Zbornik 22. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2019

Zvezek H

Proceedings of the 22nd International Multiconference

INFORMATION SOCIETY – IS 2019

Volume H

Interakcija človek-računalnik v informacijski družbi
Human-Computer Interaction in Information Society

Uredili / Edited by

Bojan Blažica, Klen Čopič Pucihar, Matjaž Kljun, Ines Kožuh, Jure Žabkar

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9. oktober 2019 / 9 October 2019
Ljubljana, Slovenia

Uredniki:

Bojan Blažica
Odsek za računalniške sisteme
Institut »Jožef Stefan«, Ljubljana

Klen Čopič Pucihar
Fakulteta za matematiko, naravoslovje in informacijske tehnologije
Univerza na Primorskem, Koper

Matjaž Kljun
Fakulteta za matematiko, naravoslovje in informacijske tehnologije
Univerza na Primorskem, Koper

Ines Kožuh
Fakulteta za elektrotehniko, računalništvo in informatiko
Univerza v Mariboru, Maribor

Jure Žabkar
Fakulteta za računalništvo in informatiko
Univerza v Ljubljani, Ljubljana

Založnik: Institut »Jožef Stefan«, Ljubljana
Priprava zbornika: Mitja Lasič, Vesna Lasič, Lana Zemljak
Oblikovanje naslovnice: Vesna Lasič

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Ljubljana, oktober 2019

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2019

Multikonferenca Informaci družba (http://is.ijs.si) je z dvaindvajseto zaporedno prireditvijo tradicionalni osrednji srednjeevropski dogodek na področju informacijske družbe, računalništva in informatike. Informacijska družba, znanje in umetna inteligenca so - in to čedalje bolj – nosilci razvoja človeške civilizacije. Se bo neverjetna rast nadaljevala in nas ponesla v novo civilizacijsko obdobje? Bosta IKT in zlasti umetna inteligenca omogočila nadaljnji razcvet civilizacije ali pa bodo demografske, družbene, medčloveške in okoljske težave povzročile zadušitev rasti? Čedalje več pokazateljev kaže v oba ekstrema – da prehajamo v naslednje civilizacijsko obdobje, hkrati pa so notranji in zunanji konflikti sodobne družbe čedalje težje obvladljivi.

Letos smo v multikonferenco povezali 12 odličnih neodvisnih konferenc. Zajema okoli 200 predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic. Prireditev bodo spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica (http://www.informatica.si/), ki se ponaša z 42-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2019 sestavljajo naslednje samostojne konference:

- 6. študentska računalniška konferenca
- Etika in stroka
- Interakcija človek računalnik v informacijski družbi
- Izkopavanje znanja in podatkovna skladišča
- Kognitivna znanost
- Kognitonika
- Ljudje in okolje
- Mednarodna konferenca o prenosu tehnologij
- Robotika
- Slovenska konferenca o umetni inteligenci
- Srednje-evropska konferenca o uporabnih in teoretičnih računalniških znanostih
- Vzgoja in izobraževanje v informacijski družbi

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija, SLAIS, DKZ in druga slovenska nacionalna akademija, Inženirska akademija Slovenije (IAS). V imenu organizatorjev konference se zahvaljujemo združenjem in institucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V 2019 bomo sedmič podelili nagrado za življenjske dosežke v čast Donalda Michieja in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe bo prejel [redacted]. Priznanje za dosežek leta bo pripadlo [redacted]. Podeljujemo tudi nagradi »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je [redacted], jagodo pa [redacted]. Čestitke nagrajencem!

Mojca Ciglarič, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2019

The Information Society Multiconference (http://is.ijs.si) is the traditional Central European event in the field of information society, computer science and informatics for the twenty-second consecutive year. Information society, knowledge and artificial intelligence are - and increasingly so - the central pillars of human civilization. Will the incredible growth continue and take us into a new civilization period? Will ICT, and in particular artificial intelligence, allow civilization to flourish or will demographic, social, and environmental problems stifle growth? More and more indicators point to both extremes - that we are moving into the next civilization period, and at the same time the internal and external conflicts of modern society are becoming increasingly difficult to manage.

The Multiconference is running parallel sessions with 200 presentations of scientific papers at twelve conferences, many round tables, workshops and award ceremonies. Selected papers will be published in the Informatica journal with its 42-years tradition of excellent research publishing.

The Information Society 2019 Multiconference consists of the following conferences:

- 6. Student Computer Science Research Conference
- Professional Ethics
- Human – Computer Interaction in Information Society
- Data Mining and Data Warehouses
- Cognitive Science
- International Conference on Cognitonics
- People and Environment
- International Conference of Transfer of Technologies – ITTC
- Robotics
- Slovenian Conference on Artificial Intelligence
- Middle-European Conference on Applied Theoretical Computer Science
- Education in Information Society

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, SLAIS, DKZ and the second national engineering academy, the Slovenian Engineering Academy. In the name of the conference organizers, we thank all the societies and institutions, and particularly all the participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

For the fifteenth year, the award for life-long outstanding contributions will be presented in memory of Donald Michie and Alan Turing. The Michie-Turing award will be given to [redacted] for his life-long outstanding contribution to the development and promotion of information society in our country. In addition, an award for current achievements will be given to [redacted]. The information lemon goes to [redacted] The information strawberry is awarded [redacted] Congratulations!

Mojca Ciglarič, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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PREDGOVOR

Interakcija človek–računalnik v informacijski družbi je konferenca, ki jo organizira Slovenska skupnost za
proučevanje interakcije človek–računalnik. Namen konference je zbrati raziskovalce, strokovne delavce in študente s področja in ponuditi možnost izmenjave izkušenj in raziskovalnih rezultatov, kakor tudi navezave stikov za bodoče sodelovanje.

Tokratna, četrta reinkarnacija konference se prvič odvija pod okriljem novoustanovljenega SIGCHI poglavja ACM Chapter Bled k ustanovitvi katerega so prispevale ravno pretekle konference. O rasti HCI skupnosti v regiji pa priča tudi podvojeno število prispevkov, ki prihajajo z vseh večjih visokošolskih zavodov v Sloveniji in tudi iz tujine.

Teme, ki jih konferenca pokriva pa segajo od bolj uveljavljenih, kot so uporabnostno testiranje, vizualizacija in snovanje grafičnih uporabniških vmesnikov pa do virtualne in nadgrajene resničnosti, uporabniških vmesnikih v zdravstvu, avto-moto industriji, umetnosti in e-učenje.

FOREWORD

Human-computer interaction in information society is a conference organized by the Slovenian HCI community. The purpose of the conference is to gather researchers, practitioners and students in the field and offer the opportunity to exchange experiences and research results, as well as to establish contacts for future cooperation.

This year's fourth reincarnation of the conference is, for the first time, organized by the newly established SIGCHI Chapter ACM Chapter Bled, which is partly a result previous conferences. The growth of the HCI community in the region is also witnessed by the doubled number of contributions coming from all major higher education institutions in Slovenia and abroad.

The topics covered by the conference range from the more established ones, such as usability testing, visualization and design of graphical user interfaces to virtual and augmented reality, user interfaces in healthcare, automotive industry, arts and e-learning.

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Jure Žabkar

Analiza vpliva težavnosti računalniške igre na izmerjene vrednosti fizioloških signalov

Timotej Knez
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani
Večna pot 113
Ljubljana, Slovenija
tk7225@student.uni-lj.si

Martin Gjoreski
Odseka za inteligentne sisteme, Institut Jožef Stefan
Jamova cesta 39
Ljubljana, Slovenija
martin.gjoreski@ijs.si

Veljko Pejović
Fakulteta za računalništvo in informatiko, Univerza v Ljubljani
Večna pot 113
Ljubljana, Slovenija
veljko.pejovic@fri.uni-lj.si

POVZETEK

Dobra računalniška igra je več kot samo privlačna grafika in zvok, ali zanimiv scenarij. Igralnost, pri čemer upoštevamo tudi njeno tekmovalnost in zahtevnost, predstavlja zelo pomemben vidik privlačnosti igre. Sprotno prilagajanje težavnosti med igranjem je osnova za dolgoročno privlačnost igre, vendar tovrstno prilagajanje zahteva poznavanje trenutne kognitivne obremenjenosti igralca. V tej študiji preiskujemo zmožnost široko dostopnih cenovno ugodnih naprav, ki merijo fiziološke signale, kot so pametne zapestnice, za sprotno ugotavljanje kognitivne obremenjenosti igralca. V naši študiji s pomočjo Microsoft band 2 zapestnice merimo fiziološke signale med igranjem preproste mobilne računalniške igre na treh zahtevnostnih stopnjah, ki smo jo izdelali v ta namen. Na podlagi izmerjenih podatkov in z uporabo algoritmov strojnega učenja poskušamo napovedati težavnostno stopnjo igrane igre. Rezultati kažejo, da pri napovedovanju tristopenjske težavnosti najbolje deluje model zgrajen z algoritmom Random Forest, ki je dosegel klasifikacijsko točnost 64%, pri čemer je kontrolna točnost znašala 33%. Ko pa smo omejili učinke časa nošenja zapestnice na izmerjene vrednosti, je najbolje deloval model zgrajen s pomočjo algoritma podpornih vektorjev. V tem primeru je šlo za klasifikacijo prve igrane težavnosti, ki je bila lahko lahka ali težka. V tem primeru je model dosegel 67% klasifikacijsko točnost.

Keywords

mobilno zaznavanje, strojno učenje, kognitivna obremenjenost

1. UVOD IN OZADJE PROBLEMA

Industrija računalniških iger zahteva od izdelovalcev visoko uspešnost. Zato se že od prvih začetkov komercializacije poskuša najti način, kako pridobiti igralce.

Liu et al.[6] omenja vrsto tehnik, s katerimi ustvarjalci poskušajo izboljšati uporabniško izkušnjo svojih igric. Te so na primer izboljšava vizualnega okolja ali izdelava čim boljše zgodbe, vedno več pozornosti pa se posveča tudi prilagajanju težavnosti igre posamezniku.

Za doseganje sprotnega prilagajanja se lahko uporablja podatke, ki jih pridobivamo neposredno iz spremljanja igranja, primer takšnih podatkov bi bilo število zbranih točk, dosežen nivo, uporabnikov reakcijski čas, ali hitrost pritiskanja gumbov. Vendar ta način ugotavljanja obremenjenosti uporabnika zahteva posamezen model reakcij za vsako igrico posebej. Poleg tega so pri nekaterih igrah (npr. šah) reakcije bolj redke ali takšne, da je hitrost reakcije nepovezana z kognitivno obremenjenostjo uporabnika.

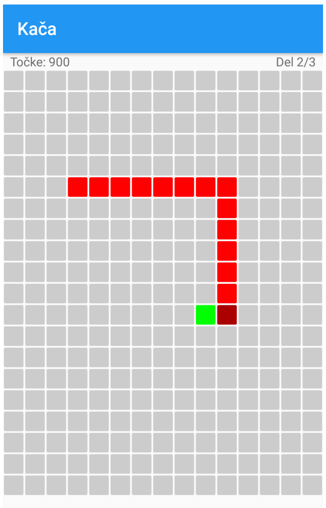
Zvišana psihološka obremenitev, npr. v obliki zahtevne naloge, povzroča aktivacijo simpatičnega živčevja, ki pa pospeši nekatere procese v telesu [2]. Znana je vrsta fizioloških signalov, ki sovpadajo z nivojem stresa, kot so na primer telesna drža, smer pogleda, EMG (elektromiogram) obraznih in drugih mišic, EKG, EEG signali. Bernardi et al. [1] so prikazali povezavo med nivojem stresa in podatki pridobljenimi iz različnih parametrov srčnega utripa. Podobno kot za srčni utrip je bila povezava prikazana tudi za druge signale, kot sta prevodnost in temperatura kože [7, 5]. Za meritev teh signalov se običajno uporablja posebna merilna oprema, ki pa je lahko draga in za uporabnika moteča. Za praktično uporabo bi bilo koristno, če bi bilo mogoče podatke pridobivati s pomočjo enostavno dostopne večnamenske in uporabniku nemoteče opreme. Poleg tega je nekatere izmed fizioloških signalov lažje meriti kot druge, zato se je za enostavno merjenje podatkov potrebno osredotočiti na lahko merljive signale, kot so srčni utrip, prevodnost kože in temperatura. Pomembno je tudi, da so ti signali čim bolj enoznačni, ponovljivi, ter da nanje vpliva čim manj stranskih dejavnikov.

Cilj raziskave je ugotoviti, ali bi bilo mogoče za določanje kognitivne obremenjenosti uporabnika uporabiti fiziološke signale, merjene z uporabo pametne zapestnice, sicer namenjene spremljanju športne vadbe. Na podlagi teh signalov bi potem lahko sprotno prilagajali parametre računalniške igre. Za preverjanje naše hipoteze smo izdelali Android aplikacijo s preprosto računalniško igro, ki jo je mogoče igrati na več težavnostnih stopnjah, med igranjem pa s pomočjo pametne zapestnice spremlja fiziološke signale igralca. Iz podatkov 22 prostovoljcev smo pripravili modele strojnega učenja, ki napovedujejo težavnost igre izključno na podlagi fizioloških signalov zajetih iz zapestnice. Rezultati kažejo, da je model zgrajen s pomočjo Random Forest tehnike najbolj natančen pri napovedovanju tristopenjske težavnosti – 64%, vendar, pri upoštevanju efekta časa nošenja zapestnice na zajete vrednosti fizioloških signalov, najbolj natančen model temelji na metodi podpornih vektorjev in dosega 67% natančnost pri napovedovanju dvostopenjske težavnosti.

2. UPORABNIŠKA ŠTUDIJA

2.1 Igrica

Za potrebe študije je bilo potrebno izdelati primerno računalniško igrico. Pomembno je bilo, da je igrica enostavna in razumljiva najširšemu krogu uporabnikov, da ima na igranje igre izkušenost igralca čim manjši vpliv, da igra omogoča enostavno spreminjanje težavnosti, ter dovolj zahtevna, da od uporabnika zahteva dovoljšnjo mero miselnega napora. Na podlagi teh zahtev smo se odločili za uporabo igre Kača. Izdelali smo svojo verzijo Kače za Android naprave. Igrici smo lahko enostavno prilagajali težavnost s pomočjo spreminjanja hitrosti premikanja kače. Med igro aplikacija zbira in shranjuje podatke s pametne zapestnice, ki je prek Bluetooth povezave povezana na telefon.



Slika 1: Zaslonski posnetek igre Kača

2.2 Pametna zapestnica

Uporabili smo pametno zapestnico Microsoft band 2 nižjega cenovnega razreda (cca. 100 EUR), ki je primarno namenjena spremljanju telesne vadbe. Zapestnica je merila podatke o srčnem utripu, prevodnosti kože in temperaturi kože. Poleg tega smo merili tudi pospeške, ki jih je občutila zapestnica.

2.3 Protokol testiranja

Med testiranjem so udeleženci raziskave igrali igro Kača na treh različnih težavnostnih nivojih. Vsak nivo je trajal vsaj dve minuti, vendar ne več kot tri minute. Takoj po končani posamezni težavnostni stopnji so udeleženci odgovorili na vprašalnik za določanje občutene zahtevnosti. Težavnostne stopnje so si sledile v vrstnem redu od najlažje do najtežje ali pa od najtežje do najlažje. Izbira med enim ali drugim zaporedjem je bila določena naključno. V naši raziskavi je tako 59% uporabnikov začelo igro z najtežjo stopnjo težavnosti. Za dve možni zaporedji smo se odločili zato, da smo lahko zagotovili čimbolj enostavno analizo podatkov. Zaradi pomanjkanja prostovoljcev so nekatere osebe izvedle več testov. Vse skupaj smo tako izvedli 27 eksperimentov.

Vprašalnik za določanje občutene zahtevnosti je vseboval šest vprašanj, ki jih določa NASA-TLX [4] vprašalnik, dodali pa smo še dve splošni vprašanji in sicer kako zahtevna ter kako zabavna se je uporabniku zdela igra. Vprašanja, ki jih določa NASA-TLX vprašalnik ocenjujejo miselni, fizični, ter časovni napor, kvaliteto izvedbe, vloženi trud in frustracijo. Na ta vprašanja so uporabniki odgovarjali z odgovori na 21 stopenjski Likertovi lestvici. Za oceno občutene zahtevnosti smo uporabili povprečno vrednost vseh odgovorov na NASA-TLX vprašanja.

3. ANALIZA IN REZULTATI

Zbrane podatke smo analizirali tako, da smo iz surovih podatkov najprej izračunali vrsto različnih značilk, nato pa smo uporabili različne algoritme strojnega učenja za napovedovanje težavnosti igre na podlagi teh značilk. Algoritme smo nato testirali z uporabo prečnega preverjanja, pri katerem smo v vsakem koraku kot testno množico uporabili podatke enega od uporabnikov, čigar podatkov nismo uporabili za gradnjo modela. Povezavo med značilkami in težavnostjo smo ocenjevali s pomočjo dosežene klasifikacijske točnosti.

3.1 Uporabljene značilke

Iz izmerjenih podatkov smo na podlagi metode Gjoreskega [3] izpeljali različne značilke osnovane na srčnem utripu, prevodnosti kože in temperaturi kože.

Značilke osnovane na srčnem utripu. Pričakujemo, da se bosta stres in miselni napor v srčnem utripu odražala tako, da se ob prisotnosti miselne obremenitve frekvenca srčnega utripa zviša, posledično se povprečen interval med utripi zmanjša, variabilnost intervalov med udarci srca pa se zmanjša [1], [8]. Zato so najpomembnejše lastnosti srčnega utripa, ki jih želimo zajeti v izpeljanih značilkah, frekvenca srčnega utripa in variabilnostih intervalov med posameznimi utripi (glej Tabelo 1).

Značilke osnovane na prevodnosti kože. Nourbakhsh et al. [7] so pokazali, da se stres in miselni napor odražata tudi v prevodnosti kože, zato smo uporabili tudi več značilk izpeljanih od tod (Tabela 2).

Značilke osnovane na temperaturi kože. Prikazano je bilo, da se stres in miselni napor odražata tudi v temperaturi kože. Primer tega so pokazali Herborn et al. [5], ki so raziskovali vpliv stresa na temperaturo kože pri toplokrvnih živalih. Zato smo izpeljali tudi nekaj osnovnih značilk iz temperature kože (Tabela 3).

Ime značilke	Oznaka
Povprečni srčni utrip	mean_hr
Povprečen čas med dvema zaporednima utripoma	ibi
Standardna deviacija časov med zaporednimi utripi	sdnn
Koren povprečja kvadratov razlik med sosednimi intervali	rmssd
Odstotek intervalov med zaporednimi utripi, ki so večji od 20 milisekund	pnn20
Odstotek intervalov med zaporednimi utripi, ki so večji od 50 milisekund	pnn50
SD1 indeks Poincarjevega grafa	sd

Tabela 1: Značilke osnovane na srčnem utripu.

Ime značilke	Oznaka
Povprečje prevodnosti kože	meanGsr
Standardna deviacija prevodnosti kože	stdGsr
25. centil prevodnosti kože	q25Gsr
75. centil prevodnosti kože	q75Gsr
Razlika med 1. in 3. kvartilom	qdGsr
Vsota odvoda signala prevodnosti kože	derivGsr
Povprečna moč signala, ki je izračunana kot povprečje kvadratov prevodnosti	powerGsr
Povprečno število vrhov na sekundo	rate_peaks
Vsota pozitivnih vrednosti v odvodu signala deljeno s številom meritev	sum_pos_deriv
Delež pozitivnih vrednosti v odvodu signala	prop_pos_deriv
Vsota odvoda osnove signala	deriv_tonic
Povprečna razlika med signalom in osnovo signala	sig_tonic_diff
Moč signala v različnih frekvencah	fp01-fp06
Razlika med maksimumom in minimumom signala	sig_overall_change
Razmerje med trajanjem največje spremembe in velikostjo spremembe.	change_rate
Značilke spremembe amplitude signala	*
Značilke vrhov signala	*

Tabela 2: Značilke osnovane na prevodnosti kože. * - združeno zaradi prostornih omejitev.

3.2 Rezultati klasifikacije

Podatke za analizo smo pripravili tako, da smo iz izmerjenih podatkov izračunali značilke. Napovedovalne modele smo nato testirali na rezultatih enega udeleženca naenkrat. Model smo učili na rezultatih preostalih udeležencev. Pri tem smo uporabili naslednje algoritme: random forest (RF), support vector machine (SVM), AdaBoost in logistična regresija (Log. reg.). Najboljšo klasifikacijsko točnost smo dobili z uporabo random forest (RF) algoritma, ki je pravilno napovedal 64% meritev (Tabela 4). Za kontrolo smo uporabili konstantni klasifikator.

Glede na to, da nam random forest klasifikator daje najboljše rezultate, je smiselno, da si ga podrobneje ogledamo. Če pogledamo matriko napovedi (Slika 2), lahko vidimo, da se srednja težavnost klasificira zelo dobro, med tem ko se pri ostalih dveh težavnostih bolj pogosto zgodi, da jih klasifikator zameša.

Ime značilke	Oznaka
Povprečna vrednost temperature kože	st_mean
Standardni odklon temperature kože	st_std
Razlika med kvartili temperature kože	st_qd
Povprečna hitrost spreminjanja temperature kože	st_diff

Tabela 3: Značilke osnovane na temperaturi kože.

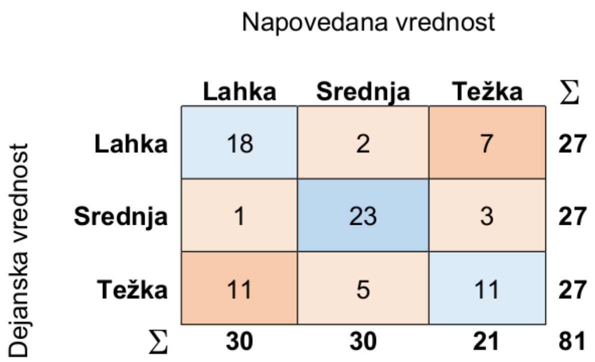
Tabela 4: Rezultati testiranja napovednih modelov. CA – classification accuracy (natančnost klasifikacije), AUC – Area Under Curve (območje pod krivuljo).

	Več. klas.	RF	SVM	AdaBoost	Log. reg.
CA	0.333	0.642	0.494	0.519	0.506
AUC	0.500	0.815	0.636	0.639	0.660

3.2.1 *Odvisnost meritve od trajanja uporabe zapestnice*

Kar nekaj izmed uporabljenih značilk se močno spreminja v odvisnosti od časa nošenja zapestnice, kar bi lahko povzročilo, da bi se klasifikator naučil ločevati med fazami testa na osnovi časa nošenja zapestnice namesto na osnovi dejanske težavnosti naloge. Ta učinek smo poskusili zmanjšati tako, da je polovica udeležencev različne težavnosti reševala v obratnem vrstnem redu, vendar pa se nam je ravno zaradi rezultata, da klasifikator večkrat zameša skrajni težavnostni stopnji, pojavil sum, da je težava kljub temu ukrepu še vedno prisotna. Ta sum smo še dodatno potrdili s tem, da smo uporabljene značilke rangirali na podlagi vrednosti gain-ratio. Ob tem smo ugotovili, da najvplivnejše značilke temeljijo na prevodnosti ter temperaturi kože in so zato odvisne od časa nošenja zapestnice.

Da bi to neželeno odvisnost odstranili, smo analizo podatkov ponovili na ta način, da smo pri vsakem izmed testiranj enako kot prej podatke normirali na podlagi vseh treh faz testiranja, pri klasifikaciji pa smo uporabili samo prvo fazo testiranja. Na ta način smo izločili večino učinkov, ki jih ima čas nošenja zapestnice na rezultate. V tem primeru sta bila ciljna razreda samo dva: lahka in težka stopnja, pri tem je težki stopnji pripadalo 59% podatkov (Tabela 5).



Slika 2: Matrika napovedi za random forest.

Tabela 5: Rezultati napovedovanja težavnosti prve faze testiranja.

	Več. klas.	RF	SVM	AdaBoost	Log. reg.
CA	0.593	0.630	0.667	0.667	0.630
AUC	0.500	0.600	0.625	0.625	0.600

V tem primeru vidimo, da je najboljši klasifikacijski algoritem metoda podpornih vektorjev (SVM), ki je dosegel 67% klasifikacijsko točnost. Ta vrednost sicer ni veliko višja od izhodiščne vrednosti, ki znaša 59%, vendar pa kljub temu nakazuje na to, da obstaja določena povezava med izmerjenimi fiziološkimi podatki ter težavnostjo igrane igre. Nekoliko slabši rezultat lahko pripišemo tudi dejstvu, da je bila za postavitev modela uporabljena samo tretjina meritev, saj smo za analizo uporabili samo podatke prve težavnostne stopnje od treh odigranih.

4. ZAKLJUČEK

V tem projektu smo poskusili ugotoviti, ali bi bilo mogoče uporabiti fiziološke signale, pridobljene s pomočjo pametne zapestnice, za ugotavljanje zahtevnosti igre, ki jo igra igralec. Poskušali smo potrditi hipotezo, da obstaja povezava med izmerjenimi biološkimi signali in težavnostjo igre, ki jo igra igralec. Za potrditev hipoteze smo izvedli eksperiment, pri katerem so prostovoljci igrali preprosto računalniško igro na treh različnih težavnostnih stopnjah. Med igranjem smo preko pametne zapestnice Microsoft band 2 spremljali njihove fiziološke signale in iz njih izračunali vrsto značilk. Na podlagi teh značilk smo z uporabo različnih algoritmov strojnega učenja izdelali modele za napovedovanje težavnosti igrane igre na podlagi uporabljenih značilk. Težavnost smo klasificirali v tri razrede in dosegli 64% klasifikacijsko točnost, vendar smo odkrili, da na napovedi vpliva čas nošenja zapestnice. Zaradi tega smo analizo ponovili tudi tako, da smo za vsak test upoštevali le prvo stopnjo testiranja, ki je imela pri nekaterih testih težko, pri nekaterih pa lahko težavnost. Na ta način smo se izognili učinkom trajanja nošenja zapestnice. V tem primeru so klasifikatorji dosegli točnosti okoli 67%, kar je občutno več kot 59%, ki jih je dosegel kontrolni klasifikator. Na podlagi teh rezultatov lahko potrdimo, da povezava med našimi izmerjenimi signali in težavnostjo igre res obstaja in da bi bilo mogoče sprotno prilagajanje iger z uporabo komercialno dostopne in splošno namenske opreme, ki igralcu ni moteča. V prihodnosti načrtujemo eksperiment razširiti z uporabo značilk, ki niso odvisne od časa nošenja zapestnice oziroma bi učinek nošenja zapestnice pri odvisnih značilkah zmanjšali z uporabo ustrezne normalizacije signalov.

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Privacy preserving indoor location and fall detection system

Aleksandar Tošić
aleksandar.tosic@upr.si
University of Primorska, UP FAMNIT
Koper, Slovenia
InnoRenew CoE
Izola, Slovenia

Jernej Vičič
jernej.vicic@upr.si
University of Primorska, UP FAMNIT
Koper, Slovenia
ZRC-SAZU
Koper, Slovenia

Michael David Burnard
mike.burnard@innorenew.eu
InnoRenew CoE
Izola, Slovenia
University of Primorska, UP IAM
Koper, Slovenia

ABSTRACT

In this paper we present a prototype implementation of location aware floor tiling system. The prototype is based on cost effective and readily available sensors and controllers. They were designed to be easy to install and modular. A dynamic range adjustment algorithm was developed to make the system more flexible and more material agnostic. This allows the sensors to be integrated under virtually any flooring. The system was designed for passive and privacy preserving location detection but can be applied in various fields. In this paper we focus on the application of the technology for fall detection, studying behaviour patterns of buildings occupants, and other telemetry related to health.

CCS CONCEPTS

• **Computer systems organization** → **Embedded and cyber-physical systems**; • **Human-centered computing** → *Human computer interaction (HCI)*; • **Software and its engineering** → Software notations and tools.

KEYWORDS

Privacy preservation, Sensor Network, Location Detection, Smart Buildings

1 INTRODUCTION

Smart buildings have gained a lot of attention from both research and industry. Collecting information about the state of the building and its occupants can be very beneficial to many fields ranging from structural health monitoring, studying behavioral patterns that aid in designing buildings, and monitoring the health of a building's occupants. Most software and hardware combinations require knowledge about the position of occupants within the building at any given time. The existing approaches to on-site location data collection suffer from both usability issues and technological obstacles. Typical implementations include but are not limited to wearable devices (i.e., location aware bracelets) that can be discarded by unaware users, or require frequent battery charging, on-site support, and maintenance. Sensor networks that do not rely on wearable devices usually include cameras and microphones coupled with automatic face detection software that have a psychological impact on occupants and raise privacy concerns. To overcome these issues, the inventors designed a network of force resistor sensors deployed under the finishing layer of a floor. A high enough density of sensors allows for very accurate location detection, as well as detection of other forced-based phenomena such as falls. Additionally, walking patterns can be detected and analyzed to not only locate buildings occupants but plot a historical path. Moreover, the data can be used to create a heat-map and study behavioural patterns in of certain locations within the building. The Internet of Things (IoT) is experiencing widespread adoption across industry sectors ranging from supply chain management to smart cities, buildings, and health monitoring. However, most architectural patterns for IoT deployment rely on centralized cloud computing infrastructures [10] for providing storage and computing power. Cloud providers have high cost-based incentives to organize their infrastructure into clusters. Concerns about data protection and privacy have been growing in recent years due the frequency and severity of big data breaches becoming public [13]. As IoT adoption grows, more privacy preserving solutions and architectures must be developed to protect sensitive user data and at the same time allow harnessing the true potential of large scale sensor networks. The overall fall detection system market was valued at USD 358.6 million in 2016 and is expected to reach USD 497.3 million by 2022, at a CAGR of 5.58 % between 2017 and 2022 [12]. The growth of the fall detection market is largely driven by the growing population of older adults that can benefit from better accessibility to assistance in case of falls, improved health outcomes for those that fall, reduced medical expenses. In turn, these factors have driven increased demand for smartphone and wearable technology-based fall detection systems, and increased demand for multimodal technology. However, the low practicality and acceptability of the technology among older adults, and the use of data from simulated conditions for designing fall detection system algorithms acts as a restraining factor for the market. The technology proposed here addresses exactly these restraints. Multimodal sensors include accelerometers and gyroscopes; magnetometers; and audio, images, and video clips via speech recognition and on-demand video techniques. The last group is avoided by our system as it clashes with personal data concerns. The popularity of machine learning methods is the primary reason behind the growth of the market for multimodal sensors in the fall detection system market. Machine learning algorithms needs an array of data sources (e.g., sensor data) to carry out a real-time analysis of numbers and differentiate a fall from other activities of daily living [4]. Along with this, multimodal sensors also use artificial intelligence (AI) to detect falls.

2 POTENTIAL USE CASES

Two key features of the proposed solution are high availability and low costs. These attributes make the technology suitable for a wide range of solutions in a variety of environments. The inventors have proposed the following use-cases:

- Specifically designed algorithms that can detect accidental falls which can be used in homes for older adults, rehabilitation centres, and other cases that support fall-prone individuals. In case a fall is detected the system alerts caregivers.
- Analyzing collected data can provide more insights into how specific areas of the building are being used. This information can help optimize the design of future buildings (and improve existing ones), improve energy efficiency, and optimize the use of active systems. These gains apply to multi-passenger vehicles such as cruise ships and airplanes, as well.
- Specific solutions where anonymous tracking of occupants is needed, such as health institutions treating patients with Alzheimer's, and buildings with high occupancy dealing with extraordinary situations (i.e., when evacuation is required before activating fire suppression systems).

The proposed solution falls into the broad category of smart building technologies. It is estimated that global IoT smart building market will approach $51.44B USD globally by 2023 and 33 % of IoT smart building market will be powered by AI technologies by then. North America will lead the IoT smart building market with 36 % share. Smart building automation systems will grow at 48.3 % CAGR from 2018 − 2023. The key solution areas are MEC, 5G, real-time IoT data analytics, and asset tracking.

3 STATE OF THE ART - RESEARCH AREA DESCRIPTION

Demographic change towards an older society has driven both interest and innovation in technological solutions for older adults. However, technology adoption by older adults is lower than in other demographic segments. Lee and Coughlin [9] cite a lack of understanding in the needs, lifestyles, and expectations from technologies designed for them by a younger demographic. This gap poses an obstacle to realizing the potential of fall-detection technologies (and other solutions). However, passive solutions that remain cost competitive should encounter fewer barriers to adoption. Fall detection systems that maintain privacy and don't require active use (i.e., don't require actively wearing a monitoring device) are likely to be considered a valuable system by more users.

While there is no clear agreement on how to classify fall detection systems [6], the simplest classification is into two broad categories: wearable, and non-wearable [2, 8]. Wearable systems are typically based on accelerometers or gyroscopes in garments or other worn items (i.e., jewelry) that detect changes in the plane of motion [2]. Non-wearable systems are typically environmental sensors that may be cameras (e.g., infrared, video), acoustic sensors like microphones, or pressure plates [2]. Other classifications of fall detection systems are divided based on data source (i.e., vision-based, ambient sensors, kinematic sensors; [5]); data availability (i.e., because falls are rare events, a taxonomy based on data sufficiency is critical [7]). Other perspectives on fall detection are based on more human-centric approaches and discuss the status of the person before and after the fall (i.e., falls from sitting and standing positions may present themselves differently to different sensors, or that differences in body shape and position may impact fall detection to different sensors) [14]. Fall detection systems based on mobile devices has recently gained interest as well (c.f., [3], [1], [11]).

In addition to the value fall detection systems provide and their cost, other major concerns are privacy and reliability. The reliability of passive wearable devices are influenced by system issues (e.g., power source, connectivity, functionality, etc.) in addition to the requirement that they be worn, which requires active measures from the user. Non-wearable passive systems have the same system reliability concerns, but do not require active engagement from the user to fulfill their purpose. However, passive systems require the system be installed where the user will spend their time. Some active systems can follow the user beyond the confines of their residence, for example those based on mobile devices connected to cellular networks.

Fall detection systems are largely targeted towards older adults and other vulnerable groups that are likely to suffer from falls. However, the same technology can be applied in other situations as well. Pressure sensing floors may also be used to detect the presence of people in critical areas, for example to ensure an evacuation has occurred before fire suppression systems that can harm or kill people are activated. These systems operate based on sensors installed in floor systems that may replace standard floors entirely or may be mats that cover floors in critical areas.

4 THE PILOT IMPLEMENTATION

The pilot implementation is a floor system measuring 120 cm by 120 cm, with a standard laminate flooring surface over a layer of rolled foam insulating subfloor. Below this layer, a system of 9 force sensors are placed and wired to an Arduino micro-controller. When force is applied to the floor, for example by walking across, standing, or placing objects on it, voltage differential is measured to obtain estimates of amount of force applied to each sensor individually. The type of sensors used in pressure sensing tiles are force sensitive resistors that can sense force anywhere in the range of 100g-10kg.

The range can be altered by applying different resistance which was used to increase the interval to 30kg. The sensor network is dynamic, making it difficult to model. There are many factors contributing to the constant change in differential between force applied on the top of the floor tiling (i.e., walking) and measured force mostly due to unpredictable changes in the materials on all layers. Moreover, there are discrepancies between the sensing ranges of each individual sensor. Due to the varying compression resistance in the floor materials, one sensor in the network can measure higher pressure differentials than others where the material compresses less. Our solution is a dynamic range adaptive algorithm that constantly adapts the sensing range obtained from the initial calibration process. For each sensor, bounds are set as an interval $[x, y]$. The algorithm monitors the data stream and searches for new maximum and minimum values that are used to decrease the lower bound x or increase the upper bound y respectively. However, the increase is done by using the moving average with a configurable window. This is to mitigate potential outliers. To test the prototype, an application was built that can process the data stream from the controller and visualize the pressure detection in a form of a heat map. The software also includes a calibration guide for the initial setup that can be observed in Figure 2. The application also provides the an interface for data analysis. Modules can be developed to hook up to the data stream. The data stream is a snapshot of sensor data sent over a serial port (USB) every 200ms. The interface will be used to develop different modeling techniques to detect falls such as neural networks, association rules, etc.

5 DISCUSSION AND FUTURE CHALLENGES

A pilot implementation of the hardware and software solution was prepared at the beginning of 2019 and presented at the Chamber of Commerce and Industry of Slovenia at the Future Living exhibition. The setting was on display (and available for testing) for four months with no intervention. The setting comprised of an array of pressure sensing sensors integrated in a laminate floor system. The sensors were connected to a micro-controller that dynamically adjusted the sensing ranges of the array. The algorithm was capable of sensing and later ignoring placed objects. Although the technology has been tested on a small pilot implementation, the challenges presented by a specific implementation setting will bring unforeseen challenges. These challenges are amplified as most of the expected use cases involve humans and

Figure 1: Prototype solution using off-the-shelf sensors under a standard laminate floor. Arduino Mega collects all the data and a program on a notebook running all our algorithms visualizes possible fall situations.

Figure 2: Software calibration

human behaviour is hard to model. The integration of the proposed systems to the customer's environment depends also on the technologies used by the customer although the systems were developed using open interfaces. Additionally, the behaviour of the sensor grid must be tested on other materials that are less flexible and hence, decrease the sensing accuracy of the load cells. Mass production of the sensor tiles is also an aspect that still needs to be addressed. At the time of writing, a modular design based on integrated connectors in the shape of puzzle pieces is being considered. The puzzle type tiles could allow for seamless assembly with no wiring needed to create a special sensing layer underneath any type of floor.

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Exploratory data analysis of stream data in sports medicine domain

Maja Vrancich
maja.vrancich@inf.uniri.hr
University of Rijeka, Department of Informatics
Rijeka, Croatia

Maja Matetic
majam@inf.uniri.hr
University of Rijeka, Department of Informatics
Rijeka, Croatia

ABSTRACT

In statistics, exploratory data analysis (EDA) is an approach to analyzing datasets to summarize their main characteristics, often with visual methods. A statistical model may optionally be used, but primarily EDA is for seeing what the data can tell us beyond the formal modeling or hypothesis-testing task. In this paper, we focus on analyzing stream data for the sports medicine domain, collected with a Polar M400 sports watch, with the aim of predicting the heart rate that the athlete must sustain on each race segment in order to achieve the best overall result (finishing time). We first provide an overview of data analyzing models for stream data. Next, we present related work, our data, and preliminary insights from visualizations after data preprocessing. Finally, we conclude the paper with a summary and future work.

CCS CONCEPTS

• **Applied computing** → *Health informatics*; • **Computing methodologies** → *Machine learning approaches.*

KEYWORDS

Data analysis, stream data, time-series data, sports medicine, heart rate.

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1 INTRODUCTION

Advances in GPS technology have enabled users to track outdoor activities like running, swimming, hiking, or cycling with their smartphones or GPS-enabled watches. Instead of merely gauging average pace, users can record their exact routes, as well as elevation changes, heart rate (HR) frequency, and other data.

In sports such as cycling, the main variable for training planning and analysis is the power expressed by each pedal stroke, but in running, and particularly in trail running, there is no universally accepted method to measure the power output of the athlete. For that reason, the main variable we consider in this study is heart rate. Accurate heart rate monitoring is essential in fitness, training, and testing. Clapp and Little [3] showed that manual pulse palpation provides inaccurate results. The use of the electrocardiogram (ECG) or Holter monitoring is too costly and complex for athletes to use in the field. The first wireless heart rate monitor, the portable Polar PE 2000, was introduced in 1983. It consisted of a transmitter and a receiver. The transmitter could be attached to the chest using either disposable electrodes or an elastic electrode belt. The receiver was a watch-like monitor worn on the wrist. The wireless Polar heart rate monitoring method was developed in the Department of Electronics at the University of Oulu. In the beginning, the heart rate monitors were targeted for coaches and athletes to optimize the quality and efficiency of training. Soon, exercise scientists started to research the monitors and use them in their work. Today, the selection of heart rate monitors includes easy-to-use products for everyone interested in wellness, fitness, and health [9].

Sports watches had been one of the most important training tools for every amateur and professional athlete in the past, and after incorporating GPS technology, they became even more valuable. These watches have huge advantages over previous generations of devices, because they precisely measure characteristic training data. As a result, runners and cyclists do not need to use any special sensors for determining their speed, altitude, or duration of activity [6].

Selecting the most promising algorithm to model and predict a particular phenomenon is the main interest of temporal data forecasting. Forecasting (or prediction), similarly to other data mining tasks, uses empirical evidence to select the most suitable model for the problem at hand, since no modeling method may be considered the best [12]. Each tracked activity is saved into a file. Data mining could be applied to this collection of data, which would help athletes analyze their workouts, predict their further training activities, give advice about nutrition, etc. [5].

This paper is organized as follows. In Section 2 we go over related work. Next, in Section 3 we present our data and the results of EDA. Finally, we present future work and conclude the paper in Section 4.

2 RELATED WORK

Current state-of-the-art in data analysis for time-series data based on HR comprises diverse research, ranging from clinical decision-support systems, over heart disease predictions, to smart coaching. In this section, we briefly review existing work in the sports domain, which is closely related to our proposed problem.

Fister et al. [6] introduce a novel intelligent planning method for training sessions: training plans are computer-generated using the Bat Algorithm, according to reliable data obtained from sports watches.

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Gronwald et al. [7], use detrended fluctuation analysis to assess heart rate correlation properties, examine the influence of exercise intensity on total variability and complexity in non-linear dynamics of heart rate variability.

Billat et al. [1] detect marathon asymmetry with a statistical signature. They tested marathon running performance, and revealed significant statistical features by analyzing speed time-series data recorded by 273 runners' GPS trackers. The combination of trend and asymmetry build up a statistical signature for the speed time-series, which is identical regardless of performance level, gender, or race profile.

Using data from the GPS-based Strava application, Marty [11] predicts the speed of individual riders, at specific times in the day, on a 2-mile segment of a popular cycing track using Ridge Regression model.

Jin [8] uses data from previous training runs, and applies four regression models to predict a run pace for a specific route or segment in future runs: basic linear regression, as well as Weighted, Ridge regression, and Lasso regression.

Pharoah [13] develops and validates a new walking pace function using crowd-sourced GPS data. There are several functions hikers use to predict walking time based on elevation change or slope, the most popular of which is the Naismith function.

Parmezan et al. [12] provides a systematic literature review of the last decade, identify state-of-the-art models for time-series prediction, and test those methods on 95 datasets. They conclude that SARIMA is the only statistical method able to outperform, but without a statistical difference, the following machine learning algorithms: ANN, SVM, and kNN-TSPI. However, such forecasting accuracy comes at the expense of a larger number of parameters.

3 DATA COLLECTION

The dataset used for this project was extracted from the Polar Flow API[1]. Polar Flow is a free online tool for planning and analyzing training, activity, and sleep, using data tracked with Polar devices.

The analyzed data was collected from a single athlete's Polar M400 sports watch, in the period between June 2017 and July 2019. In that time, 133 training sessions were logged in various sport profiles: 'running', 'trail running', 'hiking', 'orienteering', 'vertical sports wall climbing', 'watersports kayaking', 'strength training', 'mobility dynamic', 'mobility static', 'core', 'other outdoor', and 'other indoor'. The Polar M400 wrist watch is equipped with a GPS sensor, and paired with a chest strap heart rate monitor. Each training session's data is stored in a separate .json file. This data was preprocessed, and multiple features used for data visualization.

The data was parsed into two separate csv files: "summary data" (further reference MV01), containing a brief overview of each logged training session; and "seconds data" (further reference MV02), containing detailed information recorded for every second of a particular training session.

In outdoor activities, GPS related data is stored in intervals of one second: HR (heart rate), altitude, speed, distance and GPS position (longitude and latitude). This were the training sessions we are interested in because we want to find out how is one's heart

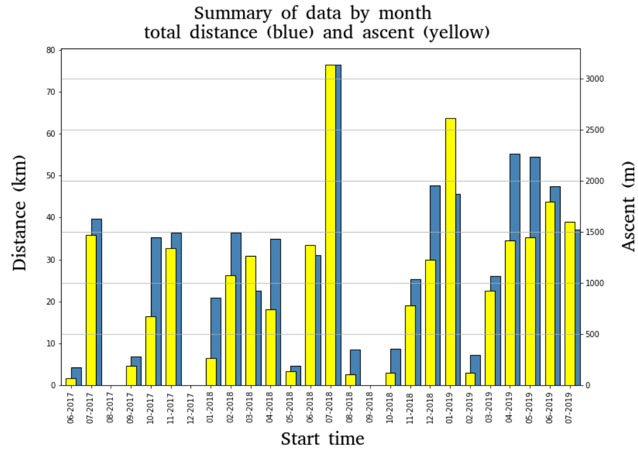

Figure 1: Summary of data by month; total distance (blue) and ascent (yellow)

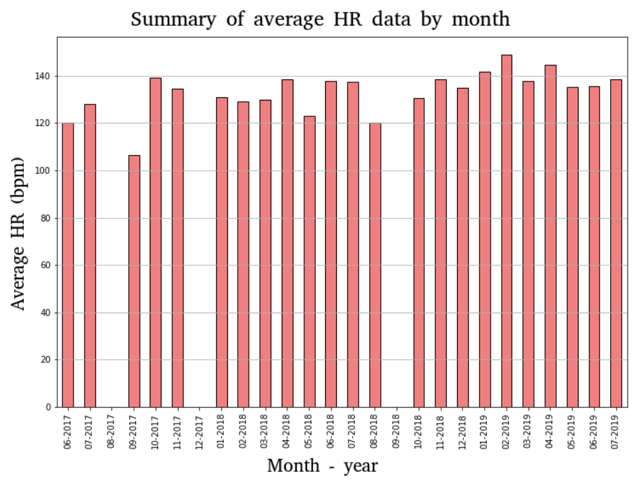

Figure 2: Summary of average HR data by month

responding to different terrain (slopes) and to progress over time due to training sessions done in the past.

In parsed files (MV01 and MV02), if some row of the file had missing data, it meant that it either wasn't done outside (no GPS related data like speed and altitude) or that heart rate strap haven't been worn (no HR data). There was no reason for keeping this rows and they were eliminated (dropped). In the end only training sessions of running, trail running and hiking were kept.

Table 1 lists the parameters recorded in MV01. The data in this file shows a general picture of the training sessions, and is used for extracting metadata about the person conducting the training sessions. In this case, VO_2 max, maximum and resting heart rate, aerobic and anaerobic threshold were changed only once. To increase data precision, the VO_2 max [14] test should be done periodically.

From summary data given in Figure 1, we can easily see the total distance and ascent done in training sessions of every month. When the distance bar is higher then the ascent bar, the training sessions

[1] https://flow.polar.com/

were done on easier terrain (less altitude difference gained), and on steeper terrain in the opposite case. The longest distance was crossed in July 2018 (76.5 km), followed by May and June 2019 (55.3 and 54.5 km, respectively). Additionally, Figure 2 shows the average heart rate by month. One might expect higher average HR in months of higher training intensity, but this is not the case. This data is not very useful or explanatory without information on how "hard" the training was (which is based on speed and altitude difference). That is why we moved to more informative data, aggregated in MV02.

Parameters used in MV02 are shown in Table 2. Data was collected from the same training session files, and again preprocessed.

Table 1: Attributes of summary data file

Parameter	Description
startTime	Date and time at the beginning of the training session
stopTime	Date and time at the end of the training session
sport	Activity practised in given training session (for example: running, trail running, orienteering, stretching, hiking, core, etc.)
VO2max	VO_2 max is the maximal rate of oxygen uptake it is an important determinant of cardio-respiratory fitness and aerobic performance [14]
maximumHeartRate	Maximum heart rate – a variable that is editable in an athlete's on-line profile (based on latest test)
restingHeartRate	Resting heart rate
aerobicThreshold	Aerobic threshold – the exercise intensity (HR) beyond which blood lactate concentration is no longer linearly related to exercise intensity, but increases with both exercise intensity and duration [10]
anaerobicThreshold	Anaerobic threshold – maximum steady-state lactate concentration [4]
distance	Overall distance crossed in given training session, measured in meters (every training session starts at 0 and counts meters continuously)
ascent	Overall ascent done in given training session, measured in meters
descent	Overall descent done in given training session, measured in meters
HRmin	Minimal HR measured during given training session
HRavg	Average HR measured during given training session
HRmax	Maximal HR measured during given training session

Table 2: Attributes of detailed data file

Parameter	Description
datetime	Exact time when sensors send data, every 1 second for every training session
f_num	File number, used for easier data editing
altitude	Altitude expressed in meters (exact altitude in given second)
heartrate	Heart rate frequency (e.g. 155)
speed	Moving speed in given second
distance	Distance, measured in meters (every training session starts at 0 and counts meters continuously; this parameter shows meters crossed from start of session to current point in time)
sport	Activity practised at given training session (for example: running, trail running, orienteering, stretching, hiking, core, etc.)

Table 3: Standard slope descriptors

Slope (%)	Approximate degrees	Terminology
0 - 0.5	0	Level
0.5 - 2	0.3 - 1.1	Nearly level
2 - 5	1.1 - 3	Very gentle slope
5 - 9	3 - 5	Gentle slope
9 - 15	5 - 8.5	Moderate slope
15 - 30	8.5 - 16.5	Strong slope
30 - 45	16.5 - 24	Very strong slope
45 - 70	24 - 35	Extreme slope
70 - 100	35 - 45	Steep slope
> 100	> 45	Very steep slope

We used only training sessions of running, trail running and hiking, and missing or incomplete data was dropped. Altitude difference was calculated over intervals of one second, and data aggregated in intervals of approximately 100 meters. Slope classification was added according to Barcelona Field Studies Centre [2] to each segment (see Table 3), along with ascent or descent labels, and the data was further grouped by slope and aggregated. We can see in Figure 3 that most training sessions were done on very gentle and gentle slope.

This data is going to be used in further modeling and predicting the best HR for each incline category of future races, based on provided GPS data on the particular track, and generated heart model of the athlete.

It is visible from Figure 4 that, while average HR has its own peaks (highest HR is achieved on races), average speed increases constantly over time, which means that athlete's overall form is improving over time.

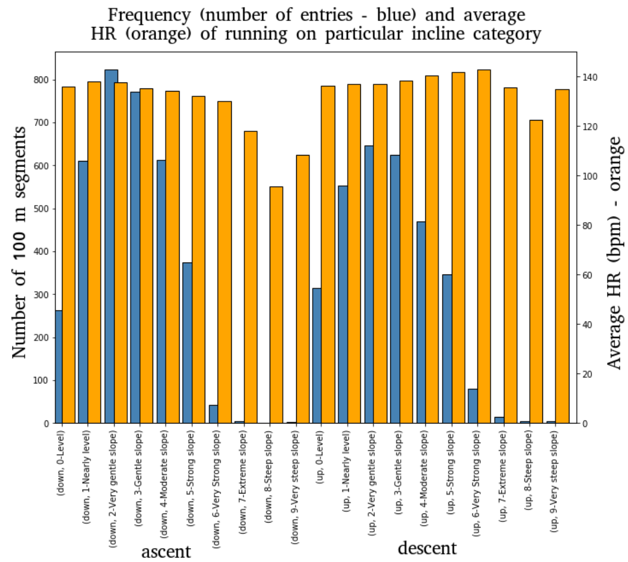

Figure 3: Frequency (number of entries - blue) and average HR (orange) of running on particular incline category

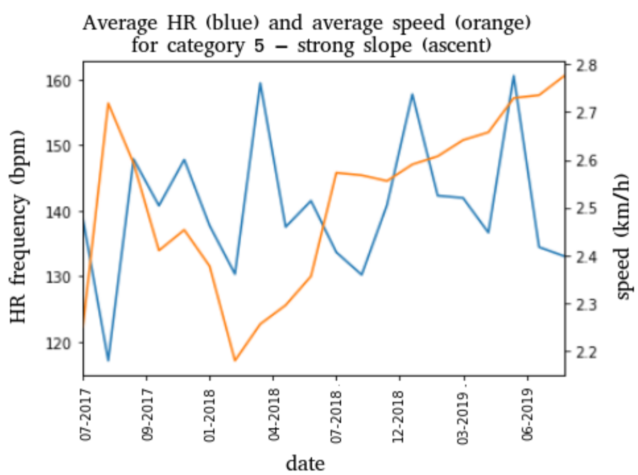

Figure 4: Average HR (blue) and average speed (orange) for category 5 – strong slope (ascent)

4 CONCLUSION AND FUTURE WORK

In recent years, wearable smart watches and devices have become very popular and widely used, along with the data-collecting capabilities they provide. Different makers of sports watches are making efforts to improve their products, in order to make them more accurate, and thus more helpful to users wanting to lead healthy lifestyles and gain improvements in sports and personal fitness.

The ultimate goal of our research is building a model for predicting a runner's ideal heart rate for particular moments and segments of their training session or future race, developed by taking into account gradual fitness improvements through time (learned through monitoring regular training), and dependant on current position (slope and incline, distance, time elapsed). Combining this information with the GPS route provided for a particular training or race track, the HR model would provide a prediction of finishing time and best maximal HR on different sections of the route, to help the athlete adjust their pace throughout the running session.

The first step in future research is to apply the most appropriate data mining methods for time-series data analysis, e.g. SARIMA, Support Vector Machine and kNN-TSPI, in order to extract interesting and usefull knowledge from our data.

ACKNOWLEDGMENTS

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Sledenje pogledu s spletno kamero

Luka Vranješ
Univerza v Ljubljani Fakulteta za računalništvo in informatiko
Večna pot 113
1000, Ljubljana
luka.vranjes5@gmail.com

Jure Žabkar
Univerza v Ljubljani Fakulteta za računalništvo in informatiko
Večna pot 113
1000, Ljubljana
jure.zabkar@fri.uni-lj.si

POVZETEK

Sledenje pogledu uporabnika med uporabo računalnika je najbolj priljubljeno v industriji iger in medicinskih aplikacijah. Čeprav so prvi sistemi za sledenje pogledu uporabljali spletne kamere, so se sčasoma v ta namen razvile posebne naprave, ki jih odlikuje precej večja natančnost in temu primerno višja cena. V naši raziskavi napravo za sledenje pogledu uporabljamo za odkrivanje disleksije pri osnovnošolcih. Zaradi želje po širši uporabi aplikacije, želimo napravo za sledenje pogledu nadomestiti s cenovno ugodnejšo spletno kamero. V pričujočem delu nas zanima, kakšno natančnost lahko dosežemo z uporabo spletne kamere in globokimi nevronskimi mrežami, ki jih uporabljamo pri učenju preslikave med položajem oči in točko na zaslonu.

Keywords

eye-tracking, webcam

1. UVOD

Sledenje očem pri uporabi računalnika postaja vse bolj priljubljeno. V industriji se najpogosteje uporablja za testiranje uporabniške izkušnje pri uporabi aplikacij in pri oglaševanju ter v industriji računalniških iger, kjer igralcu s prilagajanjem vmesnika omogoči večjo vživetost. Na raziskovalnem področju se zelo pogosto uporablja v medicinskih in psiholoških študijah, saj očesni gibi odražajo mnoge kognitivne in nevrološke motnje.

Aplikacija za odkrivanje disleksije, ki smo jo razvili v okviru projekta ŠIPK Disleksija [10], za sledenje pogledu uporablja sledilec očem proizvajalca Tobii. Čeprav je naprava relativno poceni, brez drage licence ni uporabna za naš namen. Testiranje otrok z aplikacijo je zato omejeno in dostopno le redkim. V želji po širši uporabi aplikacije želimo sledilec očem Tobii nadomestiti s cenovno ugodnejšimi in zelo razširjenimi spletnimi kamerami, kar bi uporabnikom omogočilo testiranje na domu.

V tej raziskavi poskušamo z uporabo globokega učenja in pristopov računalniškega vida doseči čim večjo natančnost sledenja pogledu s spletno kamero. Omejimo se na uporabo v aplikaciji za odkrivanje disleksije, ki je sestavljena iz šestih nalog. Štiri naloge uporabljajo večje grafične elemente in glede natančnosti niso zahtevne, dve bralni nalogi pa zahtevata visoko natančnost.

2. PREGLED PODROČJA

Sledenje pogledu s kamero je dobro raziskano; pregled metod je povzet v [2]. Problem sledenja tipično obravnavamo kot dva podproblema – zaznave očesa in napovedovanje točke pogleda. V splošnem se sorodna dela izogibajo uporabi specializiranih kamer. Tako so uporabljene kamere, kot tudi v našem primeru, povprečne kakovosti. Zaradi potrebe po delovanju v realnem času, sledenje pogledu onemogoča uporabo zahtevnih algoritmov. Komercialni sledilci očem ponujajo minimalno frekvenco 30Hz, kar je maksimalna hitrost zajemanja slik preprostih spletnih kamer.

Med pristopi, ki uporabljajo zgolj spletno kamero, so se za zelo uspešne izkazale metode, ki uporabljajo konvolucijske nevronske mreže, kar zahteva veliko količino podatkov [4, 12]. V prvem so uspeli zbrati podatkovno množico 2445504 slik in pripadajočih točk na zaslonu ter z njo dosegli odlične rezultate na pametnih telefonih in tabličnih računalnikih. V [12] so imeli bistveno manjšo učno množico – 213659 slik in priležnih točk. Primer klasičnega pristopa je predstavljen v [8], kjer za napoved uporabljajo interpolacijo, kot vhod pa točki središča zenice in zunanji očesni kotiček. Zanimiva je rešitev v [5], kjer za napoved uporabljajo vektor pridobljen iz slike očesa. Podrobnosti tega koraka lahko najdemo v [11]. Presenetljivo redko raziskave upoštevajo obraz; enostaven primer sledenja očem pri upoštevanju obraza najdemo v [7]. V članku je tudi opisano, da upoštevanje obraza ni pogosto zaradi potrebe po čim hitrejšem delovanju predlaganih pristopov.

Naša rešitev preizkuša primernost uporabe globokega učenje brez predhodnega učenja, kar ni preizkušeno v nobeni od predstavljenih implementacij.

3. TEORETIčNO OZADJE

Naš algoritem je sestavljen iz štirih delov: zaznavanje obraza (algoritem Viola-Jones), poravnave obraza z ansamblom regresijskih dreves, ocenjevanja centra očesa z gradienti slike in globoko nevronsko mrežo za modeliranje preslikave med očesom in točko na zaslonu.

Zaznavo obraza na podlagi preprostih značilk smo implementirali po [9]. Metoda razdeli obraz na kvadratne bloke, ki podajo oceno glede na razliko vsot dveh izbranih pravokotnih skupin slikovnih pik. To je mogoče izračunati zelo hitro z uporabo integralne slike, ki jo z enim obhodom izračunamo iz vhodne slike. Ker je število možnih preprostih značilnosti veliko (preko 180000 v primeru, ko je detektor velikosti 24×24), se za izbiro najboljših uporablja različico algoritma

AdaBoost. S tem med vsemi značilnostmi izberemo nekaj 100 ali nekaj 1000 takih, ki skupaj dobro delujejo. Končni algoritem deluje po principu kaskade klasifikatorjev. Za vsak nivo se z uporabo algoritma AdaBoost izbere nekaj preprostih klasifikatorjev. Njihove uteži so prilagojene tako, da na testni množici prepoznajo čim več obrazov. Napačno zaznane poskušamo odstraniti v kasnejših nivojih kaskade. Takoj, ko v enem nivoju v interesnem območju ne zaznamo obraza, to območje zavržemo.

Za poravnavo obraza smo uporabili ansambel regresijskih dreves [3]. Za učenje enega regresijskega drevesa uporabimo trojček, ki je sestavljen iz slike obraza, začetne napovedi oblike in ciljnega popravnega vektorja. Iz tega se naučimo regresijske funkcije, z uporabo algoritma iz [3] in vsoto kvadratov napake kot funkcijo izgube.

Center očesa določimo z gradienti slike po metodi [6]. Za vsako točko na sliki izračunamo vsoto vektorskih produktov med vsemi gradienti g_i in normaliziranim vektorjem premika d_i, ki imajo enako orientacijo. Vektor premika izračunamo z:

$$d_i = \frac{x_i - c}{||x_i - c||}, \forall i : ||g_i|| = 1, \quad (1)$$

kjer x_i predstavlja lokacijo gradienta g_i na sliki. Za boljšo robustnost algoritma se priporoča normalizacija gradientov. Prav tako je normaliziran vektor premika, saj tako ohranimo enako utež za vse slikovne pike. Končni optimalni center nato dobimo po enačbi:

$$c^* = \arg\max_c \left\{ \frac{1}{N} \sum_{i=1}^{N} (d_i^T g_i)^2 \right\} \quad (2)$$

Hitrost izračuna lahko zmanjšamo tako, da upoštevamo le gradiente z dovolj visoko magnitudo.

4. IMPLEMENTACIJA

Algoritem smo implementirali v programskem jeziku Python. Razdelimo ga lahko na štiri korake: zaznavanje obraza, zaznava interesnih točk na obrazu, zaznava središča zenice in napovedovanje točke pogleda.

4.1 Zaznavanje obraza

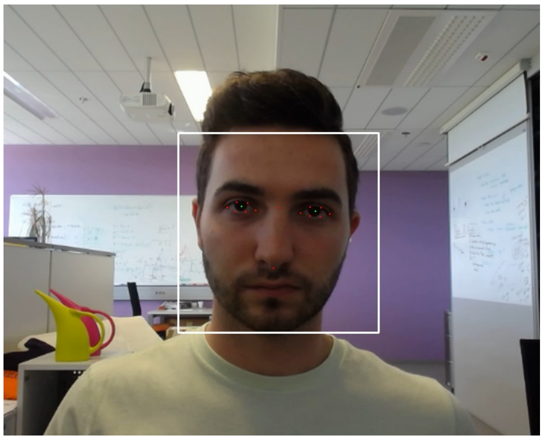
Za implementacijo algoritma smo uporabili že obstoječo implementacijo iz knjižnice openCV. Razred CascadeClassifier smo inicializirali s prednaučenimi kaskadami ("haarcascade_frontalface_default.xml"), ki so ravno tako del knjižnice. Za hitrejše delovanje smo sliko predhodno pomanjšali na velikost $(426, 240)$ in jo pretvorili v sivinsko sliko. Slednje od nas zahteva funkcija detectMultiScale, ki je del razreda CascadeClassifier. Ostala dva parametra, ki jih ta funkcija zahteva sta še skalirni faktor, ki smo ga nastavili na 1.3, kar je najmanjše število bližnjih mejnih pravokotnikov, katerega smo nastavili na 5. Rezultat funkcije so mejni pravokotniki vseh najdenih obrazov. Ker nas zanima le en obraz, med vsemi ohranimo le največjega. Razultat koraka je prikazan kot bel kvadrat na sliki 1.

4.2 Zaznava interesnih točk na obrazu

Za implementacijo tega koraka smo uporabili razred shape_predictor, ki je vključen v knjižnici dlib. Ta vsebuje tudi datoteko shape_predictor_68_face_landmarks.dat, ki jo uporabimo za inicializacijo razreda in vsebuje potrebne prednaučene parametre. Za pridobitev interesnih točk smo uporabili funkcijo predictor(), ki je del razreda shape_predictor in kot vhodna argumenta prejme sivinsko sliko in mejni pravokotnik. Sivinska slika je celotna slika, pridobljena iz spletne kamere, pretvorjena v sivinsko sliko. Mejni pravokotnik je rezultat prejšnjega koraka. Od 68 interesnih točk ohranimo le 14 izbranih. Rezultat koraka je prikazan kot množica rdečih točk na sliki 1.

4.3 Zaznava središča zenice

Za ocenjevanje centra zenice z gradienti slike smo uporabili [1]. Vhod v algoritem je sivinska slika očesa. Iz sivinske slike kamere iz prejšnjega koraka na podlagi interesnih točk izrežemo obe očesi. Nad dobljenima slikama uporabimo funkcijo iz knjižnice openCV, equalizeHist(). Obe sliki nato ločeno podamo v funkcijo locate(). Rezultat funkcije za vsako sliko sta x in y koordinati središč obeh zenic. Rezultat koraka je prikazan z zelenima točkama na sliki 1.



Slika 1: Prikaz dobljenih središč zenic (zelena barva), ohranjenih interesnih točk (rdeča barva) in mejnega pravokotnika okoli obraza.

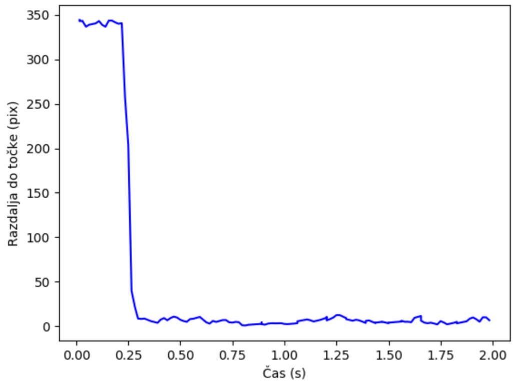
4.4 Napovedovanje točke pogleda

Iz knjižnice dlib smo uporabili razred MLPRegressor za implementacijo globokih nevronskih mrež. Tej smo pri inicializaciji nastavili 5 parametrov. Velikost skritih nivojev smo nastavili na $(23, 14, 6)$. Največje število epoh smo omejili na 500. Za aktivacijsko funkcijo smo uporabili ReLU. Za reševalnik smo nastavili adam. Toleranco smo nastavili na 10^{-5}. Vhodni nivo mreže prejme 48 parametrov sestavljenih iz 14 interesnih točk in 2 točk, ki predstavljata center zenice. Vhodne parametre pred učenjem s pomočjo razreda StandardScaler (del openCV knjižnice) s funkcijo transform() prilagodimo na interval, primeren za učenje.

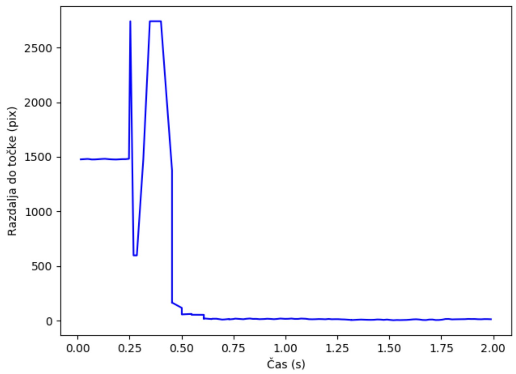
5. EKSPERIMENTI

Velik vpliv na točnost napovedi ima začetna kalibracija sistema: uporabnik na črnem zaslonu gleda v prikazujoče se rdeče točke. Na zaslonu je hkrati prikazana le ena točka na naključni lokaciji. Kalibracija je nujen korak za uporabo sledilca in je unikatna za vsakega uporabnika.

V sklopu delovanja in za potrebe eksperimentov definiramo



Slika 2: Prikaz razdalje od napovedane točke pogleda do dejanske točke v odvisnosti od časa.



Slika 3: Prikaz razdalje od napovedane točke pogleda do dejanske točke v odvisnosti od časa.

dodatne omejitve, vezane na aplikacijo za odkrivanje disleksije. Kamera mora biti fiksna, z resolucijo 1280 in hitrostjo vsaj 30 sličic na sekundo. Glava mora biti med uporabo od začetka kalibracije naprej v statičnem položaju, uporabnik pa v dobro osvetljenem okolju. Poleg tega pri vseh eksperimentih uporabljamo še nekaj statičnih parametrov. Zaslon z diagonalo 59.44 cm in ločljivostjo 1920 × 1080. Oddaljenost uporabnika od zaslona je 55 cm. Dolžina kalibracije je omejena na 5 minut. Predstavljeni eksperimenti so izvedeni na enem uporabniku.

5.1 Okno zajema podatkov in dolžina prikaza točke

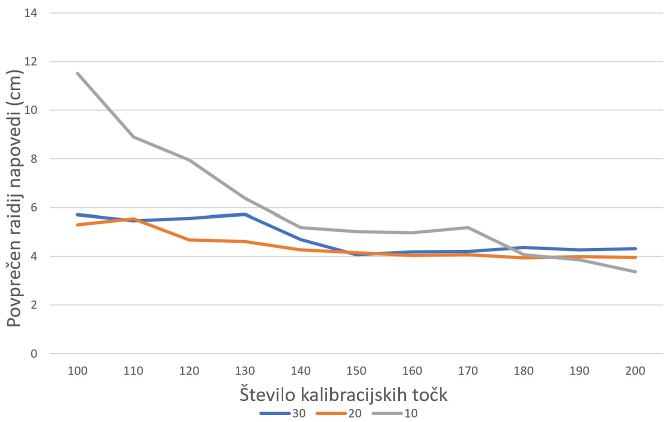
Za čim hitrejši proces kalibracije si želimo čim krajši čas prikaza točke. Ta sicer ne sme biti prekratek, saj si želimo, da uporabik udobno sledi menjavi točk. Pri oknu zajema je pomembno, da znotraj okna ne prihaja do večjih sprememb vhodnih parametrov (mirno oko). Hkrati si želimo, da je okno čim daljše, kar nam omogoča zajeti večje število podatkov.

Za nastavitev teh dveh parametrov bomo uporabili sledilec pogleda Tobii Pro nano. Na zaslonu prikazujemo točke in beležimo razdalje med dejansko točko na zaslonu in napovedano točko sledilca Tobii. Vsaka točka bo na zaslonu prikazana $2s$. Primer dobljenih rezultatov prikazuje graf na sliki 2. Ta graf prikazuje standardni primer preskoka očesa med kalibracijskima točkama. Po menjavi kalibracijskih točk potrebuje oko testiranca približno $0.25s$, da pogled preusmeri na novo točko. Med testom je v najslabšem primeru oko potrebovalo približno $0.5s$ za dokončno stabilizacijo, saj je preskosku sledil še manjši popravek. Graf na sliki 3 prikazuje primer preskoka, ki sta mu sledila kratek in malo daljši mežik očesa. Mežiki se lahko pojavijo kadarkoli v času prikaza točke, zato jih je potrebno upoštevati.

Na podlagi dobljenih rezultatov smo se odločili omejiti čas prikaza točke na $1.5s$, ter okno zajema na interval $[0.75, 1.5]$. Začetek okna zajema je nastavljen tako, ker želimo biti popolnoma prepričani, da je uporabnik pogled uspešno ustalil na točki, se pravi je dovolj oddaljen od točke preskoka. Konec okna je pomaknjen do konca prikaznega časa točke, saj iz pridobljenih podatkov ni videti, da bi kakovost fokusa v tem času padla. Za izbrano dolžino prikaza smo se odločili, ker nam omogoča zajem dovolj podatkov in uporabnik med kalibracijo ne dobi občutka čakanja.

5.2 Velikost in število kalibracijskih točk

Testirali smo tri velikosti kalibracijskih točk, s polmeri 30, 20 in 10 slikovnih pik. Za vsako velikost naredimo ločeno kalibracijo z 200 kalibracijskimi točkami. To je zgornja meja števila točk zaradi izbrane zgornje meje časa kalibracije in dožine prikaza ene točke. Takoj za kalibracijo zajamemo podatke novih 30 naključno generiranih točk, ki jih uporabimo kot testno množico. Za testiranje števila kalibracijskih točk razdelimo učno množico, ki smo jo pridobili med kalibracijo, na 20 podmnožic. Prva vsebuje 10 točk, vsaki naslednji pa dodajamo 10 točk tako, da zadnja vsebuje vse točke. Točke se dodajajo v enakem vrstnem redu, kot so bile zajete. Vpliv števila in velikosti kalibracijskih točk ocenimo iz grafa na sliki 4. Iz grafa je razvidno, da najboljši rezultat,



Slika 4: Graf povprečne napake napovedi v odvisnosti od števila kalibracijskih točk za 3 velikosti kalibracijskih točk.

$3,37$ cm, doseže kalibracija z 200 točkami, s polmerom 10 slikovnih pik. Graf je narisan le za učne podatke, ki vsebujejo med 100 in 200 kalibracijskih točk; rezultati množic z manj točkami so slabši in posledično neuporabni. Na grafu najbolj izstopa kalibracija s točkami polmera 10, katerih napaka je na začetku bistveno večja od ostalih, vendar hitro pade in da na koncu najboljše rezultate. Tukaj gre najverjetneje za visok delež šuma v zgodnjih podatkih, kar se nato z dodajanjem novih popravlja. Če primerjamo rezultate vseh treh velikosti kalibracijskih točk, opazimo, da z manjšanjem radija točke za 10 slikovnih pik napaka pade med 15 in 20 slikovnih pik. Manjšega polmera točke nismo testirali.

6. ZAKLJUčEK

Predstavili smo algoritem za oceno točke pogleda s spletno kamero. Z uporabo referenčnih točk in globoke nevronske mreže smo v najboljšem primeru dosegli napako $3,37$ cm. Na osnovi poskusov ugotavljamo, da naša metoda deluje pri različnih svetlobnih pogojih (različna jakost svetlobe, luč v ozadju), vendar bolje deluje pri močnejši osvetlitvi, brez ambientne osvetlitve pa metoda ni uporabna. Zaradi specifičnih omejitev predlaganega pristopa, bo tega težko direktno primerjati z drugimi. Za primerjavo bi morali omiliti omejitve ali testirati ostale pristope z enakimi omejitvami. V obeh primerih, bi za uspešno primerjavo potrebovali večje število ljudi. Predstavljen pristop je pogojno primeren za uporabo s ciljno aplikacijo, saj ne omogoča spremljanja branja.

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Prepričljive tehnologije za spodbujanje pravilne drže telesa pri sedenju

Luka Zorč, Klen Čopič Pucihar, Matjaž Kljun
Fakulteta za Matematiko, Naravoslovje in Informacijske Tehnologije
Univerza na Primorskem
Glagoljaška 8
Koper, Slovenija
luka.zorc@student.upr.si, klen.copic@famnit.upr.si, matjaz.kljun@upr.si

POVZETEK
Članek obravnava tematiko prepričljivih tehnologij v povezavi z nepravilnim sedenjem. Dosedanje metode opazovanja pravilne drže telesa in spodbujanja pravilnega položaja telesa se delijo na video zaznavo in zaznavo s pomočjo senzorjev. Vsaka od teh metod ima določene prednosti in slabosti. Za potrebe raziskave smo izdelali rešitev, ki temelji na video zaznavi in predstavlja nov pristop pri spodbujanju pravilne drže sedenja z uporabo pametnega telefona usmerjenega v uporabnika. S pomočjo izdelane programske opreme smo izvedli raziskavo s prvim avtorjem članka v obdobju 30ih ur. V članku je predstavljena metoda merjenja sedenja in namestitev prototipa. Poleg merjenja sedenja s telefonom smo uporabili tudi študijo z dnevnikom. Rezultati kažejo, da se je kakovost sedenja izboljšala, kar nakazuje, da rešitev pomaga pri vzpostavitvi boljše drže hrbtenice pri sedenju.

Ključne besede
prepričljive tehnologije, položaj sedenja, ergonomija

Slika 1: Grafična ponazoritev uporabe prototipa.

1. UVOD
Današnji način življenja in dela vključuje veliko sedenja [12], ki je vključno s telesno neaktivnostjo vzrok mnogih bolezni, kot so debelost, visok krvni tlak, sladkorna boležen, tesnoba, depresija, rak debelega črevesa, bolečine v križu itd. Težava sedenja je tudi nepravilna drža, ki je vzrok ovirane zmožnosti za širitev pljuč, bolečine v hrbtenici, bolečin vratu, čeljusti itd. [2] Nepravilno sedenje vpliva na produktivnost [17] in povzroča visoke stroške za javno zdravstvo, saj nepravilna drža 80% ljudem povzroča zdravstvene težave vsaj enkrat v življenju. V članku predstavljamo enostavno rešitev, ki temelji na pametnem telefonu in meri ukrivljenost hrbtenice v realnem času s pomočjo računalniškega vida. Ker želimo graditi nov vedenjski vzorec, smo v sistem vključili koncept prepričljivih tehnologij s proženjem različnih sprožilcev.

2. PREGLED PODROčJA

2.1 Sedenje in položaj hrbtenice
V literaturi je opisanih več različnih a zelo podobnih pravilnih položajev sedenja [9]. Najpogosteje omenjana je definicija Evropske agencije za varnost in zdravje pri delu, ki opisuje pravilno ureditev delovne postaje. Kot pravilno telesno držo hrbta definicija omenja hrbet poravnan pravokotno na tla, da je kot med hrbtenico in koleni 90 stopinj pri čemer mora pogled glave biti usmerjen vodoravno.

2.2 Dosedanje metode opazovanja položaja telesa
Večina metod je namenjena sledenju gibanja telesa in zaznavanju različnih položajev, ki jih je mogoče uporabiti tudi za zaznavanje položaja sedenja. Načini zaznavanja položaja telesa se delijo v splošnem na dve metodi: prva uporablja video zaznavo telesa s pomočjo računalniškega vida, druga pa uporablja senzorje, nastavljene na telo ali na stol. Mogoča je tudi kombinacija obeh ali uporaba drugih ne-tehnoloških rešitev kot na primer PEO (Portable Ergonomic Observation). Slednja temelji na prisotnosti dodatne osebe.

2.2.1 Zaznavanje z računalniškim vidom
Ti pristopi lahko uporabijo eno ali več kamer [15], neposredno analizo videa v realnem času ali kasnejšo analizo slik pridobljenih iz videa, 3D modela telesa ali pa delujejo brez modelov. Ocenjevanje položaja telesa se uporablja za različne namene. Na primer za spremljanje starejših oseb [10], utrujenosti voznikov osebnih vozil tako z zaznavo položaja oči in ust [20], za ugotavljanje konteksta v pisarni [1] kot tudi za zaznavo položaja sedenja z zaznavo obraza uporabnika z merjenjem Hausdroffove razdalje s pomočjo kamere na ekranu [16]. Na enakem principu delujejo komercialni izdelki kot so Posture Minder, Philips Ergo Sensor in Visiomate (slednji za merjenje uporqablja ultrazvočni senzor razdalje). Obstoječe rešitve imajo določene pomanjkljivosti kot na primer: (i) dodajanje video kamer v prostor predstavlja težavo zasebnosti, kar je posebej problematično, ko kamer

ne upravlja opazovana oseba, (ii) nenatančno zaznavanje položaja sedenja, ki temelji le na zaznavanju relativni poziciji obraza/glave, (iii) potreba po dodatni strojni opremi, in (iv) nezdružljivost z obstoječo strojno opremo.

2.2.2 Zaznava s pomočjo senzorjev

Najpogostejši za zaznavo položaja telesa so senzorji pritiska telesa na stol in taki, ki merijo razdaljo med naslonjalom stola in hrbtom uporabnika. V porasti so tudi rešitve, ki uporabljajo merilnike pospeška, in pametna oblačila opremljena z različnimi senzorji.

Senzorji sile se uporabljajo na stolih za zaznavo zasedenosti stola ter za zaznavo položaja sedenja osebe na stolu. Tan et al. [18] so senzorje sile uporabljali za klasificiranje statičnih sedečih položajev in z metodo PCA (Principal Component Analysis) prepoznali 10 različnih sedečih položajev z 79% natačnostjo za nove uporabnike in 96% za znane uporabnike. Podobno so izvedli še v [8] medtem, ko so McCormick et al. [14] opazovali še ali so naslonjala za roke v uporabi, ali je v uporabi ledvena opora in ali je naslonjalo nagnjeno. Senzorje sile so uporabili tudi v metodi Preslikava pritiska [ang. Pressure mapping] za ocenjevaje udobja sedenja v avtomobilih in zdravstvu [3]. Pri metodi CARPIO so [7] uporabili poleg senzorjev na stolu še sistem, ki preko zaznavanja uporabe miške in tipkovnice ugotavlja, ali je računalnik v uporabi, kar z brezžično povezavo s senzorji na stolu omogoča večjo natančnost rezultatov. Xu et al. [19] so uporabili blazino eCushion, opremljeno s senzorji sile, ki jo lahko postavimo na obstoječi stol. Senzorje na stolih najdemo tudi v komercialnih izdelkih. Stol Axia Smart Chair je opremljen s šestimi senzorji, Darma pa pametna blazina, ki jo nastavimo na stol in beleži podatke o položaju sedenja, srčni utrip, dihanje.

Najpogostejši senzorji na telesu uporabnika so merilniki pospeška. S takimi senzorji, postavljenimi na ledvenem predelu hrbta, so v [5] prišli do zadovoljivih rezultatov sledenja položaja sedenja. Namesto merilnikov pospeška je mogoče uporabiti tudi (i) sprejemnike radio frekvenc ali WLAN omrežja, ki s pomočjo triangulacije določijo položaj telesa ali (ii) senzorje upogiba. Komercialna izdelka UPRIGHT[1] in Lumo Back[2] uporabljata merilnik pospeška nalepljen na vratni oz. ledveni predel hrbta in z vibracijo opozarjata uporabnika na napačen položaj. Lumo Lift[3] je pa senzor, ki ga namestimo na obleko. Izdelki iPosture[4], Prana Tech[5] in Fineck[6] nudijo podobne rešitve kot Lumo Lift, le da ima prvi še možnost zaznavanja dihanja, tretji pa je v obliki ogrlice. Obstajajo tudi oblačila z vgrajenimi senzorji, s katerimi lahko sledimo položaju telesa [13]. Na voljo so tudi komercialne rešitve, kot je na primer TruPosture, ki je namenjen izdelavi pametnih oblačil in omogočajo zaznavo pravilne drže telesa. Poleg omenjenih načinov, se lahko za zaznavanje položaja telesa uporabi še elektromiografija (EMG) [6], ki iz podatkov o mišični dejavnosti pridobi podatke o položaju telesa. Obstoječe rešitve imajo tudi določene pomanjkljivosti: (i) vstavljanje senzorjev na vsa oblačila iz garderobne omare lahko predstavlja finančni zalogaj, (ii) trajnost pametnih oblačil in ostalih pametnih izdelkov (npr. obraba, čiščenje, hitra zastarelost itd.), (iii) vsakemu pametnemu izdelku (stol, oblačilo) moramo nuditi tudi oskrbo z energijo.

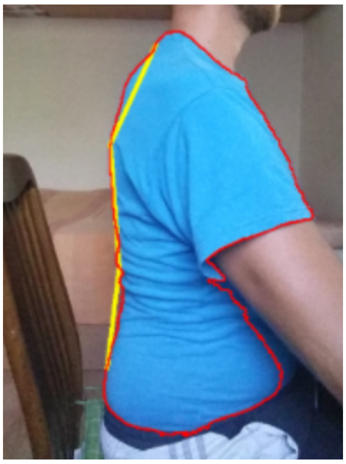
[1] `https://www.uprightpose.com/`
[2] `https://www.kickstarter.com/projects/lumoback/lumoback-the-smart-posture-sensor`
[3] `https://www.lumobodytech.com/`
[4] `http://www.iposture.com/`
[5] `http://prana.co/`
[6] `https://www.slashgear.com/fineck-smart-necklace-tracks-posture-neck-health-08358781/`

3. OPIS PROTOTIPA

Kot je razvidno na Sliki 1 smo v našem primeru uporabili stol brez naslonjala. Da bi dobili položaj hrbtenice pri pravilni sedeči drži smo eksperimentalnega uporabnika posedli na stol in njegovo držo popravili na željen končni položaj. Nato smo izmerili kot:

- spodnjega predela hrbta od najnižjega (medeničnega) dela hrbtenice do dela kjer je hrbtenica najbolj ukrivljena navznoter (4. vretence),
- srednjega dela hrbta kjer je hrbtenica najbolj ukrivljena navzven (od 4. do 12. vretenca) in
- zgornjega predela prsnega dela hrbtenice do začetka vratnega dela (od 12. do 18. vretenca).

Postopek smo večkrat ponovili in prišli do intervala mejnih vrednosti: spodnji del hrbtenice ne sme preseči 91 stopinj, srednji del hrbtenice mora biti med 80 in 100 stopinj, zgornji del hrbtenice pa ne manjši od 60 stopinj. Trije koti si vidni na Sliki 2.



Slika 2: Zaslonska slika prototipa s sledenjem obrisa majice in treh kotov hrbtenice.

Za implementacijo rešitve smo uporabili pameten telefon s sistemom Android, ker je to najbolj razširjena naprava s kamero. Pametni telefoni so prenosni, imajo veliko procesorske moči in zanje obstaja nekaj knjižnic namenjenih računalniškem vidu. Razvita aplikacija s pomočjo kamere in računalniškega vida sledi oprijeti majici uporabnika in ga s kratkim piskom opozori na nepravilen položaj glede na zgoraj navedene vrednosti. Ko je aplikacija odprta meri položaj enkrat na minuto, vsako merjenje pa traja 5 sekund. Aplikacija lahko prikaže tudi graf meritev v odvisnosti od časa. Za zaznavanje položaja telesa smo uporabili odprtokodno knjižnico OpenCV, aplikacijo pa razvili v JAVI. Podrobnejši opis algoritma je na voljo v [21].

4. EVALVACIJA PROTOTIPA

Pri pisanju zaključne naloge je prvi avtor članka namestil prototip za merjenje sedečega položaja hrbtenice na desno stran pisarniške mize, kjer je pisal nalogo. Sistem je uporabljal nekaj ur dnevno. Poleg podatkov o sedečem položaju, pridobljenih iz aplikacije, je po vsaki uri pisanja te naloge ustvaril nov vpis v dnevnik. Dnevnik je sestavljen v obliki vprašalnika. Vsak zapis v dnevnik zajema odgovor na naslednja vprašanja: (i) Koliko časa menite, da ste sedeli pravilno na lestvici od 1 do 10?, (ii) Kolikšno je bilo število opozoril aplikacije o napačnem sedenju?, (iii) Kako moteče je bilo opozarjanje aplikacije na lestvici od 1 do 10? (iv) Kolikšna je bila stopnja bolečin v hrbtu na lestvici od 1 do 10?, (v) Katero dejavnost ste opravljali med merjenjem?, (vi) Kakšna je bila stopnja koncentracije med dejavnostjo (1–5)? in (vii) Komentarji. Merjenje je trajalo 30 ur skozi 13 dni.

Vprašalnik dnevniške študije (ang. diary study) je bil razvit za potrebe naše raziskave. Pri dnevniški študiji raziskovalec namreč zastavi vprašanja glede na to, kaj želi od uporabnikov beležiti. Uporabniki lahko samoporočajo o določenem vedenju, frustracijah, mennjih, ponavljajočih se dogodkih, ipd. skozi daljše časovno obdobje in ko se odzivi pojavljajo sporadično ali v nenačrtovanih trenutkih. Vprašalnik je tako zelo odvisen od same študije.

5. REZULTATI RAZISKAVE ININTERPRETACIJA

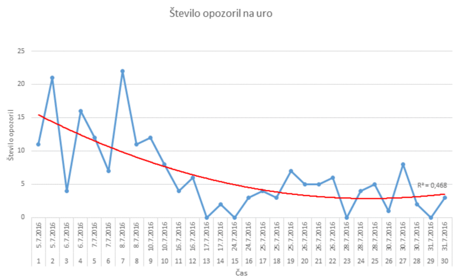
5.1 Bolečina v hrbtu

Izvor bolečine je bila uporaba stola brez naslonjala za hrbet in naslonjal za roke saj avtor navadno uporablja stol z naslonjali, ki omogočajo sedenje v položaju pri katerem so hrbtne mišice manj obremenjene. Avtor je tako na lastni koži izkusil, da je vzravnana sedeča drža zahtevna za hrbtne mišice. Posledica tega je bila, da je avtor moral po vsaki uri meritve vzeti nekaj minut premora. Prve dni je bilo težko sedeti v takem položaju več kot dve uri na dan. Prav tako je avtor med študijo (večinoma na začetku) od enkrat do dvakrat na uro zavestno prešel za nekaj sekund v nepravilno držo z namenom, da razbremeni mišice v hrbtnem predelu. Posebej zanimivo je, da je prototip kljub bolečini v hrbtu uspešno silil k pokončnem sedenju navkljub dejstvu, da je sedenje na stolu brez naslonjala v nepravilnem skljUčenem položaju manj utrujajoče za hrbtne mišice. Iz dnevnika je razvidno, da se je subjektivna ocena bolečine v hrbtu, zmanjševala saj so se tekom časa hrbtne mišice okrepile.

5.2 Vpliv prototipa na pravilno držo pri sedenju

Graf na Sliki 3 prikazuje število opozoril, ki so se zgodila tekom enournega cikla merjenja. Iz grafa je jasno razviden trend zmanjševanja kljub dejstvu, da se podatki ne prilegajo učni krivulji. Glede na to dejstvo (R2=0.487), iz zbranih podatkov ne moramo sklepati ali se je učenje pravilnega položaja sedenja zaključilo. Kljub temu lahko povzamemo, da je prototip pozitivno vplival na držo pri sedenju.

Zanimiv je tudi podatek o izmerjenih vrednostih treh predelov hrbtenice in spremembi skozi čas (Slika 4). Dnevna povprečja so bila vedno v meji pravilnega sedenja. Pozitiven trend se je pokazal pri zgornjem in spodnjem kotu, kjer se je s časom dnevno povprečje kota oddaljevalo od



Slika 3: Odstotek opozoril v razmerju s časom.

limitne vrednost. Pri srednjem kotu pa je velikost ostajala podobna čez celotno študijo. Pri rezultatih smo tudi opazili, da ledveni kot hrbtenice največkrat preide kritično mejo a so hkrati njegove povprečne vrednosti najbližje mejni vrednosti pravilnega sedenja (91 stopinj). Podatki tudi nakazujejo, da je ledveni del hrbtenice tisti, ki prvi odstopi iz pravilnega območja sedenja, šele nato sledita druga dva dela. Od tod sledi, da je prav spremljanje položaja ledvenega dela hrbtenice ključnega pomena.

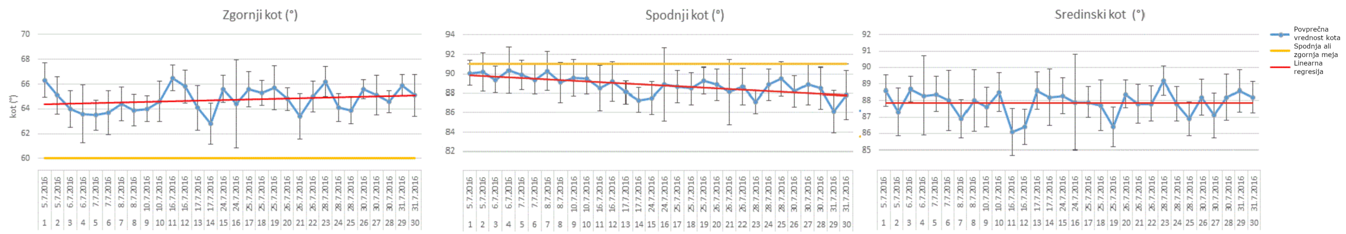
5.3 Ostale ugotovitve

Med uporabo aplikacije je postalo jasno, da je aplikacija veliko bolje zaznavala obris hrbtenice, če je prostor osvetljen z dnevno svetlobo. To ni bila težava, saj je bila soba, v kateri je avtor izvajal meritve, dobro osvetljena večji del dneva. Zagotovo pa obstaja možnost dodatne izboljšave pri zaznavi barv. Po nekaj dneh meritev je avtor ugotovil, da je pomemben odstotek časa uporabljal nepravilen položaj nog (prekrižane pod stolom). Tega podatka aplikacija ne meri. Ker je položaj nog ravno tako pomemben element pravilne drže pri sedenju, bi bilo v prihodnjih različicah aplikacije primerno razmisliti o rešitvi, ki vključuje sledenje položaja nog. V študiji z dnevnikom avtor podaja oceno o nadležnosti piska aplikacije, ki oznanja nepravilno držo. Rezultati kažejo, da opozorilo ni bilo moteče. Kot zadnje avtor ugotavlja, da je uporaba aplikacije vplivala na položaj sedenja tudi izven časa merjenja, ko je večkrat opazil, da podzavestno prehaja v vzravnano držo hrbtenice in jo uspe zadržati v takem položaju daljše obdobje.

Iz predstavljenih rezultatov lahko zaključimo, da se je stanje sedečega položaja sproti jasno izboljševalo, kar nam nakazuje, da rešitev pomaga pri vzpostavitvi nove navade: izboljšati držo hrbtenice v sedečem položaju. Žal na podlagi zbranih podatkov ni mogoče trditi, da je sprememba trajna. Novejše raziskave kažejo, da je za trajno spremembo navad potrebno od dva do osem mesecev [11], kar je odvisno predvsem od težavnosti želenega vedenja in motivacije ter sposobnosti uporabnika, ki želi vedenje doseči.

6. ZAKLJUčEK

Rezultati študije nakazujejo, da se je stanje sedečega položaja s pomočjo predstavljene rešitve tekom študije izboljševalo, kar nam nakazuje, da rešitev lahko pomaga pri vzpostavitvi nove navade: izboljšati držo hrbtenice v sedečem položaju. Trajnosti navade, ki jo je uporabnik pridobil ob uporabi aplikacije, žal nismo uspeli preveriti, saj le-ta zahteva daljše obdobje opazovanja.



Slika 4: Povprečne vrednosti kotov treh delov hrbtenice v razmerju s časom.

Študijo smo zasnovali samo z enim uporabnikom na podlagi trendov, ki nakazujejo veliko število aplikacij za manjše število uporabnikov in iskanje izjemne pozitivne izkušnje v nasprotju s preteklimi trendi, ko je majhno število aplikacij uporabljalo veliko število ljudi in je izkušnja bila lahko le povprečna [4]. Kljub temi bi v prihodnje bilo potrebno spremljati več uporabnikov in njihove navade v daljšem obdobju in upoštevati vse dejavnike kot so na primer bolezenska stanja.

Poleg tega obstaja tudi nekaj možnosti za izboljšave predstavljene rešitve, kot na primer izboljšava sledenja majice v slabših svetlobnih pogojih, sledenje nog med sedenjem, igrifikacija in spremljanje navad sedenja znotraj družbenega omrežja posameznika z večanjem možnosti družbene podpore.

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Nuni- A case study: A platform to distribute digital content to analog television data towards enhancing quality of life of senior citizen in Mexico.

Cuauhtli Campos
University of Primorska
Glagoljaška 8
Koper, Slovenia
cuauhtli.campos@famnit.upr.si

Carlos A. Martinez Sandoval
Universidad Tecnologica de la Mixteca
Carretera a Acatlima Km. 2.5
Huajuapan de León, Oaxaca, Mexico
carlosmtz@outlook.com

ABSTRACT
Nuni is a platform to distribute digital content for analog television. This was the final product derived of an student research project that was carry out to design a digital product to enhance quality of life of elderly people. This exploratory study help us to obtain quantitative and qualitative data from real users. The following document relates the process of implementing a User-Centered approach to identify a problem in an specific population and come out with a potential solution to improve, in this case, elders' lifestyle from a Mexican village in a southern state of Mexico who were the target audience in such project.

Keywords
Seniors, UCD, UX, Usability

1. INTRODUCTION
In 2017 young researches as part of one of the Human-Computer Interaction (HCI) courses in the Master Degree from the Technological University of the Mixteca were challenged to design a product/service to help a vulnerable population in a semi-rural context. Researches chose by convenience a village (Huajuapan de León) located in a poor zone in Oaxaca state (a region in the south of Mexico). The constraint to do the activity was to use the existing knowledge in HCI to solve the problem. The topic selected by students was: Elderly people.

Nowadays, there is a gap between technology and old adults that cuts off or limits the ability of the last ones to do their daily life and in some sense affects the way they interact with the surrounding world. According to the United Nations Fund for Population Activities (UNFPA) the number of elderly people in the world is increasing and the global population aged 60 year or more is twice larger than in 1980 [11] and is expected that this quantity will continue growing in future years. Mexico is not the exception and according to the federal government is estimated to have a population of 32.5 million of elders in 2050[5]. This is a major concern since seniors are been overtaken by the upgrades, changes and evolution related with technology. Such phenomena is forcing them to dislike, reject or in the worst case: being subjects of abuse, extortion or fraud through technology-related scams[9] as they become digital illiterates. From the perspective of Human-Computer Interaction we have observed that this phenomenon could be approached in another way, the idea is exceed the usability frontier and also fulfilling user experience attributes, name them: utility, adaptability and satisfaction.

1.1 Assistive technology for seniors
Technology for elderly people is not a new topic in the field. There are tools destined to help seniors in their day to day life, such as: hearing aids, conversation companions, digital tablets or mobile applications[7, 8]. Tools like those are categorised as "Assistive Technology" (AT).

An AT is defined as any tool that allows individuals with special necessities or disabilities to perform one specific activity without any kind of physical or mental barrier. There are many examples but the most commons are the wheel chair and the walkie-talkie. Despite the variety and quantity of technologies oriented to this population the misconception of them can lead to the dis-likeness or rejection of the tool, because of this, we consider relevant to distinguish between two different dimensions of ATs: i) Technologies designed for Seniors and ii) Technologies designed for care takers.

In this context, researches in HCI community have proposed new approaches that deal with this challenge of designing tools for old adults[10, 1]. But even though there are meaningful advances in the field is evident that old adults still show some resilience to use technology in their daily life. We see in this context an area of opportunity to do research and come up with one potential solution. We believe that by following a methodology centered in the senior, we will produce a consistent and feasible tool.

2. METHODOLOGY
For the purpose of this project we used a User-Centered Design Methodology (UCD) and combined it with some elements presented in other design models, such as: Norman's Emotional Design (2005)[6] and Design Aesthetics: principles of pleasure in design from Hekkert (2006)[4](see Figure 1)[3].

2.1 User Experience (UX)
User Experience (UX) is concept related with assessment of interactions produced between users and technological products/services. The goal is to provide meaningful and relevant experiences to users [2]. The value and interest that one

users gives to one specific tool/product/service come from the field of HCI. At the beginning, evaluations in this field were merely focused in assessing metrics, such as: success, efficiency, learnability and satisfaction. Usability was the most important metric of quality of any system.

As time passed, UX has included some other aspects that go beyond the usability and focuses in: a) motivations, values and views; b) characteristics of system (functionality, features) and c) interaction process (accessibility, aesthetics)[2].

For this project UX played a significant role in developing a system for old adults because it was important to pay attention in:

- What encourages elderly people to use technology, what makes an user like or dislike it, how do users feel regarding technology
- Are the existing systems suited for these special users, the system accomplish the goal it was meant for, what features make the system unique
- Is the system following patterns or guidelines of design for this population, is the system aesthetically attractive for users

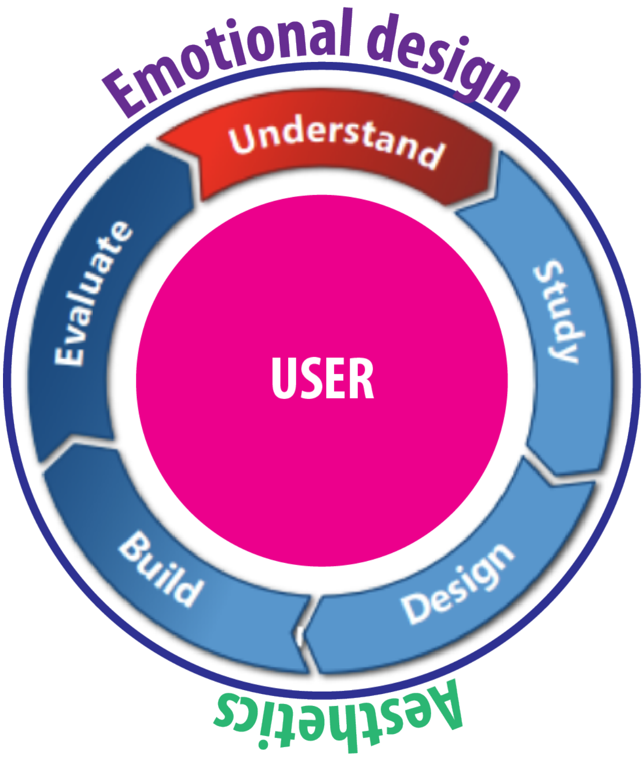

Figure 1: UCD-e: A typical iterative methodology.

3. EXPLORATORY STUDY

In this section the findings of the study are listed following the structure the methodology implemented during research.

3.1 Understanding

In order to comprehend what elderly people in Huajuapan de Leon face or struggle with in daily life, we did a documentary research followed by interviews with experts in the corresponding topic. This allowed us to understand the political, social and cultural variables that surround old adults. For instance, we found out among other findings, that mostly the person who takes care and/or is responsible of the grandfather or grandmother is the oldest woman related with them, namely: daughter, sister, auntie, etc.

3.2 Study

After previous stage, we visited the only nursing home in town to observe every-day life of the subjects. In order to do that, we used a technique called: contextual inquiry. We worked with 46 old individuals in between 60 and 95 years. The outcomes were the description of activities of the subjects in their day to day life. We were witnesses in real life of: the poverty, abandonment, harassment, cognitive and physical sickness they are exposed. In the other hand, we could also observe the relation they have with technology and the type of technology they use, which were mostly analog devices. Another technique to collect data during this stage was the focus group, which was implemented with people who is responsible whether of a grandfather or grandmother. In this activity, participants talked about how they support older people, specifically, how they supply medication, how they establish communication via phone with them and also how they implement activities to distract them from depression, such as: chitchatting, handcrafting, playing or walking.

3.3 Design and development

Findings from contextual inquiry and focus group allowed us to discuss, plan and propose a solution to deal with some of the problems elderly people face in daily life. The concept of the project was generated through the sketch board technique. The result was the design and development of a platform to distribute digital content for analog television. The project was named in Mixtecan (native indigenous Mexican language): Nuni that literally means corn but in this context works as analogy of something that needs no be cared.

3.3.1 What is Nuni?

Nuni is a web platform that hosts mobile apps designed for seniors. The apps can be installed in an android phone and are designed to work in complement with a Google Chromecast (take carer dimension). Nuni merges analog and digital technologies, allowing old adults to manipulate a medium that they are used to, in this case an analog television, and complement them whit the features of new technologies (elderly people dimension). The idea is to take advantage of the already existing mental model in the users (e.g. users know how to operate an analog radio or use a sewing machine).

3.3.2 How it works?

The Chrome-cast is connected to the analog television by using a modified HDMI to RCA converter. The Nuni system installs by default 4 applications that can be controlled using the standard TV remote control. The default applications are listed as: Inner calls: This app allows the grandparents just to receive inner calls from the smartphone. When the user gets a call, the picture and name of the caller is displayed in the TV. The call can be picked up whether using the button enter of the control remote or directly in the phone. Reminders: This app allows the caretaker to send reminders of medication via message to the grandparents. The app shows in the screen the image of the medication, the generic name of the medication, the underlying type of treatment and also the time and possible restriction of the medication. Mobility: Designed for the grandparent, the app encourage users to do some exercises, specifically designed for the limitation of their motor skills. This app uses the smartphone's camera to monitoring the workout. Stories: The application contains an avatar that pops-up randomly in time to ask the user to tell one history. The objective is to record the subject when telling the story. This story can be saved and later propagated to the family members of the user.

As we noticed, the system it self was not enough instrument to offer a solution to many different problems. There was a huge diversity and variety of issues that affects grandparents, and try to solve them all with one app was no ideal. For this reason, we went one step forward and propose to make an inclusive platform, where anybody interested in developing tools for one specific problem could do it just by reusing already existing projects or build with other users a social solution. In this context and to unify standards and generate well designed interfaces for seniors, Nuni platform offers pre-coded building blocks, apps presets, design guidelines, pre-design elements that helps developers to create more usable and efficient apps for the final user.

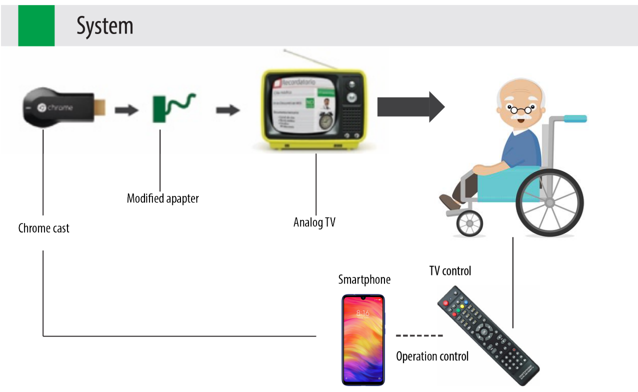

Figure 2: Nuni's workflow

3.4 Evaluation

First iteration. Using a first low fidelity prototype we assessed the interfaces by implementing a Wizard Oz technique with 5 real users. The intention was to validate the idea proposed. The outcomes of this exercise were: User struggled with icons and colors Interfaces. They were adapted accordingly to users feedback.

Second iteration. After implementing the modifications to the system a second prototype was tested with 10 users. The findings can be summarized as: Users faced problems with the typography and its size. Overall the system was accepted by users.

Third iteration. The high fidelity prototype was evaluated by 5 users. The technique implemented was usability testing. The overall results are:

- For the first prototype we evaluated 45 tasks of which 66.6% were successfully done.
- For the second prototype 170 task were evaluated with 92.9% of success fullness.
- For the last prototype we assessed 50 task and the completeness of the was 98%. 80% percent of users accepted and trust the system.
- Satisfaction of the system was mark with 9/10.

Figure 3: Usability testing

4. DISCUSSION

UCD is a methodology that is focused on identifying, comprehend and solve a potential problem but lacks of tools to deal with: aesthetics and emotional issues linked to the problem. In this case after reviewing the models of Norman and Hekker we were able to understand the problem as one small part of major problem. This conducted us to propose not just one product but a family of products that complement each other. With this exercise we learned good practices like:

- Make the task easy to understand and according to the user's context, skills, knowledge and background.
- Merge existing and new knowledge to generate an easy to remember-model.
- Re-use technology that people is familiar with.
- Create short tasks that don't demand an excessive use of retention. Seniors tent to have short memory and they struggle recalling details.

5. CONCLUSION

Developing tools for any group should consider not just usability and innovative features. Furthermore, while doing it, it should pay attention in cultural, social, personal, affective, and aesthetic implications. Applying UX tools allowed us to generate positive emotions in users. The result was a total users' adoption of the system.

Regarding to the observation we realized that there is more than one actor involved in elderly people life. To build better tools for them was important to consider caretakers, family members, doctors and neighbors, among others when developing tools for old age people.

Although Nuni is a scholar project, it has provided tools and guideline for future works related with seniors in semi-rural context. This work can easily be replicated in other contexts and adapted to different cultures. However, there is still too much to explore and consolidate in order to achieve a feasible result.

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Umestitev interaktivnih elementov in elementov igrifikacije na vnaprej zastavljeni učni poti

Borut Kolar, Matjaž Kljun, Klen Čopič Pucihar
Fakulteta za Matematiko, Naravoslovje in Informacijske Tehnologije
Univerza na Primorskem
Glagoljaška 8
Koper, Slovenija
borut.kolar@student.upr.si, matjaz.kljun@upr.si, klen.copic@famnit.upr.si

POVZETEK

Članek obravnava možnosti umestitve interaktivnih elementov in elementov igrifikacije na učni poti Parka Škocjanske jame. Učno pot spremljajo informacijske table, ki obiskovalcem podajajo informacije o značilnostih parka. Table tako omogočajo pridobivanje znanja, ki je podkrepljeno z opazovanjem realnega sveta. Prav tako so dobrodošle za tiste, ki učne poti ne obiščejo v obratovalnem času parka in zato ne morejo dostopati do vsebin, ki so ponujene na informacijski točki parka. Informacijske table pa lahko dopolnimo z digitalnimi večpredstavnostnimi vsebinami, do katerih bi lahko uporabniki imeli dostop na učni poti in bi bile tako predstavljene v kontekstu okolja v katerem se uporabnik nahaja. Ena od možnih rešitev predstavlja združitev vsebin prek aplikacije za pametne telefone. V članku je predstavljena rešitev z osnovno strukturo in delovanjem aplikacije, ki vsebuje lokacijsko pogojene kvize na učni poti ter nagrade v obliki dodatnih digitalnih vsebin v virtualni resničnosti. Uporabnikom smo tako želeli ponuditi kvize in kratke digitalne vsebine samo na določenih lokacijah in jih odvrniti od nenehnega spremljanja uporabljane naprave. Z aplikacijo tako ne želimo spreminjati klasičnega obiska parka in raziskovanja okolice, temveč le popestriti doživetje obiskovalcev.

Ključne besede

igrifikacija, učna pot, dopolnjena resničnost, virtualna resničnopst, vseprisotno računalništvo

1. UVOD

V današnjem času se veliko ljudi odloča za obisk naravnih parkov in učnih poti kjer se najpogosteje preko informacijskih tabel ali drugih pripomočkov seznanijo z rastlinskim in živalskim svetom, tradicionalnimi obrtmi, naravnimi pojavi ter ostalimi naravnimi in kulturnimi znamenitostmi. [3, 1].

Primer učne poti je tudi učna pot Škocjan, ki se nahaja v Regijskem parku Škocjanske jame[1]. Učno pot spremljajo informacijske table, ki obiskovalcem podajajo informacije o značilnostih parka. Table tako omogočajo pridobivanje znanja, ki je podkrepljeno z opazovanjem realnega sveta. Ena od omejitev tovrstnih tabel je razpoložljiv prostor, kar upravljavce parka omejuje pri količini informacij, ki jih lahko podajo. Za rešitev te težave so v parku izdali vodnik v obliki žepne knjižice, ki dopolnjuje vsebino tabel[2]. Informacijske table in vodniki pa imajo tudi nekaj slabosti. Obiskovalci morajo za vodnik vedeti in si ga morajo predhodno priskrbeti pred obiskom parka in obstaja velika verjetnost, da ga bodo ljudje ne bodo brali med raziskovanjem učne poti. Poleg tega težavo predstavlja tudi težko spreminjanje vsebin tabel in vodnikov in s tem povezani stroški. Tako table kot vodnik žal ne omogočajo interaktivnosti. Večpredstavnostne vsebine pa bi bile odlično dopolnilo tabel na učni poti, saj bi lahko z njim popestrili obisk parka. V članku je predstavljena naša rešitev z osnovno strukturo in delovanjem aplikacije, ki vsebuje lokacijsko pogojene kvize na učni poti ter nagrade v obliki dodatnih digitalnih vsebin v virtualni in dopolnjeni resničnosti.

2. ZASNOVA APLIKACIJE

Pri zasnovi aplikacije smo sledili naslednjim vodilom: (i) Ponuditi smo želili lokacijsko pogojene vsebine na točno določenih lokacijah in nanje opozoriti uporabnika, (ii) Vsebine morajo biti kratke in zanimive, (iii) Odvrniti želimo uporabnika od uporabe elektronske naprave, kadar vsebine niso na voljo, in (iv) Uporabnika želimo motivirati z elementi igrifikacije.

Uporabniku želimo torej ponuditi kratke digitalne vsebine samo na določenih lokacijah in ga želimo odvrniti od nenehnega spremljanja uporabljene naprave, kar je ena ključnih težav pri večini lokacijsko pogojenih iger. Zaradi zahteve po čim krajšem času, preživetem na napravi, količina ponujenih digitalnih vsebin ne sme biti prevelika ne predolga saj ne želimo spreminjati klasičnega obiska parka in raziskovanja okolice, temveč le popestriti doživetje obiskovalcev.

2.1 Implementirana rešitev

Zaradi razširjenosti pametnih telefonom s sistemom Android smo se odločili, da izberemo to mobilno platformo za razvoj rešitve. Osnovna interakcija je predstavljena na Sliki 1. Po najdenem GPS signalu aplikacija pozove uporabnika naj telefon pospravi v žep in da ga bo opozorila, ko bo v bližini digitalnih vsebin. V bližini lokacije z digitalnimi vsebina dobi uporabnik opozorilo preko vibriranja. V okolici z digitalno vsebino morajo uporabniki poiskali NFC značko, ki bo omogočila sprožitev prikaza določene vsebine na telefonu. Pri prikazu vsebin smo se odločili za uporabo kratkih vpra-

[1] https://www.park-skocjanske-jame.si/si/vsebina/izobrazevalni-programi/ucna-pot-skocjan

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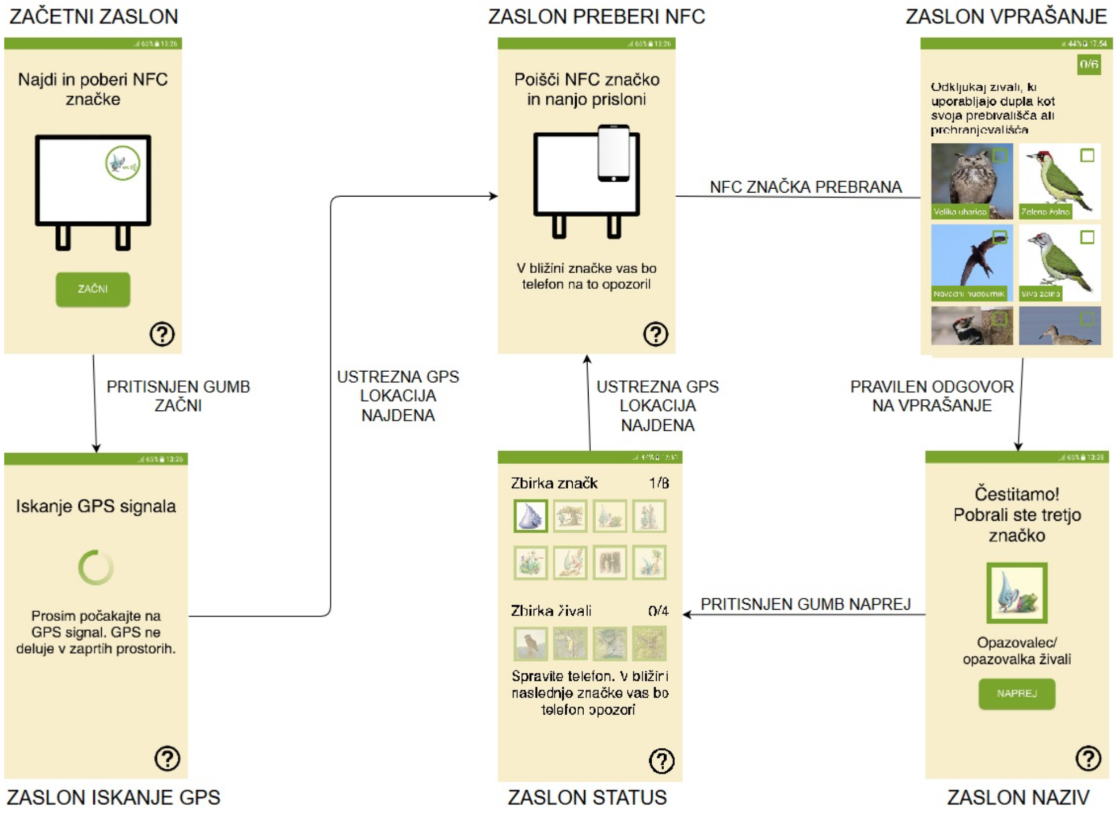

Slika 1: Diagram, ki predstavlja potek interakcije z aplikacijo po korakih. "Zaslon vprašanje" ponudi uporabniku drugo vprašanje pri vsaki dopolnjeni tabli. Pri nekaterih tablah uporabnik dobi tudi živali v dopolnjeni ali virtualni resničnosti, kar je vidno na "Zaslon status". Na posamezno žival iz Zbirke živali ali značko iz Zbirke značk lahko upabnik tapne in s tem odpre posamezno vsebino.

šanj s slikovnim gradivom, ki so povezana z vsebino na informacijski tabli na določeni lokaciji. Po najdeni in uspešno prebrani NFC znački uporabnik dobi vprašanje in s pravilnim odgovorom pridobi še značko. Pri vsaki znački dobi uporabnik tudi enega od nazivov poznavalca parka (na sliki je to "opazovalec/opazovalka parka"). Po uspešno odgovorjenih nekaterih vprašanjih ima na voljo še dodatne vsebine, ki jih lahko "odnese" s seboj in si jih lahko ogleda tudi izzven parka kot nagrado. Dodatne vsebine so 360 stopinjski posnetki lokacij parka v katerih se nahajajo animirane živali. Podrobnejša implementacija je podana v [2].

3. ZAKLJUčEK

Aplikacijo nameravamo v prihodnosti dati na uporabo parku in uporabnikom. Uporabniki bodo s tem pridobili dodatno izkušnjo pri obiski parka. S seboj bodo lahko "odnesli" nagrado. S parkom smo se tudi dogovarili, da bi lahko uporabniki, ki so pridobili vse virtualne značke, dobili tudi fizično broško kot poznavalci parka. Z anonimiziranimi zajetimi podatki bi lahko upravljavci parka še bolje razumeli kateri deli učne poti so najbolj obiskani ter kako dobro informacijske table obiskovalce informirajo o značilnostih obiskanega območja. S tem znanjem bi lahko učno pot še bolje prilagodili različnim ciljnim skupinam. Poleg tega nameravamo z zbranimi podatki ugotoviti katere dele aplikacije uporabniki uporabljajo in katere ne ter poskušati izboljšati uporabniško izkušnjo.

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Interakcija z umetniškimi deli preko množičnega ocenjevanja

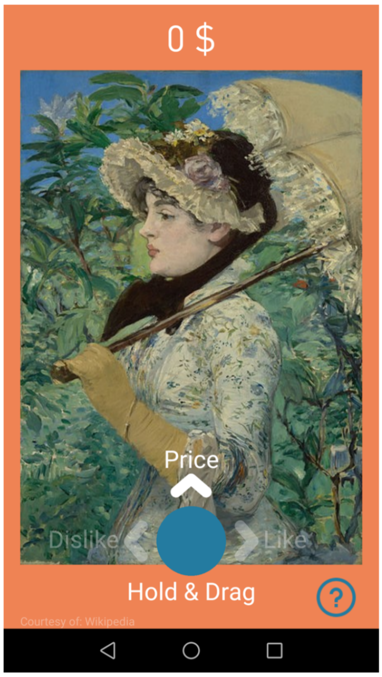
Patrik Širol, Klen Čopič Pucihar, Matjaž Kljun
Fakulteta za Matematiko, Naravoslovje in Informacijske Tehnologije
Univerza na Primorskem
Glagoljaška 8
Koper, Slovenija
patrik.sirol@student.upr.si, klen.copic@famnit.upr.si, matjaz.kljun@upr.si

POVZETEK
V realnem svetu (na primer v muzejih in galerijah) in pri uporabi spleta ali mobilnih aplikacij, ki prikazujejo umetniška dela, je uporabnik le pasiven bralec oziroma gledalec. Pri pregledu aplikacij za mobilne telefone, ki so namenjene umetninam, lahko opazimo, da jih velika večina samo podaja informacije. Gledalcu oziroma uporabniku takih aplikacij ponavadi ni mogočeno izraziti svoje mnenje in ga deliti z drugimi uporabniki. V ta namen smo razvili aplikacijo, s katero lahko uporabnik izrazi svoje mnenje o opazovanem umetniškem delu (ali mu je všeč ali ne) in določijo subjektivno vrednost umetnine. Po postavljeni oceni se lahko uporabniki primerjajo z drugimi uporabniki aplikacije. Z aplikacijo smo želeli ugotoviti, ali se lahko veliko število uporabnikov s svojim subjektivnim ocenjevanjem približa prodajnim cenam slik, kot to predvideva Wisdom of the crowd oziroma ocena velike množice ljudi. Izkazalo se je, da se ljudje v večini niso približali prodajni ceni slik. Izpostavili smo dva razloga: premajhen vzorec ocenjevalcev in subjektivna ter abstraktna narava umetnosti.

Keywords
umetnost, mobilna aplikacija, masovno ocenjevanje, ocena množice

1. UVOD
Pri obisku muzejev in galerij pa z umetniškimi deli nimamo nobene interakcije. Lahko jih samo opazujemo in podamo oceno umetnine. Ena od težav umetnosti je objektivno ocenjevanje kakovosti tako umetniških del kot umetniškega izražanja. Če neko umetniško delo oceni nekaj kritikov, ki se z umetnostjo ukvarjajo, obstaja velika verjetnost, da bomo dobili zelo različne ocene [1]. Poleg tega na ocenjevanje vplivajo različni dejavniki. Eden od teh je podzavestno odločanje za nakup izdelkov in storitev, ki so dražje in lepše zavite, saj so razumljene kot kakovostnejše [2]. Raziskave so na primer pokazale, da ljudje raje uživamo izdelke, kot sta vino in čokolada, če se zavedamo, da je njihova nakupna cena višja od primerljivih izdelkov [3].

Pri različnih ocenjevanjih lahko uporabimo koncept Wisdom of the crowd oziroma t. i. oceno množice, ki pravi, da je povprečje odgovorov na neko vprašanje velikega števila ljudi znotraj skupine skoraj enako ali celo natančnejše od najboljšega posameznika znotraj skupine [4]. Če na primer veliko število ljudi ocenjuje težo nekega objekta ali število kroglic v posodi ali kakšno drugo količino, se povprečna vrednost vseh ocen zelo približa realnemu številu. Tako ocenjevanje množice smo želeli uporabiti pri ocenjevanju umetniških del. V ta namen smo razvili mobilno aplikacijo Art Value, s pomočjo katere lahko uporabniki ocenjujejo umetniška dela.



Slika 1: Zaslonska slika ocenjevanja umetnine. Z vlečenjem krogca navzgor višamo ceno. Z vlečenjem levo in desno pa sliko včečkamo ali ne.

2. IMPLEMENTACIJA
Aplikacija ponuja 96 umetniških del 70 različnih avtorjev. Uporabnik lahko posamezni sliki poda subjektivno oceno na dveh ravneh: všeč/ni všeč in določajo vrednost umetniškega dela (slej Sliko 1). Po ocenjevanju se prikažejo dejanska vrednost dela, podatki o sliki (ime avtorja, slike, letnica nastanka) in ocene vseh uporabnikov v obliki grafa. S predstavljenimi podatki želimo uporabnikom nuditi ozaveščanje o umetniških izdelkih, njihovih avtorjih in obdobju, v katerem so dela nastajala. Poleg tega pa želimo preko grafa omogočiti primerjavo lastne ocene z oceno množice. Nato gre lahko uporabnik na naslednjo sliko in jo oceni. Vsem

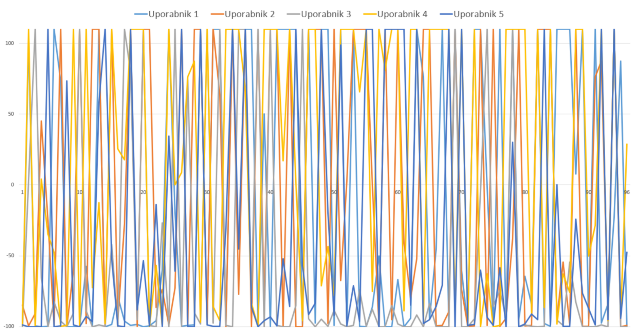
uporabnikom se slike prikazujejo v istem zaporedju.

3. EVALVACIJA IN REZULTATI

Po slabem letu od objave aplikacije Art Value v Googlovi trgovini Play Store smo se odločili opraviti analizo rezultatov do 23. marca 2018. Aplikacijo je uporabljalo 79 uporabnikov. Vsak uporabnik je v povprečju ocenil 14 slik, poleg tega je v povprečju všečkal 14 slik, ni všečkal pa zgolj 5 slik. Od 1122 ocen je bilo všečkanih kar 817 (72,8 %), za 305 (27,2 %) slik pa so uporabniki izbrali možnost "ni mi všeč". Pri tem je potrebno poudariti, da se je, glede na visoko število všečkanih slik, le to ujemalo pri večini uporabnikov.

26,% (21 uporabnikov) vseh ocenjevalcev ocenilo samo 1 sliko. 12,7% oziroma 10 uporabnikov je ocenilo dve sliki, 13,9% oziroma 11 uporabnikov je ocenilo 3 slike, 11,4% (9 uporabnikov) je ocenilo samo 4 slike in 7,6% (6) uporabnikov je ocenilo 8 slik. Vredno je še poudariti, da so samo 4 uporabniki ocenili več kot 100 slik (to pomeni da je določene slike ocenil dvakrat), samo en uporabnik pa je ocenil več kot 200 slik. Preostali odstotki se porazdelijo med enim oziroma dvema uporabnikoma na oceno. To je bilo veliko pod pričakovanji, saj smo menili, da bo večina ocenila vsaj 5 slik.

Uporabniki so zelo slabo ocenjevali vrednost slike. Skoraj polovica vseh ocen je bila med 0 in 10% realne cene. Predpostavljamo lahko, da je za to krivo premajhno število uporabnikov in premajhno število ocen slik, zaradi česar ocenjevanje množice ni prišlo do izraza. Ali pa je umetnost je morda preveč subjektivna in abstraktna za množično ocenjevanje. Možno je tudi, da so slike precenjene v očeh ljudi ali pa so uporabniki ciljali na slepo.



Slika 2: Stopnje napak za prvi krog ocen 5 uporabnikov z največ ocenami.

Na Sliki 2 so prikazane stopnje napak za prvi krog (do 96. slike) ocen petih uporabnikov, ki so ocenili največje število slik (več kot 100). Na vertikalni osi je prikazan interval od –100% do 110% realne cene, na horizontalni osi pa, katera je bila ocena po vrsti. –100% na vertikalni osi pomeni nič dolarjev, 0% je realna cena slike, 100% pa pomeni dvakratna cena slike. Poudariti je treba, da smo zaradi nazornejšega prikaza vse ocene, ki gredo nad dvakratno vrednostjo slike, zaokrožili na 110%. S pomočjo grafa smo želeli ugotoviti, ali se bodo ocene vrednosti posameznih uporabnikov pri ocenjevanju skozi čas izboljševale (približevale realnim cenam). Če bi se to zgodilo, bi se koncentracija napak iz leve proti desni zmanjševala in približevala 0%, torej realni ceni. Kakor je razvidno iz grafa, se to ni zgodilo, saj vidimo konstantno naključno nihanje skozi celoten krog ocenjevanja. Iz tega lahko zaključimo, da se pri ocenjevanju uporabniki niso ničesar naučili, temveč so ocenjevali naključno. Seveda je treba poudariti, da je vzorec uporabnikov zelo majhen, tako je mogoče, da bi se pri večjem vzorcu stvari spremenile.

4. ZAKLJUčEK

Z aplikacijo smo želeli doseči, da čim več ljudi oceni čim večje število slik, pri tem pa smo želeli ugotoviti, ali se uporabniki s svojim subjektivnim ocenjevanjem lahko približajo prodajnim cenam slik, kot to predvideva Wisdom of the crowd oziroma ocena velike množice ljudi. Izkazalo se je, da se ljudje v večini niso približali prodajni ceni slik. Potencialnih razlogov za to je kar nekaj. Izpostavili smo predvsem dva.

Prvi je ta, da je bil vzorec ocenjevalcev premajhen, kar je posledično privedlo do preveč naključnih ocen. Za realno oceno množice bi potrebovali veliko več uporabnikov. Aplikacijo smo sicer reklamirali med svojimi prijatelji in znanci na straneh socialnih omrežij a smo to naredili le nekajkrat. Za doseči večje število uporabnikov bi bilo potrebno aplikacijo reklamirati skozi daljše časovno obdobje.

Drugi razlog je vezan na samo umetnost, pri kateri sta lepota in cena precej subjektivne in abstraktne narave. Oceno množice so najpogosteje raziskovali in dokazali pri reševanju težav, ki zahtevajo enotno številčno oceno. Enak učinek je možno doseči tudi pri težavah, pri katerih odgovor zahteva usklajevanje več informacij [4]. Ko govorimo o enotni številčni oceni mislimo na primer na oceno množice pri ocenjevanju vrednosti nekega izdelka, za katerega bi nekateri ljudje plačali manj, nekateri več, v povprečju bi pa plačali približek realne vrednosti. Podobno bi lahko pričakovali pri umetniških delih a je to potrebno šele dokazati. Lahko predpostavljamo, da je ocenjevanje vrednosti umetnin podobno kot ocenjevanje drugih izdelkov. Hkrati pa lahko predpostavljamo, da je umetnost precej subjektivna in so cene umetniških del precej visoke in uporabnikom tudi nedoumljive. To bi lahko trdili na podlagi dejstva, da se pet uporabnikov, ki so ocenili slabih 100 slik, pri ocenjevanju vrednosti ni približalo dejanski vrednosti skozi čas. V prihodnje bi bilo potrebno aplikacijo bolje reklamirati in pridobiti večje število uporabnikov, da bi lahko ovrgli ali sprejeli našo hipotezo o delovanju ocene množice pri umetninah.

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Igrifikacija virtualnega obiska učne poti Škocjan z uporabo mobilnih tehnologij in 360-stopinjskih posnetkov

Tilen Jesenko, Matjaž Kljun, Klen Čopič Pucihar
Fakulteta za Matematiko, Naravoslovje in Informacijske Tehnologije
Univerza na Primorskem
Glagoljaška 8
Koper, Slovenija
patrik.sirol@student.upr.si, matjaz.kljun@upr.si, klen.copic@famnit.upr.si

POVZETEK

V zadnjem desetletju se na svetovnem spletu pojavljajo storitve, ko je na primer Google Street View, ki nam omogočajo virtualni ogled cest, ulic, trgovin, muzejev in drugih objektov na ekranu ali s pomočjo naglavnih prikazovalnikov virtualne resničnosti. Za virtualne obiske oz. ogled se uporablja 360 stopinjske panoramske posnetke. V članku je opisan prototip virtualnega obiska učne poti v Parku Škocjanske jame, ki na poučen in interaktiven način predstavi učno pot ljudem pred samim fizičnim obiskom, ljudem, ki po fizičnem obisku želijo podoživeti pot in ljudem z omejeno možnostjo gibanja, da lahko pot, ki jim je nedostopna, sploh doživijo.

Ključne besede

virtualni sprehod, igrifikacija, panoramski posnetki, spletna aplikacija

1. UVOD

Učne poti so lahko zahtevne za obiskovalce z zmanjšano mobilnostjo, lahko vzamejo preveč časa, ali pa se ljudje želijo poučiti o poti pred samim obiskom. Zato smo želeli omogočiti virtualni obisk učne poti na zabaven in hkrati poučen način. Virtualni obisk poti smo želeli prilagoditi na način, da uporabnika zadržimo skozi celoten virtualen sprehod vključno s prvotnim namenom učnih poti - poučiti uporabnika o naravni in kulturni dediščini okolja v katerem se nahaja.

2. PREGLED OBSTOJEčIH VIRTUALNIH OBISKOV

Ker je virtualnih obiskov precej, bomo predstavili le dva kot primera dobre prakse. Pirvi je Night Walk, ki obiskovalca popelje po ulicah francoskega mesta Marseille. Sestavljen je iz številnih 360 stopinjskih posnetkov na katerih so označene zanimive točke; s klikom nanje se nam pokaže ali dodatna slika ali pa videoposnetek. Nekatere od njih vsebujejo vprašanje, ki je povezano z mestom. V zgornjem levem kotu je prikazano število vseh in število ogledanih točk. Ves čas nas spremljajo zvočni posnetki, ki so tako ali drugače povezani s trenutno panoramo. Na ekranu je viden tudi zemljevid, ki prikazuje, kje v mestu se uporabnik nahaja ter katere dele mesta si lahko ogleda. Drugi primer je aplikacija CŠOD Misija, ki omogoča virtualno-fizične sprehode na različnih lokacijah. Sestavlja jo veliko število učnih ali pohodniških poti, na katerih so označene zanimive geografske lokacije. Ko na podprti lokaciji uporabnik odpre aplikacijo mu ta ponudi izziv v obliki vprašanja. Pravilen odgovor je mogoče prebrati v opisu lokacije ali najti nekje v bližini. Za vsak pravilen odgovor uporabnik prejme točke in ko jih zbere dovolj pridobi značko uspešno opravljenega obiska.

3. ZASNOVA APLIKACIJE

Po pregledu različnih obiskov smo si virtualen obisk učne poti Parka Škocjanske Jame zamislili na podlagi sledečih zahtev.

(i) Enostaven dostop do virtualnega sprehoda (brez nameščanja dodatne programske opreme na uporabnikovo napravo, na primer preko spletnega brskalnika).

(ii) Prilagodljivost različnim velikostim zaslonov.

(iii)Prikaz interaktivnega zemljevida lokacij posameznih točk na učni poti. Možnost "sprehoda" z izbiro posamezne točke na zemljevidu ali pa zaporedno od prve do zadnje, kot bi jih obiskali v realnem svetu.

(iv) Prikaz in interakcija s 360 stopinjskimi posnetki za posamezno točko iz zemljevida tako, da omogočimo usmerjanje pogleda uporabnika v 360 stopinjskem posnetku z giroskopom na pametnem telefonu ali z miško na namiznih računalnikih in prikažemo označene zanimive dele na posnetku z dodajanjem opisov, slik, ali video posnetkov v 360 stopinjski posnetek.

(v) Prikazovanje vprašanja in možnih odgovorov povezanih s trenutno lokacijo, odgovarjanje in beleženje odgovorov kot element igrifikacije. Pri vsaki lokaciji na učni poti je na voljo vprašanje. Pravilen odgovor se skriva v dodanih opisih na 360 stopinjskem posnetku. Uporabnik ima na voljo 3 možnosti, od katerih je vedno pravilna le ena. S klikom na enega izmed odgovorov se prikaže pojavno okno z razlago. Ne glede na rezultat ima uporabnik možnost nadaljevati na naslednjo lokacijo.

(vi) Zbiranje nagradnih značk kot element igrifikacije. Uporabnik bo z odgovarjanjem na vprašanja povezanimi z lokacijo na učni poti zbiral nagradne značke. Če uporabnik pravilno odgovori na vprašanje, si pridobi značko, ki si jo lahko odpre v večji velikosti. Če uporabnik klikne na značko, ki je še ni pridobil, se mu pojavi opozorilo, ki ga vljudno povabi k odgovarjanju. Da bi obisk uporabniku predstavljal izziv, bo

Slika 1: Vmesnik virtualne poti na zaslonu namiznega računalnika. Uporabnik se trenutno nahaja na tretji točki sprehoda od osmih kar je vidno na zemljevidu zgoraj levo. Med točkami se lahko premika samodejno zaporedno z odgovarjanjem na vprašanja ali pa klikne na poljubno točko na zemljevidu in se premakne nanjo. Desno od zemljevida se nahajajo vprašanja in skrajno desno pridobljene značke. V spodnjem delu je panoramska slika na kateri lahko uporabnik odpira dodatne slike in besedilne opise.

lahko na vsako vprašanje odgovoril le enkrat. Če se zmoti, mora obisk začeti ponovno da bi zbral vse značke.

4. OPIS VMESNIKA

Vmesnik lahko vidimo na Sliki 1. Za virtualni obisk učne poti smo izbrali 8 geografski lokacij na sami učni poti, ki bodo predstavljene z 360 stopinjskimi posnetki. Pri postavitvi smo se odločili, da spletno aplikacijo razdelimo na 2 dela: zgornji, se deli še na 3 enote. Na levi je slika zemljevida učne poti Škocjan, na kateri so tudi označene geografske točke virtualnega obiska. Na sredini je prostor za vprašanje ter možne odgovore, desno pa so v 2 enaka stolpca po vrsti razvrščene nagradne značke. Celoten spodnji del zaseda interaktivna panoramska slika. Za prikaz panoramskih sliksmo uporabili orodje Google Poly.

Uporabnik začne svoj virtualni obisk na prvi točki. Če odgovori na zastavljeno vprašanje in če je odgovor pravilen, se odklene nagradna značka na katero lahko uporabnik klikne in si jo ogleda. Če je odgovor napačen, se pri nagradni znački pojavi rdeč X in odpre okno s pravilnim odgovorom. Odgovor na vprašanje se nahaja na panoramski sliki v dodatnih opisih. V kolikor želi uporabnik nadaljevati obisk, se naloži naslednja panorama in novo vprašanje. Uporabnik lahko na zemljevidu izbere tudi poljubno lokacijo in tako ne obišče virtualne poti v zaporedju. Ko uporabnik odgovori na vprašanje pri zadnji lokaciji se odpre novo okno, ki uporabnika obvesti, da je prispel na konec in ga povabi, da si s klikom na lokacijo na zemljevidu še enkrat pogleda 360 stopinjske posnetke.

5. ZAKLJUčEK

V spletno aplikacijo smo vgradili anonimno sledenje interakciji. V prihodnosti nameravamo izvesti študijo, ki bo razkrila kaj uporabniki počnejo na virtualni učni poti in ali je namen (učenje preko odkrivanja informacij na panoramskih slikah in zbiranja značk) dosežen. Podrobnejši opis ideje, zasnove in izvedbe izdelave spletne aplikacije virtualnega obiska učne poti je dosegljiva v [1].

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Virtual Reality and Neurocognitive Intervention: Rehabilitation approaches towards assisting autistic children with cognitive deficit

Maheshya Weerasinghe*
FAMNIT, University of Primorska
Koper
Slovenia
maheshya@famnit.upr.si

Nuwan Attygalle
LK Simulations Pvt Ltd
Colomo 03
Sri Lanka
nuwan.t.attygalle@gmail.com

Julie Ducasse
FAMNIT, University of Primorska
Koper
Slovenia
julie.ducasse@famnit.upr.si

ABSTRACT
Autism Spectrum Disorder (ASD) is a developmental condition in which the sufferer experiences difficulties in communication with other people, struggles with social interaction and is confused by the world around. Although there is no remedy for this condition, Various medical and technological organizations are working on the development of unconventional solutions such as therapy and assistance for aiding individuals with ASD to manage their condition. Information and communications technology (ICT) is used as a form of therapy in the clinical treatment of psychological disorders. Virtual Reality (VR) is a reasonably new addition to ICT based therapy which can be used to encourage, guide and support individuals with cognitive disorders to develop their skills necessary for independence. Previous researches and experiments have shown that it is possible to enhance the level of concentration, coordination, socialization, communication, self-awareness, and memory in individuals supported with VR. It is not only an ideal way of ameliorating these skills before encouraging individuals to try these out in the real world but also creates a safer environment. This paper focuses on exploring the VR based rehabilitation systems that look into the efficacy of the combination of VR and interactive rehabilitation techniques to complement the current conventional rehabilitation treatments for individuals with ASD. This will be presented through two examples: enhance awareness and coordination by teaching autistic children how to cross a road, and enhance focus and attention using a virtual classroom.

Keywords
Virtual reality, autism spectrum disorder, cognitive rehabilitation

1. INTRODUCTION
The incidence of ASD has increased steadily over the last twenty years. According to the National Autism Association statistics, it is the fastest growing developmental disorder, yet most underfunded [5]. Some studies have been published which show that in recent years there has been an increase in ASD cases by 78% since 2002 [5][1]. However, it must be noted that there is a lack of consensus regarding the prevalence of ASD. Recent studies published in March 2014 by the Center for Disease Control and Prevention (CDC) show that about 1 in 68 children has been identified with ASD in the USA. Studies in Asia, Europe, and North America have identified individuals with ASD with an average prevalence of between 1% and 2% [5]. ASD itself does not affect life expectancy; however research has shown that the mortality risk among individuals with ASD is twice as high as the general population, in large part due to drowning and other accidents. These numbers clearly exemplify that this is indeed an area of concern. Currently there is no cure for ASD, though with early intervention and treatment, the diverse symptoms related to ASD can be improved significantly to enable the person with ASD to lead a useful and productive life.

Since the 1960s the brain has been considered an irrecoverable organ, unable to substitute lost nerve cells [6]. As a result the loss of cognitive functioning were considered to be irreversible and untreatable. When the concept of neuroplasticity gained popularity in the 1980s, this view of the hardwired brain started to change and the potential for cognitive rehabilitation was acknowledged. Neuroplasticity entails the ability of the brain to alter existing connections between cells, to form new connections, to create new cells, and to resist cell death. It allows the neural networks in the brain to reorganize their architecture and functioning through exposure to new sensory experiences [14]. The idea was first proposed in 1892 by Santiago Ramon y Cajal, and subsequently neglected for the next 50 years [13]. Along with the support for the concept of neuroplasticity and how it may enable cognitive rehabilitation, VR was investigated as an enabling technology for cognitive interventions [13].

2. VR AND COGNITIVE REHABILITATION
The perceived impact of cognitive impairment on day-to-day functioning has led to the development of cognitive rehabilitation approaches intended to remedy these impairments, thus improving the functioning of people with psychiatric disabilities. In this context, professionals from different fields have been studying and developing cognitive rehabilitation strategies, generating controversy, and a variety of views regarding the effectiveness of each one. In general, these approaches may be classified as restorative or compensatory, as well as computerised and non-computerised.

*School of Computer Science, University of St Andrews.

Some areas of particular interest in which applications of VR are being researched and developed are in clinical psychology, and the cognitive and neurosciences. VR can be used as an assessment or intervention instrument for the clinical treatment of psychological disorders. Studies have been conducted which focused on cognitive behavioral therapy for the rehabilitation of anxiety disorders such as fear of heights (acrophobia) [11], fear of flying (aviophobia) [11], fear of open spaces (agoraphobia) [7] and social phobia [7]. Other applications involve the rehabilitation of anxiety disorders such as Post Traumatic Stress Disorders for war veterans (Vietnam, Iraq, and Afghanistan) [9]. VR applications have also been developed to clinically rehabilitate a degradation of cognitive functioning resulting from a range of diseases including Alzheimers [8], schizophrenia [4] or conditions such as autism [3] and intellectual disabilities [12]. A functional overlap exists in many of these applications in that they can aim to achieve similar goals such as training with activities of daily life which support more independent living, enhancing cognitive performance and improving social skills.

2.1 Case Study I:Awareness and Coordination

One example of a VR for enhancing the awareness and coordination of ASD individuals is a study conducted by a team of researchers at the University of Haifa, Israel [2]. This system features several scenarios which are all designed to teach autistic children how to cross a road. The simulation shows a street with traffic lights and cars which the child interacts with. The child learns to cross a road safely and without placing them in danger or causing undue stress. Plus these skills are then practiced in a real-world but controlled area.

2.2 Case Study II:Focus and Attention

Virtual reality is also used to help autistic children with social attention problems. An autistic child often finds it difficult to read facial expressions, pick up visual cues or pay attention to another person while they speak. An example of a VR for enhancing the focus and attention of ASD individuals is a system developed in the US which aims to improve social attention in autistic children [10]. The child wears a head-mounted display (HMD) which shows images from a virtual classroom. This classroom contains a set of 3D virtual people or avatars who deliver an individual presentation. But each of these avatars starts to fade if the child looks away or loses interest.Figure 1 illustrates a scene from the commercial prototype of the virtual classroom.

Figure 1: A Scene from the virtual classroom [10]

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Interakcija z umetninami z uporabo tehnologije dopolnjene resničnosti

Boštjan Čotar, Matjaž Kljun, Klen Čopič Pucihar
Fakulteta za Matematiko, Naravoslovje in Informacijske Tehnologije
Univerza na Primorskem
Glagoljaška 8
Koper, Slovenija
bostjan.cotar@student.upr.si, matjaz.kljun@upr.si, klen.copic@famnit.upr.si

POVZETEK

V članku je predstavljena zasnova in in opis prototipa aplikacije v obliki igre lov na zaklad v navezi z interakcijo z umetniškimi deli. Med obiskom muzeja ali galerije prototip uporabnikom ponudi uporabo dopolnjene resničnosti za popestritev samega obiska, kjer s pomočjo tabličnega računalnika (tablice) obiskovalec išče predhodno izbran in pobarvan kip. Lov na zaklad oziroma intzerakcija je zamišljena tako, da uporabnik pobarva pobarvanko, jo slika in se s tablico poda po galeriji ali muzeju. Če najde pobarvanki pripadajoči kip, se le ta ovije v pobarvano preobleko glede na pobarvano pobarvanko. Če pa izbere napačen kip, ga aplikacija na to opozori.

Ključne besede

dopolnjena resničnost, umetnine, igrifikacija, lov na zaklad

1. UVOD

Galerije in muzeji želijo ponuditi obiskovalcem izkušnjo, ki jim bo ostala v spominu, predvsem pa želijo v njih vzbuditi željo, da bi prišli še kdaj. Eden od načinov popestritve obiska galerije je uporaba sodobnih tehnologij kot na primer uvedba avdio vodičev ali postavitev zaslonov (lahko tudi QR kod) poleg umetnine, na katerih lahko preberemo nekaj več o umetnini sami, zgodovini avtorja, času nastanka umetnine ali pogledamo dodatne multimedijske vsebine. Tak pristop obiskovalcu kopico novih informacij, ki so povezane z določenim eksponatom.

Poleg naštetih tehnologij za uporabo v galerijah in muzejih obstaja še veliko možnosti, med katere sodi tudi dopolnjena resničnost. Dopolnjena resničnost je vrsta tehnologije, ki nam pogled na realni svet dopolni z računalniško ustvarjenimi virtualnimi vsebinami, kot so besedilo, zvok, slika ali video. Tehnika dopolnjevanja se odvija v realnem času in v korelaciji z obstoječo okolico. Na ta način gradimo uporabniško izkušnjo, kjer se digitalni svet in naša okolica prepletata in tako uporabniku omogočata nove načine interakcije z okoljem.

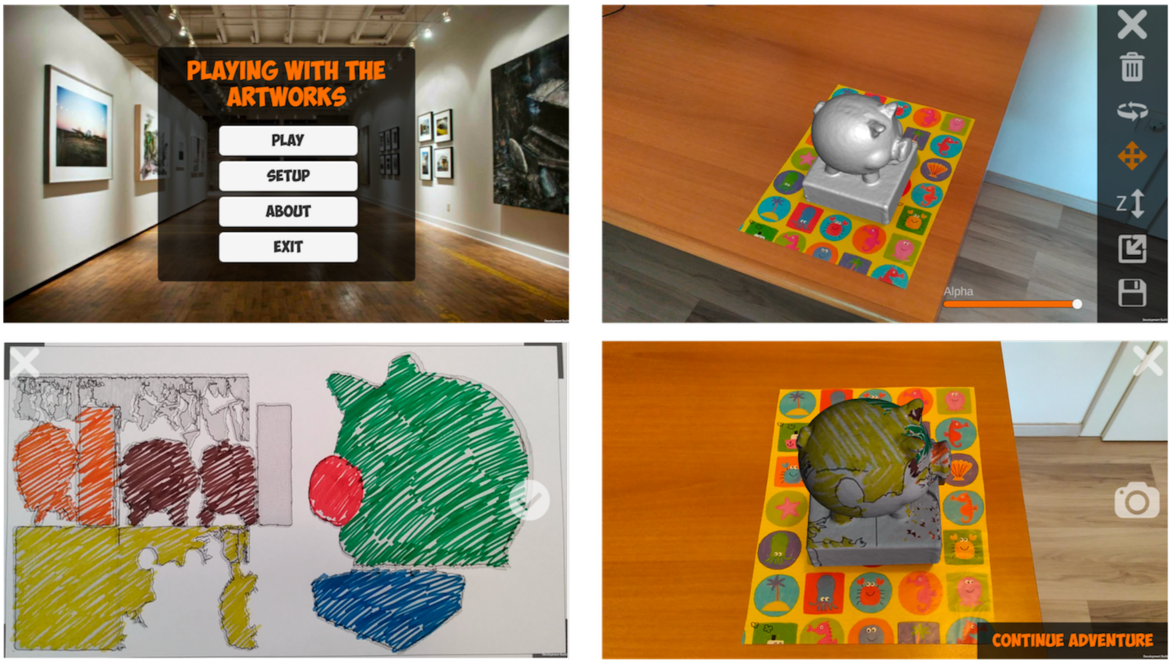
Članek nadgrajuje delo opisano v [1], ki opisuje način uporabe tehnologije dopolnjene resničnosti, ki omogoča uporabnikom, da med obiskom galerije postanejo soustvarjalci. Izdelan je bil prototip igre po zgledu igre lov na zaklad, ki je bil že večkrat raziskan v različnih okoljih in različnimi skupinami uporabnikov[2, 3, 4]. V [1] je bila ideja zasnovana tako, da vsak udeleženec prejme pobarvanko in jo pobarva po svoji želji. Pobarvanko slika s tabličnim računalnikom (tablico) in se poda na iskanje pobarvanki pripadajočega kipa. V primeru usmerjene tablice na pripadajoče umetniško delo pobarvana kontura prekrije le to. Prototip predstavljen v [1] je deloval le za 2D vsebino. Naša ideja je bila ustvariti podoben prototip, ki bo s pomočjo dopolnjene resničnosti omogočal interaktivnost s 3D objekti oziroma kipi.

2. ZASNOVA PROTOTIPA

Za razvoj aplikacije smo uporabili programsko opremo Unity3D, ki je namenjena razvoju računalniških iger in je hkrati tudi razvojno okolje. Kot privzeti programski jezik smo izbrali C#. Za razvoj rešitve smo uporabili platformo dopolnjene resničnosti Google Tango[1], vgrajeno v tablico Tango Development Kit, ki omogoča sledenje napravi v prostoru. Uporabili smo še programsko knjižnico Tango SDK za orodje Unity3D. 3D objekte smo dobili tako, da smo s Structure IO senzorjem[2] objekt skenirali in nato uporabili programsko opremo Skanect[3], ki zgenerira model oz. mrežo objekta s primerno geometrijo in primernim številom oglijšč. Dobljen model smo obdelali v orodju Blender kjer smo naredili UV preslikavo (ang UV texture mapping) in jo spremenili do te mere, da je preslikava še vedno nakazovala kaj naj bi uporabnik barval. Preslikava je tako bila osnova za pobarvanko. Ker se Tango tablica "zaveda" svojega položaja v prostoru smo lahko postavili pridobljen 3D objekt točno na položaj realenega objekta in hkrati pobarvanko (oz. pobarvano preslikavo) napeli nanj.

Delovanje aplikacije se deli na dva dela glede na skupino uporabnikov: obiskovalci galerij in uredniki vsebine, zadolženi za vzdrževanje podatkov v aplikaciji (Slika 1 zgoraj levo). Uredniki niso nujno kuratorji muzeja saj potrebujejo za postavitev igre nekaj naprednega tehničnega znanja. Uredniki morejo najprej posneti notranji razstavni prostor, kjer bodo obiskovalci kasneje uporabljali aplikacijo. To omogoča sama tablica Tango. Nato morejo izdelati 3D modele kipov, ki jih bi želeli v muzeju ali galeriji uporabiti v igri. 3D modele je nato potrebno uvoziti v aplikacijo in jih nato umestiti v prostor na položaj realnih kipov. Pri tem lahko urednik opravi manjše popravke (spremeni koordinate, velikost in orientacijo kipa). Končni izdelek je virtualni 3D-model kipa, ki sovpada s fizičnim kipom v realnem svetu kar je vidno na

[1] https://en.wikipedia.org/wiki/Tango_(platform)
[2] https://structure.io/
[3] https://skanect.occipital.com/



Slika 1: Vmesnik aplikacije. Zgoraj levo: izbira med uredniškim in uporabniškim delom. Zgoraj desno: urednikovo prilagajanje 3D modela kipu. Spodaj levo: uporabnikovo slikanje pobarvane pobarvanke. Spodaj desno: prilepljena tekstura iz pobarvanke na kip.

Sliki 1 zgoraj desno. Ker so vsi 3D modeli uvoženi v aplikacijo, ta ne potrebuje nobene povezave z internetom.

Druga vrsta uporabnikov so obiskovalci. Na začetku bo vsak uporabnik dobil tablico Tango in delovni list, na katerem se bodo nahajale pobarvanke (obdelane UV preslikave 3D modela), ki predstavljajo predele površine realnega kipa. Obiskovalci bodo pobarvanko po želji pobarvali in jo nato s pomočjo fotoaparata na napravi Tango znotraj aplikacije slikali (Slika 1 spodaj levo). Tu se začne lov na zaklad. Obiskovalci se bodo sprehajali po galeriji in iskali kip, za katerega menijo, da mu pripada pobarvanka. Z usmeritvijo kamere mobilne naprave proti določenemu kipu in izbiro preko zaslona bodo iskali ujemajoči se kip. V primeru izbire neujemajočega se kipa jih bo sistem na to opozoril in iskanje se bo nadaljevalo. V nasprotnem primeru se jim bo fizični kip na ekranu prikazal z njihovo pobarvano teksturo (Slika 1 spodaj desno). Tu se celoten postopek ponovi.

3. ZAKLJUčEK

V članku smo razvili prototip aplikacije v obliki igre lova za zakladom. S pomočjo tehnologije dopolnjene resničnosti smo želeli obiskovalcem med obiskom muzeja ali galerije omogočiti soustvarjanje in interakcijo z objekti v resničnem svetu.

Za implementacijo prototipa smo uporabili tehnologijo Tango, ki je bila ta dosegljiva v času izdelave. Tehnologijo Tango je podjetje Google 1. marca 2018 žal opustilo in nekatere od funkcionalnosti vgradilo v AR Core. Za nadaljno uporabo bi bilo potrebno aplikacijo prilagoditi novi AR knjižnici. Osnovna cena malega števila Tango naprav je bila okoli $500. Mobilni telefoni in druge naprave z AR Core pa so bolj razširjene in tudi cene se začnejo pri $300. Strošek za muzej ali galerijo je tako le nakup določenega števila naprav.

Poleg tega v zasnovi opisanega prototipa ni nobenih elementov igrifikacije oz. besedil, saj bi bilo te potrebno izdelati s kuratorji muzeja. V prihodnje bi bilo potrebno aplikacijo dopolniti še s temi vsebinami, glede na vsebine določiti ciljno skupino uporabnikov in raziskati uporabniško izkušnjo v realnem okolju. Aplikacijo bi lahko uporabili tako v zaprtih prostorih (muzeji in galerije) kot odprtih prostorih (mesto s kipi na trgih). Pri našem testiranju v notranjem okolju z uporabo aplikacije ni bilo težav. Uporabo v zunanjih prostorih bi bilo potrebno še raziskati.

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In-Game Economy Based on Blockchain

Gašper Moderc
moderc.gasper@gmail.com
University of Primorska, UP FAMNIT
Koper, Slovenia

Aleksandar Tošić
aleksandar.tosic@upr.si
University of Primorska, UP FAMNIT
Koper, Slovenia
Innorenew
Koper, Slovenia

Jernej Vičič
jernej.vicic@upr.si
University of Primorska, UP FAMNIT
Koper, Slovenia
ZRC-SAZU
Koper, Slovenia

ABSTRACT

In this paper we review the potential of using blockchain technology to tokenize in-game assets such as items and currency. We review existing projects developing technology to support this and through various available metrics and argue their potential for success. We provide insight into the potential formation of a global decentralized virtual marketplace where players can leverage the free market to seamlessly migrate between supported games taking the value with them. We also argue, that blockchain would infuse the much needed trust in virtual economies and make them more secure, less prone to manipulation, and easier to regulate and police.

CCS CONCEPTS

• **Applied computing** → **Electronic commerce**; • **Human-centered computing** → *Human computer interaction (HCI)*; • **Software and its engineering** → Software notations and tools.

KEYWORDS

in-game transaction, blockchain, coin, game engine, comparison

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1 INTRODUCTION

Games designers have steadily explored different models of monetization. A recent and emerging monetization model usually referred to as free-to-play is becoming more popular. The idea of this freemium business model is to monetize the content in the game instead of the game itself. More specifically, games frequently introduce an in-game virtual currency that users can buy with real currency and use in the game to buy items. With the growing support of fiat gateway, a service that allows you to convert fiat currency (a national currency, say US Dollars) in to cryptocurrency, and in-game purchase services in game platforms, such as Google Play and Apple's App Store, there is much less friction in buying in-game items. Such models have been a great success, with games like Clash Royale by Supercell creating 1 billion USD in revenue less then a year after launch [14]. There are many elements contributing to this success. In most cases, players must acquire virtual in-game currency by playing or acquiring it with real money in order to progress, speed up game processes that require waiting, upgrading items to lower the difficulty, etc. However, the virtual currencies are spendable only in the game and there is rarely a bi-directional value transfer of money. This prevents players from migrating their in-game valuables to other games, consequently forcing them to spend additional money should they choose to play a different game.

To overcome this limitation, independent marketplaces were created by players where items and accounts can be traded for currency or exchanged for other items and accounts. Due to the unregulated nature of these markets, trading is very risky. Additionally, the use of third party marketplace services creates a lot of unnecessary friction for users, requiring them to constantly switch between the game screen and different web-based marketplace services. A blockchain-based inter-operable protocol would revolutionize the gaming industry by enabling global virtual markets with no unnecessary friction and thereby increase market participation. Owning, transferring and trading digital assets could become as easy as playing a game.

2 GAME ENGINES AND BLOCKCHAIN

This section describes various game engines and possible options for blockchain payment integration, i.e. how different gaming platforms have begun to enable integration with their platform.

When the first games were introduced, the term "game engine" did not exist at all, since what we now understand as a game engine evolved with the computer game. Namely, each game had its own game drive, which made it possible to quickly debug, add new functionality and encapsulate logic, graphics and other components.

In the 1990s [6], however, the first broad-spectrum game engines began to develop, allowing the construction of similar games. For example, if a programmer wanted to make a racing game with a car, he made a game engine for such games and used a template to change the game to get from one version to another version. Examples of such gaming engines are Hydro thunder Engine [9], Quake [12], Doom [9], etc.

Subsequently, fully self-contained game engines began to develop, allowing the development of a wide range of different games, some of which have survived to this day. Examples of such engines that are still in the top spot in popularity today are Unity 3D [3] and Unreal Engine [6]. Among other things, these gaming engines are available free of charge, so that any future developer can get them for free and can immediately start making their own computer game.

Same parts of this paper are based on just one game engine technology. For these purposes, we have chosen Unity 3D [3]. The decision was mostly pragmatic as we had more experience in using the selected engine.

Games and blockchain

The widespread model of micro-payments in games resulted in a heterogeneous ecosystem of virtual currencies that are not inter-operable and often prone to manipulation. One of the key concerns are the so called "game of luck" elements of random chance to obtain virtual items, which have met some regulatory issues and are often compared to gambling. Another issue for costumers is the constantly changing chance for loot boxes in order to achieve more balance and in-game economic stability. Hence, the in-game economy can not be considered free and open market. Instead, it is heavily regulated and manipulated, with a goal to set the best ratio between player engagement and revenue. Virtual markets can become quite large, and often though basic principles of supply and demand should drive the market [15], virtual markets behave very differently [2]. Additionally, game designers can manipulate the supply of goods without player's awareness should they choose to conceal it due to the centralized nature of the virtual currency and luck ratios in loot boxes. These issues can be addressed by using a trust-less system (that does not depend upon the intentions of its participants, who may be honorable or malicious), which is one of the key properties blockchain technology has.

Tokenization of real and virtual assets is one of the use-cases for blockchain-based tokens. At the time of writing (May 2019), Ethereum [1] was home to more then 200,000 ERC20 token contracts alone, making it the largest blockchain network for tokenized assets and utility tokens. Ethereum has many token standards, among which the ERC-721 token standard for non-fungible tokens allows games to represent a specific virtual item as a unique token, while the ERC20 standard can serve as fungible in-game currency. There are many benefits to tokenizing in-game assets such as:

- Transparency of supply and demand: The smart contract can keep record of all tokens (in-game items) and their owners. Due to the immutable and transparent nature of blockchain, these contract states can be queries by anyone.
- Transparency for trades, transfers and value at any given time: Decentralized protocols supporting an ERC standard can inherently support all tokens in compliance with the standard. An illustrative example would be the 0x Protocol [16] that enables most popular ERC standards including ERC-721 to be traded between two parties in a completely decentralized and trusted way. This would enable players to trade their tokenized assets between games.
- Transparency of loot box chances and inability to manipulate: Loot box chances can also be written in smart contracts to prevent manipulation. Additionally, with the help of oracles providing safe random, the randomness .
- Easier regulation: The blockchain can provide a historical and immutable record that can be used by regulators to monitor and police the virtual markets.
- Interoperability between games, merging virtual economies: With interoperability standards for trading, landing, borrowing, etc., currently separated virtual markets can be a bridge through trade. This could create a global in-game virtual economy where players are free to migrate their value from game to game through trade.

Due to the high potential of blockchain technology in revolutionizing gaming, many start-ups were funded through initial coin offerings to try and build the technology needed for integration.

3 PRESENTATION OF THE AVAILABLE TECHNOLOGIES

This section presents the blockchain technologies that were found by the authors and tested on a proof of case implementation with mostly default settings. The observed technologies are:

- Enjin [4],
- WAX [8],
- Decentraland [5],
- Loom Network [11],
- Funfair [10].

Each blockchain technology is presented and a comparison of the comparable properties is presented in Section 3.

Enjin

The oldest blockchain technology aimed at in-game transactions is Enjin [4] that was presented to the public in 2009, but the blockchain-based crypto coin with the same name was presented in 2017. The vision of this technology is to allow developers to develop their games as easily as possible, with as little background as possible, so anyone with some programming knowledge can integrate their technology and easily connect to blockchain. The focus of Enjin technology is on the Unity 3D game engine.

From a practical point of view, the use of Enjin looks like this: first, the user (in this context, the developer) must provide the Unity 3D game engine and prepare the foundations of the game. Once this is set up, it has to download the Enjin SDK from the Internet, which ensures proper communication of Unity 3D and the Enjin platform. The integration of these two technologies is automatic.

WAX

WAX technology [8] has not yet come fully into use but is already extremely popular and highly anticipated. WAX technology is praised for its full compatibility with the very popular and well-known EOS [7] technology (at the time of writing [1] this is the third most popular Blockchain technology). WAX promises developers an easy integration of their technology into existing systems, regardless of the game drive or the game program where current technology is in use.

The user will either play a game or see something related to the game online (say, some good) and decide to buy it. All he/she has to do is to click on a button to purchase this item, which may be a direct purchase, or request a replacement for another user. Clicking on the button will introduce the WAX authorization to complete the entire process for the user.

[1]Coincodex, May 2019: https://coincodex.com/crypto/eos/?period=YTD

Decentraland

This is a technology that allows the user to buy a virtual estate on the Ethereum network [1], modify, edit and monetize them. As the name implies, the point is that all these virtual estates are decentralized. Which means that there is no central institution that controls who owns any of the possessions and that can also be used (or that the institution would collapse and all users would lose all the possessions). Thus, the whole system is decentralized, which enables, among other things, direct purchase, sale and control of the user's part of the property. The process of using this technology is very different from all the others presented in this paper, namely, the whole system is divided into two goods: Mana and Land. If we want to have our digital property inside Decentraland, we can buy it through their "Mana" store. This is essentially the cryptocurrency behind Decentraland. So the developer first has to buy the right amount of "Mana" through an online exchange, then go to the Decentraland store and buy any property there.

Loom Network

The technology is based on the very popular Ethereum [1] technology, allowing the user to build their own Ethereum private chain. As Ethereum is considered the most popular blockchain technology (besides Bitcoin, which cannot be used for this purpose), Loom Network has become very popular as well.

The entire communication with Loom Network goes through Loom SDK (software development kit). The interface of the SDK takes care of converting user function calls into their Loom network equivalents. Loom SDK is independent of the gaming engine.

Funfair

The company's focus is on online casino games, but, in general, their technology can be used in other games, even in gaming engines. The technology allows players to look into the code, which means they can see if the game is really fair. Among other things, they can see its operation on the blockchain itself, so fair play can prove its "honesty" immediately.

Comparison

These projects are still in early deployment phases; currently, there are only a few small games testing out the potential of tokenizing in-game assets. There are also issues with scalability of the Ethereum's base layer, which has a relatively low transaction throughput. Ethereum has a plan to address this issue in the following years by upgrading to Ethereum 2.0. Meanwhile, some projects decided to implement plasma [13] chains to speed up and batch transactions to achieve higher

Table 1: Comparison of monetised values of presented technologies.

Technology	ERC-721	Plasma	Engine integration	Market cap ($)	Place
Enjin	Yes	Yes	Yes (Unity)	120	top 60
WAX	Probably	No	No	72	top 90
Decentraland	No	Yes	No	64	top 100
Loom network	Yes	Yes	No	62	top 100
Funfair	No	Yes	No	41	130

throughput. In Table 3, we compare selected projects by market cap that could be a measure of market confidence in the project, support for plasma chain (which indicate innovation and scalability), support for non-fungible token standard ERC-721 and game development engine integration.

As it is shown in the Table 3 both Enjin and Loom Network support ERC-721 standard (while WAX will most likely support it at its release). Interesting point is that both technologies offer even better token standards (Enjin supports ERC-1155 and Loom Network supports ERC-1187). The Ethereum Plasma support metric did not prove to be helpful in this study, since every technology supports it (aside from WAX, which is on EOS, therefore it cannot support it). A real breakthrough of the study was the Engine integration metric, which showed why the Enjin dominates the ladder - it is the only top 100 technology which supports an engine integration. We observe that Enjin has the most potential regarding support, which is further validated by market confidence – the last two metrics.

4 PILOT IMPLEMENTATION

The implemented game possesses a fully functional decentralised system for trading cards between players. The game is made in Unity 3D game engine with Enjin SDK integration for supporting decentralised trading. The system detects tokens from player's digital wallet and recognize every token as an in-game virtual item. The trading system is generic, so a token can represent any virtual item, for example a card, sword, skill, pet, car, house, etc.

5 CONCLUSION

Blockchain technology has the potential to revolutionize the in-game virtual markets. The standards for tokenizing assets enable easy support by decentralized protocols. Clearly, there is a a growing interest within the gaming industry to adopt this technology, with an ever-growing number of protocols with some already integrated in-game development engines. The potential to bridge virtual markets into a global economy is very ambitious and requires further analysis to address question such as:

- How these markets would behave?
- Would they need to be regulated?
- Will more profitable games be played more?
- Can game designers attract players by increasing demand for their in-game items instead of investing in marketing?

However, there is currently very little data available to analyze, simulate or predict potential market behaviour.

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