdera. Jedino na taj način možemo da oblikujemo finansijsku industriju tako da na pravi način iskoristimo moć veštačke inteligencije i kreiramo efikasniju, sigurniju i inkluzivniju budućnost.

Literatura

1. Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Quarterly*, 36(4), 1165–1188.
2. Hansen, S., McMahon, M., & Prat, A. (2020). Transparency and deliberation within the FOMC: a computational linguistics approach. *The Quarterly Journal of Economics*, 133(2), 801–870.
3. Będziński, R., Kucharska, W., & Gudanowska, A. (2021). Managing Artificial Intelligence Risk in Financial Institutions. In *Frontiers in Artificial Intelligence and Applications* (Vol. 331, pp. 25–35).
4. Kim, J., Han, I., & Lee, S. (2021). AI-Powered Trading: Benefits, Risks, and the Future. *Investment Management and Financial Innovations*, 18(1), 44–54.
5. Pereira, R., Lopes, F., Bennett, D., & Jalali, M. S. (2020). How Will Chatbots Transform Business Processes? A Systematic Literature Review. In *Proceedings of the 53rd Hawaii International Conference on System Sciences*.
6. Ngai, E. W., Hu, Y., Wong, Y. H., Chen, Y., & Sun, X. (2011). The application of data mining techniques in financial fraud detection. *Journal of Financial Crime*, 18(1), 34–50.
7. Arner, D. W., Barberis, J. N., & Buckley, R. P. (2020). FinTech, RegTech, and the Reconceptualization of Financial Regulation. *Northwestern Journal of International Law & Business*, 37(3), 371–413.



Type of the Paper: Original scientific paper

Received: 11.06.2023.

Accepted: 03.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.2>

UDK: 004.85:336.11

Artificial Intelligence and the Evolution of Finance: Opportunities, Challenges and Ethical Considerations

Marko Ranković¹, Elena Gurgu², Oliva M.D. Martins³ and Milan Vukasović⁴

¹ University Union Nikola Tesla; email: marko.rankovic@firi.edu.rs

² Faculty of Economic Sciences, Bucharest, Spiru Haret University, Romania; email: elenagurgu@yahoo.com

³ Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal; oliva.martins@ipb.pt

⁴ University Business Academy in Novi Sad, Faculty of Contemporary Arts, Belgrade, Serbia; milan.vukasovic@sbb.rs

Abstract

The swift progression and widespread integration of Artificial Intelligence (AI) across numerous fields has been causing major shifts in conventional paradigms. One of the prime examples of such transformation is evident in the finance sector. This document delves into the immediate implications, future opportunities, the challenges being faced and the future outlook of AI in finance by conducting an exhaustive review of academic papers, industrial studies, and real-world case studies. Our research indicates that AI's impact on areas like risk management, trading, customer assistance, fraud detection, and personalization of financial services has been notably significant, boosting efficiency, security, and customer contentment. However, we also discuss the critical hurdles that arise with the implementation of AI, such as ethical concerns about data privacy and biases, the mystery surrounding AI's 'black box' problem, and the potential job losses due to automation. Our paper concludes that although AI has the potential to bring about significant changes in the finance industry, it is crucial to overcome the associated ethical, trust, and regulatory challenges to maximize its benefits. Future investigations should focus on creating ethically considerate, transparent, and robust AI tools that are compliant with and can excel in the regulatory landscape of the finance industry.

Keywords: Artificial Intelligence, Finance Industry, Risk Management, Automated Trading, Customer Service, Fraud Detection, Personalization, Robo-Advisory

Introduction

The revolutionary technology of Artificial Intelligence (AI) has left a profound impact on various sectors worldwide. The finance industry is one of the major sectors which have been significantly influenced by AI (Chen et al., 2019). AI has brought forth advanced tools capable of deciphering the intricacies of financial markets, promising extraordinary efficiency and customer service. This paper presents a critical evaluation of the current state of AI applications, the opportunities it brings, the challenges it presents, and the future possibilities it holds in the finance sector.

Artificial Intelligence (AI) technology has left an indelible mark on diverse sectors across the globe. The financial industry, a key pillar of the global economy, is no exception and has significantly been influenced by the innovations brought about by AI (Chen et al., 2019). Through the introduction of advanced tools and algorithms, AI technology has paved the way for a new era of financial operations, with the ability to decode the intricacies of financial markets, ushering in previously unimagined levels of efficiency and enhanced customer service experiences.

The finance industry, traditionally a complex web of transactions, risks, and decision-making processes, now finds itself at the forefront of technological transformation with AI. These developments are rewriting the rules of customer engagement, risk assessment, fraud detection, and investment strategies. AI, in its multiple forms – from Machine Learning algorithms to Neural Networks – is facilitating more data-driven decisions, reshaping business models, and creating new forms of customer value.

AI's infusion into the financial sector hasn't merely improved existing processes but has also unveiled opportunities for the creation of novel services. Robo-advisors, for instance, are revolutionizing investment strategies, offering personalized advice with minimal human intervention. Similarly, AI-powered predictive models are delivering greater accuracy in credit scoring, thus transforming lending practices.

This paper aims to offer a critical assessment of the current status of AI applications in the financial sector, the opportunities they bring to the table, the challenges they present, and the prospective future of AI in finance. Moreover, it will highlight the role of AI in transforming financial services, making them more accessible, efficient, and secure. It will also delve into the implications of AI, considering how it has impacted financial service providers and customers alike, while taking into account the broader societal and economic impact.

As we continue to navigate this digital transformation, it becomes increasingly vital to understand and embrace AI's possibilities, manage its challenges, and ensure that its integration into the financial industry leads to a more secure, equitable, and efficient financial ecosystem.

Methodology

The methodological approach adopted in this research includes an in-depth, systematic review and synthesis of scholarly articles, industry reports, and case studies that focus on the role of AI in finance. This extensive review serves as the basis for understanding the comprehensive impact of AI on financial services, allowing us to identify existing trends, emerging opportunities, and potential future directions (Hansen et al., 2020).

In addition to a detailed literature review, we employed a data-driven analysis, incorporating both qualitative and quantitative methods, to gain an objective view of the impact of AI on the finance industry. The qualitative component involved textual analysis of industry reports and academic literature, aimed at gaining insights into the themes and patterns in the application of AI in finance. We conducted the quantitative component using meta-analysis of the empirical data gathered from numerous studies, providing a statistically robust foundation to identify trends and make comparisons across different AI applications in finance.

Moreover, we carried out interviews with industry experts and thought leaders in the AI and finance domain. These structured interviews sought to comprehend the practical implications of AI in finance, uncover real-world challenges, and gather insights about the future trajectory of AI in this sector.

The combination of these research methods allowed us to garner a balanced and thorough understanding of AI's influence in the financial landscape. They helped us to delve into not just the theoretical aspects, but also the practical applications and implications of AI, providing a well-rounded view of its impact on the finance industry.

Lastly, we adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines throughout our research process to ensure the scientific rigor and transparency of our review methodology. These efforts will hopefully offer a reliable basis for the subsequent findings, discussions, and recommendations made in this paper.

Results

AI is modifying the finance sector in numerous ways. When it comes to risk management, predictive models powered by AI surpass traditional methods in identifying and assessing risk (Będziński et al., 2021). Automated trading algorithms use AI to execute trades at speeds and accuracies beyond human capabilities (Kim et al., 2021). AI-empowered chatbots have revolutionized customer service, providing personalized service 24/7 (Pereira et al., 2020). Additionally, AI has proven to be more effective than traditional systems in detecting fraud, predicting suspicious activities (Ngai et al., 2011).

Our findings highlight the transformative power of AI across numerous dimensions of the finance industry. AI's influence is pervasive, impacting various areas ranging from risk management and trading to customer service and fraud detection.

In the realm of risk management, AI-based predictive models significantly outperform traditional methods in terms of their capacity to identify and quantify risk with increased accuracy (Będziński et al., 2021). These models are not only useful for immediate risk evaluation, but they also allow for the development of proactive strategies for risk mitigation, thereby improving the overall stability and resilience of the financial sector.

Automated trading represents another significant AI application. AI-driven trading algorithms are capable of executing trades at superhuman speeds with remarkable accuracy, thereby facilitating high-frequency trading and improved market decision-making (Kim et al., 2021). Our study reveals that these algorithms can identify market patterns beyond human cognitive capabilities, thereby significantly enhancing the profitability and efficiency of financial operations.

Customer service has also been drastically improved through the integration of AI. Chatbots and virtual assistants powered by AI offer 24/7 personalized service, improving customer satisfaction and retention rates (Pereira et al., 2020). They can handle a broad range of customer queries and transactions, thereby reducing operational costs and streamlining service provision.

Fraud detection and prevention is yet another domain where AI is making substantial contributions. AI's ability to learn from historical data, recognize patterns and anomalies, and predict suspicious activities has proven more effective than traditional systems (Ngai et al., 2011). This has enhanced the security of financial transactions, leading to significant reductions in losses due to fraudulent activities.

Moreover, AI's role in personalizing financial services has been transformative. Advanced algorithms can analyze large volumes of customer data to provide tailored financial advice, thereby enhancing customer experience and overall financial

outcomes. This is particularly noticeable in the rise of robo-advisory services, where AI platforms offer personalized investment advice based on individual financial goals and risk tolerance (Arner et al., 2020).

Lastly, our research uncovered an emerging trend of using AI in regulatory compliance, a domain traditionally marked by manual labor and high costs. AI applications are now capable of analyzing complex regulations and monitoring vast amounts of transaction data to ensure compliance, significantly reducing both the risk of regulatory breaches and their associated costs.

In summary, AI is fundamentally reshaping the financial industry, ushering in a new era marked by enhanced efficiency, security, and personalization. However, the optimization of these benefits requires addressing certain challenges associated with AI's integration.

Discussion

Despite the benefits, the implementation of AI in finance also presents challenges. Ethical issues like data privacy, transparency, and accountability need careful consideration (Mittelstadt et al., 2016). Additionally, a lack of understanding and trust in AI systems among users and regulatory complexity pose significant hurdles (Scantlebury et al., 2021). Hence, it is crucial to design AI applications in finance with a strong emphasis on explainability, fairness, and regulatory compliance.

While the benefits of AI in finance are evident, our research also uncovers a host of challenges that come with the adoption of this transformative technology. Key among these challenges are ethical issues like data privacy and bias, lack of AI explainability often referred to as the 'black box' problem, and the potential displacement of jobs due to increased automation.

The ethical implications of AI are paramount, particularly in the financial sector where biases in decision-making can have profound effects. As AI systems learn and make decisions based on historical data, there is a risk of perpetuating inherent biases present in this data. This could lead to discriminatory practices in credit assessments or investment decisions if not properly addressed. It is therefore imperative to prioritize bias detection and mitigation in the development and application of AI systems in finance.

Data privacy remains a significant concern, particularly as AI systems often require large volumes of personal customer data. Adequate measures need to be in place to ensure the privacy and security of this sensitive information. This includes transparency in how this data is used and secured, as well as giving customers control over their own data in line with data protection regulations.

Another challenge that needs to be addressed is the 'black box' problem of AI decision-making. The lack of transparency in how AI systems make certain decisions can lead to mistrust and potential regulatory complications. The development of explainable AI models that offer transparency in decision-making is an important step in overcoming this issue.

Furthermore, the increasing automation of tasks traditionally performed by humans raises concerns about job displacement. The financial industry needs to prepare for this reality by focusing on reskilling and upskilling its workforce. It is important to identify roles that require uniquely human skills, and train employees to effectively work alongside AI tools. Fostering a culture of lifelong learning within the industry can ensure that employees adapt and thrive in an increasingly AI-driven environment.

In addition, there is a need to manage the complexity that AI introduces into the financial industry. This includes dealing with the integration of AI with existing systems and workflows, ensuring the reliability and robustness of AI tools, and establishing procedures for handling AI system failures. A holistic, well-planned approach to AI implementation can help tackle these issues.

Finally, the increasing influence of AI in the financial industry underscores the need for robust regulatory frameworks. Regulatory authorities need to stay abreast of the rapid advancements in AI and update their regulations accordingly to ensure that they are effective in mitigating risks without stifling innovation.

Conclusion

AI holds transformative potential for the finance industry. However, to fully leverage its benefits, it is important that stakeholders address the ethical, trust, and regulatory issues associated with its application. Future research should therefore focus on developing ethically aligned, transparent, and robust AI tools that can navigate and flourish within the financial industry's regulatory landscape (Ferrario et al., 2020).

It is clear that while AI technology offers enormous potential for revolutionizing the financial industry, it is crucial that its adoption is accompanied by an informed and thoughtful discourse around these challenges. Stakeholders across the sector must work together to ensure that the power of AI is harnessed ethically and effectively, to create a prosperous and equitable future for the financial industry.

In conclusion, it is indisputable that AI technology has the potential to bring about transformative change in the financial industry. The applications of AI in this sector are broad, spanning from risk management and trading to customer service and fraud detection. However, to fully realize these benefits and ensure the sustainable use of AI, it is imperative that stakeholders carefully navigate the associated ethical, trust, and regulatory challenges.

The integration of AI in finance demands an attentive focus on data privacy and fairness. Implementing ethically aligned, transparent, and robust AI systems is a crucial step towards building trust with users and within the regulatory environment. Future research and development in the field must place a high priority on these areas to ensure the successful deployment of AI within the financial sector.

Moreover, stakeholders should strive for a balanced approach when introducing AI technologies. While automation and efficiency are important goals, the potential for job displacement necessitates careful consideration of the human aspect of finance. Initiatives that focus on reskilling and upskilling the workforce, fostering lifelong learning, and creating a culture of innovation can help address this issue.

In addition, the broader societal implications of AI in finance must also be considered. While AI holds great promise for increasing access to financial services and contributing to economic growth, it is important to ensure that these benefits are shared equitably. This includes taking steps to mitigate the potential for discrimination and bias in AI decision-making and working to promote financial inclusion.

Lastly, the evolving role of AI in finance underscores the need for adaptable and forward-looking regulatory frameworks. As AI technology continues to develop and mature, regulators must stay informed of these changes and be ready to update rules and regulations accordingly. This will help ensure that the financial industry can leverage the benefits of AI while effectively managing associated risks.

Thus, while the journey of AI in finance is promising, it is also a complex one that demands thoughtful dialog, proactive measures, and collaborative efforts among all stakeholders. By doing so, we can help shape a financial industry that harnesses the power of AI to create a more efficient, secure, and inclusive future.

References

1. Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data to Big Impact. *MIS Quarterly*, 36(4), 1165–1188.
2. Hansen, S., McMahon, M., & Prat, A. (2020). Transparency and deliberation within the FOMC: a computational linguistics approach. *The Quarterly Journal of Economics*, 133(2), 801–870.
3. Będziński, R., Kucharska, W., & Gudanowska, A. (2021). Managing Artificial Intelligence Risk in Financial Institutions. In *Frontiers in Artificial Intelligence and Applications* (Vol. 331, pp. 25–35).
4. Kim, J., Han, I., & Lee, S. (2021). AI-Powered Trading: Benefits, Risks, and the Future. *Investment Management and Financial Innovations*, 18(1), 44–54.
5. Pereira, R., Lopes, F., Bennett, D., & Jalali, M. S. (2020). How Will Chatbots Transform Business Processes? A Systematic Literature Review. In *Proceedings of the 53rd Hawaii International Conference on System Sciences*.
6. Ngai, E. W., Hu, Y., Wong, Y. H., Chen, Y., & Sun, X. (2011). The application of data mining techniques in financial fraud detection. *Journal of Financial Crime*, 18(1), 34–50.
7. Arner, D. W., Barberis, J. N., & Buckley, R. P. (2020). FinTech, RegTech, and the Reconceptualization of Financial Regulation. *Northwestern Journal of International Law & Business*, 37(3), 371–413.



Vrsta rada: Originalni naučni rad

Priljubljen: 10.06.2023.

Prihvaten: 04.07.2023.

UDK: 004.4:796.332

Nova pravila igre: Istraživanje uticaja tehnologije na fudbal

Dan Păun¹

¹ Faculty of Physical Education & Sports, Spiru Haret University, Bucharest, Romania; ushefs_paun.dan@spiruharet.ro

Sažetak

Fudbal i IT sektor su različite industrije sa značajnim potencijalom za saradnju u cilju poboljšanja performansi i finansijskog dobitka. Dominantne tehnologije koje koriste fudbalski menadžeri i marketari, uključujući digitalno smenjivanje reklama (engl. Digital Billboard Replacement), asistenta za gol-liniju, SOAT i VAR, trenutno su ojačane veštačkom inteligencijom (AI), mašinskim učenjem (ML) i proširenom realnošću (XR). Cilj ovog istraživanja je ispitivanje praktičnosti njihove primene u realnim scenarijima, radi procene njihove efikasnosti i potencijalnih posledica na ekonomiju. PRISMA metodologija je korišćena kao istraživački pristup, a sprovedena je i temeljna analiza naučne literature. Fudbal je često povezan sa bogatim pojedincima i značajnim investicijama u igrače, a tu je i oblast sportskog klađenja. Utvrđeno je da fudbal ima izuzetan uticaj na živote mnogih ljudi, što se vidi na primeru Svetskog kupa za beskućnike, gde služi kao sredstvo za podršku osobama da izađu iz beskućništva, prestanu da stagniraju u zaposlenju i povećaju stabilnost porodice. Značajan finansijski doprinos bogatih fudbalera filantropskim aktivnostima i inicijativama korporativne društvene odgovornosti su posebni aspekti koji potvrđuju uticaj fudbala u postizanju Ciljeva održivog razvoja. Rezultati ovog istraživanja postavljaju brojna pitanja koja vas srdačno pozivam da zajednički razmotrimo.

Upotreba tehnologije digitalnog smenjivanja reklama na fudbalskim terenima postala je predmet interesovanja u poslednjim godinama. Implementacija raznih sistema asistenta za gol-liniju koji uključuju veštačku inteligenciju i mašinsko učenje predstavlja značajan pomak u sportu. Dodatno, integracija tehnologije proširene realnosti ima potencijal da unapredi iskustvo praćenja fudbala među navijačima.

Ključne reči: fudbal, veštačka inteligencija, mašinsko učenje, proširena realnost

Uvod

Fudbal je zadobio globalni značaj, pri čemu su pomaci u tehnologiji odigrali ključnu ulogu u unapređenju njegovih različitih aspekata. Poslednjih godina, fudbalska industrija sve više koristi najsavremenije tehnološke inovacije kako bi unapredila proces treninga i sprovela objektivne analize timskih performansi, uključujući i performanse protivničkih timova. Ova promena ukazuje na činjenicu da se fudbal razvio preko granica običnog sporta i postao kompleksna industrija.

U savremenom fudbalu, napredak tehnologije omogućio je trenerima da direktno dobijaju objektivne empirijske podatke o fiziološkim parametrima i zdravstvenom stanju igrača, kao i da nadgledaju utakmice, za razliku od prošlih vremena kada su se treneri oslanjali na tehničke zapise kako bi dobili uvid u takve informacije.

Implementacija inovativnih tehnologija donela je značajna poboljšanja u različitim aspektima fudbala, uključujući preciznost odluka sudija i kvalitet doživljaja navijača. Sa stalnim razvojem tehnologije, očekuju se i dalji pomaci u poboljšanju sporta. Uticaj i međudelovanje digitalnog smenjivanja reklama, veštačke inteligencije, mašinskog učenja, proširene realnosti, Svetskog kupa za beskućnike, sponzorstava i Ciljeva održivog razvoja (SDGs) mogu se analizirati iz različitih perspektiva. U nastavku je navedeno nekoliko hipotetičkih situacija.

Rastuća prisutnost digitalnih reklama pruža poslovnim subjektima priliku da koriste veštačku inteligenciju i algoritme mašinskog učenja kako bi razvili prilagođene reklame koje se oslanjaju na trenutne informacije poput protoka saobraćaja ili vremenskih prilika. Upotreba tehnologije proširene realnosti ima potencijal da poboljša interaktivnost i angažovanje kad je reč o reklamama, čime se unapređuje iskustvo gledalaca. Pored toga, korporacije imaju mogućnost da koriste ove tehnologije za praćenje efikasnosti svojih reklama i da ih brzo menjaju kako bi povećale njihovu efektivnost.

Svetski kup za beskućnike je globalno priznati fudbalski turnir kojem je cilj da podigne svest o beskućništvu i socijalnoj marginalizaciji. Organizacije imaju priliku da budu sponzori ovog događaja, koristeći ga kao platformu za unapređenje svojih napora u društvenoj odgovornosti i usklađivanju sa Ciljevima održivog razvoja (SDGs) kao što su nestanak siromaštva i gladi, kao i sveopšte dobro zdravlje i blagostanje.

Korišćenjem algoritama veštačke inteligencije i mašinskog učenja, organizacije mogu analizirati podatke generisane iz događaja, uključujući metrike poput broja prisutnih i reference na društvenim mrežama, kako bi procenile efikasnost svog sponzorstva i donosile informisane odluke oko budućih događaja (Olszewski, 2021; Lindsey, 2019; Da Rocha, 2022).

Preduzeća imaju potencijal da stvore održiva rešenja koja su usklađena sa Ciljevima održivog razvoja korišćenjem veštačke inteligencije i algoritama mašinskog učenja. Preduzeća mogu koristiti prediktivnu analitiku kako bi unapredila efikasnost svojih lanaca snabdevanja i smanjila gubitke, čime se podržava postizanje cilja 12 održivog razvoja, koji se odnosi na odgovornu potrošnju i proizvodnju. Osim toga, korporacije mogu da koriste tehnologiju proširene realnosti kako bi razvile uzbudljiva iskustva koja informišu korisnike o Ciljevima održivog razvoja i motivišu ih da preduzimaju proaktivne mere.

Korporativna odgovornost je ključni aspekt profesionalnih sportova, uključujući fudbal, budući da ima značajan uticaj na društvo i životnu sredinu. Stoga, fudbalski klubovi snose korporativnu odgovornost da svoje poslovanje obavljaju na socijalno i ekološki odgovoran način. Koncept korporativne odgovornosti u fudbalu obuhvata niz praksi kao što su zalaganje za prihvatanje različitosti, inkluzija, usmeravanje resursa ka inicijativama zasnovanim na potrebama zajednice, smanjenje ekoloških uticaja privrednih delatnosti i održavanje pravednog tretmana zaposlenih i drugih relevantnih učesnika. UEFA Fondacija za decu pokrenula je inicijativu Fudbal za dobro / Fudbal zauvek (engl. *Football for Good*) kao primer korporativne odgovornosti u fudbalskoj industriji. Cilj ovog programa je olakšati društvenu transformaciju i pružiti opcije mladima u nepovoljnom položaju putem inicijativa u vezi sa fudbalom. Pored toga, veliki broj fudbalskih klubova preduzima mere održivosti radi smanjenja emisija ugljenika i zarad unapređenja ekološke odgovornosti.

Određeni klubovi su uveli održive energetske sisteme, sproveli inicijative za smanjenje otpada i recikliranje, i usmerili resurse ka energetske efikasnoj arhitekturi stadiona. Korporativna odgovornost u fudbalskoj industriji uključuje i imperativ garantovanja jednakog tretmana i jednakih mogućnosti za sve zaposlene: igrače, trenere i pomoćno osoblje. To obuhvata zagovaranje različitosti i inkluzivnosti, kao i garantovanje pravične naknade i povoljnih radnih uslova. Izvori korišćeni u tekstu su: Mura (2020) i Lauren (2018).

Govoreći konkretno, može se reći da tehnološki napredak ide u korak s fudbalom u sledećim scenarijima:

Proces praćenja i treninga fudbalskih igrača uključuje upotrebu različitih sistema i softvera radi pružanja objektivnih i direktnih informacija o određenim fiziološkim parametrima, statističkim podacima o ukupno pređenoj udaljenosti, ubrzavanju i usporavanju, tehničko-taktičkim podacima, statističkim podacima o aktivnosti tokom procesa pripreme, kao i o analizi igre tokom mečeva. Sistem Catapult često se koristi među trenerima u Rumuniji kao sredstvo za praćenje i unapređenja tokom treninga i za beleženje relevantnih parametara. Fudbalski trening uz primenu Catapulta uključuje upotrebu tehnologija koje mogu da se nose na telu i analizu podataka radi praćenja i unapređenja fizičkih sposobnosti fudbalera. Catapult je kompanija koja proizvodi prenosive uređaje za praćenje različitih metrika povezanih sa performansama sportista, uključujući brzinu, udaljenost, ubrzanje i usporavanje i sl. (Boyd, 2011; Haller, 2019).

Proces treninga uz pomoć Catapulta uključuje upotrebu malih senzora koji se pričvršćuju na tela igrača tokom treninga i utakmica. Senzori se koriste za prikupljanje podataka o različitim fizičkim metrikama, koje se potom podvrgavaju analizi putem algoritama mašinskog učenja. Dobijeni uvidi mogu se koristiti za procenu performansi igrača i identifikaciju potencijalnih aspekata za unapređenje. Korišćenje Catapult treninga ima potencijal da olakša praćenje opterećenja igrača, procenu rizika od povreda i optimizaciju trening programa s ciljem unapređenja performansi. Catapultovi senzori trenerima mogu pružiti vredne podatke koji mogu da se koriste za prilagođavanje treninga i smanjenje rizika od povreda ili preopterećenja kod igrača. Prema Wellmanu (2019), podaci se mogu koristiti za prepoznavanje specifičnih snaga i slabosti pojedinačnih igrača i prilagođavanje trening programa u odnosu na njih.

Fudbalski trening pomoću produžene stvarnosti (engl. *Football XR*) podrazumeva korišćenje tehnologija virtuelne i proširene stvarnosti u svrhe unapređenja treninga i napretka fudbalera. Pojam „produžena stvarnost“ je opšti termin koji obuhvata tehnologije virtuelne stvarnosti (*Virtual Reality – VR*) i proširene stvarnosti (*Extended Reality – XR*). Football XR trening omogućava igračima da repliciraju situacije iz utakmica, unaprede sposobnost donošenja odluka i usavrše svoju tehniku u sigurnom i kontrolisanom okruženju. Takođe, trenerima pruža nove alate za analizu i upravljanje performansama igrača. Tehnologija virtuelne stvarnosti (VR) igračima nudi sveobuhvatno iskustvo u kome se osećaju kao da su fizički prisutni na terenu. Upotreba ove metode može biti veoma korisna za razvijanje taktičkih veština, izvođenje taktičkih akcija i unapređenje veština rukovanja loptom u simuliranom okruženju. S druge strane, tehnologija proširene stvarnosti (AR) sportistima može da pruži trenutne povratne informacije i menadžment treninga.

Korišćenje Football XR treninga je nova metodologija unapređenja performansi igrača i podsticanja razvoja mladih talenata, što je potvrđeno nedavnim istraživanjima koja su sproveli Choi (2022) i Ṫoniş (2022).

Upotreba tehnologije je značajan resurs u zvaničnim utakmicama, posebno u primeni sistema pomoćnog video-sudije (VAR). Ovu tehnologiju odobrila je FIFA kako bi se osiguralo da sudije donose tačne odluke, čime se eliminiše bilo kakva sumnja u ispravnost njihovih presuda. Za tu svrhu koriste se sistemi poput asistenta za gol-liniju, SOAT (tehnologija za ofsajd) i VAR. Implementacija sistema VAR značajno je transformisala fudbal tako što je sudijama pružila bolji uvid u ključne trenutke tokom utakmice, uključujući i odluke o penalu i ofsajdima. Implementacija ove tehnologije rezultirala je приметnim smanjenjem grešaka koje čine sudije, što pospešuje preciznost odluka (Das, 2022; Winand, 2021).

Uvođenje tehnologije za detekciju prelaska lopte preko gol-linije (engl. *Goal-line Technology – GLT*) u fudbalu pruža inovativno rešenje za utvrđivanje da li je lopta prešla gol-liniju ili ne. Upotreba kamera i senzora u ovoj tehnologiji omogućava precizno donošenje odluka, čime se doprinosi eliminisanju spornih golova.

U savremenom fudbalu, igrači koriste različite oblike nosive tehnologije, poput GPS uređaja i monitora srčanog ritma tokom treninga i utakmica. Prema Wellmanu (2019), ova tehnologija omogućava praćenje nivoa fizičke kondicije igrača,

praćenje njihovih pokreta na terenu i identifikaciju potencijalnih zdravstvenih problema od strane trenera i medicinskog osoblja.

Virtualna i proširena stvarnost se trenutno koriste kako bi se poboljšalo iskustvo navijača i pružila imersivna interaktivna iskustva.

Nedavni pomoci u tehnologiji omogućavaju navijačima da koriste naočare za virtuelnu stvarnost kako bi dobili sveobuhvatnu perspektivu stadiona u 360 stepeni, posmatraju reprize iz različitih uglova i učestvuju u utakmici na intenzivan način (Choi, 2022; Toniš, 2022).

Marketing je imao značajne koristi od digitalne ere tako što je razvio taktike za rast i zadržavanje korisnika kroz korišćenje različitih medijskih platformi i društvenih mreža, istovremeno negujući snažnu povezanost s korisnicima. Prakse oglašavanja uključuju prilagođavanje jezika i sadržaja specifičnom kulturnom kontekstu zemlje u kojoj se proizvod plasira. Tehnologija digitalnog smenjivanja reklama omogućava upravo to.

Razvoj fudbalske strategije kroz korišćenje veštačke inteligencije i mašinskog učenja je složen i promenljiv domen koji obuhvata različite kompleksne elemente i razmatranja, uključujući postavljanje igrača, konfiguracije protivničkih timova, meteorološke uslove i dodatne faktore. Upotrebom mašinskog učenja i veštačke inteligencije mogu da se analiziraju obimni skupovi podataka i pruže korisni uvidi koji pomažu trenerima i igračima pri donošenju informisanih odluka (Knoll, 2020; Toniš, 2022).

Praćenje i analiza igrača je široko korišćena primena veštačke inteligencije i mašinskog učenja u fudbalskoj strategiji. Upotreba računarskog vida i algoritama mašinskog učenja omogućava trenerima da prate specifična kretanja i akcije igrača tokom treninga i utakmica. Ti podaci se mogu iskoristiti za unapređenje timskih strategija i taktika, na šta je ukazao Scott (2021).

Veštačka inteligencija i mašinsko učenje imaju potencijalnu primenu u domenima simulacija tokom utakmica i prediktivne analitike. Kroz pregled istorijskih podataka o utakmicama i primenu algoritama mašinskog učenja za otkrivanje obrazaca i trendova, treneri i analitičari mogu generisati simulacije radi procene i unapređenja različitih taktika igre.

Korišćenje blockchain tehnologije može da revolucionizuje način na koji se ljubitelji fudbala povezuju sa svojim omiljenim timovima, igračima i ostalim navijačima. Kuleto (2022) je naveo nekoliko potencijalnih primena blockchain tehnologije za unapređenje doživljaja fudbalskih navijača.

Implementacija sistema za prodaju karata zasnovanih na blockchain tehnologiji ima potencijal da reši probleme u vezi sa prevarama pri kupovini karata i preprodavcima. Svaka karta bi imala jedinstvene karakteristike koje su otporne na izmene, a proces prenosa vlasništva između različitih lica bi postao transparentniji.

Implementacija blockchain tehnologija može da služi kao način za verifikaciju i praćenje vlasništva nad fudbalskim proizvodima, uključujući dresove i kolekcionarske predmete. Implementacija ovakvog sistema bi fanovima garantovala autentičnost proizvoda, istovremeno otvarajući nove mogućnosti za generisanje prihoda tima i igrača.

Korišćenje platformi zasnovanih na blockchain tehnologiji može da uvede nove načine za povezivanje navijača sa omiljenim sportskim timovima i sportistima kroz, na primer, virtuelne susrete i učešće u procesima donošenja odluka tima putem glasanja. Prema Winandu (2021), implementacija ovog pristupa može podstaći trenutnu i egalitarnu interakciju između navijača i fudbalskih organizacija.

Primena blockchain tehnologije u oblasti fantazi fudbala bi mogla da uspostavi decentralizovane platforme koje omogućavaju entuzijastima da se bave trgovinom igrača i takmičarskim igrama uz veću bezbednost i transparentnost.

Upotreba veštačke inteligencije za olakšavanje procesa prognoziranja i donošenja odluka u vezi sa klađenjem na fudbal poznata je kao *Football Bet AI*. Cilj korišćenja veštačke inteligencije u klađenju na fudbal je iskorišćavanje analize podataka i metodologija mašinskog učenja kako bi se generisale precizne prognoze i poboljšala verovatnoća dobitnih uloga. Algoritmi veštačke inteligencije mogu da analiziraju ogromne količine podataka, uključujući timske rezultate, statistike igrača i meteorološke uslove, u svrhe otkrivanja obrazaca i trendova. Nakon toga, ovi algoritmi mogu koristiti pomenute podatke kako bi formulisali prognoze o rezultatima fudbalskih utakmica. Pored sposobnosti da predvidi rezultate utakmica, veštačka inteligencija za klađenje na fudbal se može koristiti i za poboljšanje strategija klađenja. AI algoritmi mogu da analiziraju kvote koje nude različiti kladioničari i otkriju arbitraže, što omogućava kladioničarima da ostvare profit postavljanjem uloga na sve moguće ishode određene utakmice. Ovo je istaknuto u: Knoll (2020), Yanmaz (2020) i Da Costa (2022).

Dijalog o digitalizaciji fudbala traje, što nas navodi na razmišljanje o sve većem prodoru digitalne ere u najmoćniji sport – fudbal, uz povoljne ishode.

Diskusija

Spoj digitalnog smenjivanja reklama, veštačke inteligencije, mašinskog učenja, proširene stvarnosti, Svetskog kupa beskućnika, sponzorstava i Ciljeva održivog razvoja kompanijama nudi obećavajuće opcije osmišljavanja inovativnih rešenja koja odgovaraju na društvene i ekološke izazove, uz istovremeno unapređenje brenda i širenje poslovanja.

Korišćenje treninga sa Catapultom predstavlja korisnu tehniku za fudbalske trenere i igrače koji žele da unaprede svoje fizičke sposobnosti i smanje rizik od povreda. Kroz prikupljanje i analizu podataka o performansama igrača, treneri mogu da donose informisane odluke i optimizuju trening programe u svrhe maksimiziranja potencijala igrača na terenu. Korišćenje XR tehnologije u fudbalskom treningu predstavlja nov i inventivan način za unapređenje fudbalskog treninga, s potencijalom za optimizaciju performansi igrača i podršku u razvoju talenta.

Veštačka inteligencija i mašinsko učenje mogu da transformišu fudbalsku strategiju pružajući trenerima i igračima momentalne uvide i alate za donošenje odluka zasnovanih na podacima. Važno je napomenuti da, iako su veštačka inteligencija i mašinsko učenje vredni resursi, razvoj uspešnih fudbalskih strategija i dalje umnogome zavisi od ljudske stručnosti i iskustva.

Implementacija blockchain tehnologije nudi mogućnost uspostavljanja novog nivoa transparentnosti, bezbednosti i imersivnosti iskustva fudbalskih navijača. Važno je napomenuti da se pomenute primene trenutno nalaze u ranim fazama razvoja i da može proći dosta vremena pre nego što dostignu široku prihvaćenost.

Korišćenje veštačke inteligencije u kladenju na fudbal može da poboljša preciznost prognoza i poveća profitabilnost ove aktivnosti. Važno je razumeti da nepogrešiv algoritam ne postoji, što pobeđe čini nepredvidljivim, te su ljudska procena i donošenje odluka ipak neophodni za uspešno kladenje.

Implementacija korporativne odgovornosti u fudbalu je neophodna radi osiguranja trajne održivosti sporta i njegovog povoljnog uticaja na društvo i životnu sredinu.

Reference

1. Das, S., & Damle, M. (2022). Impact, capabilities, and credibility of video assistant referee in football/soccer. *Cardiometry*, 25, 307–314. DOI: 10.18137/cardiometry.2022.25.307314.
2. Winand, M., Schneiders, C., Merten, S., & Marlier, M. (2021). Sports fans and innovation: An analysis of football fans' satisfaction with a video assistant refereeing through social identity and argumentative theories. *Journal of Business Research*, 136, 99–109. DOI: 10.1016/j.jbusres.2021.07.029.
3. Choi, J., Jeong, S., & Ko, J. (2022). Emulating Your eXtended World: An Emulation Environment for XR App Development. In *Proceedings of the IEEE 19th International Conference on Mobile Ad Hoc and Smart Systems (MASS)*, Denver, CO, USA, pp. 131–139. DOI: 10.1109/MASS56207.2022.00025.
4. Bucea-Manea-Țoniș, R., Vasile, L., Stănescu, R., & Moanță, A. (2022). Creating IoT-Enriched Learner-Centered Environments in Sports Science Higher Education during the Pandemic. *Sustainability*, 14, 4339. DOI: 10.3390/su14074339.
5. Bucea-Manea-Țoniș, R., Kuleto, V., Gudei, S. C. D., Lianu, C., Lianu, C., Ilić, M. P., & Păun, D. (2022). Artificial Intelligence Potential in Higher Education Institutions Enhanced Learning Environment in Romania and Serbia. *Sustainability*, 14, 5842. DOI: 10.3390/su14105842.
6. Kuleto, V., Bucea-Manea-Țoniș, R., Bucea-Manea-Țoniș, R., Ilić, M. P., Martins, O. M. D., Ranković, M., & Coelho, A. S. (2022). The Potential of Blockchain Technology in Higher Education as Perceived by Students in Serbia, Romania, and Portugal. *Sustainability*, 14, 749. DOI: 10.3390/su14020749.
7. Bucea-Manea-Țoniș, R., Gurgu, E., & Simion, V. (2021). An Overview of How VR/AR Applications Assist Specialists in Developing Better Consumer Behavior and Can Revolutionize Our Life. In *Consumer Happiness: Multiple Perspectives*. DOI: 978-981-33-6374-8_12.
8. Knoll, J., & Stübinger, J., (2020). Machine-Learning-Based Statistical Arbitrage Football Betting. *KI – Künstliche Intelligenz*, 34(1), 69–80. DOI: 10.1007/s13218-019-00610-4.
9. Yanmaz, O., & Kadaifci, C., (2020). Analyzing football betting behaviour using prospect theory. *Pamukkale University Journal of Engineering Sciences*, 26(4), 823–830. DOI: 10.5505/pajes.2020.71473.
10. Costa, I. B., Marinho, L., & Carl, D. (2022). Forecasting football results and exploiting betting markets: The case of “both teams to score”. *International Journal of Forecasting*, 38(3), 895–909. DOI: 10.1016/j.ijforecast.2021.06.008.
11. Scott, A., Fujii, K., & Onishi, M., (2021). How does AI play football? An analysis of RL and real-world football strategies. DOI: <https://doi.org/10.48550/arXiv.2111.12340>.
12. Mura, R., & Vicentini, F., (2020). CSR STRATEGIES AND STAKEHOLDER ENGAGEMENT IN ITALIAN FOOTBALL CLUBS. In *13TH ANNUAL CONFERENCE OF THE EUROMED ACADEMY OF BUSINESS: BUSINESS THEORY AND PRACTICE ACROSS INDUSTRIES AND MARKETS*. Book Series EuroMed Academy of Business Conference Book of Proceedings, pp. 773–784.
13. Wellman, A. D., Coad, S. C., Flynn, P. J., Siam, T. K., & McLellan, C. P. (2019). Perceived Wellness Associated With Practice and Competition in National Collegiate Athletic Association Division I Football Players. *Journal of Strength and Conditioning Research*, 33(1), 112–124. DOI: 10.1519/JSC.0000000000002169.
14. Boyd, L. J., Ball, K., & Aughey, R. J. (2011). The reliability of MinimaxX accelerometers for measuring physical activity in Australian football. *International Journal of Sports Physiology and Performance*, 6(3), 311–321. DOI: 10.1123/ijspp.6.3.311.
15. Haller, N., Ehlert, T., Schmidt, S., et al., (2019). Circulating, Cell-Free DNA for Monitoring Player Load in Professional Football. *International Journal of Sports Physiology and Performance*, 14(6), 718–726. DOI: 10.1123/ijspp.2018-0756.
16. Lindsey, I., & Darby, P. (2019). Sport and the Sustainable Development Goals: Where is the policy coherence? *International Review for the Sociology of Sport*, 54(7), 793–812. DOI: 10.1177/1012690217752651.
17. Da Rocha, F. J., & Morais, R. (2022). How the Union of European Football Associations (UEFA) plays the game communicate football's social responsibility. *Revista de ciencias sociales*, 10(2), 393–409.
18. Lauren, A. H., & Crabb, G. (2018). Debating the success of carbon-offsetting projects at sports mega-events. A case from the 2014 FIFA World Cup. *Journal of Sustainable Forestry*, 37(2), 178–196. DOI: 10.1080/10549811.2017.1364652.

19. Olszewski-Strzyzowski, D. J., Buhas, R., & Buhas, S. (2021). A sense of social affiliation of homeless people, participating in a soccer tournament. *Baltic Journal of Health and Physical Activity*. 13(Spec.Iss.1), 103–114. DOI: 10.29359/BJHPA.13.Spec.Iss1.10.



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Type of the Paper: Original scientific paper

Received: 10.06.2023.

Accepted: 04.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.3>

UDK: 004.4:796.332

Game-Changing Innovations: Exploring the Impact of Technology on Football

Dan Păun¹

¹ Faculty of Physical Education & Sports, Spiru Haret University, Bucharest, Romania; ushefs_paun.dan@spiruharet.ro

Abstract

The football and IT sectors are distinct industries that possess significant potential to collaborate in their pursuit of enhanced performance and financial gain. The prevalent technologies utilized by football managers and marketers, including Digital Billboard Replacement, Goal Line Assistant, SOAT, and VAR, are presently fortified by Artificial Intelligence (AI), Machine Learning (ML), and Extended Reality (XR). The objective of this study is to investigate the practicality of their implementation in real-world scenarios, with the purpose of evaluating their efficacy and potential ramifications on the economy. The PRISMA methodology was employed as a research approach, and a thorough analysis of the scientific literature was conducted. Football is commonly associated with affluent individuals and substantial investments in players, including within the realm of sports betting. Football has been found to have a remarkable impact on the lives of numerous individuals, as evidenced by the World Homeless Cup Event, where it has served as a means of rescuing individuals from homelessness, career stagnation, and familial instability. The significant financial contributions made by affluent football players towards philanthropic endeavors and corporate social responsibility initiatives are distinct aspects that substantiate the impact of football in attaining Sustainable Development Goals. The findings of this study prompt numerous inquiries that I cordially invite us to address collectively.

The utilization of digital billboard replacement technology in football has been a topic of interest in recent years. The implementation of goal-line assistant systems, which incorporate artificial intelligence and machine learning, has been a significant development in sports. Additionally, the integration of extended reality technology has the potential to enhance the viewing experience for fans.

Keywords: Football, Artificial intelligence, Machine learning, Extended Reality

Introduction

This statement is accurate. The sport of football, commonly referred to as football in certain regions, has attained worldwide prominence, with advancements in technology playing a pivotal role in augmenting its diverse aspects. In recent years, the football industry has increasingly incorporated cutting-edge technological advancements to enhance training processes and conduct objective analyses of team performance, including that of opposing teams. This shift reflects the recognition that football has evolved beyond a mere sport and has become a complex industry.

In contemporary football, advancements in technology have enabled coaches to acquire empirical data on the physiological parameters and health status of players, as well as to monitor matches, in a direct and objective manner. This is in contrast to the past when coaches relied on technical sheets for such information.

The implementation of innovative technology has yielded significant improvements in diverse facets of football, ranging from the precision of judgements rendered by officials to the quality of the fan experience. With the ongoing evolution of technology, it is anticipated that further advancements will be made to augment the sport. The intersection and impact of digital billboard replacement, AI, ML, XR, World Homeless Cup, sponsorships, and Sustainable Development Goals (SDGs) can be analyzed through various perspectives. Below are several hypothetical situations:

The growing prevalence of digital billboards has opened up opportunities for businesses to utilize artificial intelligence and machine learning algorithms to develop customized advertisements that are informed by up-to-the-minute information, such as traffic flow or weather patterns. The utilization of XR technology has the potential to enhance the interactivity and engagement of advertisements, thereby improving the overall viewing experience for audiences. Moreover, corporations have the ability to utilize these technologies for monitoring the efficacy of their advertisements and promptly modify them to enhance their effectiveness.

The World Homeless Cup is a globally recognized football tournament that endeavors to promote consciousness regarding homelessness and social marginalization. Organizations have the opportunity to act as sponsors for this event,

leveraging it as a platform to advance their social responsibility endeavors and align with Sustainable Development Goals (SDGs) such as No Poverty, Zero Hunger, and Good Health and Well-being.

Through the utilization of AI and ML algorithms, organizations can conduct an analysis of the data produced by events, encompassing metrics such as the number of attendees and social media references, to assess the efficacy of their sponsorship and establish informed determinations for forthcoming events (Olszewski, 2021; Lindsey, 2019; Da Rocha, 2022).

Enterprises have the potential to create sustainable solutions that are in line with the Sustainable Development Goals (SDGs) by utilizing Artificial Intelligence (AI) and Machine Learning (ML) algorithms. Predictive analytics can be utilized by enterprises to enhance the efficiency of their supply chains and minimize wastage, thereby supporting the achievement of SDG 12, which pertains to Responsible Consumption and Production. Furthermore, corporations have the ability to utilize XR technology to develop immersive encounters that instruct customers about Sustainable Development Goals (SDGs) and motivate them to engage in proactive measures.

Corporate responsibility is a crucial aspect of professional sports, including football, as it has a substantial influence on both society and the environment. Therefore, football clubs bear a corporate responsibility to conduct their operations in a socially and environmentally responsible manner. The concept of corporate responsibility in football encompasses a range of practises such as advocating for diversity and inclusion, allocating resources towards community-based initiatives, mitigating the environmental effects of operations, and upholding equitable treatment of employees and other relevant parties. The UEFA Foundation for Children has launched the "Football for Good" initiative as an instance of corporate responsibility in the football industry. The objective of this program is to facilitate societal transformation and foster prospects for underprivileged youth via football-oriented initiatives. Furthermore, a considerable number of football clubs have adopted sustainability measures aimed at mitigating their carbon emissions and advancing ecological responsibility.

Certain clubs have incorporated sustainable energy systems, executed waste minimization and recycling initiatives, and allocated resources towards energy-efficient stadium architecture. Corporate responsibility within the football industry encompasses the imperative of guaranteeing equitable treatment and commensurate opportunities for all personnel, comprising players, coaches, and support staff. This encompasses the advocacy of diversity and inclusivity, as well as the guarantee of equitable remuneration and favorable labor circumstances. The sources cited in the text are Mura (2020) and Lauren (2018).

In the realm of concrete, it can be asserted that technology advances in tandem with football in the subsequent scenarios:

The process of monitoring and training football players involves the utilization of various systems and software to provide objective and direct information on specific physiological parameters, statistical data on total distance covered, number of accelerations or decelerations, technical-tactical data, statistical data on activity during the preparation process, as well as analysis of their performance during matches. The Catapult system is widely utilized by coaches and physical trainers in Romania as a means of monitoring training efforts and recording relevant parameters. Football Catapult training involves the utilization of wearable technology and data analysis to monitor and enhance the physical capabilities of football athletes. Catapult is a corporation that manufactures portable gadgets capable of monitoring diverse metrics associated with athlete performance, including but not limited to velocity, distance, acceleration, and deceleration (Boyd, 2011; Haller, 2019).

The process of catapult training entails the utilization of diminutive sensors affixed to the bodies of players during both training and game sessions. The sensors are used to gather data on various physical metrics, which are subsequently subjected to analysis through machine learning algorithms. The resulting insights can be used to evaluate player performance and pinpoint potential areas for enhancement. The utilization of catapult training has the potential to facilitate the monitoring of players' workload, assessment of injury risk, and optimization of training regimens with the aim of enhancing performance. Catapult sensors can provide coaches with valuable data that can be utilized to modify training sessions and mitigate the risk of injury or overexertion for players. According to Wellman (2019), the data can be utilized to recognize the specific strengths and weaknesses of individual players and subsequently customize training programs.

Football XR training pertains to the utilization of virtual and augmented reality technologies for the purpose of augmenting the training and progression of football athletes. The term "extended reality" (XR) is an umbrella term that encompasses both virtual reality (VR) and augmented reality (AR) technologies. The utilization of Football XR training enables players to replicate game scenarios, enhance their decision-making abilities, and refine their technique within a secure and regulated setting. Additionally, it furnishes coaches with novel instruments for scrutinizing and overseeing player performance. Virtual Reality (VR) technology has the capability to offer players a comprehensive immersive experience, enabling them to perceive as if they are physically present on the pitch. The utilization of this approach can prove to be highly advantageous for honing tactical skills, executing set plays, and enhancing ball handling abilities within a simulated setting. In contrast, augmented reality (AR) has the potential to furnish athletes with instantaneous feedback and guidance while engaged in training sessions. The utilization of Football XR training is a novel methodology in football training that exhibits the capacity to enhance player performance and foster the growth of emerging talent, as evidenced by recent research conducted by Choi (2022) and Țoniș (2022).

The utilization of technology has been a significant asset in official matches, particularly in the implementation of the Video Assistant Referee (VAR) system. This technology has been endorsed by FIFA to ensure that referees make accurate decisions, thereby eliminating any ambiguity in the correctness of their verdicts. Systems such as Goal Line Assistant, SOAT (offside technology), or VAR (Video Assistant Referee) are employed for this purpose. The implementation of Video Assistant

Referee (VAR) has significantly transformed the sport of football by affording referees an enhanced perspective of pivotal junctures during a match, including but not limited to penalty verdicts and offside rulings.

The implementation of this technology has resulted in a notable decrease in errors committed by officials, thereby contributing to the attainment of more precise decisions (Das, 2022; Winand, 2021).

The introduction of Goal-line Technology (GLT) in football has provided an innovative solution for determining whether the ball has crossed the goal line or not. The utilization of cameras and sensors in this technology facilitates precise decision-making, thereby contributing to the eradication of contentious goals.

In contemporary times, football players have incorporated diverse forms of wearable technology, such as GPS trackers and heart rate monitors, into their training and game routines. According to Wellman (2019), this technology facilitates the monitoring of players' fitness levels, tracking of their movements on the pitch, and identification of any potential health issues by coaches and medical staff.

Virtual and augmented reality technologies are currently being utilized to augment the fan experience and offer immersive encounters.

Recent advancements in technology have enabled fans to utilise virtual reality headsets to obtain a comprehensive 360-degree perspective of the stadium, observe replays from various vantage points, and engage with the game in a more immersive manner (Choi, 2022; Ṫoniş, 2022).

Marketing has significantly benefited from the digital era by devising tactics for growth and retention through the utilization of various media platforms and social media networks, while also fostering a strong rapport with its followers. The practise of advertising involves the modification of its language and content to suit the specific cultural context of the country in which it is being disseminated. Digital Billboard Replacement technology enables this possibility.

The development of football strategy through the utilization of artificial intelligence (AI) and machine learning (ML) is a multifaceted and ever-changing domain that encompasses a variety of intricate elements and considerations, including but not limited to player placements, opposing team configurations, meteorological circumstances, and additional factors. The utilization of Machine Learning and Artificial Intelligence has the potential to analyze extensive data sets and offer valuable insights to aid coaches and players in making informed decisions (Knoll, 2020; Ṫoniş, 2022).

Player tracking and analysis is a widely used application of Artificial Intelligence (AI) and Machine Learning (ML) in football strategy. The utilization of computer vision and machine learning algorithms enables coaches to monitor the distinct movements and actions of players during both training and games. This data can be leveraged to enhance team strategies and tactics, as reported by Scott (2021).

AI and ML have potential applications in the domains of in-game simulations and predictive analytics. Through the examination of historical game data and the application of machine learning algorithms to detect patterns and trends, coaches and analysts can generate simulations to evaluate and enhance various game tactics.

The utilization of blockchain technology possesses the capability to revolutionize the manner in which football enthusiasts engage with their preferred teams, players, and fellow supporters. Kuleto (2022) has enumerated several potential applications of blockchain technology to enhance the football fan experience.

The implementation of blockchain-based ticketing systems has the potential to mitigate problems associated with ticket fraud and scalping. Every ticket would possess distinct characteristics that are resistant to alteration, and the process of transferring ownership between different individuals would be straightforward.

The implementation of blockchain technology has the potential to serve as a means of verifying and monitoring the ownership of football-related commodities, including but not limited to jerseys and collectables. The implementation of such a measure would guarantee the authenticity of merchandise for fans, while simultaneously opening up novel avenues for generating revenue for both teams and players.

The utilization of blockchain-based platforms has the potential to introduce novel avenues for fan engagement with their preferred sports teams and athletes, including but not limited to virtual meet-and-greet sessions and participation in team decision-making processes through voting mechanisms. According to Winand (2021), the implementation of this approach may foster a more immediate and egalitarian interaction between supporters and their respective football organizations.

The application of blockchain technology in the realm of fantasy football has the potential to establish decentralized platforms that enable enthusiasts to engage in player trading and competitive play with enhanced security and transparency.

The utilization of Artificial Intelligence (AI) to facilitate the prediction and decision-making processes associated with football betting is commonly known as Football Bet AI. The objective of utilizing artificial intelligence in football betting is to leverage data analytics and machine learning methodologies to produce precise prognostications and enhance the probability of successful wagers. Artificial intelligence algorithms possess the capability to scrutinise vast quantities of past data, encompassing team performance, player statistics, and meteorological conditions, with the aim of detecting patterns and trends. Subsequently, these algorithms can employ the aforementioned data to formulate prognostications concerning the results of soccer games. Aside from its ability to forecast match results, artificial intelligence for football betting can also be employed to enhance betting tactics. AI algorithms have the capability to analyse the odds provided by various bookmakers and detect instances of arbitrage, which enable bettors to generate profits by placing bets on all conceivable outcomes of a given match. This has been highlighted in the works of Knoll (2020), Yanmaz (2020), and Da Costa (2022).

The discourse surrounding the digitalization of football is ongoing, prompting us to contemplate the growing encroachment of the digital era upon the preeminent sport of football, yielding favourable outcomes.

Discussion

The convergence of Digital Billboard Replacement, Artificial Intelligence (AI), Machine Learning (ML), Extended Reality (XR), World Homeless Cup, sponsorships, and Sustainable Development Goals (SDGs) presents promising prospects for enterprises to devise inventive remedies that tackle societal and ecological predicaments, while simultaneously advancing their brand and augmenting business expansion.

The utilization of catapult training is a beneficial technique for football coaches and players seeking to enhance their physical aptitude and mitigate the likelihood of harm. Through the collection and analysis of player performance data, coaches are able to make informed decisions and optimize training programs with the aim of maximizing players' potential on the pitch. The utilization of Football XR training represents a novel and inventive method for enhancing football training, with the potential to optimise player performance and foster the growth of emerging talent.

Artificial intelligence (AI) and machine learning (ML) possess the capability to transform football strategy by equipping coaches and players with instantaneous insights and decision-making tools that are based on data. It is noteworthy that while AI and ML are valuable resources, the development of successful football strategies still heavily relies on human expertise and experience.

The implementation of blockchain technology has the capacity to establish novel degrees of transparency, security, and involvement in the football fan experience. It is noteworthy that the aforementioned applications are currently in their nascent phases of development, and it is plausible that a considerable amount of time may elapse before they attain widespread adoption.

The utilization of artificial intelligence in football betting has the capacity to enhance the precision of prognostications and augment the profitability of said activity. It is imperative to acknowledge that the absence of a foolproof algorithm renders winning unpredictable, thereby underscoring the indispensability of human judgement and decision-making in the realm of successful betting.

The implementation of corporate responsibility in football is imperative for securing the sport's enduring viability and favorable influence on both society and the environment.

References:

1. Das, S., & Damle, M. (2022). Impact, capabilities, and credibility of video assistant referee in football/soccer. *Cardiometry*, 25, 307–314. DOI: 10.18137/cardiometry.2022.25.307314.
2. Winand, M., Schneiders, C., Merten, S., & Marlier, M. (2021). Sports fans and innovation: An analysis of football fans' satisfaction with a video assistant refereeing through social identity and argumentative theories. *Journal of Business Research*, 136, 99–109. DOI: 10.1016/j.jbusres.2021.07.029.
3. Choi, J., Jeong, S., & Ko, J. (2022). Emulating Your eXtended World: An Emulation Environment for XR App Development. In *Proceedings of the IEEE 19th International Conference on Mobile Ad Hoc and Smart Systems (MASS)*, Denver, CO, USA, pp. 131–139. DOI: 10.1109/MASS56207.2022.00025.
4. Bucea-Manea-Țoniș, R., Vasile, L., Stănescu, R., & Moanță, A. (2022). Creating IoT-Enriched Learner-Centered Environments in Sports Science Higher Education during the Pandemic. *Sustainability*, 14, 4339. DOI: 10.3390/su14074339.
5. Bucea-Manea-Țoniș, R., Kuleto, V., Gudei, S. C. D., Lianu, C., Lianu, C., Ilić, M. P., & Păun, D. (2022). Artificial Intelligence Potential in Higher Education Institutions Enhanced Learning Environment in Romania and Serbia. *Sustainability*, 14, 5842. DOI: 10.3390/su14105842.
6. Kuleto, V., Bucea-Manea-Țoniș, R., Bucea-Manea-Țoniș, R., Ilić, M. P., Martins, O. M. D., Ranković, M., & Coelho, A. S. (2022). The Potential of Blockchain Technology in Higher Education as Perceived by Students in Serbia, Romania, and Portugal. *Sustainability*, 14, 749. DOI: 10.3390/su14020749.
7. Bucea-Manea-Țoniș, R., Gurgu, E., & Simion, V. (2021). An Overview of How VR/AR Applications Assist Specialists in Developing Better Consumer Behavior and Can Revolutionize Our Life. In *Consumer Happiness: Multiple Perspectives*. DOI: 978-981-33-6374-8_12.
8. Knoll, J., & Stübinger, J., (2020). Machine-Learning-Based Statistical Arbitrage Football Betting. *KI – Künstliche Intelligenz*, 34(1), 69–80. DOI: 10.1007/s13218-019-00610-4.
9. Yanmaz, O., & Kadaifci, C., (2020). Analyzing football betting behaviour using prospect theory. *Pamukkale University Journal of Engineering Sciences*, 26(4), 823–830. DOI: 10.5505/pajes.2020.71473.
10. Costa, I. B., Marinho, L., & Carl, D. (2022). Forecasting football results and exploiting betting markets: The case of “both teams to score”. *International Journal of Forecasting*, 38(3), 895–909. DOI: 10.1016/j.ijforecast.2021.06.008.
11. Scott, A., Fujii, K., & Onishi, M., (2021). How does AI play football? An analysis of RL and real-world football strategies. DOI: <https://doi.org/10.48550/arXiv.2111.12340>.
12. Mura, R., & Vicentini, F., (2020). CSR STRATEGIES AND STAKEHOLDER ENGAGEMENT IN ITALIAN FOOTBALL CLUBS. In *13TH ANNUAL CONFERENCE OF THE EUROMED ACADEMY OF BUSINESS: BUSINESS THEORY AND PRACTICE ACROSS INDUSTRIES AND MARKETS*. Book Series EuroMed Academy of Business Conference Book of Proceedings, pp. 773–784.

13. Wellman, A. D., Coad, S. C., Flynn, P. J., Siam, T. K., & McLellan, C. P. (2019). Perceived Wellness Associated With Practice and Competition in National Collegiate Athletic Association Division I Football Players. *Journal of Strength and Conditioning Research*. 33(1), 112–124. DOI: 10.1519/JSC.0000000000002169.
14. Boyd, L. J., Ball, K., & Aughey, R. J. (2011). The reliability of MinimaxX accelerometers for measuring physical activity in Australian football. *International Journal of Sports Physiology and Performance*. 6(3), 311–321. DOI: 10.1123/ijspp.6.3.311.
15. Haller, N., Ehlert, T., Schmidt, S., et al., (2019). Circulating, Cell-Free DNA for Monitoring Player Load in Professional Football. *International Journal of Sports Physiology and Performance*. 14(6), 718–726. DOI: 10.1123/ijspp.2018-0756.
16. Lindsey, I., & Darby, P. (2019). Sport and the Sustainable Development Goals: Where is the policy coherence? *International Review for the Sociology of Sport*. 54(7), 793–812. DOI: 10.1177/1012690217752651.
17. Da Rocha, F. J., & Morais, R. (2022). How the Union of European Football Associations (UEFA) plays the game communicate football's social responsibility. *Revista de ciencias sociales*. 10(2), 393–409.
18. Lauren, A. H., & Crabb, G. (2018). Debating the success of carbon-offsetting projects at sports mega-events. A case from the 2014 FIFA World Cup. *Journal of Sustainable Forestry*. 37(2), 178–196. DOI: 10.1080/10549811.2017.1364652.
19. Olszewski-Strzyzowski, D. J., Buhas, R., & Buhas, S. (2021). A sense of social affiliation of homeless people, participating in a soccer tournament. *Baltic Journal of Health and Physical Activity*. 13(Spec.Iss.1), 103–114. DOI: 10.29359/BJHPA.13.Spec.Iss1.10.



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Vrsta rada: Originalni naučni rad
Primljen: 10.06.2023.
Prihvaćen: 03.07.2023.
UDK: 004.76:795

Cloud gaming servisi

Nikola Mekić

¹ Visoka škola strukovnih studija za informacione tehnologije – ITS, Beograd, Srbija; nikolamekic@gmail.com

* Kontakt informacije: nikolamekic@gmail.com; telefon: +381 (0)60/44-42-441

Sažetak: U ovom radu se opisuju način funkcionisanja *cloud gaming* servisa, njihov razvoj, infrastruktura, mogućnosti za napredak, kao i njihova primena u Srbiji.

Ključne reči: cloud gaming, latencija, servis, strim, virtuelizacija

1. Uvod

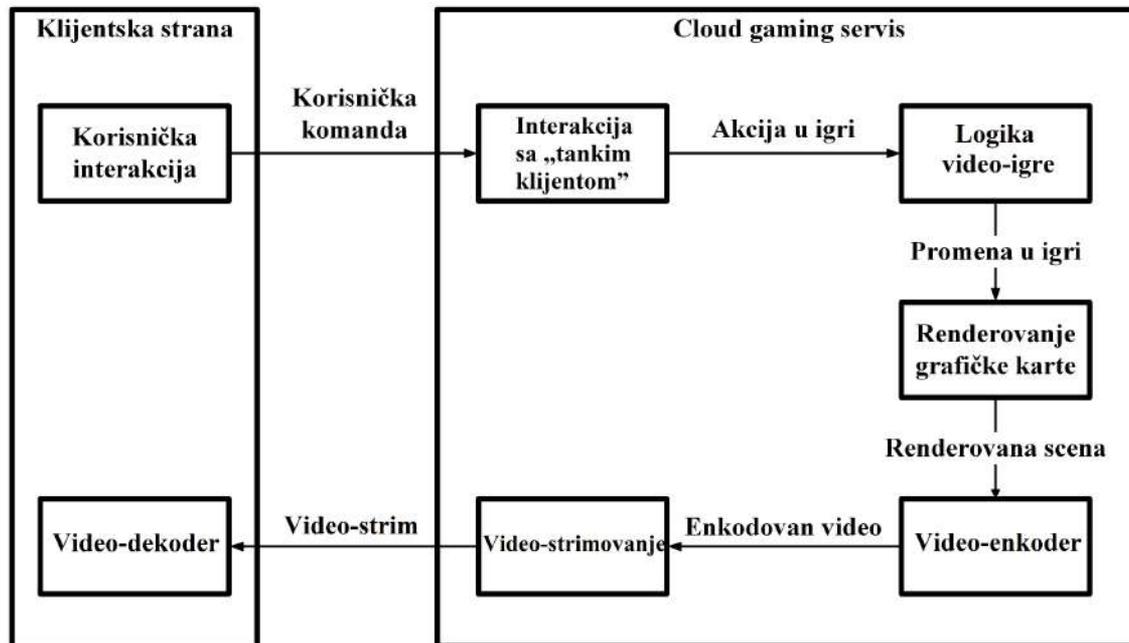
Poput samih računara, popularnost video-igara takođe je porasla vremenom, tako da video-igre danas imaju značajan uticaj na popularnu kulturu. Nikada nije bilo više različitih mogućnosti igranja najnovijih video-igara, bilo to na lokalnom računaru visokih performansi, igračkim konzolama ili *cloud gaming* servisima, nego što je to slučaj danas. Navedena literatura uglavnom obuhvata veb-portale sa informacijama o *cloud gamingu* relevantnim za određeni vremenski period ili konkretna istraživanja koja se tiču njegovih performansi. Za razliku od toga, ovaj rad bi trebalo da pojašni nastanak, infrastrukturu i način rada *cloud gaming* servisa, da istakne najnaprednije i najpopularnije servise i ukaže na važnost ovih tehnologija za svet video-igara, kako u svetu tako i u Srbiji.

2. Način rada *cloud gaming* servisa

Cloud gaming platforme funkcionišu na sličan način kao softveri za upravljanje na daljinu (engl. *Remote desktop software*) i servisi *Video na zahtev* (engl. *Video on Demand*) [1]. Video-igre se skladište i izvršavaju na daljinu, na hardveru provajdera i strimuju u formi video-snimka na uređaj korisnika preko softvera koji se nalazi na strani korisnika. Softver prihvata komande koje mu je zadao korisnik, koje se šalju nazad do servera i izvršavaju u igri [1]. Neki *cloud gaming* servisi funkcionišu poput virtuelne mašine. Korisnicima se nudi mogućnost virtuelizacije *Windows* okruženja, dopuštajući korisnicima da preuzimaju i instaliraju servise i video-igre na isti način kao i na lokalnom računaru.

Ove tehnologije mogu biti veoma korisne jer umanjuju potrebu za kupovinom skupog hardvera i instaliranjem video-igara direktno na lokalnu mašinu. Primenljive su na širok spektar uređaja, uključujući mobilne uređaje poput pametnih telefona, tableta, uređaja za strimovanje ili *tankih klijenata* (engl. *thin client*), uređaja malih performansi koji se uglavnom koriste za povezivanje sa udaljenim lokacijama [3]. Neki servisi nude dodatne mogućnosti u vidu omogućavanja gledaocima da se uključe u sesiju i privremeno upravljaju igrom [4].

Međutim, *cloud gaming* zahteva pouzdanu i brzu internet konekciju, što može predstavljati otežavajuću okolnost za ljude iz područja u kojima je teško obezbediti ovakve uslove. Na osnovu iskustava ljudi sa raznih društvenih mreža i foruma, možemo sa sigurnošću reći da Srbija spada u ta područja. Čak i uz pouzdanu i brzu internet konekciju, preopterećen onlajn-saobraćaj i druge stvari koje utiču na latenciju mreže mogu uticati i na performanse *cloud gaminga* [3]. Pored toga, troškovi *cloud gaminga* sa tradicionalne distribucije preko fizičkih i digitalnih kopija igara prelaze na *data* servere koji izvršavaju *cloud gaming* servise. Potrebne su nove strukture troškova kako bi se pokrili ovi operativni troškovi u poređenju sa tradicionalnom distribucijom. Uglavnom to funkcioniše po osnovnom modelu pretplate, ali usluga obuhvata i troškove kupovine igara koje će se pokretati u *cloud* servisu, iako korisnik ne poseduje igru na isti način kao da je kupio fizičku ili digitalnu kopiju [3]. Na slici 1 može se videti okvir funkcionisanja *cloud gaming* servisa.



Slika 1. Okvir funkcionisanja cloud gaming servisa [31]

Korisnik zadaje komandu i vrši se interakcija sa *tankim klijentom*, koji tu komandu predstavlja video-igri po njenoj logici. Time se reflektuje promena u samoj igri koja se renderuje, zatim kao video-snimak enkoduje i putem video-strima šalje video dekoderu.

3. Infrastruktura

Ove tehnologije zahtevaju dobro osmišljenu infrastrukturu kako bi servisi radili kako je zamišljeno, uključujući *data centre* i *farme servera* na kojima se izvršavaju igre. Takođe, zahtevaju internet konekciju sa visokim propusnim opsegom (engl. *bandwidth*) i niskom latencijom kako bi se korisnicima mogao isporučiti strim bez kašnjenja [5]. U radu *On the Quality of Service of Cloud Gaming Systems* se navodi kako infrastruktura neophodna za implementaciju *cloud gaminga* dugo nije bila dostupna mnogim geografskim lokacijama [5]. Govori se u prošlom vremenu, ali mnogi korisnici ovih servisa iz raznih delova Srbije bi mogli posvedočiti da je to i dalje tako. Zbog zavisnosti od strimovanog video-snimka visokog kvaliteta, neki provajderi često ograničavaju korišćenje servisa u vidu limitiranog prenosa podataka (engl. *data cap*) [6].

Glavna jedinica kvaliteta jednog *cloud gaming* servisa je latencija – dužina vremenskog perioda između korisničkog zadavanja komande i izvršavanja te komande u igri može uticati na kvalitet igranja, pogotovo kod igara koje zahtevaju brze reakcije korisnika, poput pucačkih igara iz prvog lica ili borilačkih igara [7].

Hardver provajdera se vremenom može nadograđivati kako bi podržavao veće rezolucije i broj slika po sekundi (engl. *frame rate*) kod renderovanja i strima [3].

Kvalitet iskustva (engl. *Quality of Experience*) predstavlja mernu jedinicu zadovoljstva korisnika prilikom korišćenja nekog servisa i treba je uzeti u obzir prilikom faze razvoja *cloud gaminga* [8].

4. Istorija cloud gaming servisa

4.1. Prvobitni pokušaji

Startup kompanija *G-Cluster* prva je pristupila ovim tehnologijama 2000. godine i prvi proizvod plasirala 2003. godine. Njihov početni model nudio je igre za personalne računare koje se izvršavaju na njihovim serverima pomoću servisnih provajdera *Video na zahtev* i uređaja *Set-Top Box* za prijem i obradu signala i provajdera za posredne softvere (engl. *middleware*) koji bi im omogućavali da obezbede svoje usluge mrežnim operaterima. Na taj način bi pružali video-igre krajnjim korisnicima kroz tzv. portale (engl. *enterprise portal*), okvire za integraciju informacija, ljudi i procesa, sličnih veb-portalima. Do 2010. godine, zbog promena na tržištu, kompanija *G-Cluster* promenila je model funkcionisanja. Prešli su na rad sa velikim proizvođačima servera kako bi lakše obezbeđivali svoje usluge mrežnim operaterima i krajnjim korisnicima. Ova promena je bila izazvana sve većom dostupnošću besplatnih igara za personalne računare, pa je kompanija odlučila da se fokusira na korisnike internet protokola televizija (engl. *Internet Protocol Television – IPTV*), gde je ciljna grupa obuhvatila oko tri miliona korisnika. Iste godine u Francuskoj je implementiran *gaming servis G-Cluster* [9]. Kompanija *Orange* je 2012. godine ušla na tržište *cloud gaminga*. Obe kompanije su komercijalno uspešne od kada su uvele ove servise za mobilne i TV klijente.

4.2. OnLive i Gaikai

Preduzetnik Stiv Perlman je 2009. godine izjavio da je, imajući u vidu današnji napredak na polju kompresije podataka i video-snimaka i mogućnosti pametnih telefona, pravo vreme za iskorišćavanje potencijala *cloud gaminga*. *Cloud* provajder *OnLive* zvanično je počeo sa radom 2010. godine. Korisnici su igrali *Igre na zahtev*, plaćajući pretplatu uz dodatne troškove iznajmljivanja ili kupovine igara. Imali su pristup naslovima koji su se pokretali u rezolucijama do 720p i brojem slika u sekundi do 60 fps. Stekli su podršku velikih izdavača kao što su *Ubisoft*, *2K Games* i *THQ*. Međutim, imali su problema da pridobiju ostale izdavače [10].

Paralelno, Dejvid Peri je osnovao *cloud* provajdera pod nazivom *Gaikai*. Oni su se odlučili za strimovanje demo verzija umesto kompletnih igara, učinivši tako ovaj servis određenom vrstom onlajn-oglasa za video-igre. *Gaikai* je stekao mnogo veću podršku izdavača, uključujući *Electronic Arts* [10]. Kompanija *Sony* je jula 2012. godine kupila *Gaikai* za 340 miliona dolara i već do oktobra iste godine u ponudu uvrstila *PlayStation* igre. Na kraju je tehnologija na kojoj je zasnovan *Gaikai* iskorišćena kao osnova za *PlayStation Now*, servis koji je predstavljen 2014. godine [10].

Servis *OnLive* nije bio profitabilan, te je, nakon tužbe koju je uložila kompanija *HP*, propao. Njihovu opremu nasledio je novoformirani entitet nazvan *OL2*. Nova kompanija pokušala je da promeni svoj poslovni model gde bi se korisniku omogućilo strimovanje igara koje su već u njegovom vlasništvu, ali to nije bilo isplativo. Aprila 2015. godine kompanija *Sony* kupila je intelektualnu svojinu servisa *OnLive* i *OL2*, da bi ih zatim zatvorila oko mesec dana kasnije [11]. Kako navodi veb-sajt *The Verge*, sticanje intelektualne svojine provajdera *Gaikai* i servisa *OnLive* kompaniji *Sony* je omogućilo pristup nizu patenata koji se odnose na *cloud gaming* [11].

4.3. Skorašnji napredak

Kompanija *Nvidia* je 2012. godine najavila svoj *cloud gaming* servis, *Nvidia Grid* (kasnije preimenovan u *GeForce Now*). Servis je predstavljao kombinaciju hardvera korišćenjem svojih procesora i softvera. U početku je partner za obezbeđivanje igara na servisu trebalo da im bude *Gaikai* [12]. *Ubisoftov GameCloud* predstavljen je uz *Nvidia Grid* i zamišljen je kao *white-label* servis zasnovan na *Nvidia Gridu* koji bi drugi provajderi mogli da koriste za pružanje usluga svojim korisnicima [13].

Godine 2013. *Grid* je predstavljen kao deo *Nvidia Shield* uređaja za *Android* televizore. Servis je najpre (novembra 2014) lansiran u Severnoj Americi, gde je bio dostupan ograničen broj igara, da bi se 2017. proširio na personalne računare, uz mogućnost povezivanja sa korisničkim *Steam* i *Epic Games* nalogom. [14]. Model povezivanja sa drugim nalogima naišao je na kritiku mnogih izdavača poput *Activisiona* jer su kupovine igara bile namenjene za personalne računare a ne za *cloud gaming*. Izdavači su prisilili kompaniju *Nvidia* da povuče te igre sa svog servisa.

U Japanu se 2014. godine pojavila video-igra *Dragon Quest X* za *Nintendo 3DS* koristeći *Ubisoft* kao striming tehnologiju [15].

Godine 2017. godine francuska startup kompanija *Blade* pokrenula je servis *Shadow*, gde su korisnici imali mogućnost iznajmljivanja instance *Windowsa 10* na daljinu na data centru i korišćenja *Intel Xeon* procesora i *Nvidia Quadro* grafičkih karata. Usluga je geografski ograničena u smislu zavisnosti od blizine korisnika jednom od njihovih *data* centara. Ovaj servis lansiran je u Francuskoj, ali je 2019. počeo da se proširuje i na prostor Sjedinjenih Američkih Država [16].

Maja 2018. kompanija *Electronic Arts* otkupila je opremu i kadar od *GameFlyja*, servisa za onlajn iznajmljivanje video-igara [17]. Kompanija je zatim objavila *Project Atlas* – projekat koji se bavi istraživanjem integracije veštačke inteligencije, mašinskog učenja i *Frostbite* tehnologije za kreiranje *ujedinjene* platforme za obavljanje procesa na daljinu, strimovanje filmova, HD video-igara uz minimalnu latenciju i otkrivanje novih mogućnosti za dinamično i multiplatformsko (engl. *cross-platform*) igranje [18]. Istog meseca *Google* i *Microsoft* takođe objavljuju tendencije za *cloud gaming*. *Google* započinje *Project Stream*, uključujući zatvoreno beta testiranje video-igre *Assassin's Creed Odyssey*, koju bi korisnik pokretao kroz pregledač *Google Chrome* [19]. *Microsoft* je objavio da radi na projektu *xCloud*, gde bi se u najvećoj meri koristila *Microsoft Azure* tehnologija [20].

Google 2019. godine zvanično je predstavio svoj *cloud gaming* servis pod nazivom *Stadia*, koji je zvanično lansiran novembra te godine [4]. U maju je kompanija *Sony* objavila partnerstvo sa *Microsoftom* prilikom rada na *cloud* rešenjima, uključujući i video-igre [21].

Kompanija *Apple* pokušala je da blokira *cloud gaming* aplikacije na svojim servisima sredinom 2020. godine. Izjavili su da *cloud gaming* servisi dozvoljavaju developerima da dodaju igre na *iOS* sistem, što zaobilazi sigurnosne provere koje se sprovode za svaku aplikaciju pre nego što se doda na *App Store* i time krši njihove uslove korišćenja. Međutim, septembra iste godine izmenili su pravila i time omogućili izvršavanje *cloud gaming* aplikacija na *iOS*-u, uz ograničenje da svaka igra mora biti ponuđena kao zasebno preuzimanje na *iOS* prodavnici [22]. Novembra 2020. *GeForce Now* i *Stadia* objavili su planove da izbace *iOS* verzije svojih servisa u vidu progresivnih veb-aplikacija (engl. *progressive web applications*) koje će se pokretati preko *Google Chrome* i *Safari* pregledača na *iOS* uređajima [23], [24]. Početkom 2021. godine *Microsoft* je takođe objavio planove za korišćenje sličnog pristupa za korišćenje *xCloud* tehnologije na *iOS*-u preko pregledača [25].

Kompanija *Amazon* predstavila je svoj *cloud gaming* servis *Luna* u septembru 2020. godine. Umesto pretplate prema kojoj će sav sadržaj biti dostupan, *Amazon* je napravio tzv. kanale za razne izdavače za koje će korisnici plaćati mesečnu pretplatu [26].

Asus i *Intel* novembra 2020. objavili su da je u toku snabdevanje hardverom, istraživanje i optimizacija softvera za *cloud gaming* platformu *Boosteroid* [27].

Nintendo trenutno ima igre na *Nintendo Switchu* koje podržavaju *cloud gaming*, kao što su na primer: *Control Ultimate Edition-Cloud Version*, *Hitman 3-Cloud Version*, i *Marvel's Guardians of the Galaxy: Cloud Version* [28].

5. Najpopularniji *cloud gaming* servisi

Kada pogledamo samu ulogu ovih tehnologija, vidimo da svi servisi, u suštini, nude istu stvar. Međutim, svi oni se drugačije ponašaju zbog razlika u svojim algoritmima, gde će jedan servis bolje ispuniti neki zadatak ali ne nužno i neki drugi. Na linku https://hal.inria.fr/hal-03421031/file/cloud_gamig_traffic_under_constraints_CR.pdf se može naći istraživanje sa zadatkom da odredi koji servis najefektivnije adaptira svoj saobraćaj u skladu sa mrežnim ograničenjima. Istraživanje je sprovedeno za četiri najpopularnija servisa: *GeForce Now*, *Stadia*, *Playstation Now* i *Xbox Cloud Gaming* uz razna mrežna ograničenja: propusni opseg, stopa gubitka paketa, latencija i džiter [32]. Sve u svemu, *GeForce Now* se pokazao kao najefikasniji servis, dok su ostali u nekom trenutku *zakazali* sa očuvanjem kontinuiteta usluge.

6. Cloud gaming u Srbiji

Kako je i rečeno u prethodnim delovima rada, najvažniji uslov za kvalitetno korišćenje ovih servisa je stabilna i brza internet konekcija, a baš na tom polju Srbija dosta zaostaje u odnosu na najrazvijenije zemlje. Međutim, prema iskustvima korisnika, *GeForce Now* se ističe kao servis koji radi poprilično dobro čak i uz nestabilnu i sporu internet konekciju. Takođe, dobro se pokazao i *Boosteroid*, kao i *Playstation Now*, koji teoretski nije dostupan u Srbiji, ali se može koristiti uz neke VPN softvere i nudi korisnicima mogućnost igranja određenih *Playstation* ekskluziva na personalnom računaru. Pretpostavlja se da renesansa na ovom polju u Srbiji tek sledi, ali i danas su ovi servisi korisni i isplativi za korišćenje ako se uzme u obzir odnos cene hardvera i igračkih konzola i prosečne plate u Srbiji.

7. Potencijalna poboljšanja

7.1. Deljenje resursa

Predloženi metod za poboljšanje skalabilnosti striminga igara je virtuelizacija grafičkih karata (engl. *Adaptive GPU resource scheduling*) [29]. Većina provajdera koristi posebnu grafičku kartu za svaku osobu koja igra igru. Rezultat ovoga su najbolje performanse, ali i rasipanje resursa. Uz bolje algoritme za deljenje grafičkih karata, ukoliko igra ne koristi u potpunosti određenu grafičku kartu, ona se može iskoristiti kao pomoć nekom drugom korisniku. U prošlosti se ovaj metod slabije koristio zbog loših performansi algoritma za virtualizaciju. Međutim, osmišljeni su novi algoritmi koji koriste do 90% snage grafičke karte, čak i kad je ona podeljena između korisnika [29].

7.2. Predviđanje komandi

Mnogi algoritmi se mogu koristiti kako bi predvideli korisnikov sledeći korak, što bi moglo smanjiti uticaj latencije na performanse *cloud gaming* aplikacija. Majd Bakar, glavni inženjer zadužen za rad na platformi *Stadia*, predviđa mogućnost korišćenja tog koncepta kako bi se latencija smanjila do tačke gde praktično ne postoji, nazivajući ovaj koncept *negativnom latencijom* [30].

8. Zaključak

Cloud gaming je, kao i sve *cloud* tehnologije, relativno nova oblast, ali je ujedno i oblast koja se razvija velikom brzinom. Ima brojne prednosti i mane, ali se intenzivno radi na otklanjanju tih mana i samo je pitanje vremena kada će one nestati. Ova oblast ima veliki komercijalni potencijal s obzirom na veliku gejmersku zajednicu, o čemu svedoči i upuštanje gotovo svih velikih kompanija u ovaj vid poslovanja. Servisi konstantno rastu i razvijaju se i u narednih nekoliko godina bi *cloud gaming* mogao postati sasvim uobičajena stvar na nivou cele planete.

Zahvalnica

Rad je rađen za potrebe predmeta Osnove primenjenih istraživanja kod mentora prof. dr Slavka Pokornog.

Reference

1. Computerworld <https://www.computerworld.com/article/3445366/is-xcloud-a-glimpse-at-the-future-of-the-desktop.html> (pristupljeno: 14. 1. 2022)
2. Techcrunch <https://techcrunch.com/2019/02/27/the-shadow-ghost-turns-cloud-gaming-into-a-seamless-experience/> (pristupljeno: 14. 1. 2022)
3. Theverge <https://www.theverge.com/2019/6/19/18683382/what-is-cloud-gaming-google-stadia-microsoft-xcloud-faq-explainer> (pristupljeno: 14. 1. 2022)
4. Polygon <https://www.polygon.com/2019/3/19/18272976/google-stadia-gdc-2019-crowd-play-youtube-streamers> (pristupljeno: 14. 1. 2022)
5. K. Chen. On the Quality of Service of Cloud Gaming Systems. IEEE Transactions on Multimedia. 2014.
6. pcworld <https://www.pcworld.com/article/403463/data-caps-must-die-how-google-and-microsofts-cloud-gaming-ambitions-could-conquer-isp-greed.html> (pristupljeno: 15. 1. 2022)
7. Techcrunch <https://techcrunch.com/2019/03/20/what-latency-feels-like-on-googles-stadia-cloud-gaming-platform/> (pristupljeno: 14. 1. 2022)
8. Content.iospress <https://content.iospress.com/articles/multiagent-and-grid-systems/mgs190313> (pristupljeno: 15. 1. 2022)
9. Telecompaper <https://www.telecompaper.com/news/sfr-launches-ondemand-video-games-on-tv--763381> (pristupljeno: 15. 1. 2022)
10. Polygon <https://www.polygon.com/features/2020/10/15/21499273/cloud-gaming-history-onlive-stadia-google> (pristupljeno: 15. 1. 2022)
11. Theverge <https://www.theverge.com/2015/4/2/8337955/sony-buys-onlive-only-to-shut-it-down> (pristupljeno: 15. 1. 2022)
12. Theverge <https://www.theverge.com/2012/5/15/3022233/nvidia-geforce-grid-gtc-2012> (pristupljeno: 15. 1. 2022)
13. Theverge <https://www.theverge.com/2012/5/16/3023502/ubitus-cloud-gaming-service-gtc-2012> (pristupljeno: 15. 1. 2022)
14. Theverge <https://www.theverge.com/2014/11/13/7211181/nvidia-launching-grid-cloud-gaming-for-shield-platform> (pristupljeno: 15. 1. 2022)
15. Gamespot <https://www.gamespot.com/articles/dragon-quest-x-uses-streaming-tech-to-come-to-3ds-/1100-6420972/> (pristupljeno: 15. 1. 2022)
16. Techcrunch <https://techcrunch.com/2020/03/12/cloud-gaming-platform-shadow-brings-its-new-plans-to-the-us/> (pristupljeno: 15. 1. 2022)
17. Cnet <https://www.cnet.com/news/ea-acquires-gamefly-subsidiarys-cloud-technology-assets/> (pristupljeno: 15. 1. 2022)
18. Engadget <https://www.engadget.com/2018-10-30-ea-project-atlas-engine-game-streaming.html> (pristupljeno: 15. 1. 2022)
19. Theverge <https://www.theverge.com/2018/10/8/17950998/google-project-stream-gaming-assasins-creed-odyssey-first-impression> (pristupljeno: 15. 1. 2022)

20. Ign <https://www.ign.com/articles/2018/10/08/microsoft-announces-global-game-streaming-service-project-xcloud-beta-next-year> (pristupljeno: 15. 1. 2022)
21. usgamer <https://www.usgamer.net/articles/sony-and-microsoft-set-aside-differences> (pristupljeno: 15. 1. 2022)
22. Cnbc <https://www.cnbc.com/2020/09/11/apple-app-store-new-rules-will-affect-google-stadia-microsoft-xcloud.html> (pristupljeno: 15. 1. 2022)
23. Gamedeveloper <https://www.gamedeveloper.com/business/nvidia-sidesteps-the-app-store-to-bring-geforce-now-game-streaming-to-ios> (pristupljeno: 16. 1. 2022)
24. Gamasutra https://www.gamasutra.com/view/news/374067/Stadia_plans_to_bypass_App_Store_with_web_app_iOS_launch.php (pristupljeno: 16. 1. 2022)
25. Theverge <https://www.theverge.com/2020/12/9/22165280/microsoft-xcloud-ios-pc-launch-spring-2021-announced> (pristupljeno: 16. 1. 2022)
26. Cnbc <https://www.cnbc.com/2020/09/25/amazon-luna-will-take-on-microsoft-xbox-game-streaming-google-stadia.html> (pristupljeno: 16. 1. 2022)
27. Intel <https://www.intel.com/content/www/us/en/customer-spotlight/stories/boosteroid-customer-story.html?wapkw=boosteroid> (pristupljeno: 16. 1. 2022)
28. Nintendolife <https://www.nintendolife.com/guides/nintendo-switch-cloud-games-list> (pristupljeno: 16. 1. 2022)
29. H. Yadav; B. Annappa, Adaptive GPU resource scheduling on virtualized servers in cloud gaming, Conference on Information and Communication Technology, 2017.
30. Wired <https://www.wired.com/story/google-stadia-negative-latency/> (pristupljeno: 16. 1. 2022)
31. Sfu <https://www.sfu.ca/~rws1/papers/Cloud-Gaming-Architecture-and-Performance.pdf> (pristupljeno: 17. 1. 2022)
32. Inria https://hal.inria.fr/hal-03421031/file/cloud_gamig_traffic_under_constraints_CR.pdf (pristupljeno: 17. 1. 2022)



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Type of the Paper: Original scientific paper

Received: 10.06.2023.

Accepted: 03.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.4>

UDK: 004.76:795

Cloud Gaming Services

Nikola Mekić

¹ Information Technology School – ITS, Belgrade, Serbia;

* Contact information: nikolamekic@gmail.com; Phone number: +381 (0)60/44-42-441

Abstract: This paper describes the functioning of cloud gaming services, their development, infrastructure, possibilities for advancement, and their application in Serbia.

Keywords: cloud gaming, latency, service, stream, virtualization.

1. Introduction

Similar to computers, the popularity of video games has also grown over time, having a significant influence on popular culture today. There have never been more diverse possibilities for playing the latest video games, whether on high-performance local computers, gaming consoles, or cloud gaming services. Existing literature mainly covers websites with information about cloud gaming relevant to specific time periods or specific research related to its performance. In contrast, this paper aims to clarify the origins, infrastructure, and operation of cloud gaming services, highlight the most advanced and popular services, and emphasize the importance of these technologies in the world of video games, both globally and in Serbia.

2. Operation of Cloud Gaming Services

Cloud gaming platforms operate in a similar manner to remote desktop software and video-on-demand services [1]. Video games are stored and executed remotely on the provider's hardware and streamed as video footage to the user's device through software located on the user's end. The software receives user commands, which are then sent back to the server and executed in the game [1]. Some cloud gaming services function as virtual machines, offering users the ability to virtualize a Windows environment, allowing them to download and install services and video games in the same way as on a local computer.

These technologies can be highly beneficial as they reduce the need to purchase expensive hardware and install video games directly on the local machine. They are applicable to a wide range of devices, including mobile devices such as smartphones, tablets, streaming devices, or thin clients, which are low-performance devices primarily used for connecting from remote locations [3]. Some services offer additional features, such as allowing viewers to join a session and temporarily control the game [4].

However, cloud gaming requires a reliable and fast internet connection. This can be a challenging aspect for people in areas where it is difficult to provide such conditions. Based on the experiences shared by people on various social media platforms and forums, we can confidently say that Serbia falls into such areas. Even with a reliable and fast internet connection, overloaded online traffic and other factors that affect network latency can impact cloud gaming performance [3]. Additionally, the costs of cloud gaming, compared to traditional distribution through physical and digital game copies, shift to data servers that run cloud gaming services. New cost structures are needed to cover these operational costs. Subscription models are commonly used, but the service also includes costs for purchasing games to be played on the cloud service, although the user does not own the game in the same way as if they had bought a physical or digital copy [3]. The framework of cloud gaming service operation can be seen in "Figure 1".

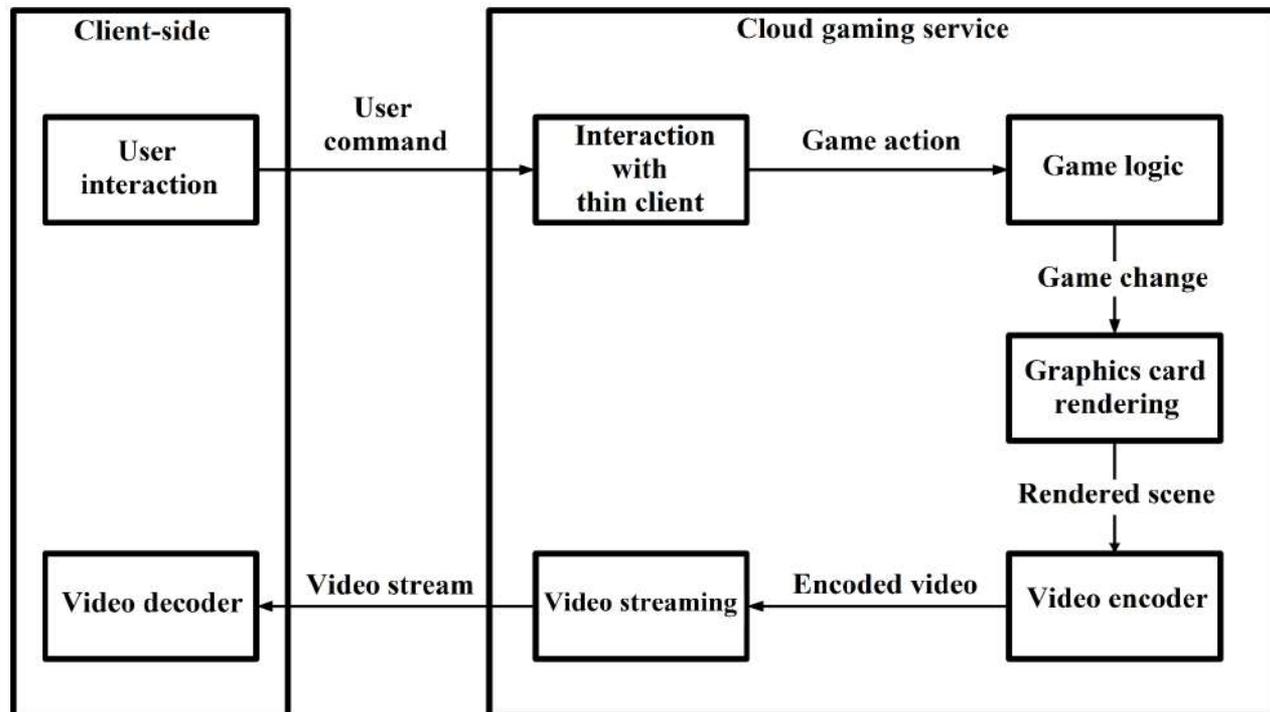


Figure 1. Framework of Cloud Gaming Service Operation [31].

The user issues a command and interacts with a thin client, which represents that command to the video game based on its logic. This reflects a change in the game itself, which is rendered, encoded as video footage, and sent to the video decoder via video streaming.

3. Infrastructure

These technologies require a well-designed infrastructure for services to work as intended, including data centers and server farms where games are executed. They also require an internet connection with high bandwidth and low latency to deliver a seamless stream to users without delay [5]. In the paper *On the Quality of Service of Cloud Gaming Systems*, it is mentioned that the infrastructure necessary for implementing cloud gaming was not available in many geographic locations for a long time. Although it is mentioned in the past tense, many users of these services from various parts of Serbia could testify that it is still the case. Due to the reliance on high-quality streamed video footage, some providers often limit the usage of services through data caps [6].

The key quality factor of a cloud gaming service is latency, the time period between a user issuing a command and that command being executed in the game. Latency can impact the gaming experience, especially for games that require fast user reactions, such as first-person shooters or fighting games [7].

The provider's hardware can be upgraded over time to support higher resolutions and frame rates during rendering and streaming [3].

Quality of Experience (QoE) is a measure of user satisfaction when using a service and should be considered during the development phase of cloud gaming [8].

4. History of Cloud Gaming Services

4.1. Initial Attempts

The startup company G-Cluster was the first to approach these technologies in 2000 and released its first product in 2003. Their initial model offered games for personal computers executed on their servers, with the help of Video on Demand service providers and Set-Top Box devices for signal reception and processing, as well as middleware providers to enable them to deliver their services to network operators. In this way, they provided video games to end users through enterprise portals, which are frameworks for integrating information, people, and processes, similar to web portals. By 2010, due to market changes, G-Cluster changed its operational model. They started collaborating with major server manufacturers to more easily deliver their services to network operators and end users. This change was prompted by the increasing availability of free games for personal computers, leading the company to focus on Internet Protocol Television (IPTV) users, with a target group of around three million users. In the same year, the G-Cluster gaming service was implemented in France [9]. In 2012, Orange entered the cloud gaming market. Both companies have been commercially successful since introducing these services for mobile and TV clients.

4.2. OnLive and Gaikai

Entrepreneur Steve Perlman stated in 2009 that with the advancements in data compression, video streaming, and the capabilities of smartphones, it was the right time to harness the potential of cloud gaming. OnLive, a cloud provider, officially launched in 2010. Users could play "Games on Demand" by paying a subscription fee along with additional costs for renting or

purchasing games. They had access to titles running at resolutions up to 720p and frame rates up to 60fps. They gained support from major publishers such as Ubisoft, 2K Games, and THQ. However, they struggled to attract other publishers [10].

Parallel to OnLive, David Perry founded a cloud provider called Gaikai. They opted for streaming game demos instead of full games, making their service a form of online advertising for video games. Gaikai gained much greater support from publishers, including Electronic Arts [10]. In July 2012, Sony acquired Gaikai for \$340 million and by October of the same year, integrated PlayStation games into their offering. Eventually, the technology on which Gaikai was based became the foundation for PlayStation Now, a service introduced in 2014 [10].

OnLive was not profitable, and after a possible lawsuit from HP, the service failed. Their equipment was inherited by a newly formed entity called OL2. The new company attempted to change its business model to allow users to stream games they already owned, but it was not financially viable. In April 2015, Sony acquired the intellectual property of OnLive and OL2, only to shut them down about a month later [11]. According to The Verge, Sony's acquisition of Gaikai's and OnLive's intellectual property provided them access to a range of cloud gaming-related patents [11].

4.3. Recent Progress

In 2012, Nvidia announced its cloud gaming service, Nvidia Grid (later renamed GeForce Now). The service represented a combination of hardware, using Nvidia's processors, and software. Initially, Gaikai was intended to be the partner for providing games on the service [12]. Ubitus' GameCloud was introduced alongside Nvidia Grid, envisioned as a white-label service based on Nvidia Grid that other providers could use to offer services to their users [13].

In 2013, Grid was introduced as part of the Nvidia Shield device for Android TVs. The service was initially launched in North America in November 2014, with a limited number of games available. It expanded to personal computers in 2017, with the option to link users' Steam and Epic Games accounts [14]. The integration with other accounts faced criticism from many publishers such as Activision because game purchases were intended for personal computers and not for cloud gaming. Publishers forced Nvidia to withdraw those games from its service.

In Japan, in 2014, the video game Dragon Quest X appeared on Nintendo 3DS using Ubitus as the streaming technology [15].

In 2017, the French startup company Blade launched the Shadow service, where users had the ability to rent remote instances of Windows 10 in data centers and use Intel Xeon processors and Nvidia Quadro graphics cards. The service is geographically limited, depending on the proximity of the user to one of their data centers. It was initially launched in France but began expanding to the United States in 2019 [16].

In May 2018, Electronic Arts acquired equipment and staff from GameFly, an online video game rental service [17]. The company then announced "Project Atlas," a project focused on exploring the integration of artificial intelligence, machine learning, and Frostbite technology to create a "unified" platform for remote processing, streaming movies, HD video games with minimal latency, and discovering new possibilities for dynamic and cross-platform gaming [18]. In the same month, Google and Microsoft also revealed their ambitions for cloud gaming. Google initiated "Project Stream," including a closed beta test of the video game "Assassin's Creed Odyssey" that users could play through the Google Chrome browser [19]. Microsoft announced its work on Project xCloud, leveraging Microsoft Azure technology to a significant extent [20].

In 2019, Google officially unveiled its cloud gaming service called Stadia, which was launched in November of that year [4]. In May, Sony announced a partnership with Microsoft to collaborate on cloud solutions, including video games [21].

In mid-2020, Apple attempted to block cloud gaming apps on its platforms. They stated that cloud gaming services allowed developers to add games to the iOS system, bypassing the security checks conducted for each app before being added to the App Store, thereby violating their terms of service. However, in September of the same year, Apple changed its rules, allowing the execution of cloud gaming apps on iOS, with the limitation that each game must be offered as a separate download on the iOS store [22]. In November 2020, both GeForce Now and Stadia announced plans to release iOS versions of their services as progressive web applications that would run through the Google Chrome and Safari browsers on iOS devices [23], [24]. In early 2021, Microsoft also announced plans to use a similar approach to enable the use of xCloud technology on iOS devices through browsers [25].

In September 2020, Amazon introduced its cloud gaming service called Luna. Instead of a subscription that grants access to all content, Amazon implemented "channels" for various publishers, for which users would pay a monthly subscription fee [26].

In November 2020, Asus and Intel announced their ongoing collaboration in supplying hardware, researching, and optimizing software for the Boosteroid cloud gaming platform [27].

Currently, Nintendo has games on the Nintendo Switch that support cloud gaming, such as Control Ultimate Edition-Cloud Version, Hitman 3-Cloud Version, and Marvel's Guardians of the Galaxy: Cloud Version [28].

5. The most popular Cloud Gaming Services

When we look at the role of these technologies, all services essentially offer the same thing. However, they behave differently due to differences in their algorithms, where one service may perform better in one task but not necessarily in another. The research available at the link https://hal.inria.fr/hal-03421031/file/cloud_gamig_traffic_under_constraints_CR.pdf aims to determine which service most effectively adapts its traffic according to network constraints. The study was conducted for the four most popular services: GeForce Now, Stadia, PlayStation Now, and Xbox Cloud Gaming, considering various network constraints such as bandwidth, packet loss rate, latency, and jitter [32]. Overall, GeForce Now proved to be the most efficient service, while others faced occasional challenges in maintaining service continuity.

6. Cloud Gaming in Serbia

As mentioned in previous sections, a stable and fast internet connection is crucial for the quality usage of these services, and in that aspect, Serbia lags behind the most developed countries. However, according to user experiences, GeForce Now stands out as a service that performs quite well even with an unstable and slow internet connection.

Boosteroid and PlayStation Now have also shown good performance. Although PlayStation Now is theoretically not available in Serbia, it can be used with certain VPN software, offering users the opportunity to play specific PlayStation exclusives on their personal computers. It is assumed that the renaissance in this field is yet to come in Serbia, but even today, these services are useful and cost-effective considering the cost of hardware, gaming consoles, and the average salary in Serbia.

7. Potential improvements

7.1. Resource sharing

The proposed method for improving game streaming scalability is virtualization of graphics cards (Adaptive GPU resource scheduling) [29]. Most providers use a dedicated graphics card for each individual playing the game. This results in optimal performance but also resource wastage. With better algorithms for sharing graphics cards, if a game doesn't fully use a specific graphics card, it can be used as assistance for another user. In the past, this method was less used due to poor algorithm performance for virtualization. However, new algorithms have been devised that can use up to 90% of the graphics card's power even when it is shared among users [29].

7.2. Command prediction

Many algorithms can be used to predict the user's next actions, which could reduce the impact of latency on cloud gaming performance. Majd Bakar, the principal engineer working on the Stadia platform, envisions the possibility of using this concept to reduce latency to the point where it is practically non-existent, referring to it as "negative latency" [30].

8. Conclusion

Cloud gaming, like all cloud technologies, is a relatively new field but one that is rapidly evolving. It has numerous advantages and disadvantages, but efforts are being made to address these drawbacks, and it is only a matter of time before they diminish. This field has significant commercial potential, given the large gaming community, as evidenced by the involvement of almost all major companies in this form of business. Services are continuously growing and developing, and in the next few years, cloud gaming could become a commonplace phenomenon worldwide.

Acknowledgement

This work was conducted for the purposes of the course "Fundamentals of Applied Research" under the guidance of Prof. Dr Slavko Pokorni.

References

1. Computerworld <https://www.computerworld.com/article/3445366/is-xcloud-a-glimpse-at-the-future-of-the-desktop.html> (Accessed: 14/01/2022)
2. Techcrunch <https://techcrunch.com/2019/02/27/the-shadow-ghost-turns-cloud-gaming-into-a-seamless-experience/> (Accessed: 14/01/2022)
3. Theverge <https://www.theverge.com/2019/6/19/18683382/what-is-cloud-gaming-google-stadia-microsoft-xcloud-faq-explainer> (Accessed: 14/01/2022)
4. Polygon <https://www.polygon.com/2019/3/19/18272976/google-stadia-gdc-2019-crowd-play-youtube-streamers> (Accessed: 14/01/2022)
5. Chen, K. On the Quality of Service of Cloud Gaming Systems. IEEE Transactions on Multimedia, 2014.
6. Pcworld <https://www.pcworld.com/article/403463/data-caps-must-die-how-google-and-microsofts-cloud-gaming-ambitions-could-conquer-isp-greed.html> (Accessed: 15/01/2022)
7. Techcrunch <https://techcrunch.com/2019/03/20/what-latency-feels-like-on-googles-stadia-cloud-gaming-platform/> (Accessed: 14/01/2022)
8. Content.iospress <https://content.iospress.com/articles/multiagent-and-grid-systems/mgs190313> (Accessed: 15/01/2022)
9. Telecompaper <https://www.telecompaper.com/news/sfr-launches-ondemand-video-games-on-tv--763381> (Accessed: 15/01/2022)
10. Polygon <https://www.polygon.com/features/2020/10/15/21499273/cloud-gaming-history-onlive-stadia-google> (Accessed: 15/01/2022)
11. Theverge <https://www.theverge.com/2015/4/2/8337955/sony-buys-onlive-only-to-shut-it-down> (Accessed: 15/01/2022)
12. Theverge <https://www.theverge.com/2012/5/15/3022233/nvidia-geforce-grid-gtc-2012> (Accessed: 15/01/2022)
13. Theverge <https://www.theverge.com/2012/5/16/3023502/ubitus-cloud-gaming-service-gtc-2012> (Accessed: 15/01/2022)
14. Theverge <https://www.theverge.com/2014/11/13/7211181/nvidia-launching-grid-cloud-gaming-for-shield-platform> (Accessed: 15/01/2022)
15. Gamespot <https://www.gamespot.com/articles/dragon-quest-x-uses-streaming-tech-to-come-to-3ds-/1100-6420972/> (Accessed: 15/01/2022)
16. Techcrunch <https://techcrunch.com/2020/03/12/cloud-gaming-platform-shadow-brings-its-new-plans-to-the-us/> (Accessed: 15/01/2022)
17. Cnet <https://www.cnet.com/news/ea-acquires-gamefly-subsidiarys-cloud-technology-assets/> (Accessed: 15/01/2022)
18. Engadget <https://www.engadget.com/2018-10-30-ea-project-atlas-engine-game-streaming.html> (Accessed: 15/01/2022)
19. Theverge <https://www.theverge.com/2018/10/8/17950998/google-project-stream-gaming-assasins-creed-odyssey-first-impression> (Accessed: 15/01/2022)
20. Ign <https://www.ign.com/articles/2018/10/08/microsoft-announces-global-game-streaming-service-project-xcloud-beta-next-year> (Accessed: 15/01/2022)

21. Usgamer <https://www.usgamer.net/articles/sony-and-microsoft-set-aside-differences> (Accessed: 15/01/2022)
22. Cnbc <https://www.cnn.com/2020/09/11/apple-app-store-new-rules-will-affect-google-stadia-microsoft-xcloud.html> (Accessed: 15/01/2022)
23. Gamedeveloper <https://www.gamedeveloper.com/business/nvidia-sidesteps-the-app-store-to-bring-geforce-now-game-streaming-to-ios> (Accessed: 16/01/2022)
24. Gamasutra https://www.gamasutra.com/view/news/374067/Stadia_plans_to_bypass_App_Store_with_web_app_ios_launch.php (Accessed: 16/01/2022)
25. Theverge <https://www.theverge.com/2020/12/9/22165280/microsoft-xcloud-ios-pc-launch-spring-2021-announced> (Accessed: 16/01/2022)
26. Cnbc <https://www.cnn.com/2020/09/25/amazon-luna-will-take-on-microsoft-xbox-game-streaming-google-stadia.html> (Accessed: 16/01/2022)
27. Intel <https://www.intel.com/content/www/us/en/customer-spotlight/stories/boosteroid-customer-story.html?wapkw=boosteroid> (Accessed: 16/01/2022)
28. Nintendolife <https://www.nintendolife.com/guides/nintendo-switch-cloud-games-list> (Accessed: 16/01/2022)
29. Yadav, H., & Annappa, B. Adaptive GPU resource scheduling on virtualized servers in cloud gaming, Conference on Information and Communication Technology, 2017.
30. Wired <https://www.wired.com/story/google-stadia-negative-latency/> (Accessed: 16/01/2022)
31. Sfu <https://www.sfu.ca/~rws1/papers/Cloud-Gaming-Architecture-and-Performance.pdf> (Accessed: 17/01/2022)
32. Inria https://hal.inria.fr/hal-03421031/file/cloud_gamig_traffic_under_constraints_CR.pdf (Accessed: 17/01/2022)



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Vrsta rada: Originalni naučni rad
 Primljen: 10.06.2023.
 Prihvaćen: 04.07.2023.
 UDK: 004.421:795

Algoritmi za pronalaženje putanje u igrama

Marko Novaković

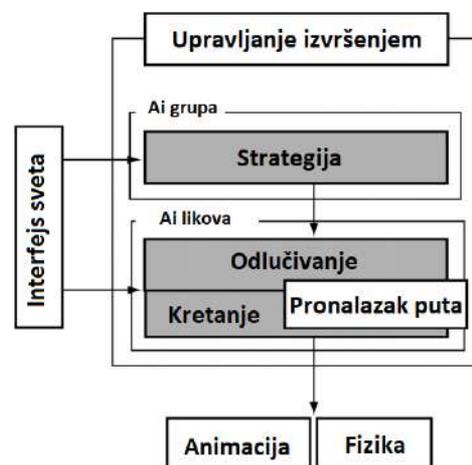
Visoka škola strukovnih studija za informacione tehnologije ITS, Beograd, Srbija, marko45521@its.edu.rs

Sažetak – U ovom članku su opisani A*, Dijkstrin i genetski algoritam za pronalaženje puteva koji se koriste u igrama radi poređenja i informisanja. Ovo nisu svi algoritmi koji se koriste u igrama pri pronalasku puteva – trenutno se najčešće koriste. Pošto postoji potreba da se u igrama prikaže što više podataka (kvalitetnija grafika, komplikovaniji sistemi za komunikaciju sa okolinom, više kvalitetnijih zvukova, komplikovaniji set pokreta koje mogu izvesti likovi, pametniji ai itd.) u što kraćem periodu, algoritmi se moraju razvijati da budu optimalniji, pa će ih u nekoj bliskoj budućnosti zameniti njihove bolje verzije ili sasvim novi algoritmi.

Ključne riječi – ant colony optimization, ai, A*, algoritam, breadth first search, Dijkstrov algoritam, dijkstra's algorithm, game character, graf, genetski algoritam, genetic algorithm, level, patfinding, traženje putanje, optimizacija kolonije mrava

I. UVOD

Likovi u igrama često imaju potrebu da se kreću po nivou. Ponekad ovo kretanje određuju programeri, npr. putanju po kojoj patrolira čuvar ili mali ograđeni deo po kojem pas može nasumično da se kreće. Fiksne putanje su jednostavne za implementaciju, ali takođe može lako doći do greške ako neki objekat dospe na putanju – likovi koji se nasumično kreću mogu izgledati kao da idu besciljno i mogu se lako zaglaviti.



Kompleksniji likovi ne znaju unapred gde će se kretati. Jedinica u strateškim igrama u realnom vremenu može dobiti naredbu od igrača da ode do određene tačke na mapi u bilo kom trenutku u vremenu, u igrama gde je važno biti neopažen će čuvar koji patrolira možda morati da ode do najbližeg mesta za alarm i pozove pojačanje, protivnici u platformskim igrama će možda morati da jure igrača preko provalija koristeći dostupne platforme.

Za svaki od ovih likova AI (Artificial Intelligence – veštačka inteligencija) mora biti u mogućnosti da izračuna pogodnu putanju po nivou igre da bi lik stigao od mesta gde je sad do cilja. Želeli bismo da putanja bude razumna i što kraća i brža (ne izgleda pametno ako lik hoda iz kuhinje do dnevne sobe preko tavana).

Ovo pronalaženje putanje (pathfinding) ponekad se naziva planiranje putanje (pathplanning) i svuda je u AI-ju igre. U primeru modela AI igre na slici 1 pronalaženje putanje je na granici između donošenja odluka i kretanja. Često se koristi samo da odredi kuda se kretati da bi se došlo do cilja. Cilj se određuje drugim AI-jem, a pronalazač puteva samo određuje putanju. Da bi se ovo izvelo, može se ugraditi u kontrolu sistema kretanja tako da se poziva samo kada je potrebno isplanirati putanju. Ali se isto tako AI za pronalaženje puteva može koristiti i da određuje cilj i putanju.

Velika većina igara koristi rešenja za pronalaženje puteva pomoću algoritma koji se zove A* (A star – A zvezda). Iako je efikasan i lako se implementira, A* ne može direktno da radi sa podacima nivoa igre. Potrebno je da se nivo predstavi u određenoj strukturi podatka: usmereni pozitivni ponderisani graf [1]. Slika 1. AI model igre [1]

II. DIJKSTROV ALGORITAM

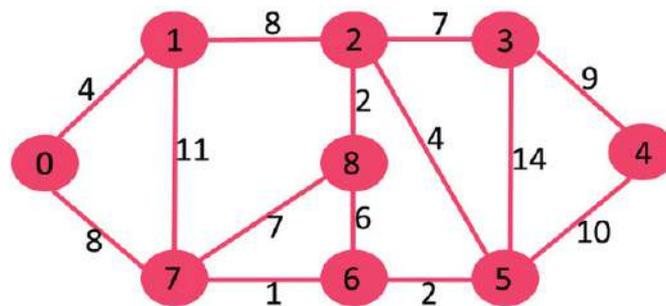
Dati su graf i početni čvor. Odrediti najkraći put od početnog čvora do svih čvorova grafa.

Generišemo stablo najkraće putanje i za koren uzimamo početni čvor. Imamo dva seta podataka. Prvi set sadrži čvorove koji su uključeni u najkraći put stabla, drugi set sadrži čvorove koji još uvek nisu uključeni u najkraći put. U svakoj iteraciji algoritma pronalazimo čvor koji se nalazi u setu koji još uvek nije uključen u najkraći put i ima najmanju udaljenost od izvora.

Detaljni koraci algoritma:

1. Kreiraj set sptSet (shortest path tree set) koji vodi računa o čvorovima koji su uključeni u najkraći put – čija je najkraća udaljenost od izvora izračunata i potvrđena; inicijalno ovaj set je prazan.
2. Dodeliti vrednosti za udaljenosti za sve čvorove grafa. Inicijalizuju se sve udaljenosti sa beskonačno. Dodeljuje se vrednost 0 za početni čvor, tako da bude izabran prvi.
3. Sve dok sptSet ne sadrži sve čvorove:
4. Izaberi čvor koji nije u sptSet i ima najmanju razdaljinu od poslednjeg čvora.
5. Uključi ga u sptSet.
6. Ažuriraj sve udaljenosti čvorova koji su susedni čvoru u (poslednji čvor). Da bi se ažurirale udaljenosti, prolazi se kroz sve susedne čvorove čvoru u. Za svaki susedni čvor v, ako je suma udaljenosti od u i pondera (težinskog faktora – udaljenost u ovom slučaju) od u do v manja od udaljenosti v, onda ažuriraj udaljenost v.

Primer grafa na slici 2 na kom će se objasniti rad algoritma:

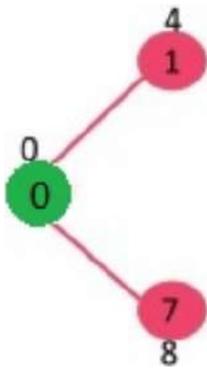


Slika 2. Primer ponderisanog grafa [2]

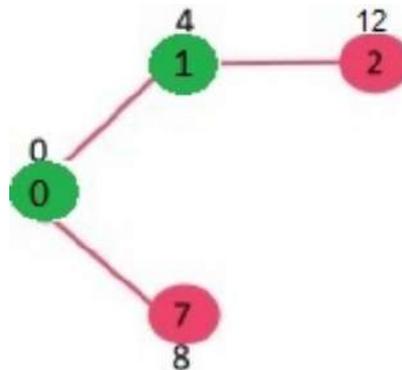
Set sptSet je na početku prazan i udaljenosti dodeljene čvorovima su $\{0, \text{INF}, \text{INF}, \text{INF}, \text{INF}, \text{INF}, \text{INF}, \text{INF}, \text{INF}\}$, gde INF označava beskonačno (infinity). Sada se bira čvor sa minimalnom vrednosti za udaljenost. Čvor 0 je izabran, uključuje se u sptSet. Sada je sptSet $\{0\}$. Posle dodavanja 0 sptSetu, ažuriraju se vrednosti njegovih susednih čvorova. Susedni čvorovi 0 su 1 i 7. Vrednosti udaljenosti 1 i 7 su ažurirane kao 4 i 8. Sledeći podgraf prikazuje čvorove sa njihovim udaljenostima, prikazani su samo oni čvorovi koji imaju konačne vrednosti udaljenosti. Čvorovi koji su uključeni u SPT (Shortest path tree) su označeni zelenom bojom (slika 3).

Odaberi čvor sa najmanjom udaljenosti koji nije već uključen u SPT (nije u sptSetu). Čvor 1 je izabran i dodat je u sptSet. Sada sptSet izgleda: $\{0,1\}$. Ažuriraj vrednosti udaljenosti susednih čvorova čvora 1. Udaljenost čvora 2 postaje 12 (slika 4).

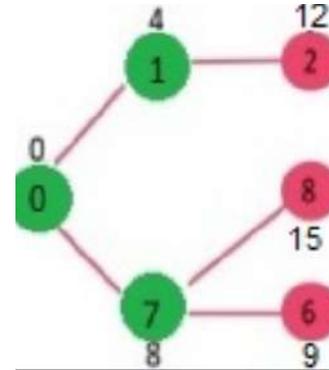
Odaberi čvor koji ima najmanju udaljenost i nije uključen u SPT (nije u sptSetu). Čvor 7 je izabran. Vrednosti udaljenosti čvorova 6 i 8 postaje konačna (15 i 9) (slika 5).



Slika 3. Podgraf 1 [2]

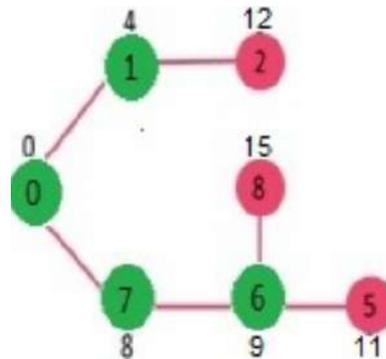


Slika 4. Podgraf 2 [2]



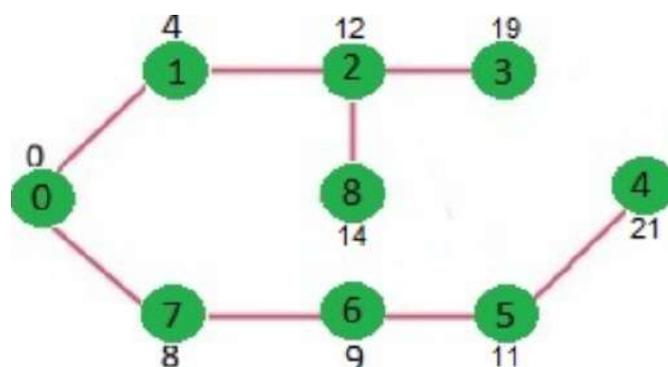
Slika 5. Podgraf 3 [2]

Odaberi čvorove sa najmanjom udaljenosti koji nisu već uključeni u SPT (nisu u sptSetu). Čvor 6 je odabran. Sada sptSet izgleda: {0,1,7,6}. Ažuriraj vrednosti udaljenosti susednih čvorova čvoru 6. Udaljenosti čvorova 5 i 8 su ažurirane (slika 6).



Slika 6. Podgraf 4 [2]

Ponavljamo ove korake dok u sptSet nisu uključeni svi čvorovi. Na kraju dobijamo sledeće stablo najkraćeg puta (SPT) (slika 7) [2].



Slika 7. Podgraf 5 [2]

III. A* ALGORITAM

A* (izgovara se A zvezda) jeste algoritam koji se često koristi u pronalaženju puteva i kretanju po grafu. Algoritam efikasno prikazuje putanju kretanja između čvorova grafa.

Na mapi sa mnogo prepreka pronalaženje puteva između tačke A i B može biti teško. Robot, na primer, bez dobijanja dodatnih uputstava o pravcu kretanja će nastaviti da se kreće sve dok ne dođe do prepreke (slika8).

Međutim, A* algoritam uvodi heuristiku u standardne algoritme za pretragu po grafovima, u suštini planirajući unapred svaki korak tako da se donese optimalnija odluka. Sa A* robot bi tražio put kao na slici 9.

A* je proširen Dijkstrov algoritam sa nekim karakteristikama algoritma pretrage u širinu (breadth-first search (BFS)) [3].

Kao i Dijkstrov algoritam, A* radi tako što napravi stablo najkraćeg puta od početnog čvora do ciljnog čvora. Ono što čini A* različitim i boljim za mnoge pretrage je to što za svaki čvor koristi funkciju $f(n)$, koja daje procenu totalne cene (dužine) puta kada bi se koristio taj čvor. Stoga je A* heuristička funkcija, koja se razlikuje od algoritma po tome što je heuristika više procena nego što je dokazivo tačna.

A* proširuje putanje koje su kraće (jeftinije) koristeći funkciju:

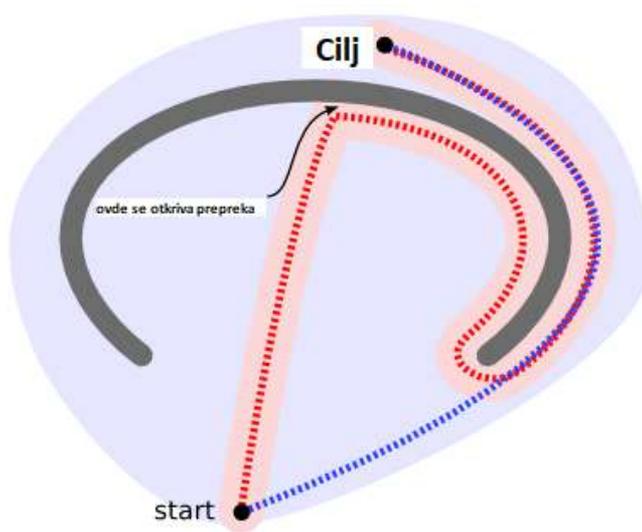
$$f(n) = g(n) + h(n),$$

gde je:

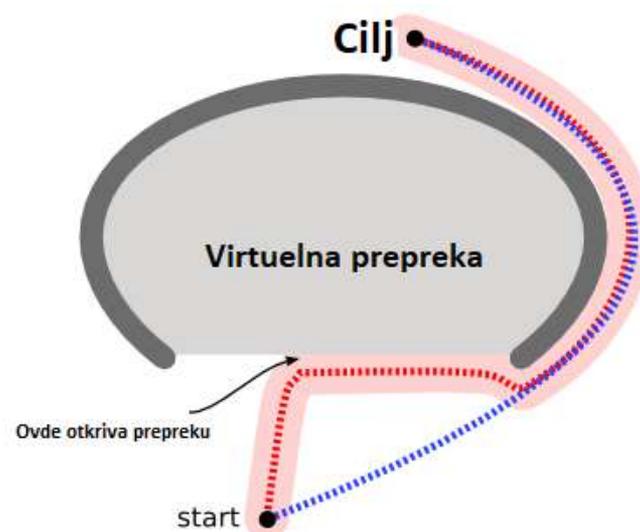
$f(n)$ = ukupna procenjena cena putanje kroz čvor n ;

$g(n)$ = akumulirana cena do čvora n ;

$h(n)$ = procenjena cena od n čvora do cilja. Ovo je heuristički deo funkcije, pa je kao pretpostavka.

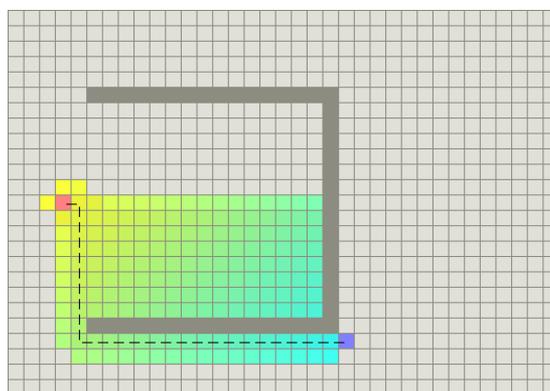


Slika 8. Neefikasan način pronalaska puta [5]



Slika 9. Primer korišćenja A* u pronalasku puta [5]

U rešetki na slici 10 A* algoritam počinje od početka (crveni čvor) i uzima u obzir sve susedne čvorove. Kada se lista susednih čvorova popuni, filtriraju se oni koji su nepristupačni (zidovi, prepreke, izvan granica). Onda se odabere čvor sa najmanjom cenom, koja se određuje sa $f(n)$. Ovaj proces se rekurzivno ponavlja sve dok se ne nađe najkraći put do cilja (plavi čvor). Proračunavanje $f(n)$ se radi heuristički, te obično daje dobre rezultate.



Slika 10. Korišćenje A* algoritma [5]

Izračunavanje $h(n)$ može da se uradi na više načina:

Manhattanova udaljenost [4] od n do cilja se najčešće koristi. Ovo je standardna heuristika za rešetku.

Ako je $h(n) = 0$, A^* postaje Dijkstrin algoritam, pomoću kog je zagarantovano da se pronađe najkraći put.

Heuristička funkcija mora biti prihvatljiva, što znači da nikad ne može da preceni cenu potrebnu da bi se došlo do cilja. I Manhattanova udaljenost i $h(n) = 0$ su prihvatljive.

Koristiti dobru heuristiku je važno u određivanju performansi A^* algoritma. Vrednost $h(n)$ bi idealno bila tačna cena stizanja do cilja. Ipak, ovo nije moguće zato što se i ne zna putanja. Ali se može odabrati metod koji će nekada dati tačne vrednosti, npr. kada se putuje u pravoj liniji bez prepreka. Ovo bi rezultiralo perfektnom performansom A^* algoritma.

Poželjno je da se odabere $h(n)$ funkcija, koja košta manje nego što bi koštalo stizanje do cilja. Ovo bi omogućilo da $h(n)$ radi precizno. Ako odaberemo vrednost koja je veća, onda bi to dovelo do bržih, ali manje preciznih performansi. Tako da je često slučaj da se $h(n)$ bira tako da bude manje nego realna cena.

Na slici 11 prikazan je pseudokod A^* algoritma napisan sintaksom nalik na Python [5].

```

napravi otvorenu listu koja se sastoji samo iz početnog čvora
napravi praznu zatvorenu listu
while (nije se stiglo do ciljnog čvora):
    uvrsti čvor sa najmanjom f vrednosti u otvorenu listu
    if(ovaj čvor je naš određeni čvor):
        završili smo
    if not:
        uvrsti trenutni čvor u zatvorenu listu i pregledaj sve njegove susedne čvorove
        for(svaki susedni čvor trenutnog čvora):
            if(ako susedni čvor ima manju g vrednost od trenutnog čvora i u zatvorenoj je listi):
                zameni suseda sa novim koji ima manju g vrednost
                trenutni čvor je sada roditelj susednom čvoru
            else if(ako je g vrednost trenutnog čvora manja od susednog i ovaj sused je u otvorenoj listi):
                zameni suseda sa novim kojim ima manju g vrednost
                ažuriraj roditeljs suseda na trenutni čvor
            else if(ovaj sused nije ni u jednoj listi):
                dodaj ga u otvorenu listu i dodeli mu g vrednost

```

Slika 11. A^* pseudokod [5]

Za više detalja o algoritmu A^* pogledajte članak [6].

IV. HEURISTIČKE TEHNIKE

Heurističke tehnike se koriste da reše problem na brži i efikasniji način, optimizujući rešenje, tačnost i preciznost [7]. Cilj heurističkih algoritama je da nađu dobro rešenje za određeni problem, kao što je pronalaženje puteva (pathfinding) u razumnom vremenu izračunavanja, ali bez zagarantovane efikasnosti. Heuristika na grčkom znači pronaći [8]. U heurističke algoritme spadaju i Dijkstrin i A^* algoritam, koji su opisani u prethodnom tekstu, kao i algoritam pretrage u širinu (breadth-first search (BFS)) [3].

V. METAHEURISTIČKE TEHNIKE

Metaheuristika je u suštini skup strategija na visokom nivou koje kombinuju tehnike nižeg nivoa za opisivanje i eksploataciju prostora pretrage. Metaheuristika je viši nivo heuristike. Obično ima bolje performanse nego heuristika. Metaheuristika može da skрати vreme pretrage i da izgleda dovoljno dobro da reši kompleksne putanje u video-igrama. Na osnovu studija metaheuristički algoritmi, kao što su genetski algoritam i optimizacija kolonija mrava, korišćeni su u igrama da bi rešili probleme pronalaska puteva. Metaheuristika je bazirana na osnovu nekih prirodnih pojava. Najuspešniji metaheuristički algoritmi su inspirisani prirodnim sistemima. Na primer, optimizacija kolonija mrava (ant colony optimization) [9] i algoritam pčele (bee algoritam) bili su razvijeni na osnovu ponašanja životinja [10].

VI. GENETSKI ALGORITAM

Genetski algoritmi su među najpopularnijim evolucionim algoritmima u smislu raznolikosti njihove primene. Za veliku većinu dobro poznatih optimizacionih problema traženo je rešenje u genetskim algoritmima. Dodatno, genetski algoritmi su zasnovani na populaciji i mnogi moderni evolucionim algoritmi su bazirani na osnovu genetskih algoritama ili imaju velikih sličnosti sa njima.

Suština genetskih algoritama je enkodiranje optimizacione funkcije kao niz bitova ili niz karaktera koji predstavljaju hromosome, kao i manipulacija stringova genetskim operatorima i selekcija pogodnih individua, sa ciljem da se pronađe dobro (pa i optimalno) rešenje problema. U daljem tekstu će se koristiti pogodnost i funkcija pogodnosti. Pogodnost se odnosi na željene karakteristike koje želimo da dobijemo iteracijama algoritma.

Ovo se najčešće radi sledećom procedurom:

1. enkodiranje ciljeva ili funkcija troškova;
2. definisanje funkcije pogodnosti (fitness function) ili kriterijuma selekcije;
3. kreiranje populacije individua;
4. sprovođenje evolucionog ciklusa ili iteracija ocenjivanjem pogodnosti svih individua populacije i kreiranje nove populacije obavljanjem prelaska i mutacije, pogodne reprodukcije itd., na kraju se menja stara populacija i vrše se iteracije korišćenjem nove populacije;
5. dekodiranje rezultata dobijenih rešenjem.

Ovi koraci mogu se predstaviti šematski kao pseudokod genetskih algoritama (slika 12).

Jedna iteracija kreiranja nove populacije naziva se generacija. Najčešće se koriste stringovi fiksne dužine u većini genetskih algoritama tokom svake generacije, iako postoji pozamašno istraživanje stringova promenljive dužine i struktura kodova. U prilagodljivim genetskim algoritmima kodiranje ciljne funkcije često je u formi binarnih nizova ili nizova sa realnim vrednostima. Zbog jednostavnosti, u diskusiji su korišćeni binarni nizovi. Genetski operatori uključuju prelazak, mutaciju i selekciju (engl. crossover, mutation and selection) iz populacije.

Prelazak dva roditeljska niza je glavni operator sa velikom verovatnoćom, označava se sa P_c i izvršava se tako što se zameni jedan segment na nasumično odabranoj poziciji jednog hromozoma odgovarajućim segmentom drugog hromozoma (slika 13).

Operator mutacije se dobija tako što se na nasumično odabranom bitu zameni vrednost ($0 \rightarrow 1$ ili $1 \rightarrow 0$) (slika 14), verovatnoća mutacije se označava sa P_m i često je mala. Dodatno se može desiti da se na više mesta dogodi mutacija, što može biti prednost u praksi i primeni.

Selekcija individua u populaciji obavlja se procenom pogodnosti i individua se može naći u sledećoj generaciji ako je određeni prag pogodnosti dostignut.

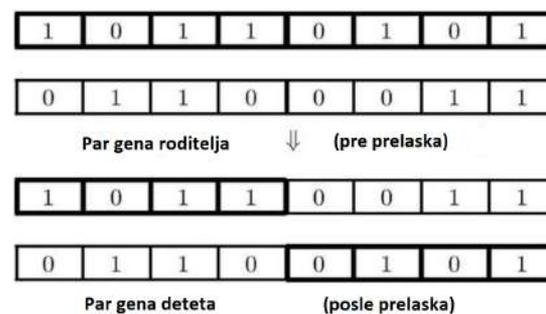
Dodatno, selekcija može biti bazirana na pogodnosti tako da razmnožavanje populacije bude proporcionalno pogodnosti, što bi značilo da je veća šansa da se individue sa većom pogodnosti razmnožavaju [11].

```

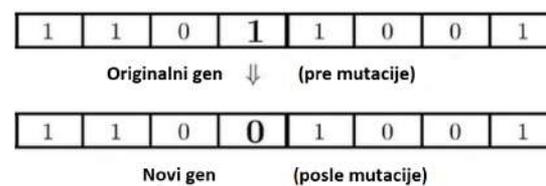
Ciljna funkcija  $f(x)$ ,  $x = (x_1, \dots, x_d)^T$ 
Enkodiraj rešenja u hromozome (stringove)
Definiši pogodnost  $F$  (npr.  $F \propto f(x)$  za maksimizaciju)
Generiši početnu proporciju
Definiši verovatnoću prelaska ( $P_c$ ) i mutacije ( $P_m$ )
while (t < maksimalnog broja generacija)
    Generiši novo rešenje prelaskom i mutacijom
    Odradi prelazak sa verovatnoćom  $P_c$ 
    Odradi mutaciju sa verovatnoćom  $P_m$ 
    Prihvati nova rešenja ako im se pogodnost poveća
    Izaberi trenutno najboljeg za sledeću generaciju
    Ažuriraj  $t = t + 1$ 
end while
Dekodiraj rezultate i vizualizuj

```

Slika 12. Pseudokod genetskih algoritama [11]



Slika 13. Dijagram prelaska nasumičnog segmenta u genetskim algoritmima [11]



Slika 14. Dijagram mutacije nasumičnog bita [11]

ZAHVALNICA

Rad je rađen u okviru predmeta Osnove primenjenih istraživanja, a mentor rada je prof. dr. Slavko Pokorni.

LITERATURA

1. I. Millington, AI for Games third edition 2019, pp. 195–196
2. „Dijkstra’s shortest path algorithm | Greedy Algo-7”, GeeksForGeeks, <https://www.geeksforgeeks.org/dijkstras-shortest-path-algorithm-greedy-algo-7/>; posećeno: 4. 4. 2022.
3. „Breadth First Search (BFS) Algorithm”, algotree.org, https://algotree.org/algorithms/tree_graph_traversal/breadth_first_search/; posećeno: 4. 4. 2022.
4. P. E. Black, „Manhattan distance”, in *Dictionary of Algorithms and Data Structures* [online], Paul E. Black, ed. 11 February 2019; <https://www.nist.gov/dads/HTML/manhattanDistance.html>; posećeno 4. 4. 2022.
5. A* Search. *Brilliant.org*. Retrieved 10:24, April 4, 2022, from <https://brilliant.org/wiki/a-star-search/>.

6. L. Patrick. „A* pathfinding for beginners.” *online*]. *GameDev* WebSite.:<https://www.gamedev.net/reference/articles/article2003.asp>; posećeno 4. 4. 2022. (2005).
7. L. A. Wolsey, „Heuristic Algorithms”, *Integer Program.*, no. January, p. 17, 1998.
8. A. Rafiq *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **769** 012021 „prihvaćen za objavljivanje”
9. X. S. Yang, *Nature-Inspired Optimization Algorithms*, 2014, pp. 305–308.
10. X. S. Yang, *Nature-Inspired Optimization Algorithms*, 2014, pp. 308–312.
11. X. S. Yang, *Nature-Inspired Optimization Algorithms*, 2014, pp. 116–130.



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Type of paper: Original scientific paper

Received: 10.06.2023.

Accepted: 04.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.5>

UDC: 004.421:795

Pathfinding Algorithms in Games

Marko Novaković*

*Information Technology School – ITS, Belgrade, Serbia; marko45521@its.edu.rs

Abstract: This article describes the A*, Dijkstra's, and genetic pathfinding algorithms used in games, providing a comparison and information about them. While these are not the only algorithms used in game pathfinding, they are currently the most commonly used ones. As games increasingly demand the presentation of more data (higher-quality graphics, complex environmental communication systems, better sound effects, advanced character movement sets, smarter AI, etc.) in shorter time frames, algorithms must be developed to become more optimal. In the near future, they will be replaced by improved versions or entirely new algorithms.

Keywords: ant colony optimization, AI, A* algorithm, breadth-first search, Dijkstra's algorithm, game character, graph, genetic algorithm, level, pathfinding, ant colony optimization.

I. INTRODUCTION

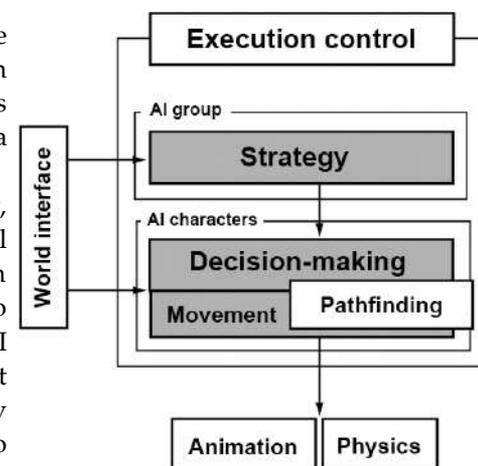
Games characters often need to move around at certain levels. Sometimes these movements are predetermined by developers, such as a guard patrolling a specific path or a small enclosed area where a dog can move randomly. Fixed paths are easy to implement, but errors can easily occur if an object ends up on the path. Characters that move randomly may appear as having no aim and can easily get stuck.

More complex characters do not know in advance where they will move. Units in real-time strategy games may receive orders from players to go to a specific point on the map at any given time. In games where stealth is important, a patrolling guard may need to go to the nearest alarm location and call for backup. Enemies in platform games may need to chase the player across gaps using available platforms.

For each of these characters, Artificial Intelligence (AI) must be able to calculate a suitable path through the game level to reach the goal from their current location. We want the path to be reasonable, as short as possible, and for the character to move fast (it wouldn't look smart if a character walked from the kitchen to the living room through the attic).

This is called pathfinding, sometimes referred to as path planning, and it is essential in AI of games. In the example of the AI game model shown in Figure 1, pathfinding lies at the boundary between decision-making and movement. It is often used only to determine how to move towards the goal, while the goal itself is determined by other AI components, and the pathfinder only calculates the path. To achieve this, it can be integrated into the movement control system so that it is called only when it is necessary to plan a path. However, the pathfinding AI can also be used to determine both the goal and the path.

The majority of games use a pathfinding solution called the A* algorithm (A-star). While efficient and easy to implement, A* cannot directly operate with game-level data. It requires the game level to be represented in a specific data structure: a directed, weighted graph. [1] *Figure 1: AI game model [1]*



II. DIJKSTRA'S ALGORITHM

Given a graph and a starting node, determine the shortest path from the starting node to all other nodes in the graph.

We generate a shortest path tree, taking the starting node as the root. We have two sets of data: the first set contains the nodes included in the shortest path tree, and the second set contains the nodes that have not yet been included. In each iteration of the algorithm, we find the node in the set that has not been included in the shortest path and has the smallest distance from the source.

Detailed steps of the algorithm:

1. Create a set called sptSet (shortest path tree set) to keep track of the nodes included in the shortest path – those whose shortest distance from the source has been calculated and confirmed. Initially, this set is empty.

2. Assign distance values to all nodes in the graph. Initialize all distances to infinity. Assign a distance of 0 to the starting node so that it is selected first.
3. While sptSet does not contain all nodes:
 - 3.1. Select the node that is not in sptSet and has the smallest distance from the last node.
 - 3.2. Include it in sptSet.
 - 3.3. Update the distances of all nodes that are adjacent to node u (the last node). To update the distances, go through all the neighboring nodes of node u . For each neighboring node v , if the sum of the distance from u and the weight (cost factor – the distance in this case) from u to v is less than the distance of v , then update the distance of v .

Example of a graph "Figure 2" to illustrate the algorithm's operation:

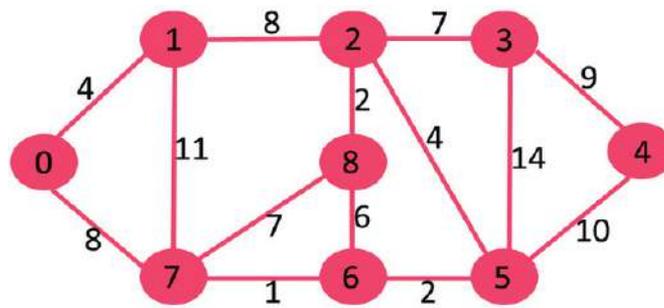


Figure 2: Example of a weighted graph [2]

The set sptSet is initially empty, and the distances assigned to the nodes are {0, INF, INF, INF, INF, INF, INF, INF, INF}, where INF represents infinity. Now, a node with the minimum distance value is selected. Node 0 is chosen and included in sptSet. Now, sptSet is {0}. After adding 0 to sptSet, the distances of its neighboring nodes are updated. The neighboring nodes of 0 are 1 and 7. The distance values of 1 and 7 are updated to 4 and 8, respectively. The following subgraph shows the nodes with their distance values, only displaying nodes with finite distance values. The nodes included in the Shortest Path Tree (SPT) are marked in green "Figure 3".

Select the node with the smallest distance that is not already included in the SPT (not in sptSet). Node 1 is selected and added to sptSet. Now, sptSet looks like: {0, 1}. Update the distance values of the neighboring nodes of node 1. The distance of node 2 becomes 12 "Figure 4".

Select the node with the smallest distance that is not already included in the SPT (not in sptSet). Node 7 is chosen. The distance values of nodes 6 and 8 become finite (15 and 9, respectively) "Figure 5".

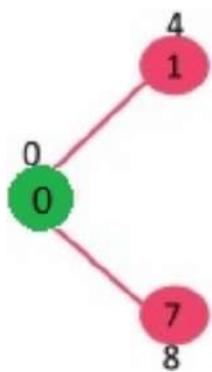


Figure 3: Subgraph 1 [2]

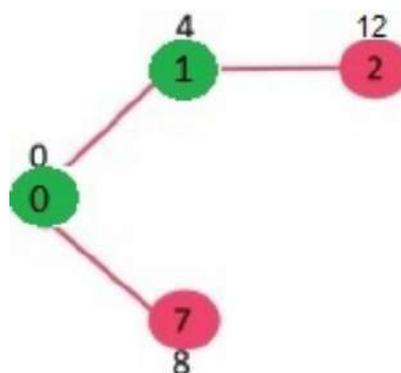


Figure 4: Subgraph 2 [2]

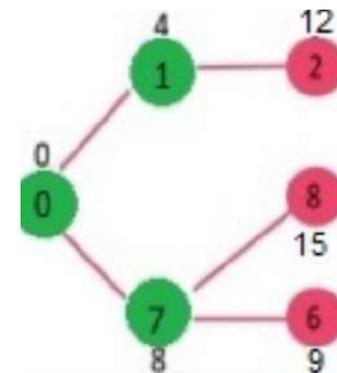


Figure 5: Subgraph 3 [2]

Choose the node with the smallest distance that is not already included in the SPT (not in sptSet). Node 6 is selected. Now, sptSet looks like: {0, 1, 7, 6}. Update the distance values of the neighboring nodes of node 6. The distances of nodes 5 and 8 are updated "Figure 6".

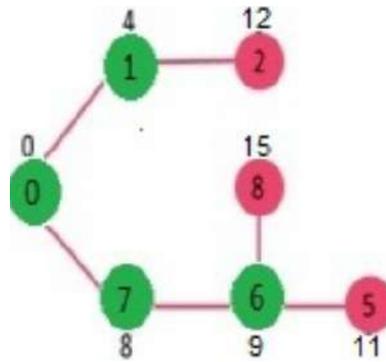


Figure 6: Subgraph 4 [2]

We repeat these steps until all nodes are included in the sptSet. In the end, we obtain the following Shortest Path Tree (SPT) "Figure 7" [2].

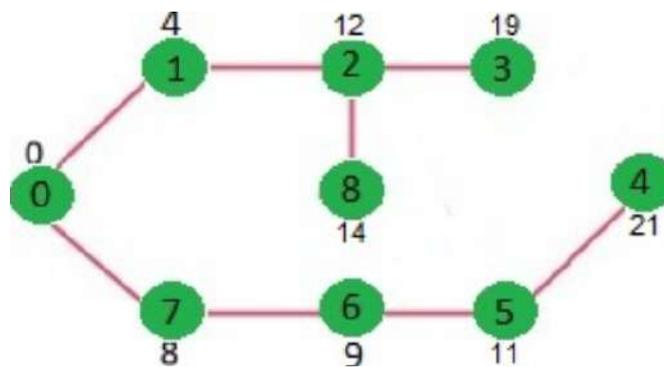


Figure 7: Subgraph 5 [2]

III.A* ALGORITHM

A* (pronounced "A star") is an algorithm commonly used for pathfinding and graph traversal. The algorithm efficiently finds the path of movement between graph nodes.

On a map with multiple obstacles, finding paths between points A and B can be challenging. For example, a robot without additional instructions about the direction of movement would continue moving until it encounters an obstacle ("Figure 8").

However, the A* algorithm introduces heuristics into standard graph search algorithms, essentially planning ahead at each step to make a more optimal decision. With A*, the robot would search for a path as shown in "Figure 9".

A* is an extension of Dijkstra's algorithm with some characteristics of breadth-first search (BFS) [3].

Similar to Dijkstra's algorithm, A* constructs the shortest path tree from the initial node to the goal node. What makes A* different and more effective for many searches is its use of a function $f(n)$ for each node, which provides an estimate of the total cost (length) of the path if that node is used. Therefore, A* is a heuristic function, which means that the heuristic is more of an estimation rather than a provably accurate value.

A* expands paths that are shorter (cheaper) by using the function:

$$f(n) = g(n) + h(n)$$

where:

$f(n)$ = total estimated cost of the path through node n ,

$g(n)$ = accumulated cost to reach node n ,

$h(n)$ = estimated cost from node n to the goal. This is the heuristic part of the function, making an assumption.

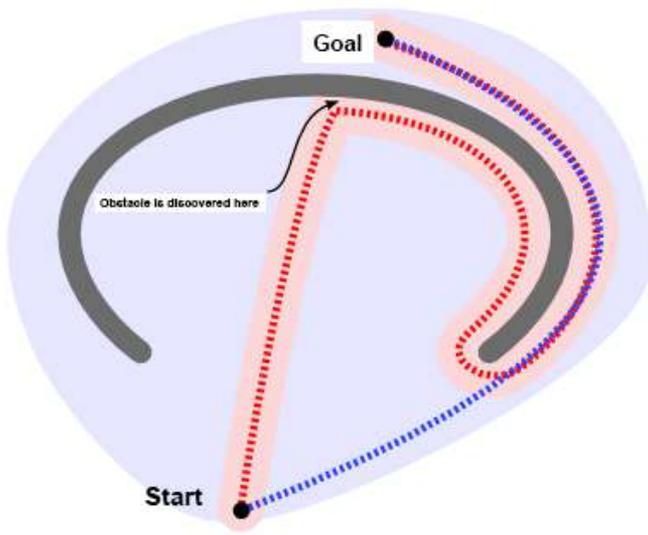


Figure 8: Inefficient way of finding a path [5]

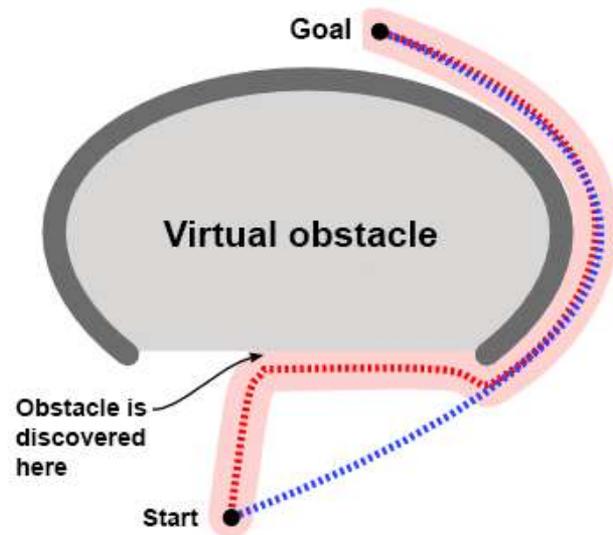


Figure 9: Example of using A* for pathfinding [5]

In the grid "Figure 10", the A* algorithm starts from the beginning (red node) and considers all neighboring nodes. Once the list of neighboring nodes is filled, those that are inaccessible (walls, obstacles, out of bounds) are filtered out. Then, the node with the lowest cost, determined by $f(n)$, is chosen. This process is recursively repeated until the shortest path to the goal (blue node) is found. The calculation of $f(n)$ is done heuristically, typically yielding good results.

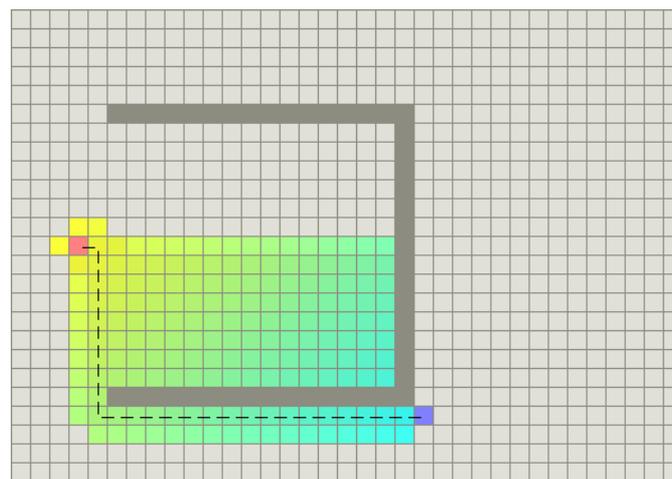


Figure 10: Using the A* algorithm [5]

Calculation of $h(n)$ can be done in several ways:

The most common approach is to use the Manhattan distance [4] from node n to the goal. This is a standard heuristic for grid-based problems.

If $h(n) = 0$, A* becomes Dijkstra's algorithm, which guarantees to find the shortest path.

The heuristic function must be admissible, meaning it should never overestimate the cost required to reach the goal. Both the Manhattan distance and $h(n) = 0$ are admissible.

Using a good heuristic is important for determining the performance of the A* algorithm. The ideal value of $h(n)$ would be the exact cost of reaching the goal.

However, this is not possible since the path is unknown. But a method can be chosen that gives reasonably accurate values, such as when traveling in a straight line without obstacles. This would result in optimal A* performance.

It is desirable to choose an $h(n)$ function that costs less than actually reaching the goal. This allows $h(n)$ to work accurately. If a higher value is chosen, it would lead to faster but less accurate performance. Therefore, it is often the case that $h(n)$ is chosen to be less than the actual cost.

Figure 11 illustrates the pseudocode of the A* algorithm written in Python-like syntax [5].

```

napravi otvorenu listu koja se sastoji samo iz početnog čvora
napravi praznu zatvorenu listu
while (nije se stiglo do ciljnog čvora):
    uvrsti čvor sa najmanjom f vrednosti u otvorenu listu
    if(ovaj čvor je naš određeni čvor):
        završili smo
    if not:
        uvrsti trenutni čvor u zatvorenu listu i pregledaj sve njegove susedne čvorove
        for(svaki susedni čvor trenutnog čvora):
            if(ako susedni čvor ima manju g vrednost od trenutnog čvora i u zatvorenoj je listi):
                zameni suseda sa novim koji ima manju g vrednost
                trenutni čvor je sada roditelj susednom čvoru
            else if(ako je g vrednost trenutnog čvora manja od susednog i ovaj sused je u otvorenoj listi):
                zameni suseda sa novim kojim ima manju g vrednost
                ažuriraj roditelja suseda na trenutni čvor
            else if(ovaj sused nije ni u jednoj listi):
                dodaj ga u otvorenu listu i dodeli mu g vrednost

```

Figure 11: A* Pseudocode [5]

For more details on the A* algorithm, refer to the article [6].

IV. HEURISTIC TECHNIQUES

Heuristic techniques are used to solve problems in a faster and more efficient way by optimizing solution quality, accuracy, and precision [7]. Heuristic algorithms aim to find a good solution to a specific problem, such as pathfinding, within a reasonable computation time, but without guaranteed efficiency. "Heuristics" means "to find" in Greek [8]. Heuristic algorithms include Dijkstra's algorithm and A* algorithm, which were described in the previous text, as well as the breadth-first search (BFS) algorithm [3].

V. METAHEURISTIC TECHNIQUES

Metaheuristics are essentially high-level strategies that combine lower-level techniques to describe and exploit the search space. Metaheuristics are a higher level of heuristics and usually exhibit better performance than heuristics. Metaheuristics can reduce search time and provide satisfactory solutions for complex pathfinding problems in video games. Based on studies, metaheuristic algorithms such as genetic algorithms and ant colony optimization have been used in games to solve pathfinding problems. Metaheuristics are based on certain natural phenomena, and the most successful metaheuristic algorithms are inspired by natural systems. For example, ant colony optimization [9] and bee algorithm were developed based on animal behaviors [10].

VI. GENETIC ALGORITHM

Genetic algorithms are among the most popular evolutionary algorithms in terms of the diversity of their applications. A wide range of well-known optimization problems have been attempted to be solved using genetic algorithms. Furthermore, genetic algorithms are population-based, and many modern evolutionary algorithms are either based on genetic algorithms or share significant similarities.

The essence of genetic algorithms is encoding the optimization function as a sequence of bits or characters representing chromosomes, manipulating strings using genetic operators, and selecting suitable individuals with the aim of finding a good (even optimal) solution to the problem. In the following text, fitness and fitness function will be used. Fitness refers to the desired characteristics to be obtained through algorithm iterations.

This is usually done through the following procedure:

1. Encoding goals or cost functions.
2. Defining a fitness function or selection criteria.
3. Creating a population of individuals.
4. Performing an evolutionary cycle or iterations by evaluating the fitness of all individuals in the population, creating a new population through crossover and mutation, suitable reproduction, etc., ultimately modifying the old population and iterating using the new population.
5. Decoding the results obtained by the solution.

These steps can be represented schematically as the pseudocode of genetic algorithms ("Figure 12").

One iteration of creating a new population is called a generation. In most genetic algorithms, fixed-length strings are commonly used during each generation, although there is substantial research on variable-length strings and code structures. In adaptive genetic algorithms, encoding the fitness function often takes the form of binary strings or arrays with real values. For simplicity, binary strings were used in the discussion. Genetic operators include crossover, mutation, and selection from the population.

Crossover, denoted as P_c , is the main operator with a high probability, and it is performed by replacing a segment of one chromosome at a randomly chosen position with the corresponding segment of another chromosome ("Figure 13").

The mutation operator is obtained by randomly changing the value ($0 \rightarrow 1$ or $1 \rightarrow 0$) at a randomly selected bit ("Figure 14"). The probability of mutation is denoted as P_m and is often small. Additionally, mutations can occur at multiple locations, which can be advantageous in practice and application.

Selection of individuals in the population is done by evaluating fitness, and an individual can be included in the next generation if a certain fitness threshold is reached. Furthermore, selection can be fitness-based, so that the reproduction of the population is proportional to fitness. This means that individuals with higher fitness have a greater chance of reproducing [11].

```

Objective function f(x), x = (x1,..., xd)T
Encode solutions into chromosomes (strings)
Define fitness function F (e.g., F (ovde ide
znak sa slike) = f(x) for maximization)
Generate initial population
Define crossover probability (Pc) and mutation
probability (Pm)
while (t < maximum number of generations)
Generate new solutions through crossover
and mutation
Perform crossover with probability Pc
Perform mutation with probability Pm
Accept new solutions if their fitness increases
Select the current best for the next generation
Update t = t + 1
end while
    
```

Decode the results and visualize them

Figure 12: Pseudocode of genetic algorithms [11]

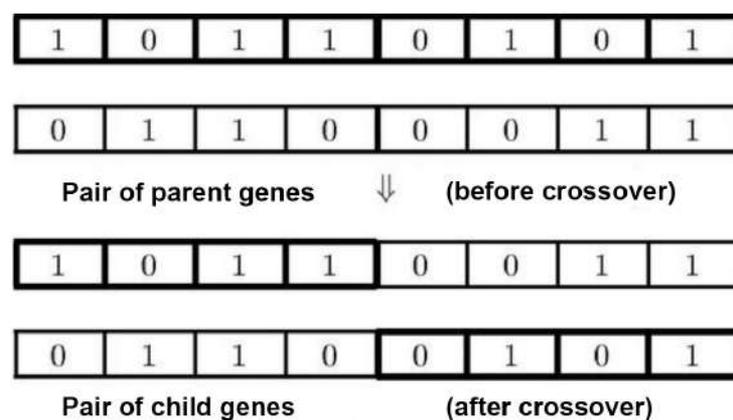


Figure 13: Diagram of crossover of a random segment in genetic algorithms [11]

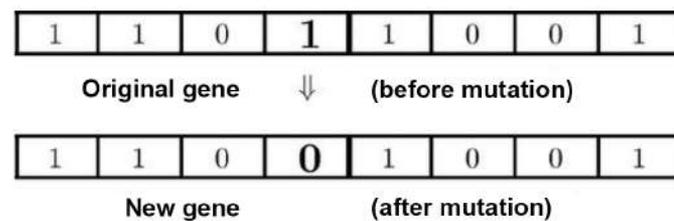


Figure 14: Diagram of mutation of a random bit [11]

ACKNOWLEDGEMENT

This work was done as part of the course "Fundamentals of Applied Research," under the guidance of Prof. Dr. Slavko Pokorni.

REFERENCES

1. Millington, I. AI for Games, 3rd edition, 2019, pp. 195–196.
2. "Dijkstra's shortest path algorithm | Greedy Algo-7." GeeksForGeeks. Available at: <https://www.geeksforgeeks.org/dijkstras-shortest-path-algorithm-greedy-algo-7/>. Accessed: April 4, 2022.
3. "Breadth First Search (BFS) Algorithm." algotree.org. Available at: https://algotree.org/algorithms/tree_graph_traversal/breadth_first_search. Accessed: April 4, 2022
4. Black, P. E. "Manhattan distance." In Dictionary of Algorithms and Data Structures [online]. Paul E. Black, ed. 11 February 2019. Available at: <https://www.nist.gov/dads/HTML/manhattanDistance.html>. Accessed: April 4, 2022.
5. "A* Search." Brilliant.org. Retrieved 10:24, April 4, 2022, from <https://brilliant.org/wiki/a-star-search/>.

6. Patrick, L. "A* pathfinding for beginners." GameDev WebSite. Available at: <https://www.gamedev.net/reference/articles/article2003.asp>. Accessed: April 4, 2022.
7. Wolsey, L. A. "Heuristic Algorithms." Integer Program., no. January, p. 17, 1998.
8. Rafiq, A. et al. "2020 IOP Conf. Ser.: Mater. Sci. Eng. 769 012021 'accepted for publication'."
9. Yang, X. S. Nature-Inspired Optimization Algorithms, 2014, pp. 305–308.
10. Yang, X. S. Nature-Inspired Optimization Algorithms, 2014, pp. 308–312.
11. Yang, X. S. Nature-Inspired Optimization Algorithms, 2014, pp. 116–130



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License.

Stručni članci / Professional articles

Vrsta rada: Prikaz knjige

Primljen: 10.06.2023.

Prihvaćen: 03.07.2023.

UDK: 004.85:37

004:929 Кадимали, С.(049.32)

Recenzija knjige: Seda Khadimally (2023). Primene mašinskog učenja i veštačke inteligencije u obrazovanju. Izdanje: Napredak u obrazovnim tehnologijama i instrukcionom dizajnu. Information Science Reference.

Valentin Kuleto

Univerzitet Privredna akademija u Novom Sadu, Fakultet savremenih umetnosti, Beograd; Visoka škola strukovnih studija za informacione tehnologije – ITS u Beogradu; valentin.kuleto@its.edu.rs

Daniel Gabriel Dinu

Škola za doktorske studije poslovne administracije, Univerzitet ekonomskih nauka, 6 Piata Romana, 010374, Bukurešt, Rumunija; daniel.dinu90@gmail.com

Sažetak

Knjiga „Primene mašinskog učenja i veštačke inteligencije u obrazovanju“ istražuje transformativni potencijal mašinskog učenja i veštačke inteligencije (AI) u savremenom obrazovanju, naglašavajući važnost prilagođavanja potrebama učenika 21. veka. Sa sve većom potražnjom za inovativnim tehnološkim alatima, tradicionalno učenje i nastavne prakse evoluiraju u mašinski olakšanu komunikaciju, obrazovanje i metodologiju nastave.

Ova knjiga se bavi različitim aspektima učenja na daljinu, mašinskog učenja, dubokog učenja (deep learning) i veštačke inteligencije u savremenom obrazovanju i pokriva teme kao što su kodiranje podataka, tehnologija društvenih mreža i računarska lingvistika. Cilj ove knjige je da pruži dragocene informacije učenicima zainteresovanim za duboko učenje, nastavnicima u oblasti obrazovne tehnologije i instrukcionog dizajna, evaluatorima podataka i posebnim interesnim grupama (SGI) u ovoj disciplini.

Ključne reči: mašinsko učenje, veštačka inteligencija, obrazovanje, duboko učenje, učenje na daljinu, instrukcioni dizajn, obrazovna tehnologija, kodiranje podataka, računarska lingvistika

Uvod

Fokus ove publikacije je na sledećim ključnim oblastima (ali nije ograničen samo na njih): istraživanju i praksi veštačke inteligencije, računarskoj lingvistici, konvolucijskim neuronskim mrežama, kodiranju podataka, dubokom učenju, obrazovnoj tehnologiji, implikacijama kodiranja i analize podataka, instrukcionoj analizi, mašinskom učenju, problemima u obrazovanju na daljinu i mogućim rešenjima, onlajn-obukama nastavnika i tehnologiji društvenih mreža.

Knjiga „Primene mašinskog učenja i veštačke inteligencije u obrazovanju“ je značajan resurs za profesionalce i entuzijaste koji žele da razumeju i iskoriste moć veštačke inteligencije i mašinskog učenja u revolucionisanju obrazovanja i poboljšanju procesa učenja.

Struktura knjige i opisi poglavlja

Knjiga se sastoji iz uvoda i tri glavna odeljka, od kojih svaki sadrži niz poglavlja fokusiranih na različite aspekte tehnologije u obrazovanju. Uvod daje pregled značaja novih tehnologija u savremenom obrazovanju. Strukturu knjige čine sledeći delovi:

1. Odeljak 1 (Poglavljia 1–4): Mašinsko učenje i primene dubokog učenja – istražuje različite primene mašinskog učenja i dubokog učenja u različitim oblastima.

2. Odeljak 2 (Poglavlja 5–8): Veštačka inteligencija i instrukcioni dizajn – razmatra integraciju tehnologija veštačke inteligencije u nastavni proces, naglašavajući njihov uticaj na učenje, nastavu i dizajn.
3. Odeljak 3 (Poglavlja 9–12): STEM obrazovanje, upravljanje projektima i izazovi učenja na daljinu nakon pandemije – bavi se izazovima i mogućnostima u STEM obrazovanju, upravljanjem projektima i učenjem na daljinu u kontekstu pandemije virusa COVID-19 i njenih posledica.

Uvodni deo je naslovljen „Postavljanje nekonvencionalnih, novonastalih tehnologija u obrazovanju i drugim oblastima u svet današnjice“. Ovaj uvodni deo predstavlja pregled potrebe za inovativnim tehnološkim alatima u trenutnom obrazovnom okruženju i uticaja istraživanja zasnovanog na podacima o instrukcionom dizajnu, izvođenju i evaluaciji nastave.

Prvi odeljak organizovan je u okviru poglavlja 1–4 i nosi naslov „Mašinsko učenje i primene dubokog učenja“.

Poglavlje 1: „Mašinsko učenje i primene dubokog učenja – praktična studija sa programskim jezikom Python“ – Ovo poglavlje uvodi tehnike mašinskog učenja i dubokog učenja kroz praktične Python projekte, fokusirajući se na njihov značaj u obradi i analizi velikih podataka.

Poglavlje 2: „Mašinsko učenje u kompjuterskom vidu“ – Ovo poglavlje razmatra različite algoritme mašinskog učenja koji se koriste u kompjuterskom vidu, pružajući teorijske koncepte koji se odnose na probleme detekcije ljudi u stvarnom svetu.

Poglavlje 3: „Regulacija emocija zasnovana na muzičkoj terapiji korišćenjem konvolucijske neuronske mreže“ – Ovo poglavlje istražuje upotrebu konvolucijske neuronske mreže (CNN) za detekciju emocija na osnovu crta lica i primenu muzičke terapije za promenu emocionalnog stanja osobe.

Poglavlje 4: „Prepoznavanje govora putem kodiranja i analize fonetskih podataka zasnovanih na softveru za analizu molekularnih puteva koji je proizvela aplikacija Ingenuity Pathway Analysis (IPA) – deskriptivno kodiranje, kodiranje obrazaca i fonetska transkripcija u fenomenološkim istraživanjima“ – Ovo poglavlje opisuje proces prepoznavanja govora putem kodiranja i analize fonetskih podataka zasnovanih na softveru za analizu molekularnih puteva koji je proizvela aplikacija Ingenuity Pathway Analysis (IPA) i njegovu primenu u fenomenološkim istraživanjima.

Drugi odeljak je organizovan u okviru poglavlja 5–8 pod nazivom „Veštačka inteligencija i instrukcioni dizajn“.

Poglavlje 5: „Duboko učenje u instrukcionoj analizi, dizajnu, razvoju, implementaciji i evaluaciji (ADDIE)“ – Ovo poglavlje govori o primeni tehnologija dubokog učenja u nastavnom procesu, fokusirajući se na integraciju dubokog učenja u sisteme za učenje na daljinu i potencijalne koristi za učenike i nastavnike.

Poglavlje 6: „Savladavanje gradiva putem tehnologije društvenih mreža – sveobuhvatan pregled literature sa sistemskim pristupom“ – Ovaj pregled literature istražuje ulogu alata društvenog umrežavanja u učenju kod odraslih, instrukcionom dizajnu i upravljanju projektima, naglašavajući inovativne aplikacije i potencijalne rizike i izazove u uključivanju tehnologije društvenih mreža u obrazovanje.

Poglavlje 7: „Prevenција je bolja od lečenja – Upotreba Excel Dashboard kontrolne table na univerzitetskom kursu engleskog jezika“ – Ovo poglavlje opisuje dizajn, razvoj i evaluaciju kontrolne table za učenje na univerzitetskom kursu engleskog, pružajući dizajnerima učenja, nastavnicima i istraživačima uvid u potencijal kontrolnih tabli za učenje jezika.

Poglavlje 8: „Razvoj nastavnog materijala gramatike pomoću korpusa“ – Ovo poglavlje ispituje primenu korpusnih podataka u razvoju materijala za učenje za nastavu gramatike, razmatra suštinske teorijske koncepte, relevantne nastavne okvire i praktične nastavne aktivnosti u nastavi gramatike pomoću korpusa.

Treći odeljak organizovan je u okviru poglavlja 9–12 i nosi naslov „STEM obrazovanje, upravljanje projektima i izazovi onlajn-učenja nakon pandemije“.

Poglavlje 9: „Implementacija novih resursa za STEM obrazovanje – veštine 21. veka posle pandemije virusa COVID-19“ – Ovo poglavlje naglašava važnost redefinisavanja obrazovnih ciljeva i uključivanja veština 21. veka u STEM obrazovanje u kontekstu pandemije virusa COVID-19. Pored toga, u poglavlju se govori i o ulozi digitalne pismenosti i primenjenih veština u olakšavanju prilagođavanja i prelaska na nove obrazovne modele.

Poglavlje 10: „Izvršni plan upravljanja projektom za obuku instruktora onlajn-kurseva u visokom obrazovanju – troslojni model promene“ predstavlja projekat onlajn-učenja zasnovanog na upravljanju projektima (PMBOLD) za pružanje onlajn-obuke instruktora u visokoškolskim ustanovama. Poglavlje govori o primeni troslojnog modela promene i korišćenju ADDIE okvira za dizajn za podršku prelasku na onlajn ili hibridni model učenja nakon pandemije.

Poglavlje 11: „Problemi sa onlajn-obrazovanjem i moguća rešenja“ – Ovo poglavlje istražuje sve veći jaz u postignućima između učenika različitih socioekonomskih statusa zbog pandemije i pitanja kao što su stalni izostanak iz

škole i niža motivacija učenika. Poglavlje nudi potencijalna rešenja za ove probleme s ciljem poboljšanja onlajn-učenja i ukupnih obrazovnih rezultata u eri nakon pandemije.

Poglavlje 12: „Uticaj i doprinos knjige ovoj oblasti” – Zaključak sumira suštinske nalaze i uvide predstavljene u poglavljima, naglašavajući važnost mašinskog učenja, veštačke inteligencije i dubokog učenja u transformaciji trenutnog obrazovnog okruženja i rešavanju izazova sa kojima se suočavaju prosvetni radnici, instrukcioni dizajneri i učenici u 21. veku. Istaknuti su doprinosi knjige literaturi iz ovih oblasti, posebno iz oblasti obrazovanja.

Autor

Seda Khadimally je stručnjak za kompjuterski potpomognuto učenje jezika (CALL) i usvajanje drugog jezika. Uža stručna oblast joj je podučavanje engleskog kao drugog/stranog jezika (ESL/EFL) za govornike drugih jezika. Sa 19 godina iskustva osmislila je, dostavila i ocenila instrukcije koristeći obrazovne tehnologije za onlajn i kombinovano učenje kako bi podučavala različite grupe učenika engleskog jezika. Njena stručnost ogleda se u podučavanju ESL/ELL studenata svih uzrasta uz nove obrazovne tehnologije, posebno mobilno učenje (m-learning).

Kao autor čiji su radovi objavljeni u istaknutim časopisima, recenzent knjiga i član Savetodavnog redakcionog odbora (EAB) za renomirane publikacije i naučne radove iz svoje oblasti, Seda je svoje istraživanje predstavila na raznim regionalnim, nacionalnim i međunarodnim konferencijama koje su održane u cenjenim javnim i privatnim obrazovnim institucijama.

Zaključna razmatranja

Na samom kraju knjige nalazi se sažetak suštinskih nalaza i uvida predstavljenih u poglavljima, naglašavajući važnost mašinskog učenja, veštačke inteligencije i dubokog učenja u transformaciji trenutnog obrazovnog okruženja i suočavanja sa izazovima sa kojima se suočavaju prosvetni radnici, instrukcioni dizajneri i učenici u 21. veku.

Literatura

1. Seda Khadimally (2023). Applications of Machine Learning and Artificial Intelligence in Education. Series: Advances in Educational Technologies and Instructional Design. Information Science Reference.
2. Applications of Machine Learning and Artificial Intelligence in Education, web page. Dostupno na: <https://www.igi-global.com/book/applications-machine-learning-artificial-intelligence/265847> (Pristupljeno: 1. 5. 2023)

Type of paper: Book review

Received: 10.06.2023.

Accepted: 03.07.2023.

DOI: <https://doi.org/10.18485/edtech.2023.3.1.6>

UDC: 004.85:37

004:929 Кадимали, С.(049.32)

Book review: Seda Khadimally (2023). Applications of Machine Learning and Artificial Intelligence in Education. Series: Advances in Educational Technologies and Instructional Design. Information Science Reference.

Valentin Kuleto

University Business Academy in Novi Sad, Faculty of Contemporary Arts, Belgrade; Information Technology School ITS – Belgrade; valentin.kuleto@its.edu.rs

Daniel Gabriel Dinu

Business Administration Doctoral School Bucharest University of Economic Studies 6 Piata Romana 010374 Bucharest, Romania; daniel.dinu90@gmail.com

Abstract:

The book "Applications of Machine Learning and Artificial Intelligence in Education" explores the transformative potential of machine learning and artificial intelligence (AI) in modern education, emphasising the importance of adapting to the needs of 21st-century learners. With the growing demand for innovative technology-moderated tools, traditional learning and instructional practices are evolving into machine-facilitated communication, education, and teaching methodologies.

This comprehensive volume delves into various aspects of remote learning, machine learning, deep learning, and AI in contemporary education, covering topics such as data coding, social networking technology, and computational linguistics. The book aims to provide valuable insights for learners interested in deep learning, educators, educational technologists, instructional designers, data evaluators, and special interest groups (SGIs) in the discipline.

Keywords: Machine Learning, Artificial Intelligence, Education, Deep Learning, Remote Learning, Instructional Design, Educational Technology, Data Coding, Computational Linguistics

Introduction:

Key areas of focus in this publication include, but are not limited to: Artificial Intelligence Research and Practice, Computational Linguistics, Convolutional Neural Networks, Data Coding, Deep Learning, Educational Technology, Implications of Data Coding and Analysis, Instructional Analysis, Machine Learning, Online Education Problems and Remedies, Online Instructor Training, and Social Networking Technology.

"Applications of Machine Learning and Artificial Intelligence in Education" is an essential resource for professionals and enthusiasts seeking to understand and harness the power of AI and machine learning in revolutionising the education landscape and enhancing the learning experience.

Book Structure and Chapter Descriptions:

The book structure consists of an Introduction and three main sections, each containing a series of chapters focused on different aspects of technology in education. The introduction provides an overview of the importance of emerging technologies in modern education. Sections of the book are:

1. Section 1 (Chapters 1–4): Machine Learning and Deep Learning Applications – Explores various applications of machine learning and deep learning in different fields.
2. Section 2 (Chapters 5–8): Artificial Intelligence and Instructional Design – Discusses the integration of artificial intelligence technologies in the instructional process, highlighting their impact on learning, teaching, and design.
3. Section 3 (Chapters 9–12): Post-pandemic STEM Education, Project Management, and Online Learning Challenges – Addresses the challenges and opportunities in STEM education, project management, and online learning in the context of the COVID-19 pandemic and its aftermath.

The introduction section is entitled: "Situating the Unconventional, Emerging Technologies in Education and Other Fields in Today's World" – This introductory section presents an overview of the need for innovative, technology-moderated tools in the current educational landscape and the impact of data-driven research on instructional design, delivery, and evaluation.

Section one is organised within chapters 1–4 and entitled. Machine Learning and Deep Learning Applications.

Chapter 1: "Machine Learning and Deep Learning for Applications – A Hands-on Study With Python" – This chapter introduces machine learning and deep learning techniques through hands-on Python projects, focusing on their importance in processing and analysing big data.

Chapter 2: "Machine Learning in Computer Vision" – This chapter discusses various machine learning algorithms used in computer vision, providing theoretical concepts related to real-world human skin detection problems.

Chapter 3: "Music Therapy-Based Emotion Regulation Using Convolutional Neural Network" – This chapter explores the use of Convolutional Neural Network (CNN) for emotion detection in facial features and the application of music therapy for changing a person's emotional state.

Chapter 4: "Speech Recognition via IPA-Based Phonetic Data Coding and Analysis – Descriptive Coding, Pattern Coding, and Phonetic Transcription in Phenomenological Research" – This chapter describes the process of speech recognition through IPA-based phonetic data coding and analysis, and its application in phenomenological research.

Section two is organised within chapters 5–8 and entitled Artificial Intelligence and Instructional Design.

Chapter 5: "Deep Learning in Instructional Analysis, Design, Development, Implementation, and Evaluation (ADDIE)" – This chapter discusses the application of deep learning technologies in the instructional process, focusing on the integration of deep learning in remote learning systems and the potential benefits for learners and instructors.

Chapter 6: "Mastery of Learning via Social Networking Technology – A Comprehensive Literature Review With a Systems Approach" – This literature review explores the role of social networking tools in adult learning, instructional design, and project management, highlighting innovative applications and potential risks and challenges in incorporating social networking technology into education.

Chapter 7: "Prevention is Better than Cure – Use of Dashboard in a University English Course" – This chapter describes the design, development, and evaluation of a learning dashboard for a university English course, providing insights for learning designers, teachers, and researchers on the potential of dashboards in language learning.

Chapter 8: "Corpus-Aided Grammar Teaching Materials Development" – This chapter examines the implementation of corpus data in developing learning materials for grammar teaching, discussing vital theoretical concepts, relevant teaching frameworks, and practical teaching activities in corpus-aided grammar teaching.

Section 3 is organised within chapters 9–12 and entitled; Post-pandemic STEM Education, Project Management, and Online Learning Challenges.

Chapter 9: "Implementing New Resources for STEM Education – 21st-Century Skills After COVID" – This chapter highlights the importance of refining educational goals and incorporating 21st-century skills into STEM education in the context of the COVID-19 pandemic. In addition, the chapter discusses the role of digital literacy and applied skills in facilitating adaptation and transition to new educational models.

Chapter 10: "Executive Project Management Plan for an Online Course Instructor Training in Higher Education – A Three-Tier Change Model" presents a project-management-based online learning design (PMBOLD) project to provide online instructor training in higher education institutions. The chapter discusses implementing a three-tier change model and using the ADDIE design framework to support the post-pandemic transition to online or hybrid learning.

Chapter 11: "Problems With Online Education and Possible Remedies" – This chapter explores the widening achievement gap between students of different socioeconomic statuses due to the pandemic and issues such as chronic absenteeism and lower student motivation. The chapter offers potential solutions to these problems to improve online learning and overall educational outcomes in the post-pandemic era.

Chapter 12: "Impact and Contribution of the Book to the Field" – The conclusion summarises the essential findings and insights presented throughout the chapters, emphasising the relevance of machine learning, artificial intelligence, and deep learning in transforming the current educational landscape and addressing the challenges faced by educators, instructional designers, and learners in the 21st century. The book's contributions to the literature in these areas, particularly in the field of Education, are highlighted.

Author

Seda Khadimally is an expert in Computer Assisted Language Learning (CALL) and second language acquisition, specialising in teaching English as a Second/Foreign Language (ESL/EFL) to speakers of other languages. With 19 years of experience, she has designed, delivered, and evaluated instruction using educational technologies for online and blended learning to teach diverse groups of English language learners. Her expertise lies in teaching ESL/ELL students of all ages through emerging educational technologies, particularly mobile learning (m-learning).

As a published author in prominent journals, a book reviewer, and an Editorial Advisory Board (EAB) member for renowned journal publications and scholarly works in her field, Seda has presented her research at various regional, national, and international conferences held at esteemed public and private educational institutions.

Concluding remarks

The book concludes by summarising the essential findings and insights presented throughout the chapters, emphasising the relevance of machine learning, artificial intelligence, and deep learning in transforming the current educational landscape and addressing the challenges faced by educators, instructional designers, and learners in the 21st century.

References

1. Seda Khadimally (2023). Applications of Machine Learning and Artificial Intelligence in Education. Series: Advances in Educational Technologies and Instructional Design. Information Science Reference.
2. Applications of Machine Learning and Artificial Intelligence in Education, web page. Available at: <https://www.igi-global.com/book/applications-machine-learning-artificial-intelligence/265847> (Accessed: 1/5/2023)

O časopisu

EdTech Journal je naučni časopis otvorenog pristupa posvećen korišćenju informacionih tehnologija u obrazovanju. Ipak, u našoj „Naučnoj politici“ priznajemo važnost istinske upotrebe IT-ja u društvu i privredi, jer obrazovanje predstavlja vitalni sektor društva. Obrazovanje za potrebe privrede i koncepti zasnovani na njemu su prekretnice koje se moraju uzeti u obzir pri razvoju budućeg opsega sektora obrazovanja.

Zašto EdTech? Računarski hardver, softver i obrazovna teorija i praksa stvaraju obrazovnu tehnologiju (EduTech ili EdTech). EdTech je skraćenica za opisivanje poslovanja razvoja obrazovne tehnologije. Pored informacionih tehnologija, u obrazovnu tehnologiju je zajedno sa praktičnim iskustvom ugrađen i širok spektar teorijskih znanja iz različitih oblasti kao što su komunikacija, obrazovanje, psihologija i sociologija. Teorija učenja, obuke zasnovane na računaru, onlajn-učenje i m-učenje, gde se koriste mobilne tehnologije, uključeni su u ovaj krovni termin. Disciplinacija se razvija dok o njoj govorimo, baš kao i IT i računarske nauke.

Primenjene obrazovne nauke, kao što su oprema, procesi i procedure proistekli iz naučnih istraživanja, uključeni su u „obrazovnu tehnologiju“, pozivajući se na teorijske, algoritamske ili heurističke pristupe u zavisnosti od konteksta. Obrazovne ustanove moraju imati najsavremenije tehnologije kao saveznike u svakodnevnom funkcionisanju. Nastavnici uče kako da poboljšaju svoje rezultate i budu najefikasniji koristeći različita IT rešenja. Učenici uče kako da koriste računare i drugu tehnologiju u učionici i završavaju svoje zadatke u raznovrsnijem i inkluzivnijem okruženju kroz obrazovnu tehnologiju.

Zato EdTech Journal podržava doprinose autora i istraživača iz različitih disciplina i naučnih oblasti koje su opisane u našoj „Naučnoj politici“, a koje se dotiču računarske nauke i IT-ja. Informaciona tehnologija pod kojom se podrazumeva upotreba računarskih programa za rešavanje poslovnih procesa ima višestruku primenu. Nova rešenja se integrišu u poslovni, obrazovni i društveni okvir svakodnevno, koristeći informacione tehnologije.

Dr Valentin Kuleto
Glavni i odgovorni urednik

About the Journal

EdTech Journal is a scientific open-access journal dedicated to the use of information technology in education. In our Scientific Policy, we acknowledge the importance of the genuine use of IT in society and the economy because education is a vital sector of society and education for the needs of the economy, and the concepts based on it are milestones that must be taken into account when developing the future scope of the education sector.

Why EdTech? Educational technology (EduTech, or EdTech) encompasses computer hardware, software, and educational theory and practice. EdTech is a commonly used abbreviation to describe the business of developing educational technology. A wide range of theoretical knowledge from various fields alongside information technology, such as communication, education, psychology and sociology, is incorporated into educational technology in addition to practical experience. Learning theory, computer-based training, online learning, and m-learning, which use mobile technologies, are all included in this umbrella term. The discipline develops as we speak, just like IT and computer sciences.

Applied educational sciences, such as equipment, processes, and procedures derived from scientific research, are all included in “educational technology,” referring to theoretical, algorithmic, or heuristic approaches depending on the context. Education institutions must have cutting-edge technologies as an ally in everyday functioning. Educators learn how to improve their outcomes and be most effective using various IT solutions. Students learn how to use computers and other technology in the classroom and complete their assignments in a more diverse and inclusive environment through educational technology.

That is why EdTech Journal welcomes the contributions of authors and researchers from various disciplines and scientific fields implemented in our Scientific Policy that feel computer science and IT. Information technology - the application of computer programs to solve business processes - has a wide range of beneficial applications. New solutions are integrated into the business, education and social framework utilizing information technology on a daily basis.

Dr Valentin Kuleto
Editor-in-Chief

Izdavač

Izdavač Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal je Institut za moderno obrazovanje (IMO), Beograd, Srbija. Cilj Instituta za moderno obrazovanje (IMO) je unapređenje kvaliteta obrazovnog procesa kroz edukaciju sadašnjih i budućih zaposlenih u obrazovanju i promociju najsavremenijih obrazovnih tehnologija. Misija IMO je pomoć pojedincima da postanu uspešnji, kao i pomoć školama i obrazovnim ustanovama u implementaciji tehnologija i tehnika za unapređenje obrazovnog procesa. IMO je i savetodavni centar za sve lidere u obrazovanju, kao i mesto profesionalne nastavne prakse za buduće profesore.

IMO je deo vodeće multinacionalne EdTech kompanije LINKgroup, koja se 25 godina uspešno bavi profesionalnom edukacijom i sertifikacijom u oblasti informacionih tehnologija i savremenog poslovanja. Kao kompanija koja se bavi edukacijom u različitim sferama, LINKgroup je prisutan u Srbiji, Hrvatskoj, Bosni i Hercegovini, Rumuniji, Ukrajini, Moldaviji i Sjedinjenim Američkim Državama, a putem jedinstvenog e-Learning sistema za učenje na daljinu okuplja polaznike iz preko 120 zemalja sveta.

U okviru LINKgroup obrazovnog sistema (LINK Educational Alliance) postoji više od pedeset obrazovnih institucija i obrazovnih servisa. LINK Educational Alliance na jednom mestu okuplja obrazovne institucije bez obzira na naučnu oblast i nivo obrazovanja, kao i kompanije i pojedince koji su svesni da samo celoživotno učenje i usavršavanje donosi profesionalni uspeh.

Publisher

The publisher of the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal is the Institute for Contemporary Education (ICE), Belgrade, Serbia. The Institute for Contemporary Education (ICE) aims to improve the quality of the educational process through the education of current and future employees in education and the promotion of the most modern educational technologies. The ICE's mission is to help individuals become more successful and support schools and educational institutions in implementing technologies and techniques to improve the educational process. ICE is also an advisory centre for all leaders in education and a place of professional teaching practice for future professors.

ICE is part of the leading multinational EdTech company LINK group, which has been successfully engaged in professional education and certification in information technology and modern business for more than 20 years. As a company involved in teaching in various fields, LINK group is present in Serbia, Croatia, Bosnia and Herzegovina, Romania, Ukraine, Moldova and the United States, and a unique e-learning system for distance learning brings together students from over 120 countries.

There are more than fifty educational institutions and services within the LINK group education system (Link Educational Alliance). The LINK Educational Alliance brings together educational institutions regardless of scientific field and level of education and companies and individuals who are aware that only lifelong learning and improvement brings professional success.

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11 4011 260
Imejl: EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Naučna politika časopisa

Kvalitetno obrazovanje je osnov napretka i uspeha pojedinca i društva – dr Valentin Kuleto

U pogledu naučnih polja kojima časopis pretežno pripada, reč je o dva naučna polja: tehničko-tehnološke nauke (elektronika i informacione tehnologije) i društveno-humanističke nauke (pravo, ekonomija i političke i organizacione nauke) i društveno-humanističke nauke (filozofija, psihologija, pedagogija i sociologija).

Časopis neguje internacionalne, ali i identitetske nauke, posvećen je sledećim naučnim oblastima: elektrotehničko i računarsko inženjerstvo; organizacione nauke; menadžment i biznis, pedagoške i andragoške nauke; ekonomske nauke, političke nauke; pravne nauke; psihološke nauke; sociološke nauke; filozofija; nauke o umetnostima.

- distance-learning sistemi;
- internet;
- informacione tehnologije;
- informacioni sistemi;
- digitalne kompetencije;
- mreža 5G;
- veštačka inteligencija (artificial intelligence – AI);
- autonomni uređaji (roboti, odnosno korišćenje veštačke inteligencije za automatizaciju funkcija koje inače obavljaju ljudi);
- blokčejn tehnologija (blockchain);
- proširena analitika (augmented analytics): big data u kombinaciji sa veštačkom inteligencijom, odnosno korišćenje mašinskog učenja za automatsko učenje i optimizaciju odluka korišćenjem dubinskih analiza podataka;
- digitalni blizanci (digital twins), odnosno virtualne replike stvarnog sveta ili entiteta;
- poboljšani edge computing (Internet of Things, komplementarni modeli sa rešenjima u kladu);
- iskustva u pametnim prostorima – smart spaces (virtualna realnost – virtual reality (VR), proširena realnost – augmented reality (AR) i mešovita realnost – mixed reality (MR));
- inovacije u privredi
- menadžment;
- marketing;
- preduzetništvo (digitalno preduzetništvo, socijalno preduzetništvo);
- poslovna ekonomija;
- ekonomija u zdravstvu;
- poslovni informacioni sistemi;
- pedagogija i andragogija;
- poslovno pravo;
- primena IT-ja u obrazovanju;
- inovacije u obrazovanju;
- održivo obrazovanje;
- daroviti učenici;
- obrazovanje 4.0;
- NEETs;
- digitalna umetnost i data art;
- nauke o umetnosti;
- kultura;
- komunikologija;

druge oblasti od interesa za primenu informacionih tehnologija u društvu, privredi i obrazovanju.

U pogledu teorijskih i metodoloških smernica za obavljanje radova, časopis preporučuje IMRAD format za

originalne naučne članke i PRISMA format za pregledne radove. Naučni radovi se upućuju na najmanje 2 recenzije, a stručni na najmanje jednu recenziju. Sve recenzije su double-blind.

Časopis koristi softver za proveru originalnosti i proverava originalnost svakog članka koji dobije pozitivne recenzije i preporuke recenzenata za objavu.

Časopis je open access i ne naplaćuje kotizaciju za obradu radova niti za njihovo objavljivanje. Svi objavljeni naučni radovi su vidljivi u celini na sajtu časopisa.

Društvena, državna i kulturna uloga časopisa ogleda se u priznavanju značaja i uloge informacionih tehnologija i na njima zasnovanih rešenja u oblasti društva, privrede i obrazovanja.

Opšti, naučni i društveni karakter časopisa ogleda se u deljenju znanja, rezultata naučnoistraživačkog rada i promocije nauke. U pogledu politike samoarhiviranja autor sme da učini vidljivom objavljenu verziju članka – Publisher's PDF, Version of Record, VoR, uz navođenje gde i kad je publikovana. Autorima je dozvoljeno da objavljenu verziju rada deponuju u institucionalni ili tematski repozitorijum ili da je objave na ličnim veb-stranicama (uključujući i profile na društvenim mrežama, kao što su ResearchGate, Academia.edu itd.), na sajtu institucije u kojoj su zaposleni, u bilo koje vreme nakon objavljivanja u časopisu. Autori su obavezni da pritom navedu pun bibliografski opis članka objavljenog u ovom časopisu (autori, naslov rada, naslov časopisa, volumen, sveska, paginacija) i postavite link, kako na DOI oznaku tog članka, tako i na korišćenu licencu.

U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik
dr Valentin Kuleto

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

The Scientific Policy of the Journal

Quality education is the basis of progress and success of the individual and society – Dr Valentin Kuleto

Regarding the scientific fields that the journal is mostly concerned with, there are two: technical-technological sciences (electronics and information technology) and social-humanistic sciences (law, economics and political and organisational sciences) and social-humanistic sciences (philosophy, psychology, pedagogy and sociology).

The journal nurtures international and identity sciences, and it is dedicated to the following areas: electrical and computer engineering; organisational sciences; management and business; pedagogical and andragogical sciences; economic sciences; political science; legal sciences; psychological sciences; sociological sciences; philosophy; the sciences of the arts.

In terms of thematic guidelines for publishing papers, the journal welcomes papers from the areas including, and not limited to:

- e-learning;
- distance-learning systems;
- Internet;
- information technology;
- information systems;
- digital competences;
- 5G network;
- artificial intelligence (AI);
- autonomous devices (robots, i.e. the use of artificial intelligence to automate functions usually performed by humans);
- blockchain technology;
- augmented analytics: big data combined with artificial intelligence, i.e. the use of machine learning for automatic learning, and optimisation of decisions using in-depth data analysis;
- digital twins, or virtual replicas of the natural world or entities;
- edge computing (Internet of Things, complementary models with solutions in the cloud);
- experiences in smart spaces (virtual reality – VR, augmented reality – AR and mixed reality – MR);
- innovations in the economy;
- management;
- marketing;
- entrepreneurship (digital entrepreneurship, social entrepreneurship);
- business economics;
- health economics;
- business information systems
- pedagogy and andragogy;
- business law;
- application of IT in education;
- innovation in education;
- sustainable education;
- gifted student;s
- Education 4.0;
- NEETs;
- digital art and data art;
- the science of art;
- culture;
- communication science;

and other areas of interest for the application of information technology in society, economy and education.

Regarding theoretical and methodological guidelines for papers, the journal recommends the IMRAD format for original scientific articles and the PRISMA format for paper reviews. Scientific articles are submitted for at least 2 reviews, and professional articles for at least one review. All reviews are double-blind.

The journal uses authentication/plagiarism software and verifies the authenticity of each article that receives positive reviews and reviewers' recommendations for publication.

The journal is open access and does not charge a fee for processing papers or their publication. In addition, all published scientific papers are visible in their entirety on the journal's website.

The social, national and cultural role of the journal is reflected in the recognition of the importance and role of information technologies and solutions based on them in society, economy and education.

The general, scientific and social character of the journal is reflected in the sharing of knowledge and the results of scientific research, and promotion of science.

Regarding the policy of self-archiving, the author is allowed to make visible the published version of the article – Publisher's PDF, Version of Record, VoR, indicating where and when it was published. Authors are permitted to deposit the published version of their work in an institutional or subject-based repository, or post it on their personal websites (including their profiles on social networks, such as ResearchGate, Academia.edu, etc.), and on the website of their affiliated institution, at any time after publication in the journal. In the process, the authors are obliged to provide full bibliographic information about the paper published in this journal (authors, article title, journal title, volume, issue, pages), as well as the relevant links concerning the article's DOI and the license used.

Belgrade, 29 December 2021

Editor-in-Chief
Dr Valentin Kuleto

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11 4011 260
Imejl: EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Na osnovu Statuta Instituta za moderno obrazovanje, član 3, stav 7, i Poslovnika o radu Uređivačkog odbora sa pravilnikom o uređivanju, Uređivački odbor Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija EdTech Journal na sednici održanoj dana 29. 12. 2021. godine donosi sledeći:

Etički kodeks Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal

Članovi Uređivačkog odbora Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal nadziru primenu etičkih standarda u naučnoistraživačkom i izdavačkom radu i odgovorni su za očuvanje etike izdavača časopisa, Instituta za moderno obrazovanje. Nadzor podrazumeva detaljnu kontrolu nad plagijarizmom i podnošenjem netačnih informacija i kršenjem autorskih prava, kao i izjašnjenje o uočenom, ispravku, uklanjanje rukopisa i druge korake.

Ukoliko uredništvo otkrije kršenje etičkih principa, odnosno da već objavljeno delo sadrži lažne podatke, rukopis će biti revidiran ili uklonjen, i to će biti jasno navedeno u časopisu.

Plagijarizam

Plagijarizam, definisan kao prisvajanje tuđih ideja, reči ili drugih oblika kreativnog izražavanja i prezentacije i njihovo predstavljanje kao sopstvenih, predstavlja teško kršenje naučne i izdavačke etike. Plagijat može uključivati kršenje autorskih prava, što je krivično delo. Plagijat obuhvata sledeća ponašanja:

- preuzimanje ili skoro doslovno parafraziranje (da bi se prikrio plagijat) delova tekstova drugih autora bez jasnog navođenja izvora ili označavanja kopiranih fragmenata (na primer, korišćenjem navodnika);
- kopiranje formula, fotografija ili tabela iz tuđih radova bez ispravnog navođenja izvora i bez dozvole autora ili vlasnika autorskih prava da ih koriste.

Savetujemo autorima da pregledaju svaki rukopis na plagijat. Rukopisi koji jasno pokazuju znake plagijata biće odbijeni. Takođe, uredništvo za proveru originalnosti naučnih i stručnih radova, nakon što oni dobiju pozitivne recenzije, koristi softver PlagScan i druge programe.

Ukoliko se otkrije da je rad već objavljen u časopisu EdTech Journal, biće povučen po metodi navedenoj u delu „Povlačenje radova”, a autorima će biti zabranjeno objavljivanje u časopisu ubuduće. Autori će takođe biti u obavezi da pošalju pisano izvinjenje autorima originalnog dela.

Povlačenje radova

Procese povlačenja i uklanjanja članaka ne treba uzimati olako i treba ih koristiti samo u retkim okolnostima. Primarni razlog za povlačenje ili uklanjanje rada je neophodnost da se greška otkloni kako bi se održao naučni integritet, a ne želja da se kažnjavaju autori.

Članci koji su prihvaćeni za objavljivanje, ali još uvek nisu na odgovarajući način objavljeni, obično se povlače. Na primer, pretpostavimo da je otkriveno da članak sadrži greške, lažne navode o autorskim pravima, da je dostavljen u više časopisa u isto vreme, da je plagiran, da manipuliše podacima radi prevare, da krši prava izdavača, nosilaca autorskih prava ili autora, ili da na drugi način predstavlja tešku povredu profesionalnog etičkog kodeksa i smernica za objavljivanje u časopisu EdTech Journal. U tom slučaju, takav rad mora biti „povučen” i pre objavljivanja.

Objavljeni članci će biti aktuelni, tačni i nepromenjeni što je duže moguće. Međutim, mogu postojati okolnosti u kojima se već objavljeni članak mora ukloniti: ako postoje naknadne greške koje se moraju ispraviti, ako postoji povreda zakonskih ograničenja izdavača, vlasnika autorskih prava ili autora, ili ako postoji povreda profesionalnog etičkog kodeksa,

kao što su višestruki podnesci, lažne tvrdnje o autorstvu, plagijat, prevara u korišćenju podataka itd. Nekoliko biblioteka i naučnih tela razvilo je standarde za uklanjanje članka iz onlajn baze podataka.

Njihove najbolje prakse je usvojio IME: sadržaj članka (HTML i PDF) se uklanja i zamenjuje stranicom (HTML i PDF) na kojoj se navodi da je članak povučen u skladu sa smernicama za povlačenje članaka u časopisu, sa vezom do trenutnog dokumenta o toj politici.

Na preporuku naučne zajednice, autor ili uredništvo može povući članak, u skladu sa dobrom praksom.

Prijava kršenja etičkih normi i provera navoda

Svaki pojedinac ili institucija može u bilo kom trenutku prijaviti kršenje etičkih normi i druge nepravilnosti urednicima i redakciji i dati relevantne informacije/dokaze.

Postupak za proveru prijava odnosno analizu izvedenih dokaza pokreće glavni i odgovorni urednik, uz konsultacije sa uredništvom. Svaki dokaz koji se izvede tokom takvog postupka smatraće se poverljivim materijalom i predstavljace se samo onima koji direktno učestvuju u postupku.

Autorima i recenzentima za koje se sumnja da su prekršili etičke norme biće dozvoljeno da reaguju na prijave protiv njih. Ako se otkriju nepravilnosti, biće utvrđeno da li predstavljaju manji prekršaj ili veću povredu etičkih standarda.

Manji prekršaj

Manje prekršajne situacije rešavaće se u neposrednom dijalogu sa autorima odnosno recenzentima koji su počinili prekršaj, bez intervencije trećih lica; na primer:

- upozoravanje autora/reczenta na manji prekršaj uzrokovan nesporazumom ili pogrešnom primenom akademskih standarda;
- pismo upozorenja autoru/reczentu koji je učinio manji prekršaj.

Evidentno kršenje etičkih principa

Glavni i odgovorni urednik donosi odluke o ozbiljnim kršenjima etičkih standarda, u saradnji sa uredništvom ako proceni da je potrebna, a ukoliko je neophodno, i sa stručnom komisijom okupljenom za tu priliku.

Mogu se preduzeti sledeće mere (pojedinačno ili istovremeno):

- pisanje izjave ili uvodnika koji opisuje slučaj etičke povrede;
- slanje zvaničnog obaveštenja autoru/reczentu;
- povlačenje objavljenog rada po proceduri opisanoj u delu „Povlačenje radova“;
- autorima će biti zabranjeno objavljivanje radova u časopisu na neodređeno vreme ili trajno;
- obaveštavanje relevantnih profesionalnih organizacija ili nadležnih organa o slučaju kako bi se mogle preduzeti neophodne radnje.

Uređivački odbor časopisa se rukovodi standardima i preporukama Komiteta za etiku publikacija (COPE): <http://publicationethics.org/resources/>.

Open access

Verzija otvorenog pristupa časopisa EdTech Journal je dostupna svima. Članci objavljeni u časopisu mogu se besplatno preuzeti i distribuirati u obrazovne i nekomercijalne svrhe sa sajta časopisa. Članci preuzeti sa veb-stranice časopisa besplatno moraju se koristiti u skladu sa licencom Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 <https://creativecommons.org/licenses/by-nc-nd/3.0/>

Autorska prava

Slanjem rada, autori se slažu sa sledećom politikom autorskih prava. Autori zadržavaju sva prava ukoliko rad ne bude odobren za objavljivanje u časopisu EdTech Journal. Međutim, kada se članak prihvati, autori se odriču određenih prava u korist izdavača.

Ukratko, autori daju izdavaču pravo da objavi članak, da bude naveden kao prvi izdavač članka u slučaju kasnije upotrebe dela i da ga distribuira u svim oblicima i medijima. Detaljnije, izdavač dobija sledeća neekskluzivna prava na rukopis, uključujući sve dodatne materijale i sve delove, izvode ili elemente rukopisa:

- pravo na reprodukciju i distribuciju rukopisa, uključujući pravo štampanja na zahtev;
- pravo na objavljivanje probnih primeraka rukopisa, reprinta i posebnih izdanja;
- pravo da prevede na druge jezike;

- pravo na reprodukciju rukopisa korišćenjem fotomehaničkih ili sličnih sredstava, uključujući, ali ne ograničavajući se na fotokopiranje, i na distribuciju takvih reprodukcija;
- pravo na reprodukciju i distribuciju rukopisa elektronski ili optički na bilo kom nosaču podataka ili medijumu za skladištenje, uključujući hard disk, CD-ROM, DVD i Blu-ray disk (BD), u bilo kom formatu, kao i pravo na reprodukciju i distribuciju rukopisa sa ovih nosača podataka;
- pravo na čuvanje rukopisa u bazama podataka, uključujući onlajn baze podataka, kao i pravo na prenošenje dokumenta na bilo koji tehnički sistem ili način;
- pravo da rukopis učini dostupnim javnosti ili lokalnim grupama korisnika na pojedinačnoj osnovi, za upotrebu na monitorima ili drugim čitačima (uključujući čitače e-knjiga), kao i u obliku koji omogućava korisniku da štampa, putem interneta, druge usluge na mreži ili interne ili eksterne mreža.

Autori imaju ista prava kao i treće strane da koriste članak pod licencom Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 Srbija (<http://creativecommons.org/licenses/by-nc-nd/3.0/rs/>).

Autori, međutim, zadržavaju sledeća autorska prava nad objavljenim člankom: pravo da prevedu članak na drugi jezik, da ga koriste u kompilacijama svojih radova, da ga koriste u doktorskoj disertaciji ili monografiji, kako za komercijalne tako i za nekomercijalne svrhe, pod uslovom da je navedeno da je novi rad derivat članka objavljenog u časopisu EdTech Journal, uz navođenje digitalnog identifikatora (DOI) objavljenog članka u obliku HTML veze, i/ili URL lokacije na kojoj se članak nalazi.

Politika privatnosti

Imena i adrese e-pošte unesene na veb-stranicu časopisa će se koristiti isključivo za potrebe ovog časopisa i neće biti dostupne trećoj strani iz bilo kog drugog razloga.

Odricanje od odgovornosti

Stavovi predstavljeni u objavljenim radovima ne predstavljaju stavove uredništva časopisa i Uređivačkog odbora. Autori prihvataju pravnu i moralnu odgovornost za ideje članaka. U slučaju da se podnese bilo kakav zahtev za naknadu štete, izdavač neće snositi zakonsku odgovornost. Izdavač niti glavni i odgovorni urednik takođe nisu odgovorni za eventualne propuste softvera za proveru originalnosti članaka, odnosno neutvrđene plagijate.

U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik
dr Valentin Kuleto

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

According to the Statute of the Association Institute for Contemporary Education, Article 3, paragraph 7 and Rules of Procedure of the Editorial Board with the Rulebook on Editing the EdTech Journal, the Editorial Board of the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal, at the session held on 29 December 2021, adopts:

Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal Code of Ethics

Members of the editorial board of the scientific journal EdTech Journal supervise the application of ethical standards in scientific research and publication operations and are responsible for upholding the ethics of the journal's publisher, the Institute for Contemporary Education. Surveillance entails thorough supervision of plagiarism and the submission of incorrect information and copyright infringement, clarification, correction, manuscript removal, and other steps.

If the editorial board discovers a violation of ethical principles, i.e. that an already published work contains false information, the manuscript will be revised or removed, and this will be clearly stated in the journal.

Plagiarism

Plagiarism, defined as appropriating other people's ideas, words, or other forms of creative expression and presentation and presenting them as one's own, is a severe violation of scientific and publishing ethics. Plagiarism may include copyright violation, which is a crime. Plagiarism covers the following behaviours:

- downloading or almost literal paraphrase (to conceal plagiarism) of parts of other writers' texts without clearly stating the source or labelling the copied fragments (for example, using quotation marks);
- copying formulae, photos, or tables from other people's works without correctly citing the source and without the author's or copyright holders' permission to use them.

We advise authors to examine each manuscript for plagiarism. Manuscripts that clearly show signs of plagiarism will be rejected.

If it is discovered that the paper has already been published in the EdTech Journal, it will be withdrawn following the method outlined under "Withdrawal of papers", and the authors will be barred from publishing in the journal in the future. Authors will also be obliged to send a written apology to the original work's authors.

Retraction of articles

Article withdrawal and removal processes should not be taken lightly and should only be used in rare circumstances. The primary rationale for withdrawing or removing a paper is the necessity to remedy the error in order to maintain scientific integrity, not the desire to punish the authors.

Articles that have been accepted for publication but have not yet been appropriately published are typically withdrawn. For example, suppose an article is discovered to contain errors, false allegations of copyright, to have been submitted to multiple journals at the same time, to be plagiarized, to manipulate data for fraud, to infringe the rights of publishers, copyright holders, or authors, or to represent otherwise a severe violation of the professional code of ethics and guidelines for publication in the EdTech Journal. In that case, such work must be "withdrawn" even before publication.

Published articles will be kept current, accurate, and unaltered for as long as possible. However, there may be circumstances in which an already published article must be removed: if there are subsequent errors that must be corrected, if there is a violation of the legal restrictions of publishers, copyright owners, or authors, or if there is a violation of a professional code of ethics, such as multiple submissions, false claims of authorship, plagiarism, fraud in the use of data, and so on. Several libraries and scientific bodies have developed standards for removing an article from an online database. Their best practices have been adopted by the EdTech Journal: article content (HTML and PDF) is removed and replaced by a page (HTML and PDF) stating that the article has been withdrawn following the Journal article withdrawal policy, with a link to the current document on that policy.

On the recommendation of the scientific community, the author or the editorial board may withdraw the article, according to good practice.

Dispute resolution and verification of the presented allegations and evidence

Any individual or institution may report violations of ethical norms and other irregularities to the editors and editorial staff at any time and give the relevant information/evidence.

The procedure for confirming the report and evidence given shall be initiated by the editor-in-chief, in consultation with the editorial board. Any evidence produced during such a procedure will be treated as confidential material and presented only to those directly participating in the procedure.

Authors and reviewers suspected of breaking ethical norms will be allowed to react to allegations levelled against them. If irregularities are discovered, it will be determined whether they constitute a minor infringement or a major violation of ethical standards.

Minor infraction

Minor misdemeanour situations will be settled in direct dialogue with the authors and reviewers who committed the misdemeanour, without the intervention of third parties; for example:

- alerting the author/reviewer of a minor infraction caused by a misunderstanding or misapplication of academic standards;
- a warning letter to the author/reviewer who committed the minor infraction.

A blatant transgression of ethical principles

The editor-in-chief makes decisions on serious violations of ethical standards in collaboration, if needed, with the editorial board, and, if necessary, a panel of specialists assembled for the occasion.

The following measures may be taken (individually or concurrently):

- writing a statement or editorial describing the case of the ethical infraction;
- sending a formal notice to the authors/reviewers;
- withdrawal of published work following the procedure outlined in “Withdrawal of works”;
- authors will be barred from publishing papers in the journal for an indefinite amount of time or permanently;
- alerting relevant professional organizations or responsible authorities about the case so that necessary action can be taken.

The journal’s editorial board is governed in resolving conflicts by the standards and recommendations of the Committee on Publication Ethics (COPE): <http://publicationethics.org/resources/>.

Open access

The open-access version of the EdTech Journal is available. Articles published in the journal can be downloaded for free and disseminated for educational and non-commercial purposes from the journal’s website. Articles downloaded from the journal’s website for free must be used in compliance with the Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 license <https://creativecommons.org/licenses/by-nc-nd/3.0/>

Copyright

The authors agree to the following copyright policy by submitting the paper. The authors reserve all rights if the work is not approved for publication in the EdTech Journal. However, when the article is accepted, the authors relinquish certain rights to the publisher.

In summary, the writers grant the publisher the right to publish the article, be listed as the article's first publisher in the event of later use of the piece, and distribute the article in all forms and media. In greater detail, the publisher receives the following non-exclusive rights to the manuscript, including all additional materials and all parts, extracts, or elements of the manuscript:

- the right to reproduce and distribute the manuscript, including the right to print on demand;
- the right to publish manuscript trial copies, reprints, and special editions;
- the right to have the manuscript translated into other languages;
- the right to reproduce the manuscript using photomechanical or similar means, including but not limited to photocopying, and to distribute such reproductions;
- the right to reproduce and distribute the manuscript electronically or optically on any data carrier or storage medium, including hard disk, CD-ROM, DVD and Blu-ray Disc (BD), and in any file format, as well as the right to reproduce and distribute the manuscript from the said data carriers;
- the right to keep the manuscript in databases, including online databases, as well as the right to convey the document in any technical system or manner;
- the right to make the manuscript available to the public or local groups of users on an individual basis, for use on monitors or other readers (including e-book readers), as well as in a form that allows the user to print, via the Internet, other online services, or an internal or external network.

The authors have the same rights as third parties to use the article under the Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 Serbia license (<http://creativecommons.org/licenses/by-nc-nd/3.0/rs/>). The authors, however, retain the following copyrights over the published article: the right to translate the article into another language, to use it in compilations of their works, to use it in a doctoral dissertation or monograph, for both commercial and non-commercial purposes, provided they state that the new work is a derivative of the article published in the EdTech Journal and provide the DOI of the published article in the form of an HTML link, and/or the URL location where the article was published.

Policy on privacy

The names and e-mail addresses entered on the journal's website will be used solely for the purposes of this journal and will not be made available to any third party for any other reason.

Disclaimer

The views represented in the published works do not represent the views of the journal's editors office and editorial board. The authors accept legal and moral responsibility for the ideas presented in the articles. In the event that any claims for damages are made, the publisher will not be held legally liable. The publisher or the editor-in-chief are also not responsible for any failures of the software for verifying the authenticity of articles or unidentified plagiarism.

Belgrade, 29 December 2021

Editor-in-Chief
Dr Valentin Kuleto

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa:
EdTech@institut.edu.rs
Sajt: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Poziv za autore Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal

Institut za moderno obrazovanje i Naučni časopis za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal pozdravljaju naučne i stručne radove, dosad neobjavljivane, u različitim oblastima usmerenim ka korišćenju informacionih tehnologija u razvoju privrede, društva i obrazovanja, u okviru naučnih polja tehničko-tehnoloških i društveno-humanističkih nauka, u skladu sa Naučnom politikom časopisa.

Pripremljene radove možete uputiti na imejl-adresu Uredništva EdTech@institut.edu.rs ili putem veb-sajtova časopisa <http://www.edtechjournal.org/> i <http://www.edtech-journal.org/> u delu „ Predajte rad“.

U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik
dr Valentin Kuleto

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Invitation for authors of the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal

The Institute for Contemporary Education and the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal welcome scientific and professional papers, previously unpublished, in various areas aimed at the use of information technology in economic, social and educational development, within scientific fields of technical and technological and social sciences and humanities, in accordance with the scientific policy of the journal.

You can send the prepared papers to the e-mail address of the Editorial Staff: EdTech@institut.edu.rs, or via the journal's websites: <http://www.edtechjournal.org/> and <http://www.edtech-journal.org/> in the section Submit a Paper.

Belgrade, 29 December 2021

Editor-in-Chief,
Dr Valentin Kuleto

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa: EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Izjava autora o originalnosti članka

Autor 1 (u ime svih autora na radu): _____
Naziv rada: _____

Ovim potvrđujem sledeće:

- Ovaj rad je originalan i u potpunosti predstavlja rezultat istraživanja autora, i ne sadrži delove teksta koji su ranije objavljivi, te kao takav ni u čemu ne narušava bilo čija vlasnička ili autorska prava.
- U potpunosti preuzimam odgovornost za sprovedeno istraživanje, analizu i interpretaciju podataka i zaključke.
- Korišćene bibliografske reference jasno su navedene u samom radu i u okviru literature.
- Ukoliko su korišćene ideje, grafikoni, slike ili navodi drugih autora, jasno je naglašeno pozivanje na izvor u skladu sa standardima pozivanja na literaturu.
- Ukoliko su korišćeni delovi teksta drugih autora u većoj meri, obezbedio sam dozvolu vlasnika autorskih prava da te delove uključim u rad.
- Ovaj rad (ili deo rada) nije objavljivani i neće biti poslat na objavljivanje ni u jedan drugi časopis ili publikaciju do trenutka dobijanja obaveštenja da li će rad biti publikovan u Naučnom časopisu za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal Instituta za moderno obrazovanje.
- Ovlašćen sam da u ime svih autora na radu potpišem ovu izjavu.

Datum:

Potpis autora:

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Statement of authorship and originality of the article

Author 1 (on behalf of all authors of the paper): _____
Title of the Article: _____

I hereby confirm that:

- This paper is original and entirely the result of research by the authors of the article, it does not contain parts of text that have been published before, and as such does not in any way infringe anyone's property or copyright;
- We take full responsibility for the conducted research, analysis and interpretation of data and conclusions;
- The bibliographic references used are clearly stated in the paper itself and within the literature;
- If ideas, charts, images or quotations from other authors are used, the reference to the source in accordance with the standards of the reference to the literature is clearly emphasised;
- If parts of the text of other authors have been used to a greater extent, I confirm that I have obtained the permission of the copyright owner to include those parts in the work;
- This paper (or part of the paper) has not been published and will not be sent for publication in any other journal or publication, until such time as it is notified whether the article will be published in the scientific journal EdTech Journal, Institute for Modern Education;
- I am authorised on behalf of all authors at work to sign this statement.

Date:

Author's signature:

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa:
EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Za potrebe časopisa EdTech Journal neophodno je da autori popune sledeći obrazac i dostave ga, uz svoj rad i ostale priloge, na mejl adresu: EdTech@institut.edu.rs.

Podaci o autoru*

Napomena: Ukoliko je više autora, popuniti ovaj obrazac za svakoga pojedinačno.

Ime i prezime autora	
Godina rođenja (zbog UDK)	
Zvanje	
Orcid id	
Institucija u kojoj je autor zaposlen (Fakultet, Univerzitet)	
Adresa, Grad, Država	
Telefon institucije	
Imejl-adresa institucije	
Adresa stanovanja u slučaju da je autor nezaposlen ili penzionisano lice	
Mobilni telefon (Viber, WhatsApp)	
Imejl-adresa (alternativna)	

Podaci o radu

Naslov rada	
Broj karaktera sa razmakom	
Jezik	
Mesto i datum slanja rada	

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

For the needs of the EdTech Journal, the authors are required to fill in the following form and submit it, along with their work and other contributions, to the e-mail address: EdTech@institut.edu.rs.

Information about the author*

Note: If there are several authors, fill in this form for each individual.

Name and surname	
Year of birth (for UDC)	
Academic title	
ORCID iD	
Institution of employment (department, university)	
Address of the institution, city, country	
Telefon institucije	
Institutional phone	
Institutional E-mail	
Residence address in case the author is unemployed or retired	
Mobile phone (Viber/WhatsApp)	
Email (alternative)	

Article data

Title of the article	
Number of characters with spaces	
Language	

Date of submission	
--------------------	--

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje

Masarikova 5, Beograd

11000 Beograd

+381 (0)11/40-11-260

Imejl-adresa:

EdTech@institut.edu.rs

Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Uputstvo za autore

Naučni časopis za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal objavljuje samo radove koji su originalni i nisu nigde prethodno objavljivi. Za podatke objavljene u tekstu odgovaraju autori. Časopis objavljuje naučne radove u okviru sledećih klasifikacija: naučni članci (originalan/izvorni naučni rad, pregledni rad, kratko ili prethodno saopštenje i naučna kritika, odnosno polemika i osvrti) i stručni članci (stručni rad, informativni prilog, prikaz i stručna kritika, odnosno polemika i osvrti).

Uredništvo zadržava pravo da tekst koji nije u skladu sa Naučnom politikom i Uputstvom za autore, odnosno za koji nije korišćen Šablon (template) časopisa vrati autoru kao neodgovarajući (da rad odbije) ili da zatraži korekcije rada pre upućivanja u postupak recenziranja.

Radovi mogu biti pisani na srpskom ili engleskom jeziku na bazi templejta (šablona) na srpskom, odnosno engleskom jeziku „Template EdTech_ENG” ili „Template EdTech_SRP” dostupnih na sajtu časopisa. Ukoliko je rad na srpskom jeziku, Uredništvo će obezbediti prevod rada na engleski jezik, i obratno. Uredništvo će po zaprimanju članka iz teksta ukloniti podatke o autorima ili metapodatke koji otkrivaju identitet autora kako bi se radovi uputili na anonimne recenzije.

Uredništvo prima radove isključivo upućene putem mejla na adresu EdTech@institut.edu.rs ili putem veb-sajta časopisa. Potrebno je da svoje radove šaljete isključivo elektronskim putem zajedno sa popunjenim formularom „Podaci o autoru” na adresu EdTech@institut.edu.rs, odnosno putem veb-sajta. Uz rad obavezno dostavite popunjen formular „Podaci o autoru”, koji se može preuzeti sa sajta časopisa, kao i obrazac „Izjava o autorstvu i originalnosti rada”.

EdTech Journal koristi springer-vankuverski (brackets) sistem citiranja. Reference su označene arapskim brojevima u zagradi, i to prema redosledu pojavljivanja u tekstu. Primeri referenciranja su navedeni u Šablonu (templejtu) za pripremu naučnih radova. Detaljna uputstva možete videti na linku: <https://citationsy.com/styles/springer-vancouver-brackets>. Predlažemo da instalirate neki citatni menadžer poput Mendeley

<https://cs1.mendeley.com/styleInfo/?styleId=http%3A%2F%2Fwww.zotero.org%2Fstyles%2Fspringer-vancouver-brackets>.

Autori su u obavezi da poštuju naučne i etičke principe i pravila prilikom priprema i izdavanja članka, u skladu sa međunarodnim standardima.

Autori se slažu sa sledećom politikom autorskih prava slanjem rada. Autori zadržavaju sva prava ukoliko rad ne bude odobren za objavljivanje u časopisu EdTech Journal. Međutim, kada se članak prihvati, autori daju izdavaču pravo da objavi članak, da bude naveden kao prvi izdavač članka u slučaju kasnije upotrebe dela i da ga distribuira u svim oblicima i medijima.”

Napominjemo da časopis koristi softver PlagScan za proveru originalnosti naučnih radova nakon dobijanja pozitivnih recenzija, odnosno u postupku donošenja odluke o prihvatanju i publikovanju rada u sveskama časopisa. Ukoliko se utvrdi plagijat ili autoplagijat, odnosno lažno autorstvo, rad ne može biti prihvaćen za objavu. Postupak testiranja na plagijat obaviće se nakon i isključivo u slučaju dobijanja pozitivnih recenzija. Radovi će biti odbijeni ukoliko se utvrdi plagijat, autoplagijat ili lažno autorstvo.

Ukoliko zbog razvojnih tendencija u budućnosti bude postojala potreba da se izvrše promene u Uputstvu za autore, o tome će odlučiti Upravni odbor na osnovu predloga Uredništva i Uređivačkog odbora, odnosno uočenih potreba.

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260
E-mail: EdTech@institut.edu.rs
Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Instructions for authors

The scientific journal for contemporary education and application of information technologies – EdTech Journal – publishes only original papers that have not been published before. The authors are responsible for the data published in the text. The journal publishes scientific papers within the following classifications: scientific articles (original scientific paper, review paper, short or previous statement and scientific criticism, i.e. polemics and reviews) and professional articles (professional paper, informative article, review and professional criticism, i.e. polemics and reviews).

The editors reserve the right to return a text to the corresponding author if it is not in accordance with the Scientific Policy and Instructions for Authors, i.e. for which no Journal template was used, to the author as inappropriate (to reject the paper), or to request corrections of the article before referring it to the review process.

Papers can be written in Serbian or English language based on a template in Serbian or English “Template EdTech_ENG” or “Template EdTech_SRP” available on the journal’s website. If the article is written in the Serbian language, the editorial board will provide a translation of the paper into English and vice versa. Furthermore, upon receipt of the article, the editorial board will remove information about the authors or metadata that reveals the identity of the authors from the text to submit papers to anonymous reviews.

The editorial board accepts papers sent exclusively by e-mail to EdTech@institut.edu.rs or through the journal’s website. Therefore, you must send your articles exclusively together with the completed form “Information about the author” to EdTech@institut.edu.rs or send them via the website. Furthermore, along with the paper, it is obligatory to submit a completed form “Information for the author”, which can be downloaded from the journal’s website, and the form “Statement of authorship and originality of the article”.

EdTech Journal uses Springer-Vancouver (brackets) referencing style. References are marked with Arabic numerals in parentheses according to the order in which they appear in the text. Examples of referencing are given in the Template for the preparation of scientific papers. Detailed instructions can be found at the link <https://citationsty.com/styles/springer-vancouver-brackets>. We suggest you install some quote manager like Mendeley: <https://cs1.mendeley.com/styleInfo/?styleId=http%3A%2F%2Fwww.zotero.org%2Fstyles%2Fspringer-vancouver-brackets>

The authors are obliged to respect scientific and ethical principles and rules when preparing and publishing articles, in accordance with international standards.

Authors agree to the following copyright policy by submitting a paper. The authors reserve all rights if the work is not approved for publication in the “EdTech Journal”. However, when an article is accepted, the authors give the publisher the right to publish the article, to be listed as the first publisher of the article in case of later use of the work and to distribute it in all forms and media.

Please note that the journal uses PlagScan software to verify the authenticity of scientific papers after receiving positive reviews, i.e., deciding on accepting and publishing the article in the journal. If plagiarism is found, or auto-plagiarism or false authorship, the paper cannot be accepted for publication. The plagiarism testing procedure will be performed after review, and exclusively in case of receiving positive reviews, and the article will be rejected if plagiarism, auto-plagiarism or false authorship is established.”

Vrsta rada:
 Primljen:
 Prihvaćen:
 UDK:

Naslov

Ime Prezime1, Ime Prezime2 i Ime Prezime2,*

1 Pripadnost ustanovi 1: Univerzitet, Fakultet, grad, država; e-mail

2 Pripadnost ustanovi 1: Univerzitet, Fakultet, grad, država; e-mail

* Kontakt-informacije: e-mail; Tel. (uključujući pozivni broj za zemlju)

Sažetak: Najmanje 150, a najviše 200 reči, u jednom pasusu. Sažeci za istraživačke radove čitaocima treba da na koncizan način predstavljaju sinopsis rezultata istraživanja. Molimo vas da koristite ovaj tip strukturiranih sažetaka, samo bez naslova, za radove koje prilažete: Cilj studije treba da bude jasno naveden u uvodu; istraživačka pitanja treba smestiti u širi kontekst. (2)

Procedure: ukratko navedite najuobičajenije metode i postupke koji su korišćeni, ukoliko je to relevantno. U ovom segmentu se sumiraju ključni zaključci. U ovom delu rada pomenite ključne rezultate ili interpretacije. Kada pišete sažetak, bitno je da imate na umu glavna poglavlja članka, ali je takođe bitno da se najvažniji zaključci ne preuveličavaju.

Ključne reči: ključna reč 1; ključna reč 2; ključna reč 3, ključna reč 4, ključna reč 5 (Odaberite pet do sedam relevantnih ključnih reči koje su istovremeno karakteristične za sam rad i dovoljno česte na dotičnom polju proučavanja).

Svaki deo ovog šablona može biti formatiran na poseban način. Odgovarajući stilovi za različite delove dokumenta mogu se pronaći u meniju „Styles” u Wordu. Segmenti koji nisu obavezni jasno su označeni kao takvi. U radovima se koriste priloženi naslovi segmenata. Kad je reč o drugim vrstama članaka, kao što su pregledni radovi, postoji veća sloboda u pogledu strukture.

Obrišite prethodnu rečenicu i započnite brojeve oznake segmenata od 1. Možete kontaktirati sa uredništvom slanjem mejla na adresu edtech@institut.edu.rs ili putem kontakt forme na sajtu časopisa.

1. Uvod

Značaj rada potrebno je istaknuti u uvodu, koji treba da predstavi širi okvir istraživanja. Potrebno je objasniti cilj i značaj rada. Prilikom pregleda trenutnog statusa istraživanja, bitno je referencirati se na najvažnije studije. Tamo gde je potrebno, molimo naglasite hipoteze koje su predmet debate ili se međusobno ne slažu. U zaključku, ukratko navedite svrhu istraživanja i naglasite najvažnije zaključke. Molimo vas da pokušate da napišete uvod tako da on bude razumljiv i naučnicima iz drugih polja, koliko je to moguće. Potrebno je koristiti redosled referenciranja u radu [1] ili [2,3] ili [4–6] da bi se identifikovao redosled u kom se reference pojavljuju. Detaljne informacije o referencama navedene su na kraju ovog teksta.

2. Materijali i metode

Potrebno je napisati detaljne opise Materijala i metoda, tako da ih drugi mogu ponoviti i vršiti dalja istraživanja na osnovu objavljenih rezultata. Svi materijali, podaci, kompjuterski kod i protokoli u vezi sa objavljivanjem vašeg rukopisa treba da budu dostupni čitaocima. Molimo vas da imate u vidu ovaj zahtev. Ukoliko postoje bilo kakva ograničenja u pogledu dostupnosti materijala ili informacija u trenutku predavanja teksta, molimo vas da ih navedete. Postojeće metode i protokoli mogu se ukratko pomenuti i navesti na odgovarajući način, dok je nove metode i protokole potrebno detaljno opisati.

3. Rezultati

U ovom segmentu poželjni su međunaslovi. On treba da pruži jezgrovit i precizan pregled rezultata eksperimenata, njihove interpretacije, kao i zaključaka koji se mogu izvesti.

3.1. Podsekcija

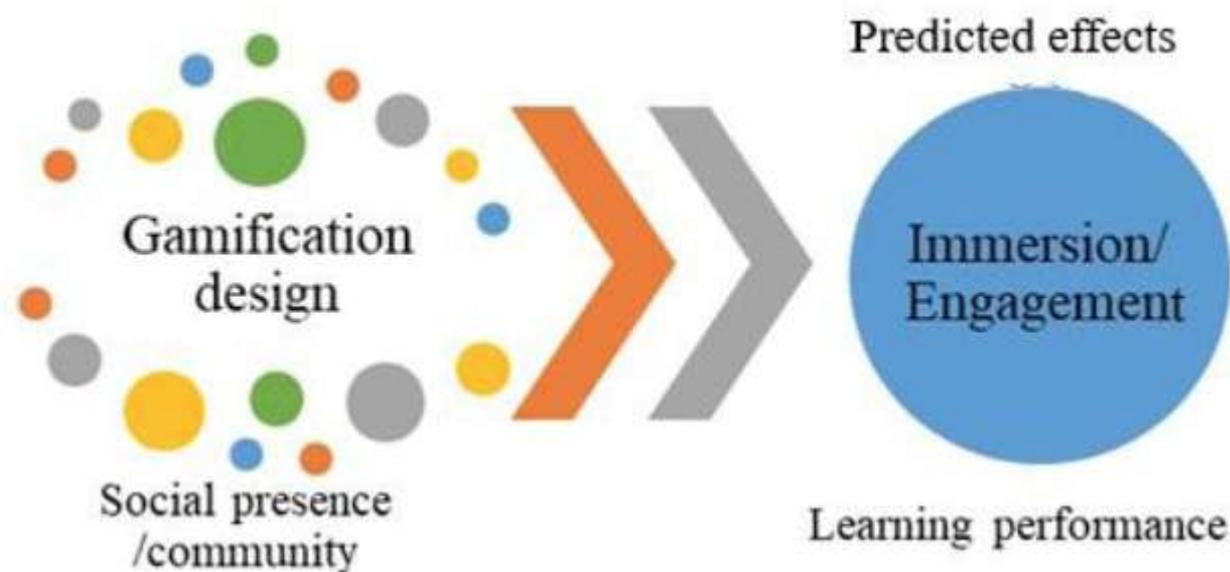
3.1.1. Potpodsekcija

Lista sa nabranjem treba da izgleda ovako:

- Stavka 1;
- Stavka 2;
- Stavka 3;

3.2. Slike, tabele i shematski prikazi

U glavnom tekstu, navodite sve slike i tabele kao Slika 1, Tabela 1 itd.



Slika 1. Veza između dizajna gejmfikacije i obrazovnih rezultata, adaptirano prema [16].

1Tabele mogu imati legendu (footer).

Tabela 1. Tabele treba postavljati u tekst u blizini mesta na kom se prvi put pominju.

Red	Naslov kolone 1	Naslov kolone 2
1	Vrednost 1	Vrednost 3
2	Vrednost 2	Vrednost 3

Tekst se nastavlja ovde (Slika 2 i Tabela 2).

Primer jednačine:

$$a = b + c + d + e + f + g + h + i + j + k + l$$

4. Diskusija

Autor(i) treba da detaljno razmotre rezultate i načine na koji se oni mogu razumeti iz perspektive ranijih istraživanja i radnih pretpostavki. Moramo razmotriti sve moguće ishode svojih rezultata i njihove posledice. Ovde se navode i mogućnosti kad je reč o smerovima u kojima bi se istraživanje moglo dalje razvijati.

5. Zaključak

Ukoliko je debata veoma duga ili kompleksna, u rukopis se može uvrstiti ovaj segment. Poželjan je pogotovo ako se ne koristi IMRAD model.

Dodatak (Appendix) 1

Dodatne informacije ili podaci mogu se navesti u dodatku – npr. objašnjenja detalja eksperimenta koja bi inače

poremetila tok glavnog teksta, ali su ipak značajna za razumevanje i ponavljanje istraživanja predstavljenog u glavnom tekstu, odnosno slike ili replike koje se odnose na eksperimente za koje su reprezentativni podaci navedeni u glavnom tekstu. Dodatak se može iskoristiti i za izvođenje matematičkih dokaza rezultata koji nisu od fundamentalnog značaja za rad.

Zahvalnica

Naziv i broj projekta, odnosno naziv programa u okviru koga je članak nastao, kao i naziv institucije koja je finansirala projekat ili program navodi se u posebnoj napomeni na kraju članka.

Reference

Reference je neophodno navesti na kraju rukopisa, brojevnim redosledom u skladu sa redosledom njihovog pojavljivanja u tekstu (uključujući tabele ili legende). Za sve reference potrebno je navesti digitalne identifikatore objekta (DOI).

[1] [1–4] i [1,3,5–13] su primeri navođenja brojeva referenci unutar uglastih zagrada, pre znakova interpunkcije.

EdTech Journal koristi Springer-Vankuverski (brackets) sistem citiranja. Reference su označene arapskim brojevima u zagradi i to prema redosledu pojavljivanja u tekstu. Detaljna uputstva možete videti na linku. <https://citationsy.com/styles/springer-vancouver-brackets>. Predlažemo da instalirate neki citatni menadžer poput Mendeley <https://cs.l.mendeley.com/styleInfo/?styleId=http%3A%2F%2Fwww.zotero.org%2Fstyles%2Fspringer-vancouver-brackets>

1. Campbell JL, Pedersen OK. The varieties of capitalism and hybrid success. *Comp Polit Stud* [Internet]. 2007 [cited 2010 Jul 26];40:307–32. Available from: <http://journals.sagepub.com/doi/abs/10.1177/0010414006286542>
2. Mares I. Firms and the welfare state: When, why, and how does social policy matter to employers? In: Hall PA, Soskice D, editors. *Varieties of capitalism The institutional foundations of comparative advantage*. New York: Oxford University Press; 2001. p. 184–213.
3. Ahlquist JS, Breunig C. Country clustering in comparative political economy [Internet]. Cologne: Max-Planck Institute for the Study of Societies; 2009 p. 32. Report No.: 09–5. Available from: www.mpifg.de/pu/mpifg_dp/dp09-5.pdf
4. Borges JL. *Selected non-fictions*. Weinberger E, editor. New York: Viking; 1999.
5. Dunnett N, Kingsbury N. *Planting green roofs and living walls*. 2nd ed. Portland, OR: Timber Press; 2008.
6. Einstein A. On the electrodynamics of moving bodies. *Ann Phys* [Internet]. 1905;17:1–26. Available from: <http://bavard.fourmilab.ch/etexts/einstein/specrel/specrel.pdf>
7. Foderaro LW. Rooftop greenhouse will boost city farming. *New York Times*. New York; 2012 Apr 6;A20.
8. Hancké B, Rhodes M, Thatcher M, editors. *Beyond varieties of capitalism: conflict, contradiction, and complementarities in the European economy*. Oxford and New York: Oxford University Press; 2007.
9. Isaacson W. *Steve Jobs*. New York, NY: Simon & Schuster; 2011.
10. McInnis MD, Nelson LP. *Shaping the body politic: Art and political formation in early america*. Charlottesville, VA: University of Virginia Press; 2011.
11. Yo-yo having a modifiable string gap. 2011.
12. Watson JD, Crick FHC. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid. *Nature* [Internet]. 1953;171:737–8. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/13054692>
13. CSL search by example [Internet]. Citation Style Editor. [cited 2012 Dec 15]. Available from: <http://editor.citationstyles.org/searchByExample/>

Type of the Paper:

Received:

Accepted:

Published:

DOI:

UDC:

Title

Firstname Lastname 1, Firstname Lastname 2 and Firstname Lastname 2,*

1 Affiliation 1: University, Faculty, city, country; e-mail

2 Affiliation 2; University, Faculty, city, country; e-mail

* Correspondence: e-mail; Tel. (including country code)

Abstract: A minimum of 150 and a maximum of 200 words in a single paragraph. Abstracts for research articles should provide readers with a concise synopsis of the findings. Please adopt the following type of structured abstracts, but with no headings, for your submissions: The objective of the study should be made clear in the introduction; the question should be placed in a broader context. (2) Procedures: briefly outline the most common methods or treatments used; if applicable. The article's key findings are summarised in this section. Indicate the key takeaways or interpretations at this point in the paper. When writing an abstract, it is important to keep the major points of the article in mind, but it is also important to avoid exaggerating the main findings.

Keywords: keyword 1; keyword 2; keyword 3, keyword 4, keyword 5 (Select five to seven relevant keywords that are both distinctive to the paper and sufficiently frequent in the field of study.)

Each section of the template can be utilised in a different manuscript. There is a style for each portion of the document, which may be found in Word's "Styles" menu. Non-mandatory sections are clearly marked as such. Articles will use the section headings provided. There is considerable latitude in the structuring of other article kinds, such as reviews.

Delete the preceding sentence and begin section numbering at 1. You can reach the journal's editorial office by sending an email to this address: EdTech@institut.edu.rs.

1. Introduction

The study's significance should be highlighted in the introduction, which should provide a broad framework for the investigation. It should explain the goal and significance of the work. When reviewing the current status of research, it's important to reference the most important studies. When required, please put an emphasis on hypotheses that are up for debate or divergent. In conclusion, briefly state the purpose of the study and emphasise the most important findings. Please try to make the introduction understandable to scientists outside of your own field of study as much as feasible. For example, [1] or [2,3] or [4–6] should be used to identify the order in which references appear. Detailed reference information is provided at the end of this text.

2. Materials and Methods

Detailed descriptions of the Materials and Methods should be included so that others can duplicate and build upon the published results. All materials, data, computer code and protocols related with your manuscript's publishing must be made available to readers. Please be aware of this requirement. Please indicate any limits on the availability of materials or information at the time of submission. Existing methods and protocols can be briefly discussed and suitably cited, whereas newer methods and protocols need to be described at length.

3. Results

Subheadings are desirable in this section. It should offer a succinct and precise account of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Subsection

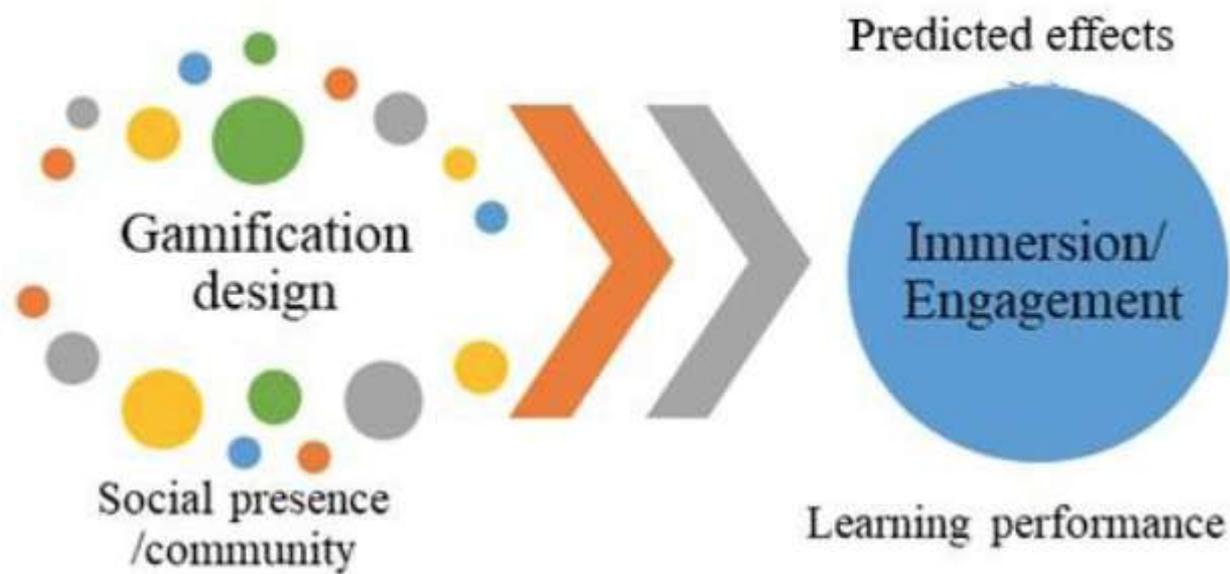
3.1.1. Subsubsection

This is what a bulleted list looks like:

- Bullet 1;
- Bullet 2;
- Bullet 3;

3.2. Figures, Tables and Schemes

Cite all figures and tables as Figure 1, Table 1, etc. in the main text.



1 Figures may have a footer.

Figure 1. Relating gamification design with the education performance, adaptation after [16].

Table 1. Tables should be put in the text around their initial citation.

Row	Column 1 title	Column 2 title
1	Value 1	Value 3
2	Value 2	Value 3

1 Tables may have a footer.

The text continues here (Figure 2 and Table 2).

An equation example:

$$a = b + c + d + e + f + g + h + i + j + k + l$$

4. Discussion

Results and how they can be understood from the perspective of past studies and working hypotheses should be discussed in detail by the author(s). We must consider all the possible outcomes of our results and their consequences. There are also possibilities for future study directions to be mentioned here.

5. Conclusions

If the debate is particularly lengthy or complex, this section can be added to the manuscript. It is desirable especially if IMRAD model is not used.

Appendix 1

It is possible to include additional information and data in the appendix, such as explanations of experimental details that would otherwise interrupt the flow of the main text, but which are still critical to understanding and reproducing the research shown in the main text, or figures of replicates for experiments of which representative data is shown in the main text. An appendix can be used to include mathematical proofs of results that are not fundamental to the paper.

Acknowledgements

The name and number of the project, i.e. the name of the programme within which the article was written, as well as the name of the institution that financed the project or programme is stated in a special note at the end of the article.

References

References must be provided at the end of the manuscript in numerical sequence according to where they appear in the text (including in tables and legends). The digital object identifier (DOI) should be included for all references. [1] [1–4] i [1,3,5–13] are examples of listing the references inside square brackets, before punctuation.

EdTech Journal uses Springer-Vancouver (brackets) referencing style. References are marked with Arabic numerals in parentheses according to the order in which they appear in the text. Detailed instructions can be found at the link <https://citationsy.com/styles/springer-vancouver-brackets>. We suggest you install some quote manager like Mendeley <https://cs.l.mendeley.com/styleInfo/?styleId=http%3A%2F%2Fwww.zotero.org%2Fstyles%2Fspringer-vancouver-brackets>

1. Campbell JL, Pedersen OK. The varieties of capitalism and hybrid success. *Comp Polit Stud* [Internet]. 2007 [cited 2010 Jul 26];40:307–32. Available from: <http://journals.sagepub.com/doi/abs/10.1177/0010414006286542>
2. Mares I. Firms and the welfare state: When, why, and how does social policy matter to employers? In: Hall PA, Soskice D, editors. *Varieties of capitalism: The institutional foundations of comparative advantage*. New York: Oxford University Press; 2001. p. 184–213.
3. Ahlquist JS, Breunig C. Country clustering in comparative political economy [Internet]. Cologne: Max-Planck Institute for the Study of Societies; 2009 p.32. Report No.: 09–5. Available from: www.mpifg.de/pu/mpifg_dp/dp09-5.pdf
4. Borges JL. *Selected non-fiction*. Weinberger E, editor. New York: Viking; 1999.
5. Dunnett N, Kingsbury N. *Planting green roofs and living walls*. 2nd ed. Portland, OR: Timber Press; 2008.
6. Einstein A. On the electrodynamics of moving bodies. *Ann Phys* [Internet]. 1905;17:1–26. Available from: <http://bavard.fourmilab.ch/etexts/einstein/specrel/specrel.pdf>
7. Foderaro LW. Rooftop greenhouse will boost city farming. *New York Times*. New York; 2012 Apr 6;A20.
8. Hancké B, Rhodes M, Thatcher M, editors. *Beyond varieties of capitalism: conflict, contradiction, and complementarities in the European economy*. Oxford and New York: Oxford University Press; 2007.
9. Isaacson W. *Steve Jobs*. New York, NY: Simon & Schuster; 2011.
10. McInnis MD, Nelson LP. *Shaping the body politic: Art and political formation in early America*. Charlottesville, VA: University of Virginia Press; 2011.
11. Yo-yo having a modifiable string gap. 2011.
12. Watson JD, Crick FHC. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid. *Nature* [Internet]. 1953;171:737–8. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/13054692>
13. CSL search by example [Internet]. Citation Style Editor. [cited 2012 Dec 15]. Available from: <http://editor.citationstyles.org/searchByExample/>

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa:
EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Odluka

o izboru / listi recenzenata

Formira se Lista recenzenata u sledećem sastavu:

1. Dr Aleksandar Kostić, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
2. Dr Slavko Pokorni, Professor of vocational studies, Information Technology School ITS-Belgrade
3. Dr Svetlana Anđelić, Professor of vocational studies, V Information Technology School ITS-Belgrade
4. Dr Milosav Majstorović, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
5. Dr Šemsudin Plojović, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
6. Dr Miloljub D. Luković, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
7. Msc Aleksandra Rosić, Lecturer, Information Technology School – Belgrade, Serbia
8. Dr Ivan Anić, Professor of vocational studies, Information Technology School – Belgrade, Serbia
9. Dr Hana Stefanović, Professor of vocational studies, Information Technology School – Belgrade, Serbia
10. Dr Zoran Grubišić, Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
11. Dr Velimir Dedić, professor, Faculty of Information Technology and Engineering, University Union Nikola Tesla, Belgrade, Serbia
12. Dr Marko Ranković, Assistant Professor, Faculty of Information Technology and Engineering, University Union Nikola Tesla, Belgrade, Serbia
13. Dr Rocsana Manea Bucea Tonis, Associate Professor Faculty of Physical Education & Sports, Spiru Haret University, Bucharest Romania
14. Dr Elena Gurgu, Assistant Professor, Department of Economic Sciences Bucharest, Spiru Haret University, Bucharest, Romania
15. Dr Oliva MD Dourado, Assistant Professor, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugalija
16. Dr Dušica M. Filipović, Assistant Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
17. MsC art. Saša Fiipović, Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
18. Dr Dragan Čalović, Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
19. Dr Dušan Stojaković, Assistant professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
20. MArch Nina Stojanović, Assistant professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
21. Dr Nevenka Popović Šević, Assistant Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
22. Dr Slavko Vesković, Professor, Faculty of Transport and Traffic Engineering, University of Belgrade, Belgrade, Serbia
23. MSc Milutin Dobrilović, Faculty of Economics, University of Belgrade, Belgrade, Serbia
24. Dr Lazar Janić, Professor of vocational studies Belgrade Academy of Professional Studies, Department Medical College of Professional Health Studies, Belgrade, Serbia
25. Dr Jasmina Bašić, Professor of vocational studies, Belgrade Academy of Professional Studies, Department Medical
26. Dr Vladimir Simović, Assistant Professor, Australian College of Kuwait, Australia
27. Dr Panos Photopoulos, Professor, University of West Attica, Atina, Greece
28. Dr Ashok Pundir, professor, IN, NITIE-National Institute of Industrial Engineering, Mumbai, India

29. Dr Milica Drobac Pavićević, Associate Professor, Faculty of Philosophy, University of Banja Luka, Republic of Srpska
30. Dr art. Vesna Opavski, Lecturer, University of Donja Gorica in Montenegro, Humanistic studies, Montenegro
31. Dr Miodrag Ivanović, Professor, University of Hertfordshire, Hatfield, United Kingdom
32. Dr Ana Kovačević, Assistant Professor, Faculty of Security Studies, University of Belgrade, Belgrade, Serbia
33. Dr Sonja D. Radenković, Assistant Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
34. Dr Sandra Kamenković, Assistant professor, Assistant Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
35. Dr Ana Belén López Martínez, Professor, Grado en Ciencias de la Actividad y del Deporte UCAM, Spain
36. doc. dr Velinka Tomić, Faculty of Production and Management Trebinje, University of East Sarajevo, The Republic of Srpska, Bosnia and Herzegovina
37. Dr Radnović Branislav, professor, Educons University, Faculty of Business Economics, Novi Sad-Sremska Kamenica, Serbia
38. Dr Ana Savić, Professor of vocational studies, Academy of Technical and Art Applied Studies, School of Electrical and Computer Engineering, Belgrade, Serbia
39. Dr Perica Štrbac, Professor of vocational studies, Academy of Technical and Art Applied Studies, School of Electrical and Computer Engineering, Belgrade, Serbia
40. Dr Miodrag Paspalj, Professor of vocational studies, Belgrade Business and Arts Academy of Applied Studies, Department of Business and Information Studies, Belgrade, Serbia
41. Dr Natasa Marjanović, Assistant Professor, University of Business Studies Banja Luka in Banja Luka, Republika Srpska
42. Dr Carmen Eugenia Costea, Professor, Business Administration Doctoral School, Bucharest University of Economic Studies, Romania
43. Dr Larisa Mihoreanu, Associate Professor, Faculty of Administration and Public Management, Bucharest University of Economic Studies, Romania
44. Dr Senad Bušatlić, Professor, International University of Sarajevo, Faculty of Business and Administration, Sarajevo, Bosnia and Herzegovina
45. Dr Ognjen Ridić, Associate Professor, International University of Sarajevo, Faculty of Business and Administration, Sarajevo, Bosnia and Herzegovina

Ukoliko u budućnosti zbog razvojnih tendencija bude postojala potreba da se izvrše promene sastava recenzenata, o tome će odlučiti Upravni odbor na osnovu predloga Uredništva, svakog člana pojedinačno u pogledu prestanka njegovog članstva, odnosno uočenih potreba.

U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik
dr Valentin Kuleto

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education

5 Masarikova Street, Belgrade

11000 Belgrade

+381 (0)11 4011 260

E-mail: EdTech@institut.edu.rs

Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Decision

on the selection/list of reviewers

A List of Reviewers is formed comprising the following individuals:

1. Dr Aleksandar Kostić, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
2. Dr Slavko Pokorni, Professor of vocational studies, Information Technology School ITS-Belgrade
3. Dr Svetlana Anđelić, Professor of vocational studies, Information Technology School ITS-Belgrade
4. Dr Milosav Majstorović, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
5. Dr Šemsudin Plojović, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
6. Dr Miloljub D. Luković, Professor of vocational studies, Information Technology School ITS-Belgrade, Serbia
7. Msc Aleksandra Rosić, Lecturer, Information Technology School – Belgrade, Serbia
8. Dr Ivan Anić, Professor of vocational studies, Information Technology School – Belgrade, Serbia
9. Dr Hana Stefanović, Professor of vocational studies, Information Technology School – Belgrade, Serbia
10. Dr Zoran Grubišić, Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
11. Dr Velimir Dedić, professor, Faculty of Information Technology and Engineering, University Union Nikola Tesla, Belgrade, Serbia
12. Dr Marko Ranković, Assistant Professor, Faculty of Information Technology and Engineering, University Union Nikola Tesla, Belgrade, Serbia
13. Dr Rocsana Manea Bucea Tonis, Associate Professor Faculty of Physical Education & Sports, Spiru Haret University, Bucharest Romania
14. Dr Elena Gurgu, Assistant Professor, Department of Economic Sciences Bucharest, Spiru Haret University, Bucharest, Romania
15. Dr Oliva MD Dourado, Assistant Professor, Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugalija
16. Dr Dušica M. Filipović, Assistant Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
17. MsC art. Saša Fiipović, Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
18. Dr Dragan Čalović, Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
19. Dr Dušan Stojaković, Assistant professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
20. MArch Nina Stojanović, Assistant professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
21. Dr Nevenka Popović Šević, Assistant Professor, Faculty of Contemporary Arts, University Business Academy in Novi Sad, Serbia
22. Dr Slavko Vesković, Professor, Faculty of Transport and Traffic Engineering, University of Belgrade, Belgrade, Serbia
23. MSc Milutin Dobrilović, Faculty of Economics, University of Belgrade, Belgrade, Serbia
24. Dr Lazar Janić, Professor of vocational studies Belgrade Academy of Professional Studies, Department Medical College of Professional Health Studies, Belgrade, Serbia
25. Dr Jasmina Bašić, Professor of vocational studies, Belgrade Academy of Professional Studies, Department Medical College of Professional Health Studies, Belgrade, Serbia
26. Dr Vladimir Simović, Assistant Professor, Australian College of Kuwait, Australia
27. Dr Panos Photopoulos, Professor, University of West Attica, Atina, Greece
28. Dr Ashok Pundir, professor, IN, NITIE-National Institute of Industrial Engineering, Mumbai, India
29. Dr Milica Drobac Pavićević, Associate Professor, Faculty of Philosophy, University of Banja Luka, Republic of Srpska

30. Dr art. Vesna Opavski, Lecturer, University of Donja Gorica in Montenegro, Humanistic studies, Montenegro
31. Dr Miodrag Ivanović, Professor, University of Hertfordshire, Hatfield, United Kingdom
32. Dr Ana Kovačević, Assistant Professor, Faculty of Security Studies, University of Belgrade, Belgrade, Serbia
33. Dr Sonja D. Radenković, Assistant Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
34. Dr Sandra Kamenković, Assistant professor, Assistant Professor, Belgrade Banking Academy - Faculty for Banking, Insurance and Finance, Union University, Belgrade, Serbia
35. Dr Ana Belén López Martínez, Professor, Grado en Ciencias de la Actividad y del Deporte UCAM, Spain
36. doc. dr Velinka Tomić, Faculty of Production and Management Trebinje, University of East Sarajevo, The Republic of Srpska, Bosnia and Herzegovina
37. Dr Radnović Branislav, professor, Educons University, Faculty of Business Economics, Novi Sad-Sremska Kamenica, Serbia
38. Dr Ana Savić, Professor of vocational studies, Academy of Technical and Art Applied Studies, School of Electrical and Computer Engineering, Belgrade, Serbia
39. Dr Perica Štrbac, Professor of vocational studies, Academy of Technical and Art Applied Studies, School of Electrical and Computer Engineering, Belgrade, Serbia
40. Dr Miodrag Paspalj, Profesor of vocational studies, Belgrade Business and Arts Academy of Applied Studies, Department of Business and Information Studies, Belgrade, Serbia
41. Dr Natasa Marjanović, Assistant Professor, University of Business Studies Banja Luka in Banja Luka, Republika Srpska
42. Dr Carmen Eugenia Costea, Professor, Business Administration Doctoral School, Bucharest University of Economic Studies, Romania
43. Dr Larisa Mihoreanu, Associate Professor, Faculty of Administration and Public Management, Bucharest University of Economic Studies, Romania
44. Dr Senad Bušatlić, Professor, International University of Sarajevo, Faculty of Business and Administration, Sarajevo, Bosnia and Herzegovina
45. Dr Ognjen Ridić, Associate Professor, International University of Sarajevo, Faculty of Business and Administration, Sarajevo, Bosnia and Herzegovina
Should there, according to development tendencies, occur a need to change the composition of the list of reviewers, the Management Board will decide on the basis of a proposal of the Editorial Office, i.e. each reviewer individually regarding the termination of their reviewer status, i.e. according to identified needs.

Belgrade, 29 December 2021

Editor-in-Chief
Dr Valentin Kuleto

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa: EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Poziv za recenzente Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal

Institut za moderno obrazovanje i Naučni časopis za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal stalno tragaju za osobama koje su stručne u različitim oblastima usmerenim ka korišćenju informacionih tehnologija u razvoju privrede, društva i obrazovanja, i koje bi preuzele ulogu recenzenta. Recenzenti Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal su osobe iz akademskih sredina, sa univerziteta, fakulteta i naučnih instituta, i pojedinci ostvareni u stručnom i umetničkom radu. Ukoliko se prepoznajete u ovom opisu, pošaljite nam svoj CV na imejl-adresu EdTech@institut.edu.rs ili putem naših sajtova: <http://www.edtechjournal.org/> i <http://www.edtech-journal.org/>.

U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik
dr Valentin Kuleto

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education

5 Masarikova Street, Belgrade

11000 Belgrade

+381 (0)11 4011 260

E-mail: EdTech@institut.edu.rs

Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Invitation for reviewers of the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal

The Institute for Contemporary Education and the EdTech Journal are constantly looking for experts in various fields related to the use of information technology in the development of the economy, society and education, who would take on the role of reviewer. Reviewers of the EdTech Journal are from academia, universities, faculties and scientific institutes, and individuals who are accomplished in professional work. If you recognise yourself in this description, send us your CV to EdTech@institut.edu.rs or via our websites: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>.

Belgrade, 29 December 2021

Editor-in-Chief,
Dr Valentin Kuleto

Naučni časopis za savremeno obrazovanje
i primenu informacionih tehnologija – EdTech Journal
Uređivački odbor

Institut za moderno obrazovanje
Masarikova 5, Beograd
11000 Beograd
+381 (0)11/40-11-260
Imejl-adresa: EdTech@institut.edu.rs
Veb-sajt: <http://www.edtechjournal.org/> <http://www.edtech-journal.org/>

Recenzentski formular (sa uputstvom)

Poštovani recenzente, molimo Vas da pomognete Uređivačkom odboru da oceni rad identifikovan u nastavku. Molimo Vas da ovaj materijal i sadržaj tretirate kao strogo POVERLJIVO. Rukopis koji prati ovaj recenzentski formular je intelektualna svojina autora. Sva prava su zaštićena.

Molimo Vas da popunite formular koji pomaže u proceni podobnosti rada za objavljivanje u EdTech Journalu. **Pogodnost rada za objavljivanje u EdTech Journalu može se utvrditi popunjavanjem ovog obrasca. Neophodno je oceniti originalnost, relevantnost, metodologiju, validnost rezultata, zaključaka i ukupan kvalitet i prikladnost članka za objavu na skali od 1 do 5, gde 5 predstavlja apsolutni razlog za prihvatanje, a 1 apsolutni razlog za odbijanje rada.**

NASLOV ČLANKA: (Molimo dodajte.)

I KVALITET ČLANKA (Razmotrite svaki od sledećih aspekata članka i ocenite pomoću kružića ili podebljavanjem (boldovanjem) opcija u rasponu od 1 do 5 u zavisnosti od Vaše sklonosti.):

sklon ka odbijanju --- sklon ka prihvatanju

1	Sadržaj i svrha se odražavaju u naslovu koji je u skladu sa sadržajem članka.	1	2	3	4	5
2	Rezime je sažet i relevantan (od 150 do 200 reči).	1	2	3	4	5
3	Ključne reči članka služe kao dovoljan unos u indeks (do 5 reči).	1	2	3	4	5
4	Ciljevi istraživanja su jasno navedeni u uvodu.	1	2	3	4	5
5	Pregled opšteg znanja o predmetu istraživanja je dobro prikazan.	1	2	3	4	5
6	Dat je sažet i sistematičan opis metodologije studije.	1	2	3	4	5
7	Autorovi nalazi i rezultati istraživanja su podržani opsežnim pregledom problema (podržani najnovijim referencama i ISI citatima).	1	2	3	4	5
8	Osim što je originalan, članak daje značajan doprinos teoriji i praksi.	1	2	3	4	5
9	Rezultati istraživanja su validni u pogledu korišćene metodologije, izvedenih zaključaka i preporuka, kao i validnosti nalaza.	1	2	3	4	5
10	Rezultati, nalazi i preporuke su sumirani u zaključcima.	1	2	3	4	5

II OCENA TEKSTA I NJEGOVE PRIKLADNOSTI

(Ocenite svaki od sledećih aspekata članka pomoću kružića ili podebljavanjem (boldovanjem) opcija, a u rasponu od 1 do 5 u zavisnosti od Vaše sklonosti.):

sklon ka odbijanju --- sklon ka prihvatanju

11	Članak je dobro strukturiran u skladu sa uputstvom za autore i šablonom časopisa.	1	2	3	4	5
12	Dužina članka je odgovarajuća (3.500–5.000 reči za originalne naučne članke, pregledne članke i stručne članke; 800–2.000 reči za ostale tipove članaka).	1	2	3	4	5
13	Članak efikasno koristi grafikone, dijagrame i tabele.	1	2	3	4	5
14	Reference su aktuelne, a citati su formatirani u preporučenom stilu.	1	2	3	4	5
15	Članak je napisan na standardnom engleskom jeziku, bez grešaka u pravopisu i gramatici, zanimljiv je i relevantan domaćim i međunarodnim čitaocima.	1	2	3	4	5

III KONAČNA PREPORUKA

(Razmotrite svaki od sledećih statusa i koristite podebljanje (boldovanje) ili podvucite tekst za onu opciju koju ste izabrali.):

Prihvatite u sadašnjem obliku.
Prihvatite nakon manje revizije.
Ponovo razmotrite nakon veće revizije.
Odbiti.

DA NE	Da li ste svesni bilo kakvog potencijalnog sukoba interesa koji uključuje ovaj rad?
DA NE	Da li ste uspeali da otkrijete plagijat?
DA NE	Da li ste primetili da autori neprimereno samocitiraju?
DA NE	Da li imate dodatnih zabrinutosti u vezi sa etičkim implikacijama ove studije?

IV POTENCIJALNA KLASIFIKACIJA

(Ako ne dajete preporuku da se rad odbije, predložite odgovarajuću klasifikaciju, tako što ćete podebljati (boldovati) ili podvući svoj izbor.):

Naučni članci:

- originalan/izvorni naučni rad (rad u kome se iznose prethodno neobjavljivani rezultati sopstvenih istraživanja naučnim metodom);
- pregledni rad (rad koji sadrži originalan, detaljan i kritički prikaz istraživačkog problema ili područja u kome je autor ostvario određeni doprinos);
- kratko ili prethodno saopštenje (originalni naučni rad punog formata, ali manjeg obima ili preliminarnog karaktera);
- naučna kritika, odnosno polemika (rasprava na određenu naučnu temu zasnovana isključivo na naučnoj argumentaciji i korišćenjem naučne metodologije) i osvrti.

Stručni članci:

- stručni rad (prilog u kome se nude iskustva korisna za unapređenje profesionalne prakse, ali koja nisu nužno zasnovana na naučnom metodu);
- informativni prilog (uvodnik, komentar i sl.);
- prikaz (knjige, računarskog programa, slučaja, naučnog događaja i sl.);
- stručna kritika, odnosno polemika i osvrti.

V OPŠTI KOMENTARI I PREDLOZI ZA POBOLJŠANJE ČLANKA (vidljivo autorima):

VI PODACI O RECENZENTU:

Puno ime i prezime recenzenta	
Fakultet i departman recenzenta	
Univerzitet ili institucija recenzenta	
Država recenzenta	
Nastavno zvanje recenzenta (profesor/ predavač itd.)	
Akademsko zvanje (dr, mr)	
ORCID ID recenzenta	
Imejl-adresa recenzenta	
WhatsApp/Viber broj recenzenta	
5–8 ključnih reči o poljima stručnosti recenzenta	

Datum (format DD/MM/YY):

Potpis:

Scientific Journal for Contemporary Education
and Application of Information Technologies – EdTech Journal
Editorial Board

Institute for Contemporary Education
5 Masarikova Street, Belgrade
11000 Belgrade
+381 (0)11 4011 260

E-mail: EdTech@institut.edu.rs

Website: <http://www.edtechjournal.org/>; <http://www.edtech-journal.org/>

Reviewer evaluation form (with guidelines)

Dear reviewer, you are kindly requested to help the Editorial Board to evaluate the paper identified in forwarding lines. Kindly please treat this material and contents as strictly CONFIDENTIAL. The manuscript available accompanying this reviewer evaluation form is the intellectual property of the author(s). All the rights are protected.

You are kindly requested to fill in the form which helps evaluate the suitability of the paper for publishing in the EdTech Journal. **The paper’s suitability for publication in the EdTech Journal can be determined by filling out this form. It is essential to rate the article’s originality, relevance, methodology, the validity of results, conclusions, and overall quality and suitability on a scale of 1–5, where 5 represents an absolute reason to accept and 1 an absolute reason to reject the paper.**

THE TITLE OF THE ARTICLE: (please add)

I THE QUALITY OF THE ARTICLE (Consider each of the following aspects of the article and rate by using circle or bold options ranging from 1 to 5 depending on your inclination):

inclination to reject --- inclination to accept

1	Content and purpose are reflected in a title that is consistent with the article's content.	1	2	3	4	5
2	The summary is succinct and pertinent (up to 150–200 words)	1	2	3	4	5
3	The article's keywords serve as a sufficient index entry (up to 5 keywords)	1	2	3	4	5
4	The goals are clearly stated in the introduction.	1	2	3	4	5
5	A review of general knowledge about the research subject is provided.	1	2	3	4	5
6	A concise and systematic description of the study's methodology is provided.	1	2	3	4	5
7	The author's findings and research results are supported by an extensive overview of the issue (supported by up-to-date references and ISI citations).	1	2	3	4	5
8	In addition to being original, the article makes a significant contribution to theory and practice.	1	2	3	4	5
9	The research results are valid in terms of the methodology used, the conclusions and recommendations drawn, and the validity of the findings.	1	2	3	4	5
10	Results, findings and recommendations are summarised in	1	2	3	4	5

	conclusions.	
--	--------------	--

II EVALUATION OF THE TEXT AND ITS SUITABILITY (Please rate each of the following aspects of the article using circle or bold options ranging from 1 to 5 depending on your inclination):

inclination to reject --- inclination to accept

11	The article is well-structured and adheres to the Journal's format according to Article Template and Instructions for Authors.	1 2 3 4 5
12	The length of the article is appropriate (3,500–5,000 words for original scientific articles, review articles and professional articles; 800–2,000 words for other types of articles).	1 2 3 4 5
13	The article effectively utilises graphs, diagrams, and tables.	1 2 3 4 5
14	The references are current, and the citations are formatted in the recommended style.	1 2 3 4 5
15	The article is written in standard English, is error-free in terms of spelling and grammar, and is interesting and pertinent to domestic and international readers.	1 2 3 4 5

III FINAL RECOMMENDATION (Consider each of the following statuses and use the bold or underline for the one you chose):

Accept in present form
Accept after minor revision
Reconsider after major revision
Reject

YES	NO	Are you aware of any potential conflicts of interest involving this paper?
YES	NO	Were you able to detect plagiarism?
YES	NO	Have you noticed authors making inappropriate self-citations?
YES	NO	Do you have any additional concerns about this study's ethical implications?

IV POTENTIAL CLASSIFICATION (If the article is deemed positive (not to reject), please suggest an appropriate classification, bold or underline):

Scientific articles:

- original article / original scientific work (work in which previously unpublished results of own research by the scientific method are presented);
- review paper (paper that contains an original, detailed and critical presentation of the research problem or area in which the author has made a particular contribution);
- short or previous announcement (original scientific work of full format, but smaller volume or preliminary character).
- scientific criticism, i.e. controversy (discussion on a specific scientific topic based exclusively on scientific argumentation and using scientific methodology) and reviews.

Professional articles:

- professional article (an appendix offering experiences helpful in improving professional practice, but which are not necessarily based on the scientific method);
- informative article (editorial, commentary, etc.);
- presentation (book, computer program, case, scientific event, etc.);
- professional criticism, i.e. controversy and reviews.

V GENERAL COMMENTS AND SUGGESTIONS FOR IMPROVING THE ARTICLE (visible to the authors):

VI REVIEWER'S DATA:

Name of the Reviewer	
Department	
University or Institution	
Country	
Position (professor/lecturer, etc.)	
Academic title (Dr, MSc)	
ORCID ID	
E-mail	
WhatsApp/Viber Number	
5–8 keywords regarding the fields of expertise of the reviewer	

Date (format DD/MM/YY):

Signature:

EdTech

JOURNAL



Institut za
moderno obrazovanje
Institute for
Contemporary Education

CIP -Katalogizacija u publikaciji Narodna
biblioteka Srbije, Beograd

371.3
004.9:37

EDTECH Journal : naučni časopis za savremeno
obrazovanje i
primenu informacionih tehnologija = scientific Journal
for contemporary
education and application of information technologies /
glavni i odgovorni
urednik Valentin Kuleto. - [Štampano izd.]. - Vol. 1, br. 1
(2021)- . -
Beograd : Institut za moderno obrazovanje, 2021-
(Beograd : Jovšić
printing centar). - 36 cm

Godišnje. - Tekst na srp. i engl. jeziku. -
Ima izdanje na drugom jeziku: EdTech Journal (Online) =
ISSN 2812-8761
ISSN 2812-8753 = EdTech Journal (Štampano izd.)
COBISS.SR-ID 59423497