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CONTEMPORARY TOPICS IN APPLIED INFORMATICS, SAFETY AND SECURITY SCIENCES AND SMART CITIES. EDITORIAL*

The issue articles concentrate on creative research of young researchers and is done in four different research environments. These four environments come from countries; Montenegro, Kosovo, India and Hungary. The research results in this journal include the following articles.

The article *Researcher's Choice or Just a Necessity? The Consequences of Publishing in a Predatory Journal* by László Berek discusses how the predator phenomenon affects those involved in scientific communication. The research aims to address the following questions: What are the detrimental impacts of predatory journals on individuals involved in scientific communication? What causes researchers to publish in predatory journals? What is the relationship between publication pressure and publishing in predator journals?

Article titled *Ranking of Hungarian Scientists Using h-index* by Gyula Mester presents the latest ranking list of the top 34 Hungarian scientists with the minimum h-index 104 in 2023. The ranking is edited using the Google Scholar database. Scientists with the same h-index are ranked by the number of citations. Orcid ID number of scientists is presented.

The article *Investigating the Use of Augmented Reality to Enhance the Indoor Running Experience on a Treadmill* by János Simon presents a research study focused on investigating the use of augmented reality (AR) to enhance the indoor running experience on a treadmill. The research goals of this study encompass three primary areas: understanding user perception and experience, evaluating physical performance improvements, and examining the impact on psychological factors. The findings of this research study will contribute to the growing body of knowledge on the use of AR in fitness and exercise domains. The results will shed light on the potential benefits and limitations of AR-enhanced treadmill running, informing the development of future applications and interventions.

Article titled *Managing Negative Emotions Caused by Self-Driving* by Dalma Zilahy and Gyula Mester presents reducing the negative emotions experienced in Self-Driving cars is key to increasing the number of users. To reduce anxiety, AI-based systems that measure the physiological response of passengers, mainly using biometric data, are used. In the future, the vehicle must be sufficiently empirical to reduce people's distrust. The potential for hacking is still one of the main sources of anxiety about Self-Driving Cars.

The article *Fuzzy Aggregators – an Overview* by Dragan Z. Saletic described deals with mathematical formalism of the process of combining several inputs into a single output in fuzzy intelligent systems, the process known as aggregation. A brief overview of the field of fuzzy aggregators is given. Attention is devoted to so called graded logic aggregators. The role of fuzzy aggregators in modelling reasoning and the way they are chosen in modelling are pointed out.

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In article titled *Assessment of the impact of the Covid-19 crisis on transportation and mobility – analysis of applied restrictions* by Malak M. Shatnawi and Zoltan Rajnai research showed the mobility that the non-motorized modes such as walking, and bike riding increased during the pandemic. These changes indicate a significant shift in transport modes and travel activities. While mobility patterns are directly correlated with the spread of the COVID-19 virus.

The article *Are we ready for Smart Cities?* by Kornélia Lazányi has managed to enrich the existing body of smart cities-related literature by combining the socioeconomic and cultural aspects in the interpretation of individual choices.

Article titled *The role of Closed Circuit Television in institutional artwork protection as a subsystem of smart city* by László Lőrincz and Tamás Berek describe the essential functions of CCTV, the authors also highlight the possibilities of further particular parts of CCTV systems installed in Smart City environments in the field of the structure of Institutional Artwork protection.

The article *Autonomous cars-what lies behind the lack of readiness* by Péter Szikora and Rozália Szatmáry highlights the biggest perceived threats and their prevalence and tries to uncover why more than half of the respondents are afraid of autonomous vehicles.

The research results of article titled *Scientific research-based view in construction projects: creating intelligent infrastructure* by Dániel Tokody, Peng Zhang, László Ady, Richárd Haddad, Fatmir Azemi and Stabak Roy show us that construction projects need to improve their efficiency. According to the research, AI can be a great tool to improve project management or on-site system operation.

All the presented articles provide the careful studies of the problems, and the editors believe that the whole issue is a very interesting read.

Cordially,

Budapest, 8 August 2023

Guest editors
Gyula Mester
Dániel Tokody

Interdisciplinary Description of Complex Systems 21(4), 324-332, 2023

RESEARCHER'S CHOICE OR JUST A NECESSITY? THE CONSEQUENCES OF PUBLISHING IN A PREDATORY JOURNAL

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Regular article

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ABSTRACT

The research community has been continuously investigating the issue of predatory journals. With the rapid development of technology and the world, online publishing has also accelerated, making it crucial to publish and disseminate scientific results as quickly as possible due to the "publish-or-perish" phenomenon. The number of open-access, online-only journals is increasing each year. Predatory publishers and journals have taken advantage of this trend by engaging in profit-driven, unethical practices. This article discusses how the predator phenomenon affects those involved in scientific communication. The research aims to address the following questions: What are the detrimental impacts of predatory journals on individuals involved in scientific communication? What causes researchers to publish in predatory journals? What is the relationship between publication pressure and publishing in predator journals?

KEY WORDS

online publishing, publication ethics, predatory journal, predatory publishing, research evaluation

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INTRODUCTION

Scientific communication has changed continuously over the centuries. Of course, as in any other area of life, the development process has not slowed down but has accelerated exponentially. If we look only at the last two decades, scientific communication has so clearly moved into the online space that it is now primarily present there. The pace of scientific research has also accelerated, as have the associated expectations, and the tools used in the research process have evolved accordingly. The acceleration of the pace of research is accompanied by a reduction in the time needed to communicate the results.

Publishing key research results as quickly as possible has always been important, and in recent years, technological advances have made this possible. This has been accompanied by the emergence of online scientific platforms and a growing number of Open Access journals. In recent years, even the traditional large scientific publishers have moved to new forms of publication. Open Access's philosophy is that the research results - and indeed the data – should be available to all. This perspective has become a fundamental condition for scientific progress and access to information today. The Open Access initiative has also had a significant impact on publishing policy, one important consequence of which is the introduction of the Article Processing Charge (APC).

An essential element in the communication of research results is that journals validate the data, methods, integrity of the manuscript and originality through peer review processes and peer review. This peer-review process impacts the quality of the articles accepted and published in the journals, but the reverse is also true: the quality and scientific impact of the articles published in a given journal qualifies and strongly influences the journal's quality. The fundamental difference between predatory and credible scientific journals is in professional, scientific peer review and proofreading. To be more specific, predatory journals do not use peer review or any form of scrutiny. These journals do not aim to make progress in the field of scientific metrics to be included in an indexing database. The only aim is to publish as many articles as possible so that they can make as much profit as possible. Predatory publishers publish studies of questionable scientific value - or mostly of no scientific value - without peer review and peer editing. These journals usually publish manuscripts indiscriminately if the author has paid the article processing fee.

Predatory activity can be identified through various distinct and specific characteristics. Many recent studies have been conducted to define and group these traits. When authors examine journals, they can look for certain signs to determine if a journal is a predator. It is important to note that just because a journal has one of these signs does not necessarily mean it's a predatory publication. However, the more signs that are present, the more suspicious the journal may be [1]:

- competent scientific databases do not index the journal,
- the journal website does not contain information about the editorial board,
- there are non-academic advertisements on the webpage,
- the journal's website needs to contain information on the address and contact details of the editorial board,
- the manuscript's review time (Article Publication Time) is suspiciously short,
- it is not easy to verify the credibility of the scientific work produced by the editor-in-chief, editorial board, and columnists,
- there is no transparent description of the publishing process,
- the journal claims an "alternative" (fake) impact factor score,
- the scientific contributions of the editor-in-chief and the members of the editorial team cannot be found in scientific databases [2].

THE HARMFUL IMPACT OF PREDATORY PUBLISHING

The predatory phenomenon of online scholarly communication threatens the scientific community on several levels. It is essential to consider the vulnerability of the participants involved. What kind of participants might be exposed? What levels can we divide the participants into?

- author, researcher,
- faculty, department, institute,
- university, research centre, scientific institution,
- country, nation, society.

Of course, there are also participants on the "other side", the predatory publishers, but these are not covered by this research in terms of vulnerability.

AUTHOR, RESEARCHER

The number of publications in predatory journals is increasing every year. Such a high number of published articles cannot be explained by the fact that all of the researchers were misled, inexperienced, and poorly informed about the world of online publishing. There are other explanations for why researchers and academics publish in such journals [3].

When exploring the issue of predatory journals, it's important to start with the researcher's motivation. Specifically, we need to understand why someone would choose to publish in a predatory journal. There have been many studies conducted in an effort to answer this question [3-7].

Meeting the Expected Requirements for Academic Progress

Researchers face different publication and citation requirements at every stage of their scientific career. Whether we are talking about a doctorate or a university professorship, there is the expectation of a highly cited article published in an international scientific journal at each level. In the case of publication for a doctorate or promotion, there may be a need to publish papers in a short time. In such cases, an Impact Factor or SJR Q1 journal is out of the question, as the peer review process for these publications can take up to a year. Predatory journals, conversely, promise extra fast publication and mislead researchers with false information about the expected indexing or scientific quality of the publication [8].

Scientific journals have always been meticulous in ensuring the scientific integrity of their published articles, and this is especially true for those with high-impact factors. This process can take up to 6-8 months. However, due to the pressures of publication and the need for quick scientific communication, some journals may be tempted to offer rapid peer review as a selling point. Unfortunately, some predatory journals offer this service with a significantly reduced timeline, sometimes as short as a few days. In such cases, a quality review is not guaranteed, as the journal promises a 1-3 day review. These journals also often charge an additional fee and may offer a "fast track" service, promising even faster review times of "2-5" days for an extra fee.

Figure 1. Promising a fast "review" on a predatory journal's website.

Fear of Job Lost / Publish or Perish Pressure

Researchers in scientific research centres and universities often face pressure to meet publication requirements. These expectations only increase when a project is funded by a grant and a predefined number of publications has to be delivered on time. In universities, the number of publications to be completed is often set for researchers and teachers at the beginning of the year. The university management counts these publications, and if the researcher does not meet the publication expectations, his/her contract may be terminated [8].

Scientific Research Awards, Performance Evaluation System

In many countries, centrally, but almost everywhere in universities, there are publication performance awards and research reward programmes, with cash prizes based on researchers' performance in the previous year. In many cases, the criteria for such awards must be correctly and precisely defined so that publication in a foreign journal may be sufficient. Furthermore, any predatory journal would fit into such a category. In many such cases, the author will publish even if he knows of the predatory nature of the publication. Naturally, the researcher expects that his publication will appear very quickly after paying a lower article processing fee.

If a researcher has often tried to publish in highly ranked journals with scientific value, indexed by Scopus or Web of Science, but failed. In this case, although the researcher may be aware of the predatory nature of the journal, he or she may still choose to use the platforms of the non-peer-reviewed, predatory journals.

Research Rankings

Many research institutions and universities regularly produce and publish their current researcher rankings. These rankings show, in a way that is accessible to all, which researchers have published the most in a given period and who are at the 'bottom of the list'. In many cases, these rankings do not distinguish between the quality of the journals for indicators such as "number of articles published in foreign journals" or "number of publications in foreign languages". Furthermore, the value of such indicators is increased even if the researcher submits his manuscript to a predatory journal. In many universities, this researcher ranking is the basis – or at least a significant part – of the performance evaluation system, which can even influence the following year's salary of the lecturer.

Inexperience in Publishing

Predatory journals are often successful with less experienced researchers who need to gain the knowledge to recognise such publications. Online scholarly communication and publishing journal metrics are constantly changing and evolving. At the same time, some predatory publishers and journals are evolving, and it is becoming increasingly difficult to recognise among the many misleading and deceptive signs that they should avoid these publications by far. The authors' uncertainty is compounded by the fact that these journals and publishers display misleading journal metrics and "fake" databases on their websites to "prove" the scientific quality of the publication. However, these fake metrics and databases are designed to fool less experienced researchers by predatory journals.

It can be a problem for researchers who unknowingly submit their manuscripts to predatory journals and later realize their mistake. The question then becomes how to retract the published article since it can no longer be published elsewhere. Unfortunately, retracting an article from a predatory journal is often difficult as these journals may ignore or refuse such requests. Additionally, if the article has already been published without notification, the researcher might face ethical issues if they try to submit it to another journal. This is regardless of whether or not copyright has been assigned.

The situation worsens when such a journal asks the researcher to serve on its editorial board. This is often done similarly to unsolicited letters sent for manuscripts. A letter is sent to the researcher, praising his or her academic achievements and describing how much of an honour it would be for the journal to have him or her on the editorial board. Many researchers will welcome such an opportunity with pride if they must become more familiar with the journal's quality. Moreover, being on the editorial board of an international journal can be a plus point at different stages of a researcher's career. The predatory journal has already taken this to a new level by allowing the name (and, of course, the institution) of a credible – and existing – researcher to appear on the journal's website. This, of course, opens the door to further deception. It is perhaps somewhat easier to withdraw editorial board membership, but predatory journals often do not deal with such requests [8].

A group of researchers at Wroclaw University in Poland has investigated the editorial practices of predatory journals, setting a trap for dubious publications. The research team created a fake profile of a researcher who did not actually exist, Anna O. Szust (the author's surname comes from the Polish word for "cheater"). The CVs posted online also included fake academic degrees. On behalf of the fake researcher, they applied to be an editorial board member of 360 selected journals. The selection of 360 journals was evenly split: 120 journals were selected as clearly predator-suspect, 120 as indexed by the Directory of Open Access Journals (DOAJ) and 120 as having a Clarivate IF score. In the study, the researchers rated the journal's response – or lack of response – to the query [9].

Table 1. Predatory journal editorial board member test results [9].

Journal Type	Accepted	Accepted, but later disputed	Rejected	No Response	SUM
Predatory	36	4	15	65	120
DOAJ Index	7	1	45	67	120
IF (JCR)	0	0	48	72	120

It is of utmost importance for researchers to be aware of the potential dangers associated with publishing their work in predatory journals. Failure to recognize this fact could lead to disappointment when attempting to advance one's academic career or participate in international competitions. Additionally, publishing in such journals could harm a researcher's reputation within the academic community. It is important to note that retracting a manuscript once it has been submitted to a predatory journal is an incredibly difficult task. It is, therefore, essential for researchers to be careful when choosing where to publish their work. This is particularly important because inappropriate publication behaviour by researchers can negatively impact the broader scientific community and the performance of scientific institutions and universities.

FACULTY, DEPARTMENT, INSTITUTE

In the last few years, the literature on predatory journals and publishers has included several researchers from the perspective of higher education institutions [10-13]. The negative impact of predatory publishers and journals is not only at the level of the researchers, the adverse publication outcomes and loss of prestige are further transmitted to the level of the organizational unit, the faculty. In the case of a faculty or research position, there are ongoing challenges. Whether in the form of rankings within the university, performance comparisons, or accreditation processes, the unit's overall performance is decisive. Monitoring the academic performance of departments and faculties – at least quarterly – is now essential. The publication output to be achieved at the researcher and faculty level is often determined at the beginning of the year. These results are, of course, also taken into account by the management of the faculty or department. If

it turns out at the time of accounting that the publication is, in fact, "worthless" in terms of output, it is too late. Moreover, this is not only a loss of prestige but can also harm the budget of, for example, the following year of a university faculty. In addition, departments can be ranked according to their academic performance, and a specific part of the budget is often linked to this criterion.

UNIVERSITY, RESEARCH CENTRE, SCIENTIFIC INSTITUTION

Just as the performance of the researchers in their department is the determinant, the impact of the researcher's predator relationship with journals is naturally transmitted to the faculty. In the case of universities and scientific institutions, there are specific requirements for the number, quality and citations of scientific publications, which must be met year after year because the budget of the whole institution depends on them. The proportion of model-switching universities in the Hungarian higher education system is currently almost 95 %. This form of higher education funding is common in the region, with universities in Poland, the Czech Republic and Slovakia operating similarly.

Under this system, the state and the higher education institution sign a contract setting out the requirements to be met in a given year, for example, regarding teaching and academic achievements. For the annual performance of the universities, they must meet the publication and citation figures set out in the contract. These include the composite of Scimago Journal Rank D1-Q1-Q2 and Clarivate/InCites Top 10 % publications and the number of citations received for the university's publications in the Web of Science and Scopus databases. To ensure the quality of the university's scientific output, it is important to continuously monitor it. The impact factor of scientific journals and the h-index depend on the citation. The impact factor is recommended to be used to determine the value of journals, and the h-index is also used to determine author and journal metrics. The university should avoid publishing papers in questionable journals when they could be published in reputable ones that meet the necessary indicators. The value of the h-index is, of course, based on the content of the database on which the calculation is based. If the database does not index the journal, it will not be reflected in the author and institutional science metric values [14, 15].

Another major challenge for universities and higher education is participating in the various international rankings of higher education. Of course, these organisations use different methodologies and calculation rates to assess universities and update the rankings for a given year. Whichever university rankings are used - and they are authoritative - all use Web of Science or Scopus data to examine scientific indicators. So again, publishing in predatory journals harms the university as a whole [16-18].

Many universities and scientific institutions receive a significant portion of their research funding from national and EU sources. These funds come with strict accountability requirements and performance milestones. To show completion of the research, most grants require a certain level of research results publication. If the research is published in an insufficient publication, the grant may need to be repaid by the institutions involved in the proposal.

The loss of prestige for researchers not only impacts them but also the university and academic institution. The author's affiliation is typically mentioned in the published article, and the institution from which researchers have published is often indicated on the journal's website. Reputation, which includes achieving a higher ranking in university rankings, is crucial for the university's operation, whether in terms of enrolment, joint research with internationally renowned researchers or possible contracting.

COUNTRY, NATION, SOCIETY

When it comes to the effects of predatory journals on research, the performance of a country's researchers reflects the country's overall performance. Each year, rankings and statements are

produced for countries. For instance, Scimago provides a Country Rank which lists countries based on their publication output. Scimago is well-known for its journal rankings [19].

The impact of predatory journals has been characterised in scientific communication, but the impact on mass communication and, thus, on society cannot be ignored. In recent years, it has become increasingly apparent that the content of predator journals is also present in the media, on social media platforms, but indirectly. On social media, through various channels, conspiracy theories and deception, disinformation can be easily credited with content that is perceived as scientific. The content of predatory journals can, if social media tools are used "properly", spread just as fast as those of credible scientific journals. This can result in the dissemination of unreliable information. A recent study examined the spread of dental journal publications on social media platforms (Instagram, Facebook, and Twitter) at a discipline level, distinguishing between predatory and authoritative journals based on available information. The data revealed that the dissemination of publications in predatory and authoritative journals in this specialty was nearly identical on the studied social media platforms [20].

Predatory journals often bear a deceptive similarity to an accepted scientific journal, but of course, the similarity is only apparent in appearance. In terms of content, however, the need for more scientific scrutiny, criticism and peer review means that we read the results of apparently scientific research as a publication. Moreover, these publications are perfect for the scientific substantiation of a manipulative, deceptive or fake news story. Just think of the thousands of currently identifiable predatory journals that even deceive experienced researchers and authors who live, work and publish in this sphere. How can the ordinary person be expected to recognise the cited 'scientific' backing behind the news? Today's social media platforms are the best places to spread conspiracy theories and misleading news. Furthermore, ordinary people rarely check the information they receive from the media. Moreover, even if they did investigate the source more deeply, they would find it very difficult to identify the quality of the source. From this point of view, the problem is that predatory publishers can be unwitting disseminators and supporters of various counterfactuals and, of course, disinformation. For example, some video-sharing channels promote debunked conspiracy theories while citing questionable sources. These further distances us from the truth.

Figure 2. "Direction of the effects of publishing in predatory journals" pyramid.

The adverse effects of publishing in predatory journals can be seen to be inherited across levels in different participants in online scientific communication. These effects range from the smallest unit to the largest.

When researchers publish in predatory journals, the harmful effects trickle down to the next level. The pressure to publish, which is a major factor in the rise of predatory journals, works in the opposite direction in this pyramid. The publication expectations set by the institution or

university are passed down to the next level. These expectations are typically distributed by university management at the institutional level, then further distributed among faculties, institutes, and departments. Ultimately, researchers and lecturers are tasked with meeting these publication expectations.

CONCLUSIONS

Online scholarly communication is at risk due to predatory journals and publishers. The changes in online scientific communication, science metrics and publishing over the last decade have radically changed how researchers publish their results. In a rapidly changing environment, it is difficult for researchers and academics to keep up with the changes and the evolving scientific environment.

The scientific community can currently only provide a semblance of a solution to the predator phenomenon, or at best, only half a solution. Black-and-white lists of predator publishers and journals are not workable solutions. It would take a massive amount of work to keep them updated and up to date, and of course, there is no guarantee that all predatory journals are listed. The scientific world uses different sub-solutions, which create additional problems. The scientific community is still searching for a satisfactory solution to this issue.

In research careers, we also face increasingly high expectations internationally. Publication output is now almost exclusively defined in terms of publications, and only those indexed by the systems and databases of the major science metrics providers are recognised as such. This means that in all parts of the world, but most strongly in developing countries, a new journal has almost no chance of proving itself in the scientific world. These journals thus look for other opportunities and increase the number of misleading journal metrics and indexing sites. This ultimately puts them in the same category as predatory journals deliberately set up for financial gain and do not strive to achieve scientific quality.

From a researcher's perspective, the issue of increasing scientific requirements means that in many cases the decision to use predatory journals is a matter of necessity. The pressure on researchers to publish ultimately favours predatory journals, as this results in more manuscripts and more publication fees for the journal.

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RANKING OF HUNGARIAN SCIENTISTS USING H-INDEX

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Regular article

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ABSTRACT

The article presents the latest ranking list of Hungarian scientists in 2023. The ranking is presented primarily according to the h-index of scientists. Scientists with the same h-index are ranked by the number of citations. We present the top 34 Hungarian scientists with the minimum h-index 104. h-index can be determined from the following online databases: Web of Science, Scopus, Google Scholar and the Publish or Perish program. The ranking is edited using the Google Scholar database. We also present the Orcid ID number of scientists. The first chapter is the introduction, in the second chapter we present the latest ranking list of Hungarian scientists in 2023, the third chapter is the conclusions.

KEY WORDS

Hungarian scientists, Google Scholar, h-index, citations, Orcid ID

CLASSIFICATION

ACM: K.4.2
JEL: Z19

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INTRODUCTION

The article presents the latest ranking list of Hungarian scientists using h-index in 2023.

Indexes in Scientometrics are based on citations. However, in contrast to the journal impact factor, which gives only the ranking of the scientific journals, ordered by impact factor, indexes are suitable for ranking of:

- scientists,
- scientific journals,
- countries.

An effective way to measure scientific performance is to measure citations, because if someone is cited a lot by other scientists, they are probably a better scientist. The ranking is presented primarily according to the h-index of Hungarian scientists.

The h-index is the largest h number, indicating that h number of publications contain at least h citations, h-index can be determined from the following online databases: Web of Science, Scopus, Google Scholar and the Publish or Perish program. The h-index, also known as the Hirsch index, is based on citations. The h-index was published by physicist Jorge E. Hirsch (University of California, San Diego) in 2005:

"A scientist has index *h* if *h* of his/her N articles have at least *h* citations each, and the other (*N* –*h*) articles have no more than *h* citations each" [1].

The h-index was originally proposed by Hirsch to compare individual performance only, but it can also be used to compare the h-index of:

- research groups,
- journals,
- disciplines,
- institutions,
- countries.

The advantage the h-index is that it combines both the:

- quantity – number of articles,
- quality – citations to these articles.

A researcher cannot have a high h-index without publishing a considerable number of articles. The h-index favours researchers that publish a continuous stream of articles.

The original h-index does not distinguish between dependent and independent citations, i.e., it also takes self-citations into account. The ranking is edited using the Google Scholar database [2].

Scientists with the same h-index are ranked by the number of citations. We present the top 34 scientists in the ranking list of Hungarian scientists with the minimum h-index 104.

The article is organized as follows:

- in Section 1 the Introduction is given,
- in Section 2 the ranking list of Hungarian scientists in 2023 is presented,
- conclusions are given in Section 3.

THE LATEST RANKING LIST OF HUNGARIAN SCIENTISTS IN 2023

The latest ranking list of Hungarian scientists in 2023 is presented primarily according to the scientists h-index. The ranking has been constructed using the Google Scholar database. Scientists with matching h-index are ranked by the number of citations [3-8].

34 scientists are included in the ranked list [9, 10]. The minimum h-index of the ranked scientists is 104. We also present the Orcid ID number of the scientists. The ranking list is the following:

1. Gábor I. Veres
   h-index = 221, 227 861 citations, Orcid ID: 0000-0002-5440-4356

Gábor I. Veres

FOLLOW

Eötvös Loránd Tudományegyetem
Verified email at ludens.elte.hu
részecskefizika

Cited by	All
Citations	227861
h-index	221

2. Daniel Dobos
   h-index = 210, 212 543 citations, Orcid ID: 0000-0001-5343-5583

Daniel Dobos

FOLLOW

Other names

CERN, University of Lancaster, Swisscom
Verified email at cern.ch
Particle Physics AI/ML/QML Graph Analytics

Cited by	All
Citations	212543
h-index	210

3. Gabriella Pasztor
   h-index = 205, 293 487 citations, Orcid ID: 0000-0003-0707-9762

Gabriella Pasztor

FOLLOW

Senior Research Fellow, Eötvös Loránd University, Budapest
Verified email at ttk.elte.hu - Homepage
Particle Physics

Cited by	All
Citations	293487
h-index	205

4. Zoltán Trócsányi
   h-index = 196, 203 552 citations, Orcid ID: 0000-0002-2129-1279

Zoltán Trócsányi

FOLLOW

Institute of Physics, ELTE Eotvos Lorand University, Budapest, Hungary
Verified email at ttk.elte.hu - Homepage
Particle physics Beyond Standard Model Quantum Chromodynamics Phenomenology

Cited by	All
Citations	203552
h-index	196

5. Dezso Horvath
   h-index= 194, 211 244 citations, Orcid ID: 0000-0003-0091-477X

Dezso Horvath

FOLLOW

Unknown affiliation
Verified email at rmki.kfki.hu - Homepage
Physics

Cited by	All
Citations	211244
h-index	194

6. Ferenc Jolesz
   h-index = 168, 89 095 citations, Orcid ID: -

Ferenc Jolesz M.D.

FOLLOW

Harvard Medical School, Brigham and Women's Hospital
Verified email at bwh.harvard.edu - Homepage
First interest Neuroscience Second interest Magnetic r… Third Interest Image-guided…

Cited by	All
Citations	89095
h-index	168

7. Peter Fonagy
   h-index = 167, 141 629 citations, Orcid ID: 0000-0003-0229-0091

Peter Fonagy

FOLLOW

University College London, The Anna Freud Centre
Verified email at ucl.ac.uk
Borderline personality disor… psychotherapy outcomes attachment theory psychoanalysis

Cited by	All
Citations	141629
h-index	167

8. Gyorgy Buzsaki
h-index = 167, 132 654 citations, Orcid ID: 0000-0002-3100-4800

Gyorgy Buzsaki

NYU Neuroscience Institute
Verified email at nyumc.org - Homepage
Systems Neuroscience

FOLLOW

Cited by	All
Citations	132654
h-index	167

9. Albert-László Barabási
h-index = 163, 277 890 citations, Orcid ID: 0000-0002-4028-3522

Albert-László Barabási

Northeastern University, Harvard Medical School
Verified email at neu.edu - Homepage
network science statistical physics biological physics physics medicine

FOLLOW

Cited by	All
Citations	277890
h-index	163

10. Csaba Szabo
h-index = 145, 82 986 citations, Orcid ID: 0000-0003-3110-4235

Csaba Szabo

Professor, Chair of Pharmacology, University of Fribourg, Switzerland
Verified email at unifr.ch - Homepage
pharmacology nitric oxide hydrogen sulfide PARP mitochondria

FOLLOW

Cited by	All
Citations	82986
h-index	145

11. József Pálinkás
h-index = 141, 121 656 citations, Orcid ID: -

József Pálinkás

Institute of Nuclear Research of the Hungarian Academy of Sciences
Verified email at atomki.hu - Homepage
particle physics

FOLLOW

Cited by	All
Citations	121656
h-index	141

12. Mate Csanad
h-index = 139, 77 174 citations, Orcid ID: 0000-0002-3154-6925

Mate Csanad

Eötvös Loránd University
Verified email at elte.hu - Homepage
Particle physics nuclear physics heavy ion phyics high energy physics

FOLLOW

Cited by	All
Citations	77174
h-index	139

13. Ferenc Siklér
h-index = 137, 104 811 citations, Orcid ID: 0000-0001-9608-3901

Ferenc Siklér

Research professor at Wigner RCP, Budapest
Verified email at wigner.hu - Homepage
Experimental particle physics

FOLLOW

Cited by	All
Citations	104811
h-index	137

14. Steve Horvath
h-index = 134, 98 827 citations, Orcid ID: 0000-0002-4110-3589

Steve Horvath

Professor of Human Genetics and Biostatistics, University of California, Los Angeles
Verified email at mednet.ucla.edu
Bioinformatics Human Genetics Biostatistics Systems Biology Network Analysis

FOLLOW

Cited by	All
Citations	98827
h-index	134

15. Peter Levai
h-index = 132, 78 741 citations, Orcid ID: 0009-0006-9345-9620

Peter Levai

FOLLOW

MTA Wigner RCP, Budapest, Hungary
Verified email at wigner.hu
Theoretical nuclear physics Heavy ion collisions Quark-gluon plasma

Cited by	All
Citations	78741
h-index	132

16. Peter Mészáros
h-index = 130, 68 206 citations, Orcid ID: 0000-0003-0123-2674

Peter Mészáros

FOLLOW

Pennsylvania State University
Verified email at psu.edu - Homepage
High energy and particle as…

Cited by	All
Citations	68206
h-index	130

17. Peter Somogyi
h-index = 120, 49 972 citations, Orcid ID: 0000-0001-7650-684X

Peter Somogyi

FOLLOW

University of Oxford
Verified email at pharm.ox.ac.uk - Homepage
Neuroscience

Cited by	All
Citations	49972
h-index	120

18. Tamas L. Horvath
h-index = 118, 57 456 citations, Orcid ID: -

Tamas L. Horvath

FOLLOW

Yale University
Verified email at yale.edu

Cited by	All
Citations	57455
h-index	118

19. Zsuzsa Marka
h-index = 117, 95 907 citations, Orcid ID: -

Zsuzsa Marka

FOLLOW

Columbia Astrophysics Laboratory, Columbia University in the City of New York
Verified email at astro.columbia.edu - Homepage
Multimessenger Gravitational waves Astrophysics Astroparticle Physics Biophysics

Cited by	All
Citations	95907
h-index	117

20. Imre Bartos
h-index = 117, 93 232 citations, Orcid ID: 0000-0001-5607-3637

Imre Bartos

FOLLOW

University of Florida
Verified email at ufl.edu - Homepage
gravitational wave astrophy… multi-messenger astrophysics high-energy astroparticle p…

Cited by	All
Citations	93232
h-index	117

21. Andras Nagy
h-index = 116, 73 188 citations, Orcid ID: 0000-0003-4311-0413

Andras Nagy

FOLLOW

Senior Scientist, Mount Sinai Hospital, Lunenfeld-Tanenbaum Research Institute
Verified email at lunenfeld.ca - Homepage
stem cells regenerative medicine

Cited by	All
Citations	73188
h-index	116

22. Lajos Pusztai
h-index = 116, 68 086 citations, Orcid ID: 0000-0001-9632-6686

Lajos Pusztai
Yale School of Medicine
Verified email at yale.edu - Homepage
breast cancer

FOLLOW

Cited by

	All
Citations	68086
h-index	116

23. Csaba P. Kovesdy
h-index = 116, 51 261 citations, Orcid ID = 0000-0002-8204-911X

Csaba P Kovesdy
University of Tennessee
Verified email at uthsc.edu

FOLLOW

Cited by

	All
Citations	51261
h-index	116

24. Bencedi Gyula
h-index = 113, 43 395 citations, Orcid ID: 0000-0002-9040-5292

Bencedi Gyula
Research fellow at Wigner RCP
Verified email at wigner.hu
experimental particle physics

FOLLOW

Cited by

	All
Citations	43395
h-index	113

25. Peter Falkai
h-index = 112, 49 749 citations, Orcid ID: 0000-0003-2873-8667

Peter Falkai
Professor of Psychiatry und Psychotherapy
Verified email at med.uni-muenchen.de - Homepage
Schizophrenia Neuroimaging Neurobiology

FOLLOW

Cited by

	All
Citations	49749
h-index	112

26. Peter Raffai
h-index = 109, 86 148 citations, Orcid ID: 0000-0001-7576-0141

Peter Raffai
Institute of Physics, Eötvös Loránd University, 1117 Budapest, Hungary
Verified email at ttk.elte.hu - Homepage
physics astrophysics gravitational waves cosmology

FOLLOW

Cited by

	All
Citations	86148
h-index	109

27. Endre Nagy
h-index = 109, 45 489 citations, Orcid ID: 0000-0002-3863-4194

Endre Nagy
University of Pannonia
Verified email at mukki.richem.hu - Homepage
chemical and biochemical p…

FOLLOW

Cited by

	All
Citations	45489
h-index	109

28. Zsolt Frei
h-index = 108, 88 204 citations, Orcid ID: 0000-0002-0181-8491

Zsolt Frei
Eötvös Loránd University
Verified email at ttk.elte.hu

FOLLOW

Cited by

	All
Citations	88204
h-index	108

29. Zoltan Acs
h-index= 108, 74 437 citations, Orcid ID: 0000-0001-5284-0149

Zoltan Acs

FOLLOW

George Mason University
Verified email at gmu.edu - Homepage
Innovation entrepreneurship economic geography economic development small business

Cited by	All
Citations	74437
h-index	108

30. Laszlo Lovasz
h-index = 108, 67 495 citations, Orcid ID: 0000-0001-6596-0465

Laszlo Lovasz

FOLLOW

professor of mathematics, Eotvos University, Budapest
Verified email at cs.elte.hu - Homepage
discrete mathematics combinatorics

Cited by	All
Citations	67495
h-index	108

31. Peter Daszak
h-index = 107, 65 980 citations, Orcid ID: 0000-0002-2046-5695

Peter Daszak

FOLLOW

EcoHealth Alliance
Verified email at ecohealthalliance.org

Cited by	All
Citations	65980
h-index	107

32. Tamás Csörgő
h-index = 106, 47 927 citations, Orcid ID: 0000-0002-9110-9663

Tamás Csörgő

FOLLOW

Scientific Advisor, Wigner RCP Budapest, and Research Professor, MATE Institute of Technology
Verified email at cern.ch - Homepage
theoretical nuclear physics experimental nuclear physics theoretical partice physics experimental particle physics

Cited by	All
Citations	47927
h-index	106
i10-index	461

33. Robert Vertesi
h-index = 105, 43 293 citations, Orcid ID: 0000-0003-3706-5265

Robert Vertesi

FOLLOW

Senior Researcher, Wigner RCP Budapest
Verified email at wigner.hu - Homepage
high-enery physics heavy ions jets heavy flavor

Cited by	All
Citations	43293
h-index	105

34. Robert Vajtai
h-index = 104, 50 526 citations, Orcid ID: 0000-0002-3942-8827

Robert Vajtai

FOLLOW

Rice University
Verified email at rice.edu
material science nanomaterials

Cited by	All
Citations	50526
h-index	104

CONCLUSIONS

The article presents the top 34 researchers in the latest ranking list of Hungarian scientists in 2023. The ranking is presented primarily according to the h-index of scientists. Scientists with the same h-index are ranked by the number of citations.

The advantage the h-index is that it combines both the quantity – number of articles and quality – citations to these articles. The ranking is edited using the Google Scholar database. The minimum h-index for scientists is 104. We presented the scientists Orcid ID.

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Interdisciplinary Description of Complex Systems 21(4), 341-350, 2023

INVESTIGATING THE USE OF AUGMENTED REALITY TO ENHANCE THE INDOOR RUNNING EXPERIENCE ON A TREADMILL

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DOI: 10.7906/indecs.21.4.3
Regular article

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ABSTRACT

This article presents a research study focused on investigating the use of augmented reality to enhance the indoor running experience on a treadmill. The rapid advancements in augmented reality technology offer exciting opportunities to revolutionize traditional exercise routines and provide users with an immersive and engaging workout environment. This study aims to explore the potential benefits and challenges associated with integrating augmented reality into treadmill running, ultimately seeking to improve motivation, enjoyment, and overall fitness outcomes. The research goals of this study encompass three primary areas: understanding user perception and experience, evaluating physical performance improvements, and examining the impact on psychological factors. The findings of this research study will contribute to the growing body of knowledge on the use of augmented reality in fitness and exercise domains. The results will shed light on the potential benefits and limitations of augmented reality-enhanced treadmill running, informing the development of future applications and interventions. Moreover, the study will offer valuable insights into user preferences, perception, and motivation, enabling designers and developers to create more tailored and engaging augmented reality experiences for indoor exercise enthusiasts. This research study aims to explore the integration of augmented reality into treadmill running to enhance the indoor running experience. By investigating user perception, physical performance improvements, and psychological impacts, the study seeks to uncover the potential of augmented reality as a tool to motivate and engage individuals in their fitness journeys on the treadmill.

KEY WORDS

augmented reality, indoor running, unity, vuforia, treadmill

CLASSIFICATION

JEL: L86

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INTRODUCTION

The prevalence of non-communicable diseases, including diabetes, heart disease, and cancer, has significantly increased, leading to high rates of illness and death in modern society. It is unfortunate that many of these diseases could be prevented through the adoption of a healthy lifestyle, particularly by incorporating regular physical exercise. Engaging in just 20 minutes of jogging consistently over an extended period has been shown to substantially decrease the risk of developing these ailments. Consequently, numerous health policies introduced by national governments and international organizations in recent years prioritize the promotion of physical exercise as a fundamental component [1]. However, individuals who lead sedentary lives often struggle to find the time and motivation to engage in regular physical activities. Consequently, researchers from various fields have sought innovative approaches to motivate and encourage people to partake in sustained exercise. Interestingly, digital technology has emerged as a promising solution in this regard. Recent studies have demonstrated the potential of mobile and ubiquitous sensor technology to provide users with feedback on their progress and performance toward their exercise goals. Figure 1 shows the holistic system proposal.

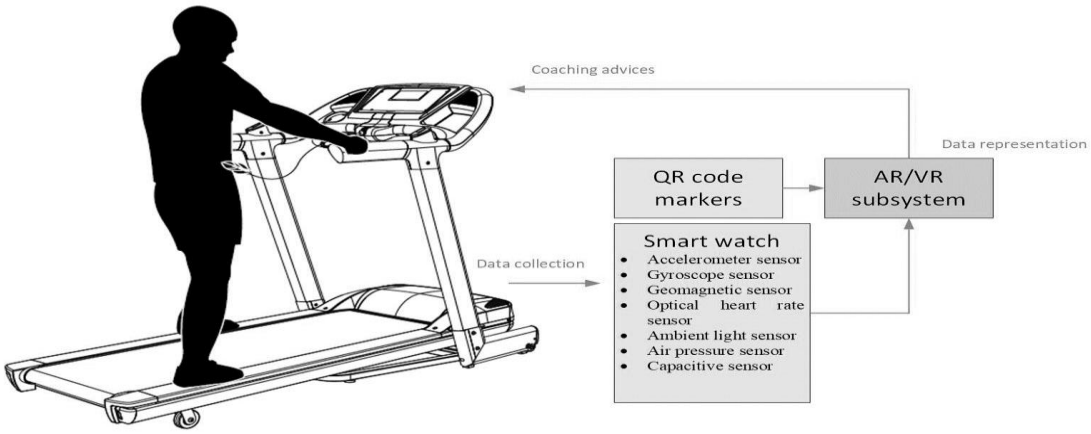

Figure 1. Augmented reality (AR) subsystem with treadmill.

This feedback enhances users' awareness of their achievements and serves as a catalyst for further commitment to their exercise routines. Moreover, the integration of gamification and persuasive technology methodologies, which aim to design technology in ways that positively influence users' attitudes and behaviours, can amplify the effectiveness of mobile technologies in engaging users [2]. The rise of non-communicable diseases necessitates urgent action to promote healthier lifestyles, with physical exercise playing a crucial role. However, the challenge lies in motivating individuals who lead sedentary lives to incorporate exercise into their daily routines. Digital technology has emerged as a valuable tool in addressing this issue. By leveraging mobile and sensor technology, individuals can receive real-time feedback on their progress, fostering a sense of accomplishment and encouraging continued dedication to exercise. Furthermore, the incorporation of gamification and persuasive technology techniques enhances the effectiveness of these systems, making them even more engaging and influential. These findings offer promising avenues for interventions aimed at motivating individuals to adopt and sustain regular physical exercise habits [3]. The first research goal is to understand user perception and experience when using AR on a treadmill. Through qualitative and quantitative methods, user feedback will be collected to assess the subjective experience of individuals during AR-enhanced treadmill running. Factors such as perceived enjoyment, engagement, and immersion will be evaluated through questionnaires, interviews, and observation. This analysis will provide insights into the user's perspective and inform the development of effective AR interfaces and applications. The second research goal is to

evaluate the potential physical performance improvements resulting from the use of AR during treadmill running [4]. By comparing the performance metrics, such as speed, endurance, and calorie expenditure, of individuals using traditional treadmills and AR-enhanced treadmills, the study aims to determine whether AR can positively impact physical fitness outcomes. This investigation will involve controlled experiments and measurements to objectively assess the differences in performance and endurance between the two conditions. The third research goal focuses on examining the impact of AR on psychological factors related to treadmill running. The study will explore how AR can influence motivation, self-efficacy, and adherence to running routines. Various psychological constructs, including motivation theories and self-perception, will be assessed through surveys and interviews. Understanding the psychological effects of AR during treadmill running will provide valuable insights for designing interventions that enhance individuals' engagement and commitment to regular exercise [5]. To achieve these research goals, an experimental study will be conducted involving a diverse group of participants, including both experienced runners and novices. Participants will engage in treadmill running sessions with and without AR integration [6]. The AR system will provide interactive elements, such as virtual landscapes, coaching avatars, and progress tracking, to enhance the indoor running experience. The study will be conducted over a specific duration, allowing for a longitudinal analysis of the effects of AR on various outcomes.

RELATED WORK

Several studies have explored the use of AR in various contexts, including fitness and exercise. This related work section reviews relevant research that investigates the application of AR to enhance the indoor running experience on a treadmill. A study conducted by authors in [7] examined the effects of an AR-based virtual environment on treadmill running. The researchers developed a system that projected a virtual landscape onto a screen in front of the treadmill user. The results indicated that participants who ran in the AR environment reported higher levels of enjoyment and engagement compared to those running in a traditional setting. The immersive and visually stimulating nature of the AR environment contributed to a more positive running experience. In a similar vein, authors [8] investigated the impact of an AR fitness game on treadmill running. The participants engaged in a game where they had to collect virtual objects and avoid obstacles projected onto a screen in front of them. The study found that the incorporation of gamification elements through AR technology increased motivation and enjoyment, resulting in improved exercise adherence. The participants showed higher levels of physical exertion and reported a greater sense of accomplishment during the AR-enhanced running sessions. Another relevant study by [9] focused on the use of AR to provide real-time feedback and coaching during treadmill running. The researchers developed an AR system that displayed personalized running statistics, such as speed, distance, and heart rate, overlaid onto the runner's field of view. The feedback provided by the AR system significantly improved the participants' running performance, as they were able to monitor their progress and make necessary adjustments in real time.

Furthermore, a study by [10] explored the integration of AR technology into treadmill running to simulate outdoor running experiences. The researchers developed an AR system that projected virtual landscapes, such as cityscapes and natural environments, onto a screen in front of the runners. The study found that participants who ran with the AR-enhanced treadmill reported higher levels of immersion and perceived enjoyment compared to those running without AR. The virtual landscapes created a more engaging and visually appealing running environment, contributing to a more positive exercise experience. While these studies provide valuable insights into the potential of AR in enhancing the indoor running experience on a treadmill, there is still ample room for further research. Future investigations could delve into

the long-term effects of AR integration, examine the impact of different AR content and interfaces, and explore the combination of AR with other technologies, such as wearable sensors or haptic feedback, to create more comprehensive and immersive running experiences. In conclusion, previous research has demonstrated the positive effects of augmented reality on the indoor running experience on a treadmill [11]. The studies reviewed here highlight the potential of AR in enhancing user enjoyment, motivation, and performance during treadmill running. These findings lay the groundwork for further exploration and development of AR-based interventions that can revolutionize the way individuals engage with and benefit from indoor running activities.

RESULTS AND DISCUSSION

In this study, an AR System was developed, which allowed users to achieve an optima fat burning effect by giving an audio instructions as a couching advices, for use in the experiment. The system was developed as a mobile application for both Android and iOS, using the Unity software [12]. The goal is to keep the user's current heart rate in fat burning spectrum as long as possible during the one-hour exercise. Table 1 shows the hardware specification of the system needed to run the software.

Table 1. Smartphone specification used for testing.

Chipset	Qualcomm SM7125 Snapdragon 720G (8 nm)
Processor	Octa-core (2x2.3 GHz Kryo 465 Gold & 6x1.8 GHz Kryo 465 Silver)
Memory	6GB RAM
GPU	Adreno 618
Internal Storage	128GB
Main Camera	Quad 64 MP, f/1.9, 26mm (wide), 1/1.72", 0.8µm, PDAF 8 MP, f/2.2, 119˚ (ultrawide), 1/4.0", 1.12µm 5 MP, f/2.4, (macro), AF 2 MP, f/2.4, (depth)

As can be seen in Table 2, the following sensors were used to monitor and collect user's body data. The Huawei watch GT 2 is a smartwatch that offers various health and fitness tracking features, making it suitable for collecting users' body data. This smartwatch incorporates sensors and algorithms to monitor and record different biometric measurements, providing valuable insights into users' health and fitness levels. The smartwatch utilizes an optical heart rate sensor to continuously track and record users' heart rate throughout the day and during exercise sessions. This data can be used to monitor heart rate trends, assess exercise intensity, and identify any irregularities.

Table 2. Smart watch specification used for testing – HUAWEI WATCH GT 2.

Display	1,39 inch AMOLED 454 x 454 HD
GPS	Supported
Connectivity	Bluetooth: BT5.1, BLE / BR / EDR
Sensors	Accelerometer sensor Gyroscope sensor Geomagnetic sensor Optical heart rate sensor Ambient light sensor Air pressure sensor Capacitive sensor
Weight	Approximately 41 g
Size	45.9 x 45.9 x 10.7 mm

The fat burning zone refers to a specific heart rate range achieved during exercise, which is considered optimal for maximizing fat loss. Typically, this range is estimated to be between 64 % and 76 % of an individual's maximum heart rate. However, it is important to note that the specific fat burning zone can vary based on factors such as age, diet, and fitness level as shown in Table 3.

Table 3. Fat burning zones by age.

Age	Estimated Fat Burning Zone
20 years	128 – 152bpm
30 years	122 – 144bpm
35 years	118 – 141bpm
40 years	115 – 137bpm
45 years	112 – 133bpm
50 years	109 – 130bpm
55 years	106 – 125bpm
60 years	102 – 122bpm
65 years	99 – 118bpm
70 years	96 – 114bpm

Let us consider the example of a 40-year-old individual engaging in running laps. For people within this age group, the estimated maximum heart rate is 180 beats per minute (bpm). To enhance their overall fitness and effectively burn excess fat, it is recommended for the runner to aim for a heart rate ranging from approximately 115 bpm to 137 bpm during their running session [13]. By maintaining their heart rate within this range, users can optimize the fat-burning potential of their workout.

QR codes can be employed as unique digital indicators within an AR system to provide diverse feedback and coaching advice to users. By integrating QR codes into the AR experience, users can access additional information, instructions, and guidance related to their indoor running activities on a treadmill as can be seen in Figure 2.

Figure 2. Placing QR codes strategically in the user's environment.

The process begins with placing QR codes strategically in the user's environment, such as on the treadmill, walls, or other relevant locations. These QR codes serve as markers that the AR system can recognize and interpret. When the user scans a QR code using a mobile device or AR-enabled smart glasses, the AR system responds by overlaying digital content onto the user's view, augmenting their reality, see Figure 3.

Figure 3. Accessing personalized information and guidance on AR-enabled device.

QR codes can indeed be used as unique digital indicators within an augmented reality (AR) system to provide various types of feedback and coaching advice. By scanning QR codes with a smartphone or AR-enabled device, users can access personalized information and guidance relevant to their current activity or context. QR codes can enhance the AR experience and provide valuable feedback and coaching as follows:

- Contextual Information: QR codes placed strategically on equipment or within the environment can provide contextual information related to specific exercises or areas. When scanned, the AR system can overlay relevant instructions, technique tips, or safety guidelines directly onto the user's field of view, enhancing their understanding and performance,
- Exercise Demonstrations: QR codes can link to video demonstrations of exercises or movements. When users scan the code, the AR system can play instructional videos that show proper form, technique, and variations of the exercise. This visual feedback can help users improve their performance and reduce the risk of injuries,
- Performance Metrics: QR codes can be used to capture and display real-time performance metrics. For example, scanning a QR code on a cardio machine can bring up an AR interface showing data such as heart rate, pace, distance covered, and calories burned. This feedback allows users to monitor their progress, set goals, and make adjustments to their workout intensity,
- Virtual Coaching: QR codes can provide access to virtual coaching sessions or personalized training programs. Scanning the code can trigger the AR system to display pre-recorded or live coaching sessions, guiding users through workouts and offering motivational cues and tips,
- Progress Tracking: QR codes can be associated with user accounts or profiles. By scanning their personal QR code at the beginning and end of each session, users can track their progress over time. The AR system can display visual representations of progress, such as charts or graphs, highlighting improvements in performance or adherence to exercise routines,
- Interactive Challenges: QR codes can initiate interactive challenges or gamified elements within the AR system. Scanning a code may unlock mini-games, time trials, or virtual competitions, providing a fun and engaging way to enhance motivation and encourage users to push their limits,

By leveraging QR codes as unique digital indicators within an AR system, users can access a wealth of feedback and coaching advice tailored to their specific needs and goals. This integration creates an interactive and immersive fitness experience, enhancing users' engagement, motivation, and overall enjoyment of their exercise routines.

TEST SCENARIO – WITHOUT AUGMENTED REALITY SUPPORT

This research study explores the impact of AR on sport performance. The study relies on primary research data analysis to measure the effects. The research study investigates the utilization of AR and is primarily based on collected data. The data analysis was conducted using a newly developed application to generate results.

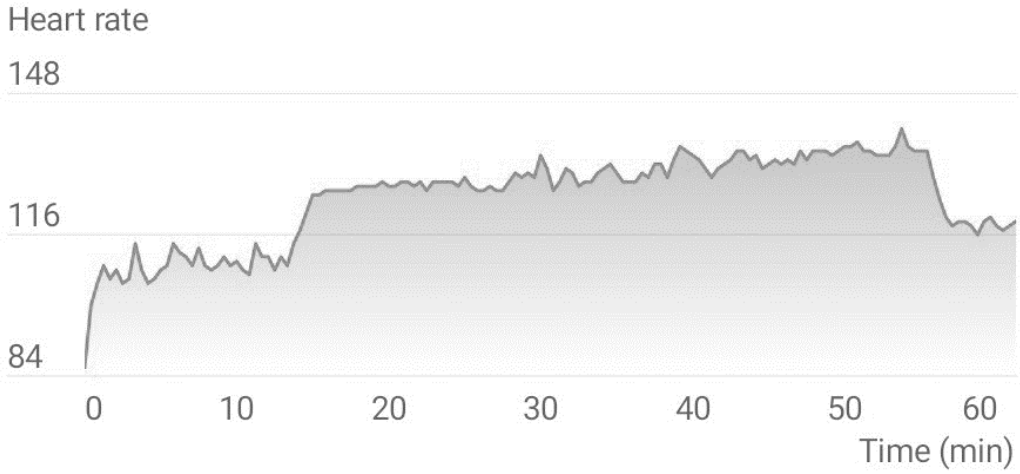

Figure 4. User's current heart rate during exercise without AR support.

Figure 4 shows the User's current heart rate during exercise without AR support, and a higher heart rate is measure than needed for optimal fat burning.

Figure 5. Classification of the measured heart rate.

As can be seen on the Figure 5, the fat burning time was not optimal during the exercise. The reason for this is the higher heart beat rate.

TEST SCENARIO – WITH AUGMENTED REALITY SUPPORT

This test scenario aims to investigate the use of AR to enhance the indoor running experience on a treadmill. The study seeks to assess the potential benefits and challenges associated with integrating AR technology into treadmill running, focusing on user perception, physical performance improvements, and psychological factors. The developed system gives audio-visual feedback to users. The test will involve participants engaging in treadmill running sessions with and without AR integration, allowing for a comparative analysis of the effects. By using the developed AR coaching software, the user`s heart rate was kept in a lower region needed for optimal fat burning process as can be seen in Figure 7.

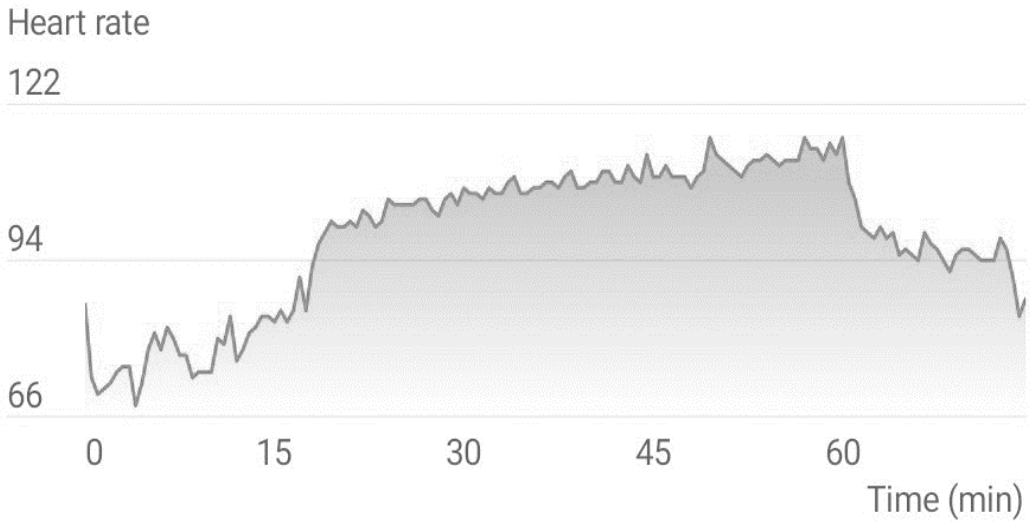

Figure 6. User's current heart rate during exercise with AR support.

The test scenario will be conducted over a specific duration, consisting of multiple sessions. Each participant will complete two types of treadmill running sessions: one without AR integration (control condition) and another with AR enhancement (experimental condition). The order of the sessions will be randomized to avoid any bias. Participants will be given a break of at least one day between sessions to minimize fatigue and ensure a fair comparison.
The experimental condition will involve the use of an AR system specifically designed for treadmill running.

Figure 7. Classification of the measured heart rate.

The AR system will provide interactive elements such as virtual landscapes, coaching avatars, and real-time progress tracking. The system will be calibrated for each participant to ensure accurate tracking and synchronization with their running pace. The research results will provide insights into the effects of AR on the indoor running experience. The findings will include quantitative data comparing physical performance metrics, subjective user feedback, and psychological assessments between the control and experimental conditions. The results will shed light on the potential benefits and challenges associated with using AR to enhance treadmill running and provide recommendations for future development and implementation.

CONCLUSIONS

This research study focused on investigating the use of augmented reality (AR) to enhance the indoor running experience on a treadmill. The study aimed to explore the potential benefits and challenges associated with integrating AR into treadmill running, with a focus on user perception and experience, physical performance improvements, and psychological factors. The results of this research study provide valuable insights into the use of AR to enhance the indoor running experience on a treadmill. Firstly, regarding user perception and experience, the qualitative and quantitative data collected indicate a positive reception of AR-enhanced treadmill running. Participants reported higher levels of enjoyment, engagement, and immersion when using AR during their running sessions. The incorporation of interactive elements, such as virtual landscapes and coaching avatars, contributed to a more immersive and stimulating exercise environment. These findings highlight the potential of AR to enhance the overall running experience, making it more enjoyable and engaging for individuals. Secondly, in terms of physical performance improvements, the study revealed significant enhancements when utilizing AR during treadmill running. Participants demonstrated improved performance metrics, including increased speed, endurance, and calorie expenditure, compared to traditional treadmill running. The interactive features provided by AR, such as real-time progress tracking and feedback, were instrumental in motivating participants to push their limits and achieve higher fitness outcomes. These findings suggest that AR has the potential to enhance physical performance during indoor running, providing individuals with an effective tool to improve their fitness levels. Lastly, the research study explored the impact of AR on psychological factors related to treadmill running. The results indicate that AR can positively influence motivation, self-efficacy, and adherence to running routines. Participants reported feeling more motivated and confident when using AR, as the immersive and interactive nature of the technology created a sense of accomplishment and progress. The integration of gamification and persuasive technology techniques further enhanced the psychological impact, making participants more inclined to continue their exercise activities. These findings highlight the potential of AR to positively influence individuals' psychological well-being and contribute to long-term adherence to regular exercise. Overall, the results of this research study demonstrate the potential of augmented reality to enhance the indoor running experience on a treadmill. The findings suggest that AR can positively impact user perception, physical performance, and psychological factors related to treadmill running. By creating a more enjoyable and immersive exercise environment, AR has the potential to motivate individuals and improve their fitness outcomes. These results contribute to the growing body of knowledge on the use of AR in fitness and exercise domains, offering insights for the development of future applications and interventions. It is important to acknowledge some limitations of this research study. The study sample may not fully represent the diverse population of treadmill runners, and the research was conducted over a specific duration, limiting the assessment of long-term effects. Additionally, the study primarily focused on subjective measures of user perception and experience, with relatively fewer objective measurements of physical performance. Future research could address these limitations by incorporating larger and more diverse samples, conducting longitudinal studies, and employing more comprehensive performance measurements. In conclusion, the investigation of augmented reality to enhance the indoor running experience on a treadmill offers promising results. The positive impact on user perception, physical performance improvements, and psychological factors highlight the potential of AR as a tool to motivate and engage individuals in their fitness journeys. Further research and development in this area can lead to the creation of innovative AR applications that revolutionize the way individuals approach indoor running and exercise, ultimately promoting healthier and more active lifestyles.

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MANAGING NEGATIVE EMOTIONS CAUSED BY SELF-DRIVING

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ABSTRACT

Reducing the negative emotions experienced in Self-Driving cars is key to increasing the number of users. To reduce anxiety, AI-based systems that measure the physiological response of passengers, mainly using biometric data, are used. In the future, the vehicle must be sufficiently emptical to reduce people's distrust. The potential for hacking is still one of the main sources of anxiety about Self-Driving cars. To live with this difficulty, users need to be confronted with what machine learning means and accept that, contrary to expectations, Self-Driving cars cannot yet be 4 or 5 times safer than manual driving. To achieve the greater good – energy savings and lower emissions, efficient transport networks, greater use of digital infrastructure, safer and more usable public spaces, etc. – we need to be patient with Self-Driving vehicles.

KEY WORDS

self-driving cars, acceptance, trust, hacking

CLASSIFICATION

ACM: J.4, K.4, H.1.1
APA: 4010
JEL: O18, R41
PACS: 01.70. + w

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NEGATIVE EMOTIONS AND BELIEFS ABOUT SELF-DIRECTION

Studies have investigated the negative feelings of Self-Driving users, as their market uptake and acceptance also depends on reducing users' doubts. Of the many negative emotions, the most commonly identified in previous research are 'anxiety', 'ungrounded fear', 'hesitation' and 'overload'. People fear that AI could take control and drive the vehicle without human intervention, and they also fear that Self-Driving cars' systems could be hacked, which explains the 'fear' [1].

Users are 'sceptical' about whether they should try the vehicle, and this is most common among older people, car addicts and those living in less populated areas. And the feeling of being 'overwhelmed' is related to the lack of information for many about how the car will get the user from point A to point B [2].

The fear of technology taking control of our lives – and the possibility that it may not always do so benignly – is deep-rooted and has been present in popular culture long before the first Self-Driving experimental vehicle was on the market [3].

A sense of 'safety' also helps predict the likelihood of technology adoption, but people feel much safer and more protected when they drive their own car. This sense of insecurity influences high levels of anxiety about AVs. The perception of 'efficiency', or 'productivity' is also problematic for the AV industry. People expect distracting technologies to make them feel more efficient and productive, but if they do not really feel that way when using the technology, they are unlikely to change their existing habits.

AI-BASED SYSTEMS TO REDUCE NEGATIVE EMOTIONS

Negative emotions such as anxiety and stress reactions resulting from the mental processes of human functioning can be experienced when using Self-Driving cars. To reduce the unwanted feelings experienced in this way, systems are used that infer emotions based on pulse and blood pressure. Depending on the user's emotional state, the vehicle recommends colours and music to stabilise the emotional state. In a future study, emotions will be classified based on situational and environmental factors and biometric information of the user AI devices [4].

The acceptance of a human-like AI device is higher if it can show empathy towards the human consumer. Therefore, if the auto is able to continuously monitor human emotional states in a situation-dependent manner, strong intelligence and empathic behaviour will help the user to adopt AI devices [5].

Fear of hacker attacks is a combination of emotional and cognitive reactions to possible stimuli from the external environment. Machine Learning, Deep Learning, can be associated with learning from data, which is a characteristic of the way AI systems operate.

In so-called Input attacks or Input attacks, attackers alter the input data provided to the AI system to manipulate the output desired by the attackers. Another way of interfering is the so-called 'poison attack', where attackers either alter the data used to train the system or manipulate the data training. These types of attacks mainly occur during the development and training of the system, i.e. during the initial process of AI system development. The third most well-known mode is so-called offline learning, where attackers learn offline to discover information for future attacks.

In the case of a Self-Driving car, this can be done by the attacker slightly modifying or partially obscuring a stop sign on the road to trick the AI system. This type of attack is called an 'input attack' in the AI system. These attacks can be defended against by combining input data from multiple sources, using data aggregation and algorithms [6].

One method to protect Self-Driving vehicles is to have connected Self-Driving vehicles (CAVs) train ML (machine learning) models locally and upload them to the blockchain network, thus using the 'collective intelligence' of the CAVs while avoiding large amounts of data transfer. The blockchain is then used to protect the distributed learning models. The performance of the presented framework is evaluated by simulations [7].

Another method is to generate adversarial datasets by a conventional attack engine, which are easily detected by ML models for CAV behaviour detection. Supervised learning algorithms are developed over time-series data from the attacker dataset, then translated into the neural network and recurrent long short-term memory by deep learning (DL) models [8].

REDUCING NEGATIVE EMOTIONS THROUGH TOLERANCE OF TRAFFIC RISKS

A study with participants in South Korea and China shows that Self-Driving cars should be safer than human-driven vehicles, and that since Self-Driving is seen as a new, less controllable activity than human driving, people would demand higher safety standards for Self-Driving.

Like the Chinese participants, the South Korean participants wanted Self-Driving to be 4-5 times safer than human driving. The number of fatal accidents caused by Self-Driving cars in both countries would have to be 5-8 times lower to be acceptable to the public. To ensure the benefits and usefulness of vehicles, people must tolerate traffic risks that are higher than their expected risk [9].

Like all new technologies, autonomous driving technology will be fully operational and reliable, but will need more time for testing and regulatory approval. Self-Driving cars will face higher external costs, higher accident risk rates and higher delays for other road users, i.e. higher testing and regulatory requirements compared to other technological innovations.

It is essential to recognise that the frequent interactions, unexpected interactions and weather conditions with other unpredictable objects – non Self-Driving vehicles, pedestrians, cyclists, animals, to name but a few – and the frequent interactions with the vehicle's control, mean that Self-Driving vehicles require even more complex software than aircraft, which 'only' need to follow a route without constantly monitoring the environment and avoiding sudden obstacles [10].

INCREASING TRUST IN TECHNOLOGY

The interest in using Self-Driving cars is based on a lower perception of risk, which can be reduced by increasing the perception of the usefulness of Self-Driving and the confidence in the technology. People's perceptions of advanced vehicle technologies are mainly associated with individual experience and knowledge. Their acceptance is largely influenced by the fact that many people have simply never encountered the technology and know little about it [11].

In terms of adopting Self-Driving and reducing negative feelings, it may be useful to link Self-Driving to the integration of technological developments in smart cities. Through the development of smart cities across digital platforms, on-demand and Self-Driving transport is enabled for the user:

- the best and most cost-effective choice of possible routes and modes of transport,
- tools for safer urban mobility through connected and autonomous vehicles, because Self-Driving vehicles can communicate with other Self-Driving vehicles and ITS,
- more efficient use of travel time,
- energy savings and lower emissions, efficient transport networks, greater use of digital infrastructures, safer and more usable public spaces (parking, charging networks, cycle

lanes, electric cars, car sharing, traffic reduction, smart flows),
- the expectation that by 2050 half of all vehicles sold and 40 % of journeys will be autonomous,
- car-sharing and ride-sharing, reducing car ownership, car dependency and parking demand,
- and increasing accessibility to cars [12],
- increased safety in transport and thus a reduction in the number of accidents,
- easier transport for elderly and disabled people,
- reduce stress levels for drivers [13-19].

CONCLUSIONS

In order for negative feelings and cognitions about the zone to be resolved, more information needs to be provided to the user. On a cognitive level, it is necessary to prepare what machine learning means and what algorithms are currently used to train the memory of Self-Driving cars in order to make them safer.

On an emotional level, users need to be influenced, which can be monitored by the car by measuring biometric data, or by using its own tools – temperature control, music, lights, radio stations, IoT coordination – to intervene in ways that reduce the amount of stress, anxiety and other negative emotions during the journey.

Finally, understanding and accepting that Self-Driving, one of the many AI-based services that will help future life, is essential to humanity's ability to better use the Earth's carrying capacity. This requires asking for people's patience and giving them accurate information about what Self-Driving can do at this stage, where the legal and ethical regulations stand and what the limits are for its application.

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FUZZY AGGREGATORS – AN OVERVIEW

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ABSTRACT

The article deals with mathematical formalism of the process of combining several inputs into a single output in fuzzy inteligent systems, the process known as aggregation. We are interested in logic aggregation operators. Such aggregators are present in most decision problems and in fuzzy expert systems. Fuzzy inteligent systems are equipped with aggregation operators (aggregators) with which reasoning models adapt well to human reasoning. A brief overview of the field of fuzzy aggregators is given. Attention is devoted to so called graded logic aggregators.. The role of fuzzy agregators in modelling reasoning and the way they are chosen in modelling are pointed out. The conclusions are given and research in the field is pointed out.

KEY WORDS

aggregation, fuzzy intelligent systems, conjunction, disjunction, compensatory operators

CLASSIFICATION

ACM: D.1.1.
JEL: O31
PACS: 89.70.H

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INTRODUCTION

In order to achieve an intelligent system, we need intelligence and a device – a computer. In order to implement intelligence with a computer, we need to model intelligence (knowledge representation), we need the automation of the process of (intelligent) reasoning to get new ideas about the world, and we need to implement the process of intelligent action based on new ideas [1].

Logic is one of tools for modelling the observable properties of human reasoning. We use logic to implement decision-making process or knowledge representation and automatic reasoning. In the last century, it has been noticed that the classical two-value logic is a limited framework for modelling the representation of knowledge and human reasoning. The ways to expand the possibilities of representation by logic have been proposed. One of the most fruitful of these attempts was initiated by Lotfi Zadeh [2].

Zadeh has expanded the idea of the degree to which an element belongs to a set from two values, 0 (for non-belonging), and 1 (for belonging), to a range between 0 and 1, which allows the development of models in which key elements are not precise numbers but vague sets, i.e. a class of objects in which the transition from non-belonging to belonging is gradual, not abrupt. Zadeh described the mathematical theory of fuzzy sets and the corresponding fuzzy logic (a kind of a continuous logic with truth value from [0, 1], instead as in standard logic where each sentences have truth value from {0, 1}, there is no "in between"). Zadeh, also, proposed appropriate set and logical operations, which improved the expressiveness of the model, i.e. enabled dealing with uncertain and vague information common in human reasoning. Operations on fuzzy sets of unions, intersection and complement are defined using *max*, *min* and $1 - \mu(x)$ operations, (where μ is degree of membership of element x in a fuzzy set), which correspond to fuzzy logic functions disjunction, conjunction, and negation. In fuzzy intelligent systems [3], one of the key issues is the problem of aggregation of fuzzy information represented by membership functions (whose values are in [0, 1]). Fuzzy membership can be interpreted as a degree of truth, so we have fuzzy logic aggregation. Aggregation operators combine multiple input values into one output value, which represents all input values.

In this article, the aggregation operator (aggregator), present in fuzzy intelligent systems, is considered. In Section 2, the considered problem is formulated. In Section 3 a formal definition of aggregator is given, as well as main classes of that operator. Section 4 deals with compensatory aggregators. Special attention is devoted to the aggregator called graded conjunction/disjunction. The selection of an aggregator is discussed in Section 5. Section 6 contains the conclusions. A list of references is given.

AGGREGATION

In fuzzy intelligent systems, one of the key problems is the problem of agrregating fuzzy information represented by membership functions (whose values are in [0, 1]). Aggregators combine multiple input values into one output value, which represents all input values.

For example, the general form of a fuzzy multicriteria decision-making system is shown in the Figure 1.

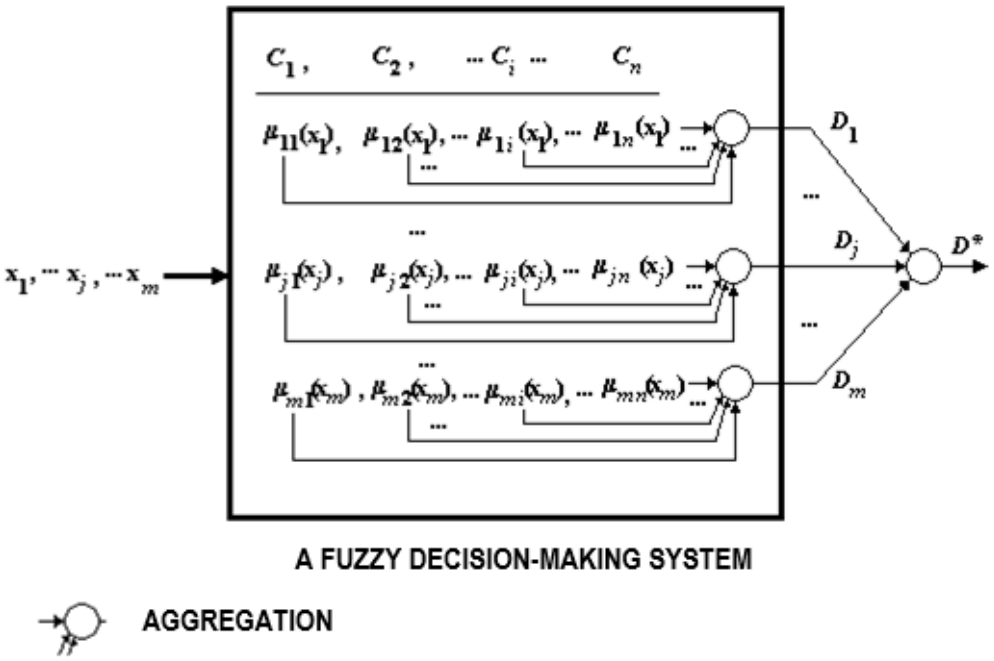

Figure 1. Aggregation in a type of fuzzy multicriteria decision-making system.

In Figure 1 meanings of symbols are as follows:

- $\mathbf{x}_i$, $i = 1, 2, ..., m$, are vectors of object properties, which are considered in decision-making process;
- C_j, $j = 1, 2, ..., n$, are decision-making criteria;
- $\mu_{ji}(\mathbf{x}_j)$, $j = 1, 2, ..., m$, $i = 1,2, ...,n$, $\mu_{ji} \in [0, 1]$, are scores – degrees in which an object $\mathbf{x}_i$ (or its property) satisfies the criteria C_j, μ_{ji} is the degree of fuzzy membership in a fuzzy set of object property that completely satisfies criterion C_j;
- D_i, $i = 1, 2, ..., m$, $D_i \in [0, 1]$, are decisions (performance indices) of an object $\mathbf{x}_i$ with respect to all the criteria C_j; decisions D_i are obtained by aggregation of information $\mu_{ji}(\mathbf{x}_j)$, using appropriate aggregation operation.
- The decision D^*, on object $\mathbf{x}_i$ that best satisfies all the criteria C_j, $j = 1, 2, ..., m$, is obtained by aggregation of decisions D_i – using suitable aggregation operation, appropriate for the considered problem.

The procedure used to combine the scores by which the object $\mathbf{x}_i$, or one of its characteristics, satisfies the criteria C_i into one decision D_j, i.e. D^*, is:

$$D_j = A_1(\mu_{j1}(\mathbf{x}_j), ..., \mu_{jn}(\mathbf{x}_j)), D^* = A_2(D_1, ..., D_m). \quad (1)$$

The symbol A in the above expressions indicates aggregators. In the more general case, expressions (1) can be given in the form

$$a = A(a_1, ..., a_r), \quad (2)$$

where a_j, $j = 1, ... , r$, $r \in \{n, m\}$, and a are values from interval of degrees of membership [0, 1].

Fuzzy operators, min for conjunction and max for disjunction, for A_1 or A_2 in (1), are to restrictive in practice and do not coincide with how people perform this operations. This lead to studies of other aggregators. In the huge majority of applications, primarily in decision-support systems, aggregators are developed as models of observable human reasoning.

So, we are interested in graded logic aggregators, i.e., aggregators that aggregate degrees of truth. Such aggregators are present in most decision problems. We assume that decision-making commonly includes evaluation of alternatives and selection of the most suitable alternative, Figure 1.

Some other examples of applications of fuzzy set theory, for modelling complex and perhaps incompletely defined systems, use knowledge bases in which knowledge is represented by a base of fuzzy rules. These applications include fuzzy rule-based systems (and fuzzy logic control). What is typical for these situations is the set of rules, which emphasizes the aggregation components, also.

DEFINITION AND CLASSES OF AGGREGATORS

Let us aggregate n degrees of truth $\mathbf{x} = (x_1,...,x_n)$, $n > 1$, $x_i \in I = [0, 1]$, i=1, ..., n. A *general logic aggregator* A: $I^n \rightarrow I$ is defined as a continuous function that is nondecreasing in all components of $\mathbf{x}$:

$\mathbf{x} \leq \mathbf{y}$ implies $A(\mathbf{x}) \leq A(\mathbf{y})$ for every $\mathbf{x}, \mathbf{y} \in [0, 1]^n$, (nondecreasing monotonicity);

and satisfies the boundary conditions (idempotency in extreme points):

$$A(\underbrace{0, 0, \ \ldots, 0}_{n \text{ times}}) = 0 \text{ and } A(\underbrace{1, 1, \ \ldots, 1}_{n \text{ times}}) = 1.$$

It is assumed that the vector inequality is componentwise.

Typical examples of aggregators are: weighted means, medians, *OWA* operators and *t*-norms / *t*-conorms. But there are many other aggregators and an infinite number of aggregator members in most families. Not all aggregators have the same properties, so they are grouped into separate classes according to the properties they satisfy.

CLASSES OF AGGREGATORS

Some classes of aggregators are, as follows:

conjunctive aggregators A have the following property:

$$\min(\mathbf{x}) \geq A(\mathbf{x});$$

disjunctive aggregators A have the following property:

$$A(\mathbf{x}) \geq \max(\mathbf{x});$$

averaging aggregators A if they are bound by:

$$\min(\mathbf{x}) = \min_{i=1,\ldots,n} x_i \leq A(\mathbf{x}) \leq \max_{i=1,\ldots,n} x_i = \max(\mathbf{x});$$

mixed, if they are neither conjunctive, disjunctive or averaging;

idempotent, if $A(t, \ldots, t) = t$ for any $t \in [0, 1]$;

symmetric (commutative) if $A(\mathbf{x}) = A(\mathbf{x}_P)$ for any $\mathbf{x} \in [0, 1]^n$ and any permutation P of $\{1, \ldots, n\}$.

Monotonicity and idempotency implies averaging behavior.

MAIN CLASSES

Conjunctive/Disjunctive Aggregators

For this class of aggregators holds duality: for strong negation N,

$$A_N(\mathbf{x}) = N(A(N(\mathbf{x}))),$$

is N-dual of operator A.

In a special case of standard negation:

$$A_d(x_1, x_2, \ldots, x_n) = 1 - A(1 - x_1, 1 - x_2, \ldots, 1 - x_n).$$

Duals of conjunctive operators are disjunctive operators, and vice versa, duals of disjunctive operators are conjunctive operators

Among conjunctive/disjunctive aggregators are *t* (triangular) norms – conorms, copulas and their duals, and others, [3].

Averaging Operators

Averaging operators model trade-offs between goals. These include:

- weighted arithmetic means: $M_{\mathbf{w}}(\mathbf{x}) = \sum_{i=1}^{n} w_i x_i$, $\sum_{i=1}^{n} w_i = 1$ (in the general case they do not satisfy the condition of commutativity);
- weighted quasi-arithmetic means: $M_{\mathbf{w},g}(\mathbf{x}) = g^{-1}(\sum_{i=1}^{n} w_i g(x_i))$;
- ordered weighted averaging (Yager) $OWA_{\mathbf{w}}(\mathbf{x}) = \sum_{i=1}^{n} w_i x_{(i)}$;
- generalised ordered weighted averaging: $OWA_{\mathbf{w},g}(\mathbf{x}) = g^{-1}(\sum_{i=1}^{n} w_i g(x_{(i)}))$;
- weighted ordered weighted averaging (*WOWA*) aggregator (Torra), combines advantages of *OWA* operator and weighted means operator;
- other means (identric, logarithmic, …);
- median, weighted median, quasi-median;
- fuzzy integrals: Choquet**,** Sugeno, and particular cases; (the Choquet integral allows expressing interaction between criteria in multicriteria decision-making, and, for example, expressing (physician's) preferences [4]).

Other Aggregators, Not Conjunctive/Disjunctive Or Averaging

In that class of aggregating operators are uninorms, nulnorms, T-S operators, symmetric sums, and others operators.

COMPENSATORY AGGREGATORS

Fuzzy logic theory offers a multitude of connectives that can be used as aggregators to aggregate membership values representing uncertain information. These operators can be classified, as we have seen, into the following three general classes: conjunction, disjunction (Section 3.2.1), and compensation operators (Section 3.2.2). In the case of Zadeh's operators, *min* for conjunction and *max* for disjunction, used as aggregators, only inputs with extreme values affect the value of the output fuzzy set. However, both intuitive and formal criteria of human reasoning contain numerous requirements that are combined using models of simultaneity and substitutability (partial conjunction and partial disjunction), which set requirements for further development of fuzzy aggregators. In [5], logic operators based on continuous transition from conjunction to disjunction, were introduced, see also [6]. Results from [5] were strong contribution to development of aggregation as part of a soft computing. Those results, [6], improve Zadeh's approach in dealing with uncertain and vague information common in human reasoning.

So, any operator *A*, that, for example, applies to two arguments a_1 and a_2 from [0, 1], is compensatory operator if it satisfies the following:

$$\min(a_1, a_2) \le A(a_1, a_2) \le \max(a_1, a_2).$$

After [5], others also dealt with this issue of compensatory operators, the review is given in [3; p.183].

The disjunction (union) operator provides full compensation, and the conjunction (intersection) operator does not allow compensation. The arithmetic mean is neutral in terms of disjunction and conjunction. It represents the midpoint between them and represents a special case of weighted averaging.

In [5] andness and orness were defined by Dujmović as the level of simultaneity and substitutability, respectively, of the aggregation. They are defined in terms of the similarity to minimum and maximum, respectively. Andness was introduced as a degree of conjunction, Orness was introduced as a degree of disjunction. A high orness permits that a bad criteria be compensated by a good one. On the other hand, a high andness requires both criteria to be satisfied to a great degree. Andness and orness are related and add up to one. So, andness-directed transition from conjunction to disjunction (introduced in 1973 to its current status [6]), is the history of an effort to interpret aggregation as a soft computing propositional calculus.

In some cases, we need to consider stronger functions in the sense that the outcome of an aggregation is less than the minimum or it is larger than the maximum. Fuzzy logic provides these type of operators, they are called t-norms and t-conorms, ($xy \leq \min(x, y)$, product t-norm is still more conjunctive than minimum). Because of this relationship, while minimum has an andness equal to one, product t-norm has an andness that is larger than one. When operators are between minimum and maximum, andness is for any number of inputs in the range [0, 1]. Operators that can return values smaller than the minimum (as t-norms) or larger than the maximum (as t-conorms) will provide andness outside [0, 1], reaching the minimum and the maximum of the interval with drastic disjunction and drastic conjunction [6].

The resulting analytic framework is a graded logic [6], based on analytic models of graded simultaneity (various forms of conjunction), graded substitutability (various forms of disjunction) and complementing (negation).

Basic graded logic functions can be *conjunctive*, *disjunctive*, or *neutral*. Conjunctive functions have andness α greater than orness ω, $\alpha > \omega$. Similarly, disjunctive functions have orness greater than andness, $\alpha < \omega$, and neutral is only the arithmetic mean where $\alpha = \omega = 1/2$. Between the drastic conjunction and the drastic disjunction, we have andness-directed logic aggregators that are special cases of a fundamental logic function called *graded conjunction/disjunction* (GCD) [6]. GCD has the status of a logic aggregator, and it can be idempotent or nonidempotent, as well as *hard* (supporting annihilators) or *soft* (not supporting annihilators). The annihilator of hard conjunctive aggregators is 0, and the annihilator of hard disjunctive aggregators is 1.

The whole range of conjunctive aggregators is presented in Figure 2 [6].

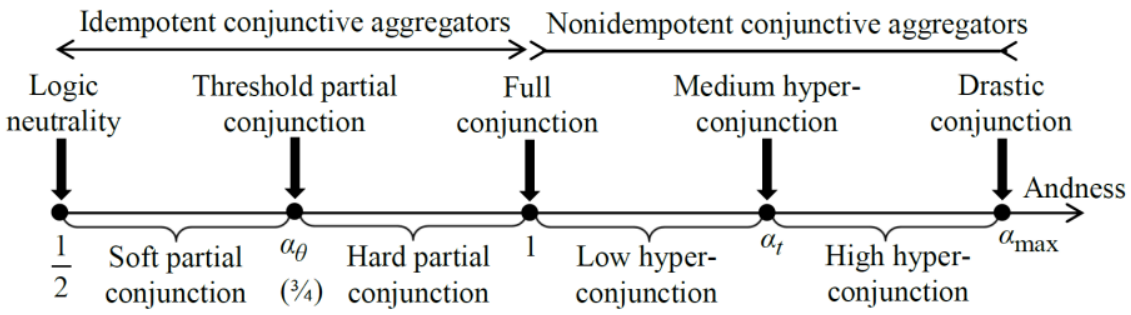

Figure 2. The range of conjunctive aggregators: border aggregators and aggregation segments [6].

A detailed classification of GCD aggregators, based on combinations conjunctive/ disjunctive, idempotent/nonidempotent, and hard/soft aggregators is presented in Table 1 [6].

Table 1. Classification of andness-directed graded logic (GL) functions and aggregators [6].

	Logic function/aggregator		I	T	A	Global andness (α)	
GRADED LOGIC FUNCTIONS	CONJUNCTIVE	Drastic conjunction	N	H	0	$\alpha = \alpha_{max} = n / (n - 1)$	BASIC GL AGGREGATORS
		High hyperconjunction	N	H	0	$\alpha_t < \alpha < \alpha_{max}$	
		Medium hyperconjunction	N	H	0	$\alpha = \alpha_t = (n\,2^n - n - 1) / (n - 1)\,2^n$	
		Low hyperconjunction	N	H	0	$1 < \alpha < \alpha_t$	
		Full conjunction	Y	H	0	$\alpha = 1$	
		Hard partial conjunction	Y	H	0	$\alpha_\theta \le \alpha < 1;\ 1/2 < \alpha_\theta < 1$	
		Soft partial conjunction	Y	S	-	$1/2 < \alpha < \alpha_\theta$	
	Neutrality		Y	S	-	$\alpha = 1/2$	
	DISJUNCTIVE	Soft partial disjunction	Y	S	-	$1 - \alpha_\theta \le \alpha < 1/2$	
		Hard partial disjunction	Y	H	1	$0 < \alpha \le 1 - \alpha_\theta$	
		Full disjunction	Y	H	1	$\alpha = 0$	
		Low hyperdisjunction	N	H	1	$1 - \alpha_t < \alpha < 0$	
		Medium hyperdisjunction	N	H	1	$\alpha = 1 - \alpha_t$	
		High hyperdisjunction	N	H	1	$\alpha_{min} < \alpha < 1 - \alpha_t$	
		Drastic disjunction	N	H	1	$\alpha = \alpha_{min} = -1/(n - 1)$	

Columns: **I** = idempotent, **Y/N =** yes/no; **T =** type, **H/S** = hard/soft; **A** = annihilator

All disjunctive aggregators can be realized as De Morgan duals of conjunctive aggregators, so, it is sufficient to analyse only the conjunctive aggregators.

In the case of using weighted conjunctive means or weighted disjunctive means as a aggregator, the value of the output fuzzy set is affected by all the inputs or by outputs of all rules in a case of a fuzzy rule-based system.

In addition, weighted conjunctive means and weighted disjunctive means enable continuous weighting of the influence of the output of individual rules on the total output fuzzy set.

CHOOSING AGGREGATOR

The aggregator is chosen on the basis of available data about modelled system and about application requirements of developed (fuzzy) intelligent system. Requirements are translated

into mathematical properties: idempotency, neutral element, commutativity, and similar. These mathematical properties, in turn, define the class of aggregators. The data allows us to select specific members of the aggregator families that are best suited to the data.

In the case of GCD aggregator, the specification of requirements for aggregator consists of choosing features of an aggregator: *idempotent or nonidempotent*; s*imultaneity or substitutability*; *hard or soft*; *the desired strength of simultaneity/substitutability* (andness/orness); *the degrees of importance.*

The andness-directed interpolative method for implementing GCD [6], consists of implementing the border aggregators shown in Figure 2 and then using interpolative aggregators in the range of andness between them. This method can be used to implement all logic GCD aggregators shown in Table 1.

The family of graded logic functions and similar aggregators, investigated in [6], includes GCD (introduced in 1973), various OWA aggregators (introduced in 1988), aggregators based on fuzzy integrals (introduced in 1974), and various means (introduced more than 2000 years ago).

CONCLUSIONS

Models of combining information are integral parts of the methods of implementation of artificial-intelligent systems. In many applications, and especially in the development of artificial-intelligent systems, there is a need to aggregate not only numerical, but also linguistic, qualitative, organized information.

Research in the field of aggregators includes purely theoretical studies (which include sophisticated mathematics), the development of practical aggregation tools (programming), as well as the applications of aggregators.

The process of aggregating information occurs in many applications related to the development of not only fuzzy systems but also other intelligent systems: neural networks, vision systems, robotics, multicriteria decision making systems in general, robotic networks (for example, platforms in smart cities [7], Self-Driving car networks [8]) and others. Aggregators represent a current research topic [9, 10]. For example, in [11] a new approach is proposed upon which a new theory of aggregation could be developed. The aggregation method dealing with so called order-2 fuzzy sets is considered in [12]. Work is also underway on the development of aggregators for aggregating arguments of various natures (numerical, qualitative, mixed), as well as on the systems for determining the parameters of aggregators (learning systems).

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ASSESSMENT OF THE IMPACT OF THE COVID-19 CRISIS ON TRANSPORTATION AND MOBILITY – ANALYSIS OF APPLIED RESTRICTIONS

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ABSTRACT

The COVID-19 pandemic has imposed radical transformations in many areas and caused a negative impact on the transportation sector and mobility activities due to the successive waves of mutated coronavirus strains. The study proposed an assessment of the impact of the pandemic on passengers' use of different transport modes and travel activities by conducting a survey in two capitals, Budapest – Hungary, and Amman – Jordan, based on the frequency of usage of mobility services before and during COVID-19, associated with various socio-economic and demographical characteristics. The SPSS software v.26 and Structural Equation Models, SEM were used for analysing and emphasizing the hypotheses. Investigations show a significant shift in transport modes and travel activities with the applied travel restrictions, while mobility patterns are directly correlated with the spread of the COVID-19 virus.

KEY WORDS

COVID-19 pandemic, mobility activities, travel restrictions, non-motorized modes, motorized modes

CLASSIFICATION

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INTRODUCTION

The research will focus on the impact of the COVID-19 pandemic on mobility and transportation and whether the procedures and forced restrictions that have been applied at that time were efficient and worked effectively to prevent the spread of the disease. Mobility and movement are essential for sustaining life and achieving economic, social and environmental integration. Unfortunately, the errors that occurred during the waves of the COVID-19 pandemic paralysed life in several respects causing negative impacts. Therefore, researchers should cooperate to conduct a comprehensive plan that – by including all necessary dimensions, by assessing the risks and consequences of COVID-19, and by taking into account all threats and obstacles that occured - will – be the basis for other comprehensive strategic sustainable plans in the future. It is a fact that even if we have begun to recover from this crisis and the disease has been contained to some degree, this does not mean that the dangers disappeared or the threats will not return in one way or another. It was necessary to study the impact of the pandemic from the users' point of view and their satisfaction in light of the applicable preventive measures and instructions, as well as to measure the impact on the sustainability of the transport sector, in addition to anticipating the future of digital transformation from the users' perspective. The seriousness of the pandemic compared to others meant that it was not confined to a certain region to be quarantined and contained as its predecessors. Unfortunately, the disease developed itself so that vaccines did not constitute complete protection, and the fact that some people disregarded safety measures, whether when using modes of transportation or in other places, led to disasters. Governments can achieve sustainability if they maintain sustainable transportation balances. A sustainable transportation system is defined as "one in which (a) current social and economic transportation needs are met in an environmentally conscious manner while (b) future generations' ability to meet their own needs is not jeopardized". However, the public transport system will not be successful unless it satisfies passengers, as it is essential to increase the use of public transport at a regional level, it is essential to stop reducing the number of public transport service routes to decrease travel times, cover more comprehensive areas, and improve service quality to ensure customer satisfaction [1]. Challenges regarding transportation infrastructure planning are connected with development, including current issues such as the debate on how to achieve "transport sustainability" [2, 3] or "sustainable mobility" [4]. The evaluation intelligent mobility model consists of four indicators to measure and assess the sustainability of the system these are: Efficiency, Technology integration, Traffic congestion, and Accessibility rate. If they do not work as they should, a major delay will be caused spreading all over the day. As it continues to rush hours, a smart system should be applied to solve this problem by providing accurate data and convenient information and suggesting suitable directions all along the road until arriving at the destination [5]. The systems should include a combination of ICT and AI that help people navigate other smart public transport services; so when it works effectively and efficiently, it will serve as the backbone [6].

LITERATURE REVIEW

Since mobility played a major role in the spread of COVID-19 disease, most countries applied restrictions for commuters within transport modes to control the spread as much as possible. During the COVID-19 pandemic some choose to use public transport for long-distance trips, while others have entirely shifted to other motorized or non-motorized modes. In many cities hygiene, cleanliness, temperatures checking, safe social distancing, masks, and gloves were mandatory, or at least masks were made compulsory [7]. For this and for other reasons passengers tried to shift to modes that are less congested or avoid travelling during peak hours as much as they can. In some developed countries, innovative technology, AI, and mobile applications for checking were used; Beijing allows access just through appointment to prevent

crowding, Singaporeans used a Bluetooth signal between devices to prevent close distancing and to avoid connecting with infected people, some countries urged people to download an application to mobiles and smart devices that contain demographic data not just for transport access but also in any public places and buildings [8]. Many attempts to study the current situation in the presence of COVID-19, and because the transportation system has a wide flexibility and can be evaluated and assessed for any risk with a comprehensive performance to reach an optimal solutions [9], and to search for the practical means of application for the benefit of the transportation sector by evaluating the current situation, making simulations similar to reality and studying the modes and activities before and during the pandemic. Several observations, qualitative and quantitate studies found that to make a comparison between before and during the COVID-19 pandemic the suitable scenario is to measure the frequency of use [10]. Many researchers conducted interesting studies to assess the various transportation risk management, for example, but not limited to, some studies that assessed the air transport combined with risk management [11], while other studies assessed only roads transport [12]. COVID-19 and other global illnesses have a massive influence on tourism, transportation, economics, and energy demand [13]. Therefore, an efficient transportation system should be linked to enhance sanitary conditions and ventilation in public transit and lowering the risk of the pandemic [14]. According to the findings of the study, hazard increases primarily in public transportation because it is a shared environment. However, some public spaces are much worse than public transport due to CO2 concentration, so it is a matter of design and operation that is always connected with efficiency regardless of the place or period of exposure. How to maintain passenger safety in public transport, whereas companies suffer financially? This is a balanced equation that should be achieved, it is the responsibility of the companies, the stakeholders, and transport sectors to assess the risk management tools and to conduct the essential cost-effective analysis, such assessment will make the mobility system more effective, because public transit sector caused enormous socioeconomic and environmental problems that can be avoided [15]. To explore the impacts of COVID-19 on people movements, some interviews were made with young adults in Melbourne and Victoria, Australia. The study indicates that there are considerable effects on short-distance travel by all young people, but for long-distance travel, consequences are dependent on how they are progressing through critical life stages, because the pandemic had a negligible impact on some respondents, while it had a more significant impact on others, due to the acceleration in life which coincided with the presence of the COVID-19 crisis [16]. A travel survey questionnaire was used to perceive passenger satisfaction during several types of daily trips; based on a survey in New Delhi. The critical variables that were found significant on commuters' trip satisfaction and were taken into consideration include some demographic characteristics, such as gender, age, security, comfort, etc. The trip-satisfaction data are perfectly represented by logistic regression models using trip satisfaction modelling [17].

Countries took a different path when dealing with the pandemic; some countries, such as China, Spain, and Italy, applied lockdowns in some stages to control the disease, and others used what is called intelligent lockdowns such as Netherlands, Japan, and Turkey and asked the citizens not to move and stay home as much as they can. Other crucial notes during the pandemic were the positive environmental impact due to the reduction in vehicle usage, because of online learning and working, as well as people decreased their shopping, free time and social trips to the minimum and concentrated on essential trips. This significant reduction was the dominant feature in many countries, for example in the early stages of the pandemic, in Australian cities, car use decreased by 35 % compared to the pre-COVID-19 period [18]. Other cities experienced a huge reduction: more than 80 % in Milan, Rome, Barcelona, Madrid, Paris and around 70 % in Moscow, New York, London, Boston, Lisbon in car traffic in March 2020 [19].Threats in using public transport should make planners seriously think of solutions using modern technology to

develop smartphone applications to use for choosing the suitable mode of transportation, suitable activity, or suitable areas during the day, while they should also try to shift toward more sustainable urban mobility by encouraging walking and cycling as much as possible by implementing certain services with suitable infrastructure and facilities [20].

METHODOLOGY

The study consists of a questionnaire survey that intended to use the necessary tools to make a comparison between two capitals: Budapest in Hungary and Amman in Jordan. The questions are defined by the frequency of usage with several multiple-choice answers assessing the passenger' perception for mobility, before and during the COVID-19 pandemic. Figure 1 shows the outdoor activities vs. transportation modes.

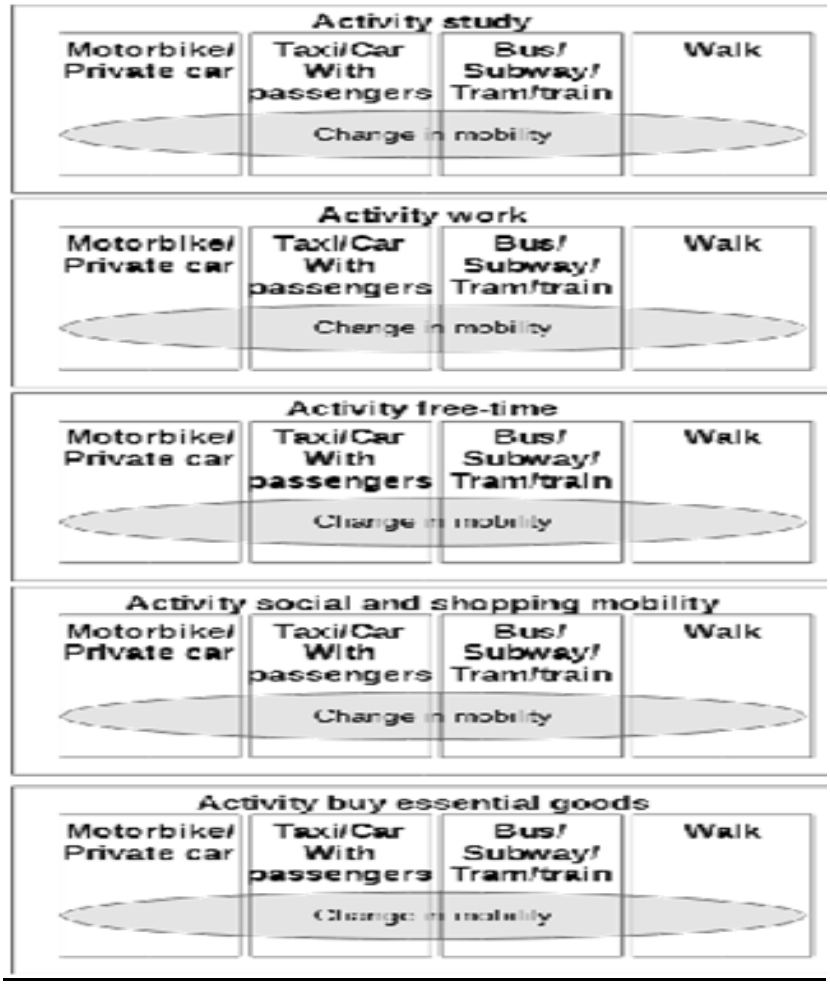

Figure 1. Outdoor activities vs. transportation modes.

The study summarizes the hypotheses as follows:

Hypothesis H_1 assesses the frequencies of usage of each transport mode the participants have been asked about; how often they use each transport mode before and during the pandemic for different outdoor activities [21, 22].

Hypothesis H_2 studies the effectiveness of the restrictions and procedures applied to prevent catching COVID-19 while using transport modes.

PRIMARY STATISTICAL ANALYSIS

Viewing the outcomes, which aimed to assess the impact of COVID-19 on users of road transport before and during the pandemic by testing the variables and items with statistical analysis using Microsoft Excel, statistical programs SPSS v. 26 [23] and AMOS [24].The major descriptive and analysis plan concentrated on the frequency of usage as a matrix, where several multiple-choice questions were asked simultaneously in a grid format. The Pearson Coefficient for validity and Cronbach's Alpha for reliability were helpful and worthy at significant level ($\alpha = 0{,}05$), the mean, standard deviance, variance, skewness and kurtosis [25] were generated to make the necessary comparison.

TEST OF NORMALITY

HYPOTHESIS H_1

Normality for before and during the COVID-19 pandemic is checked [26] through the Kolmogorov-Smirnov test [27].At the level of significance ($\alpha \geq 0{,}05$), the kurtosis and skew values were also checked to ensure the acceptable ranges (–10, +10) and (–3, +3), respectively [28], for both Amman and Budapest. The reults shows that the distribution for the first hypothesis is not normal for all variables (gender, educational level, age, occupation and income) for the items related to the frequent use of different modes of transportation as shown in Figure 2.

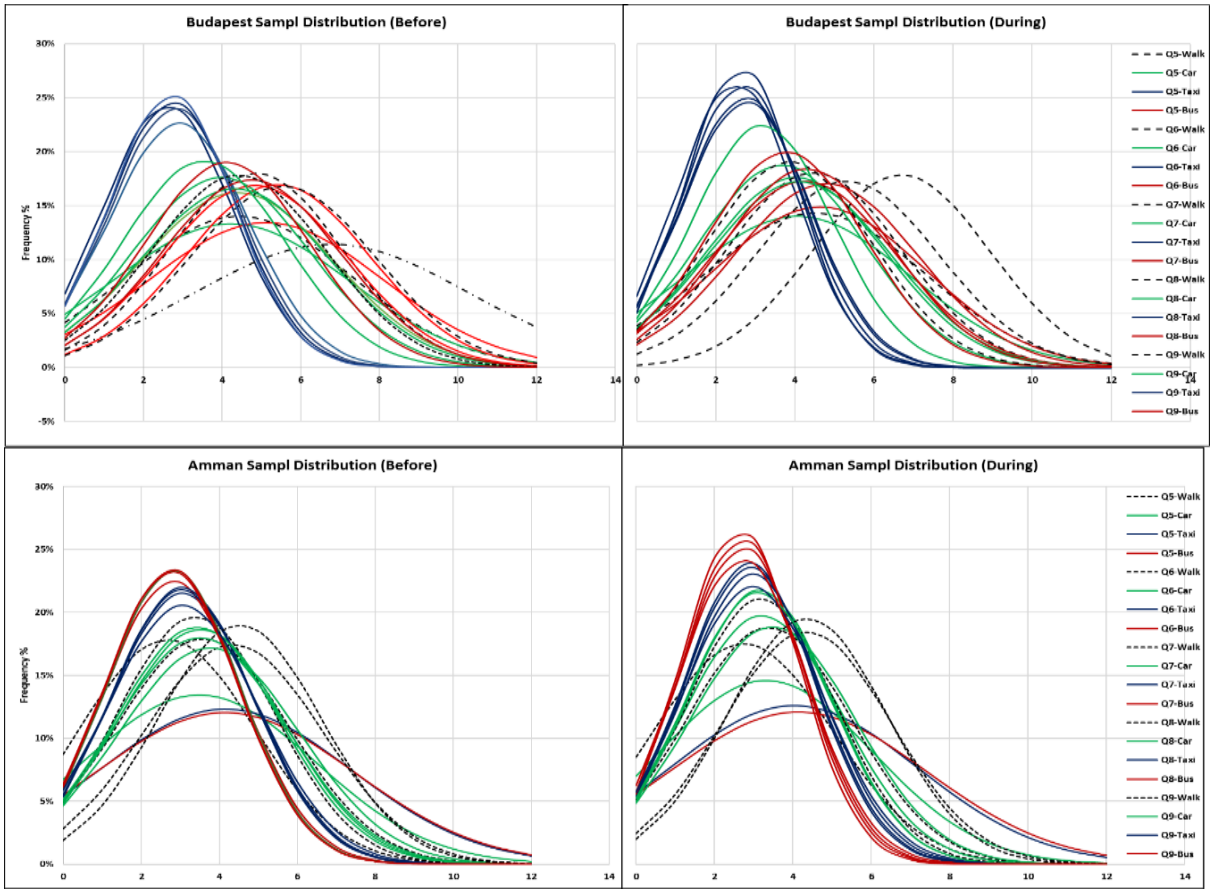

Figure 2. Distribution test for Budapest and Amman.

HYPOTHESIS H_2

Amman shows that the distribution of the Kolmogorov-Smirnov test for most variables (educational level, occupation and income) was more than the level of significance ($\alpha = 0{,}05$),

This indicates that the distribution is normal for these variables. While for Budapest, the distribution of the Kolmogorov-Smirnov test is statistically significant for the variable (age, education, and income) and the distribution is not normal, while the statistical significance values for the variable (gender) indicates that the distribution is normal for this variable. In addition, the tests confirm that the values of kurtosis and skewness are acceptable for all variables and located within the ranges (–10, +10) and (–3, +3), respectively.

SECONDARY STATISTICAL ANALYSIS

Such tests include Homogeneity, the purpose is to test if the variances of groups are equal. If such an assumption is violated, a statistical adjustment needs to be done. It is assessed by using the Levene's test for equality of variances and the Scheffé statistical test [29]. The test of Multicollinearity measures the correlation between variables and logistic regression. Multicollinearity means that there should be no interaction between the independent variables [30]. The Variance Inflation Factor (VIF) values should be measured less than three to guarantee the independency between variables [31]. The test of Reliability [32], Cronbach's Alpha [33] is used since it measures the internal consistency, that is, how closely related a set of an acceptable level of reliability is. The higher the value, the greater is the stability of the value. For the questionnaire it was greater than 0,8 which is considered a very good level of stability. However to check the independent variables and their interaction i.e. how they act with each other, the ANOVA test was used under the conditions of normality distribution and homogeneity with values less than the level of statistical significance ($\alpha = 0,05$) [34]. Although such tests explain the significant of the hypothesis, it does not specify which variable or variables have the greatest impact. On the other hand, validity is a measurement of the correlation between variables, degree and direction of the relationships. The Pearson Coefficient [35] is used to generate a correlation matrix for all items of the hypothesis. It found significant at 0,01 level (2-tailed), which means that the phrases of hypothesis, are understandable and clear to the participants. Exploratory Factor Analysis (EFA) [36], and Confirmatory Factor Analysis (CFA) were conducted for identifying and explaining the relationship between variables by categorizing them based on specific linkages and to discover the underlying factors by computing the factor scores to represent the items as groups. A very important analysis is the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity [37]. The test measures sampling adequacy for each variable in the model, see Tables 1 and 2. CFA used to confirm the relationship between variables by testing the hypotheses, then to ensure that the hypotheses' variables fit as model/ models. However, it should be mention at this stage that sometimes we cannot assume the groups are indeed totally independent, because under the influence of several variables the users can easily move from one mode to another [38, 39]. CFA allows for the assessment fit for the model that specifies the hypothesized causal relations between latent factors and their indicator [40].

STRUCTURAL EQUATION MODELS SEM

Utilizing SPSS and AMOS to reach the final model, Confirmatory Factor Analysis CFA to investigate whether the results based on EFA as the initial model need to be modified, by checking the goodness of fit. Also the indeces should be taken into consideration when applying the Structural Equation Models SEM [41]. The significance and acceptance are determined by Chi-squared goodness of fit test, normed Chi-squared test, Chi-squared Ratio, Goodness of fit index (GFI), Adjusted goodness of fit index (AGFI), Normed fit index (NFI), Tucker-Lewis Index (TLI). The Comparative fit index (CFI) is between 0,9 and 1,0 and Root mean square error of approximation (RMSEA) less than 0,08 [42].

Table 1. Amman EFA before COVID-19, during COVID-19 and the change between them [37].

	KMO and Bartlett's Test		
Before COVID-19	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,891
	Bartlett's Test of Sphericity	Approx. Chi-Square	15473,935
		Df	1431
		Sig.	0,000
During COVID-19	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,894
	Bartlett's Test of Sphericity	Approx. Chi-Square	15577,402
		Df	1431
		Sig.	0,000
Change *(Before – During COVID-19)*	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,718
	Bartlett's Test of Sphericity	Approx. Chi-Square	1436,029
		Df	190
		Sig.	< 0,001

Table 2. Budapest EFA before COVID-19, during COVID-19 and the change between them [37].

	KMO and Bartlett's Test		
Before COVID-19	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,875
	Bartlett's Test of Sphericity	Approx. Chi-Square	12276,555
		Df	1431
		Sig.	0,000
During COVID-19	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,877
	Bartlett's Test of Sphericity	Approx. Chi-Square	12268,974
		Df	1431
		Sig.	0,000
Change *(Before – During COVID-19)*	Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,874
	Bartlett's Test of Sphericity	Approx. Chi-Square	2300,692
		Df	190
		Sig.	0,000

After computing the measurement models and utilizing the fit statistics tests, the results show that the best fit models for Amman and Budapest are significant for the hypotheses H_1 and H_2 i.e., identify the relationship between COVID-19 and the transport mode, as well as the correlation between the change in mobility for the same activities between (before and during) and the probability of catching the disease while using the different transport modes. Both hypotheses are statistically significant. By obtaining the p-value (probability) of less than 0,05 which is acceptance, the findings revealed that the moderate degree of infection or catching the disease is the core factor influencing the respondents in deciding movements and mobility. Thus, hypotheses H_1 and H_2 have supported the assumptions, and the results improved significantly by utilizing both hypotheses together to represent the structural model.

CONCLUSION

The statistical analysis revealed that, in most cases, there are statistically significant differences between variables, which fulfils the requirements for Homogeneity and Multicollinearity.

The reliability and validity results are acceptable since they are at statistical threshold rates, even though there are apparent differences in the values of reliability between Amman and Budapest. This can be clearly and logically justified based on the fact that primary modes of transportation in Amman relies on private vehicles and taxis, while in Budapest it is basically trams, motors and buses.

The findings from the descriptive analysis corresponding with activities and mobility showed that the non-motorized modes such as walking and bike riding increased during the pandemic. Concerning the second hypothesis, comparing the mean for how the respondents would rate the probability of catching COVID-19 while using transport modes such as buses, trams, and the metro showed the highest values. They were ranked as high to extremely high probability to catch the disease. Chi-Square tests and the degree of freedom showed good EFA formulas, and this explains why CFA was used to assess the model's fitness. Both findings supported the critical factors that must be considered and incorporated for a transportation study to be comprehensive.

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ARE WE READY FOR SMART CITIES?

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ABSTRACT

Smart cities are an emerging phenomenon, which is not only called for by their inhabitant's needs, but also by the more and more pressuring external factors, such as global economic slowdown, the increasing scarcity of resources and climate change. While smart cities are to increase the quality of life of the people, often the people themselves are not ready, not smart enough for them. Technology readiness is an important factor of technology adaptation; hence it is the basis of whether people are looking forward to smart cities or are rather afraid of them. In the current article, the readiness of people in an international sample is assessed with the help of a questionnaire, but the understanding of their choices is enriched by cultural and economic background data stemming from two representative international surveys, namely the Cultural Dimensions research of Geert Hofstede and the Global Entrepreneurship Monitor data. The results presented in the article are in line with the international literature but are enriching the existing body by combining the socioeconomic and cultural aspects in the interpretation of individual choices.

KEYWORDS

smart cities, readiness, perceptions, cultural embeddedness, socio-economic factors

CLASSIFICATION

JEL: E66, O14, O18, O33, O57

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INTRODUCTION

There is no universally accepted definition of a smart city, however, certain elements are usually inevitable when labelling a city smart. These are the use of novel info-communication technologies, sustainable solutions and an infrastructure that enables the improvement of the quality of life of its inhabitants in an efficient manner.

The phenomenon itself is multifaceted and has numerous notions that enable/belong to the core phenomenon: smart economy, smart environment, smart government, smart living conditions, smart mobility and last but not least smart people.

According to Kumar and Dahiya [1] smart economy is a result of the deliberate decision of people to switch from a conventional urban economy to a more diverse, more inclusive smart economy, where economic growth is achieved through the development of new technologies and effective means of production; where the sustainable development is nurtured by efficient management and participatory decision making to address the effects of global economic slowdown, the increasing scarcity of resources and the climate change.

A smart environment is an intelligent environment, which can acquire and apply knowledge about its inhabitants and their surroundings and adapt to the residents and their needs. Hence, the goals of a smart environment are the comfort of its inhabitants and the efficiency of the system catering to that. In line with this, the smart environment – through harnessing the benefits of multiple heterogeneous learning algorithms – can identify repeated patterns to control many aspects of the environment to match the activities of its inhabitants predicted based on their past behaviour. All in all, a smart environment is a label for a control strategy for a substantial and extremely complex environment [2].

Smart government is supposed to be the next step of e-government with improved use of technology and innovation for better performance. While municipalities may play a crucial role in smart cities' lives through funding initiatives for smart city development, it also includes the umbrella government and its inclination/tendency towards transforming into a more efficient, transparent, and publicly available service provider, which can be easily accessed by the citizens with the help of ICT [3]. On top of this, smart government is responsible for developing and providing sufficient infrastructure for high-quality services, efficient and future-oriented (increasing employability and technology readiness) training and education and fostering efficient information flow among all actors of the system to cope with the increasing complexity and uncertainty of the environment and to build resilience [4].

Smart living conditions are a synonym for a more comfortable and protective indoor environment for work and living, which is enabled through environmental control systems that not only monitor environmental conditions in real-time but also regulate the operation of household appliances [5]. Smart living conditions do not only affect the mood of their inhabitants, but through effective regulation, they have positive psychosomatic effects as well. The system is supportive not only through alleviating the burden on the human body caused by pressure to adjust to changes in temperature, humidity or fight allergies but also through positively influencing the root causes of such effects, diminishing the pollution, and in line with it the smog and the greenhouse effect.

Smart mobility enables a more efficient and coordinated travelling of people and the transfer of goods in a more coordinated traffic management system [6]. Intelligent vehicles can monitor and react to their environment while fostering the emergence of green mobility [7]. In line with this, smart mobility is not only about the vehicles, or the infrastructure necessary for private and public transport, but is also about the technology used to create and coordinate the vehicles and the resources that make the traffic sustainable [8, 9]. In the 21st century, smart mobility

could not be imagined without the (semi-)autonomous vehicles and their massive employment [10], in line with this, the research introduced in the article will also address this segment of smart cities separately.

Smart people are the cornerstones, but also the biggest weaknesses of smart cities. While educated people who are ready and eager to engage with the newest technology are the motors of the development of smart cities, it is easy to understand, how lack of technology readiness, distrust or technostress can adversely affect the development and implementation of smart technologies [11]. Even when it comes to the above-mentioned autonomous vehicles, the perceptions and attitudes of people are not unequivocal [12].

In line with the above introduced, a smart city is a settlement that develops its natural and artificial environment, digital infrastructure, as well as the quality and economic efficiency of the services available in its area, using modern and innovative information technologies, sustainably, with increased involvement of its residents. This last part of the definition is going to be the central notion of the research introduced in the current article, since without smart – ready and motivated – people smart cities cannot be established.

SOCIO-ECONOMIC FACTORS

Yigitcanlar and his co-authors [13] argue that smart cities shall address the existing economic, environmental, social and governance challenges since these are the factors that affect the readiness of the people for smart transformation. Noori, de Jong and Hoppe [14] have also highlighted the importance of socio-economic and political factors in addition to the actual level of technology when exploring smart city readiness. Technology readiness, according to Bui, Sankaran, and Sebastian [15] is influenced by eight socio-economic factors, namely: macroeconomy, competitiveness, ability to invest, cost of living and pricing, digital infrastructure, knowledgeable citizens, access to skilled workforce and culture. Chourabi and his co-authors [16] also recommend eight, but slightly different factors: economy, governance, policy context, built infrastructure, technology, management and organization, people and communities and natural environment.

In line with this, the socioeconomic embeddedness of individual decision-makers is deemed to be an important factor when it comes to readiness for smart cities or smart technology in general. However, it is not an easy task to collect and collate comparable international socio-economic data that can serve as a trustworthy starting point for further research. Hence, current research did not aim to collect data through primary research – which would surely have been insufficiently representative – but has tried to find publicly available databases, which can provide data to enrich de primarily collected data and support a more in-depth analysis of the topic under scrutiny.

The Global Entrepreneurship Monitor [17] carries out survey-based research on entrepreneurship for more than 20 years now, having started their research in 1999 as a joint project of Babson College (USA) and London Business School (UK). While entrepreneurship is not closely related to the topic under scrutiny, GEM is not only exploring entrepreneurial attitudes in multiple countries with primary data collected from various stakeholders-entrepreneurs, policymakers, experts – but also assesses the ecosystem enveloping (supporting or hindering) the entrepreneurial activities in the given countries. These environmental factors will be the ones used in our current research supporting the holistic understanding of readiness for smart cities in line with the embedded nature of the concept.

While for each country in the annual research – based on the data collected through the questionnaire – an economy profile is created, which is freely accessible through the GEM

webpage (https://www.gemconsortium.org/economy-profiles), the dataset for inquiries older than 3 years old is also available as SPSS files, enabling the further research of the variables by researchers. Such a dataset from 2016 is used for the current research article, since the novel samples from later years did not contain Hungarian data, and the dataset of 2021 – which had Hungarian data – is not openly available yet. While the dataset might seem outdated, in the case of the 2021 data the effects of COVID might have influenced the respondents in a way that makes the responses less comparable since the pandemics have hit different countries to different extents and have influenced the socioeconomic ecosystem differently.

As already indicated above, GEM does not only collect attitudinal indicators related to entrepreneurship but also explores the entrepreneurial framework conditions, to explore, how different countries provide various (un) favourable conditions for their business ventures. In line with this understanding, GEM explores a multitude of factors that might directly or indirectly influence business ventures:

- financing for entrepreneurs,
- governmental support and policies,
- taxes and bureaucracy,
- governmental programs,
- basic school entrepreneurial education and training,
- post-school entrepreneurial education and training,
- R&D transfer,
- commercial and professional infrastructure,
- internal market dynamics,
- internal market openness,
- physical and services infrastructure,
- cultural and social norms.

While most of them – at least indirectly – might also influence the technology readiness of individuals, in current research we concentrate on factors, that are indicated by international literature as being closely related to acceptance; namely: infrastructure, market opportunities, financing, governmental role, knowledge of people, availability of skilled workforce, R&D opportunities. The relevant statements describing these factors have been added to the dataset collected through primary research indicating the country averages for each respondent.

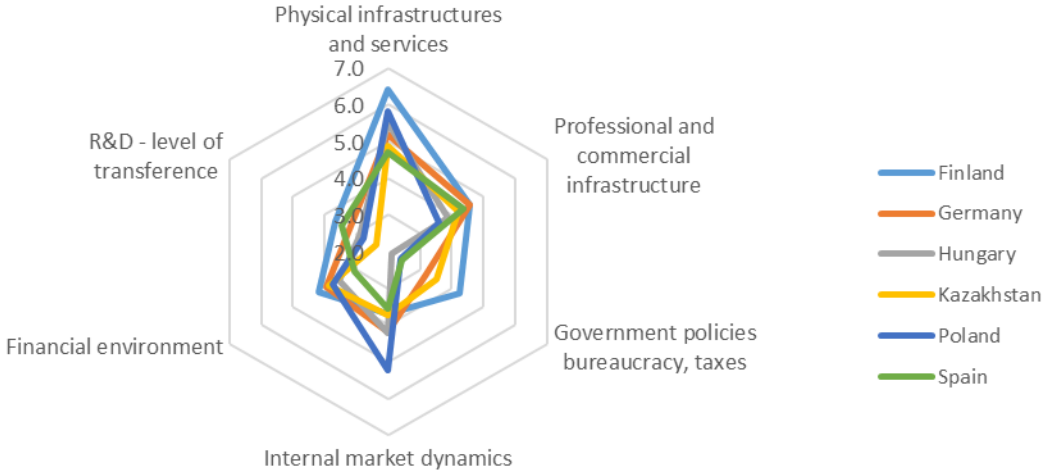

Figure 1. GEM indicators of countries in the sample [18].

As displayed in Figure 1, the differences among the explored countries cannot be regarded as extreme, however, it is visible that Finland – a country which is performing far better than the others in the sample is lagging in regards to internal market dynamics, or that Poland, which is an average performer in most of the factors explored has superior indicators when it comes to internal market dynamics and is only second to Finland in regards to physical infrastructures and services. The order of performance – be it by averages or by ranks within this list of countries – Finland has the best opportunities, followed by Germany and Poland. Based on the GEM data presented below, in regards, to the supportive environment, Hungary is only in the 5th place out of the 6 presented countries, only performing better than Sain, and slightly worse than Kazakhstan.

CULTURAL DIMENSIONS

The influence of cultural factors on new technology adoption has been recognised as a highly relevant field to be explored by many scientists [19, 20]. While it is commonly accepted that culture has an immense influence on human behaviour, there are only a few rigorous research exploring cultural factors over time, for a multitude of countries. Even though Staub, Keil and Brenner already in 1997 [21] highlighted that the Technology Acceptance Model (TAM) does not have sufficient predictive power when it comes to different cultures. Zakour [22] using Hofstede's [23] dimensions has already found data to support the cultural embeddedness of technology acceptance.

Luckily, Hofstede Insights, established by Geert Hofstede has not only been collecting data for over 30 years now, involving more and more countries in their sample, but they also provide their research results in a publicly available manner to support researchers in creating their models with the help of their cultural dimensions. While Hofstede has initially identified 4 different factors based on which national cultures might be compared:

- power distance,
- individualism,
- masculinity,
- uncertainty avoidance.

By now, the number of factors utilised has increased to six; Long-term orientation having been added by Hofstede later on and Indulgence having been recommended by Minkov [24], which also became an internal part of the six-factor model by now. The dimensions enable researchers to understand the hidden motives, norms and values behind individual decisions and behaviour, hence are of utmost importance from the point of view of our current research.

The first factor to be identified by Hofstede [25] was power distance which describes the degree of inequality between people that is still considered acceptable in a given culture. A low power distance shows relatively little inequality, where society does not accept or perceive functional human inequality in power, wealth, and prestige as inevitable [26]. Huang, Lu and Wok [27] have already highlighted the relevance of this cultural dimension incorporating it into the TAM model to understand the subjective perceptions of people in the People's Republic of China. According to Nikolov and Krumova [28] power distance even has a strong predictive power within the group of European countries when it comes to a very specific segment of smart cities, the e-Governance.

Individualism-collectivism as a spectrum indicates a cultural preference regarding being integrated into a group; whether the people in a given country prefer activities carried out individually, or those that are carried out as a member of a group. Individualistic societies prefer individuals, who can manage on their own, while in collectivist societies helping each other is important, hence the individual is supposed to show strong loyalty to the group and

community. Lee, and his co-workers [29] have found that individualism has a direct positive effect on technology acceptance. Tarhini and his team [30] have also highlighted that individualism has not only a positive effect on readiness but also a mediating effect when it comes to other cultural dimensions. According to Masimba, Appiah and Zuva [31] individualism has a positive correlation with technology adoption.

Masculinity as a cultural dimension can be well characterized by the behaviour associated with gender roles. Masculine traits, such as achievement, success, competition, endurance, and feminine traits, such as tenderness, solidarity, support, and human relationships, are features of the two ends of the continuum. What is more, in masculine societies, gender roles are more distinct than in feminine ones. According to Tarhini and his co-workers, [30] feminine cultures support the adoption of new technology more, through subjective norms and a more positive behavioural intention. In line with this Sun, Lee and Law [32] have also highlighted that masculine societies have a more negative attitude towards technology. Negara and Setyohadi [33] on the other hand emphasise that masculinity in itself might not be a good predictor of technology acceptance when it comes to smart city solutions. Contrary to this, Meyer-Warden and his colleagues [34] argue that femininity has a moderating value on uncertainty avoidance and hence has a positive effect on trust towards smart solutions that increase the subjective well-being of individuals.

Uncertainty avoidance is a cultural dimension that highlights the individuals' needs for structured, regulated situations. A too-high level of uncertainty avoidance usually indicates an anxious, aspiring society, while a society with a lower value is more flexible and easygoing. Based on research data presented by Venkatesh and Zhang [35] implementation of new technology is likely to cause a state of uncertainty, which in cultures with high uncertainty avoidance causes a higher level of perceived stress and discomfort. Negara and Setyohadi [33] have found that uncertainty avoidance is a good predictor of technology acceptance when it comes to smart city solutions. In line with this, according to Meyer-Warden and his colleagues [34] users from cultures with high uncertainty avoidance demonstrate higher levels of anxiety in cases of change, and implementation of new technologies, and have a high need for control.

Long-term orientation is a cultural dimension which has a holistic view of time, regarding not only the past and the present but also looking into the future. In line with this, in a culture characterised by a long-term orientation, the society's time orientation is determined by long-term thinking, judging a technology or a situation both by its present and future effects rather than just seeing the immediate short-term consequences. Long-term orientation is closely related to frugality and perseverance, building lasting relationships, and prioritising future rewards [36]. On this note, according to Tran Le Na and Hien [37] long-term orientation positively affects functional, social and emotional values of new technologies; hence is positively related to technology acceptance. However, while Negara [38] also proposes pragmatic societies with long-term orientation to adapt their traditions more easily to changing conditions, his research did not support the hypotheses.

Indulgence is a cultural dimension that indicates to what extent people tend to prioritise the enjoyment of life and seek immediate satisfaction and gratification. Indulgent societies tend not to control the individual urge to hedonism and do not control the desire to acquire a product or service. Low-indulgence societies on the other hand tend to be cynical and pessimistic, emphasising work above leisure time and controlling the gratification of desire. The actions in low-indulgence societies tend to be restricted by social norms, hence free will is of lesser importance. In countries with lower indulgence levels technology adoption is determined by levels of anxiety and uncertainty, while in indulgent cultures the basic motive behind adoption is the emotion attached to the good/service/situation. In line with this, they have found

indulgence to be rather a mediating variable than one that has an immediate effect on technology adoption. However, Escandon-Barbosa and her colleagues [39] have found a much more immediate relation between indulgence and the risk perception of individuals, with indulgence directly affecting purchasing behaviour related to new technologies.

Figure 2 shows the differences between the cultures represented in our survey based on the above-introduced cultural dimensions, highlighting that even though most of the cultures belong to the Western culture, there are still plenty of differences.

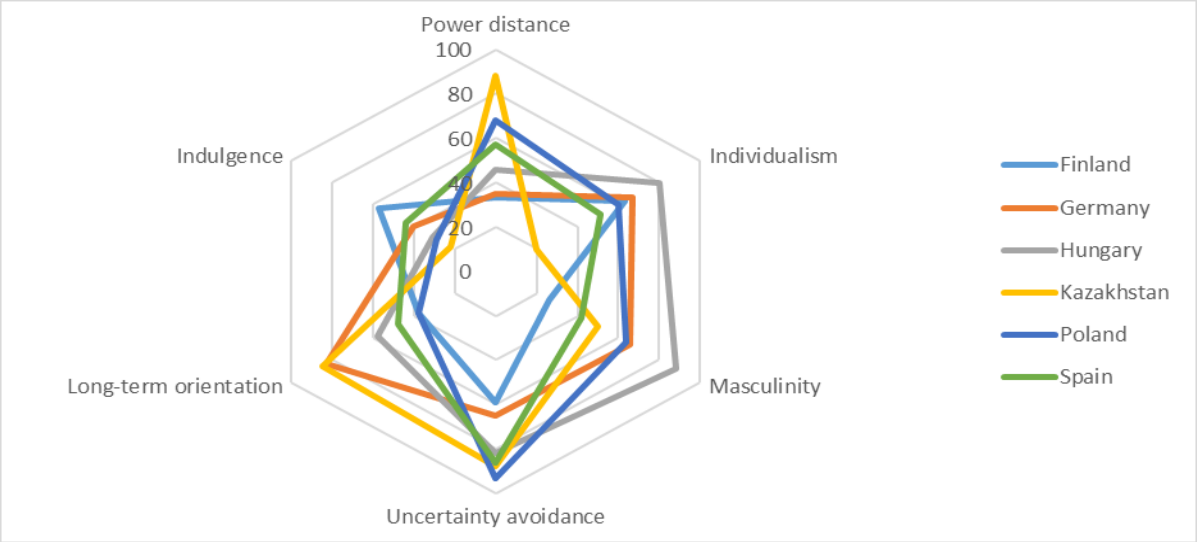

Figure 2. Evaluation of six different countries based on Hofstede's cultural dimensions.

As is visible from Figure 2, the power distance is the biggest in Kazakhstan, while Individualism is the lowest. On top of this, the Indulgence score is below average and Long - term orientation is far above the average of the displayed six countries. Among the European countries, Finland and Germany have the lowest Power distance, while Poland is by far the highest (but not even near Kazakhstan). In regards to Individualism, Hungary has the highest score and Spain the lowest, while other countries oscillate around 64. Hungary has the highest score also in Masculinity, and Finland has the lowest. The difference between these two extremes is 62, which on the 100 points scale – especially considering they both belong to the Western culture – shall be considered a radical contrast. The European cultures tend to be high on uncertainty avoidance, Poland leading the row with 93 points. Finland has the lowest uncertainty of all with a score of 59, which still shall be considered a preference for uncertainty avoidance. Germany is by far the most Long-term oriented culture, being followed, with a 15 points difference from Hungary. Other countries in the European sample were below 50, meaning that they tend to be rather short-term oriented. Regarding Indulgence, yet again Finland is the outlier, the only culture being above 50 on Indulgence. Other countries all have scores below 50, with Poland at the end of the row with 29.

RESEARCH GOALS AND METHOD

To understand, how socioeconomic and cultural factors influence the readiness of people for smart cities, primary research has been initiated among Generation Z people from these countries.

The research questions - in line with the already introduced international literature – were:

- Which factors have a significant influence on the readiness of people?
- How do these factors influence the perceptions of individuals towards smart technologies?
- What features will the fastest-adopting cultures have when it comes to smart cities?

While the socioeconomic and cultural factors were not explored within the frame of current research, on the one hand, because of potential lack of representativity, on the other hand, because the metrics introduced above have already been validated and used by many, hence the results that are based on them will be comparable.

Readiness and the underlying factors, such as motivation, fear and risk perception however have been explored through targeted primary research with the help of an online questionnaire. The sampling methodology was snowball since respondents to the questionnaire were collected through students studying at Óbuda University (Budapest, Hungary). The only criteria are age, ongoing or finished higher education, and a place of residence in a capital, city or at least a bigger town. With these metrics, the sample on hand could be focused on the age group that is soon to be the decision maker when it comes to purchasing decisions related to smart solutions, the other hand, while targeting those with (ongoing) higher education, the research intended to reach out to those, who will potentially have not only some basic knowledge related to smart solutions but also sufficient purchasing power to be able to afford them. The third criterium – place of residence – was important, since smart solutions can be employed individually but only if utilised in a greater mass and initiated by the local municipality can they foster the development of a smart city.

The questionnaire contained explorative questions where respondents had to rate their perceptions on a five-point Likert scale and some questions related to their demographic features, first and foremost to be able to validate their belonging to the targeted group.

RESEARCH SAMPLE

With the help of a Google questionnaire, 483 responses have been collected, but only 405 did meet the above-described criteria. As indicated in Figure 3 below, the majority of the respondents were from Hungary, even though the language of the questionnaire was English. However, the research has managed to reach out to at least 20 people from the selected countries, Figure 3.

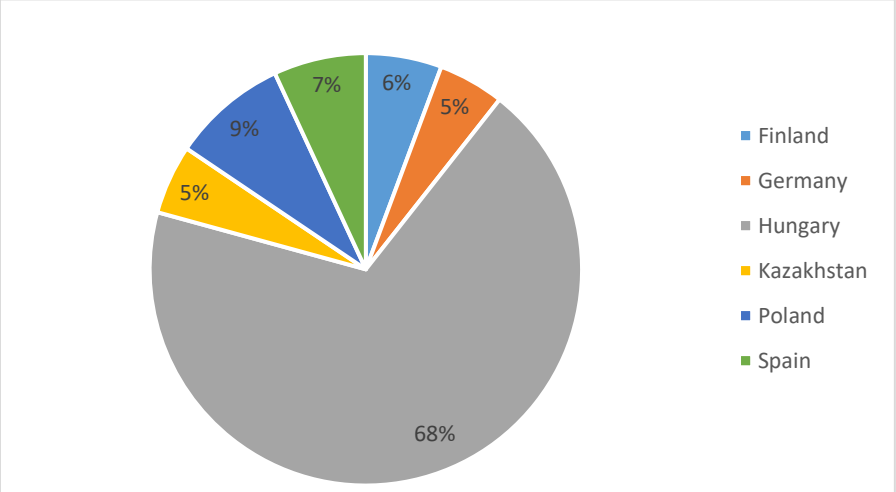

Figure 3. Distribution of respondents by country.

Altogether 55 % of the respondents were still in their bachelor studies, 21,5 in their master studies, and 13,1 have been pursuing postgraduate education at the time of the research. In line with this, the average age of respondents was 22,48 with a standard deviation of 2,579.

The sample contained 218 male, 182 female respondents and 5 indicated a preference not to identify with either gender. 58 % of the respondents were living in capital cities, 14 % in big cities and 28 in bigger towns, which is not only in line with the selection criteria but also enables us to test, whether smaller cities have the same opportunities as capital cities to become smart. The distribution of respondents by country and place of residency is introduced in Table 1.

Table 1. Distribution of respondents by countries and place of residency.

	capital	big city	town
Finland	4,0	5,0	14,0
Germany	8,0	0,0	12,0
Hungary	185,0	34,0	59,0
Kazakhstan	17,0	0,0	4,0
Poland	18,0	3,0	14,0
Spain	2,0	13,0	13,0

RESEARCH RESULTS

The respondents in the sample had very different attitudes towards smart solutions and new technologies. As indicated in Table 2, approximately half of the respondents perceive the benefits of smart technologies, only 84 % have stated to be afraid of new technologies, 54 % of the responses indicate that smart technologies are perceived to be too expensive and 37 % have issues regarding data security when it comes to smart solutions.

On the one hand, even though 57 % of the respondents have indicated a lack of fear of new technologies, there is still a significant part (25 %) of the young people (Generation Z) still do not perceive the potential benefits of emerging technologies, hence would not support the development of smart cities.

Table 2. Distribution of individual responses regarding factors affecting attitude towards smart solutions.

	Smart technologies positively affect emission	Smart technologies positively affect the society	Self-driving cars will reduce the occurrence of accidents	The security of personal data cannot be provided	Smart solutions are too expensive	I fear new technology
disagree	51	55	39	69	36	124
mostly do not agree	44	48	58	71	60	105
neither agree nor disagree	110	129	83	115	89	92
rather agree	116	108	141	86	118	48
completely agree	84	65	84	64	102	36

The male respondents in the sample had a slightly better perception of the new technologies (Smart technologies positively affect emission Correl.: 0,139; Sig, 0,005; Smart technologies positively affect the society Correl.: 0,148, Sig.:0,003; Self-driving cars will reduce the occurrence of accidents Correl.: 0,187; Sog.: 0,000) while people living in smaller towns had reported higher level of fear from new technology (Correl.: 0,123; Sig.:0,013). As it is visible, the correlations are modest and although significant, they cannot serve as the basis of further decisions.

The respondents had very different attitudes regarding automatization as well. As indicated by Figure 4, almost half of the respondents (40 %) preferred no, or very low level of automatization, and only 26 % full, or high-level automatization. Hence, the sample is rather balanced in this regard. Despite the young average age of respondents, not all of them indicated a preference for automated systems, and this ratio would be even less beneficial in the case of older generations.

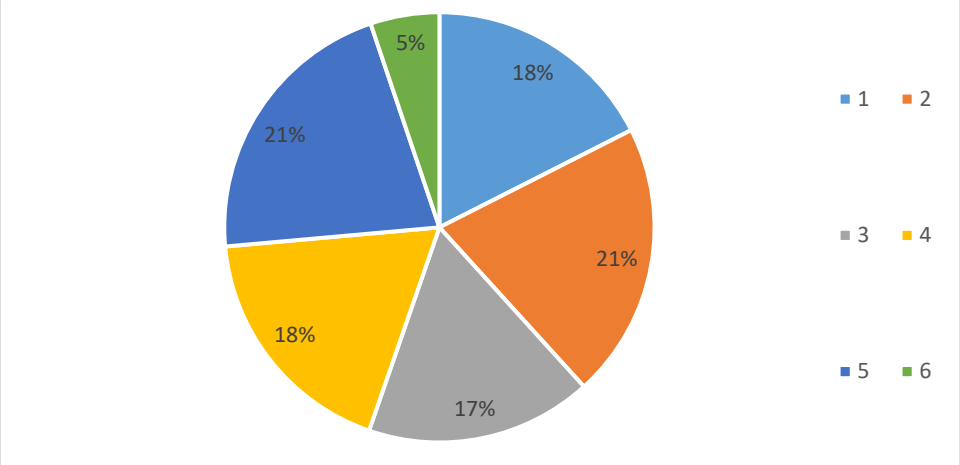

Figure 4. Distribution of respondents by preferred level of automatization.

Even though the international literature indicates plenty of connections between cultural dimensions and individual attitudes, in the sample only Individualism, Masculinity and Long-term orientation had significant correlations with perceptions related to smart technologies. As indicated in Table 3, the more individual a country was, the lower the preferred level of automatization was and the higher the perceived level of fear the respondents reported. The more feminine and/or long-term oriented a country was, the more its people were interested in the long-term effects of the smart technologies and have highlighted their agreement with its positive effects on emission. However, in the case of the preferred level of automatization, these two dimensions had adverse effects. While feminine cultures prefer a lower level of automatization in line with the traditional gender stereotypes, the more long-term oriented cultures prefer a higher-level automatization. Unfortunately, as indicated in Table 3, these correlations were also not strong enough to highlight real relations between the variables.

Table 3. Correlations of cultural dimensions with variables describing perceptions.

		Smart technologies positively affect emission	I fear new technology	Preferred level of automatization
Individualism	**Pearson Correl.**		0,126*	–0,164**
	Sig.		0,011	0,001
Masculinity	**Pearson Correl.**	–0,125*		–0,129**
	Sig.	0,012		0,009
Long Term Orientation	**Pearson Correl.**	0,165**		0,143**
	Sig.	0,001		0,004

*significant at the level $p < 0,05$
**significant at the level $p < 0,01$

Exploring the relations between socio-economic factors and perceptions related to smart solutions some factors, such as cybersecurity threats and perceived benefits were only related to a limited number of factors. While security was perceived to be an issue in countries where access to utilities was more problematic (Correl.: 0,105, Sig.: 0,035), the societal effect was evaluated as significantly higher for countries with higher levels of government support (Correl.: 0,107, Sig.: 0,032) and better access to basic infrastructures (Correl.: 0,111, Sig.: 0,026). In countries where the physical infrastructures were of good quality (Correl.:0,128, Sig.:0, 010), and those where the financial conditions were better (Correl.: 0,119, Sig.: 0,017) the perceived benefits of self-driving vehicles were also higher. The availability of professional and

commercial infrastructures (Correl.: 0,100, Sig.: 0,044), the access to physical infrastructures and services (Correl.: 0,133, Sig.: 0,007) along with government programs (Correl.: 0,126, Sig.: 0,011) positively affected the perception of smart technologies decreasing emission.

The two general factors describing the attitude of the respondents towards smart technologies had multiple correlations with socioeconomic factors, as indicated by Table 4. The preferred level of automatization was negatively affected by Internal market dynamics Physical infrastructures and services access. The more dynamic a market was, the less willing respondents seemed to accept high-level automatization. In the case of access to physical infrastructures and services, the negative relation is easily explainable through the lack of need for further improvement. Where the population is already satisfied with the advanced level of services, there is less need (drive) towards the application of novel technologies. Government programs, policies, professional and commercial infrastructures, education, and social norms were in positive relation with the preferred level of automatization, indicating that the more supportive the government is, the higher the level (of proficiency) of the education is, or the more supportive the societal values are, the higher the preferred level of automatization of the respondents were. These findings are in line with the results indicated by international literature, and even though the findings only indicate low levels of correlation, the tendencies are corroborating the findings of relevant international sources.

The fear of new technology was negatively related to higher-level education; the more information the respondents are provided the more aware they are of the potential benefits and the less risky they perceive new technologies. The more dynamic internal markets were or the more burdens they formed in the life of business ventures the more fear people indicated regarding new technologies. Interestingly, government policies were also positively related to

Table 4. Correlations of socioeconomic factors with variables describing the attitude of respondents.

		Preferred level of automatization	I fear new technology
Government concrete policies, priorities and support	Correl.		0,123*
	Sig.		0,013
Government policies bureaucracy, taxes	Correl.	0,153**	
	Sig.	0,002	
Government programs	Correl.	0,132**	
	Sig.	0,008	
Level of education (Primary and Secondary)	Correl.	0,141**	
	Sig.	0,005	
Level of education (Vocational, Professional, College and University)	Correl.	0,098*	–0,117*
	Sig.	0,049	0,018
Professional and commercial infrastructure access	Correl.	0,198**	
	Sig.	0,000	
Internal market dynamics	Correl.	–0,224**	0,115*
	Sig.	0,000	0,021
Internal market burdens	Correl.		0,106*
	Sig.		0,033
Physical infrastructures and services access	Correl.	-0,130**	
	Sig.	0,009	
Cultural, social norms and societal support	Correl.	0,177**	
	Sig.	0,000	

*significant at the level $p < 0,05$

**significant at the level $p < 0,01$

the perceived level of fear, which can only be explained through some other mediating variables. In countries, where the government provides concrete policies to guide the everyday life of its citizens, the people are much less open to change and much less prone to accept or employ new technologies.

Interestingly, neither the factor of financial environment nor, the R&D transference as important GED indicators had any significant correlation with perceptions related to smart technologies. This, however, might only be because of the limited size of the sample, since previously highlighted correlations were also weak, especially compared to those presented by relevant international literature.

CONCLUSIONS

While there is no consensus on the definition of smart cities it is indisputably an emerging phenomenon, which is not only called for by people who seek to find a better environment, but also by the more and more pressuring external factors, such as global economic slowdown, the increasing scarcity of resources and the climate change. There are multiple factors contributing to the smartness of a settlement, among them technological, infrastructural, environmental and governmental variables, but the necessity of smart people is beyond doubt.

While smart cities are supposed to increase the quality of life of their people, often the people themselves are not ready for them. Technology readiness is an important factor of technology adaptation; hence it is the basis of whether people are looking forward to smart cities or are rather afraid of them. According to multiple international literature introduced in the current article, technology readiness is multifaceted. It is not only individual variables, such as age, gender or educational level, that influence it, but also economic and cultural variables have a direct or a mediating effect regarding the perceptions of their potential risks and benefits.

In the current article, the readiness of people was assessed with the help of a questionnaire completed by 405 respondents from 6 different countries, and the understanding of their choices was enriched with the help of country-specific variables stemming from two representative international surveys, namely the Cultural Dimensions research of Geert Hofstede [18] and the Global Entrepreneurship Monitor data [17]. While the correlations between various variables were rather weak, the results were in line with the international literature, highlighting the importance of socioeconomic as well as cultural embeddedness of people, when it comes to readiness for smart cities, or simply for novel technology. The current article has managed to enrich the existing body of smart cities-related literature by combining the socioeconomic and cultural aspects in the interpretation of individual choices.

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THE ROLE OF CLOSED-CIRCUIT TELEVISION IN INSTITUTIONAL ARTWORK PROTECTION AS A SUBSYSTEM OF SMART CITY

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ABSTRACT

When planning the Institutional Artwork Protection of a temporary or permanent exhibition, it is not enough to adopt a template property protection plan or security protocol. In order to develop complex protection plans it is essential to consider professional specialities, since it is necessary to prepare for entirely different risk factors, hazards, and environmental conditions depending on the special characteristics of the protected work of art. In line with the smart city concept, research is also being carried out to examine the needs of smart public service infrastructure, the innovative implementation of which contributes to sustainable development and also provides security functions. In addition to describing the essential functions of Closed-circuit television, the authors also highlight the possibilities of further particular parts of Closed-circuit television systems installed in Smart City environments in the field of the structure of Institutional Artwork protection.

KEYWORDS

Smart City, Institutional Artwork Protection, CCTV, safety

CLASSIFICATION

JEL: O14, O18, R58

PACS: 07.07.Hj

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SECTION TITLE INTRODUCTION

Artwork Protection, as a concept, covers two large basic areas: the property protection for works of art (complex protection: exhibition, storage, warehousing, packaging, transportation), and the value protection of works of art, as a stock protection (maintaining value and conditions: storage, restoration, conservation), in relation to which a number of research studies, publications and legal regulations have already been presented.

The use of Closed-circuit television (CCTV) systems in Institutional Artwork Protection, both for temporary and permanent exhibitions, is supported by the fact that it is not enough to ensure that the buildings or premises hosting the exhibitions comply with basic security requirements. It is very important that they cannot be moved inside or outside the building without inspection or supervision, neither by the institution's employees nor by other persons. Furthermore, the condition of works of art must also be protected, as it plays an important role in Artwork Protection.

Therefore, the planning of Artwork Protection for a temporary or permanent exhibition is not the same as developing a typical property protection plan or security protocol, in fact, much more than that, as it is necessary to prepare for completely different risk factors, imminence and environmental conditions. When temporary exhibitions are organized, the frequency of possible risks and the extent of potential damage also changes from the beginning to the end of the project, and accordingly, the structure of the built-in protection system must be appropriately flexible, and its elements must be determined in consideration of the threats.

With the development of various autonomous intelligent city systems and their expansion, innovative solutions that improve our everyday lives are being applied one after the other, and they have a direct and indirect effect on other systems and processes. Among others, this also necessitated their coordination and the development of the Smart City concept.

In terms of the operation of these autonomous systems, the sensors of the IoT system play an important role, which, connected through different networks, provide various information about the environment [1].

The technology that ensures data transfer between individual system elements plays an important role in these systems' Smart City environments. The adequate technology may be difficult to choose due to the variety of technologies applicable in the given environment and the difference in their technological characteristics [2].

CCTV SYSTEMS IN INSTITUTIONAL ARTWORK PROTECTION

In terms of its basic functions, CCTV is an essential security technical tool for institutions that provide space for exhibitions. Through the design of the CCTV system it can be ensured that the circle of people accessing the images of the cameras can be well defined, and only specific people can reach these images [3]. The CCTV system is a closed video surveillance system in which the data transmission between the camera, the image recorder and the image display device takes place on a closed or open channel in such a way that the transmitted images can only be viewed by a predetermined target group. The basic purpose of a CCTV system is to observe and document the actions in such a way that it can be used later as proof in the course of a trial [4].

The views formed in professional circles must be broadened with such an approach and with a proactive way of thinking that theoretical and practical research are not only visible to one or another protection areas, or only a part of the areas, should be visible should not only be visible for one protection area or a part of these areas. The role of security cameras is not limited to monitoring the entrance to buildings or rooms that provide space for exhibitions. The cameras

provide versatile and continuously expanding capabilities to significantly expand the above-mentioned role. The importance of CCTV system(s) is present from the preparation stage, in the object and room protection, through the processes of transportation, loading and unloading, to temporary storage, or even when highlighting an international example of "profiling", and, last but not least, it has an indisputable role in the creation of "masked" area protection alarm systems.

The CCTV system also plays a very important role in the protection of temporary exhibitions. Only a small circle within the group of those watching the camera images has the opportunity to control the fixed cameras of the CCTV system, as well as to review any recorded images. CCTV systems are used in outdoor surveillance systems, to monitor the environment of buildings (such as the space and environment of the Van Gogh Museum in the Netherlands for "profiling"), interior spaces and/or rooms, but even inside the transport device, container or box into which the artifact was packed. CCTV systems can be installed even to simply monitor visitor behavior and movement in an area where there is no alarm, signaling or artefact protection function paired with the CCTV system.

Good preparation, prior orientation, necessary information and data collection, analysis, evaluation and planning can significantly determine the effectiveness of Artwork Protection and the effectiveness of the CCTV system. This process is similar to a survey before the installation of a general security system, with the addition that all possible events and "negative activities" must be assessed in advance in such a way that they are always "in front of the camera", or become visible, even if the perpetrator (thief, vandal) has an advantage over those providing art protection.

The complexity of Institutional Artwork Protection including the CCTV system always depends on the particularities of the given temporary (or permanent) exhibition, its degree of difficulty and the expected level of danger.

There is no pre-determined date or interval for when, by whom and how to start the preparatory Artwork Protection, but based on experience, it is recommended that in the first phases of the initial period, the persons responsible for the exhibition and the organization (artist, curators, institutional managers) consult with the expert of Artwork Protection during the planning period of the temporary exhibition. In general, it can be said that the institutional Artwork Protection and related preparations should begin days before, but even weeks or months before the temporary exhibition.

The usefulness and applicability of the CCTV system(s) resulting from their basic function is well known in the field of temporary Artwork Protection. At the same time, its role in complex protection is multifaceted, given that in integrated physical protection, the elements of the CCTV system, or the cameras, can typically be installed in almost the entire vertical of the protection structure. During the protection of the institutional artefacts the main functions of the CCTV system can be divided into the following groups based on the nature of the monitored area:

- monitoring the area outside the object and fence (access road, square, park),
- observation of the building's surroundings outside the object, but inside the fence or directly the surroundings,
- monitoring of the spaces within the building,
- monitoring rooms, security center watch,
- special CCTV functions.

Of course, additional groups can be formed according to demand and necessity, but care must be taken to ensure that the Artwork protection is not compromised due to possible lack of transparency.

The grouping also shows that the increasingly specific observation areas represent different risk factors. In the Artwork Protection of Institutions, special attention must always be paid to the weakest and most vulnerable points of the areas and zones, such as the gates and other points providing access and exit.

OBSERVATION OF OBJECTS AND AREAS OUTSIDE THE FENCE

According to an international approach, 'everyone and everything outside the protected area can be a risk factor, even our friends and family'. Therefore, when designing Institutional Artwork Protection, attention must be paid to being able to access information outside the fence (preferably as soon as possible and at the same time as far away from the protected area as possible), in order to be able to prepare for a possible "event" and at the same time to keep away a poorly prepared "perpetrator". The cameras are built in a clearly visible, strikingly marked (demonstrative) camera housing, which are evenly equipped with lighting, have a distancing effect, which can be enhanced with two property warning signs. Hidden (conspiratorial) cameras, which can even play an important role in preventing possible sabotage against other cameras, can be installed with a different purpose than the ones above.

Day-night cameras must be placed outside the fence that can withstand extreme weather or other possible events (vandalism). Furthermore, it is important to equip them with lenses that ensure, even in minimal light, that the fence and everything else within a few meters is clearly visible. Despite their great advantage, hidden cameras can also be a weakness of the systems, from installation difficulties, protection and power supply, to good image quality, so in such cases it is advisable to install them only with a control role or for security purposes. The increase in temperature causes the cameras to produce more and more noise in the absence of adequate cooling or ventilation. This noise can result in distorted images, which makes the recognition of small details increasingly difficult [5]. A similar problem occurs with low ambient light. The detail and contrast of the image can even be halved compared to normal lighting. In the case of small-format but high-resolution security cameras (e.g. 4K) extremely high lighting (e.g. daylight outdoor lighting conditions) can also cause a decrease in resolution [6].

However, the information transmitted by the cameras deployed to monitor the areas outside the object does not only carry valuable content from a security point of view at the moment of the crime. The new Institutional Artwork Protection involves "profiling", which is carried out by the security specialists of the Van Gogh Museum in the Netherlands as a preventive approach in the field and environment of the institution. If a loud person is detected in the monitor room through the CCTV system, the civilian and security personnel outside the building are notified, and they personally collect additional information to decide whether the person carries a risk or not. For example, if in sunny weather, someone in a big coat, perhaps a hat covering his face, with an umbrella stick or with a strange package approaches the institution, a civil security guard will politely initiate communication about where this person came from, where he is going, etc. With this method, it has already been possible to stop and prevent a damaging act outside the building several times.

In addition to the direct information transmitted by the cameras, there is also a lot of additional information that is useful only in specific circumstances, but which is particularly important in certain cases, for which human power is not enough to analyze, and therefore, artificial intelligence is of particular importance. Additional information can be defined as information that appears in addition to the content of intentionally conveyed information, which represents added value based on specific criteria [7].

Instead of the operator, the video analytics software evaluates the image and gives an alarm when certain criteria are reached. These criteria can be predefined, but most of them can be changed or adapted to the given location. Simpler analytics are static, while more complex ones are self-learning or dynamic [5]. In the processing of the large amount of data generated during the operation of such a system, the information created by transforming the data collected by various sensor networks plays a key role. Based on this information, serious predictions and

important conclusions can be drawn. Therefore, the processing of such amount of data (data mining, data science) provides information that can be used for security [8].

Cameras in public areas serve security in countless cases, but their increasing number raises other questions. Research is also undergoing about the impact of CCTV systems installed in public areas on crime patterns. There are indications that, under certain circumstances, CCTV may also lead to an increase in crime. For example, it can give potential victims a false sense of security and make them more vulnerable as they let their guard down [9]. During today's urban development, various diverse digital, autonomous and physical systems are integrated into the built environment, and it is very important to determine the appropriate evaluation method for their effectiveness [10].

When planning the installation of expensive outdoor camera systems, other aspects must also be carefully considered, one of them being the optimization of the number and location of cameras. In order to effectively install CCTV's, the condition of the built environment and the density of personal traffic must be taken into consideration, while the spatial characteristics of the monitored environment affect the flow of pedestrians. Full monitoring of the latter is very difficult. Research is also being conducted on the placement model of public CCTV cameras using a genetic algorithm. After analyzing the monitoring conditions, the model is able to place the surveillance cameras into the optimal space. In practice, the installation of the cameras cannot always be done according to the instructions of the plan, so its subsequent inspection and analysis is absolutely necessary [11].

OBSERVATION OUTSIDE THE OBJECT, BUT INSIDE THE FENCE OR DIRECTLY THE BUILDINGS ENVIRONMENT

The aim of the installation here is to ensure that the outer part is well-covered, trying to keep the "blind" space as minimal as possible. Cameras connected to other security signals are also usually installed here, such as:

- the camera connected to the hydraulic step indicator,
- the camera connected to the magnetic field sensor,
- the camera connected to the infrared field sensor,
- the camera connected to the microwave field sensor.

which, while giving a signal to the security monitoring center (monitor room) automatically activates a camera and/or cameras in the alarmed area at the same time, and this can be used to collect information about the alarm even more easily. In today's fast paced development, there are of course many other alarm options that can be connected to the CCTV system, such as fence protection devices. At the same time, the CCTV system can effectively support the functions of outdoor protection elements by itself [12]. In the case of the installed cameras, choosing the right optics ensures the accurate monitoring of the activity and identification of the persons. It must be possible to track movement in open spaces without "blind" spots [13].

OBSERVATION OF SPACES INSIDE THE OBJECT

From the point of view of Institutional Artwork Protection, this is perhaps the most complex, complicated and at the same time the most dangerous area, since everything must be subject to Artwork Protection, and in such cases the privacy rights of the visitors and/or employees may be impaired, because cameras often have to be installed in places where otherwise it would not be necessary for general safety reasons. However, the necessity of these cameras must be understood both by visitors, employees, artist and curators. According to the specific interpretation of the artist and curators, not only the displayed art is the object of the exhibition,

but also the installation where the art object was placed, in most cases. Of course, within an object, in case of closed and/or highly important rooms, the special Artwork Protection security devices can control additional cameras in the event of an alarm, or even in the event of movement. According to some professional assumptions, these are theoretically not necessary, since the intruder has to overcome multiple zones, other special security technical devises and in some cases even the protection of manpower, which is almost impossible, but in practice it is used in many cases in rooms for the temporary storage of works of art.

SPECIAL CCTV FUNCTIONS

License plate recognition CCTV systems are well known and can be used as a part of the central CCTV system or as a stand-alone system which can send (provide) a signal to the central system, besides allowing or prohibiting entry, if a barrier/gate entry is connected with the security system. In addition to vehicles, the entry of people can be supported indirectly or even directly with CCTV systems or the central security system, so, for example, the entry of employees can be controlled completely automatically with a facial recognition CCTV system. In this case, it is possible to prohibit the entry of persons who are not authorized to enter at a specific time and in a given place by signaling the CCTV facial recognition system in the monitor room. Regardless whether they have the necessary authorization for the entry (code, proxy, card) or not, the security staff in the monitor room can manually block entry and notify the security service [14].

Given that the buildings of the institution organizing the exhibition may have work areas in which specialized activities are subject to special authorizations or qualifications, the facial recognition function may prove particularly useful. This also effectively supports safety in work processes where the rules require the presence of at least two people. Biometric identification of people has become a rapidly developing area of security technology. The use of biometric identification tools may become an integral part of our lives in the future. Due to its advantages it provides an identification method in which it is difficult to find a security hole in modern devices. A big advantage over possession or knowledge-based identification methods, is that our biometric tickets are constantly available to us. The development of the modern technical background enables its use in areas of security risk where the proxy card or code-based systems cannot be used. Depending on the convenience and the appropriate level of security, biometric identification can be used in all areas of life, therefore it is expected to spread dynamically in the future [15]. The secure storage of data related to certain biometric characteristics of individuals is evident in this area as well, to which special attention must be paid. With the rise of biometric identification systems, more and more accurate data will be mapped on the daily habits of individuals, their routes and so on, while the sensitivity of these data will raise additional security questions. Note that the problem is not new, decades ago the spread of surveillance cameras raised similar problems.

The CCTV system supported by the appropriate analysis algorithm, in addition to its security role, can effectively serve the operation of a Smart Museum in the Smart City project, with its special function which analyzes the activities of the visitors. It is possible to study the on-site interactions and similarities of the visitors, and it is possible to explore new behavioral patterns, so visitor models can be of particular importance when furnishing the physical exhibition space [16].

MONITOR ROOM, SECURITY CENTER, SURVEILLANCE CENTER

The monitor room is the center of the CCTV system, which can also be called the monitoring center or security center. These are all concepts with different meanings, but in case of temporary Artwork Protection this fact can be disregarded, since there is no precise definition of what a security center is like, where the signals of the CCTV system and the information run

into, as it always depends on many factors, such as the given temporary exhibition (Value, artefacts, needs). Therefore there are only recommendations, which are always advisable to consider. The central design of a CCTV system should be placed in a "protected" room, where even security personnel have limited access, and only specially authorized persons with adequate theoretical and practical knowledge should manage the system [17].

If required, with special privileges, the entire CCTV system, including the complete security technology and other alarms can be monitored or controlled by persons working in the security center or in other positions, which requires nothing more than a personal computer and a protected line ensuring a secure or an encrypted connection [18].

Data is playing an increasingly important role in order to ensure successful and secure operation, representing an ever increasing value. Because of this, in addition to security, creating an environment that supports information and data security is a fundamental requirement. Data and information of significant value must be protected not only by legislation, but also by the provisions of the organization's internal regulations. These must cover the prohibition of the transfer of confidential and secret company information, the use of the IT and other devices, the way that company data is stored and the access rights [19].

Experience shows that clearly defined and structured regulations create the conditions for the protection of sensitive data. The safety conscious behavior of employees effectively contributes to reducing the risk of the human factor as an error. Given that nowadays the collecting and storage of data is processed and transmitted by using IT tools, the protection of these IT systems is of utmost importance.

SECURITY POWER SUPPLY OF CCTV SYSTEMS

It is very important that the alternative or parallel power supply of the CCTV systems and other security centers must be ensured even in case of Artwork Protection, because even an innocent power outage can cause a very serious problem, as the entire system can collapse for a longer or shorter time. In order to ensure a continuous power supply, not only uninterruptible power supplies must be used, but also alternative power generation, which can be based on renewable, and environmentally friendly, natural sources, or on power generating aggregators.

SUMMARY

CCTV systems are nowadays an indispensable part of a complex protection system in Artwork Protection, both in relation to permanent and temporary exhibitions, and they play an increasingly important role not only in the protection of artefacts and in their stock, but in relation to the mapping of visitor statistics and habits.

During the preliminary assessment of the CCTV needs of the given exhibition, in addition to the asset and stock protection requirements, attention must be paid to the nature of the given exhibition and in many cases to the fact that the given room itself can be part of the installation. It is very important that not only the design and construction of the CCTV system must precede the installation of the exhibition, but that it must also be commissioned and tested before the installation of the artefacts, as well as integrated with other security systems, such as alarm systems, and in some cases with technical means, such as fire protection. The management of installed and tested CCTV systems must also be taught to users and operators of the system before the installation of the artefacts, and this must be reviewed at intervals and the training must be repeated if necessary or the CCTV system must be modified.

An institution providing space for a permanent or even a temporary exhibition must have various emergency plans and related protocols in place in order to optimize Artwork Protection, since even with the support of CCTV systems, there is no one hundred percent protection.

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AUTONOMOUS CARS – WHAT LIES BEHIND THE LACK OF READINESS

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ABSTRACT

Autonomous systems are already available for public and private transport. The necessary hardware and software products have been created, and novel designs for (semi-) autonomous vehicles are launched every year, but their use is limited, and the penetration is not increasing rapidly. While this might be owing to their high price, their perception is also not universally positive. Many are afraid of not only using, but being around them. After introducing the relevant literature on trust in autonomous vehicles and the factors affecting it, the current article presents the data of an international quantitative research of 666 people. It highlights the biggest perceived threats and their prevalence, and also tries to uncover why more than half of the respondents are afraid of autonomous vehicles. In line with the data presented in the article, the topic is gendered – male respondents were more open towards autonomous vehicles. Furthermore, those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control. On the other hand, those in favour of automated vehicles believe that they have a positive effect on the occurrence of accidents, owing to their heightened reaction speed provided by the sensory system and the computing capacity which is far superior to that of humans, as well as on the society, on carbon emission, and, as a result, on our natural environment. Consequently, autonomous vehicles could form an important element of the transport systems of future smart cities.

KEYWORDS

autonomous cars, self-driving cars, covid-19

CLASSIFICATION

JEL: O14, O18, R49

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LEGAL REGULATION

The technology of self-driving cars has long been developed, but their mass introduction is still a long way off, since there are plenty of concerns regarding the technology and its trustworthiness. While autonomous vehicles are supposed to be means of transportation where human supervision is not necessary to perform predefined tasks, full autonomy is barely provided to vehicles, or any other systems. Since the term of self-driving vehicles is used as a synonym for autonomous vehicles, the term self-driving better describes the situation we are advancing towards. While autonomous systems do not need any intervention from humans, hence humans are not present or in interaction with the system, self-driving vehicles are able to perform their duties on their own, but a human driver shall be present at all times.

According to SAE International (2016) 6 different levels of autonomy can be defined, where level 0 stands for no autonomy, that is the human driver does everything on his/her own, and level 5 is the topmost level, where a "driver" is not needed any more, since the vehicle does all the driving-related tasks on its own. This top level would be considered the level of autonomous cars, while level 4, where the vehicle performs all necessary tasks related to driving, but a human supervision is necessary when out-of-the-box decisions are needed, and at level 3, the human driver provides constant surveillance and is able to engage in the act of driving when necessary [1].

Figure 1. Levels of driving automation [2].

But why is there a need for all these levels and different terminologies if the technology of autonomous vehicles is already available? The problem is multifaceted. First, there are still multiple legal and ethical issues related to responsibilities regarding autonomous systems. Second, only very few are willing to give up complete control over a vehicle and with it over their or their family's life to an autonomous system.

It is a well-known fact that technological development is far ahead of the relevant legislative environment regarding autonomous vehicles in the European Union. However, there are encouraging signs that the distance between them will slowly but surely shrink in the near future. We encounter vehicles with autonomous decision-making functions every day. The biggest obstacle to the spread of driverless cars in the EU is the 1968 Vienna Convention [3] on Road Transport, which states that the vehicle must have a driver and that the driver must be in control of the vehicle. On 23 March 2016, Articles 8 and 39 of the Convention were amended at the proposal of Austria, Belgium, France, Germany and Italy [3]. According to these amendments, technical systems affecting the control of the vehicle are considered acceptable if they comply with the relevant regulations of the UN Economic Commission for Europe, and the same applies to systems that can be overridden by the driver of the vehicle at any time. This means that the driver can switch them off or take back manual control at any time. As a result of the amendments, vehicles equipped with acceptable systems can practically be licensed up to high level (level 4) automation i.e., the stage before fully autonomous control.

On the other hand, in the USA, the age of self-driving cars is almost here. The US National Highway Traffic Safety Administration (NHTSA) has issued new regulations for self-driving

vehicles. Every car manufacturer knows exactly that these special and modern cars must be extremely safe. Even though they do not have a steering wheel, pedals or even a driver's seat, it is equally important to guarantee the safety of both passengers and other cars driving around them. Certain regulations in the Federal Motor Vehicle Safety Standards (FMVSS) define the characteristics, performance, and testing procedures that, with very few exceptions, all vehicles produced in the United States must pass. Hence, they managed to clarify and update exactly what rules apply to the third, fourth and fifth generation of self-driving vehicles [4].

FEARS

Self-driving cars, like any new technologies, arouse many fears in people. Industrial revolutions and the machines that appeared have always been terrifying for people primarily because of the potential loss of jobs. In addition, people fear new technology for many other reasons. While self-driving cars may be the future of transportation, it is still not proven if they are safer than non-autonomous vehicles. Unexpected events can happen while driving, which may force one to make sudden decisions, often they are just small decisions, such as going through or stopping at the yellow light, but sometimes there are situations where one has to make decisions about other people's or their own lives.

Only few people feel comfortable using a new and not yet well-known transportation technology. This phenomenon is also reflected in the history of flying. Although the Wright brothers flew the Kitty Hawk as early as 1903, the United States did not have a major passenger airline until the 1920s [5]. Similar concerns have been raised about the safety and reliability of self-driving car technology [6-9]. In addition, people are concerned about giving full control to a system whose operation is not fully regulated.

Car manufacturers spend billions every year on developing self-driving cars. However, various studies have shown that people are more concerned than enthusiastic about the emergence of this new technology [10]. The University of Michigan has conducted a number of studies that systematically demonstrate that drivers are concerned about fully autonomous cars, while they still want some automated features.

In 2011, Accenture conducted a survey with 2006 consumers in the United States and in the United Kingdom. Nearly half of the respondents reported that they would be comfortable using driverless cars, while the other half would be more likely to use a technology where they could retrieve control if needed [11]. In 2012, JD Power and Associates conducted a survey with 17 400 vehicle owners. Only 37 % indicated that they would be interested in buying a fully autonomous car, but this number dropped by 20 % when they were made aware of the costs [12].

The responses do not only differ between people aware of the potential price of the technology and those who are not, but also by age and gender [13]. While male respondents would generally be more open to using autonomous technology, the willingness drops with age. The same survey has shown that female respondents were less likely to offer full trust to (semi-) autonomous systems and were more eager to accept partially self-driving vehicles.

Table 1. Result of the resource of [13].

Response	Gender		Age				Total
	Female	Male	18-29	30-44	45-59	60+	
No self-driving	48,4	43,1	41,3	35,2	50,6	56,2	45,8
Partially self-driving	39,8	37,5	39,9	42,6	37,8	34,2	38,7
Completely self-driving	11,8	19,4	18,8	22,2	11,6	9,6	15,5

In 2014 even in the US, UK and Australia the majority of people were concerned when it came to autonomous vehicles, be it private or commercial vehicles. Interestingly they would have been happy to have more autonomy when it came to their driving experience, but were not willing to pay extra for such features [14]. Contrary to this, the research results of Kyriakidis et al. (2015) based on 5000 responses from 109 countries, see the future of self-driving cars in a much brighter light [15]. According to 2/3 of the respondents, self-driving cars will have made up 50 % of the vehicles on the road by 2050. Nonetheless, 2050 is still far away. In a recent research Kettles, Van Belle (2019) found that more than 60 % of the people are not willing to use self-driving cars within 6 months after their local availability and only 20 % would do so. The same study emphasised the importance of performance expectations and hedonistic motivation to be two of the most important motivators for using self-driving vehicles [16].

Interestingly, the public attitude is far more positive when it comes to public transportation. On the one hand, people do not really care or mind if the means of transport they are using is self-driving, as long as it takes them to their destination. Other features of the public transport, such as cleanliness, comfort are more important [17]. In addition, the overall perception is rather positive. However, there are differences based on socio-economic factors as well as traffic related variables, such as the location, route design number and duration of stops. There was also significant difference between the satisfaction level of male and female passengers [18].

All in all, we must state that even though the technology is available, the readiness to use it is still to catch up with the availability. Hence, in order to explore the limitations of the more widespread use of the technology, we need to investigate the factors related to readiness when it comes to self-driving vehicles.

As in case of any new technological developments, people's reaction differs over time. Early adopters rush to a new technology, but many are afraid of anything new, as the S curve of innovation also depicts [19]. While the speed of technology adoption is increasing, the readiness is still a phenomenon to be considered and measured.

The readiness of users and onlookers is almost as important of a factor when it comes to technological improvements as the technology itself, since it depicts the usability of the given technology. If the readiness level is low, it will induce lower level of acceptance, lower demand and at the end of the day, lower penetration, while with high level of readiness people are eager to join in on new experiences and explore fields and technologies previously unexplored. Hence, readiness, the people's trust in the "perfection" or well-functioning of a given technology is one of the most important factors to be considered, when it comes to self-driving cars [20]. What is more, trust is considered a general factor of ICT readiness [21].

Trust as a basic requirement of the widespread use of autonomous vehicles on the roads has long been recognised by scientists as well as practical specialists. With the increasing complexity of intelligent systems, the perceived vulnerability of users increases in an extreme speed [22]. Hence, trust in such complicated and inconceivable systems is not easy to be established. While trust offers the deliberate acceptance of the state of vulnerability (being in risk) from certain agents in return for foreseeable advantages – and, therefore, it can be used as a substitute for the lack of control in certain situations – there is no straightforward way of how to efficiently induce or improve trust towards AI, or more specifically, in autonomous vehicles.

What is more, in case of the wide scale emergence of self-driving cars on the roads, we shall not only consider the individual layer of the phenomenon, but we must also take into consideration the ethical and social dilemmas that may be raised by the greater public [23]. While the software and hardware providers for autonomous vehicles will most possibly stick to the most self-protective approaches – i.e the driver always needs to provide supervision to

the system, even if it is labelled autonomous – the reality is not only about who is responsible or who takes the blame in case of an accident, but also about how and whether people are comfortable with self-driving vehicles on the road that are (or are not) sufficiently supervised by their drivers [23]. What is more, ever since Asimov we have all well known that it is not only the fear of those who are outside of the vehicle that must be considered, but also the fear of losing or having no control over the vehicle and the car deciding against its driver or passengers is also an extremely prevalent phenomenon. [24].

Self-driving cars and the computer program that controls them must make difficult moral decisions in extreme situations. These hypothetical situations are often debated and explored by researchers of autonomous vehicles. One such situation is when a child runs out in front of a car and a collision is inevitable. The question is whether the car should jerk the steering wheel, endangering the passengers, or it would rather hit the child on the road [18]. Many researchers have sought answers to the question of how machines should make ethical decisions. For example, the Massachusetts Institute of Technology [25] has created the Moral Machine, which was designed to gather human perspectives on ethical issues related to self-driving cars. The questions they tried to explore were:

- How should the car be programmed to act in the event of an inevitable accident?
- Should the vehicle minimize the loss of life, even if it means sacrificing the passengers, or protect those inside at all costs?

Answers to these ethical questions are important because they can have a big impact on the acceptability of autonomous cars in society. The question is not only hypothetical, after all who would buy a car programmed to sacrifice the owner [26]?

The dilemma about inevitable accidents where people have to decide the outcome of the event, was presented to hundreds of workers on Amazon Mechanical Turk [26]. Participants were given tasks in which one or more pedestrians could be rescued when the car hit an obstacle, killing the passenger or pedestrian while saving the other pedestrians. According to the research results people are generally comfortable with the idea that self-driving vehicles should be programmed to reduce casualties. However, these results only prevailed while respondents viewed the problem from the perspective of a pedestrian or an unaffected third party, and perspective suddenly changed when respondents were supposed to relate to the casualties imagining that they were sitting in the car (see trolley problem).

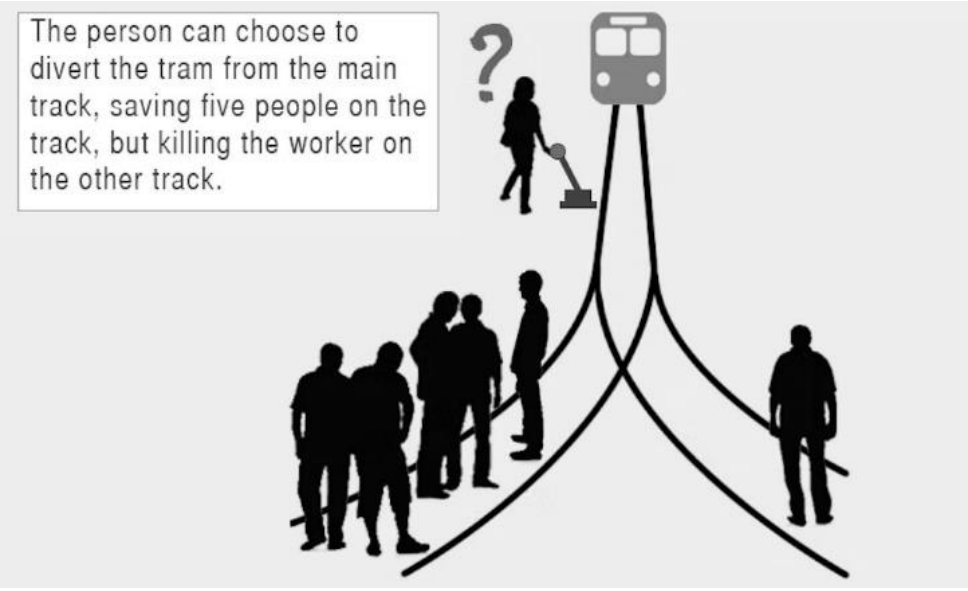

Figure 2. The trolley problem [27].

As it has already been stated in the introduction of the present article, autonomous systems are already available for public and private transport. The necessary hardware and software products have been created, and novel designs for (semi-) autonomous vehicles are launched every year. However, besides the hardware, it is extremely important that the software is regularly updated; since it is the software and the artificial intelligence running in it that evaluates its own environment based on the collected data and makes decisions to achieve the goal. Trained on a large amount of data, the system will be able to judge traffic situations and decide on the behaviour of the vehicle, as well as to recognize patterns for later situations. The software must know that traffic signs exist as objects, and that these signs have their meanings, and therefore they should be differentiated from similar objects (e.g. advertising signs) [28].

Overall, the software in the car must know everything and be able to prepare for any situation, since it takes care of the lives of the people sitting in it. Any computer that communicates with or is accessed in some way by another computer is vulnerable to computer hackers. In recent years, there has been a lot of news about hackers breaking into various databases and viruses infecting a large number of computers. This is not the first time that cars have been used as a tool for terrorist acts [29] This might even be easier with self-driving cars in the future. If someone hacks into the system, they can have the data and take control of the car – so they can even stop the brakes or control the steering, etc. An example of this was when in 2015 two hackers, Charlie Miller and Chris Valasek, took over a Jeep Cherokee's UConnect system (Internet-connected computer function) for testing, which controls everything from the navigation system to the driver's outgoing calls [30]. The Wired journalist was just sitting in the car helpless and shocked, while the hackers controlled the car, the pedals and the steering wheel as well. In view of this, building a safety system is a huge challenge for car manufacturers and also for consumers, because as long as the car is not safe, people will not trust them.

In line with the above described, and in addition to social and ethical dilemmas, technological insecurities must also be tackled to achieve the widespread use of autonomous vehicles on the roads. Furthermore, issues arising from the encounter between a self-driving vehicle that always considers safety first, and a vehicle that is driven by a person who knows that the other will surely behave 'properly' also need to be addressed. In such cases, self-driving vehicles are expected to always give priority to other cars in order to avoid accidents. Hence, "drivers" of such vehicles will experience handicaps on a regular basis in everyday traffic situations, which can also be a great drawback when it comes to purchasing decisions.

According to Jiang et al. (2021), providing more information might increase a specific segment of people's trust, namely that of technical trust. However, to complicate the situation, providing more and more information about the system, its internal logic and technological parameters might not improve the situation, but it might make everyday people trust autonomous vehicles less [31]. Since their perceived level of understanding, and in line with this, their perceived level of potential exertion of control in dangerous situations might even decrease as a result. Hence, while transparency and communication related to autonomous vehicles is a must, the sufficient level of information provided might be up to rigorous market research [32]. To be able to work around this information trap, to lessen the stress and anxiety induced by the systems and increase the perceived level of information, the awareness of people towards autonomous systems in general must be improved. Only then will they be ready to accept self-driving cars around them [33].

According to the Technology Acceptance Model (TAM) [34] model, which is especially adequate when it comes to understanding early adopters of a new technology, external environmental factors affect users/buyers through two mediating variables, namely: perceived usefulness and perceived ease of use of the technology under scrutiny. In case of self-driving

cars, the latter one is a clear advantage of the technology, since it does not require prior training or knowledge. On the other hand, the perceived level and assortment of benefits differ from user to user. While some regard driving as a hobby, other only look at is as a way of transportation. Hence, the perspective of the abovementioned groups of users will be undoubtedly different.

THE RESEARCH

In order to explore the individual attitudes of potential users/buyers, we have initiated a quantitative research study with the help of an online questionnaire. The sampling was comfort sampling hence the data cannot be regarded representative. However, since we have managed to reach 666 people in a time frame of 3 months from 2022 January to 2022 April, the data shall be regarded as relevant for the topic of our question under scrutiny. The majority of data came from Hungarian respondents (N = 550), but an additional 116 responses were collected from international respondents to see if there is a pattern of difference in the responses by country of birth. While the number of non-Hungarian respondents was relatively low, there were no significant differences to showcase for any of the countries involved in the research (namely Albania, Finland, Germany, Kazakhstan, Mongolia, Poland, Romania, Serbia and Slovakia). As a consequence, all collected data is presented further in the text.

The sample contained 368 male and 288 female respondents' responses while 10 respondents opted for not disclosing their gender. The average age of the respondents was 27,366 years, with a standard deviation of 10,978 years, indicating that the respondents were mostly young people, but the query managed to reach a wide variety of people from age 12 to 70.

The distribution of the respondents by age is shown in Figure 3.

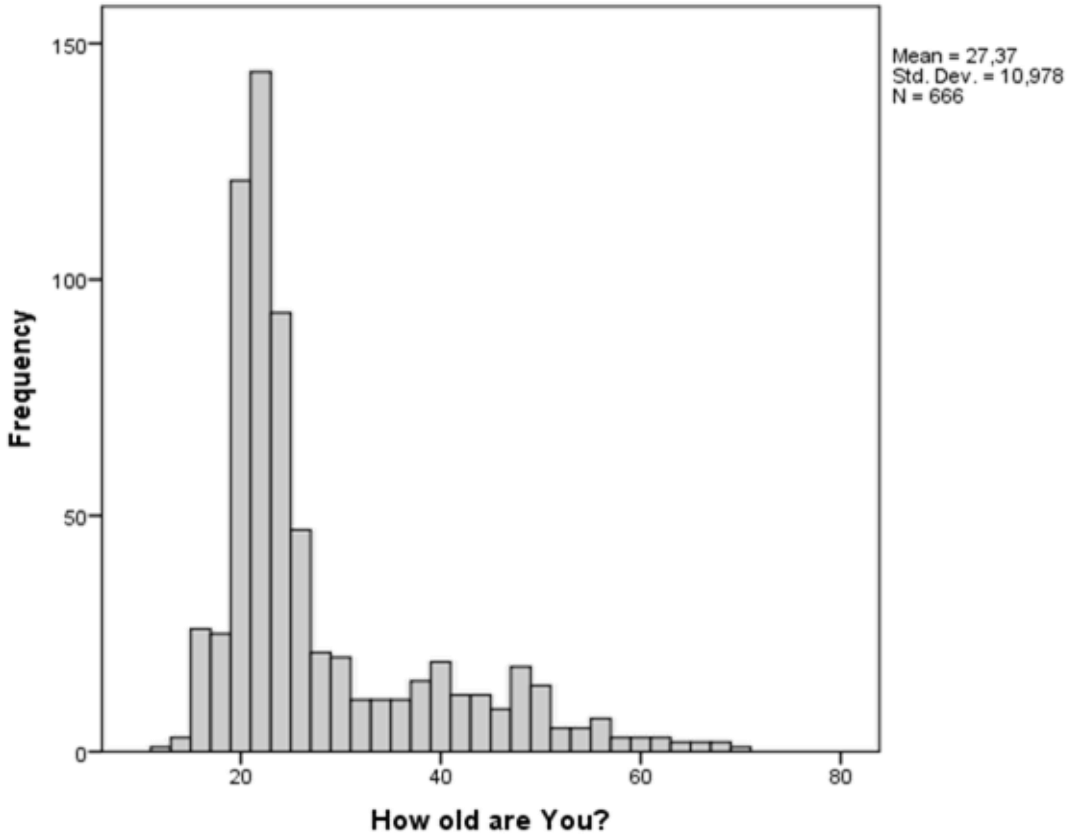

Figure 3. Distribution of the respondents by age.

The female population was slightly older (Avg.:28,326, Std.Dev.:11,989) than the male population (Avg.:26,696, Std. Dev.:10,087), but the difference was not significant owing to the big variance in ages.

The respondents had different attitudes towards self-driving cars and autonomous vehicles in general. Assessing their trust in such vehicles with the help of the six stages of autonomy described previously, the distribution is created as shown in Figure 4.

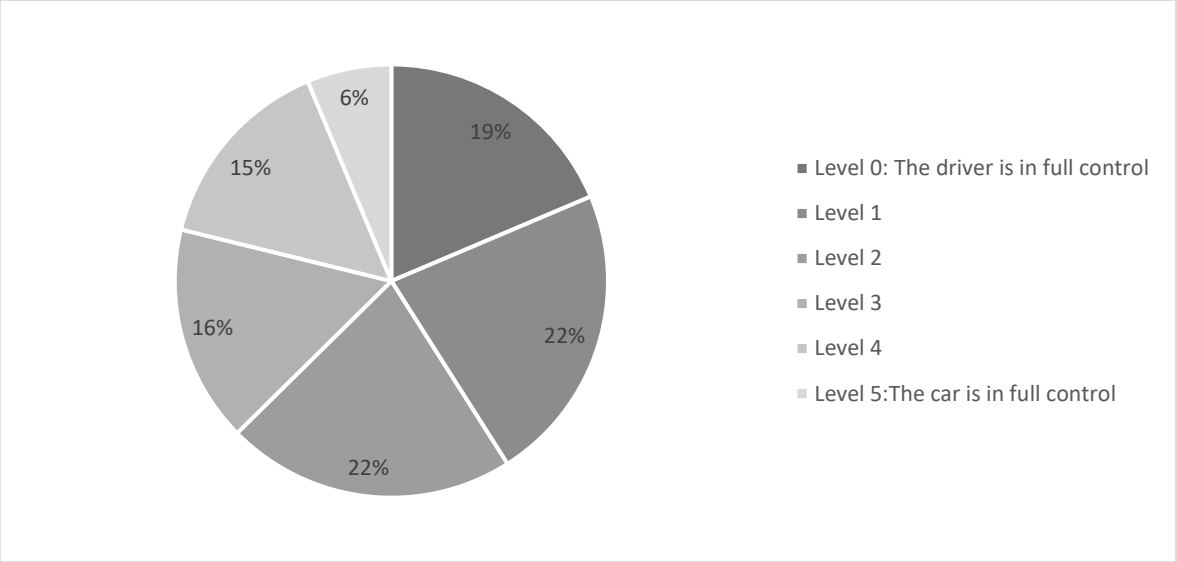

Figure 4. Six stages of autonomy.

As is seen in Figure 4, the majority of the respondents was only interested in a lower level of autonomy provided to their vehicles. Only 6 % would be interested in using self-driving vehicles, where the car is in full control, and 15 % would want to use self-driving cars if they would still be able to regain control in case it would be needed. These data are in line with the previously mentioned international findings. The majority of the population is not ready for self-driving cars yet.

For this purpose, the responses to the statement "I would support the introduction of autonomous vehicles" were used. The distribution of the respondents is shown in Figure 5.

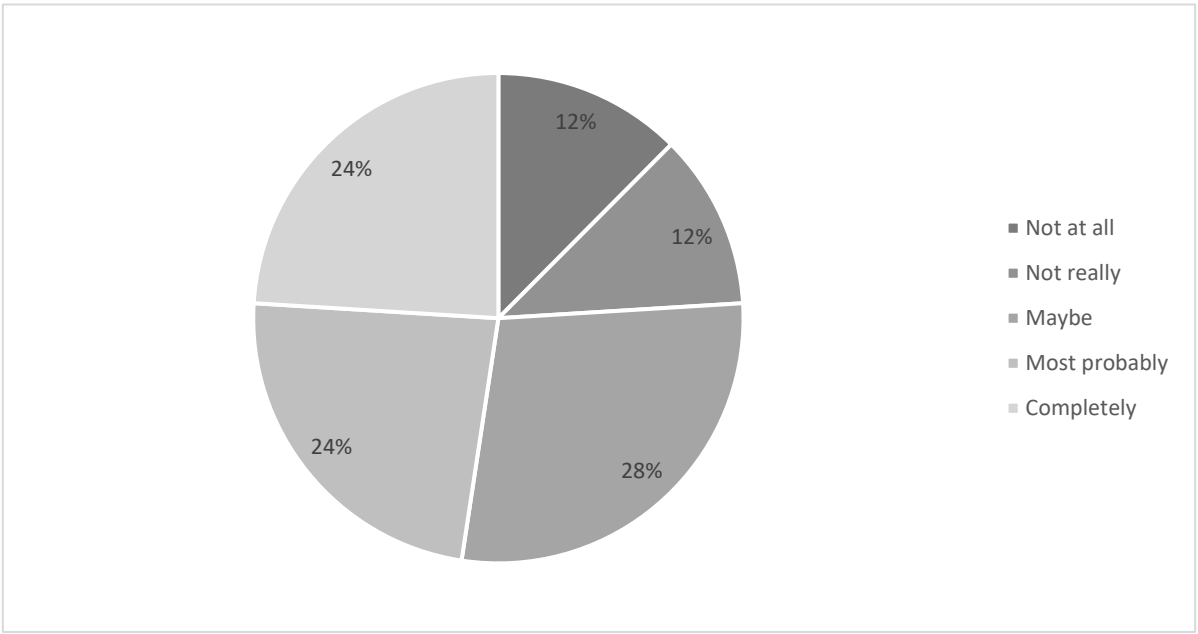

Figure 5. Distribution of the respondent's reluctance to accept autonomous vehicles.

The major question is whether there is a pattern based on which it can be clearly identified who are in favour of self-driving vehicles and who are against their widespread use on the roads.

While the numbers are in line with the data highlighted in Figure 5 indicating the reluctance to accept autonomous vehicles, approximately half of the respondents (maybe not as a direct user/owner) would support the introduction of self-driving cars. In comparison, only one fourth of the respondents were against it. The respondents with an intermediate "maybe" answer are considered neither for nor against the notion of autonomous vehicles, hence, in the following analysis they will be excluded and only a sample of 470 respondents will be considered.

Interestingly, as depicted in Table 2, the distribution of those against the introduction of automated vehicles by gender was balanced. However, there were more males supporting the introduction of autonomous vehicles than females. Hence, the autonomous vehicles and their acceptance can be regarded as a gendered topic, which is fully supported by international literature introduced previously.

Table 2. Distribution of respondents by gender and attitude towards autonomous vehicles.

	What is your gender?		**Total**
	Male	**Female**	
Does not support the introduction of autonomous vehicles	78	79	157
Supports the introduction of autonomous vehicles	208	105	313
Total	286	184	470

According to our research data those who would like to have self-driving cars have some distinctive features. The Table 3 shows only the values explored through our questionnaire, where the averages of those for and against self-driving cars were significantly different.

Table 3. Difference between those who want to have self-driving cars and those who do not.

		Levene's Test for Equality of Variances		**t-test for Equality of Means**				
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**
I would be afraid of self-driving cars in my environment	*	17,165	0,000	13,567	475	0,000	1,652	0,122
Self-driving cars will positively affect emission	*	19,269	0,000	–14,127	475	0,000	–1,499	0,106
Self-driving cars will positively affect the society	**	0,971	0,325	–21,211	311,78	0,000	–1,980	0,093
Self-driving cars will reduce the occurrence of accidents	*	14,153	,000	–22,519	475	0,000	–2,023	0,090

As these data indicate, those in favour of automated vehicles believe autonomous cars to positively affect not only the occurrence of accidents owing to their heightened reaction speed

provided by the sensory system and the computing capacity which is far superior to that of humans, but also the society and carbon emission, and through it, our natural environment as well. On the other hand, those who would not like to have an autonomous car are also afraid of having them driving around in their surroundings, Table 4.

Table 4. Difference in the relevance of various fear-inducing factors.

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. 2-tailed	Mean Diff.	Std. Error Diff.
Fear: Hackers tamper with the car	**	1,709	0,192	4,071	328,468	0,000	0,557	0,137
Fear: The self-driving system breaks down	*	34,534	0,000	7,574	475	0,000	0,819	0,108
Fear: The car decides different from how I would like it to	*	13,075	0,000	9,264	475	0,000	1,048	0,113
Fear: Fear from the new technology	*	6,691	0,010	7,639	475	0,000	0,928	0,121
Fear: People (in various professions, such as chauffeurs) will lose their jobs	**	3,473	0,063	6,241	289,252	0,000	0,857	0,137
Fear: Control cannot be regained	*	17,769	0,000	7,190	475	0,000	0,920	0,128
Fear: I lose the joy of driving	*	11,664	0,001	7,150	475	0,000	0,974	0,136
Fear: The security of personal data cannot be provided	**	0,467	0,495	6,610	317,859	0,000	0,836	0,127

While in general those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control, the fear is triggered differently in case of different concerns. While the difference is the biggest in case of decisions made in an alternative way – which is different from that of the driver, and the smallest in case of hacker threats, the above table underlines that the fears are significantly different in all cases.

SUMMARY AND CONCLUSIONS

While autonomous vehicles are already an inevitable part of the public transport system in many cities, the private use of autonomous vehicles is still in its infancy. Autonomous systems are already available for public and private transport. While adequate hardware and software have been created for autonomous systems to be readily available, and the number of (semi-) autonomous vehicles is increasing year by year, their acceptance still seems to be low. In line with international literature from various countries and the research data presented in the current article, many are afraid of not only using, but also being around them.

The current article, after introducing the relevant literature of trust in autonomous vehicles and the factors affecting it, presents the data of an international quantitative research of 666 people.

While the questionnaire was disseminated online, with the majority of respondents belonging to the Z and Y generations, the research managed to reach out to other age groups, too.

In line with the data presented in the article, the biggest perceived threats and their prevalence is gendered – female respondents are less open and accepting with autonomous vehicles. As a consequence, manufacturers and producers must be ready to separately address the two groups' requirements. In addition to the exploration of how males and females differ regarding autonomous vehicles, the article highlights and also tries to uncover why more than half of the respondents are afraid of autonomous vehicles.

According to the research data, those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control. However, whether it is a root cause of their negative attitude, or its consequence is yet to be explored.

The findings also suggest that those in favour of automated vehicles believe autonomous cars to positively affect not only the occurrence of accidents, owing to their heightened reaction speed provided by the sensory system and the computing capacity which is far superior to that of humans, but also the society, the carbon emission, and through it, our natural environment as well. In line with the previous statement, this discrepancy may also be the result as well as the reason for the respondents' attitude towards self-driving cars.

All in all, the article managed to clarify some factors related to trust in autonomous systems, enabling manufacturers and policy makers to tackle the listed issues so that autonomous vehicles could become an innate part of the private transport system of future smart cities.

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SCIENTIFIC RESEARCH-BASED VIEW IN CONSTRUCTION PROJECTS: CREATING INTELLIGENT INFRASTRUCTURE

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ABSTRACT

Among the top ten construction projects in 2023, Crossrail 2 – London in the UK is the first, Mumbai International Airport in India is the second, and the third is the Grand Ethiopian Renaissance Dam in Ethiopia. The first two projects are transport investments and the third is the largest hydroelectric energy investment in Africa. Crossrail 2 was estimated to cost £32,6 billion in 2016. In 2019 Crossrail 2 related reports suggested that the scheme might add up to more than £45billion. At Navi Mumbai International Airport the estimated cost of the project was US$ 600 million, this has since grown to US$2,0 billion. The Grand Ethiopian Renaissance Dam is estimated to cost close to 5 billion US$. These hugely expensive projects impose a significant burden on society. How can those infrastructural investments be implemented so that the infrastructure to be built can be used safely and economically for several decades?

KEYWORDS

infrastructure development projects, trustworthy AI, railway 4.0, smart transport

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INTRODUCTION

Our research is motivated by the fact that the planning, implementation and operation of infrastructural (e.g. transport [1-4], energy [5], telecommunications, etc.) systems require a significant investment of time and money, even for the richest countries. Thus, even the smallest increase in efficiency can bring significant results. These projects (which affect the Community infrastructure) have a particularly large and long-term social impact and role in terms of social well-being. People's well-being covers joy, safety, and health [6, 7].

We examine several types of infrastructure construction projects (eg. Crossrail 2 [1-3], Navi Mumbai International Airport [4], Grand Ethiopian Renaissance Dam [5]). The main question of our study is that on the basis of which methodology the work is organised in the case of different types of construction projects, and which organising principle characterises the construction project management. The priority probe aspects cover the creation phase of the concept, preliminary feasibility studies (scope of the project), the method of setting deadlines, and preparatory work. How to reach the perfect planning of the project? Its elements can include the contract, the project milestones, information sharing, risk management, project roadmap with dependencies, project budget, work breakdown structure (listing all project deliverables and sub-deliverables), and project execution [8].

The construction industry is faced with many challenges [9]. Despite the large financial sums invested, its growth led to extremely low productivity levels when compared with other industries [10].

On the other hand, several scientific sources point to the fact that artificial intelligence technologies are being used in all industries worldwide to increase efficiency, improve productivity and reduce costs [11].

MATERIALS AND METHODS

In most cases, the data of construction projects constitute a trade secret, so we could only work from open data that can be found, for example, in the European public procurement journal. In some cases, such as the Crossrail project, more information and documents are available from open sources,. Also, a number of scientific publications have been published about The Grand Ethiopian Renaissance Dam project. We examined these references and sources during our research work.

We reviewed the announced tenders from 01/01/2022 to 30/06/2023 in connection with infrastructure constructions the submission deadline of which were no later than 30.06.2023. During this period, we found a railway construction works tender [12]. In this period, most of the existing tenders focused on airport buildings construction work [13], construction work for pipelines [14, 15], communication and power lines, highways, roads, airfields and railways [16], construction work for electricity power lines [17] and road construction works [18].

RESULTS AND DISCUSSION

Understanding and managing new risks is indispensable for investments that have significant environmental impacts or involve shaping the environment (infrastructure construction projects). Moreover, this management task must be understood in the entire lifecycle of these projects [19].

As the synthesis of the literature and open access datasets, it can be concluded that the efficiency (improved productivity and solved challenges) of construction projects should be increased especially under the conditions of modern economic insecurity and construction made over a long period [20-22]. Sha'ar et. al found ten main problems: "(1) unstable client requirements; (2) lack of proper coordination between various disciplines of the design team; (3)

awarding the contract to the lowest price regardless of the quality of service; (4) lack of skilled and experienced human resources in the design firms; (5) lack of skilled human resources at the construction site; (6) delay of dues payments; (7) lack of a specialised quality-control team; (8) lack of professional construction management; (9) delaying the approval of completed tasks; and (10) vague and deficient drawings and specifications" [23].

According to Egan [24] the construction industry is underperforming, which is manifested in low profitability, capital investment, research and development caused by delays in construction projects as a result of the high dissatisfaction from the part of the industry's customers with its overall performance.

Some research publications such as Flyvbjerg [25] and Rhodes [26] have indicated that 9 out of 10 global megaprojects experience delays, which usually lead to excessive cost overruns. Obviously, this is also a problem for smaller projects. An innovative solution to the above-mentioned problem was proposed by Egwim et al. The suggestion was to apply artificial intelligence for predicting construction project delay [11].

Dikareva et. al investigates four fields of efficiency of a project, such as budgetary efficiency, social efficiency, economic efficiency, and commercial efficiency [20]. Our research group proposes to approach the efficiency improvement question from two sides. One is the application of technological systems in project management, such as the use of AI in project management. And the other suggestion is the application of technological systems during the implementation of the infrastructural system of the managed project, that is using AI directly in the built infrastructure and subsystems.

These already mean, for example, improving efficiency with pre-construction planning [27], investing in construction technology to enhance project management, and increasing efficiency and productivity on the construction site through the training of construction teams (AI in teaching).

The project's main resource asset is information. Information is important for pre-construction planning and scoping to ensure on-time and on-budget success. For every level of the project, we need to find an understanding of the type of information necessary at each stage. We need efficient technology to collect and handle this information. The key to success is having the single version of the valid information (objectives, tasks, outputs, deadlines, and budgets) [7, 28]. In the first figure, we can see the PIM model of the Crossrail project.

We recommend using artificial intelligence to support project management techniques [11].

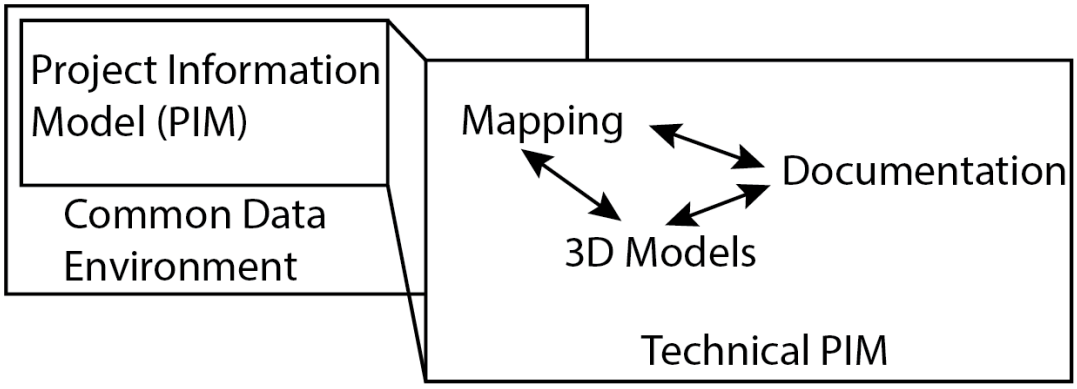


Figure 1. An example of information types on projects eg.: Crossrail PIM model [28].

Another level of information sharing in projects is collaborative decision making. Collaborative management can be a successful tool for cross-border projects involving several international actors. An example of such cooperation is the Grand Ethiopian Renaissance Dam project. In 2018, Ethiopia, Sudan, and Egypt formed a National Independent Scientific

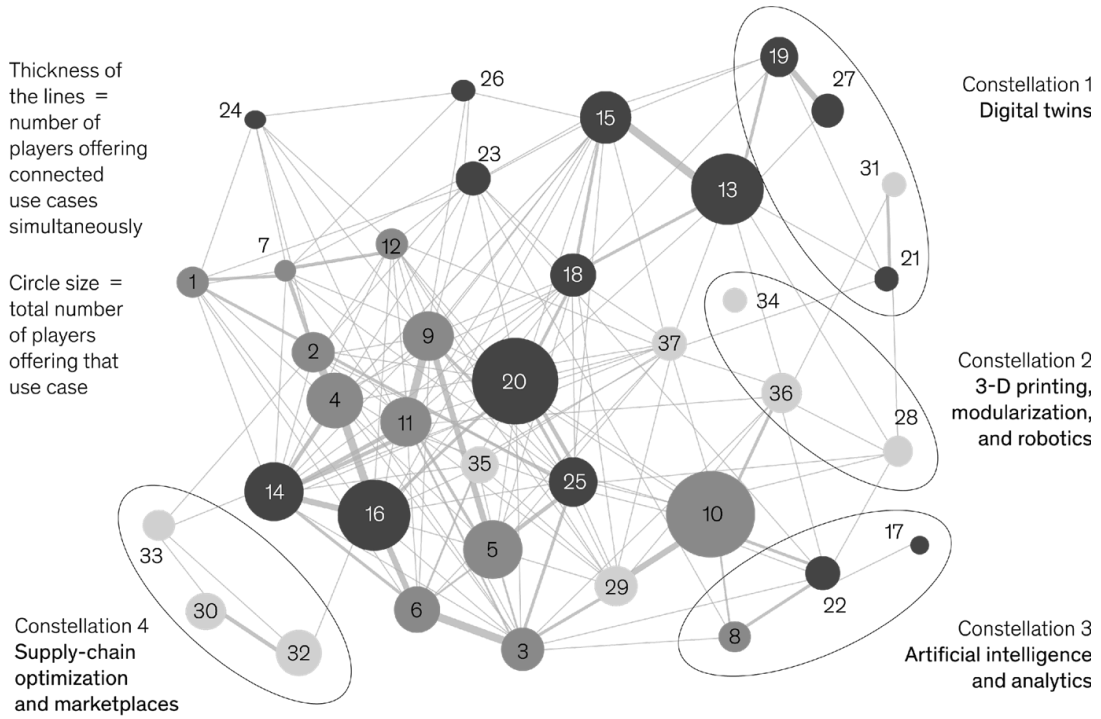
Research Group (NISRG) of researchers from the three countries [29]. The example of this project shows that in the case of an international project, project management organised on a scientific basis is particularly important. Moreover, we think that this principle could also be an important aspect in the decision making of other projects [30, 31].

By the mapping of artificial intelligence on infrastructure development project management and on the industry, Figure 2). McKinsey visualised the connections of the Global construction technology industry ecosystem. Figure 2 shows the globally used AI technology in the Construction industry [32].

For a deeper investigation, we chose one industrial sector where we have more experience. This was the railway sector [33].

Our second proposal is to build systems with artificial intelligence in infrastructural systems [34-42]. We can create a new structure which is an intelligent infrastructure.

At this time, it is not yet a widespread solution in everyday life. To accomplish this, we recommend the following roadmap for the industry.



Digital collaboration

1 Capital financing
2 Customer relationship management
3 Equipment management
4 Estimating
5 Manpower optimization
6 Materials management
7 Portfolio planning and management
8 Predictive assessment performance
9 Project scheduling
10 Real-time monitoring and control
11 Resource planning
12 Risk management

Back office

13 3-D modeling
14 Bidding process
15 Building-information modeling
16 Contract management
17 Deep learning
18 Design management
19 Design simulation
20 Document management
21 Laser scanning
22 Machine learning
23 Process simulation
24 Productivity management
27 Progress tracking and performance dashboards
26 Value engineering
27 Virtual learning

On-site execution

28 3-D printing
29 Compliance
30 Construction materials marketplace
31 Drone-enabled yard inspection
32 Equipment marketplace
33 Labor and professional marketplace
34 Off-site fabrication
35 Quality control
36 Robotics/automation
37 Testing and training

Figure 2. Global construction technology industry ecosystem [32].

Strategic Priority Step 1

Examining, updating and actualizing industry standards either based on industry-specific results or experience outside the sector.

The importance of reaching this milestone can be traced back to the fact that railway industry players place a strong emphasis on the application of standards for safety. Therefore, until these standards do not include the method of how to apply AI technology, it will certainly not spread within the railway industry.

Naturally, at the same time, the regulations characterising the industry need to be changed and clarified. In this regard, it is particularly interesting how the various railway regulations can be kept up to date.

Strategic Priority Step 2

The commitment of the manufacturers towards the awaiting application of AI technology in their products.

Is there any AI technology ready to use? Within 5 years the AI-based non-intrusive infrastructure inspection technology will reach the TRL 9 level. Also, the same status will be true for train delay prediction using Machine Learning and a little more time is needed for the predictive maintenance of railway assets to become market-ready.

Strategic Priority Step 3

Development of industry certifications flows. Since the railway industry produces a significant number of safety-critical products and systems, it is particularly important to develop the related certification requirements and methods, similarly to the aviation industry.

Strategic Priority Step 4

Additional demands are expressed in railway tenders. From the point of view of the tenderer, it is a simple question whether the industry standards include the possibility of applying AI technology. The tender will call attention to the application of the industry standards as it is usually the case. In relation to AI, there are few specific regulations which prescribe that the risks must be examined from several points of view. These categories can be seen in Figure 3.

It would be too early to talk about the mandatory use of AI technology by manufacturers. The application will gain momentum if the respective manufacturers see a significant competitive advantage in it.

These Strategic priority steps can be milestones of the Roadmap for Trustworthy Artificial Intelligence usage, especially in the Railway industry.

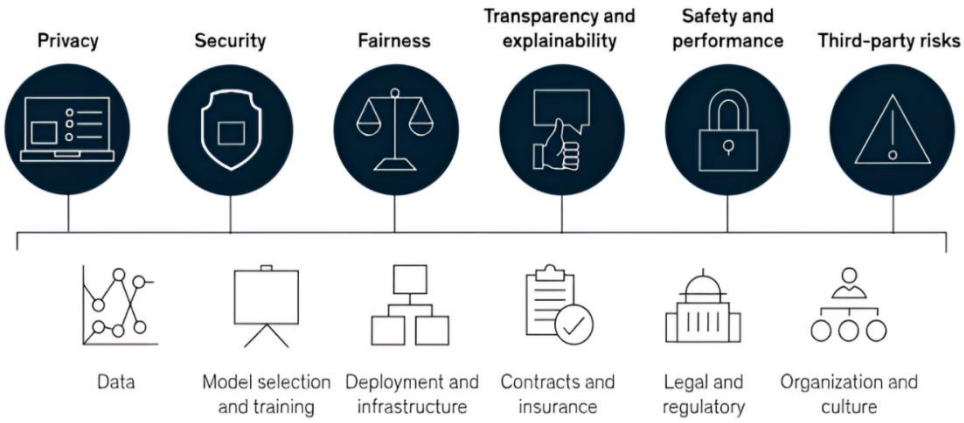


Figure 3. AI risks in global construction technology [45].

CONCLUSION

The research results show us that construction projects need to improve their efficiency. According to our research, AI can be a great tool to improve project management or on-site system operation. The barrier to AI use is its questionable trustworthiness. Therefore, the trustworthiness of AI to be used in the future is an important issue, especially in the case of its application in safety-critical systems [43]. These Trustworthy systems have to reach the ethics standard which means adequate human oversight, technical robustness and safety, privacy and data governance, transparency, diversity, non-discrimination and fairness, environmental and societal well-being and accountability [44].

In our study, we connected infrastructure construction projects to AI technology in the management field and technological field in order to improve efficiency. We can find good examples at different levels, but sectoral changes are ahead of us. To facilitate this, we outlined our proposed roadmap for the use of trustworthy artificial intelligence.

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