Zbornik 24. mednarodne multikonference

INFORMACIJSKA DRUŽBA

Zvezek D

Proceedings of the 24th International Multiconference

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Delavnica projekta Insieme

Insieme Project Workshop

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Matjaž Gams, Primož Kocuvan, Flavio Rizzolio

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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2021

Štiriindvajseta multikonferenca *Informacijska družba* je preživela probleme zaradi korone v 2020. Odziv se povečuje, v 2021 imamo enajst konferenc, a pravo upanje je za 2022, ko naj bi dovolj velika precepljenost končno omogočila normalno delovanje. Tudi v 2021 gre zahvala za skoraj normalno delovanje konference tistim predsednikom konferenc, ki so kljub prvi pandemiji modernega sveta pogumno obdržali visok strokovni nivo.

Stagnacija določenih aktivnosti v 2020 in 2021 pa skoraj v ničemer ni omejila neverjetne rasti IKTja, informacijske družbe, umetne inteligence in znanosti nasploh, ampak nasprotno – rast znanja, računalništva in umetne inteligence se nadaljuje z že kar običajno nesluteno hitrostjo. Po drugi strani se je pospešil razpad družbenih vrednot, zaupanje v znanost in razvoj. Se pa zavedanje večine ljudi, da je potrebno podpreti stroko, čedalje bolj krepi, kar je bistvena sprememba glede na 2020.

Letos smo v multikonferenco povezali enajst odličnih neodvisnih konferenc. Zajema okoli 170 večinoma spletnih predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic ter 400 obiskovalcev. Prireditev so spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad – seveda večinoma preko spleta. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica (http://www.informatica.si/), ki se ponaša s 45-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2021 sestavljajo naslednje samostojne konference:

- Slovenska konferenca o umetni inteligenci
- Odkrivanje znanja in podatkovna skladišča
- Kognitivna znanost
- Ljudje in okolje
- 50-letnica poučevanja računalništva v slovenskih srednjih šolah
- Delavnica projekta Batman
- Delavnica projekta Insieme Interreg
- Delavnica projekta Urbanite
- Študentska konferenca o računalniškem raziskovanju 2021
- Mednarodna konferenca o prenosu tehnologij
- Vzgoja in izobraževanje v informacijski družbi

Soorganizatorji in podporniki multikonference so različne raziskovalne institucije in združenja, med njimi 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.

S podelitvijo nagrad, še posebej z nagrado Michie-Turing, se avtonomna stroka s področja opredeli do najbolj izstopajočih dosežkov. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejel prof. dr. Jernej Kozak. Priznanje za dosežek leta pripada ekipi Odseka za inteligentne sisteme Instituta "Jožef Stefan" za osvojeno drugo mesto na tekmovanju XPrize Pandemic Response Challenge za iskanje najboljših ukrepov proti koroni. »Informacijsko limono« za najmanj primerno informacijsko potezo je prejela trditev, da je aplikacija za sledenje stikom problematična za zasebnost, »informacijsko jagodo« kot najboljšo potezo pa COVID-19 Sledilnik, tj. sistem za zbiranje podatkov o koroni. Čestitke nagrajencem!

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

FOREWORD - INFORMATION SOCIETY 2021

The 24th *Information Society Multiconference* survived the COVID-19 problems. In 2021, there are eleven conferences with a growing trend and real hopes that 2022 will be better due to successful vaccination. The multiconference survived due to the conference chairs who bravely decided to continue with their conferences despite the first pandemic in the modern era.

The COVID-19 pandemic did not decrease the growth of ICT, information society, artificial intelligence and science overall, quite on the contrary – the progress of computers, knowledge and artificial intelligence continued with the fascinating growth rate. However, COVID-19 did increase the downfall of societal norms, trust in science and progress. On the other hand, the awareness of the majority, that science and development are the only perspectives for a prosperous future, substantially grows.

The Multiconference is running parallel sessions with 170 presentations of scientific papers at eleven conferences, many round tables, workshops and award ceremonies, and 400 attendees. Selected papers will be published in the Informatica journal with its 45-years tradition of excellent research publishing.

The Information Society 2021 Multiconference consists of the following conferences:

- Slovenian Conference on Artificial Intelligence
- Data Mining and Data Warehouses
- Cognitive Science
- People and Environment
- 50-years of High-school Computer Education in Slovenia
- Batman Project Workshop
- Insieme Interreg Project Workshop
- URBANITE Project Workshop
- Student Computer Science Research Conference 2021
- International Conference of Transfer of Technologies
- 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 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.

The award for lifelong outstanding contributions is presented in memory of Donald Michie and Alan Turing. The Michie-Turing award was given to Prof. Dr. Jernej Kozak for his lifelong outstanding contribution to the development and promotion of the information society in our country. In addition, the yearly recognition for current achievements was awarded to the team from the Department of Intelligent systems, Jožef Stefan Institute for the second place at the XPrize Pandemic Response Challenge for proposing best counter-measures against COVID-19. The information lemon goes to the claim that the mobile application for tracking COVID-19 contacts will harm information privacy. The information strawberry as the best information service last year went to COVID-19 Sledilnik, a program to regularly report all data related to COVID-19 in Slovenia. Congratulations!

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

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FOREWORD

The year 2021 is the first Insieme (ISE-EMH) Workshop since we have reached some achievement to present in the second year of the Insieme Italian-Slovenian Interreg project. Unfortunately, 2021 is also the second year of the Covid-19 pandemics, causing several problems. For one thing, we received less papers for the workshop than expected, although still quite a reasonable number. The second undesired Covid-19 problem is that the participants will not be able to meet in person and discuss the presentations and also the Insieme project progress. There is a certain difference when people meet alive and discuss issues also in the free time after the conference compared to the virtual official-time only events. However, that is the reality that we face these months.
Nevertheless, the Insieme Worksop was proclaimed open to the broader area of Electronic and Mobile health (EMH). As a result, a couple of quite interesting papers were submitted, while on general the quality was extraordinarily high for a workshop. Some of the Insieme and EMH papers seem to bear a huge potential to progress towards decent SCI papers since they indeed tackle important issues and present novel research ideas and methods.
Some of the additional papers deal with the research that yielded 2nd place in one of the top worldwide Xprize competitions for non-pharmaceutical measures against Covid-19. This research also resulted in some other awards, e.g. at the ETAI conference.
There are 13 accepted papers for this year's workshop. Nine of them are related to JSI and the other four to the Insieme project partners. Each Insieme partner submitted at least one paper, which demonstrates the successful cooperation on this project. The workshop consists of two subsections. One is directly related to the Insieme project and the other is for general EMH topics, mainly to the Covid-19, and Comparison between health platforms – another European project Platform Uptake.

Flavio Rizzolio, Primož Kocuvan
Program Chairs

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Platform for Multi-Omics Integration (PlatOMICs) applied to skin diseases with alterations in Notch signaling pathway.

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ABSTRACT

Over the last years, a huge amount of information concerning Omics data have been produced and are of crucial significance for the understanding of the molecular mechanisms and for the identification of potential molecular targets associated to many diseases. Indeed, Omics approaches allowed to initially decipher several biological processes found to be critically involved in the context of various pathologies. Despite these remarkable scientific advances, the majority of obtained results are disconnected and divergent, making their use limited. Thus, our team started the deployment of PlatOMICs, a new Platform for multi-omics integration, carrying an user-friendly interface. Currently, PlatOMICs is under deployment in an international cooperation including Brazil, Qatar and Italy and has been divided into three phases. In the present work we report phase I in which multiple database/resource/repositories were interrogated to access data from skin diseases presenting alterations in Notch signaling pathway, as they constitute a cluster of disorders that were extensively studied during the Omics era, in order to perform biological syntactical analysis to be implemented in the next PlatOMICs phases.

KEYWORDS

Omics, genomics, transcriptomics, proteomics, network interaction, skin diseases.

1 INTRODUCTION

We developed a Platform for Multi-Omics Integration (PlatOMICs) that assembles a set of tools and bioinformatics applications that can allow the retrieval of scientific literature data (genomics, epigenomics, transcriptomics, proteomics and microbiomics) together with the analysis, deciphering, interpretation and integration of all these set of information automatically, therefore building networks of molecular interactions and Omics meta-analysis.
Our goal is to refine the data available in scientific literature and in Omics databases/resource/repositories relative to skin diseases that are characterized by defects in Notch signaling route, seeking to describe networks of molecular interactions in the epithelial tissue potentially involved in the loss of homeostasis in this district, event that may lead to the onset of different skin pathologies.

1.1 Multi-omics integration applied to skin diseases with Notch signaling alterations

An aberrant progression of Notch signaling, either due to altered regulation or direct mutations, can induce skin diseases [1,2]. To date, molecular alterations in Notch signaling pathway have been reported for five human skin diseases including: Hidradenitis Suppurativa (HS), Dowling Degos Disease (DDD), Adams–Oliver Syndrome (AOS), Psoriasis (PS) and Atopic Dermatitis (AD) [1,3]. Therefore, a deep characterization of this cellular route seems to be of pivotal importance in order to clarify potential new pathogenic scenarios involved in these skin diseases. Indeed, considering this critical aspect, in order to further restrict the search, we decided to consider in this study only skin diseases possessing alterations in Notch pathway excluding malignancies.

These skin disorders have been thoroughly studied in the last five years; indeed, 1555 articles regarding these five diseases and OMICs (genomics, transcriptomics, proteomics and microbiomics) studies are available in PubMed [4].

Specifically, considering these five skin disorders possessing alterations in Notch signaling, 821 articles about genome, 225 about transcriptome, 143 about proteome and 602 about microbiome, were published.

1.2 Perspectives on multi-omics integration for skin diseases with alterations in Notch signaling pathway

Currently, PlatOMICs is under deployment in an international cooperation including Brazil, Qatar and Italy. PlatOMICs will be an online platform offering services to access and analyze scientific literature and Omics data automatically with great accuracy. The deployment was divided into three phases and in the present work, we report phase 1. Briefly, the various phases that constitute PlatOMICs multi-omics analysis are given by: phase I, step based on the interrogation and analysis of the whole available literature and Omics databases; phase II, stage regarding the analysis and questioning of previous and new Omics (or multi-omics) studies; phase III, part relative to the merge of findings deriving from phases I and II in order to finally compose the ultimate multi-omics integration in a meta-multi-omics analysis (Figure 1).

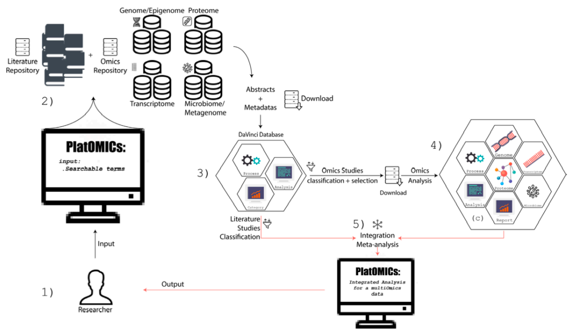

Figure 1. Workflow of OMICs Platform (PlatOMICs) for Omics integration. (1) The user informs the descriptors, categorical terms and keywords in PlatOMICs. (2-3) Through DaVinci tool, the literature and the OMICs databases will be evaluated. (4) Selected omics studies and new ones are (re)analyzed and integrated by standard pipelines. (5) PlatOMICs produces the final meta-analysis multi-omics integration results in a friendly interface.

The first analysis (phase I) outputted by PlatOMICs is performed by the new tool called *DaVinci Literature and Database Analysis* (under submission and not publicly available). Briefly, DaVinci is able to scan several databases, such as PubMed, SRA, GEODatabase and GWAS Catalog, extracting multiple information from summary, abstracts and other meta-data information to report a syntax analysis and molecular panels (genes, variants, tissues, cells and drugs). Next, following the study and sample selection from the previous researches, raw data might be downloaded. The analysis, including the new Omics (or multi-omics) studies, will be carried out by the same standard pipeline when performed, hence securing a more reliable and homogeneous investigation. Therefore, PlatOMICs will contain the results obtained from literature and their integration, databases and new Omics studies.

2 RESULTS

As a validation model, phase I of PlatOMICs was executed on skin diseases presenting alterations in Notch signaling pathway by examining the literature, thus providing molecular insights to multi-omics integration approaches.

2.1 Results deriving from literature analysis: molecular insights to multi-omics integration

The literature scan was accomplished by assessing the following term "(Hidradenitis Suppurativa OR Dowling Degos Disease OR Adams Oliver Syndrome OR Psoriasis OR Atopic Dermatitis) AND (Genome OR transcriptome OR proteome OR epigenome OR microbiome OR metagenome OR metabolome OR omic OR multi-omic) AND 'Homo sapiens'[orgn:__txid9606]" using the DaVinci tool.

A DaVinci literature database (DaVinci Lit) was created with 1252 articles retrieved from PubMed, and amongst all recovered papers 82 were excluded due to the absence of abstract/summary. Next, the remaining 1170 articles were analyzed, classified and categorized. The most cited words were 'skin' and 'patient'. The words ‘immune’, ‘inflammatory’ and ‘inflammation’ were common. 742 (63.4%) of articles cited, at least once, one of the indicated words. Next, we seeked the context of each of these terms, revealing that they were mainly used to explain the immune and inflammatory conditions of each disorder. 'Expression' was cited along 333 (28.4%) articles to demonstrate molecular expression on experimental works of transcriptome (48 articles), epigenome or methylome (36 articles) and proteome (12 articles). The last word worth commenting is 'gut'. Gut was present in 158 articles and refers to the existing relationship between gut dysbiosis and the onset of allergic, the latter also represents a term included in the top cited words, disbalance. The overview of word atomization enabled us to understand what was the main focus of Omics literature for skin diseases with alterations in Notch signaling pathway.

Next, we categorized the whole DaVinci Lit into five classes of Omics. Most of the articles were included as a genome or microbiome (metagenome) study, followed by transcriptome and multi-omics approaches (Table 1). Moreover, in the multi-omics category, the most commonly employed approaches included the combination between genome and transcriptome and genome and microbiome.

Category	Number of article
Genome	245
Microbiome	241
Transcriptome	97
Proteome	32
Metabolome	2
Multi-Omics	95

Table 1. Omic categorization of literature from Omics studies concerning skin diseases with alterations in Notch signaling pathway.

The next step in PlatOMICs is to extract genes and variants from the literature. The goal is to unravel genes/variants previously established as involved with skin disorders characterised by alterations in Notch signaling route. In this circumstance, the gene atomization process retrieved 546 genes. From obtained genes, we extracted each time the context in which the gene was cited. In total, 465 articles and 1308 gene contexts were analysed. Subsequently, four researchers classified, independently, the gene relations as associated or not associated with the disease. Of these, 80 genes were excluded, and 426 genes were associated.

Next, PlatOMICs outputted the top 10 pathways and gene ontology (GO) predicted by these genes (Table 2). Enrichment pathway and a GO analysis were conducted by reactomePA, limma and topGO Bioconductor package. The pathway reveals the role of interleukin (IL) signaling, mainly driven by IL-4, IL-13 and IL-10. GO adds the defense response and interspecies interactions between organisms. Collectively, both descriptions point out that inflammation and skin microbial host defense are to be considered as key outcomes from the global literature findings, suggesting that these pathways and GO should be included in future Omics studies.

PlatOMICs also performed a gene atomization on DaVinci Omics. This analysis was assessed on 158 genes, most of which were found to be similar to the DaVinci Lit output. Equals enriched pathways and GO from Table 2 were found, thereby ratifying the importance of these pathways and GO on multi-Omics integration.

3 CONCLUSION

The scientific goal of PlatOMICs is to promote the understanding of biological mechanisms and molecular networks, underlining both health and diseases states, using existing data. The presented platform for multi-omics integration constitutes a time-saving and cost-efficient approach that might surely guide researches in the advancement of more elaborate and articulated hypothesis. Indeed, PlatOMICs is able to refine, assemble and integrate thousands of information spread around multiple database/resource/repositories. In the future, PlatOMICs will present an intuitive and automated friendly web-end interface with accessible tables, graphs and images.

The accumulation of scientific texts and Omics data settled in various databases may have never been correlated and analysed in conjunction. In this perspective, it is presumable that significant scientific responses may have been generated but are still uncovered. In this critical context, PlatOMICs was developed in order to promote the analysis and integration of the available Omics data, and in the present study we applied PlatOMICs for the analysis of skin diseases as a validation model. Our approach allowed us to further emphasize that our integrated strategy seeks to identify a common link between skin diseases and deregulations in homeostatic processes in epithelial tissues.

ACKNOWLEDGMENTS

This work was supported by a grant from the Institute for Maternal and Child Health IRCCS "Burlo Garofolo/Italian Ministry of Health" (BioHub 03/20), by the grant Interreg Italia-Slovenia, ISE-EMH 07/2019 and by CNPq (311415/2020-2).

Reactome ID	Pathway Description	GO ID	GO Description
R-HSA-449147	Signaling by Interleukins	GO:0034097	Response to cytokine
R-HSA-6785807	Interleukin-4 and Interleukin-13 signaling	GO:0019221	Cytokine-mediated signaling pathway
R-HSA-6783783	Interleukin-10 signaling	GO:0071345	Cellular response to cytokine stimulus
R-HSA-877300	Interferon gamma signaling	GO:0002376	Immune system process
R-HSA-447115	Interleukin-12 family signaling	GO:0006952	Defense response
R-HSA-8854691	Interleukin-20 family signaling	GO:0009605	Response to external stimulus
R-HSA-913531	Interferon Signaling	GO:0044419	Interspecies interaction between organisms
R-HSA-380108	Chemokine receptors bind chemokines	GO:0070887	Cellular response to chemical stimulus
R-HSA-451927	Interleukin-2 family signaling	GO:0010033	Response to organic substance
R-HSA-1059683	Interleukin-6 signaling	GO:0051707	Response to other organism

Table 2: Top 10 Enriched pathway and a gene ontology of 426 genes associated with skin diseases with alterations in the Notch signaling pathway.

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Implementing the INSIEME portal according to the patients and caregivers' point of view

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Figure 1: Official logotype from the project

ABSTRACT / POVZETEK

The 2030 Agenda for Sustainable Development highlights that the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies[1].

†Corresponding name

In the health sector as well, technology can help people tracking and controlling their own health information and make informed decisions about their health but only at two conditions[2]:

- Technology must be really accessible
- Health information must be really understandable, scientifically correct and aligned with the reality

The project Interreg Italia Slovenia ISE-EMH aims to create a health portal integrating useful information about health topics and health facilities related to a specific interregional area both in Slovenian and Italian languages. INSIEME is the name of the portal.

[1] WHO, Draft Global strategy on Digital Health 2020-2025. Available at http://bit.do/fLkpp

[2] Australia's health 2018, available at http://bit.do/fLkoA

KEYWORDS

Oncology, health topics, health facilities, patients, caregivers, cancer survivors, digital health

1 Introduction

The contribution of the Ca' Foscari University, partner of the project, was to integrate into this portal INSIEME some categories of useful resources related to the cancer topic. The selection of these categories was made with the contribution of a cancer survivors and caregivers association. It is a fact that very often a patient relies on the search engines algorithms to find out the information he/she needs. But it happens that resources ranked as not important by the search engines are actually very useful to him/her. So, the point of view of some individuals, both cancer patients and caregivers, was the main guide to identify the resources to be listed in the portal. Not only the management of the cancer disease is important to a patient but also his/her mental condition, his/her wellness and practical things such as accommodation and work related issues [3]. There are good examples of this integration[4]

2 Results

A preliminary search was made to find out informational resources about cancer to widen the spectrum of categories and services. Then we tried to categorize the cancer services related both to the area of the metropolitan city of Venice and the Region Friuli Venezia Giulia.

In addition to basic services, the search has highlighted the following complementary categories:

- Hospital services
- Social services
- Physiotherapy services
- Physical activities opportunities and related opportunities
- Psychological services
- Accommodation services for patients and/or family members
- Information and counselling services about health topics and patients' rights
- Administrative services
- Local social and health services – screening
- Local social and health services - palliative care
- Voluntary associations
- Independent information on cancer
- Information on fake news

For each category, a minimum of 5 websites was listed if available.

Below a brief summary of the research carried out through the consultation of a large number of websites.

- Hospital health services: nº 15 facilities were found in the province of Venice and nº 24 in Friuli Venezia Giulia.
- Social services: the individual municipalities of the province of Venice and the Region of Friuli Venezia Giulia offer social services to citizenship
- Physiotherapy and rehabilitation services: as far as the province of Venice is concerned, the two main departments of Physical Medicine and Rehabilitation of the San Giovanni e Paolo Hospital of Venice and the Angelo Hospital of Mestre have been described. In addition, the local rehabilitation and physical therapy services in the different health and social authorities have been listed. About the Friuli Venezia Giulia Region, the two University & health agencies of Udine and Trieste have been described, in addition to health services of home rehabilitation
- Psychological services: the family counselors are available in the metropolitan area of Venice and in the Friuli Venezia Giulia Region. In addition, the ANT Foundation 1978 Onlus has been described that offers psychological support at home to all patients.
- Accommodation services: accommodation facilities near the main hospitals have been described with the information of their websites. Some of them are free, others offer low price accommodation. In addition, the channels of Airbnb and Booking.com have been reported;
- Information and advocacy services for the protection of patients' rights: for both areas were listed the main services
- Administrative services
- Local health and social services - Screening: the cancer prevention opportunities of the Friuli Region has been listed
- Local social and health services - Palliative care: the Health District of Mirano and Dolo has been reported with regard to palliative care services;
- Specialized voluntary associations through the useful webtool of Oncoguida[5], the large number of voluntary associations operating in the area of Venice and Friuli can easily be identified.
- websites with dealing with current information about cancer topics and tools to easily discover fake news were also described
- websites with patients stories or personal narrations were also indicated as they are very helpful to patients wellness. Last but not least the websites related to all the hospitals and Health Comprehensive Centers of the Friuli Venezia Giulia Region and Venice area were listed and described.

[3] Truccolo I, Cipolat Mis, C, De Paoli P (eds), Insieme ai pazienti. Costruire la Patient Education nelle strutture sanitarie. Il Pensiero scientifico, 2016

[4] Kildea J, Battista J, Cabral B, Hendren L, Herrera D, Hijal T, Joseph A. Design and Development of a Person-Centered Patient Portal Using Participatory Stakeholder Co-Design. J Med Internet Res. 2019 Feb 11;21(2):e11371. doi: 10.2196/11371

[5] Oncoguida, available at [5] http://www.oncoguida.it/html/home.asp

Figure 2: View of the Oncology section in the INSIEME portal

3 Conclusions

The different categories of resources integrated into the INSIEME portal are not exhaustive of course. They just give a hint of the importance of taking into account both informational and practical resources and involving patients and caregivers in the building of digital health portals

ACKNOWLEDGMENTS

The paper was supported by the ISE-EMH project funded by the program: Interreg V-A Italy-Slovenia 2014-2020. We thank the patients and caregivers that help to identify the resources listed in the portal.

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[5] Oncoguida, available at http://www.oncoguida.it/html/home.asp

An Analytical and Empirical Comparison of Electronic and Mobile Health Platforms

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ABSTRACT

Electronic and mobile health (EMH) is a new way of delivering health services to patients with the use of small portable devices like mobile phones or tablets. The term electronic indicates that doctors and medical personnel use electronic health records or electronic prescribing of medicine for patients. Some countries like Slovenia, use electronic prescriptions of medicine for many years now. According to World Health Organization (WHO), mHealth has the ability to transform the delivery of health services all over the world and bring about a paradigm shift in healthcare delivery processes [6]. By using technological innovations we can overall improve healthcare not only in developed countries but also in countries that are still in the developing phase. In these countries, there is a lack of doctors, so optimizing the process of delivering medicine and information to the patients is very desirable. In this paper, we describe some of the EMH online available platforms and compare them with the one which we developed within the ISE-EMH project.

KEYWORDS

mHealth, eHealth, electronic and mobile health, EMH, comparison of EMH platforms, ISE-EMH

1 INTRODUCTION

From the early beginning of the web when there was only limited information about key institutions, e.g., universities, libraries, and organizations, available on the web and till this day where we can find practically anything including illegal organizations and activities, the public need platforms or portals which will aggregate all useful information on one central place. While anything can be found on the web, it is often difficult to find proper and useful information [9].

To overcome the issues of disinformation especially in the field of medicine and products for the elderly, as part of the ISE-EMH project we implemented a unified EMH platform together with an application for smart hardware devices. We described the application for smart devices in [9]. The EMH platform is a central entity where the user can find key information about health and elderly, and where he can converse with other patients and doctors via text- or video-based call centers, or exchange information, e.g., x-ray images or photographs of the patient skin. We analytically and empirically compare the existing EMH platforms with each other to learn more about the pros and cons, and to improve the ISE-EMH platform in the future.

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The rest of the paper is organized as follows: In Section 2, we describe existing platforms. Section 3 presents the ISE-EMH platform, The results of analytical and empirical comparison of the platforms are given in Sections 4–5. Finally, Section 6 summarizes the paper with ideas for future work.

2 AN OVERVIEW OF EXISTING EMH PLATFORMS

2.1 Genoa

Genoa is a platform that offers telepsychiatry services [5]. It is, for now, available only in the United States. It connects people (patient-doctor) through a system of video-conference technology. Telepsychiatry is a branch of telemedicine where they only provide help for psychiatric and mental disorders.

2.2 DigiGone

DigiGone is a packet of services, including a medical one called DigiMed [2]. Their philosophy is like that of Genoa. However, they offer general medical services, not only for psychiatric problems. For example, when applying as a patient, you get a technical kit. When you have an appointment with a doctor, your nurse or caregiver comes to your home and examines you, and via video conference tells the information to a doctor. In this kit, you have also an ultrasound device, so it can stream the data to the doctor in real-time.

2.3 Doxy.me

Doxy.me is a free telemedicine service, implemented as a web application, thus no installation is needed. It is also accessible from various devices. All you need is a microphone and a web camera. All the data is encrypted and also no account is needed, in contrast to many other platforms [3].

2.4 eVisit

eVisit is a telehealth service that is not free of charge. For the doctors and patients it offers virtual flexible scheduling [4]. For doctors it provides a list of medications for prescription to patients, which is a very convenient and helpful feature that saves time. Other platform services are similar to the already described ones in other telemedicine platforms.

2.5 iPath

iPath is the oldest telemedicine platform from the early beginning of the development of protocols for the internet. iPath is a case-based collaboration platform that is used in telemedicine applications to share information within a distributed group of people. It is being used in the domains of consultation, teaching and research [8]. It is also multilingual like the ISE-EMH platform.

2.6 MedSymphony

The MedSymphony platform is build for telemedicine electronic and mobile health, MedSymphony is directed to accelerate the use of telemedicine as a key platform for providing health care. The key feature is to provide better health care for millions of patients anywhere and anytime. MedSymphony was created to qualify doctors, medical personnel, caretakers and health institutions as well as patients with a complete electronic and mobile health technology platform. The platform includes everything you need to establish a video-based doctor's office. – a completely cloud-based compliant solution with integrated video conferencing, online prescription ordering joined with SMS, MMS, and email integration to facilitate the doctor-patient relationship, and automated billing for recurring and one-time fees [10].

2.7 Bodi Zdrav

Bodi Zdrav (in English "Be Healthy") is a Slovenian health-related platform [1] and it is only meant for patients in Slovenia. Its purpose is to give information about the services and to connect the patients and doctors. It only offers services that are not officially recognized in medicine, e.g., homeopathy, bio-resonance, hypnotherapy, etc. Its main content is a search function through regions in Slovenia and filtering of services from specific medical branch.

2.8 EcoSmart

The EcoSmart project was a three-year project that included the participation of 26 partners. It included smart cities as well as eHealth and mHealth domains. Within the project, an electronic and mobile health system was developed. The purpose of the system was to provide key information about the project partners and municipalities in Slovenia, as well as health domains and prototypes. It also included a smart bot for which the main task was to answer questions to users.

3 THE ISE-EMH PLATFORM

3.1 Basic Information

The ISE-EMH platform is being developed within an Interreg Italy-Slovenia project, where the final goal is to develop a unified telemedicine (EMH) platform for both Slovenian and Italian public and private institutions, with the aim of accelerating the cooperation between Italian and Slovenian stakeholders and transfer knowledge from academic field into practice. The platform includes new diagnostic approaches, advanced sensors, including devices that monitor vital signs, and also methods of Artificial Intelligence (AI) that will help patients overcome anxiety, depression and sedate stress. By connecting various stakeholders, the platform also aims at overcoming the main problem of EMH that is the lack of transfer of innovative services from laboratories into practice, due to the lack of support services in terms of both ICT systems and human partners, and their integration [9].

3.2 Detailed Description of the ISE-EMH Platform

The purpose of the ISE-EMH is to connect different partners, medical personnel, doctors, patients, and end-users. This is done through different logic and programmatic mechanisms. The platform uses the Rocketchat text-based communication system to enable users, e.g., patients to send questions to doctors. Also, the patients can converse with each other in the public channels, where they can exchange thoughts / opinions about their diagnosis, disease or condition. Also, the platform includes a virtual assistant (bot) and connects it with the Rocketchat system. The purpose of bot is to answer questions about medicine, partners, waiting queues, and similar. This is helpful when no doctor is available. There is also an advanced search mechanism, implemented with the versatile, fast, and efficient Elasticsearch.

The ISE-EMH platform development will result in an EMH ecosystem that will include/provide [7]:

- A platform that connects products and services, i.e., the backbone of the ecosystem;
- Integration and connection of existing products, services, and systems through the platform in a complete ecosystem.

4 ANALYTICAL COMPARISON

The described platforms were compared with respect to a set of selected features (see Section 4.1). The comparison was performed analytically and empirically, where the results of the former evaluation are presented in Section 4.2 and the results of the latter one are given in Section 5.

4.1 Choosing the Features for Comparison

The set of features for the platform comparison consists of carefully selected features, selected based on the state-of-the-art research in the EMH domain. Demographic and social characteristics were also carefully taken into account, e.g., if it is free of charge for using it and if it is available in more than one language. We also included some of the other key features which are important for user experience, e.g., if it has a GUI and if it is responsive or not. The selected features are the following:

- Free: Is the EMH platform free of charge to use it?
- Graphical user interface: Does it have a GUI or is it just text-based?
- Dynamic data: Can we insert new data and update the fields via a form?
- Responsive: Is the web platform responsive, which means, does it automatically resize the website when viewing on the different devices?
- Virtual assistant: Does the platform offer the chance to talk with a bot, e.g., about medicine, diagnosis, partners, etc.?
- Use without registration: Can we use the EMH platform without registration?
- Multilingual: Is the EMH platform available in more than one language?
- Official medicine: Does the EMH platform offer services to the people from only official (recognized) medicine?
- Call center: Does the EMH platform offer call centers (text-based or video-based) for getting help?
- General medicine: Does it offer services from different medicine practices or only one?

4.2 Results of the Analytical Comparison

The results of the analytical comparison of platforms are shown in Table 1. Based on these results we constructed a histogram of features, where each bar presents the percentage of included features in a specific EMH platform (see Figure 1). This histogram shows that the worst platforms with respect to the chosen features are Genoa and BodiZdrav.

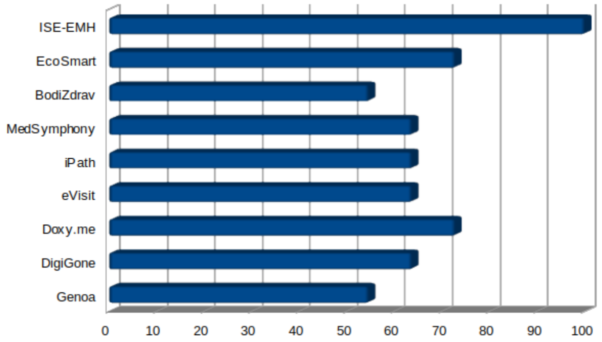

Figure 1: A histogram of platform feature percentages, where each bar represents the percentage of checkmarks from Table 1.

For Genoa the cons are that it is not free, it does not have a virtual assistant, e.g., a bot that can answer your question at any time of the day, you cannot use it without registration, it is not multilingual, and also the usage is limited to only psychiatric conditions, since they are specialized only in telepsychiatry.

For BodiZdrav the cons are that it does not have a virtual assistant, it is only available in the Slovenian language, the services which they offer are not from officially recognized medicine, it does not have call centers, and also they do not have services from general medicine but only alternative medicine.

The most versatile and useful system based on the selected features is the ISE-EMH platform.

5 EMPIRICAL COMPARISON OF SIMPLY ACCESSIBLE PLATFORMS

Among the evaluated platforms, the ones that are simply accessible, i.e., they do not require to create an account to use them, were further analysed. This analysis was empirical, from the user perspective usage, and it also included side features such as user story. Based on the simply accessible criterion, three systems were empirically analysed: Bodi Zdrav, EcoSmart and ISE-EMH.

5.1 Bodi Zdrav User Experience

The Bodi Zdrav platform has a good graphical user interface design. When the user visits the page, it has only one component on the landing page, i.e., a search. The user can select a category and a region, which act as filters for search. As already mentioned, it does not have a virtual assistant nor call centers (see Figure 2).

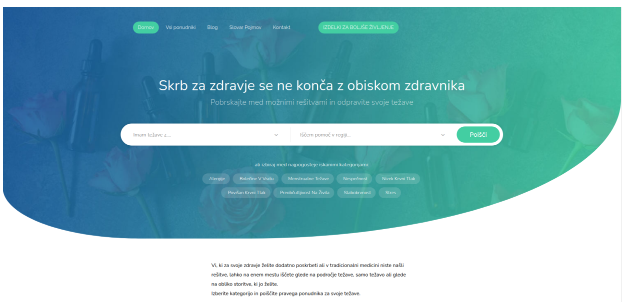

Figure 2: Bodi Zdrav Homepage.

5.2 EcoSmart User Experience

The EcoSmart platform has a simple and sleek graphical user interface design. When the user first visits the page it has ten categories on the landing page. It does not provide a search tool, but it has a link to the EcoSmart bot and other bots on the page (see Figure 3).

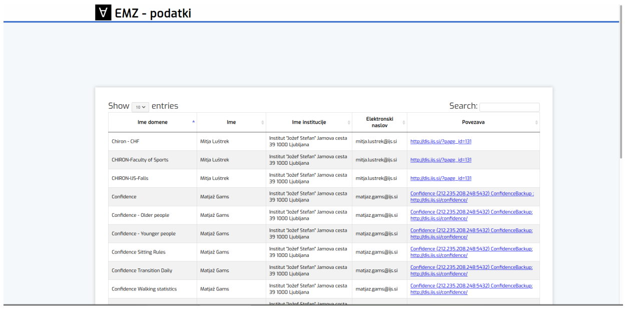

Figure 3: EcoSmart Homepage.

5.3 ISE-EMH User Experience

The ISE-EMH platform has an original graphical user interface design. A user visiting the page for the first time has all the components on the landing page (see Figure 4). These components are a virtual assistant, services, search tool, and button for changing the language. This is very crucial when users need to find specific information fast. The user interface is constructed and designed in such a way that every person no matter the age can use the platform.

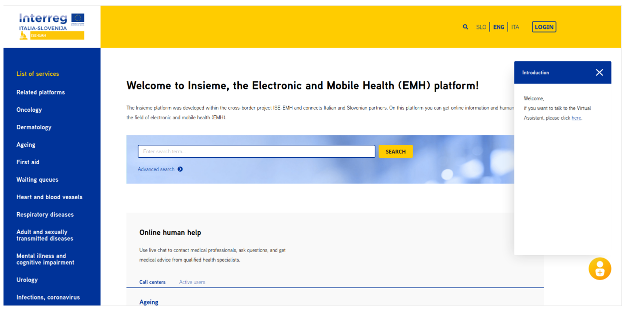

Figure 4: ISE-EMH Homepage.

6 CONCLUSION

In this paper, we described and compared a set of most important EMH platforms that are available on the web. Also, we presented the developed ISE-EMH platform. We also analytically compared these platforms based on a selected set of key features. In addition, a subset of platforms was empirically compared by focusing on a user's point of view. This analysis shows that the best-rated platform is the ISE-EMH platform.

In our future work, we will test our hypothesis stating that a user can find specific information about health-related topics on the ISE-EMH platform in under 30 seconds, instead of searching for more than 30 minutes on other platforms or through the search engine like Google or Bing. We will conduct the experiment with the help of volunteers, where they will try to find 10 randomly selected services on the ISE-EMH platform and also using a general search engine.

	Genoa	DigiGone	Doxy.me	eVisit	iPath	MedSymphony	BodiZdrav	EcoSmart	Insieme
Free	✗	✗	✓	✗	✓	✗	✓	✓	✓
User-friendly	✓	✓	✓	✓	✗	✓	✓	✓	✓
Graphical user interface	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dynamic data	✓	✓	✓	✓	✓	✓	✓	✗	✓
Responsive	✓	✓	✓	✓	✗	✓	✓	✓	✓
Virtual assistant	✗	✗	✗	✗	✗	✗	✗	✓	✓
Use without registration	✗	✗	✗	✗	✓	✗	✓	✓	✓
Multilingual	✗	✗	✗	✗	✓	✗	✗	✗	✓
Official medicine	✓	✓	✓	✓	✓	✓	✗	✓	✓
Call center	✓	✓	✓	✓	✗	✓	✗	✗	✓
General medicine	✗	✓	✓	✓	✓	✓	✗	✓	✓

Table 1: Comparison between the analysed EMH platforms.

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Android Application for Remote Monitoring of the Elderly's Parameters

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ABSTRACT

According to the latest predictions, the average age in Europe in 2050 will be 49, whereas today it is only 39 years [3]. Europe, therefore, faces quite a significant population problem. With insufficient numbers of young workers, we need technical, economic, and political solutions to help the elderly maintain vitality and independence. The aim of technical solutions is to delay the departure of the elderly to a retirement home and to help maintaining the economic stability of the country. In this paper, we describe an application that helps the elderly and relieves the society and economy. We present the technical specifications and features of the Android application, which was developed as part of the project ISE-EMH (Insieme) with the collaboration of IPM Digital within the project HoCare 2.0. The Android application is created and intended for usage for the pairs: one elder and one caretaker (e.g relatives, nurses, paramedics).

KEYWORDS

Android application, care for the elderly, elder, caretaker, fall detection, easy to use, ISE-EMH, Insieme, HoCare 2.0

1 INTRODUCTION

Due to the development and introduction of so-called MEMS (Microelectromechanical systems) technologies in mobile devices, these became smarter in terms of tracking and perceiving the environment [1]. This is achieved by using accelerometer, GPS, gyroscope, proximity sensor, and many other sensors. These sensors allow us to monitor the movement of a person, location and brightness of the room in which a person is located. This comes in handy in the research field of ambient intelligence. In our case, we developed an application for the elderly and their caretakers which allows us to use these technologies. In this paper, we will describe the application and its technical features. The paper is thus divided into two central sections. The first describes the functions that an elderly person can use and the second describes the functions caretaker can use. Finally, we describe the advantages and disadvantages of the developed application, which were highlighted by the elderly in the performed focus group.

1.1 Basic information about the project

As part of the Insieme project, we implemented a unified EMH (Electronic and Mobile Health) platform together with software for smart devices. The platform includes new diagnostic approaches, advanced sensors, including wearable devices that monitor vital signs, and sophisticated computer algorithms and artificial intelligence methods that gain new knowledge from data. The main problem regarding the introduction of EMH remains the transfer of innovative services from laboratories into practice, as there is a lack of support services in terms of both ICT systems and human partners and their integration. As a rule, researchers can not find commercial partners for even the most excellent academic prototypes, while the prototypes are rejected due to inertia, despite the indisputable advantages of both ICT and knowledge. It is difficult to implement novel ICT solutions to the elderly. The key purpose of this project is to accelerate the cooperation of Italian and Slovenian stakeholders in the field of EMH and the transfer of knowledge, systems, and services of EMH from the academic sphere to actual use. The other purpose is to enable better connections between users and providers. While anything can be found on web, it is often difficult to find proper information. Bearing these specifications in mind, several applications are being included in the platform, one of them being the Android application presented here.

1.2 Chosen Android OS and programming language

According to the global market share in Table 1, obtained in May 2021, the most used OS for smartphones is Android OS with about 72% market share [2]. Therefore, Android OS was chosen as the operating system for our application. Regarding the programming language, we were deciding between Kotlin and Java. As Kotlin is a fairly new language, we had chosen Java. Java is still a versatile and general programming language that runs inside Java Virtual Machine environment[1].

Table 1: Global market share for mobile phone's OS

Operating system	Market share in procent
Android OS	72.18%
iOS	26.96%
Samsung	0.43%
KaiOS	0.19%
Unknown	0.14%
Nokia Unknown	0.03%

1.3 Overview of the functions

Here is a list of all functions implemented.

The elder has access to these functions:

- reminders,

[1]The Kotlin also uses virtual environment

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- contacts,
- SOS function,
- settings,
- fall detection,
- pedometer,
- alarm when searching for mobile phone,
- alarm as a reminder to charge the battery.

The caretaker has access to these functions:

- overview of elder's parameters,
- history,
- exact location of the elder,
- sandbox settings,
- enable/disable the settings for the elder.

All functions for both the elder and the caretaker will be described in more details in the following sections. The application runs on two advanced mobile phones with Android OS. The general idea is that the elder needs help, support and monitoring of the caretaker, and the mobile phones enable the needed functionality.

2 THE INITIAL SCREEN

First, user has to confirm and enable access to the services of the phone. The user has to grant application permissions of:

- accessing the contacts,
- accessing the location of the device,
- accessing the multimedia and files,
- recording and taking photography,
- sending SMS messages,
- making telephone calls,
- audio recordings.

Figure 1 presents the initial screen of the Android application. The elder and the caretaker enter their role. The selected role is set once for the application, and to change it, the application has to be installed again. On the initial screen, the user can select the language. The application is available in Italian, English, and Slovene. There is also a button on the bottom of the initial screen. By pressing it, a user can start or stop a function of searching the mobile phone by vocal call.

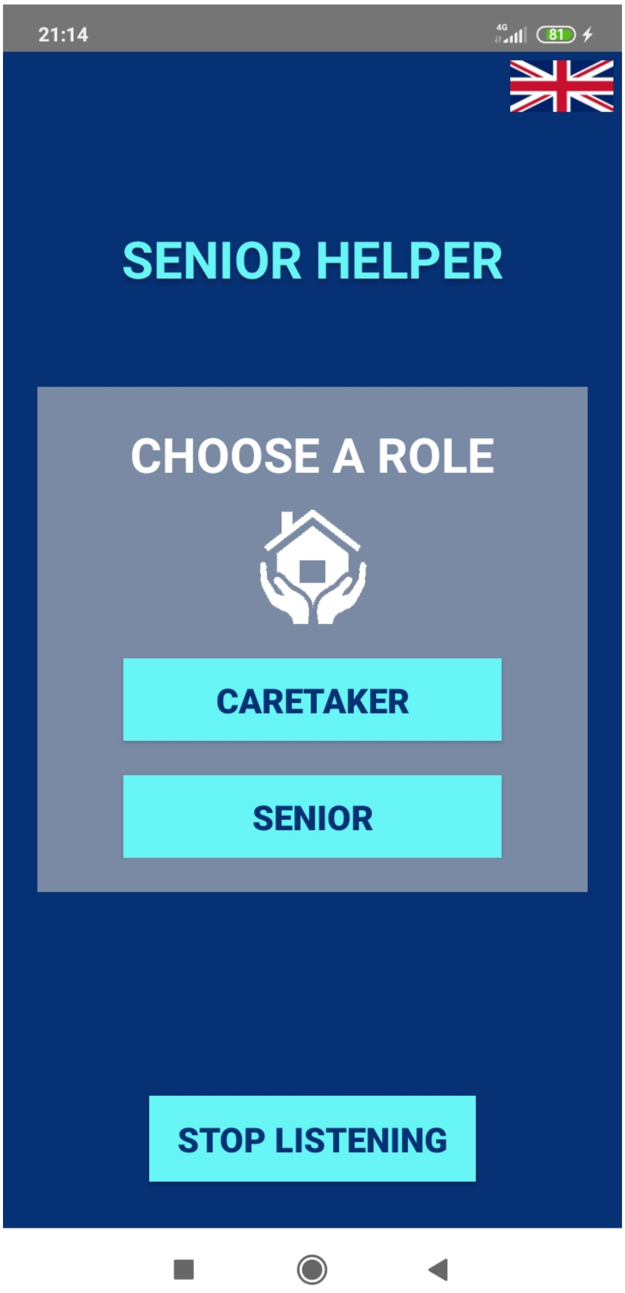

Figure 1: The initial screen, shown during the first use of the application.

3 THE ELDER'S HOME VIEW AND FUNCTIONS

3.1 Sandbox

Sandbox is a term that denotes the area of elder's home, residence or a safe place defined by the elder during the initialization of their profile. When the elder leaves the sandbox area, the caretaker is notified via SMS message. The elder or caretaker can arbitrarily set the radius of a sandbox area from minimum of 0 meters and a maximum of 500 meters. Changing the distance by elder is only possible when the caretaker allows it in the settings.

3.2 Battery

The elder is alerted when the battery charge drops to 20%. In case the elder does not connect their phone to the charger, the application warns them about it every 5 minutes.

3.3 Mobile phone location and vocal search

The application is periodically sending the location of the mobile phone to the central server. From there, the information is transferred to caretaker's mobile phone. In case the elder's phone has no internet connection or GPS service turned on, the last location on the server is displayed to the caretaker.

The elder can also enable the search for mobile phone function. If enabled, the mobile phone is constantly listening to its environment. In case the elder forgets the location of the mobile phone and wants to find it, they should say the keyword "TSUNAMI" loudly and clearly. The mobile phone will start to vibrate and ring in order to reveal its location.

3.4 Alarms and reminders

The elder has an option of adding one-time or periodic alarms. One-time alarms are designed for non-daily tasks such as visiting

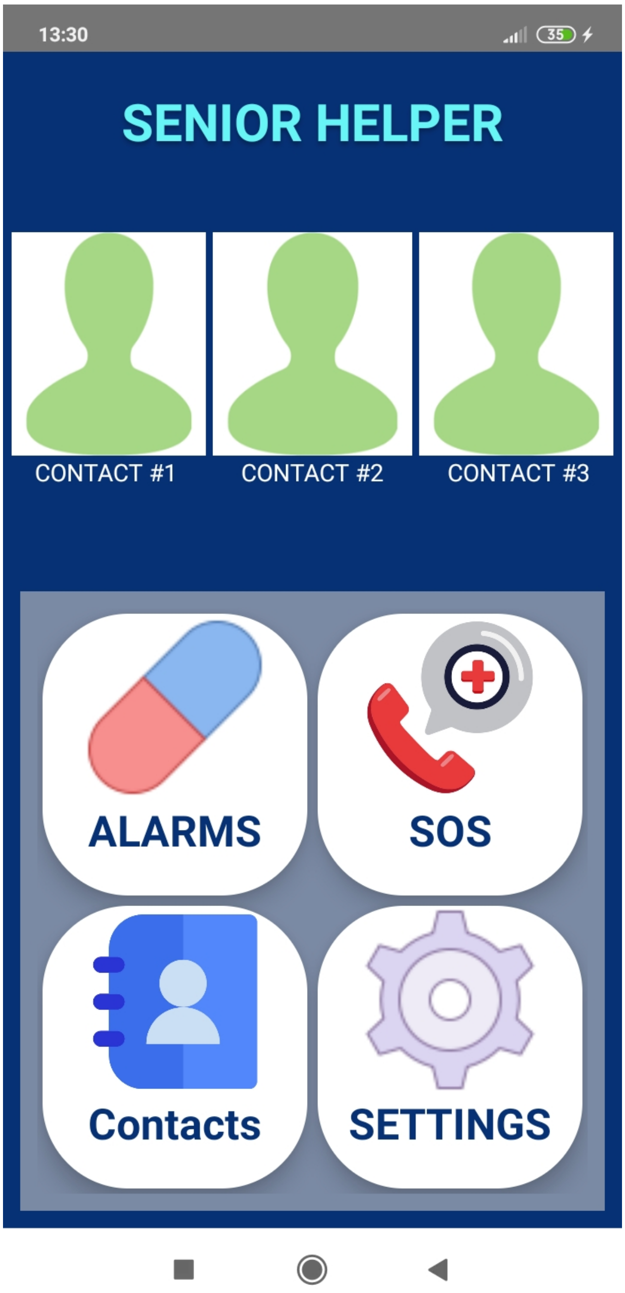

Figure 2: The elder's home view, after they enter their personal data

a doctor. Periodic alarms are designed for daily tasks such as taking medications at a specific time. When the alarm goes off, the elder must confirm it. This sends a confirmation to the central server, from which the caretaker can check the status of alarms. The elder's access to the alarms can be seen on elder's home page, depicted on Figure 2.

3.5 SOS function and fall detection

In the event of problems such as nausea or feeling unwell, the elder can press the "SOS" button, which triggers a call for help by successively calling the contacts on the list. The application calls contacts by the list order, i.e. priority. In case there is no response to the call of the first contact, it calls the second, and so on. The elder can add a maximum of three contacts to the SOS call list.

The application has an implemented algorithm that detects the falls of the elder using the phone's accelerometers. In order to do that, the elder must have a phone that has a built-in accelerometer. In case of false detection, the elder can press the "Cancel Fall" button. A SMS message is sent to the caretaker that either a fall or a false fall has occurred.

3.6 Phone book and pedometer

The elder has the option of storing existing or new contacts in the app's phone book. By arranging the contacts in the directory, priorities are assigned to the individual contacts for the SOS function.

The app measures the number of steps that the elder has taken. Depending on the refresh interval, the application sends the data to the central server, from which the values can be read by the caretaker.

4 THE CARETAKER VIEW AND FUNCTIONS

The motivation for the caretaker's application is that it enables the caretaker to monitor and communicate with the elder. The elder's application, on the other hand, has two modes of work: in case of elder's inability to set technical functions, the elder has access to limited set of functions, such as calls, SOS button and similar. If the elder is still able to control the settings of the application, then all options are enabled. The caretaker has full control of all functions.

4.1 Sandbox

In case of the caretaker, the sandbox area is denoting the home, residence, or safe place of each specific elder separately. The caretaker can arbitrarily change the radius of sandbox area from the minimum of 0 meters and the maximum of 500 meters. They do this by entering the more options extension of settings and using the slider to select the desired distance. In the menu, they can also enable access to the settings of a particular elder.

4.2 Battery

At 15% charge of the elder's battery, the application automatically sends a SMS message to the caretaker. The message contains a warning that the battery status of the elder's mobile phone is low. This gives the caretaker the chance to contact the elder and remind them about charging the phone.

4.3 Mobile phone location and vocal search

The caretaker can see the last known location of the elder by pressing the "Show exact location" button. A Google map opens, where a blue dot indicates the last known location of the elder. If the elder has internet connection and GPS location turned on, the last known location is also the current location of elder's phone. The caretaker does not have the option to perform vocal search for their mobile phone.

4.4 Alarms and reminders

The caretaker sees the confirmation of specific elderly person's alarms.

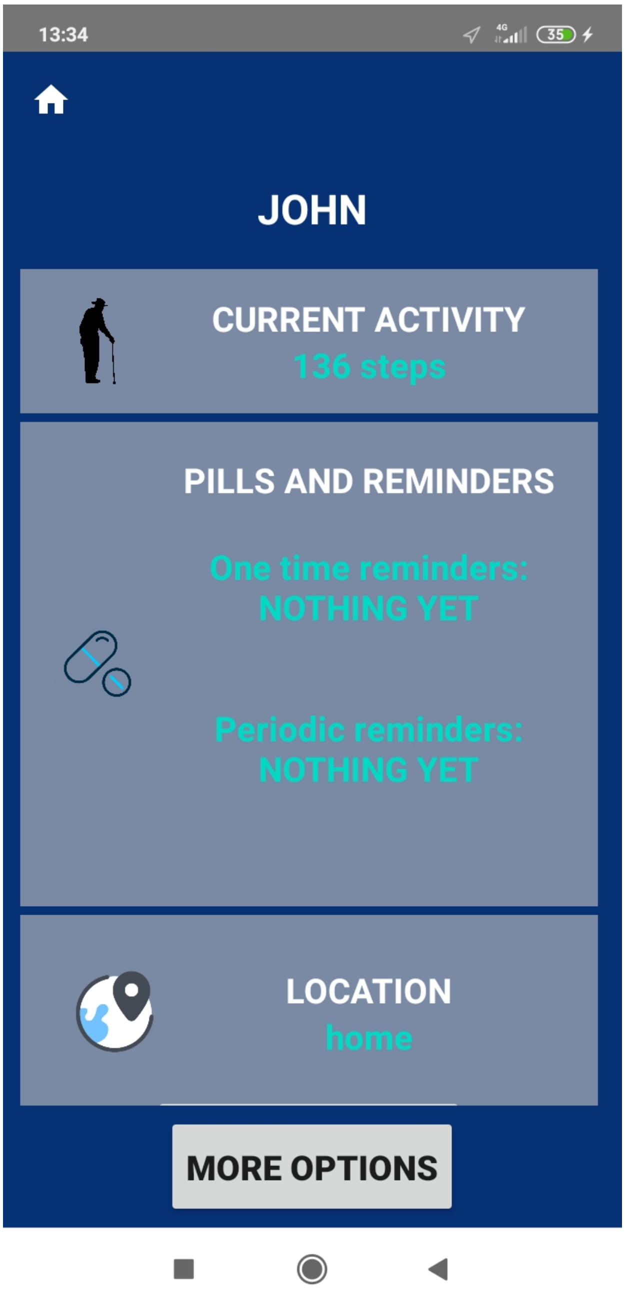

Figure 3: The caretaker's home view

4.5 SOS function and fall detection

The caretaker or elder's relative or anyone on the elder's SOS list receives a call for help. In case of a fall, the caretaker receives an SMS that there was a fall of the elderly.

4.6 Phone book and pedometer

The caretaker does not have a phone book, but a list of the elderly they take care for. The caretaker has the option to call a specific elder by pressing their contact. For the caretaker, the application does not measure the number of steps made. However, the caretaker has the ability to review the number of steps for each elder they take care for. The caretaker can see all the key information of each elder they take care of, e.g. Figure 3.

5 CONCLUSION

We developed the Android application for the elderly and their caretakers. This article describes the features of the application. Sensors integrated into today's smartphones and special software enable us to create applications which help the elderly live more independently. The drawbacks of the software which is now available on Google play market are: complicated usage, high price, lack of features. We designed the application bearing in mind ease of use for the elder and features that allow the caretakers to monitor the elderly anywhere anytime. Also, after the application is fully tested, it will be available for free.

ACKNOWLEDGMENTS

The paper was supported by the ISE-EMH project funded by the program: Interreg V-A Italy-Slovenia 2014-2020. We thank IPM Digital, which organized the focus group as part of the HoCare 2.0 project. We also thank students: Lukas Kranjc, Urša Klun and Jan Hrastnik for helping with implementation part of the project.

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Development and structural design of the frontend for unifying electronic and mobile health platform

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ABSTRACT

Eurostat on 27/03/2020 reported the survey on the use of ICT in households and by individuals, one in two EU citizens (53%) aged 16-74 reported that they sought online health information related to injury, disease, nutrition, improving health or similar [1]. On the other hand, an estimated 7 percent of Google's daily searches are health-related, according to Google Health Vice President David Feinberg, MD and Google's total daily health-related searches amount to 70,000 each minute, according to The Telegraph report [2].

Nobody really enjoys going to a doctor, but there are many reasons why you should avoid simply searching the internet for medical advice. Essentially this can go in two bad ways: either you overestimate your symptoms and end up taking the wrong medication or engaging in the wrong self-treatment, or you underestimate your symptoms and let a condition worsen.

In this paper, we describe a platform that helps an anonymous visitor to find verified health information or even chat with the call-centre operator or health expert when available. We present the technical specifications and features of the Insieme platform, which was developed as part of the project ISE-EMH.

KEYWORDS

Frontend design, the structure of the frontend, health, EMH, medical advice, health-related searches

1 INTRODUCTION

While Google certainly has a vast quantity of information, it lacks selectivity. Although it’s easy to find lists that sound like our symptoms, we don’t have the medical training to understand the other factors that go into making a medical diagnosis, like personal and family history. And neither does Google.

Insieme platform content is organized by professionals and managed by medical experts. The aim of the platform is not only to publish verified content but also to promote other proven platforms and online content. And if the site visitor doesn’t find appropriate content, he can choose to speak with the available trained operator or medical expert.

2 FRONTEND DESIGN

Anonymous visitors come to the site in order to find information about their disease or guidance on where to turn for advice. They have different knowledge not only of disease causes, symptoms, and health domain language, but also of various computer skills. Using user story mapping we isolate six stories:

1. **Browse** – Visitor is knowledgeable and can navigate through the structured content to find information.
2. **Search** – Visitor can describe the main symptoms to search for possible results.
3. **Bot** – Visitor can chat with the bot to narrow down the results and get the best information available.
4. **Chat** – Visitor is having difficulties finding useful results via navigation and he would like to chat with real person to get proper help.
5. **HelpDesk** – Call-center operator or doctor wants to supervise many chat channels and answer messages from the visitors.
6. **Administration** – Administrator of platform wants to manage the content and users (administrators, call-center operators, and doctors).

The frontend is developed as a fully responsive webpage and is also usable on mobile devices.
At this point the platform supports content in three languages (Slovene, Italian, English) as this was the objective of the ISE-EMH project.

3 FRONTEND FEATURES

Application features implement the user stories described in the previous section.

3.1 Browse

To assure to a site visitor effortless navigation through the platform content this was divided into two level services hierarchy. Visitor can select a hierarchy item on left vertical bar to get a list of all the services of the selected group each in few lines. By selecting a service from the list visitor gets detail page of that service.

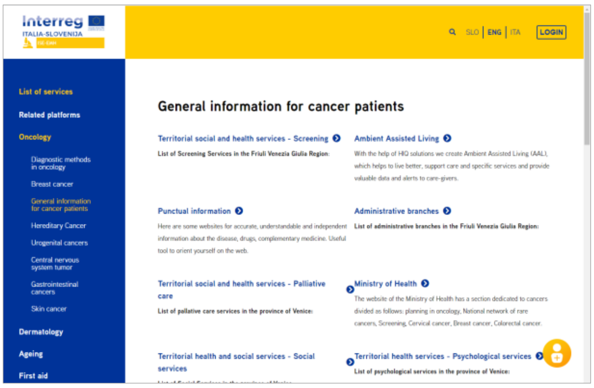

Figure 1: Platform content navigation

3.2 Search

On the middle of the home page a visitor can find a search box to insert the search string. This is sent to the backend to execute the search on the main entities (services hierarchy, companies, user groups, experts) for presence of the search string in name or description. The result is presented as a list of entities grouped by type, each in few lines of description. By selecting a result item from the list, the visitor gets the detailed page of that entity.

Using the Advanced search option, a visitor can filter the results using various parameters.

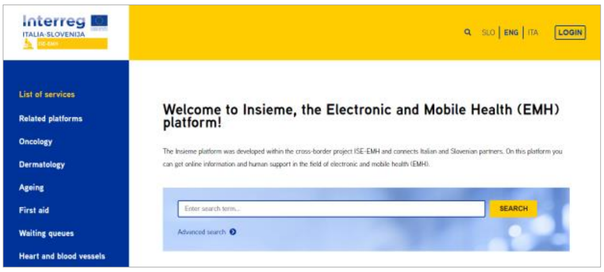

Figure 2: Search panel on the home page

3.3 Bot

Visitor can at any moment decide to invoke bot and start a chat. Bot backend tries to understand the intent of the visitor and offer the platform content, or some implemented functionality (e.g., Waiting times and booking).

Adding more content and functionality to the bot backend, we don't need to change the frontend to enable visitor to use them.

3.4 Chat

On the home page an anonymous visitor sees active operators or experts. By selecting one chat, a pop-up window opens and he can write a message and chat with the selected person as we all do using many chat applications (e.g., WhatsApp, Skype, …).

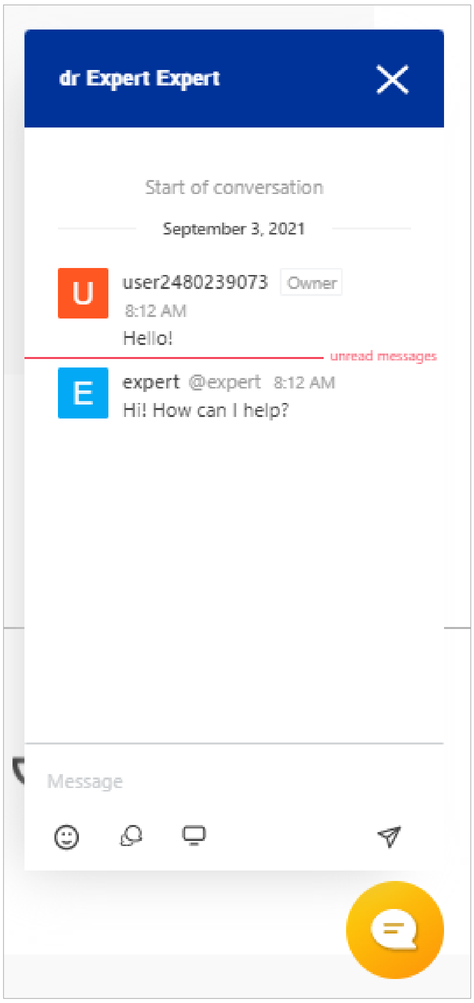

Figure 3: Chat with an operator or expert

3.5 HelpDesk

After logging in the user with the role of expert can select the HelpDesk button to open the chat dashboard with the list of active chat channels. When another visitor starts a new chat, a channel is added to the list and the dashboard user is notified. He can select the channel and chat with a visitor. There is also a possibility to use a shortcut to add a link pointing to the selected platform content to the message he is writing.

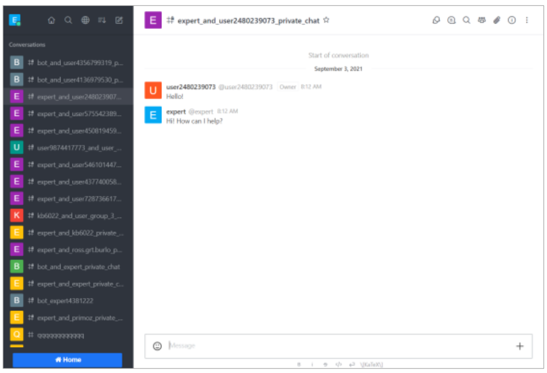

Figure 4: Operator chat dashboard

3.6 Administration

Administrators have to login to gain the possibility to manage users and their properties as roles (call-center operator, expert, …). Further he can define services, experts, companies, user groups and configure various parameters necessary for the correct functioning of the platform. The content can be described in one or more languages to be visible to the visitors of platform in a selected language.

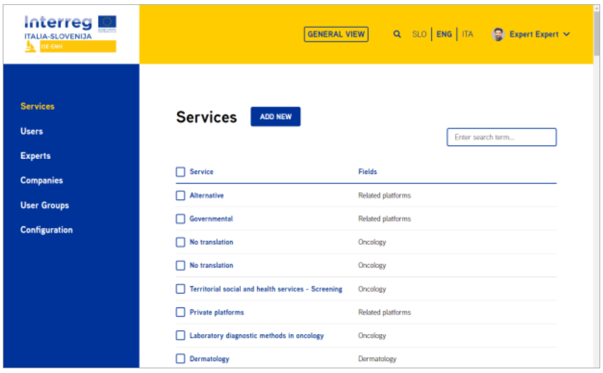

Figure 5: Platform content management

4 CONCLUSION AND FUTURE WORK

The quality and reliability of websites providing health knowledge can vary greatly. Yet despite the chances of unnecessary stress and finding incorrect, or even potentially harmful information, people are searching the internet for health advice.

In this first phase of the project, we've learned how to organize health information and make it accessible to everyone to find answers to their questions or advise them on the best way to proceed. The information can also be accessed by asking the bot or go into detailed chatting with a qualified operator or a doctor if available.

During the next phases we will offer the visitors the possibility to register, so the operator can see his/her name and conversation history. We will improve the bot's conversation recognition capabilities. By saving navigation and search history we can use Machine Learning to understand the visitor's behaviour. With this understanding and adding seasonal (e.g., winter) or exceptional (e.g., Covid) health problems we can enrich search results and bot behaviour.

ACKNOWLEDGMENTS

The paper was supported by the ISE-EMH project funded by the program: Interreg V-A Italy-Slovenia 2014-2020.

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Description of Health Service Selection and Structure of ISE-EMH Platform

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ABSTRACT

Human population is getting older and more prone to diseases. In the information society, it is possible to find lots of helpful information on the web; however, the overload of information makes it hard to find information about a particular health issue. The ISE-EMH platform aims at providing the needed medical information faster and more context-specific than general search engines. The goal is to enable finding relevant services in few minutes instead of seeking for information with general search engine in web browser spending on average half an hour for one of common actions. To achieve such goal, the platform has to be direct and transparent and well structured, and these issues were studied as part of the project. The platform also includes an administrator's webpage. Future work is described at the end of the text, where future stakeholders are mentioned – service providers and medical doctors. Their role will be significant for successful use of the platform, which can hopefully improve access to relevant information about healthcare services.

KEYWORDS

Health service, patient, disease, improving healthcare system, ICD, ISE-EMH platform, workflow diagram, medical doctor

1 INTRODUCTION

Nowadays, all the information is available on web and every user can reach them with just few computer or mobile phone clicks. But the real challenge is how to construct the right question to avoid irrelevant answers. How to access the right information and use it in the proper way? This is even more important in the area of medical or health information, which can improve or hamper health status. Proper help would be achieved by giving the user the relevant physician's contact, sharing a mobile health app or patients' association website. Our project ISE-EMH is trying to provide that – collect the most relevant medical services in the given moment and present it in a quick and efficient way in one place [1].

ISE-EMH stands for Italian-Slovene ecosystem for electronic and mobile health. It is an interregional project financed by the European Regional Development Fund with the main goal to improve e-health in Slovenian and Italian healthcare system with the help of Italian expertise in the field of medicine and Slovenian in ICT (information and communications technology). Service providers in both countries will have an opportunity to add their services and products to platform and therefore improve information flow from patients to healthcare workers and vice versa. Important aspect of the platform is a possibility to establish connections between potential partners in Slovenian-Italian area. This will be supported by the advanced search and recommendation system. As the final result at least six applications will be developed within EMH ecosystem [2].

2 ISE-EMH PLATFORM

2.1 Concept Description

ISE-EMH platform can be seen as highly specific and targeted search engine based on medicine expert's knowledge with just health issues in mind. The platform will be described in details in the following text; however, the main added value of the platform can be described with the following two scenarios:

a) Open preferred web browser, spent approximately 15 to 30 minutes searching medical services that are most appropriate for certain disease in question, critically evaluate them, select the most relevant and discard all dubious.
b) Visit our platform, in a couple of clicks or with search or with assistant get one page at most with most relevant links in several categories, such as internet services, medical professionals, call centers.

To enable the (b) scenario, the medical knowledge from medicine and pharmacy students and some experts was applied to search the web, find and evaluate health services for specific cases.

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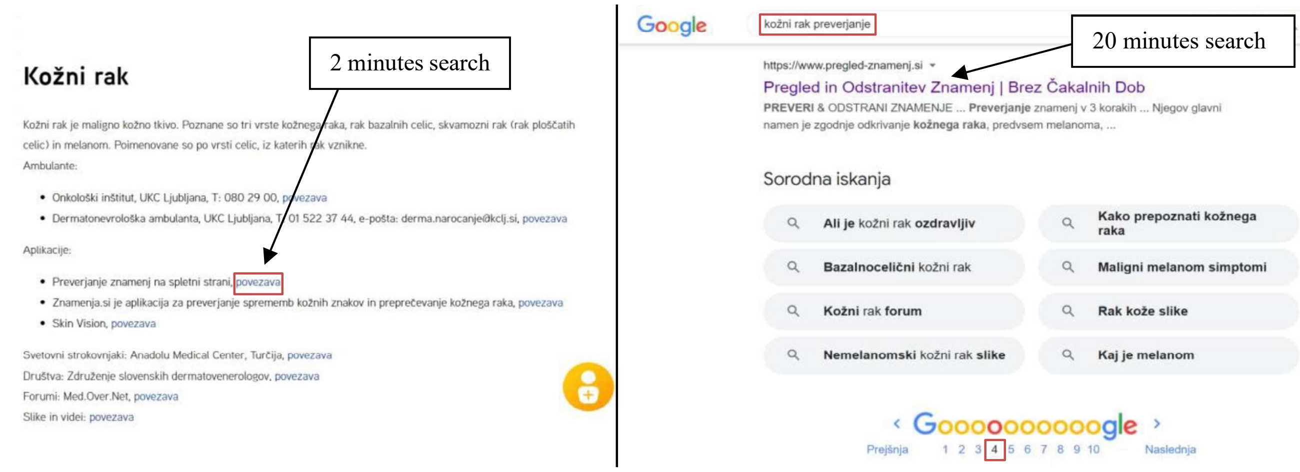

Figure 1: Comparison between searching on ISE-EMH platform and web browser.

2.2 Concept Demonstration

To demonstrate how the platform works and to emphasize its advantages, a simple demonstration is presented in Figure 1. We compared time spent for a user to find an application for skin cancer detection. Firstly, the user visited ISE-EMH platform and tried to find a link to the application. That took him around 2 minutes and can be seen on the left side of Figure 1. After that we used Google search engine to find the same result. The first search was made with word "kožni rak" (skin cancer) and the search engine could not find the preferred application within first hundred results. Then we typed "kožni rak preverjanje" (skin cancer checking) in the search engine and preferred application was found as 38th result. That can be seen on the right side of the Figure 1. This demonstration shows the real added value of the platform.

2.3 Other Health Platforms

European Public Health Association (EUPHA) recognizes public health digitalization as one of the main goals in following years. This will enable higher precision and predictability at diagnosing diseases and faster interaction with healthcare workers [3].

There has already been significant work done in this field. Some of the platforms are presented here.

zVEM is a Slovenian public health platform that enables patients to look at prescribed medicines, make an appointment at selected medical doctor or check medical history [4].

Mediately Register zdravil is also a Slovenian platform (also certified as medical device) used in 8 European countries. It offers prescribing and diagnostic tools for medical professionals and is also a simple platform to search for drug information. That feature is commonly used by patients [5,6].

NHS App is a British public health application, which enables patients to get health advice using NHS website, order their repeat prescriptions and in some cases message their medical doctor online [7].

3 THE ISE-EMH PLATFORM

3.1 Side Menu Layout

The ISE-EMH platform is of a defined structure, which can be seen in Figure 2. More information about the platform can be found on the next link: https://www.ita-slo.eu/en/ise-emh, however the platform is found at another web address [8].

On the left side of Figure 2 there is a menu, which includes 15 big sets of diseases. Each set contains from 3 to 10 specific diseases. Diseases were structured with the help of WHO International Statistical Classification of Diseases and Related Health Problems (ICD), which contains almost 70.000 different diseases and diagnosis. The most common diseases were included in our platform [9].

As an example in Figure 2, there is the Dermatology set shown in the red box, which contains five specific diseases: Pyoderma gangrenosum, Acne, Atopic Dermatitis, Rosacea and Psoriasis. At the moment, there are 82 different diseases and medical conditions included at the website more will be included as the development of the platform is in progress. In future, the platform will be used by users and medical doctors providing more input to be added to the webpage by administrators.

Figure 2: Website layout – set of diseases.

3.2 Disease Webpage Layout

Furthermore, structure of a page for each disease was defined during studying. The structure of these websites is crucial, because web users often decide about staying or leaving the website in few seconds. Therefore, relevant information has to be visible immediately that a user can very fast find and use it [10].

The structure can be seen in Figure 3 and is as follows: at the top of website there is a name of disease, followed by a brief disease definition in the following paragraph. After that it comes the most important part of the webpage – list of services. This includes several categories such as clinics in the state (with direct contact and location), mobile applications that are beneficial for users (for example, Dietary apps that reminds patients with celiac disease when and which food to eat), world leading experts in this field of medicine, patients' associations, forums, pictures and videos of disease symptoms, diets and products that can help patients with disease diagnostics or monitoring. By clicking on website links, users have immediate access to best healthcare providers in the state. We directly copied clinic's phone numbers and e-mail addresses to the ISE-EMH platform that relevant information can be found directly at the platform.

Figure 3: Disease Webpage Layout.

3.3 Administrator's Webpage

For administrators there are seven structure elements which can be selected or edited:

- Name
- Description
- Tags
- Regions
- Fields
- Subfields
- Languages

At the end there is also a box "Approved", which is meant for medical doctors, who will check the added service and then decide whether they are relevant or not.

While other elements are straightforward, "tags" needs some explanation. Tags are selected in a way that the platform suggest similar diseases to the one that is currently open. Some of the tags are:

- Organ: heart
- Organ: skin
- Sex: male
- Sex: female
- Duration: acute
- Duration: chronic
- Age: senior
- Age: children
- Progressive disease
- Vaccination option

For every element an administrator can add a text in three different languages – Slovenian, English and Italian.

4 WORKFLOW DIAGRAM

Figure 4 presents the working process at this project. Text in boxes with bold border indicates the work already done or still in progress, while text in boxes with dashed borders indicate future work.

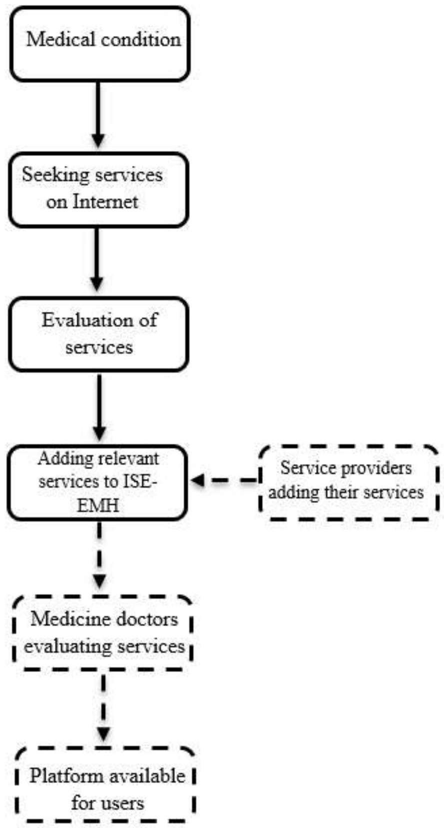

Figure 4: Workflow Diagram.

Several healthcare students cooperated in ISE-EMH project. Their first task was to create a list of common diseases. The main source of information was WHO International Statistical Classification of Diseases and Related Health Problems (ICD). Inside the team we agreed to first include around 75 most common diseases and add more of them later. That number comes from fact that they are 15 sets of diseases included at the ISE-EMH platform and we agreed to include 5 diseases in each set [9].

When all the diseases were selected the team started to write definitions of diseases. They were formulated in few sentences and include information about the cause of the disease, common symptoms, diagnostics and any special warnings about the disease (whether it is contagious or needs immediate treatment).

Next step was searching for any kind of relevant services on Web. For that purpose, we were mainly using Google as search engine and spend around one hour to go through each relevant service for patients. We arranged services in eight categories: clinic services, mobile phone applications, world leading experts, patients' associations, forums, pictures and videos of disease symptoms, diets and special products that helps diagnosing or monitoring the disease.

The relevant and checked services were added to platform. Main criteria in evaluating such services were very good reviews from patients and also healthcare students' knowledge about different clinics. For example, University Clinical Centers in Ljubljana and Maribor are part of tertiary healthcare system in Slovenia and as such have the best available equipment and also medical staff in the state [11].

5 CONCLUSION

In this paper we described the ISE-EMH platform, its detailed structure and the workflow of health service selection. The final structure of the platform is now determined and will hopefully not be significantly changed soon. We believe it is user friendly and all the important information for patients are easily seen. Patients can access information (contacts, locations of clinic) directly on our platform or can visit service provider's website. Workflow of the healthcare students working on the project, was described in detail and is represented with the workflow diagram. It is important to know that process, especially for the students, who will join the ISE-EMH project in future. This text can serve as guideline for them.

In future months, the team will continue adding services to disease webpage and once this will be finished, medical doctors will check the services as the administrators and provide their professional evaluation. After that, the next phase will begin. At that time, the platform will be already available for users (patients). Service providers will be adding their services to the platform and before adding these services to the platform, medical doctors will evaluate them and either approve it or reject it. More diseases will be added by medical doctors and more services by the service providers.

ACKNOWLEDGMENTS

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Usability of smart home and home automation data

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ABSTRACT

Technology and electrical energy are as a matter of fact closely interconnected. The electric revolution and adopted technologies that assure a better standard of living enabled a longer life span.

The demographic prediction is that by 2050, one in four persons living in Europe and Northern America could be aged 65 or over. In 2018, for the first time in history, persons aged 65 or above outnumbered children under five years of age globally. The number of persons aged 80 years or over is projected to triple, from 143 million in 2019 to 426 million in 2050. Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100 | UN DESA | United Nations Department of Economic and Social Affairs)

With the more user friendly and affordable technology, the standard of living and the quality of life for the past 60 years was rising, and it enabled to adopt many technologies from the simplest as lighting, heating to more complex as home automation technologies and solutions. The use of this technology, however, has become part of everyday life, which is reflected in the routine management or use of them.

The future demographic structure and longer life expectancy also bring challenges for society. With the increase in life expectancy and the lack of young people who opt for nursing professions, it will be necessary to find appropriate technological solutions that will help maintain the quality of life and assistance of the elderly.

To provide an adequate general care for the elderly, remotely assist them, predict health issues and to alert the caregivers appropriate technological solutions must be in place. In this paper, we describe the way how through energy management we enable to create events based on the behavior or use of devices in homes, apartments, or spatialized caregiving rooms. These events are the foundation for triggering actions for assistance or prevention and safety in the relevant behavior change.

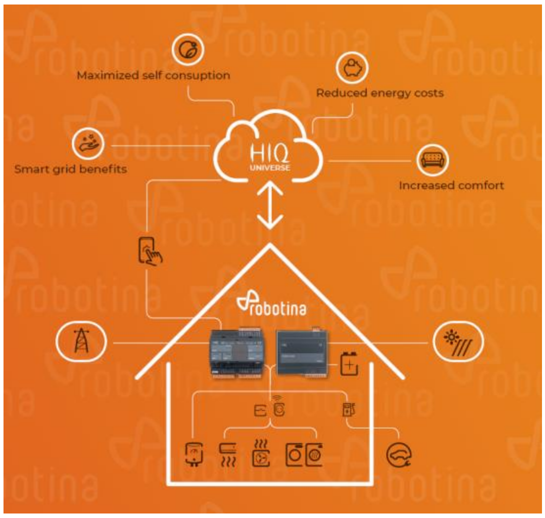
In this paper we describe the role of HEMS (Home Energy Management System) solution and 4G cloud platform in enabling a variety of services and strategies for assisted living and detection of behavior change. In this case HEMS and 4G platform act as an enabler for third party assisted living services.

KEYWORDS

HEMS (Home Energy Management System), Smart Home, care for elderly, elderly, change behavior detection. ISE-EMH, Insieme

1 INTRODUCTION

In harmony with sustainable energy use, interconnected devices and solutions for energy management in homes (HEMS), the possibilities of using the captured data for a variety of secondary use open up. Technology of connectable devices, sensors, cloud data technologies and energy monitoring and energy management technologies, such as Robotina's HEMS solution, enable real-time monitoring of energy consumption and based on this, generation of events and patterns of user behavior.



(1)

Figure 2: HEMS system operation and functionalities scheme.

1.1 Basic information about the project

As a part of Insieme project we developed the features for data acquisition, safe data transfer, models of event generation and event logging. For the purpose of third-party data use we developed a standardized Data API on 4S platform based on SMIP cloud platform API service.
For a better understanding of the topic the paper describes the possibilities and the technology behind it.

1.2 Home energy management system as a source of data

The HEMS system monitors all energy production systems and all energy consumers in an individual home and, in the case of a hospital or nursing home, energy consumption at the level of an individual floor or individual room. The feature of the Energy Management System (HEMS) works locally, and at the same time the connection to the cloud allows it to take advantage of all the benefits that cloud technologies allow. To comprehensively cover all business models and services of energy management solutions, Robotina has built the 4S cloud platform, which enables data capture and analytical data services. Event detection, event generation and consequently as the main functionality activity triggering. In case of assisted living as an example triggering a warning to caregivers. Events once generated may be used for other purposes.

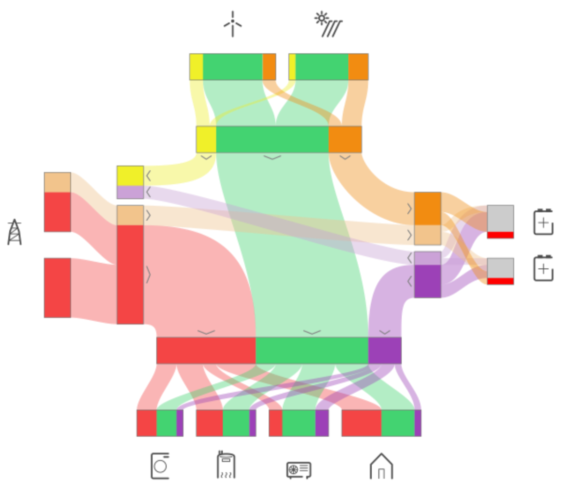


Figure 3: Sankey diagram from HEMS energy management application.

1.3 Overview of available data sets

Energy monitoring and energy management provides us with data on the use of various devices and systems. The collected data give us information on the use of an individual device or system and the time frames for the use of the devices. Depending on the time period, the duration of an individual event and the type of device or system that was used at a given time, we can specifically build events and content interpretations of events that trigger event-specific activities.

Data sets
Time of the event
Duration of the event
Type of the device or system

Additional parameters to trigger actions are:
Age of the person
Current health status

2 DATA AND CONNECTIVITY

Data collecting and data transfer to the cloud are crucial for the interoperability and inter-usability of data by third-party providers of ambient assisted living application information solutions and home care assistance solutions. At the level of the HEMS (Home Energy Management System) solution, connectivity is ensured through the edge technology of the Robotinas IoT Linker product, which ensures that data is securely transmitted to the cloud xEMS platform.

3 EVENT GENERATION

Events are generated out of available data sets and are time stamped.
Event can be generated through result of a simple equation. Let's take temperature as an example. Equation, which would generate variable high_temperature as (TRUE): if (t1)>38 then high_temperature.
More complex events may be result of an algorithm, like counting number of bathroom light_ON events between 22 and 6' o clock.
Finally, events may be result of a complex combination of algorithms, machine learning and artificial intelligence.
Events are defined/described by healthcare specialists and translated into formulas or algorithms. Artificial Intelligence is used, when patterns are not clearly known upfront or when relations are too complex.

3.1 Lighting scenarios

Lighting and its use in rooms is the simplest, but on the other hand the most used device or set of devices in daily life of every person. The data of lighting usage provides us a variety of information. Use at a certain time of the day, the frequency of its use, use in an individual, specific space provides us with valuable data in generating events and patterns of behavior. the logical consequence is that it also allows the detection of anomalies and changes in behavior. A clear example is the non-extinguishing of lights, which can serve as scenarios of causes such as insomnia, dementia or even death. The frequency of lighting in a particular room, such as the frequent use of lights in toilets at night, can provide us with information about the disruption of water drainage, ie the detection of the onset of incontinence or prostate problems in the case of the male population. However, early detection and early diagnosis of the disease can have a radical impact on further prevention of disease development. In the case of homes for the elderly, however, caregivers have the option of comprehensive insight and prompt action.

3.2 Heating scenarios

Heating and cooling are also the most common solutions in any home or building. In this case, energy management and HEMS also provide us with information on a person's health through monitoring the operation of heating and cooling systems. There are, of course, many scenarios. An example of excessive cooling or heating may indicate a physiological change in a person or a change in health.

3.3 Energy consumption scenarios

Comprehensive energy management and monitoring through HEMS provides us with rich data to interpret the behavior of the individual through monitoring energy consumption. An obvious example of such a scenario is the example of "morning coffee". Hems can clearly identify patterns of behavior and deviations, changes, or anomalies in an individual’s routine actions or tasks through monitoring peak energy consumption. In this case, “morning coffee,” which is routine for most people, can be an indicator of a person’s condition. Perceived changes in the performance of routine tasks are systematically interpreted as an event that triggers activities to inform relatives or caregivers.

4 DATA AVAILABILITY

The power of big data is in its usability. To assure 3rd party data use it is necessary to assure the data availability in a standardized way through standard protocols. This ensures to other provider to use the collected data and make them a part of an applicable solution, which provides stand-alone services based on this information or data.

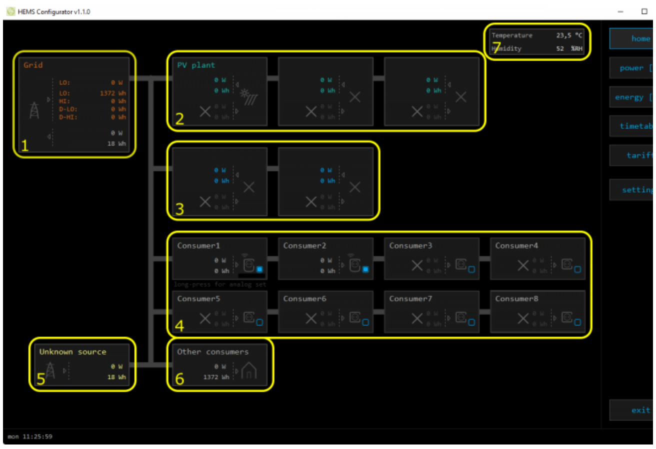


Figure 4: HEMS prosumers and consumers configurator.

4.1 Data API

As mentioned above, Robotinas HEMS (Home Energy Management System) enables to spatialized IT companies to reach key data that enable to build additional services in assisted living and other remote care services. Data API configurations enable devices to be accessible to third-party clients by calling SMIP Data API Web Services. Content developers may define which things and which variables may be accessible to which third-party. Write access to variables is also defined in Data API configurations.

5. REAL LIFE SOLUTION APPLICATION

Through energy consumption and the use of various devices, HEMS can define various events, which, of course, depend on the type of building or living environment and the age or health condition of the person.

5.1 Individual home

For an individual home as we have already mentioned in the paper, the key goal is to monitor the routine through HEMS energy management. Through an appropriate, long enough period to define individual events, the system obtains data to detect changes in routine tasks, define current health status, detect deterioration in health status, or early detection of potential new disease at an early stage. Notifications to relatives or caregivers are generated when routines change. This way they have the ability to check the situation and the ability to act quickly. The benefits of this type of solution are for the elderly and their therapists or doctors, caregivers and, of course, relatives. With the growth of the elderly population, solutions such as HEMS and the Ambient Assisted Living service can indirectly help extend the autonomy of the elderly and the independence of the elderly, as everything takes place automatically and remotely. This is especially important for seniors living in remote locations. All involved stakeholders who directly or indirectly care for a person thus have the opportunity to be informed and to act in a timely manner for the benefit of the quality of life of the elderly person ore their beloved ones.

6 CONCLUSION

We have described the possibilities offered by the energy management solution (HEMS) and the 4S cloud platform in the direction of “Ambient Assisted Living” solutions. We have prepared an environment for the capture, transfer and storage of data and the creation of events that serve to implement other applications of application solutions. We examined the possibilities of using the obtained data to generate events and trigger actions. We have identified scenarios that can provide solutions to the well-being of older people and the early detection of potentially pathological changes and diseases. These solutions can be applied fast and with the least investment in the current infrastructure.

ACKNOWLEDGMENTS

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Intelligent cognitive assistant technology for (mental) health in the ISE-EMH project

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ABSTRACT

The paper presents the inclusion of intelligent cognitive assistant technology in an electronic and mobile health system under development for the ISE-EMH project. After introducing the project and the intelligent cognitive assistant technology, the paper describes the included assistants in the developing electronic health system. The main focus of the paper is its emphasis on the current state of the design of an advanced adaptive and personalized assistant for mental health. The most in-depth description focuses on the utilization of a generative pre-trained transformer (based on OpenAI's GPT-3) to respond to users' self-reports about their mood and mental health issues.

KEYWORDS

Attitude and behavior change, digital mental health, electronic and mobile health system, intelligent cognitive assistant technology

1 INTRODUCTION

Electronic and mobile health system (emHealth) describes healthcare services that are largely enriched by the use of information and communication technology (ICT) for its functionalities. This mostly includes computers and mobile phones, which make healthcare more flexible and available at all times, but can also extend to newer technologies, such as robots. ICT is made useful in a wide range of services, from data keeping to predictive modeling. One of the existing and still evolving technologies that benefit emHealth the most is the intelligent cognitive assistant technology.

Intelligent cognitive assistant technology (ICAs) has been defined as a technology powered by complex information processing agents. These can acquire information, put it into action and transmit knowledge, bringing together perception, intelligence, thinking, calculation, reasoning, imagining and, in the end, conscience [1]. ICAs aspire to: understand context; be adaptive and flexible; learn and develop; be autonomous; be communicative, collaborative and social; be interactive and personalized; be anticipatory and predictive; perceive; act; have internal goals and motivation; interpret; and reason. Such agents are usually deployed either as conversational agents – computer systems that converse with humans in (usually written) natural language – or robots. All these characteristics make them very suitable for various functionalities inside an emHealth platform, some of which will be presented in this paper, as they also play a role in the ISE-EMH project.

The ISE-EMH project encompasses a platform of emHealth and is co-financed by the European Regional Development Fund. As a result of a collaboration of multiple Slovenian and Italian partners, it connects cross-border healthcare systems. The project consists of three main components: a mobile application, a web page and a chat system. The mobile application, available for OS Android, is developed specifically for elderly persons and their caretakers. The goal is to simplify and improve quality of seniors' lives. This is achieved through a design that provides simple usage and implementation of multiple integrations, such as alarms for taking medicines, fall detection and an SOS call option. The web page consists of several relevant information about health concerns, diseases, and fields of medicine, along with useful links for booking certain services, for waiting queues for procedures, and of presentations of other helpful platforms. Because all data are gathered in one place and easily available, it allows better access to the healthcare itself, as searching for information is intuitively designed. The chat system is implemented in the web page, and is intended for all users that have questions concerning health problems or are simply looking for more information about certain services. Its main goal is to provide answers, give advice to users, and present information about waiting queues for certain procedures and services. This is possible through the use of ICAs.

This paper presents the use of the ICA technology in the ISE-EMH emHealth platform, and focuses on an adaptive and personalized ICA for attitude and behavior change in mental health, which is planned to be implemented into the platform.

2 INTELLIGENT COGNITIVE ASSISTANT TECHNOLOGY IN THE ISE-EMH PROJECT

The ICA technology in the ISE-EMH project, similarly as other chat possibilities, is integrated in Rocket.Chat [2], a widely used open source communicating platform. The ICA technology is mostly deployed when a professional is not available to chat with the users. At that moment, the answers are provided by various ICAs. Three assistants are implemented directly in the platform, all of them with different domains they cover in terms of their semantic understanding: the JSI assistant, an assistant for waiting queues, and an assistant for service searching. They all provide their answers, but users can alternatively select only one of them. Others assistants (e.g., an assistant for information on hepatitis) are also included, but are not integrated, and they can be accessed through a link, suggested in the chat window. The three major integrated assistants are described below:

1. **The JSI assistant [3]**: An assistant developed in Bottle (Python). Jožef Stefan Institute (JSI) is a partner of the project, and this ICA's purpose is to give answers to any question related to the JSI institute and its employees. It can also provide answers to more general questions. It works by enacting the following pipeline: 1) all stop-words are removed in given text to obtain relevant keywords; and 2) lemmatization, a procedure that returns the root of a word, is used on these keywords to provide more efficient searching through the database.

2. **An assistant for waiting queues**: An assistant developed in Django (Python), which provides information on waiting queues in the Slovenian healthcare system of a given health service. The data of all the possible procedures are obtained from the website https://cakalnedobe.ezdrav.si/, which makes them non-obsolete. Based on the selected health service, urgency and the region of procedure, information on the medical institutions that provide the service along with first available time slots are given. For avoiding any misunderstandings about what procedures the user wants, stop words are removed and a lemmatizator is used. The user then chooses among all the suggested services. If a procedure is not available, other solutions are suggested, such as searching in all the available regions. This makes searching faster and more precise as well as easier to use, which is enabled through the button-based chat implementation.

3. **An assistant for service searching**: The assistant is implemented as a service search; the services are available on the ISE-EMH platform website as well. The ICA uses entered keywords to provide descriptions of services, including many useful links. With the stop-words removal and the use of Elasticsearch (a search engine that allows faster searching and analyzing large amounts of data [4]) on trigram words, it allows fast and precise searching.

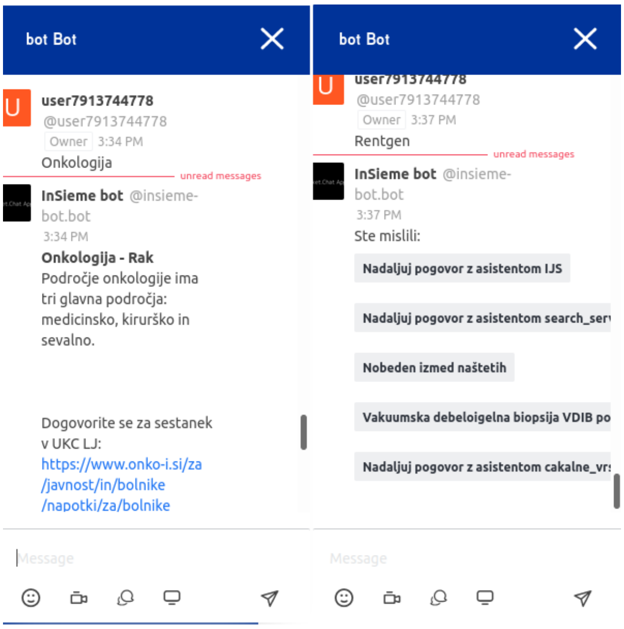

Figure 1. Left: An assistant for waiting queues giving information on oncological procedures. Right: Various possibilities from different ICAs when more answers are possible.

Another planned ICA integration is an intelligent cognitive assistant for attitude and behavior change in mental health. This is going to be an advanced adaptive and personalized ICA, planned to be state of the art (SOTA) in the field of ICAs for mental health. Its design is described in the next section.

3 DESIGN FOR AN INTELLIGENT COGNITIVE ASSISTANT FOR ATTITUDE AND BEHAVIOR CHANGE IN MENTAL HEALTH

To be able to understand how to design such an ICA, the mental health issues in the society have to be overviewed. Stress, anxiety and depression (SAD) are on the rise in the entire world, with figures in certain groups reaching 71% for stress, 12% for anxiety disorder and 48% for depression [5]. This opens the doors for technological and scientific interventions to help mitigate the occurring mental health pandemic. One such technology is persuasive technology (PT), which tries to change attitudes or behaviors without coercion or deception. ICAs can be effective vessels for such goals., as they can communicate in natural language. By employing ICAs in mental health, the benefits can be numerous: they can be free of charge, available 24/7, and available in remote locations [6]. Furthermore, people tend to be more comfortable talking to an ICA than to a person [7].

To discover what SOTA in this field was, three major ICAs for SAD were reviewed, also because only rare review articles on this topic exist [8]. An ICA by Yorita, Egerton, Oakman, Chan and Kubota [9] is based on the Belief-Desire-Intention architecture with three models: “a conversation model for acquiring state information about the individual, measuring their stress level, a Sense of Coherence (SOC) model for evaluating the individuals state of stress, and Peer Support model, which uses the SOC to select a suitable peer support type and action it" [Ibid., p. 3762]. The ICA teaches users how to improve their mental resilience to stress, which it succeeds in in the reported experiment. Another effective ICA is called Woebot [10]. It is based on a "decision tree with suggested responses that accepts natural language inputs" [Ibid., p. 3]. It intervenes by outputting educational content, personalized messages, and scripted advice by collecting data on users' emotions and identifying their errors in thinking. In one experiment, Woebot was more successful in helping with SAD symptoms than the government-prescribed material. The last reviewed ICA is called Tess, which "reduce[s] self-identified symptoms of depression and anxiety" [11]. It uses an extensive emotion ontology to identify the emotions of its users from the text. It uses prepared scripts to help the users, and collects journal data and user feedback to improve its outputs. In one experiment, Tess significantly reduced depression and anxiety symptoms as opposed to the government-approved eBook for self-help.

Reviewed ICAs seem to already be at least partly successful, but they do not fully exploit the possibilities PT offers (e.g., attitude and behavior change theories, user modeling, adaptation, personalization). The ICA we are designing takes that into account. In this paper, we focus on describing a module in the ICA that utilizes a generative pre-trained transformer (based on GPT-3 [12]) to formulate outputs.

Our ICA surpasses the SOTA by possessing a 'theory of mind'. This is achieved by the ICA a user model with the data on users' emotions, mental states, and personality, which relies on behavioral and cognitive sciences advances; a reinforcement learning algorithm to learn from historical interactions between the ICA and the user, thus capturing which strategies work and which do not; and ontologies on attitude and behavior change, stress, anxiety, and depression. The focus is however on the following module and its architecture:

Module architecture:

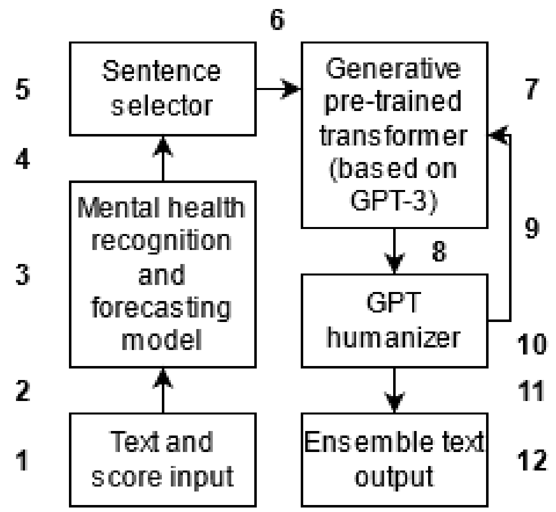

Figure 2. A module for detecting and forecasting mental health issues, and responding to the detected and forecasted issues by utilizing a generative pre-trained transformer, based on GPT-3.

The module architecture represents the following pipeline:

1. Information input. Users answer quantitative questionnaires on their mental health, and provide a textual input on their mood, their experiences while in that mood, and similar. If the user has already provided quantitative scores for enough time, only text is necessary.

2. The scores and text are automatically preprocessed to extract the features.

3. A pre-trained model is used first to recognize moods, emotions, sentiment, and other mental health markers in the text, and it uses this on conjunction with the quantitative scores to forecast mental health trends of the user. This part determines various metrics: the severity of mental health problems, the specificity of mental health problems, and the short-term trend of mental health problems.

4. The three metrics are sent to the next part of the module.

5. A pre-written text is selected according to the metrics, determined in the previous part. The text serves to mitigate the user's mental health problems, and, if the forecasted trend is negative, to try to break that trend.

6. The text is sent to be augmented with the next part of the module.

7. The text from the previous part is enriched by a generative pre-trained transformer based on GPT-3 with additional text. This makes responses more varied and alive for the user.

8. The enriched text is passed to the GPT humanizer.

9. GPT humanizer return the original text for enrichment if deemed risky for the user.

10. GPT humanizer decides whether the added text by Generative pre-trained transformer based on GPT-3 is acceptable in terms of risk for the user. It consists of a rule-based model that rejects text with certain words, sentiment analyzer that rejects text that fails to reach a certain positive sentiment threshold, and a pre-trained model based on a dataset of risky sentences that rejects text if it is detected as risky.

11. The final text goes through some additional modifications to check that everything is in order.

12. Output of the final text.

Example:

1. The user inserts text "Today I have felt very bad. I feel a lot of stress because I have a deadline at work coming, and I fought with my partner yesterday. I am anxious to talk to them tonight. The deadline is a bit scary because I did not do a good

job last time, and if it happens again, it might trigger my depression."

2. Features are extracted. This includes performing sentiment analysis, creating n-grams, vectorizing, calculating basic statistical features, and applying psychological and cognitive lexicons on the text.

3. The features from the second step are used for detecting the user's specific mental health problems, their severity and, if there is historical data of the user, the short-term trend. The model returns abnormal levels of stress and depression, and it forecasts a negative trend.

4. The information on the mental health of the user is sent to the sentence selector.

5. Due to the abnormal levels of stress and depression as well as a negative trend forecasting, the text, which also takes the user's personality, which is more easily persuaded when addressing their social circle, into account, selects the text "*Tackling stress and depression is hard, especially since many people have problems with them, but it is not impossible. Try to think outside of the current situations and discuss them with your friends. They probably have some experience with them and can offer advice as well as another perspective on the situation.*".

6. The module takes the selected text and sends it for enrichment.

7. The text is enriched with the following two sentences: "**Don't ignore or repress the problem if you need to seek help. You are not a burden and you do have worth.**" (This was an actual output of GPT-J [13]).

8. The enriched text is passed to the GPT humanizer.

9. Does not occur.

10. GPT humanizer extracts features from the added text. It does not find any risky indicators.

11. The final text is passed to the final stage without modifications.

12. The user receives the full text output: "*Tackling stress and depression is hard, especially since many people have problems with them, but it is not impossible. Try to think outside of the current situations and discuss them with your friends. They probably have some experience with them and can offer advice as well as another perspective on the situation.* **Don't ignore or repress the problem if you need to seek help. You are not a burden and you do have worth.**"

4 CONCLUSION

The paper presented an emHealth platform being developed in the ISE-EMH project. First, the paper focused on the ICA technology used in the project, and later it focused on one particular ICA, an advanced adaptive and personalized ICA for attitude and behavior change in mental health.

The field of emHealth is still developing as advancing technologies are being integrated into various domains of our society. The project ISE-EMH represents one such use case of integrating the domain of healthcare with the ICA technology.

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Analysis of a recommendation system used for predicting medical services

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ABSTRACT

Recommendation systems are widely used in prediction of user preferences given a set of data. More often these preferences are part of the domains of the entertainment or general goods industry, striving to improve recommendations for items such as songs, movies, electronics, etc. In this work, we give an overview of using a recommendation system in a electronic and mobile health platform, showcasing the applicability of such a system for recommending healthcare services and keywords relating to user's initial search query.

KEYWORDS

Electronic and mobile health, recommendation systems, Insieme

1 INTRODUCTION

Recommendations systems have been proven to provide solid recommendations in various tasks, such as movie recommendations, song recommendations, general goods recommendations on online shopping platforms, etc. With their help, using online platforms and services has become more enjoyable since they tailor suggestions in respect to each individual user. Focusing on the healthcare domain, we can see that recommender systems are able to offer help in many aspect of a patient's health [3]. Similarly, they are also used by the healthcare professionals, aiding them in decision making scenarios in order to decrease the risk of errors. An interesting approach is proposed by [2], where the entirety of the recommendation system is build as a whole platform. Their platform takes into consideration the user's health status and finds healthcare services which it considers would be of value to the user. Our work is interested in analyzing a recommender system in conjunction with an electronic and mobile health (EMH) platform. We want to recommend relevant healthcare services to the users based on their search queries. Having good recommendations allows the user to find relevant services in a faster and easier way.

Problems with recommendation systems

A recommendation system has the most difficult time achieving good results at the beginning of its work period. This is widely known as the "cold start" problem. This problem is due to the fact that a system can not infer any significant information about its users or items because previous information is scarce. There are several approaches one can take while designing a recommendation system, such as:

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Collaborative filtering

Collaborative filtering is based on the idea that users who have similar interest in the past, will be more likely to rate future items the same way. The recommendation is gathered from data from various users, but it is tailored just for the specific user that is doing the query.

Item-item collaborative filtering

Another form of collaborative filtering is the item-item collaborative filtering. Instead of looking at users which are similar based on their previous ratings, it looks at the items that are rated by one user and it suggest a new item which has the highest similarity between the previously rated ones. This form of filtering performs well when the number of users is higher than the numbers of items, which is a good fit for our problem.

Insieme

The environment where the recommendation system will be analyzed is called ISE-EMH (Insieme). It represents an EMH platform which connects various medical institutions and patients. The platform provides information about services which are obtained from medical institutions. An example use case is a patient that requires information about certain illnesses, queries information through keywords on the platform and the platform returns the relevant information.

The users who are using Insieme are not required to have an account to use its services. Because of that, a session based recommendation system is used, meaning the user's queries (searched keywords) are only relevant in only one session. The user may be able to search for different illnesses in different sessions, but we can not assume their previous searches are related to the current one.

2 EXPERIMENT

In order to carry out the analysis of the recommendation model for project Insieme, we decided to simulate a small set of input data due to lack of real data. First, we chose a subset of services and then we simulated some users' choices. The simulation was done by generating use cases which simulate a typical user using the EMH platform and choosing appropriate services. This was done because real user interaction data was unobtainable.

Input data

Insieme services are organized into medical categories. For the purpose of the experiment, we chose the following medical categories: dermatology, oncology and infections. From each of those we chose 3 to 4 services, thus obtaining 10 various medical services. Each service has keywords describing it. Since the services refer to the diseases, the keywords refer to the affected part of the body and describe some additional properties of the disease.

services \ keywords	dermatology	oncology	infections	skin	brain	lungs	vaccination	cronic illness
pneumonia			+			+		
acne	+			+				
psoriasis	+			+				+
dermatitis	+			+				+
skin cancer		+		+				
lung cancer		+				+		
brain tumor		+			+			
Lyme disease			+	+				+
tick-borne meningoencephalitis			+		+		+	+
COVID-19			+			+	+	

Table 1: A subset of services with corresponding keywords

services \ users	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
pneumonia	+					+							+								
acne				+				+			+				+	+					+
psoriasis		+						+	+	+							+				
dermatitis		+								+									+		
skin cancer			+								+				+			+		+	
lung cancer	+		+									+	+					+		+	
brain tumor			+				+													+	
Lyme disease				+				+					+	+	+						
tick-borne meningoencephalitis							+						+	+					+	+	
COVID-19					+	+						+	+			+	+				

Table 2: Users' choices of services

When choosing the subset of services, we carefully selected those with various keyword intersections. The services and keywords are shown in Table 1. The '+' sign denotes which keywords are associated with a service.

Next, we have simulated the interactions between users and services. The '+' sign denotes that the user has chosen the service. The users' choices are in Table 2. When preparing the data, we bore in mind the possible reasons to some users' choices. E. g., users 1, 7 and 10 might be concerned about some skin problems, while user 11 might be concerned about the lung problems and user 2 might be investigating all information about cancer available. However, in order to make data more realistic, the majority of users' choices don't have agenda.

Recommendation model

Our choice for a recommendation system is LightFM [1]. The reason for using this implementation is the ability to create tag embeddings by supplying user and item features. In our use case, our item features represent tags that further explain the keywords (items), for e.g. : "Acne" item has the corresponding "Dermatology" and "Skin" items associated with it. The benefit of using embeddings is that they capture semantic similarities between the keywords, which in turn will result in better inference of the model and provide an option to choose top N most similar keywords.

With the help of the learned latent vectors improvement is achieved on "cold start" scenarios. If the item features were not supplied, the model would default back to a pure collaborative filtering model. In addition, an implicit feedback model is used that regards the absence of information in the interaction matrix as negative feedback. The motive for this is that a user already made a conscious choice about what kind of services he needs information for, so the keywords that the user didn't search can be regarded as negative interactions in the interaction matrix.

We built the recommendation model using the LightFM library [1]. We compared the outcome of two various models. The first model is trained on the users' choices of the services only. The second model is additionally trained on keywords describing the service. Using these two models, we obtained the suggestions for each user.

Results

The top recommendations for all users are mostly the same. The differences between the recommended services are minimal, e. g. for user 2:

- pneumonia: 0.13
- acne: 0.18
- psoriasis: 0.13
- dermatitis: 0.15
- skin cancer: 0.18
- lung cancer: 0.18
- brain tumor: 0.13
- Lyme disease: 0.17
- tick-borne meningoencephalitis: 0.17
- COVID-19: 0.16

This data is produced by the model with only interactions. The model with item features has the same recommendations, with slightly lower probability. For each user, the top 3 suggested services are acne, skin cancer and lung cancer. These predictions are not satisfactory, since we would like to obtain the suggestions tailored to every user separately. We assume more data would be needed for training of recommendation models.

3 CONCLUSION

In this work we analyzed a recommendation system that is used with an EMH platform. The goal was to see if such a system is applicable on an EMH platform and offer medical service recommendations to users. Because of limited amount of interaction data, the recommendation system faces difficulties in learning meaningful representations. The system requires data which would be gathered during a longer period of time, in order to give more accurate and meaningful suggestions.

ACKNOWLEDGMENTS

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PlatformUptake Methodology for AHA Solution Assessment

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ABSTRACT

The EU PlatformUptake project aims for AHA solution assessment. It assesses the societal impact of the existing platforms, creates monitoring and evaluation toolkits, collects successful user stories and best practices, promotes interoperability, and defines guidelines for a common evolution of such platforms within existing policy frameworks and initiatives. In this paper we present (i) PlatformUptake methodology for AHA solution assessment and its main objectives, (ii) the results of two ways of clustering, and (iii) the results of taxonomies generation of the text descriptions of the EU PlatformUptake platforms for elderly. After the data was prepared, we ran the K-means algorithm and hierarchical clustering to get the number of clusters. We also created a decision tree of platforms for elderly.

KEYWORDS

uptake, clustering, artificial intelligence, health, elder people

1 INTRODUCTION

Ageing presents one of the greatest socio-economic challenges of the twenty-first century. According to estimates more than 20% of Europeans will be 65 or older by 2025 [5]. Reacting to related puzzlements of demographic shifts and ageing in general, and guaranteeing the availability of the required structure to help Europe utilize the active and healthy ageing sector's opportunities, the EU has devoted a high level of resources to ICT projects in the field of active and healthy ageing. As such a considerable number of open source platforms for the development of innovative solutions in the AHA domain have been created [3].

The EU PlatformUptake methodology for AHA solution assessment assesses the societal impact of these existing platforms, create monitoring and evaluation toolkits, collect successful user stories and best practices, promote interoperability and define guidelines for a common evolution of such platforms within existing policy frameworks and initiatives. Seeking to support the large-scale uptake of the platforms, the project proposes the creating of an online information hub which provides descriptive and support materials on all existing platforms, the organisation of several stakeholder events, as well as Massive Open Online Course for synergies, knowledge exchange and a common understanding among all stakeholders in the Active and Healthy Ageing market [3].

The rest of the paper is organized as follows. Section 2 presents the main objectives of the project, project methodology and platforms for elderly. Clustering and taxonomies are described in section 3. Finally, section 4 concludes the paper with summary and ideas for future work.

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2 METHODOLOGY FOR AHA SOLUTION ASSESSMENT

2.1 Main objectives

The main objectives of the EU PlatformUptake methodology for AHA solution assessment are:

- To identify the critical success factors of the development, deployment and spread of open platforms in the Active And Healthy Ageing Domain, through a sophisticated tailor-made monitoring methodology.
- To develop monitoring and self-evaluation tools to support platform providers and users self-assess their success, uptake, capability gaps and evolution potentials through smart assessment and visualization tools.
- To analyse existing platforms based on the created methodology, by assessing the projects and initiatives hosted by them, their further evolution, uptake, sustainability and socioeconomic benefits.
- To involve end-user communities and related stakeholders to initiate a knowledge exchange cycle for collecting insights on best practices and challenges of platforms' uptake, evolution and costs, etc.
- To leverage the platform uptake by their user communities as well as their continuous improvement and expansion, by elaborating and showcasing best-practice models and evaluation guidelines.
- To disseminate the acquired knowledge to end-users for increasing their uptake of existing platforms, and promote best practice models and identified benefits to foster future developments.

2.2 Methodology

The EU PlatformUptake methodology for AHA solution assessment seeks to deliver an inventory of the state of the art and analyse the use of open service platforms in the Active and Healthy domain, covering both open platforms – such as UnversAAL, FIWARE and partly-open/proprietary platforms developed by industry, and address the interactions between these platforms [3].

To measure the impacts of such platform and enhance their uptake, the project proposal presents a methodology for monitoring open platform development, adoption and spread across Europe, by listing key factors that determine success or hinderance in their uptake by the end-user groups, and also the evolution of their ecosystems and stakeholder networks.

The proposed methodology shall be employed in the project to evaluate the use of open platforms by collecting and processing data from past and currently running European projects and other initiatives that are built upon such platforms. Following the knowledge acquisition, the methodology will elaborate evaluation guidelines and best practice models of integrating multiple platforms, taking account of technical, organizational, financial/business and legal aspects.

Following the assessment of the ecosystem and output of an extended evidence on the ecosystem, the methodology will create support materials for all involved stakeholders to promote the large-scale uptake of existing platforms and also their continuous improvement. In concrete terms this action includes the creation of toolkits for Monitoring and Self-Assessment for both platform providers and platform users, the creation of an Online Information Hub which showcases all information through visually appealing smart tools, and the creation and implementation of a Massive Open Online Course and final project activities to promote synergies and knowledge exchange between the community members [3].

2.3 Platforms

Within the development of the methodology 18 platforms for elderly were analysed. These platforms are:

(1) ACTIVAGE
(2) universAAL
(3) FIWARE
(4) ReAAL
(5) VAALID
(6) GIRAFF+
(7) EkoSmart
(8) PERSONA
(9) OASIS
(10) AmIVITAL
(11) REACH2020
(12) AMIGO
(13) MPOWER
(14) SOPRANO/OPENAAL
(15) INTER-IOT
(16) UNCAP
(17) BeyondSilos
(18) INLIFE

ACTIVAGE consists of a set of Techniques, Tools and Methodologies for interoperability between heterogeneous IoT Platforms and an Open Framework for providing Semantic Interoperability of IoT Platforms for AHA while addressing trustworthiness, privacy, data protection and security.

universAAL enables seamless interoperability of devices, services and applications for IoT enabled smart environments. The platform provides the framework for communication, connectivity and compatibility between otherwise disparate products, services and devices.

The FIWARE Foundation is the legal independent body providing shared resources to help achieve the FIWARE mission by promoting, augmenting, protecting, and validating the FIWARE technologies as well as the activities of the FIWARE community, empowering its members including end users, developers and rest of stakeholders in the entire ecosystem.

REACH represents a solution that seeks to prevent elderly citizens from loss of function and a decline of being able to perform Activities of Daily Living (ADLs) independently leading ultimately to entering Long Term Care (LTC).

VAALID (Accessibility and Usability Validation Framework for AAL Interaction Design Process) is a STREP project of the 7th Marco Program for Investigation and Development of the European Commission, included within the Strategic Objective 'Accessible and Inclusive ICT'; Thematic Priority ICT-2007.7.2.

GIRAFF+ is a complex system which can monitor activities in the home using a network of sensors, both in and around the home as well as on the body.

The purpose of the EkoSmart program is to develop a smart city ecosystem with all the support mechanisms necessary for efficient, optimized and gradual integration of individual areas into a unified and coherent system of value chains.

PERSONA aims at advancing the paradigm of Ambient Intelligence through the harmonisation of Ambient Assisted Living (AAL) technologies and concepts for the development of sustainable and affordable solutions for the social inclusion and independent living of Senior Citizen, integrated in a common semantic framework.

OASIS introduces an innovative, Ontology-driven, Open Reference Architecture and Platform, which will enable and facilitate interoperability, seamless connectivity and sharing of content between different services and ontologies in all application domains relevant to applications for the elderly and beyond.

The general objective of the AmIVITAL project is the development of a new generation of ICT technologies and tools for the modelling, design, operation and implementation of Ambient Intelligence (AmI) devices and systems to be used for providing services and personal support for independent living, wellbeing and health.

REACH2020 represents a solution that seeks to prevent elderly citizens from loss of function and a decline of being able to perform Activities of Daily Living (ADLs) independently leading ultimately to entering Long Term Care (LTC).

The Amigo project develops open, standardized, interoperable middleware and attractive user services for the networked home environment.

MPOWER defines and implements an open platform to simplify and speed up the task of developing and deploying services for persons with cognitive disabilities and elderly.

SOPRANO designs and develops highly innovative, context-aware, smart services with natural and comfortable interfaces for older people at affordable cost, meeting requirements of users, family and care providers and significantly extending the time we can live independently in our homes when older.

In the absence of global IoT standards, the INTER-IoT results will allow any company to design and develop new IoT devices or services, leveraging on the existing ecosystem, and bring get them to market quickly.

UNCAP ("Ubiquitous iNteroperable Care for Ageing People ") makes use of solutions and technologies developed in previous research projects to develop an open, scalable and privacy-savvy

ICT infrastructure designed to help aging people live independently while maintaining and improving their lifestyle.

BeyondSilos aims at further spreading ICT-enabled, joined-up health and social care for older people by developing, piloting and evaluating integrated services based on two generic pathways in a multicentric approach, making extensive use of knowledge and experience gained among early adopters of integrated eCare in Europe.

INLIFE aims to prolong and support independent living for elderly with cognitive impairments, through interoperable, open, personalised and seamless ICT services that support home activities, communication, health maintenance, travel, mobility and socialization, with novel, scalable and viable business models, based on feedback from large-scale, multi-country pilots.

3 CLUSTERING AND TAXONOMIES

Here we present the results of two ways of clustering and the results of taxonomies generation of the text descriptions of the EU PlatformUptake platforms for elderly. There are 18 platforms, each of which is described by 66 features.

First, the text description of the platforms was converted into numeric values, e.g. “yes” gets converted to 10, “no” to 0, “partial” to 5. A part of features couldn’t be directly converted into numbers – mainly features with string-type unordered values, e.g. “Any (web)”, “Windows, mobile, Symbian”, “Java”.

3.1 K-means clustering

K-means clustering is a method of vector quantization, originally from signal processing, that aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean (cluster centers or cluster centroid), serving as a prototype of the cluster. This results in a partitioning of the data space into Voronoi cells. k-means clustering minimizes within-cluster variances (squared Euclidean distances), but not regular Euclidean distances, which would be the more difficult Weber problem: the mean optimizes squared errors, whereas only the geometric median minimizes Euclidean distances. For instance, better Euclidean solutions can be found using k-medians and k-medoids [2].

The goal of clustering is to determine how many and which cluster groups represent the platforms best, based on the descriptions of EU platforms for elderly, created by the EU PlatformUptake project in Spring 2021.

In Figure 1 we can see the results of k-means with four clusters. In Figure 2 we can see the results of k-means with four clusters with labels. The platforms are divided into:

- cluster 1: VAALID.
- cluster 2: AmIVITAL, EKOSMART, INLIFE, OASIS, sensiNact, UNCAP, UNIVERSAL.
- cluster 3: ActivAgeR, FIWARE, Giraff+, InterIoTL, REACH, SOFIA2.
- cluster 4: AMIGO, BeyondSilos, PERSONA, SOPRANO.

It should be noted that there are only 15 dots visible in Figure 1 although there are 18 platforms. The reason is that 4 dots are overlapped one over another, and therefore are not seen in Figure 1 separately.

3.2 Hierarchical clustering

Hierarchical clustering also known as hierarchical cluster analysis, is an algorithm that groups similar objects into groups called clusters. The endpoint is a set of clusters, where each cluster is distinct from each other cluster, and the objects within each cluster are broadly similar to each other [1].

Hierarchical clustering starts by treating each observation as a separate cluster. Then, it repeatedly executes the following two steps: first, identify the two clusters that are closest together, and second, merge the two most similar clusters. This iterative process continues until all the clusters are merged together. The main output of hierarchical clustering is a dendrogram, which shows the hierarchical relationship between the clusters [1].

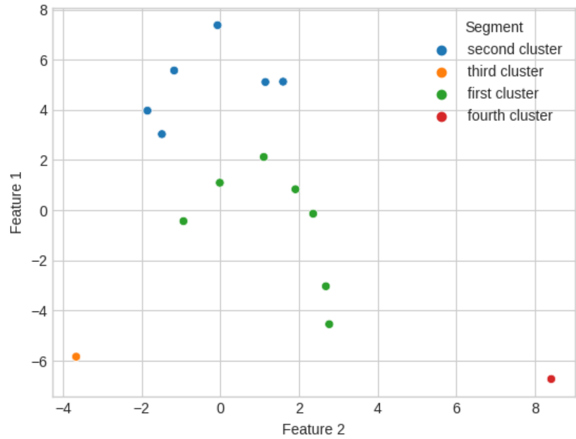

Figure 1: Result of k-means with four clusters.

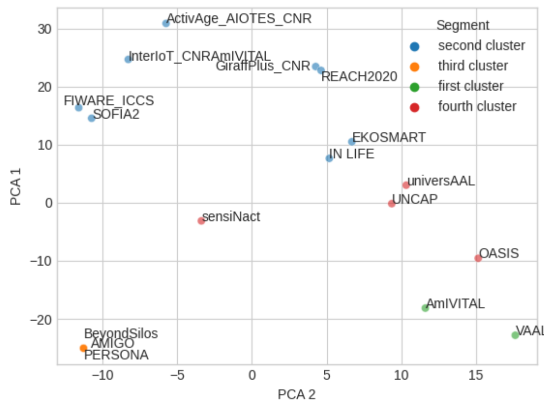

Figure 2: Result of k-means with four clusters with labels.

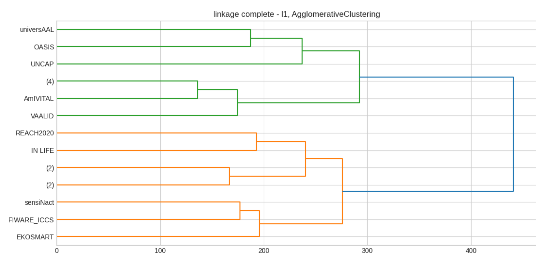

Figure 3: Result of hierarchical clustering.

We got the best result using complete linkage (linkage determines which distance to use between sets of observation).

Figure 3 shows the dendrogram for the hierarchical clustering. In general, closer and shorter lines present greater similarity. There are three clusters. One is green colored, one is orange colored and the combined one is blue colored.

3.3 Taxonomies

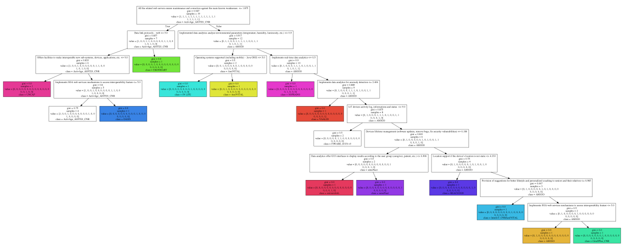

Figure 4: A decision tree of platforms for elderly.

According to Wikipedia [4], taxonomy is "the practice and science of categorization or classification based on discrete sets." It is a hierarchical classification, in which things are organized into groups or types. Many taxonomies are hierarchies in the form of a tree structure, but not all are. Creating taxonomies often corresponds to machine learning (ML) of a decision tree from input, where each leaf in a decision tree corresponds to a specific object, e.g. a specific plant species, or in our case – a taxonomy description. The input for the taxonomies generation in this section is the same as for the all other approaches in this text, e.g. clustering. There are Initially 61 features. Most of these features have values that can be easily converted into numeric values, e.g. "yes" gets converted to 10, "no" to 0, "partial" to 5. A part of features couldn't be directly converted into numbers – mainly features with string-type unordered values, e.g. "Any (web)", "Windows, mobile, Symbian", "Java". These features have been broken (hot encoding) into a bigger number of new features, e.g. "is web", "is Windows", "is mobile", "is Symbian", "is Java". After the transformations, there are 66 features.

Figure 4 represents the generated taxonomy on the platforms analyzed in the EU PlatformUptake project. It is a decision tree where most of the leafs correspond to only one platform. Starting from the root (the top of the decision tree), it contains all the platforms, hence all 1s in the "value" field. The set of all platform descriptions gets split into the left and the right node based on the feature/question "All the related web servers ensure maintenance and corrections against the main known weaknesses <= 1.875?". According to the question that was found the most relevant for this decision tree / taxonomy, the set of all taxonomies splits into two: (1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 0, 1, 0, 0) in the left subtree and (0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 0, 1, 1) in the right subtree. The procedure repeats until ideally there is just one platform left, i.e. all the other platforms do not correspond to the set of questions except the one. For example, the yellow leaf corresponds/represents to the "AmIVITAL" platform. It's parent node splits platforms looking at the feature named "Operating systems supported (including mobile) – Java OSGi". If the value is <= 5, it continues the graph over its left arrow; if the value is > 5, it continues the graph over its right arrow, in this case for a leaf "AmIVITAL". Therefore, the features (questions) leading to the yellow node, i.e. the AmIVITAL platform, are:

- All the related web servers ensure... <= 1.875
- Implemented data analytics analyze environmental ... <= 0.5
- Operating systems supported (including ... <= 0.5

In a similar way, all descriptions of the platforms can be obtained from the generated tree, best differentiating between them. The only exception is the second node from the left where it is not possible to distinguish between the three platforms. While the previous features lead to all three of them, the algorithm is not able to create further questions to differentiate between them, i.e. using additional features.

4 CONCLUSION AND DISCUSSION

We presented the EU PlatformUptake project for AHA solution assessment, its main objectives and its 18 platforms for elderly chosen because they allow elderly to live more healthy and more independently. We studied similarities and differences between the 18 platforms, and presented the results by two ways of clustering, and the taxonomies generated from the text descriptions of the EU PlatformUptake platforms. We conclude that the platforms can be clustered into similar categories and that an effective decision tree taxonomy can be created for the platforms. Clustering and structuring taxonomies for elderly in the proposed way enables an integrated understanding of the field of EU platforms for elderly.

In future work, deeper analysis of the clustering is required. With k-means it is possible to get better and more clear results with 6 or more clusters. It is feasible that hierarchical clustering could also yield more clusters which would be better for deeper analysis.

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What-If Analysis of Countermeasures Against COVID-19 in November 2020 in Slovenia

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ABSTRACT

Choosing best sets of countermeasures against COVID-19 is a difficult task, and it is often not clear whether the the countermeasures that were actually chosen were justified. In this paper we studied if the introduction of masks and school opening in the times of exponential growth in November 2020 in Slovenia were justified or not.

KEYWORDS

COVID-19, epidemiological models, multi-objective optimization, non-pharmaceutical interventions

1 INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an infectious disease that has rapidly spread across the world. Due to its high mortality rate [4], most countries deemed it too disruptive to let it run unchecked and have thus implemented countermeasures against it. The main type of countermeasures, in particular in the times when the vaccines were not yet available, were the *non-pharmaceutical interventions* (NPI) that include lockdowns, closure of schools and workplaces, and required mask usage. Due to the lack of precedent in the recent history, and several variables that influence the effect in a particular country, e.g. weather and cultural circumstances, it was and still is hard for decision-makers and domain experts to determine which NPIs to implement in a given epidemiological situation and what effect would a particular combination of NPIs have.

As we are now in the second year of the pandemic, large databases of data regarding the spread of the virus and implemented NPIs aimed at stopping it, became available. This in turn allows for the use of artificial intelligence (AI) methods to analyze the data, create predictive models, and consequently help the decision-makers in their task. It also enables reevaluation of the influence of particular NPIs at a particular time.

In our previous work [5] we built such an AI system, as part of the XPRIZE: Pandemic Response Challenge. At that competition, our system achieved second best results, and was significantly upgraded since that time.

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In the study reported here we used the improved version, specialized for Slovenia, to objectively answer a few what-if questions, such as whether school closure and mask usage were justified at a particular point in time, or were they an unnecessary burden.

These questions were posed to us by the Slovenian Ministry of Health. Namely, in August 2021 we sent the our XPRIZE system to all EU Ministries of Health with the motivation to help decision-makers better select NPIs. No ministry was able or eager to use the system itself so far, but we got some replies and requests for particular studies, such as the one tackled in this paper.

2 DATASET

Our system was trained on the data from 235 world regions between the dates of March 1, 2020 and April 14, 2021. While taking data from Slovenia only might result in a more localized model, this data does not provide the necessary range of implemented NPIs and their combinations.

The main source of data was the "COVID-19 Government response tracker" database, collected by the Blavatnik School of Government at Oxford University [2], that defines which (and in what time interval) NPIs were implemented in each country. The NPIs in this database are listed in Table 1. The database also provides the strictness of the implementations in the form of numbers, e.g., "Workplace closing – 1" represents that government only suggests closure, while "Workplace closing – 3" strictly demands it. The detailed description for each level of strictness is provided by the database authors [2].

Other key data needed for training the system are the numbers of infections and deaths, obtained from the same database. In addition we used data on weather, mobility, hospitalizations, vaccination and 93 features based on country characteristics (e.g., culture, development) from our previous work [3].

3 METHODS

The results in this work were made using an upgraded version of our XPRIZE system that can predict the number of infections given the active NPIs, and propose best NPIs to counter them.

The whole system is thoroughly described in our previous work [5]. Here, a quick overview is provided. The system first uses historical data of all regions to create a model that predicts COVID-19 infections given a set of NPIs. A SEIR epidemiological model is used for this purpose, combined with a machine-learning model that predicts the SEIR models's parameters as a function of NPIs. This model is used to predict the infections resulting

Table 1: The NPIs used in our study, and the range of values representing their strictness.

NPI	Value range
C1: School closing	[0-3]
C2: Workplace closing	[0-3]
C3: Cancel public events	[0-2]
C4: Restrictions on gatherings	[0-4]
C5: Close public transport	[0-2]
C6: Stay at home requirements	[0-3]
C7: Restrictions on internal movement	[0-2]
C8: International travel controls	[0-4]
H1: Public information campaigns	[0-2]
H2: Testing policy	[0-3]
H3: Contact tracing	[0-2]
H6: Facial Coverings outside the home	[0-4]

from a sequence of NPIs (referred to as "intervention plan") – its benefit.

The system also estimates the cost of each intervention plan. Calculating costs of NPIs is a complex issue that will be discussed in a forthcoming paper. In brief, they consist of economic costs (due to disruption of business and similar), for which some sources are available in the literature [6, 1], and social costs (due to isolation, restriction of freedom and similar). The cost of each plan is traded off against its benefit, as stricter plans results in fewer infections, but are costlier. Finally, the system uses multi-objective optimization to find intervention plans with good trade-off between benefits and costs.

The two major improvements of the system for the purpose of this paper are: 1) the added possibility to set a constraint on the maximal number of infections allowed – no plan exceeding this constraint is generated and 2) the added possibility to limit the strictness of any individual NPI. This two changes allowed us to analyze the what-if scenarios of what would happen if a certain NPI were not implemented, and what plans can we implement to have a similar number of infections, but not the undesired NPI.

The plans presented in this paper were evaluated using only their economic component (estimated GDP loss [in %] for that month), but not with the social one. While we repeated all the experiments using social costs, the results were similar, and the social costs we used are less objective than the economic ones.

4 RESULTS

All the predictions were made for the time interval 30. 10. 2020 – 30. 11. 2020, for Slovenia. That time interval was chosen because of the high number of infections observed and strict countermeasures imposed.

In the first experiment, we tested what would have happened if masks were not worn in closed spaces, and all other NPIs would remain the same as the actually implemented. The results are shown in Figure 1. They indicate an increase of infections, which was expected considering that we are simulating lowering the countermeasures during the epidemic peak, and no other NPI was simulated instead of masks.

A similar experiment was made for the hypothetical case where schools fully re-opened for a month. The results (Figure 2) show that the number of infections would grow even faster. This happens due to the exponential nature of the epidemiological model, encapsulating the actual nature of the virus infection in favorable conditions. Obviously, this reduction in strictness

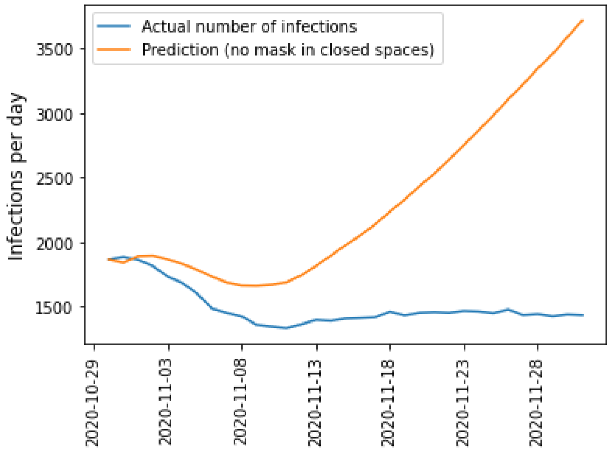

Figure 1: A comparison of actual number of daily infections, with predicted number of infections for the hypothetical case where masks were not used.

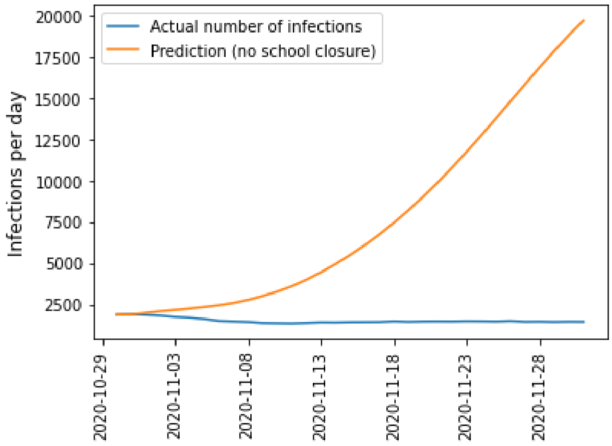

Figure 2: A comparison of actual number of daily infections, with predicted number of infections for the hypothetical case where schools were re-opened.

greatly changes the reproduction rate and consequently leads to the exponential growth.

Such fast growth as was predicted in these to experiments is probably too pessimistic, as in reality in the case that the number of infections were starting to grow so alarmingly, the population's behavior would likely become more cautious – counterbalancing the growth. Nonetheless, the model indicates that the school closure is a major contributor to regulating COVID-19, even more important than the masks. Please note that scale of the y axis differs between Figures 1 and 2.

The two described experiments show that removing an NPI from the implemented intervention plan will likely result in substantial growth, which decision-makers would not allow. Therefore, we attempted to compensate for the missing NPIs with other NPIs to prevent the exponential growth.

We used multi-objective optimization to show the best plans one can make given the restriction that a certain NPI cannot be used, at least not with a strictness exceeding a given threshold. These plans were compared based on the predicted infections

Table 2: The weekly strictness of selected intervention plans. The letters identify the plan on the Pareto front approximations in Figures 3 and 4. Strictness 0044 would indicate that the lowest strictness is used for the first two weeks, and highest for the last two ones.

NPI	a	b	c	d	e	f	g	h	i
C1: School closing	3333	3333	3333	2222	2222	1111	1111	3333	3333
C2: Workplace closing	2222	0000	2000	1000	3000	3002	3301	0000	3000
C3: Cancel public events	2222	2222	2222	2222	2222	2222	2222	2222	2222
C4: Restrictions on gatherings	4444	4444	4442	4444	4444	4444	4444	4444	4444
C5: Close public transport	0022	2222	2222	2222	2222	2222	2222	2222	2222
C6: Stay at home requirements	2222	0010	1100	1111	1110	1111	1111	1100	3110
C7: Restrictions on internal movement	2222	0000	1000	1000	2000	2011	2210	0000	2200
C8: International travel controls	2222	4343	4443	4444	4444	4444	4444	4444	4444
H1: Public information campaigns	2222	2222	2222	2222	2222	2222	2222	2222	2222
H2: Testing policy	2222	3333	3333	3333	3333	3333	3333	3333	3333
H3: Contact tracing	1111	2222	2222	2222	2222	2222	2222	2222	2222
H6: Facial coverings outside the home	4444	4444	4444	4444	4444	4444	4444	0000	0000

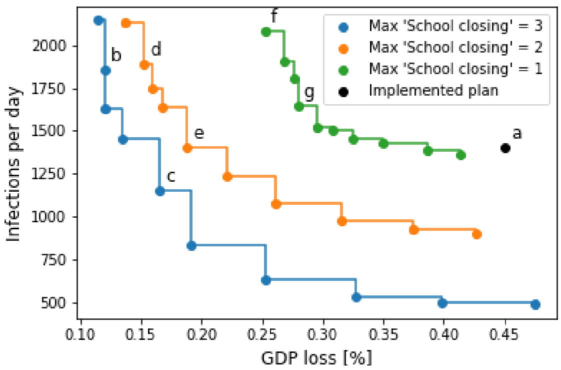

Figure 3: Proposed intervention plans using different restrictions on the value of "School closing". They were evaluated based on the predicted number of infections and estimated GDP loss. The marked plans are explained in Table 2.

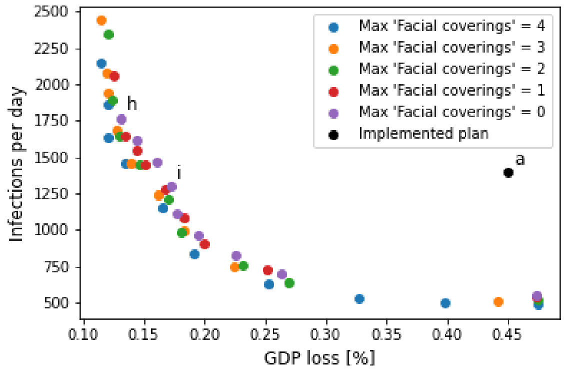

Figure 4: Proposed intervention plans generated using different restrictions on the value of "Facial covering". They were evaluated based on the predicted number of infections and estimated GDP loss. The marked plans are explained in Table 2.

and predicted GDP loss for that month. The resulting Pareto-front approximations for school closure with different levels of strictness are shown in Figure 3.

The blue line in Figure 3 represents the case with no limitations when constructing an intervention plan, and obviously these solutions are substantially better than the intervention plan actually implemented, and the plans with limitations. The orange and green lines represent plans that have schools partially or fully open. These plans are visibly worse in terms of the two desired objectives: this happens because the system is compensating for the lack of "School closing" NPI with "Workplace closing" NPI, which is more expensive. A sample of the generated plans is given in Table 2.

This experiment was repeated, this time restricting the strictness of the "Facial Coverings" NPI. The results are shown in Figure 4 and sample plans are given in Table 2.

For the mask analysis, the system found comparable solutions that compensate for the reduced "Facial Coverings" NPI. While this NPI has a good ratio between benefit and economic cost, its benefit in absolute terms is nevertheless smaller than of the "School closing" NPI, so it is easier to replace by increasing other NPIs.

5 DISCUSSION AND CONCLUSIONS

In this study we analyzed what-if scenarios in regards to reduced wearing of masks and school re-openings for Slovenia at peak infection time in November 2020. The study showed that both of these changes would worsen the epidemiological situation in the country if no other NPI was introduced instead. Furthermore, for school closure the AI model could not find proper replacement in that situation, suggesting that school closure was justified. The closest viable solution was "Solution *e*" that proposes only partial school closing, but compensates it with increased testing and international travel control. On the other hand, the model indicated that mask usage could be almost completely compensated with an increase of other NPIs. It cannot judge whether this is desirable – that may depend on social costs.

The study has a number of limitations:

(1) The study was done using historic data for Slovenia, while the AI system was trained on data from all regions and was only somewhat tuned to Slovenia.

(2) The data and the resulting model do not contain the information on vaccination, as it was not available in the tested period.
(3) The data and the resulting model do not contain the information on the Delta or newer variants, as it was not available in the tested period.
(4) The model does not predict what would happen with a different implementation of the NPI (e.g., stricter testing of students/teachers).
(5) The study uses costs available from the literature and might not fit best Slovenian specifics.
(6) The study does not use social costs, which are certainly important but difficult to set in a justifiable manner.

Because of these limitations, it is not recommended that this study be used as a basis for future policies. For such purpose, we strongly recommend performing new experiments tailored to the problem we try to address.

Comparing best AI-proposed measures with the actual ones by humans reveals a well-known phenomenon that humans cannot on their own consider all possibilities and propose best actions. Although demonstrated only on a couple of cases here, in our opinion that is a fairly general conclusion valid not only for COVID-19 NPIs. In most cases it should still be the human's role to make final decisions, but humans should take advantage of AI assistance when possible.

In summary, school closing and masks in general represent important NPIs, and the decision to use them in peak infection cases when vaccinations are not available or sufficient, seems reasonable. However, unlike the school closing, the masks can be replaced with other NPIs. Furthermore, vaccinations in particular render NPIs less important – if no new variant of COVID-19 appears.

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Effectiveness of non-pharmaceutical interventions in handling the COVID-19 pandemic: review of related studies

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ABSTRACT

In this paper, we analyse 30 articles on studies that focus on assessing the effectiveness of different non-pharmaceutical interventions (NPIs) to flatten the pandemic curve. The articles reviewed use different methods, data sources, and metrics for NPI effectiveness. They also analyse different regions in different time periods. Here, we rank the interventions from each article using a consistent scoring system. This allows us to rank and compare the effectiveness of each NPI.

We conclude that school closure, workplace closure and restrictions on gatherings are the most effective interventions. Public events cancellation and public information campaigns also appear to have a significant impact. Stay at home requirements, facial coverings, restrictions on internal movement and international travel controls have a moderate effect. The least effective NPIs across all studies were found to be public transport closure, testing policy and contact tracing.

KEYWORDS

Non-pharmaceutical interventions, COVID-19, SARS-CoV-2

1 INTRODUCTION

The COVID-19 pandemic has forced governments around the globe to implement several non-pharmaceutical interventions (NPIs). Researchers have studied the effectiveness of such interventions to help governments make more informed decisions in dealing with the crisis.

The aim of this review is to summarize and compare the findings and methods of several articles on the impact of NPIs on COVID -19 and to determine which interventions are best suited to improve the epidemiological situation.

2 METHODOLOGY

2.1 Selection of articles

For this review, we searched for articles that focused on assessing the effectiveness of NPIs in dealing with the ongoing COVID -19 pandemic. To be included here, articles had to include comparisons of at least two interventions so that each could be ranked from most to least effective. Important works on the spread of COVID -19 that do not include a comparison of different NPIs (e.g., Chang, S. et al. [5]) are therefore not included in this review.

Effectiveness of the following NPIs from the Oxford COVID-19 Government Response Tracker (OxCGRT) [14] was assessed: school closure, workplace closure, public events cancellation, restrictions on gatherings, public transport closure, stay at home requirements, restrictions on internal movement, international travel controls, public information campaigns, testing policy, contact tracing and facial coverings. The 12 NPIs listed were chosen because they are independent of each other and cover all radical government interventions used worldwide. For example, curfew is included in the stay at home requirements.

The articles included in this review, the corresponding NPI data sources, the countries included, and the time frame in which the effectiveness of the interventions was assessed can be seen in Table 1.

2.2 Articles not based on OxCGRT data

In articles on studies that obtained NPI data from other sources, intervention policies were checked for compatibility with OxCGRT descriptions wherever possible, using documentation from the individual NPI databases or descriptions provided by the authors (in studies where data collection was conducted by the authors themselves).

In this review, some interventions from the article by Haug et al. [15] were merged into those specified by OxCGRT, with the effectiveness of the merged NPI defined as the maximum effectiveness of the nonmerged ones. In this way, both small and mass gathering cancellations were merged into restrictions on gatherings. Border restriction, travel alert and warning were merged into international travel controls.

Some interventions have been reassigned to the appropriate OxCGRT definitions. Educate and actively communicate with the public was transformed into public information campaigns, enhance detection system into testing policy, and national lockdown into stay at home requirements.

The study by Bo et al. [3] analysed the impacts of four intervention categories, namely traffic restriction, social distancing, mandatory wearing of a face mask in public, and isolation or quarantine. Most of these interventions are a combination of several OxCGRT interventions, so their effectiveness score was assigned to all the NPIs that comprise them. The score of traffic restriction was assigned to restrictions on internal movement and international travel controls, and the social distancing to school closing, public events cancellation, and restriction on gatherings. Mandatory face masks in public was assigned to facial coverings and isolation or quarantine to stay at home orders.

Banholzer et al. [2] estimated the effectiveness of seven NPIs. They treated bans on small and large gatherings as two seperate interventions, so they were merged here into restrictions on gatherings. Venue closure and work-from-home order were merged into workplace closure based on the fact that the authors described venue closure as "closure of some or all non-essential businesses". Their border closure intervention was treated as international travel controls in this review.

In other articles that included the non-essential business closing intervention it was treated as OxCGRT's workplace closure.

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Table 1: Articles included in this review

Authors	Published in	NPI data source	Countries included
Askitas et al. [1]	Nature	OxCGRT	175 countries
Banholzer et al. [2]	Plos One	Collected by the authors	USA, Canada, Australia and 17 EU countries
Bo et al. [3]	ScienceDirect	Collected by the authors	190 countries
Brauner et al. [4]	Science	Collected by the authors	41 countries (of which 34 are European)
Chaudhry et al. [6]	The Lancet	Collected by the authors	50 countries
Chernozhukov et al. [7]	ScienceDirect	Covid Tracking Project	USA
Courtemanche et al. [8]	Health Affairs	John Hopkins University	3138 US counties
Deb et al. [9]	SSRN	OxCGRT	129 countries
Dreher et al. [10]	ScienceDirect	unclear	USA
Ebrahim et al. [11]	JMIR	Hikma Health	1320 US counties
Esra et al. [12]	medRxiv	WHO-PHSM	26 countries and 34 US states
Haug et al. [15]	Nature	CCCSL	56 countries, 79 territories
Hunter et al. [16]	medRxiv	IHME	30 European countries
Islam et al. [17]	BMJ	OxCGRT	149 countries
Jalali et al. [18]	medRxiv	Collected by the authors	30 most populous US counties
Jüni et al. [19]	CMAJ	Collected by the authors	144 worldwide geopolitical regions
Koh et al. [20]	ScienceDirect	OxCGRT	170 countries
Leffler et al. [21]	AJTMH	OxCGRT	200 countries
Li et al. (a) [22]	The Lancet	OxCGRT	131 countries
Li et al. (b) [23]	MDPI	NSF spatiotemporal center	USA
Liu et al. [24]	BMC Medicine	OxCGRT	130 countries and territories
Olney et al. [26]	American Journal of Epidemiology	Collected by the authors	USA
Papadopoulos et al. [27]	medRxiv	OxCGRT	151 countries
Piovani et al. [28]	ScienceDirect	OxCGRT	37 members of OECF
Pozo-Martin et al. [29]	Springer Link	OxCGRT and WHO-PHSM	37 members of OECD
Sharma et al. [30]	medRxiv	Collected by the authors	114 subnational areas in 7 European countries
Stokes et al. [32]	medRxiv	OxCGRT	130 countries
Wibbens et al. [33]	Plos One	OxCGRT	40 countries and US states
Wong et al. [34]	Journal of Infection	OxCGRT	139 countries
Zhang et al. [35]	MDPI	NY Times and CNN	USA

National lockdown was mapped to stay at home requirements. Some studies measured the effectiveness of bans on small and mass gatherings separately. Their results were combined into a single intervention - restrictions on gatherings.

2.3 Ranking effectiveness of NPIs

Different studies estimated the individual impacts of implementing interventions in different ways. We used a simplified ranking system by assigning values between 1 and 4 to the NPIs, with 1 representing the most effective and 4 the least effective interventions. Several interventions from individual studies could have been assigned the same value.

In the articles where the authors have already quantitatively estimated the impacts of individual NPIs, their results have simply been converted to new values, as described above.

Askitas et al. [1] graded interventions only descriptively. They found that the most effective interventions in reducing the spread of COVID-19 were restrictions on gatherings, public events cancellation, school closure and workplace closure, so they were assigned a value of 1. Stay at home requirements were estimated to have a smaller effect after a longer period of time and we graded its effectiveness as 2. International travel controls NPI was less effective. Restrictions on internal movement and public transport closures had a negligible impact.

In the study by Liu et al. [24], the effectiveness of NPIs was measured in two scenarios: maximum effort (i.e., the NPIs are at their maximum intensity) and any effort (i.e., the NPIs are active at any intensity). They described interventions as either strong, moderate, or weak in each of the scenarios. Their results were adapted to the simplified ranking system by assigning a value of 1 to NPIs strong in either both scenarios or in any effort scenario. NPIs that are strong only at maximum effort were graded 2, moderate NPIs were ranked as 3 regardless of the scenario and weak NPIs were ranked as 4.

In the article written by Li et al. (a) [22], the impact of NPIs was estimated 7 days, 14 days and 28 days after its implementation as the ratio between the reproduction number (R) at a given time point (after 7, 14 or 28 days) and the initial R. We simplified this by calculating the average between all three ratios for each NPI and ranking them with values between 1 to 4.

Wibbens et al. [33] estimated the effectiveness of 11 NPIs at different levels of intensity. They were first ranked at their highest intensity and then at an intermediate intensity. Our metric with values between 1 and 4 was then applied based on the average of high and intermediate intensity rankings.

2.4 Comparison with a similar article

While looking for studies to include in this review we found a similar article by Mendez-Brito et al. [25]. Their review included 34 articles on the subject of NPI effectiveness. Here, some of these articles were excluded, most of them because they only found conclusive evidence for the effectiveness of a single intervention policy. Furthermore, the study conducted by Flaxman et al. [13] is also not included in this review because Soltesz et al. [31] proved that the model used was too sensitive to subtle and realistic alterations in parameter values.

Two additional articles were included in this review [1][30]. However, all other studies included in our paper were already reviewed in the review by Mendez-Brito et al. [25]. Despite that, there are a few differences between our findings and theirs. Slight differences occur in grading effectiveness of NPIs from different studies, most likely because many studies did not present a ranking system and so our interpretation of their results might be different than that of Mendez-Brito et al.

There are some articles that do not compare impacts of different intervention policies, but rather only qualitatively mark them as effective in reducing the COVID-19 incidence. The NPIs assessed in those studies were all graded with the same grade by Mendez-Brito et al. They treated those interventions as the least effective according to their scale. Since such NPIs were only found to be effective but it was not determined how effective they were, we could not confidently grade them as the most effective interventions, but their impact likewise could not be treated as negligible. That is why they are marked here as moderately effective, i.e., they are graded with a 2.

3 RESULTS

3.1 Assessed regions and time frames

The reviewed studies assessed the impact of COVID-19 intervention policies in different time frames. Most studies only analysed the first epidemiological wave. Only Sharma et al. [30] focused on estimating effectiveness of NPIs during the second wave. Wibbens et al. [33] analysed a longer time frame - from March to November 2020. Pozo-Martin et al. [29] analysed both waves independently, but the estimates of NPI effectiveness during the second wave were not as statistically significant. Zhang et al. [35] also analysed a longer period including both waves.

The majority of studies (19 out of 30) analysed only country-level data. Two studies [29][28] used data only on countries that are members of the Organisation for Economic Co-operation and Development (OECD). The works [11][26][8][23][18][35][7][10] analysed impacts of NPIs in the United States, either state-level or county-level. The only more detailed analysis for Europe was done by Sharma et al. [30], who analysed 114 subnational areas in 7 European countries.

3.2 Metrics used in studies

The studies in this review used different metrics to evaluate the impacts of the interventions. 10 studies analysed how individual NPIs affect the reproduction number [3][4][10][12][15][20][22][24][26][30]. 8 studies estimated the effectiveness of NPIs based on case incidence or case growth rates [1][2][8][11][19][29][33][35]. 4 articles [6][21][28][32] focused only on mortality caused by COVID-19 and 5 articles [7][9][18][23][27] analysed the impact on both cases and deaths.

3.3 NPI effectiveness estimations

Some intervention policies were included in more studies than others. The ones that were included in most of the studies reviewed are school closure (conclusively assessed in 22 studies), workplace closure (in 22 studies), restrictions on gatherings (in 18 studies), and stay at home requirements (in 20 studies). The distribution of estimated effectiveness of these NPIs across included articles is shown in Figure 1. Contact tracing was only analysed in two articles [33][24] and testing policy in four articles [15][24][29][33].

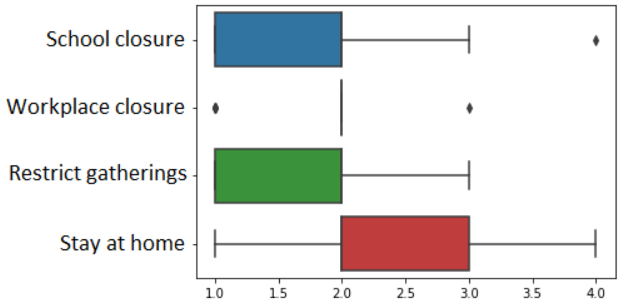

Figure 1: Distribution of effectiveness values for the most frequently represented NPIs (lower values stands for better effectiveness

The impacts of NPIs in the included studies are shown in Figure 3. Blank cells indicate that the intervention was either not included in the corresponding study or that the estimates of its effectiveness were inconclusive. Cells are also color coded according to the strength of the interventions in the corresponding articles. A darker shade indicates that the NPI is more effective. The average effectiveness, median effectiveness and the most frequent value were calculated for each NPI across all articles and are presented in Figure 2 along with inormation on how many articles conclusively assessed each NPI and the standard deviation for each NPI.

4 CONCLUSION

Studies estimating the effectiveness of COVID-19 interventions used different approaches. They analysed data from different regions and in different time frames. They did not use the same models to analyse the data or the same metrics to determine the effects different interventions had on the pandemic. Nonetheless, their findings were often agreed with each other.

The most effective interventions across the reviewed studies were school closure, workplace closure and restrictions on gatherings. School closure was estimated to be among the most effective intervention policies in 9 studies (41% of studies in which it was assessed), workplace closure in 5 (23%) studies, and restrictions on gatherings in 8 (44%) studies. Public events cancellation was also found to be one of the most effective measures in 3 (33%) out of 9 studies. Interestingly, public information campaigns appear to be as effective as cancellation of public events.

Stay at home requirements was also estimated to have a considerable impact, but the interventions mentioned above were found to be even more effective. This could be because the stay at home requirements NPI was often implemented as a last resort

	Mean	Median	Mode	Counts	Std dev
School closure	1.8	2.0	1	22	0.85
Workplace closure	1.8	2.0	2	22	0.50
Public events cancellation	2.0	2.0	2	9	1.00
Restrictions on gatherings	1.8	2.0	1	18	0.81
Public transport closure	3.6	4.0	4	7	1.13
Stay at home requirements	2.3	2.0	3	20	0.86
Restrictions on internal movement	2.6	3.0	3	9	1.13
International travel controls	2.8	3.0	3	13	0.90
Public information campaigns	2.0	2.0	2	6	0.89
Testing policy	3.8	4.0	4	4	0.50
Contact tracing	4.0	4.0	4	2	0.00
Facial coverings	2.5	2.0	2	8	0.76

Figure 2: Averaged effectiveness, median effectiveness and most frequent value (Mode) of each NPI across studies (lower value stands for better effectiveness) along with the number of studies that assessed each NPI (Counts) and standard deviations (Std dev).

in addition to many other interventions and its isolated effect might only be what it adds on top of those.

Facial coverings, restrictions on internal movement and international travel controls were generally associated with having a moderate effect on flattening the epidemic curve. The least effective NPIs were consistently found to be public transport closure, testing policy and contact tracing.

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	Interventions											
	School closure	Workplace closure	Public events cancellation	Restrictions on gatherings	Public transport closure	Stay at home requirements	Restrictions on internal movement	International travel controls	Public information campaigns	Testing policy	Contact tracing	Facial coverings
Askitas et al.	1	1	1	1	4	2	4	3				
Banholzer et al.	2	2		1		4		3				
Bo et al.	1		1	1		3	4	4				2
Brauner et al.	1	2		1		3						
Chaudhry et al.		2		2		2		3				
Chernozhukov et al.		2				2						2
Deb et al.	1	2	2	2	1	1	2	1				
Dreher et al.	2	2				1						
Ebrahim et al.		2				3						
Esra et al.		3	3			1						2
Haug et al.	1			1	4	3	3	2	2	3		
Hunter et al.	1	2		3								
Islam et al.	2	2		1	4	3	3					
Jalali et al.	2											2
Jüni et al.	2	2		2								
Koh et al.		1				2	2	3				
Leffler et al.	2		2					2				2
Li et al. (a)	1	2	1	3	4	2	3	4				
Li et al. (b)		2	2			3			1			
Liu et al.	1	1	2	2	4	3	1	4	3	4	4	
Olney et al.	2			1		1						
Papadopoulos et al.	2	2						2	2			
Piovani et al.	3			2								
Pozo-Martin et al.	3	2		1						4		4
Sharma et al.	4	1		2		3						3
Stokes et al.	1	2		3				3				
Wibbens et al.	2	1	4	3	4	2	1	3	3	4	4	
Wong et al.	3	2							1			
Zhang et al.						2						3

Figure 3: Estimated effectiveness of each NPI in different studies (lower value stands for better effectiveness)

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Napovedovanje trendov in optimiziranje ukrepov v boju proti pandemiji COVID-19: Tekmovanje XPRIZE in naslednji koraki

Forecasting trends and optimizing the intervention plans against the COVID-19 pandemic: The XPRIZE competition and beyond

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POVZETEK

V tem preglednem prispevku predstavimo delo, ki smo ga sodelavci Odseka za inteligentne sisteme opravili v zadnjem letu v povezavi s pandemijo COVID-19. Raziskave modelov, ki predvidevajo prenos okužb v lokalnem okolju in na podlagi tega predlagajo ukrepe za boj proti epidemiji, so najprej potekale v okviru mednarodnega tekmovanja $500k Pandemic Response Challenge, v organizaciji fundacije XPRIZE in podjetja Cognizant. Na tekmovanju se je ekipa JSI vs COVID uvrstila na drugo mesto. V nadaljevanju so potekale raziskave v povezavi z Ministrstvom za zdravje RS, da bi ugotovitve in modele lahko v boju proti pandemiji uporabili tudi v praksi.

KLJUČNE BESEDE

COVID-19, epidemiološki modeli, nefarmacevtski ukrepi, večkriterijska optimizacija

ABSTRACT

We present an overview of the work that was carried out by the members of the Department of Intelligent Systems in the last year, related to the COVID-19 pandemic. We were studying the models that forecast the spread of infection in local environment and tried to suggest the countermeasures based on the trends. The research first took place within the $500k Pandemic Response Challenge, organized by the XPRIZE fundation and the company Cognizant. The JSI vs COVID team won the second place in the competition. In the following months, the research focused on the applicability of the results in practive, in collaboration with the Ministry of Health.

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KEYWORDS

COVID-19, epidemiological models, nonpharmaceutical interventions, multi-objective optimization

1 UVOD

Ko se danes ozremo na prve mesece leta 2020, je jasno, da je pandemija COVID-19 zahodni svet ujela nepripravljen. Ker je šlo za nov virus, se najprej ni vedelo, kako kužen je, kako hitro se širi, predvsem pa kako se pred njim zaščititi in kako preprečiti obremenitev bolnišnic in visoka števila težko bolnih in mrtvih. Zelo hitro se je namreč pokazalo, da v primerjavi z nekaterimi drugimi respiratornimi obolenji več obolelih potrebuje bolnišnično oskrbo, nekateri tudi obravnavo na intenzivni negi in pomoč medicinskega ventilatorja. Zdravniki so poleg tega potrebovali več mesecev, da so ugotovili, kako najučinkoviteje zdraviti paciente s COVID-19. Pomembno je bilo tudi podcenjevanje nevarnosti, ker se je pričakovalo, da bo možno s sledenjem okuženih, ki so npr. prileteli z avionom, zajeziti vdor virusa v državo. Ker je virus sposoben prenašanja tudi preko na videz zdravih ljudi, ta ukrep ni bil sposoben zajeziti vdora oz. blokirati pri majhnem številu okuženih.

Med različnimi pristopi v boju proti širjenju okužb se je zelo hitro uveljavil pristop »lockdowna«, praktično popolnega zaprtja družbe. Ta pristop so najprej uporabili na Kitajskem, v mestu Wuhan, kjer so najprej zasledili virus, v Evropi so prvi začeli z zapiranjem v Italiji, februarja, najprej v posameznih občinah na severu države, kasneje po celotni državi. V Sloveniji so bili prvi primeri virusa zaznani v začetku marca, sredi marca pa je prišlo do zaprtja države. Časovni potek prvih mesecev pandemije je opisan v [1].

Kmalu se je pokazalo, da popolno zaprtje družbe sicer precej učinkovito omeji širjenje okužb, ni pa učinkovito na dolgi rok, saj je izredno drago za državo in prebivalce tako z ekonomskega kot tudi z družbenega vidika. Raziskovalci so zato začeli preučevati kombinacije ukrepov, ki bi po eni strani učinkovito omejili širjenje okužb, po drugi strani pa bi čim manj prizadeli gospodarstvo in državljane. Takih sistemskih rešitev, npr. programov, ob pojavu virusa COVID-19 še ni bilo.

Iskanje učinkovitih kombinacij ukrepov, ki hkrati ne bi prizadeli družbe, je bilo tudi vodilo tekmovanja $500k Pandemic Response Challenge, v organizaciji fundacije XPRIZE in podjetja Cognizant, ki je bilo organizirano konec leta 2020. Na tekmovanje se je prijavila tudi ekipa JSI vs COVID, ki prihaja iz Odseka za inteligentne sisteme IJS, in na koncu osvojila drugo mesto. V pričujočem prispevku najprej predstavimo tekmovanje, nato skiciramo rešitev, ki jo je razvila ekipa JSI vs COVID, na koncu pa orišemo nadaljnje raziskave, ki so potekale v povezavi z Ministrstvom za zdravje Republike Slovenije. Opisana je tudi ponudba evropskim ministrstvom za zdravje za brezplačno uporabo sistema JSI vs COVID.

2 TEKMOVANJE PANDEMIC RESPONSE CHALLENGE

Tekmovanje $500k Pandemic Response Challenge [2] je potekalo med oktobrom 2020 (registracija udeležencev) in februarjem 2021 (razglasitev zmagovalcev). Naloga, ki so jo dobili udeleženci, je bila razviti modele, ki bodo po eni strani čim natančneje predvideli lokalne izbruhe okužb (»prediktor«), po drugi strani pa predlagati čim učinkovitejši načrt ukrepov, tako da se hkrati minimizira število okužb ter ekonomsko škodo (»preskriptor«). Beseda ukrepi se v tem primeru nanaša na nefarmacevtske ukrepe (angleško non-pharmaceutical interventions, NPI), ki jih nekoliko podrobneje opišemo v nadaljevanju. Število sodelujočih ekip je bilo omejeno na 200.

V prvi fazi tekmovanja so se ekipe osredotočile na analizo obstoječih podatkov in strategij boja proti pandemiji v različnih državah. Cilj je bil razviti in ovrednotiti napovedne modele za razvoj pandemije. Pri tem so imele ekipe na razpolago zbirko podatkov o pandemiji za vrsto držav z Univerze v Oxfordu (Oxford COVID-19 Government Response Tracker (OxCGRT) [3]), vključno z ukrepi, ki so bili v državah veljavni v različnih obdobjih, ter vzorce temeljnih prediktorjev in preskriptorjev podjetja Cognizant, Evolutionary AI™.

Prediktorji, ki so jih ekipe razvile, so se nato uporabljali za napovedovanje, napovedi pa so se primerjale z razvojem pandemije v realnem svetu. Ta primerjava je bila osnova za uvrstitev v prvi fazi. Pomembno je poudariti, da so vse ekipe dobile na voljo natanko iste podatke in bile ocenjevane po enakih kriterijih.

Prva faza tekmovanja se je zaključila januarja 2021 z merjenjem dejanskih infekcij. V drugo fazo se je uvrstilo 48 najbolje uvrščenih ekip, ki so prihajale iz 17 držav. V drugi fazi tekmovanja je bil cilj razvoj preskriptorjev. V tem delu seveda ni bilo mogoče testirati v praksi, zato je testiranje potekalo na sledeči način: za predikcije se je uporabljal »standardni prediktor«, ki so ga razvili organizatorji [4]. Vsaka ekipa je predlagala do deset strategij intervencije za vsako državo. Pri ocenjevanju se je upoštevalo, da je ena strategija od druge boljša, če je boljša po enem kriteriju, ne pa hkrati tudi slabša po drugem (kriterija sta tu omejevanje širjenja okužb in cena ukrepov).

Druga faza se je končala marca 2021, ko so bili razglašeni zmagovalci [5]. Prvo mesto je osvojila španska ekipa VALENCIA IA4COVID19 iz Valencie, drugo mesto pa slovenska ekipa JSI vs COVID z zelo podobnim numeričnim rezultatom. Ekipi sta si enakovredno razdelili nagradni sklad pol milijona dolarjev. Še osem ekip je prejelo posebna priznanja in simbolične nagrade.

3 NEFARMACEVTSKI UKREPI

V okviru tekmovanja so ekipe dobile predpisan seznam NPI, ki so ga uporabile za gradnjo preskriptorja, hkrati pa so za vsak ukrep dobile tudi »ceno« uveljavljanja tega ukrepa. Seznam je vseboval sledeče NPI:

1. Zapiranje šol
2. Omejitev prihoda na delo
3. Preklic javnih dogodkov
4. Omejitve zbiranja
5. Omejitev javnega prometa
6. Omejitev izhodov od doma
7. Omejitve gibanja po državi
8. Omejitve gibanja med državami
9. Kampanja osveščanja javnosti
10. Strategija testiranja
11. Sledenje stikov
12. Uporaba zaščitnih mask

Ukrepi so se lahko izvajali v strožji ali v milejši obliki. Ukrep »Omejitve gibanje po državi« v strožji različici tako prepove gibanje izven določenega območja, v milejši pa ga samo odsvetuje, »Omejitve zbiranja« pa z naraščanjem strogosti zmanjšuje število ljudi, ki se lahko zbira. Seveda se je pri ukrepih potrebno zavedati, da se jih ljudje lahko držijo ali ne, in od posamezne države je odvisno, kako strogo bo preverjala spoštovanje ukrepov – pa tudi od tega, kako so ukrepi predstavljeni javnosti in kako jih ljudje sprejmejo.

4 MODELI

Modeli prediktorjev in preskriptorjev so oz. bodo podrobneje opisani v konferenčnem prispevku [6] in v prihajajočih publikacijah, zato tu le skiciramo rešitve.

4.1 Prediktor

Cilj prediktorja je napovedati število okužb na določenem območju (v državi ali v regiji) za vsak dan, za obdobje več mesecev v prihodnost. Pri tem upoštevamo seznam NPI, ki so v državi v danem trenutku v veljavi.

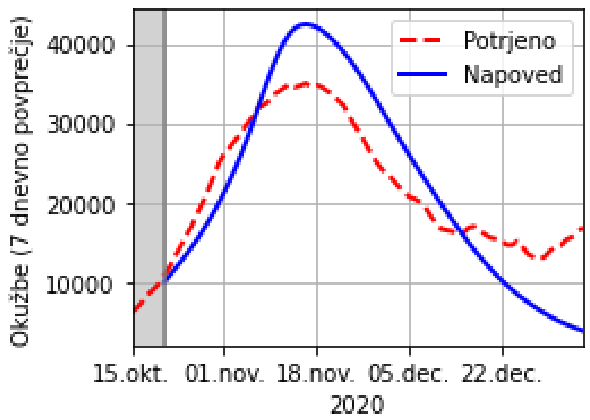
Prediktor uporablja standardni epidemiološki model SEIR, kjer upoštevamo dinamiko med skupinami posameznikov, ki so Susceptible (dovzetni), Exposed (izpostavljeni), Infected (okuženi) in Removed (ozdraveli ali umrli, se pravi niso več dovzetni za okužbo). Model SEIR [7] je sestavljen iz sklopljenih diferencialnih enačb (1), kjer uporabljamo parametre, ki določajo verjetnosti za prehode iz ene skupine v drugo: $S \rightarrow \beta \rightarrow E \rightarrow \sigma \rightarrow I \rightarrow \gamma \rightarrow R$.

$$\begin{aligned} \frac{dS}{dT} &= -\frac{\beta SI}{N} \\ \frac{dE}{dt} &= \frac{\beta SI}{N} - \sigma E \\ \frac{dI}{dt} &= \sigma E - \gamma I \end{aligned} \quad (1)$$

$$\frac{dR}{dt} = \gamma I$$

Pri tem velja zveza $S + E + I + R = N$ (vsi posamezniki). Parametre smo določili na sledeč način: β (merilo za prenos) je bil določen s prilagajanjem modela na realne podatke o okužbah. Z metodami strojnega učenja smo zgradili modele, ki se naučijo napovedovati ta parameter glede na nabor ukrepov. Pri tem smo upoštevali dejstvo, da posamezne države/regije uporabljajo različen nabor NPI in da v posameznih obdobjih število okužb narašča ali pada. β je bil zato prilagojen za posamezno situacijo. Parametra σ (inkubacijska doba) in γ (merilo za okrevanje) smo določili na podlagi podatkov iz literature.

Prediktor, ki smo ga zgradili z naborom različnih vrednosti β, se tako lahko prilagaja ukrepom, ki jih posamezne države uvajajo v različnih trenutkih. Prediktor deluje s časovno ločljivostjo enega dneva. Slika 1 prikazuje primer napovedi prediktorja v primerjavi z realnimi podatki.



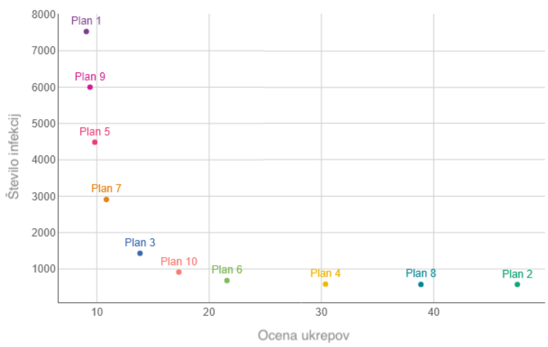
Slika 1: Primer dnevnega števila novih okužb za Italijo jeseni 2020. Modra črta predstavlja napoved, črtkana rdeča črta pa število potrjenih primerov. S sivo je označen interval za vhodne podatke.

4.2 Preskriptor

Cilj preskriptorja je izdelati plane intervencij (NPI) za posamezno obdobje za posamezno državo ali regijo. Pri tem želimo predpisati plane, ki predstavljajo dobre kompromise med omejevanjem širjenja okužb in ekonomsko in družbeno ceno teh ukrepov. Dodatna zahteva pri tekmovanju je bila časovna omejitev za izdelavo načrta, namreč, v šestih urah je bilo treba izdelati načrte za 235 regij, kar predstavlja v povprečju 90 s na regijo.

Preskripcijo planov lahko naravno predstavimo kot večkriterijski optimizacijski problem, kjer želimo minimizirati dva konfliktna si kriterija: (1) povprečno število infekcij in (2) ekonomska in družbena cena ukrepov. Za potrebe optimizacije smo uporabili dobro poznan genetski algoritem z nedominiranim sortiranjem II (ang. nondominated sorting genetic algorithm II – NSGA-II) [11].

Zaradi stroge časovne omejitve (90 s na regijo), smo za oceno kakovosti planov standardni prediktor nadomestili z nadomestnimi modeli. Standardni prediktor je namreč za posamezno oceno potreboval približno 2 s. Z uporabo slednjega bi tako lahko ocenili le približno 45 planov, kar ne zadostuje za algoritem tipa NSGA-II. Natančneje, uporabili smo dva nadomestna modela, enega na osnovi SEIR prediktorja (Sekcija 4.1) in enega na osnovi prekalkuliranih planov za različne poteke pandemije. Slednji deluje tako, da za dano regijo in čas najprej ocenimo potek pandemije in nato predpišemo plane, ki se za dani potek najbolje odnesejo. Med vsemi kompromisnimi rešitvami, ki jih dobimo tako s prvim kot drugim nadomestnim modelom, izberemo 10 takih, ki najbolje pokrijejo množico vseh »optimalnih« kompromisov. Tipičen primer kompromisnih rešitev v obliki fronte najdemo na Sliki 2.



Slika 2: Primer desetih kompromisnih rešitev v obliki fronte, dobljenih z metodo iz tekmovanja.

5 SODELOVANJE Z MINISTRSTVOM ZA ZDRAVJE RS

V okviru delovanja zadnjega avtorja kot državnega svetnika za raziskovalno dejavnost je bil dne 28. 6. 2021 izveden posvet v Državnem svetu na temo uporabe programskih metod za krotenje epidemije z naslovom: »**Problemi COVID-19 in iskanje optimalnih rešitev za naprej«.** Na komisijah DS in na plenarnem zasedanju je bila pogosta debata na temo COVID-19, kjer je avtor prispeval s strokovnimi analizami in napovedmi, dal je tudi nekaj pobud vladi v smeri najboljšega delovanja. Nekatere izmed teh zamisli so bile uresničene, druge ne.

Ministrstvo za zdravje RS je poleg tega naročilo nekaj študij. Del teh študij je prikazan v Vito Janko itd. »What-If Analysis of Countermeasures Against COVID-19 in November 2020 in Slovenia« v zborniku konference Informacijska družba 2021. Tam je pokazano, da je v fazi velike rasti smotrno vpeljati ukrepa tako zapiranja šol kot nošenja mask. Za november 2020 so analize celo pokazale, da se zapiranju šol ne da povsem izogniti, pa četudi uporabimo vrsto drugih ukrepov, če želimo ustaviti rast. Ukrep nošenja mask se glede na naš model izkaže enako učinkovit kot kombinacija bolj restriktivnih ukrepov, vendar je predvidoma do posameznikov bolj prijazen. Družbenih cen posameznih ukrepov v boju proti pandemiji v tej fazi nismo upoštevali, spada pa to med področja, ki jih bomo obravnavali v prihodnje.

6 SODELOVANJE Z EVROPSKIMI MINISTRSTVI

Julija 2021 smo vsem ministrstvom EU poslali pismo, kjer jim dajemo možnost neposredne uporabe programa XPRIZE JSI, specializiranega za njihovo državo. Vsaka država torej lahko uporablja z geslom zaščiteno verzijo programa. Poslali smo jim tudi navodila, kako uporabljati programe in na kakšen način jim nudimo podporo. Razvite rešitve so bile evropski in svetovni javnosti ponujene brezplačno.

Nimamo podatkov, koliko EU ministrstev je aktivno uporabilo ali uporablja programe, a glede na odzive in glede na to, da imamo kontakte le z nekaj ministrstvi, se zdi, da ne prav veliko.

7 ZAKLJUČEK

V prispevku so pregledno opisane programske rešitve, ki jih je skupina Odseka za inteligentne sisteme razvila v okviru tekmovanja XPRIZE. Nekatere med njimi so bile v celoti izvirne in so prispevale k drugem mestu na svetovnem prvenstvu na to temo.

Po tekmovanju smo razvili vrsto dodatnih rešitev. Eno smo uporabili za iskanje ukrepov retroaktivno – ali in v kolikšni meri je bil kak ukrep upravičen. Ena taka študija je zajemala obdobje novembra 2020 v Sloveniji. V večini študij se je pokazalo, da so bili človeški ukrepi daleč od optimalnega in bi uporaba programov, kot na primer razvitih na tekmovanju XPRIZE, omogočila bistveno boljše rezultate. Rezultate smo delili s slovenskim in z evropskimi ministrstvi za zdravje.

ZAHVALA

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Delavnica projekta Insieme

Insieme Project Workshop

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