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EDITORIAL: SMART CITIES RESEARCH FUTURE MOBILITY, FUTURE INFRASTRUCTURE, FUTURE PLACES FOR LIVING, FUTURE EDUCATION

Lectori benevolo salutem,

in this editorial, we discuss and present the current and future trends of research on smart cities in connection with the sixth Smart Sustainable and Safe Cities Conference and in the framework of ‘MEC_N-141290’ Scientific Research program for the promotion of leading-edge technologies and future science as open science.

Outstanding researchers of the Doctoral School on Safety and Security Sciences at Óbuda University and of NextTechnologies Ltd. Complex Systems Research Institute have been able to go beyond the traditional disciplinary approach and conduct real research. The authors show how to develop future tasks based on real community needs independently, by applying the skills in a synergistic and creative manner.

In this way, the sharp borderline between separate disciplines is disappearing and the project-oriented approach necessary for practical tasks is generating new disciplines and new knowledge. The research results of the Doctoral School on Safety and Security Sciences presented in this thematic issue of the INDECS journal include the following papers:

In their article *SMEs' Perceptions of the Use of Cloud Services*, **Bak** and **Reicher** highlight the relevance of cloud computing today, and give an overview of the latest studies on SMEs.

The article titled *Cyber Security Analysis of Smart Buildings from a Cyber Security Architecture Point of ivew* by **Sándor and Rajnai** presents the basic features of the emerging cyber security contents of smart buildings.

The next article *Digital Education; Governments Strategies, Teaching Tools in the EU and the Case Study of Digital Transformation in Budapest* by **Altaleb**, **Shatnawi** and **Rajnai** evaluates and analyzes e-learning and distance education in terms of threats, challenges, opportunities, strengths, and weaknesses.

According to the research on energy security, reliability, availability, accessibility, and resilience presented by **Molnár** in the article *Smart Solutions for Securing the Power Supply of Smart Cities.* a fragile balance of city infrastructures will need to be maintained to operate future smart cities.

Part of the research topic of social engineering is presented in the article titled *The Role of Social Engineering in the Energy Balance of Systems* by **Albininé Budavári**, **Albini** and **Mester**. The study examines the harmful energy role of social engineering through the parallels between the regulatory circuit of the control theory and the operating model of social engineering. The result of the study highlights the importance of cyber defence.

The article *The Role of Additional Information in the Control System* by **Albininé Budavári** and **Rajnai** examines the efficiency of system control. The basis of the study is the energetic background of the control theory cybernetic loop model. The study models the impact of sampling efficiency across the entire cybernetic loop. Modeling the role of additional information in the cybernetic loop has shown that the presence of additional information generates unnecessary energy consumption.

In the article *Autonomous Vehicles from Another Perspective - a Literature Analysis* by **Berek**, some research trends on self-driving cars are presented. The bibliometric analysis included an overview of publications on self-driving cars by year and by country. A more detailed analysis of the publication output of the last six years is also included and it shows that Asia is making significant efforts in the field of self-driving cars.

The article *Internet of Things (IOT) in Self-Driving Cars Environment* by **Bautista** and **Mester** presents how the Internet of Things technologies can drastically improve the capabilities of the autonomous vehicle to better understand its environment with the interconnection of the surrounding elements. The development of the Internet of Things in autonomous cars has resulted in more intelligent mobility with higher levels of safety, efficiency and sustainability.

The article titled *Underestimated Factors in the Adoption of Self-Driving Cars* by **Zilahy** focuses on the factors that have been underestimated in the adoption of self-driving cars. In the future, companies wishing to promote self-driving cars should use social media to describe self-driving in a way that is as clear and simple as possible. The controllability of vehicles should also be communicated.

In their article named *Methodological and Health Reasons for Unsuccessful Biometric Identification,* **Pallagi** and **Persely** examine the main causes of failed biometric identification procedures through examples.

Guaranteeing safety represents a serious issue in smart cities and it has become one of the pillars of a smart city.

These studies connect to cutting-edge smart cities research, and they can be successfully implemented in various areas of developing sustainable and safe communities all over the world. This work is connected to the project and the results of the international collaboration in promoting science, and it is a good example of supporting community science.

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, 21st March 2023

Guest editors:

Dániel Tokody and Gyula Mester

Interdisciplinary Description of Complex Systems 21(2), 131-140, 2023

SMALL AND MEDIUM-SIZED ENTERPRISES' PERCEPTIONS OF THE USE OF CLOUD SERVICES

Gerda Bak[1,] * and Regina Reicher[2]

[1]Obuda University
Budapest, Hungary

[2]Budapest Business School
Budapest, Hungary

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ABSTRACT

Although cloud computing is a rapidly evolving technology and is considered one of the key technological drivers of business digitalisation, it is still a challenge for many businesses to adopt it. Implementing the right cloud services is challenging and requires the right level of knowledge. In addition, the size of the company, its digital maturity and its financial situation are also critical factors, which are particularly relevant for small and medium-sized enterprises. Therefore, in this study, we focus on the situation of small and medium-sized enterprises regarding cloud services. To this end, we conducted qualitative research to examine the studies on cloud services, their trends, research directions, and research areas and to explore the relationship between the publications and their scientific embeddedness.

KEY WORDS

SMEs, cloud computing, qualitative research

CLASSIFICATION

JEL: O1, O3

*Corresponding author, η: bak.gerda@uni-obuda.hu; -;
Nepszinhaz str. 8, 1081 Budapest, Hungary

INTRODUCTION

In today's connected world, the phenomenon of mobile working is becoming more and more natural [1]. Digital development also significantly impacts social and economic processes, transforming how we communicate, connect, do business, and work [2].

As a result of Industry 4.0, companies face several new challenges affecting their operations and collaborations [3]. Many believe that if a company wants to remain or become competitive, it needs to respond to consumer demands and digital trends [2]. However, these technological innovations have benefits and many risks that management should consider before adopting technology [3, 4]. One such technological innovation that has been received differently by businesses is cloud computing (CC) [5], as confirmed by a Eurostat [6] survey, which shows that, on average less than half (41 %) of businesses in the EU use CC.

The article is structured in the following elements: first, an overview of the state of the art of cloud services and their relationship with small and medium-sized enterprises (SMEs), followed by a second section presenting the research methodology used. In the third section, empirical results of the research are presented and finally the article concludes with conclusions, limitations and future research directions.

LITERATURE

Nowadays, information security has become an essential factor for everyone, whether a business or an individual. Nevertheless, information technologies are indispensable in everyday life. Another critical aspect for companies is that they are highly dependent on ICT tools for business management, partner relations, marketing and many other activities, which are carried out using digital devices [7]. Therefore, addressing information security is a crucial challenge for companies, as they aim to prevent exposure to security and privacy threats to information systems and protect their network infrastructure. Although a relatively large proportion of SMEs has a minimal IT infrastructure [8, 9], this infrastructure is not enough. It lacks skilled staff, IT specialists [10], adequate and modern digital devices [11], a supportive attitude of top management [12] and the necessary financial backing [13, 14]. However, one of the benefits of digitalisation is the emergence of cloud computing, which can be of particular benefit to SMEs, as it allows companies without (advanced) IT infrastructure to take advantage of technological developments [12]. Cloud computing is a relatively new topic with many potentials [15]. While larger, multinational companies can more easily implement it in their operations [16], SMEs do not even consider implementing it due to a lack of capital and knowledge [2].

CC, as a new area of outsourcing, has a promising future. Still, there are concerns about adopting the technology: the regulations and laws and the associated security and control aspects [17]. Moreover, the literature and adoption rates show that cloud adoption is still in its early stages, especially for SMEs in developing and less developed countries. According to Gutierrez et al. [2], the service is not yet a mature technology may be due to its low adoption rate. Another potential explanation could be that SME owners and managers lack confidence in the service and are more resistant to new technologies. As a result, they fail to see the potential opportunities, savings and ease of use [18].

Many studies have addressed CC from an SME perspective, both from a technological and economic point of view, as well as from the perspective of the drivers and barriers to technology adoption [19, 20]. However, the collection and synthesis of different perspectives and results, and the networking of these studies, are rare, and this article aims to bridge this gap. The aim of this research is to understand the perceptions, knowledge and opinions of

SMEs about cloud services and their use. Furthermore, to map the networking of the studies on which the research is based, i.e. the reciprocity between individual authors and the evolution of the research field across disciplines.

METHODOLOGY

For this study, systematic literature review was used as applied methodology, with the Web of Science (WoS) database providing the data for the bibliometric analysis. The research aimed to find out the opinions and knowledge of SMEs about cloud services. For this purpose, data were extracted from the WoS as mentioned above database. We tried to draw from as wide a range of publications as possible, but we also used some limiting conditions.

The research seeks to answer the following research questions:

1. Which publications or researchers are the most influential on the subject?
2. What are the areas of focus of existing publications on cloud computing?

In the following, we present the research results to this end. The data was analysed using VOSviewer and Excel software.

With regard to the methodology used in the research, a few sentences on network analysis should be mentioned to provide some background to the analysis. Network analysis makes it possible to combine a number of disciplines and to understand and map the relationships and interactions between the points under investigation [21]. In the present case, we have examined the network of studies to identify the most relevant studies, authors and countries in terms of SMEs' use of cloud computing services.

DATA COLLECTION AND DATABASE

To collect the data, we used the Boolean terms small and medium size* (Topic) and cloud* (Topic) and 2010-2020 (Year Published) Article (Document Type) and English (Languages). This search resulted in 553 results. We then searched the publications for repeated instances but found none. Finally, we screened the papers by title, abstract and keywords to see if they were all related to the topic we were looking for, and as a result, 433 articles were filtered out, leaving 120 studies to be dealt with further.

RESULTS

We examined the year-on-year evolution of publications that satisfy our search criteria between 2010 and 2020. Out of the 120 studies reviewed, one was published in 2010, followed by four in 2011 and 28 in 2020, the last year examined. The number of publications shows an upward trend, despite two or three years of decline. The majority of studies were published in 2017 and after.

We then looked at which research area the publications under review fell into and selected the ten most researched research areas, as shown in Figure 1. Figure 1 shows the 120 publications by research topic. The Computer Science area received the most significant number of studies, with almost 41 % of the studies falling into this area. Engineering follows this with 27,5 % and Business & Economics with 25,8 %. Looking at the research areas, the question arises that while the high number of studies from computes science is understandable, the low number from the economic area is surprising. As already mentioned in the literature section, the lack of appropriate knowledge and capital is the reason for the low number of CC implementations. However, it is precisely this discipline that has not researched its effectiveness, necessity and potential.

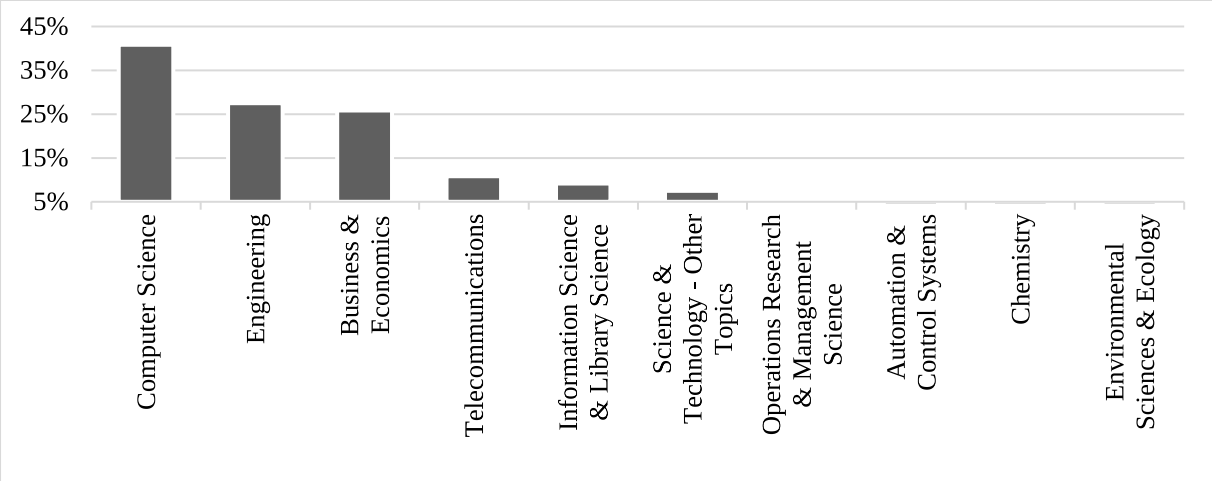

Figure 1. Research areas of the analysed papers.

KEYWORDS CO-OCCURRENCE

We analysed the co-occurrence of keywords, and the results of it can be seen in Figure 2. Out of the 661 keywords, 28 meet the threshold, which is a minimum of five occurrences of a keyword. Twenty-eight keywords were selected by the software. There are four clusters with 230 links and 507 total link strength. The most frequently used keyword was cloud computing, which appeared 47 times and was mentioned together with 25 other words. This is followed by SME with 21 occurrences and with 88 link strengths and adoption with 19 occurrences and 83 link strengths.

The minimum number of citations of a paper is five. Of the 121 documents, 74 meet the threshold. In Figure 3 can be seen 64 papers in four clusters because ten items in the network

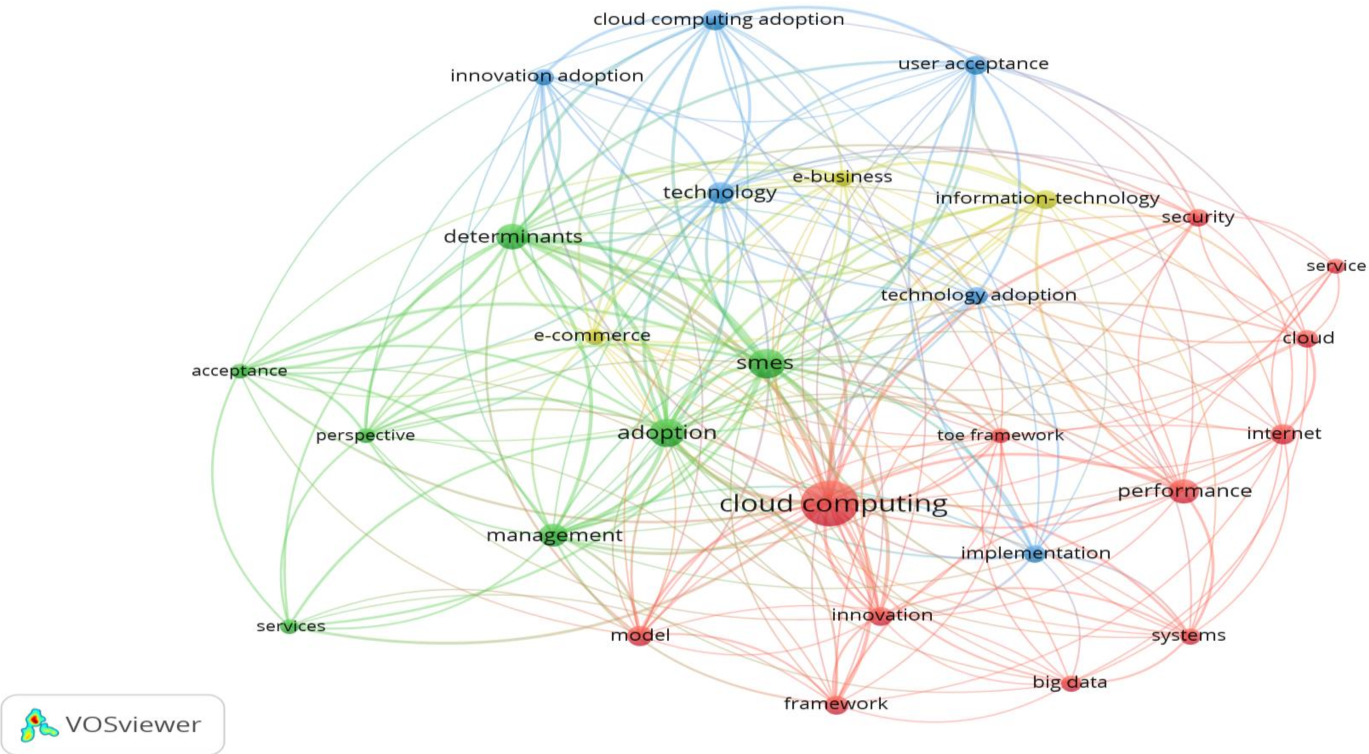

Figure 2. Keywords co-occurrence of the papers.

are not connected ,and there are 381 183 links. If two or more texts quote the same work, they are clustered closer together. Each node's size reflects the number of citations it has received. The most strength total link belongs to Seidel-Sterzik [22], which is 3 218. It is followed by Seethamraju [23] 2 177 and Vorisek [24] with 1824 link strength. However, in terms of citations, Ren et al. [25] stand out with 144 citations, but also Wu et al. [26] 137, and Huang et al. [27] have 131 citations.

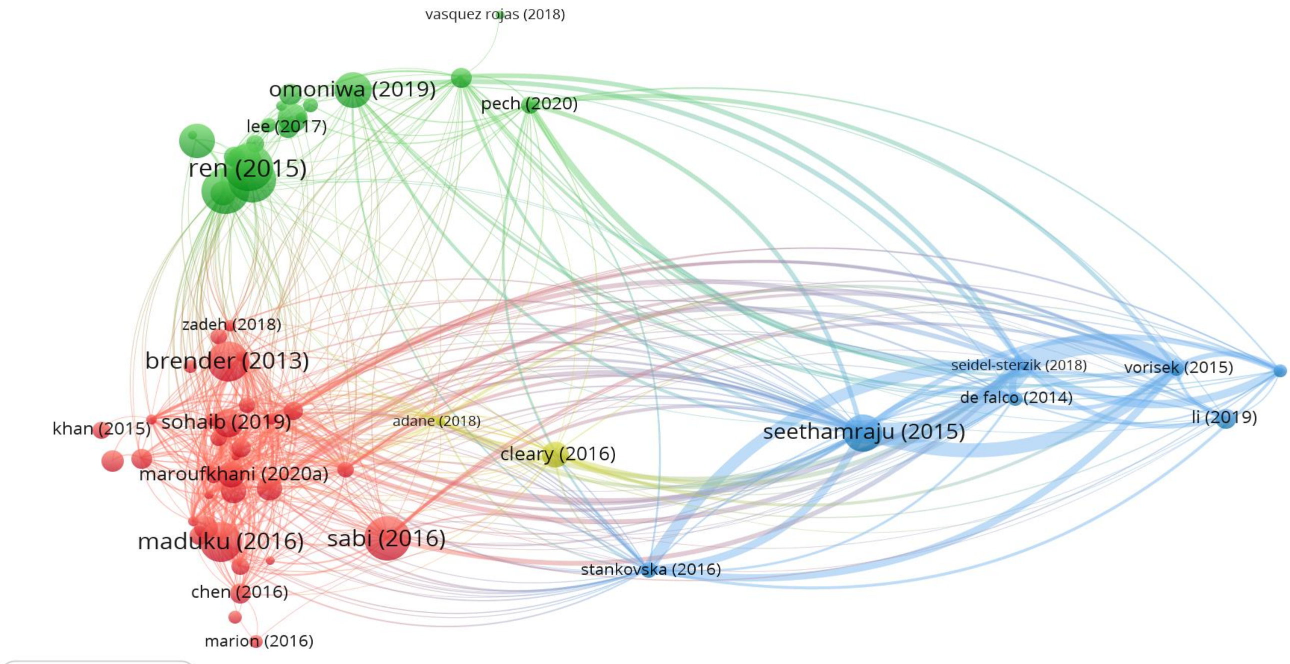

Figure 3. Analysing of bibliographic coupling of the papers.

Following that, a study of the writers who were most frequently cited by the same document (co-citation) was conducted. Co-citation coupling is a technique for determining the subject similarity of two publications. At the same time, co-citation analysis reflects significant authors on the subject [28]. In this case, the threshold was a minimum of 10 citations of cited sources. Of the 3 041 cited references, 92 meet the threshold. Figure 4 shows 91 items because one the not connected to the others. The size of the nodes corresponds to the citation number. Figure 5 illustrates the 60 items in 4 clusters with 2 510 links and a total link strength of 28 881. As shown in Figure 4, most of the studies included in our analysis refer to studies published in the International Journal of Information Management and the Journal of Enterprise Information Management.

It should be noted here that the bibliographic coupling is a connection that connects two publications that both reference the same source. In contrast, co-citation is a link that connects two objects referenced in the same document.

For further analysis, we selected the top 10 cited studies and subjected them to further analysis, the results of which are presented in Table 1.

The total amount of citations was 1163, which provides an average of 116 citations per article. Three of the most cited publications were published in 2013. These studies have been published in 8 different journals, as well as in Enterprise Information systems and the International Journal of Information Management stand out from the list with 2-2 publications.

CONCLUSION

Although cloud technology is not a new invention [34] and has been rapidly adopted by users, it is still a technology in its infancy and is only just being explored. The big problem is that SMEs can hardly keep up with technological progress [35], even though they are the engine of the economy and should be able to react or even control it faster.

The study examined the importance of CC over the past decade, exploring the directions, research areas, journals and research focus on the topic. For this purpose, we reviewed relevant and significant-high-quality publications in WoS. In addition, the study analysed the existing literature and found that cloud computing is a much researched and growing research area.

The study revealed that the use of cloud computing in SMEs is emerging and the potential is abundant. More importantly, cloud services are an inevitable way for SMEs in the sector to digitise their processes, but there are also several limiting factors. The present study has highlighted the relevance of cloud computing today and has given an overview of state of the art in studies on SMEs, which is growing in terms of the number of studies and the range of issues covered. However, in terms of research areas, the technical side still strongly dominates, despite the subject area increasingly requiring a multi-, if not trans-disciplinary approach.

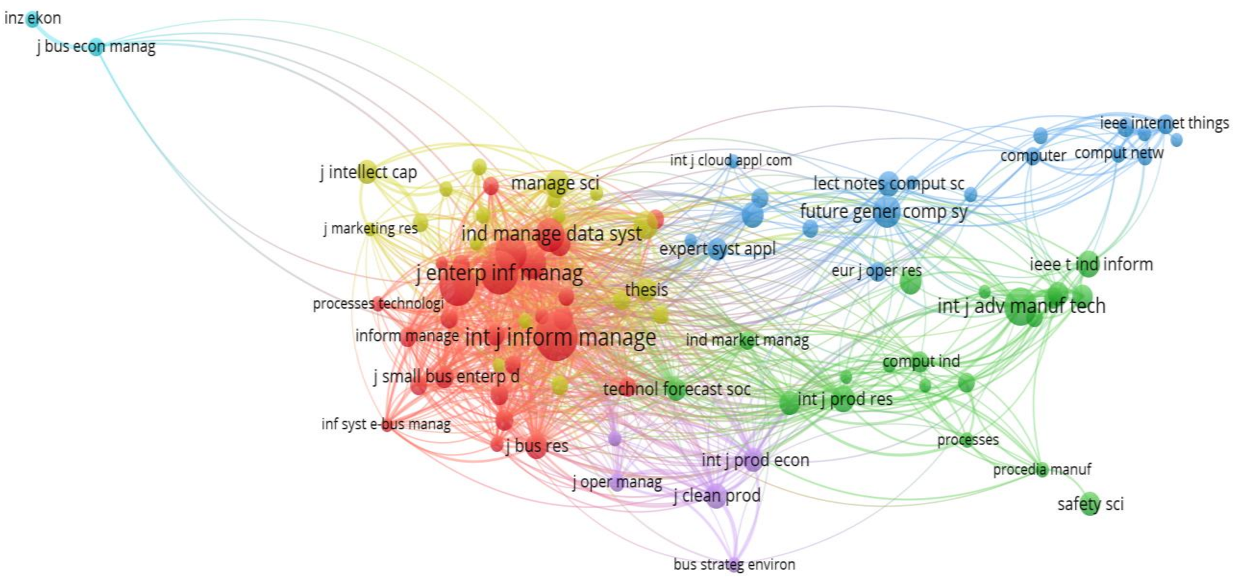

Figure 4. Analysing of co-citation of the published papers.

LIMITATIONS AND FUTURE DIRECTIONS

The limitations of the present study include two factors: first, the database used, which should be expanded in future research to include other databases, and second, the nature of the studies should be extended to include studies published in conference proceedings. The second limitation is the lack of a survey of SMEs by target country or area, which is worth looking at in a more limited way in future studies by looking at a region or country.

Table 1. Top ten cited papers.

Ref.	Title	Journal	Results
[29]	Authorised Public Auditing of Dynamic Big Data Storage on Cloud with Efficient Verifiable Fine-Grained Updates	IEEE Transactions on Parallel and Distributed System	Data security is one of the main problems with CC. Data auditing is a solution, but it is not a hassle-free solution. The paper proposes an enhancement that could reduce the additional communication costs of checking for minor updates and provide greater security and flexibility.
[25]	Cloud manufacturing: from concept to practice	Enterprise Information Systems	A cloud manufacturing system has been developed to serve as an application example.
[26]	A fog computing-based framework for process monitoring and prognosis in cyber-manufacturing	Journal of Manufacturing Systems	A new computational framework was developed and proven for remote, real-time detection, monitoring, and scalable, high-performance analysis for diagnosis and prognosis. Wireless sensor networks, CC, and machine learning are all used in this framework.
[27]	Cloud manufacturing service platform for small- and medium-sized enterprises	The International Journal of Advanced Manufacturing Technology	A framework and platform were created, and its feasibility explored to consider the possibilities of facilitating the adoption of cloud services by SMEs in the manufacturing sector.
[30]	Conceptualising a model for adoption of cloud computing in education	International Journal of Information Management	A model for the adoption of cloud-based services in education has been developed. Based on preliminary surveys conducted in sub-Saharan Africa, socio-cultural factors were found to be significant in the adoption process.
[3]	Risk perception and risk management in cloud computing: Results from a case study of Swiss companies	International Journal of Information Management	Some of the benefits of cloud services are more important for SMEs than for larger companies, but there is still a high level of mistrust in CC due to a lack of expertise and poor risk management.
[31]	Linking building data in the cloud: Integrating cross-domain building data using linked data	Advanced Engineering Informatics	The authors advocated for linked data to be used as a technology for cloud-based data services. When cross-domain data sources are migrated to a cloud-based data service, connected data technology is an effective tool for boosting interoperability.
[32]	Applications integration in a hybrid cloud computing environment: modelling and platform	Enterprise Information Systems	Companies are using several cloud services at the same time, and they also have an internal intranet network. The authors have created a run-time platform and a cross-computing environment process modelling technique to simplify this.
[23]	Adoption of Software as a Service (SaaS) Enterprise Resource Planning Systems in Small and Medium Sized Enterprises (SMEs)	Information Systems Frontiers	According to the study, the factors that determine whether a company implements a SaaS ERP include the reputation of the software vendor in the market, the fit of the software to the business, the vendor's potential willingness to support the customer throughout the product lifecycle, the vendor's involvement in creating value for the customer.
[33]	Fog/Edge Computing-Based IoT (FECIoT): Architecture, Applications, and Research Issues	IEEE Internet of Things Journal	The fog/edge computing-based IoT (FECIoT) distributed architecture enhances service provisioning and is suitable for mission-critical applications. However, it also provides better resource allocation, service delivery and higher levels of privacy.

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CYBER SECURITY ANALYSIS OF SMART BUILDINGS FROM A CYBER SECURITY ARCHITECTURE POINT OF VIEW

Barnabás Sándor* and Zoltán Rajnai

Óbuda University, Doctoral School on Safety and Security Science
Budapest, Hungary

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ABSTRACT

Nowadays, the smart city concept is gaining ground worldwide, driven by the development of information technology and IoT devices. As a result, smart buildings are built to provide more efficient, environmentally friendly, comfortable and automated features. The industry of building automation dates back nearly a hundred years. However, with the development of information technology, the size of built-in IT devices is shrinking year by year, and the amount of information generated by individual sensors, IT devices and by the people working in these buildings is fast increasing. Consequently, IT systems in intelligent buildings need to be adequately designed considering several aspects. Cyber security is one of these aspects, and it is the subject of the present research. A poorly designed and protected IT system with many Internet of Things elements creates a massive exposure to cyberattacks and hackers. After all, these systems may include the entire network IT structure, the elevator control and access control systems, the building's HVAC system, or even the parking lot system. In summary, the examination of primary cyber security factors and standards should be considered when designing a smart building.

KEY WORDS

smart city, smart building, building automation, internet of things, cyber security

CLASSIFICATION

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JEL: L86

*Corresponding author, η: sandor.barnabas@uni-obuda.hu; +;
Népszínház street 8, Budapest, 1081, Hungary

INTRODUCTION

Today, smart cities are not just a concept emerging in research papers and references. They are also gaining ground in practice, as an increasing number of cities worldwide realize that information and communication technologies (ICTs), including Internet of Things (IoT) tools are now becoming the mainstays of infrastructure. A settlement or group of settlements is a smart city if it develops its constructed environment and digital infrastructure, as well as the quality and economic productivity of its services sustainably, with the increased involvement of its inhabitants, using modern and renewable information technologies [1]. One of the distinctive forms of technologies and resources in smart cities is smart buildings, which aim to operate in an environmentally conscious, energy-efficient and economical way and increase the workers' comfort and convenience, thus increasing work efficiency. These buildings are also complex IT and cyber security solutions, including tens of thousands of sensors, actuators, IoT devices, security systems, access control systems, meeting room booking applications, elevators, and, for example, smart gardening systems. These systems, together or individually, can be threatened by cybercriminals, who, for a profit (economic or competitive), sabotage, or other reasons, attack these building systems, causing severe material, intellectual, or life-threatening damage. That is why the IT systems of these buildings must be adequately designed, implemented, and tested for cyber security to prevent or at least reduce such damage. The plans will be developed, modified, and validated by cybersecurity architects, engineers, and field specialists, and they will be deployed by integrator companies as well as tested by vulnerability experts.

WHAT IS A SMART BUILDING?

At first, it might be thought that building automation is an invention of the 21st century, but in fact it dates back more than 100 years. In 1921, the world's first lighting automation was completed, which operated in a staircase in Stuttgart and was made by the Theben company [2]. Automation has evolved steadily over the past 100 years, and convenience features have been added to each mechanical area, such as cooling-heating, fire protection, physical security, building operation, and metering, as shown in Figure 1. The primary purpose of smart buildings is to make connection between the data generated, the people inside, and the various systems [3]. The systems based on different IT solutions are managed centrally and on a cloud basis, making them more efficient to operate and troubleshoot, but more vulnerable to various hacker attacks if they are not adequately controlled on the network.

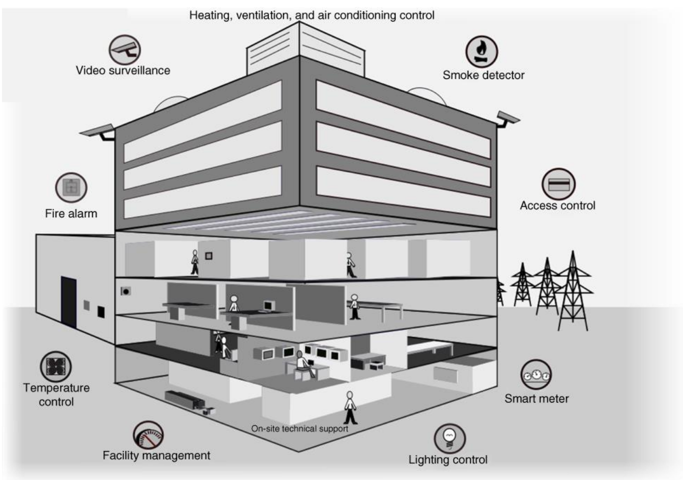

Figure 1. Smart Building Functions [3].

THE MAIN COMPONENTS OF SMART SYSTEMS

The smart systems that can be found in a building are highly dependent on the location and size of the building, the needs of the people working there, and on the services provided for the company or for the tenants [3, 4].

The first and most crucial element is the cooling-heating ventilation (HVAC), which ensures healthy air and comfort for the people working in the building. It regulates the oxygen and carbon dioxide level, the humidity, fresh air inflow, and temperature in the building, without which, or if inappropriate values are set, the basic operation of the building and the work done inside will be impossible. For the system to work, it is essential to have sensors in the building to measure the mechanical values and the number of people in each room, where the temperature is automatically controlled if there are too many people inside, because the heat output per person raises the temperature or humidity and reduces oxygen levels.

Another important system is facility management, where the systems responsible for managing intelligent buildings are interconnected. With a digital floor plan of the building and a BIM model, all devices and systems are located precisely where they are in the building.

From the point of energy efficiency, the control of the lighting system is essential, because if inadequate lights are installed, or their operation is not automated, the consumption of the building will not be optimal. In addition, individual needs, such as operating the lamps after processing the data collected by the light sensor, can be met in this way.

The primary physical security system for a smart building is a fire alarm system that can save lives if adequately calibrated and integrated into smart solutions. Sensors can be used to measure the number of people and the level of oxygen in each room, so the system can automatically intervene with ventilation, or during an emergency, the disaster management team can receive accurate information about the place and the number of people involved in the event of a fire.

CYBER SECURITY ARCHITECTURE

The cybersecurity architecture of smart buildings is comprehensive, and it incorporates a variety of industry standards and fundamentals. Zero Trust includes Public Key Infrastructure (PKI), LAN, KNX / EIB, AirPlay, Bluetooth, WiFi, ZigBee, and Z-wave. Identifying of people and devices is the primary consideration, followed by the protection of the wired or wireless technologies used, and the encryption, authorization management, and management of guest users.

Today, cloud-based solutions are essential for high-volume data processing, as storage and computing capacity are scalable, making it easy to calculate and plan the costs. Figure 2 shows the Microsoft Azure IoT Hub's device stream model, a managed, central messaging service between the IoT applications and devices connected to the system. Millions of devices and various backgrounds, solutions can be connected to it, given that it is compatible with almost any standard and device [5].

It can handle SAS token-based or X.509 certificate-based authentication for authentication and authentication. The former establishes the connection on a symmetric key basis, while the latter establishes the connection with the TLS standard [5].

In terms of cloud-based architecture, Microsoft Azure IoT is one of the providers that can offer a complex solution to create the cyber security IoT architecture of a smart building. The reference architecture shown in Figure 3 includes three main groups – things, processing/analysis (insights), and execution/action – these groups contain tools and services that can form the complex system of a smart building. For example, aggregate and control on a cloud basis, process data, transmit, manage users, and control security.

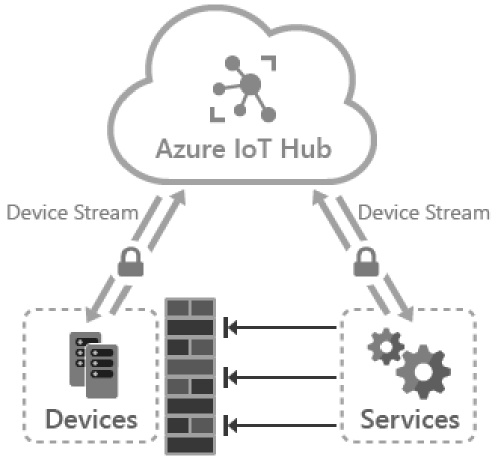

Figure 2. Microsoft Azure IoT Hub [6].

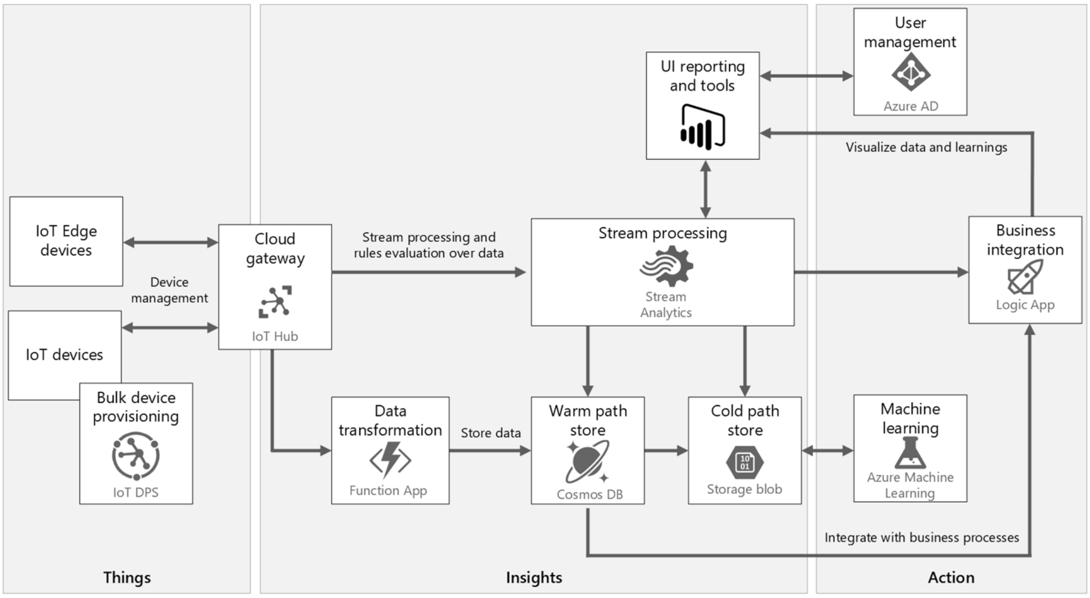

Figure 3. Microsoft Azure IoT architecture [7].

The comparison of the most common protocols in building automation should also be considered to form an idea of security (Table 1), where the most critical IT and security features are displayed. One of the main differences is network topology according to which the network can be designed, as well as the encryption protocol and algorithm within. For example, AES -128 encryption is vulnerable to brute force and man-in-the-middle (MITM) attacks, so it must be designed at a secondary security level in addition to the devices deployed.

In addition to the protocols mentioned above, Bluetooth, LonTalk, Modbus, 1-Wire, C-Bus, DALI, Insteon, oBIX, VSCP, xAP, X10, and Z-Wave are also present in the market. Several reputable manufacturers widely use them to communicate with their systems and IoT devices. These protocols include both secure and less secure ones.

CYBER SECURITY THREATS TO IOT DEVICES

Cyber security threats have been a growing threat to companies and individuals alike in recent years. Moreover, the rapid proliferation of IoT devices has added to this problem. Vedere Labs is constantly analyzing daily vulnerabilities and using a vulnerability metric to determine the top 5 IoT devices that are most at risk today (Figure 4), with projectors currently in the first

Table 1. Comparison of the various aspects of the BAS communication protocols [3].

	KNX/EIB	BACnet	ZigBee	EnOcean
ISO standard	14543-3	16484-5	-	14543-3-10
Network topology	Tree	Tree	Star, tree, mesh	Star, p2p, mesh
OSI layer	5	4	4	3
Wireless	X	X	X	X
Wired	X	X	-	X
Encryption	AES-128	AES-128 (CBC)	AES-128 (CCM*)	AES-128
Authentication	AES-CBC-MAC	HMAC	MAC	AES-CMAC
Security features easily deployed	-	-	X	X

place and printers in the last place. A number of these devices can be found in every office and in many households as well. Thus, it is relatively easy to conclude that improperly maintained devices can be potential sources of danger and primary points of intrusion in the event of a targeted cyber-attack. Currently, the highest Common Vulnerability Scoring System vulnerability is CVE-2011-4161, which affects HP printers [8].

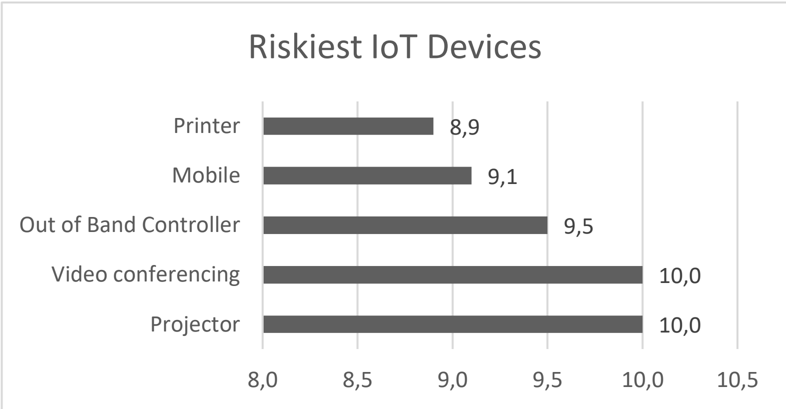

Figure 4. Riskiest IoT Devices [9].

Cyber-attacks on IoT devices have been ongoing for the past six years. Starting with the Mirai botnet attack in 2016, millions of IoT devices were infected and networked around the botnet, making it impossible to access Dyn Inc. in the U.S. and the Internet for several global companies [10]. This attack was followed by the 2017 WannaCry attack, which was a blackmail virus-based attack with a broad spectrum of attack vectors. Approximately 230 000 computers and IoT devices were infected in 150 countries. Moreover, the blackmailers demanded that cryptocurrency be issued for a ransom, which in most cases was not issued [11]. IoMT (Internet of Medical Things) devices in hospitals have also been attacked and, in many cases, made it impossible to work with the device, putting patients at risk [12]. The exposure to inadequately protected IoT devices and systems to extortion viruses is high, as the malicious code can enter the network unnoticed. In other cases, the device can even be connected to a botnet without the operator’s knowledge.

The latest research from Vedere Labs is called the “R4IoT” project, where a next-generation extortion virus attack was demonstrated in a simulated environment. The bottom line is that in a vulnerable OT (operational technology) environment, the vulnerability can be exploited and accessed through a building’s IT system. This attack concept is not based on file encryption by a classic blackmail virus, but on victim blackmail, where attackers threaten to leak sensitive data. Thus, a psychological method is added to the attack methods, so we can now talk about double blackmail. In another phase of the attack, the vulnerability of an IP camera can be exploited to gain access to the IT network and see a live image of the room through the camera. This attack makes it easy to test, for example, the vulnerability of each building control system and the success of the attack, as they get a live picture of whether or not they have managed to turn off the lights or shut down the fan. In many cases, there is no such feedback for an attack. The attack consists of several stages, one of which involves placing a blackmail virus on the network, which, if activated later, will be able to extort money from the victim [13]. Separated and properly and continuously monitored systems and devices are in place to prevent such attacks, where identification, encryption, and authorization management are adequately controlled. Of course, there are so-called 0-day vulnerabilities, which can be discovered later, when there is no patch to fix them, but these systems should be protected against them. The consequences of a cyber-attack should be considered in the security system’s design and the preliminary risk assessment, including the further economic, prestige, data protection, and physical consequences.

In 2022, the main threats to IoT devices were [14]:

1. Unencrypted data storage;
2. Unencrypted financial information;
3. Physical access through the IoT device;
4. Weak password and authentication;
5. Botnet and infected IoT devices.

FUTURE RESEARCH

In the future, the number of of these buildings will increase globally, which will be a significant step forward in environmental protection and energy efficiency. However, it will require a continuous supply of cyber security professionals, which is not easy now because there is a massive global shortage of IT and cybersecurity professionals. Furthermore, these professionals need specialized expertise in the protection of IoT, wireless devices, and systems, which are not always uniform or have different manufacturers, so they need to be integrated. To continue our research, we intend to examine the cyber security of smart homes as the next element of smart cities.

CONCLUSION

To summarize our research, it can be stated that the protection of smart buildings is a complex and multifaceted task, given that a building automated at this level is equipped with various IT systems, standards, and devices. Moreover, protecting these systems requires a high level of cybersecurity expertise, experience, and complex teamwork, as a cyber-attack can cause severe damage to the building and the people who work in it, if, for example, a malicious hacker attacks the elevator we are traveling in. Thus, the continuous training and development of these professionals is essential to design, maintain and continuously improve the cyber security protection of these buildings with appropriate expertise.

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DIGITAL EDUCATION: GOVERNMENTS' STRATEGIES, TEACHING TOOLS IN THE EUROPEAN UNION AND A CASE STUDY OF DIGITAL TRANSFORMATION IN BUDAPEST

Haya Altaleb*, Malak Shatnawi and Zoltán Rajnai

Óbuda University, Doctoral School on Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

This article reviews some governments' strategies in the field of digital education especially during the recent pandemic period in the European Union. It includes some early lessons from the COVID-19 crisis. Besides, the authors cover various essential remote teaching tools for organizing effective virtual courses by evaluating and analyzing e-learning and distance education in terms of threats, challenges, opportunities, strengths, and weaknesses. Finally, this study presents a methodology with two hypotheses using SPSS statistics v26 to perform a survey on the effect of digital transformation. During the COVID-19 pandemic in Budapest, the participants' perceptions of the disease and the efficiency of the enforced restrictions to curb its spread were studied. The study methodology includes statistical data and analytical outcomes.

KEY WORDS

digital education, remote teaching tools, technology in learning, governments strategies in digital education

CLASSIFICATION

JEL: I2

*Corresponding author, η: haya.altaleb@uni-obuda.hu; +36204107793;
H-1081 Budapest, Népszínház street 8, Hungary

INTRODUCTION

Exploring the use of digital technology in the classroom enables educators to create immersive learning environments, which may involve a mix of online and programmable learning opportunities. Virtual learning is a dynamic term. In summary, digital learning will boost learning experiences, save instructors time, allow teachers to better customize learning to individual students, help in participant tracking, provide transparency into the education process for all participants, and much more [1].

Digital education platforms are programmable digital architectures that aim to integrate and coordinate user interactions not only with end-users, but also with corporate entities and government bodies. This is referred to as an online platform. It aims to collect, store, distribute, and systematically monetize user data. It is essential to establish a definition for the term "platform". Since platforms have become so enmeshed in social life in general and in education in particular, it would be a mistake to oversimplify the concept and reserve it exclusively for major ed-tech players such as Microsoft's 365 Education or Google's G Suite. The platform concept is used so widely in educational literature that it risks becoming a catch-all term for all programs and endeavors to make education (broadly defined) "more digital" [2].

Digital games, smartphones, blogs, social media, and learning environments are becoming more prevalent as our world becomes ever more digitalized. The Covid-19 pandemic, as well as the resulting social isolation and school closures worldwide, has accelerated this digitalization, prompting an urgent need for a critical, thorough investigation of how digitalization is affecting the educational environment. This Special Issue focuses specifically on digital education platforms. Such platforms have become more common in recent years, and both multinational and local technology firms have become omnipresent providers of such platforms, in both private and public education: from primary and secondary school programs to platforms designed specifically for higher education, from digital environments designed to support students' learning to environments that monitor their performance, and from digital spaces that combine multiple functions to interfaces with a single purpose [3]. While one of the most positive global impacts of COVID-19 was the acceleration in digital transformation, one of the most significant issues was to meet the challenges that arose. It is a fact that the transformation to online and remote learning and training will become the future trend, but it requires investments in sustainable, innovative platforms with modern tools, which are considered one of the main components of an intelligent education system, combined with adequate applications, AI, cyber and autonomous technologies. To assess the impact of digital transformation, a survey was conducted, and the SPSS statistics v26 was used for analysis. The findings show that many characteristics had a significant impact on digital transformation during the COVID-19 pandemic, the perceived threats of catching the disease and the effectiveness of the applied restrictions to control the spreading were investigated from the participants' point of view. The research methodology will contain statistical information and results from the analysis.

ESSENTIAL REMOTE TEACHING TOOLS

Whether in a conventional class or in a virtual one, students need to be able to communicate clearly and effectively to be successful in their studies. Keeping in touch with not just one, but with a number of students via email is a challenge. From any workstation, participants may join in video conferencing, direct messaging, audio chats, virtual rooms, or any other technical solutions that allow them to communicate with a significant number of people at the same time. The following are amongst the most in-demand tools, like Google Meet and Microsoft Teams [4]. For a good quality teaching experience, the following strategies can be used:

- preparing a schedule for the online class and sharing it with the audience before it begins,
- explaining to students what online etiquette should be followed in class and what is expected from them before the lesson,
- all microphones, except the one used by the speaker, should be muted. This helps students maintain their concentration by cancelling out distracting noises. Anyone who wants to say something should make a gesture to get the speaker's attention without interrupting them.

ONLINE HOMEWORK PLATFORMS

Essays, speeches, tests, and other types of assignments are all examples of assignments. To encourage students to submit their assignments, you can use a combination of the following platforms: Google Docs is a document management system designed specifically for essays and other written assignments. Use Zoom, Skype or any other video conferencing tool for speaking exercises. Videos and presentations are created using YouTube, Prezi, or Google Slides. Google Classroom is used to assign and grade home assignments, as well as to communicate with students via email. Google Classroom is widely regarded as a helpful online teaching/learning tool since it is free, simple to use, and offers all of the essential functions that an online teaching tool should have to meet all potential demands. The following case study demonstrates the successful usage of Google Classroom. Most teachers and students were able to use it in less than two weeks. The online presence was occasionally superior to the face-to-face presence. Both young and older students were able to benefit from the learning tool. Effective communication between the school, represented by school administrators, headteachers, and teachers, and the beneficiaries of the learning process, represented by students and their parents, resulted in an increase in the use of the Google Classroom tool in potentially problematic situations [5].

SOCIAL MEDIA CHANNELS

Education professionals may use social media platforms such as LinkedIn, Facebook, and WhatsApp to create exclusive communities or groups for their students. For e-learning participants, social media apps and websites provide a great platform to communicate with one another and follow up with learning programs. Social media apps and websites can also be used for the following purposes:

- continually communicate and be present after the online class period has ended,
- share and save important lesson-related information, presentations, and resources with colleagues and students,
- hold open forums for questions and answers,
- encourage students to communicate with one another and interact with one another while they are studying or working on their homework assignments,
- plan live events, such as webinars, and keep track of attendance (with Facebook or Instagram Live) [6].

ONLINE VIDEO TOOLS

Zoom and YouTube are both wonderful online video platforms for creating videos with the students. These techniques may be used in many different ways: (1) Recording online lessons or lectures and making them available to students through video so if a student is absent or studying for an exam, the videos can be replayed. (2) Using pre-recorded teaching materials to encourage students to learn independently. When students comprehend an idea independently, they increase their chances of comprehension. (3) Preparing available links to pre-existing internet video services.

DOCUMENT MANAGEMENT TOOLS

Teachers must keep track of documents such as test papers and lesson plans regularly. It is critical to have a place to store, manage, and organize all of these documents to keep track of them effectively, particularly when the teaching is done remotely. The most effective tools to manage the documents, such as OneDrive, GSuite, Dropbox, MS office, and Evernote can streamline the process of preserving documents.

- All documents, files, etc. should be stored in the cloud so that teachers and students can access them from any device, from any location.
- Documents should be neatly organized in relevant folders and subfolders to make them easy to find.
- Exchanging files and documents by a link or as a file. On GSuite, users can change the permission settings to Edit, View, or Suggesting mode.
- Editing and reviewing documents with students, adding suggestions and comments and tracking changes with version history [7].

EUROPEAN UNION GOVERNMENT STRATEGIES IN THE FIELD OF DIGITAL EDUCATION AND E-LEARNING IN EUROPE

To address the effects of the lockdown on distant learning, the report "Resetting education and training for a digital era" was published in 2020. As outlined in the original action plan, the EU can assist individuals, educational institutions, and educational systems in better preparing for work and life in an era of rapid digital transformation by enhancing the use of digital technology in the classroom, and for learning, developing digital capabilities and abilities relevant to digitalization, as well as increasing data analysis and foresight to improve schooling. Additionally, the European Commission countersigned a message on the importance of education and culture in promoting European identity. This communication served as the Commission's response to the Gothenburg summit's leaders' conference on culture and education. The 2018 OECD Program for International Student Assessment (PISA) research reveals that European nations are generally among the top achievers when it comes to student access to the virtual world and teacher and school preparedness [8]. Specific requirements must be met by digital technologies to benefit education, such as having equipment and infrastructure in place, supplying technical and pedagogical support, having a collaborative school vision, establishing leadership using digital technologies, and providing policy frameworks and support. According to the research, if such prerequisites are not met, generic programs on employing digital technology in education will be at risk of not affecting students' performance or, worse yet, having negative effects on their academic results.

Adult online education has grown in prominence significantly as a consequence of the current COVID-19 problem. Previously accessible solely in the classroom, the bulk of preparatory resources are now available online. Individuals are now urged to utilize the time saved by temporary work programs to train online from home in order to learn new skills that will be valuable beyond the health crisis. As a consequence, the crisis presents an excellent chance to assess the potential of online education. The exposure uncovered several significant disadvantages, including the requirement for adequate digital skills, computing equipment, and an internet connection to conduct online training; the complexity of delivering traditional work-based learning online; and the difficulty for teachers accustomed to classroom instruction [9]. During the COVID-19 pandemic, the distribution of formal education in schools switched to e-learning. Lockdown harmed work-based learning and apprenticeships since companies often sought primarily off-the-job components. Public support for online training was crucial for a variety of training providers and end-users, ranging from sharing sites to free solutions to help instructors and students develop their digital abilities. Throughout the lockdown, states, governmental work programs, and social partners all supported the use of online training. As a consequence of COVID-19, the most productive public employment services promptly shifted jobseekers' training online; others refocused training on high-demand vocations [9].

FUNDING FOR DIGITAL LEARNING RESEARCH AND INNOVATION

The European Union finances various research and innovation initiatives in the field of digital learning via a range of programs, including Horizon 2020, the seventh Framework Program (FP7), and the Competitiveness and Innovation Framework Program (CIP) Additionally, the European Commission is co-financing the creation and demonstration of a pan-European learning and assessment technology system. Furthermore, it co-funds networks that assist Europeans at risk of exclusion with upskilling and reskilling. Horizon 2020 was divided into the following programs[10]:

- an empowering, inclusive next-generation Internet "ICT-2019-30",
- technologies for learning and skills "ICT-22-2016",
- technologies for better human learning and teaching "ICT 20-2015",
- advanced digital gaming/gamification technologies "ICT 21-2014".

GOVERNMENTS' ROLE AND ASSISTANCE IN E-LEARNING

Government support was needed to keep training stable through digital learning, and it was provided in a variety of forms in several countries to ensure training continuity through online learning. The number of people who participated in online training offered by the Public Jobs Service (VDAB) in the Flemish Region of Belgium in the second quarter of March 2020 was 4 times greater than in the same timeframe the previous year. The first Web searches reveal evidence of an increase in the consideration in online training. Furthermore, there were more searches for online learning and e-learning between the end of March and April 2020. Massive Online Open Courses (MOOCs) increased up to fourfold in Canada, France, Italy, the UK, and the US, as restrictive lockdown rules went into effect in the mainstream of OECD nations. They were roughly twice as strong as their long-term trend by the end of April 2020. [11] As an example of the government's strategies, the following sections will overview the case of Hungary and France.

Policy and Strategy of ICT in Hungary

The government launched the Digital Success Programme (DSP) to accelerate the digitalization of the Hungarian society and economy, recognizing that digital change is an inevitable part of the twenty-first century. The Hungarian Digital Education Strategy is a critical strategic component of the program (DES). It established tools and objectives for developing "a system of education and training capable of performing education, instruction, and training tasks per the infrastructure, technology, content, organizational structure, and human resource requirements of the digital society and economy". As a consequence, the DES takes into account all dimensions of education, including instructional strategy, digital readiness and attitude, physical infrastructure, available technology, content, and administration. It says that schools should include digital technology and techniques into their curriculums since they are becoming more integrated into our everyday lives. In accordance with the strategy's goals, Hungary's Digital Education Strategy (DES), which is complementary to the country's Public Education Development Strategy, intends to achieve the following:

- students graduate from public schools with adequate digital competencies and media literacy, as well as the ability to continue developing these skills through lifelong learning,
- digital tools aid in the teaching-learning process by facilitating the fulfillment of public education system expectations (effectiveness, equity, and efficiency) [12].

The Hungarian higher education strategy statement offers a standardized online digital environment that supports personalized learning possibilities. The primary strategic aim is to enhance digital readiness via the implementation of solutions that correspond to internationally recognized standards. According to the statement, one of the essential developmental adjustments that higher education institutions must do is to use the potential of ICT in teaching and learning [13].

Objectives related to the digitalization of higher education:

1. developing learning-intensive higher education,
2. raising the digital and methodological preparedness of academics to an adequate level,
3. garanted access to high-quality learning materials and learning tools,
4. developing e-learning systems and materials; some of the learning and teaching process occurs in online communities,
5. integrating online services and the electronic forms of learning support,
6. the appropriate and sustainable use of digital devices.

Other horizontal goals, in addition to the aforementioned, affect digital higher education as a whole; such as ensuring compliance with information technology security regulations, collecting and processing data on higher education processes as extensively as possible at the institutional and sectoral levels, as well as improving fair access to higher education and involving previously excluded or underserved populations. Moreover, it also means leveraging digital solutions to assist higher education's commercial operations, particularly in the areas of adult education and research, development, and innovation [12].

Policy and Strategy of e-learning in France

In response to an unprecedented health crisis that had a significant impact on higher education in France, the Ministry of Higher Education, Research and Innovation has mandated that all available training courses be delivered online beginning with the first period of containment on March 16, 2020. This pedagogical continuity must ensure the proper continuation of educational activities, the avoidance of student punishment, and the creation of favorable teaching conditions for teachers. Despite several individual initiatives during this period, France developed a digital toolkit based on three fundamental pillars to address the aforementioned difficulties [14, 15]: Primarily, it is focused on two digital platforms: FUN-MOOC and FUN Campus. FUN–MOOC is the French MOOC portal from 2013. It provides the finest of online higher education with courses produced by experts from universities, schools, and other educational institutions. It allows students to practice for free, communicate with others, and grow at their own pace. FUN Campus, designed for HEls, allows instructors to integrate online courses and SPOCs into their syllabi. The second pillar is the Digital University, a French alliance of six thematic digital institutions. Its purpose is to offer peer-reviewed digital scientific and instructional materials to professors and students in Higher Education, as well as their governance. As a rule, these items are openly accessible and free to the public. The notion of a digital university is crucial for higher education administration since it enables them to help students in the future. The third pillar is Connected Campuses, which are private/public places where students may enroll in higher education courses while getting local assistance. They intend to assist young people in pursuing higher education opportunities that they may not have followed otherwise by equipping them with the skills necessary to overcome geographic, urban, and social hurdles. Today, higher education institutions use several programs, platforms, and instructional tools for synchronous and asynchronous online education. Several classifications encompassing numerous categories have previously been offered in the literature [15].

The Ministry released a list of technological solutions to assist trainers in distance education and training, including web conferencing software, collaborative tools, server links and clouds, and other tools essential for training actors to ensure educational continuity. The Minister of Labor in France, who is also in charge of technical education, established a forum to make tools accessible to professionals in the area, allowing for greater educational continuity (https://travail-emploi.gouv.fr/formation-professionnelle/coronavirus/formation-a-distance) [16]. Today, higher education institutions use several programs, platforms, and instructional tools for synchronous and asynchronous online education. Consider Figure 1 for a suggested technique for remote knowledge gathering and assessment. Several classifications encompassing numerous categories had been previously proposed in the literature [15].

METHODOLOGY

The proposed analysis consists of two parts, the pilot study tests, which shaped the final questionnaire, and the main study, which consists of the hypotheses, survey design, a plan of investigation, statistical analysis procedures, and implementation.

RESEARCH QUESTIONS

The main Hypotheses are summarized as follows:

H_1: There are no statistically significant differences for the sections related to the digital acceleration and the use of e- (study, work, and services) after the end of the pandemic.

H_2: There are no statistically significant differences for the sections related to catching the disease through communication with others, even if enforcement restrictions are applied to control the spread.

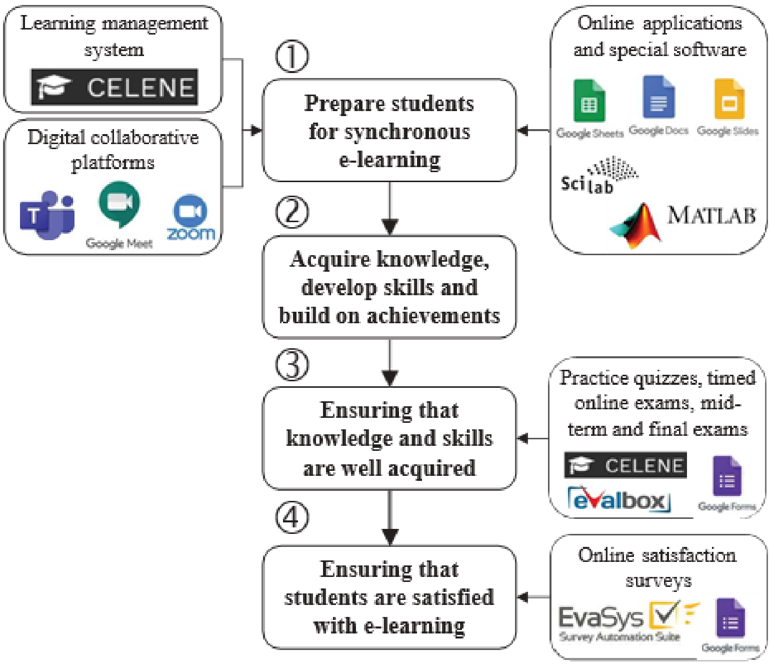

Figure 1. A proposed method for the remote acquisition and evaluation of knowledge.

THE PILOT STUDIES

The Pearson coefficient test for validity and Cronbach's Alpha test for reliability were very helpful and worthy [17-19], while revising and modifying the survey at this stage some questions were changed, merged, edited, or modified.

MAIN STUDY AND RESEARCH, METHODOLOGY AND PLAN OF IMPLEMENTATION

The survey used the Likert scale and underwent several tests through SPSS analysis [20-22] to check variables significances and research models. The check for normality and homogeneity should be carefully handled for all assumptions as seen below [23]. Initially, for reliability and validity, Cronbach alpha and Pearson coefficient were calculated at a significant level ($\alpha = 0{,}05$), and the mean, standard deviance, variance, skewness, and kurtosis [24] were generated to make the necessary comparison. Finally, the verification of the parametric and non-parametric characteristics to get confidence intervals for post-hoc analysis was achieved by Levene's and ANOVA tests [25] and through Kruskal-Wallis [26] and Friedman test [27] as non-parametric tests.

Test of Normality

Normality for each hypothesis was checked through Kolmogorov-Smirnov test [28] at the level of significance ($\alpha \geq 0{,}05$), as well the kurtosis and skew values were checked to ensure that they fall within the acceptable ranges (–10, +10) and (–3, +3) respectively [29, 30], the hypotheses H1and H2 for the gender, educational level, age, employment status, and income found statistically significant since most of the statistical significance values were below the level of significance ($\alpha = 0{,}05$). This indicates that the distribution is not normal.

Hypothesis $\mathbf{H_1}$, Table 1, confirms that values of kurtosis and skew are acceptable, and the distribution values of the Kolmogorov-Smirnov test is statistically significant where most of the statistical significance values were below the level of significance ($\alpha = 0{,}05$). This indicates that the distribution is not normal for the gender, educational level, age, employment status, and income.

Hypothesis $\mathbf{H_2}$, Table 2, confirms that values of kurtosis and skew are acceptable, and the distribution of the Kolmogorov-Smirnov test is statistically significant, the statistical significance values for the variable (age) were below the level of significance ($\alpha = 0{,}05$). This indicates that the distribution is not normal, while most of the statistical significance values for (educational level, employment status, and income) more than the level of significance ($\alpha = 0{,}05$). This indicates that the distribution is normal for this variable.

Test of Homogeneity of Variances

Homogeneity of variance [30] assessed using F-test [31] for equality of variances, the values should be more than the level of significance ($\alpha = 0{,}05$), a Scheffé statistical test which is a post-hoc test was used to study the main and simple effects for all possible paired multiple comparisons.

Test of Multicollinearity

Multicollinearity means that there should be no interaction between the variables [32, 33], the variance inflation factor (VIF) values should be less than three. The following Table (3) shows the result of the Test for Multicollinearity for both hypotheses.

The exploratory factor analysis (EFA) and Confirmatory Factor Analysis (CFA); EFA aims at creating factors from the dataset by using the Kaiser-Meyer-Olkin KMO [34] and Bartlett's test of sphericity. It is a technique to discover underlying variables or factors while using AMOS for CFA [35] to confirm the fitness of the model and relations between latent variables and their observed indicator.

RESEARCH RESULT

Statistical Analysis for the Hypotheses **H1** and **H2** state that there are no statistically significant differences at the level of significance ($\alpha \leq 0,05$) in the average respondents' answers to the items related to the applied procedures and restrictions to limit coronavirus spread during mobility through different modes of transportation, and the items related to the digital transformation and the use of e-services, e-work, and e-study even after the end of the pandemic. The means and standard deviations of the respondents' answers were computed to verify the hypothesis, according to the independent variables (gender and educational level) and examining the Nonparametric Kruskal-Wallis test to reveal the statistical significance of

Table 1. Hypothesis **H1** Test of Normality for Gender, Age, Education, Occupation, and Income.

Tests of Normality							
Budapest		Kolmogorov-Smirnov^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Gender	Male	0.109	172	0.000	0.941	172	0.000
	Female	0.154	167	0.000	0.907	167	0.000
Education	High School or Less	0.117	22	.200*	0.977	22	0.861
	Bachelor's Degree	0.137	115	0.000	0.913	115	0.000
	Master's Degree	0.118	106	0.001	0.968	106	0.012
	Ph.D.	0.125	60	0.020	0.927	60	0.001
	Other	0.154	36	0.030	0.941	36	0.053
Age	less than 18	0.157	11	.200*	0.910	11	0.245
	18 - 28	0.162	81	0.000	0.943	81	0.001
	29-39	0.165	129	0.000	0.876	129	0.000
	40-49	0.131	65	0.008	0.967	65	0.078
	50-59	0.201	43	0.000	0.890	43	0.001
	60-69	0.204	10	.200*	0.909	10	0.272
Occupation	Student	0.108	100	0.006	0.966	100	0.012
	Working	0.114	139	0.000	0.931	139	0.000
	Studying and Working together	0.131	61	0.011	0.953	61	0.019
	Unemployed	0.139	38	0.063	0.915	38	0.007
Income	< 500	0.143	47	0.018	0.932	47	0.009
	501 - 1000	0.131	112	0.000	0.921	112	0.000
	1001 - 1500	0.140	47	0.022	0.960	47	0.111
	1501 - 2000	0.190	45	0.000	0.925	45	0.006
	2001-2500	0.120	31	.200*	0.952	31	0.180
	>2500	0.156	57	0.001	0.917	57	0.001

*a lower bound of the true significance. a. Lilliefors Significance Correction

Table 2. Hypothesis **H2** Test of Normality for Gender, Age, Education, Occupation, and Income.

Tests of Normality							
Budapest		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Gender	Male	0.118	172	0.000	0.960	172	0.000
	Female	0.068	167	0.059	0.991	167	0.368
Age	less than 18	0.212	11	0.178	0.874	11	0.088
	18 - 28	0.126	81	0.003	0.964	81	0.022
	29-39	0.174	129	0.000	0.940	129	0.000
	40-49	0.148	65	0.001	0.911	65	0.000
	50-59	0.138	43	0.038	0.921	43	0.006
	60-69	0.152	10	.200*	0.908	10	0.268
Education	High School or Less	0.172	22	0.088	0.878	22	0.011
	Bachelor's Degree	0.133	115	0.000	0.956	115	0.001
	Master's Degree	0.064	106	.200*	0.985	106	0.264
	Ph.D.	0.096	60	.200*	0.951	60	0.018
	Other	0.140	36	0.070	0.899	36	0.003
Occupation	Student	0.088	100	0.052	0.959	100	0.004
	Working	0.112	139	0.000	0.975	139	0.011
	Studying and Working together	0.123	61	0.023	0.976	61	0.283
	Unemployed	0.136	38	0.074	0.950	38	0.092
Income	< 500	0.145	47	0.014	0.929	47	0.007
	501 - 1000	0.102	112	0.006	0.964	112	0.004
	1001 - 1500	0.119	47	0.095	0.926	47	0.006
	1501 - 2000	0.159	45	0.006	0.963	45	0.156
	2001- 2500	0.156	31	0.052	0.972	31	0.582
	>2500	0.201	57	0.000	0.892	57	0.000

*a lower bound of the true significance. a. Lilliefors Significance Correction

Table 3. Hypothesis Test for Multicollinearity.

Variable	Collinearity Statistics	
	Tolerance	VIF
Gender	0.938	1.066
Education level	0.93	1.075
Age	0.966	1.036
Occupation	0.898	1.113
Income	0.95	1.053

the differences, and reviewed χ^2 test which allows making inferences from the sample regarding the hypothesis relationship, when there are statistically significant differences between the respondents' answers and to figure the direction of these differences in favour of which level, the Mann Whitney test used.

CONCLUSION

In summary, this study presented a methodology with two hypotheses using SPSS statistics v26 to perform a survey on the effect of digital transformation. During the COVID-19 pandemic in Budapest, participants' perceptions of the disease and the efficiency of the enforced restrictions to curb its spread were studied. The study methodology included statistical data and analytical outcomes. Earlier the authors reviewed some Governments' Strategies in the EU in the field of digital education in Europe, especially in France and Hungary. In addition, the most effective tools in e-learning today were also discussed as well as the ways they can be used for a better teaching and learning experience.

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SMART SOLUTIONS FOR SECURING THE POWER SUPPLY OF SMART CITIES

Ferenc Molnár*

Óbudai University Doctoral School for Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

Every aspect of our lives is determined by the use of electricity. Its availability defines our everyday comfort and security. Smart cities built with smart technologies cannot operate without electricity. This electricity is produced in power plants using specific energy conversion technologies. It is then transmitted through the electrical network to industrial- and residential consumers. In order to ensure that the end-point consumers continuously receive the quality of service specified in the standards and norms, the developers and operators of electricity systems have to perform, day by day, a multitude of tasks. In this process, smart solutions play an increasingly important role. System regulation is a key aspect of electrical power supply security.

KEY WORDS

electricity, security of power supply, power plants, system control, energy storage

CLASSIFICATION

JEL: Q21, Q41

PACS: 84.70.+p

*Corresponding author, η: molnar.ferenc@mvm.hu; - ;
Nepszinhaz str. 8, 1081 Budapest, Hungary

POWER PLANT TECHNOLOGIES OF THE HUNGARIAN ELECTRICITY SYSTEM

Discussions about the emergence of smart cities play an important part in the exchange of thoughts on future developments. Smart devices and digital-based services are making every aspect of our lives safer and more comfortable. These devices are powered solely by electricity. We can only use the electricity we have produced and delivered where needed. The electricity is produced in power plants using special energy conversion technologies. This process uses a primary energy carrier medium to convert its energy into electric energy [1].

The vast majority of power plants are fixed. However, there are also mobile plants available, i.e. plants that can be repositioned or moved. Some of the examples include industrial-sized diesel engines of up to several MW capacity, which can be transported by rail, trailers, ships or helicopters. In emergency situations, these are transported to the site on short notice and are able to supply electricity to the local systems [2].

Floating nuclear power plants can also be relocated. These can be used for military or civil needs. The best example of peaceful usage is the nuclear-powered icebreaker ship, which can supply electricity to communities falling far away from the electricity and natural gas distribution networks [3].

Rooftop solar systems are stationary power plants. Household-scale small power plants have less than 50 kVA installed power. In Hungary, there are more than a hundred thousand small power plants supplying households or producing energy for low voltage electrical distribution networks [4].

Power plants are classified mainly by the nature of their primary energy sources. Among the conventional fossil power plant technologies, the coal-based energy conversion contains subsystems with many different characteristics. We can differentiate between them according to the type of fuel: black coal, lignite or brown coal. The conversion technology can be conventional, fluidised bed, bubbling, circulation, atmospheric pressure, pressurised, supercritical and gasification [5]. In the 1960s and 1970s many coal-based power plants were put into operation. In the 1970s, cheap oil led to the establishment of oil-fuelled power plants worldwide. In Hungary, the Dunamenti Power Plant has been the largest among such power plants for many decades. In Százhalombatta, the units of the power plant burn mazut, the by-product from the oil refinery, and supply the oil refinery with steam and electricity. In addition, they supply to the Hungarian electricity system a significant amount of electricity. Nowadays, light fuel oil is used to operate the gas turbines. Natural gas is an important primary energy source. Conventional gas-fired power plants possess the proper technologies for both heat- and electricity production. In addition, gas turbines are becoming increasingly important and have gained an ever-larger share of the production mix since the 1990s. State-of-the-art combined cycle units can have an energy conversion efficiency of up to 65 %. Open cycle units have an efficiency of around 40 % with a heat recovery stage added to increase efficiency. The heat recovery is used to generate additional electricity. Open cycle units are used to serve rapid changes in the load of electricity systems.

In Hungary at Paks, a nuclear power plant (NPP) was constructed in the eighties. Between 1982 and 1987 four units were put into operation and started the production of electricity. As their operation was extended by 20 years, they are expected to be shut down between 2032. and 2037. The NPP provides approximately 50 % of the domestic electricity capacity of Hungary.

Nuclear power plant technologies have developed worldwide in a wide range, and they are under continuous development and improvement. We can differentiate them according to their fuel, cooling technologies and the material of moderators. In addition to these, there are fast reactors and small and medium nuclear reactors.

The following large group of power plant technologies are associated with renewable energy production. Low-emission power plant technologies with the largest production capacities are supplied by hydropower. Its global capacity surpasses the 10 % share from the global market of nuclear-based production [6].

Hydropower provides more than 50 % of the world's renewable energy [7]. The world's first established power plants used the energy of water.

The role of hydropower is dominant in energy storage, and consequently, in system control activities. Pumped energy storages have accounted for over 90 % of energy storage capacities globally, with an installed capacity of about 160 GW [6]. The technology consists of using the low-cost electrical power coming from the surplus energy production to push the water from a lower reservoir to a higher reservoir. Then, when there is a demand for the stored energy, the water from these reservoirs is let to flow through the water turbines producing electricity into the electrical networks [8].

Other renewable energy sources include geothermal energy conversion technologies that use the earth's heat, and the technologies using waste, biomass and biogas. Wind turbines and solar power plants represent new renewable energy categories. In recent years, these have been among the dominant trends in power plant constructions.

There are many opportunities for the use of solar energy. One of them is the solar thermal power plant. Here the solar energy collected by mirrors is used to heat a working fluid to a temperature by which the water is converted into steam, which is then used for driving the steam turbines. In some technologies, the heated medium can also act as an energy storage medium. In the case of photovoltaic power plants, photons from the sun's rays are absorbed by photosensitive semiconductor elements to produce electricity. The take-up of solar energy in Hungary by the installed photovoltaic capacity has increased almost a thousand-fold during the last 10 years [9]. the Hungarian Electricity Transmission System Operator (in Hungarian: MAVIR) forecasted for year 2031 a total solar capacity of 11 600 MW [10].

The following sections will give a review of power plants according to their roles in electricity systems. Base load power plants provide a constant energy production in time, the so-called "line production". They are characterised by continuous, stable operation with low unit costs. Scheduling power plants follow the planned output variations with their controllable production characteristics. Guided technology means that the amount of input energy can be varied. In case of controllable technology, the output power can be varied. Accordingly, electricity production technologies can have both characteristics or none of them. Top power plants can manage the sudden and rapid changes taking place in the loads of the production system.

THE REGULATORY TASKS OF THE HUNGARIAN ELECTRICAL ENERGY SYSTEM

Nowadays, a revolutionary transformation is taking place in the way electricity systems operate. In traditional systems, the electrical power production was adapted to the needs of industrial and residential consumers. The electrical power was produced in 20 to 30 big power plants in a so-called centralised structure. The electrical power was then distributed to industrial and residential consumers via electricity networks in a predictable one-way flow.

Electrical networks comprise four hierarchical levels defined according to their purpose. Power plant installations with an installed capacity of several hundred up to several thousand megawatts are integrated into the basic network or, according to the current terminology, into the transmission network. The international cooperation between different countries is embodied by the interconnected electricity system through transmission networks. The name of the integrated European electricity network is: European Network of Transmission System Operators for Electricity (ENTSO-E). The typical domestic voltage levels of the basic network are 750 kV, 400 kV and 220 kV. The loss of transmission is proportional to the voltage levels. The higher the voltage level, the higher the transmission loss. For a higher voltage and the same power value, the electrical power level is proportionally lower. In Hungary, in order to reduce transmission losses, large amounts of power are delivered to the 35 transformer stations installed at the core network nodes by means of high-voltage transmission lines. The energy collected in this way is reduced to the 132 kV voltage level of the main distribution network by means of high voltage transformers and is delivered at this voltage level to the territorially competent electricity providers, formally to the network licensees. The electricity is transmitted to the distribution network following the 132 kV medium voltage transformation. The typical voltage levels for medium voltage are 35 kV, 22 kV and 11 kV. Power plants with a capacity of a few tens of megawatts supply electricity to the main distribution and distribution networks. These voltage levels are also used by large industrial consumers. At the lowest level of the distribution network which operates at 0,4 kV, the electricity is delivered via additional transformer stations to residential consumers. The NPP from Paks with an installed capacity of over 2 000 MW is connected to the 400 kV network. The solar power plant from Paks, with a capacity of over 20 MW supplies electricity through the distribution network at 132 kV while the other solar power plant from Felsőzsolca, with a similar capacity, transmits its electricity to the distribution network at 22 kV. Small household power plants with an installed capacity of up to 50 kW are connected to the lowest level of the distribution network at the residential voltage level of 0,4 kV.

The management of the electricity network systems in Hungary is carried out by the MAVIR, a limited company owned by MVM Zrt. At the distribution network level this task is performed by the District Dispatching Services and the Control Centres.

As a result of the transformations described above, the traditional large-scale centrally producing power plants, which are steadily ageing, are being replaced by decentralised small-scale power plants. This change is creating completely new phenomena in the operation of the electricity network, in the nature of electricity production and even in consumer habits. A positive aspect of this systematic transformation is that part of the electricity generated in the decentralised production is already consumed close to the point of production and therefore does not cause any more overloads in the distribution network. Whereas in the past there was a clear separation between the producer and the consumer, today the two functions are increasingly merging together.

In order to ensure the continuous and safe operation of electricity systems, solutions to new challenges need to be worked out.

New renewable-based production technologies use the wind and solar energy to produce electricity. Hungary's geographical conditions favour the expansion of solar photovoltaic (PV) power plants. The total installed capacity of 3 MW of solar PV capacity in 2011 increased to close to 3 000 MW by the end of year 2021. This amount represents more than one third of the total installed capacity at national level. In the decade ahead, this could increase several times according to the National Energy Strategy projections for 2030 [11].

The amount of photovoltaic energy production depends on weather conditions, i.e. the intensity of the solar radiation. The following figure illustrates the diagram of the output power that the sunshine can produce in solar PV power production.

The weather-dependent production is illustrated by the daily production diagram of the 20,6 MW solar power plant at Paks [12]. In the diagram we can observe the switch-on of inverters after sunrise and their switch-off during the evening's low-light period. The production

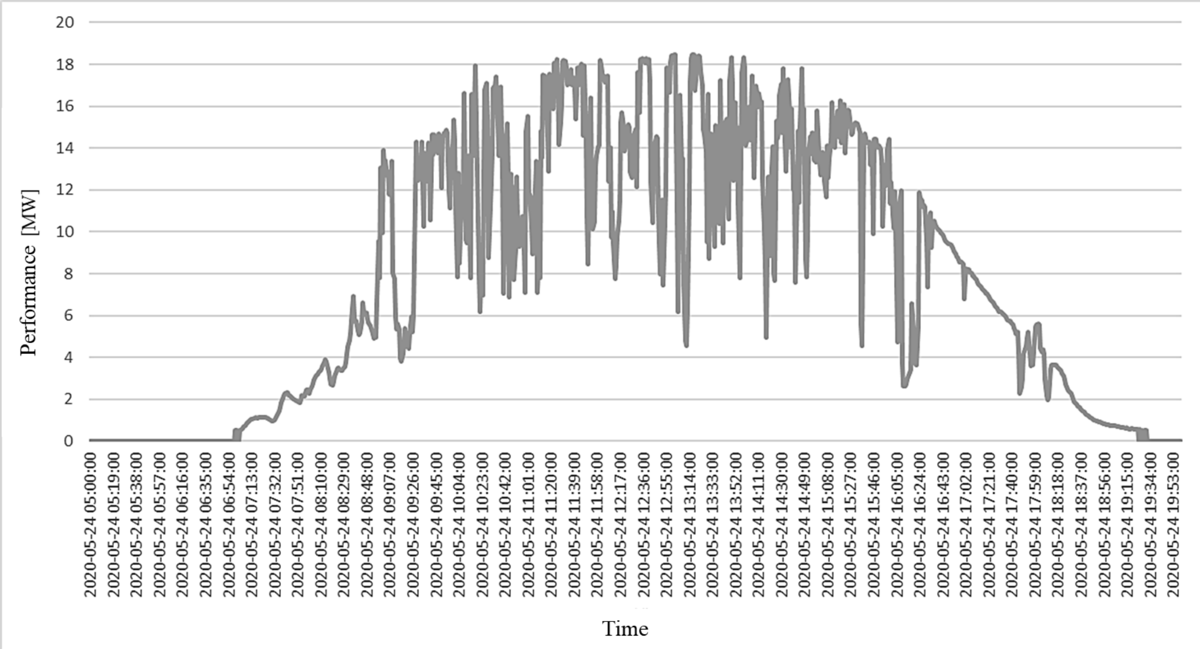

Figure 1. Daily production diagram of the 20,6 MW solar power plant, Paks [12].

curve shows a series of random power drops due to the obscuring caused by passing of clouds. The main findings for the solar PV production, as shown in Figure 1, are as follows. Electricity is needed outside the sunshine season. Production depends on the weather and cannot be adjusted to consumer demand. Because of this, the solar power plant must be connected to a sufficiently stable electricity network that is less sensitive to sudden changes in energy production. The electricity network alone cannot store electricity, so the amount of energy used, and the amount of energy produced must be the same at all times in order to keep the voltage and frequency of the network within the required range. A system regulation is necessary for the operation of conventional power plants that generate on a scheduled basis. This means that the gap between the power plant output generated in this way and the power demand, which varies randomly over time, has to be filled by so-called flexible capacities. In addition to the previous traditional need for regulation, the random power variation on the production side should also be taken into account. Gas turbines, gas engines and other various energy storage technologies can be considered as flexible capacities. The advantage of energy storage is that the electricity produced in surplus can be recovered and used in the event of energy shortages or high market prices. Consequently, these can be used for both DOWN and UP power control.

The following sections will briefly review the new impacts and challenges that need to be addressed in the context of electricity system transformations. The unidirectional power flow in the central system has been eliminated. The energy flow direction in distribution networks changes several times a day, i.e. the excess energy from the unused solar energy production flows from the lower voltage levels toward the higher voltage levels. In many cases, this takes place from the direction of the household-scale production units.

The number of newly emerging electrical devices is fast increasing as a result of the high level of automation that ensures the convenience of smart cities, which increase the load on electrical networks. Consequently, more and more points in the electrical networks are becoming overloaded, which must be managed by the system operator. Electrical heating and cooling and other large-capacity computer systems for smart homes are proliferating, putting electrical networks under pressure. Asymmetries between phases, voltage and frequency fluctuations can develop on these electrical networks.

As traditional rotating engine power plants are losing ground, the voltage regulation capability and the electrical inertia of the power system are reduced weakening the stability of the system.

CONCLUSION

Among the possible solutions we can enumerate the physical upgrades of electricity networks, the extent of which can be reduced by smart solutions. Worldwide developments are under way to achieve the synthetic electrical inertia through the use of performance electronics with smart solutions. New approaches must be implemented into the network modelling. Such an approach could be the investigation of the reliability of electricity transmission using the graph cuts method. A single-phase substitute diagram can be made for a three-phase, symmetrical loop network. By combining the impedance-free return into one node, the geometric shape of the network, free of physical characteristics, i.e. its graph, can be created. By defining graph cuts, we can examine the probability of discontinuity between two selected points of the graph [13]. MAVIR’s network design methodology needs to be brought in line with the extension of solar PV production. New test methods are required. The most important of these are partial cloud cover testing and grid reserve training to manage system disturbances and improve resilience [14]. New methods are needed to produce more accurate production and load forecasts that are capable not only to show the expected peak demands but also provide a good indication of the typical time evolution of the characteristic curves. At the same time, meteorological forecasts need to be more accurately matched to production forecasts using artificial intelligence developments. A complete overhaul of electrical protection and automation systems will be necessary. In order to ensure flexible rotating machine production, gas turbines will have to be installed. Energy storage capacities need to be drastically increased. One of the most efficient sustainable solutions could be the pumped storage, by which large amounts of electricity can be stored by increasing the stationary energy of large amounts of water [15]. Beside the technical solutions currently in use, innovations and smart solutions in the field of energy storage can bring breakthroughs in the development of future systems [16].

Last but not least, shifting consumer habits to a positive direction is also an outstanding task of the domestic energy policy. Smart cities can provide indispensable help in this, as they can be particularly effective building blocks of attitude formation due to the constructive power of the community of smart devices. Saving energy is the cheapest and cleanest way to achieve sustainability.

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THE ROLE OF SOCIAL ENGINEERING IN THE ENERGY BALANCE OF SYSTEMS

Edina Albininé Budavári*, Attila Albini and Gyula Mester

Óbuda University, Doctoral School on Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

A big problem of our time is the constant increase in the energy used. An efficient energy household is one possible solution. Increasing efficiency requires examining the energy balance. System disturbance is one of the factors influencing the energy balance of systems. Social Engineering is a form of system disruption that manifests itself in covert and conscious system control. The present study examines the harmful energy role of Social Engineering through the parallels between the regulatory circuit of control theory and the operating model of Social Engineering. The result of the study highlights the importance of cyber defense.

KEYWORDS

social engineering, cybernetic loop, energy model, energy importance, energy balance

CLASSIFICATIONS

ACM: H.1.1, J.4, K.4
APA: 4010
JEL: O13, Q43
PACS: 01.70.+w

*Corresponding author, η: abepubkut@gmail.com; +36 20 425 4605;
OE-BDI office, Nepszinhaz str. 8, 1081 Budapest, Hungary

INTRODUCTION

Today, the main goal of systems examining is to ensure sustainability. The development of the industry has unfortunately led to the depletion of fossil resources. The use of climate-neutral resources is extremely emphasized in modern systems. Furthermore, increasing efficiency has become an inevitable topic. The smart city concept is one of the products of the need for long-term sustainability [1-6].

Investigation of energy systems is an aspect of efficiency. The two main aspects of energy analysis are the study of the system's own energy balance and the study of the energy effect of the factors interfering with the system [7-9]. Factors that interfere with the system can be accidental effects or targeted effects. The latter disruptive effects include Social Engineering [10-12].

The present study examines the role of Social Engineering in the energy balance of the system. The operating mechanism of Social Engineering can be mapped to the operating model of cybernetic loop [10, 12]. Therefore, the study uses the cybernetic loop model used in control theory and the energy balance model of the systems [8-10] to model the effect of controlled disturbances.

The paralell between cybernetic loop and Social engineering is mentioned during the study. This allows the two models to be connected. Examining such aspects of systems calls attention to the protection of energy systems. Preventing the negative effects of Social Engineering not only increases information security [13-19] but also increases energy efficiency.

ENERGY BALANCE

The modeling of the energy balance of systems is worth placing on a philosophical basis. Philosophy is the ancestor of all sciences, so there is less chance of creating an incomplete model. The model serves to produce a theoretical abstraction of reality. Therefore, the initial idea of the model is based on abstract categories of human thinking [8, 9].

One can, in the abstraction of reality, classify everything into the following three categories:

- thing – an expression of some functionality. The energetic equivalent of this is *transformation*,
- property – which determines the operation. The energetic equivalent of this is *storing*,
- relation – which determines how things relate to each other. The energetic equivalent of this is *transmission*.

Elements of the model also fall into these three categories during modeling. The systems are made up of components that implement energy transmission, energy processing and energy storage. The result of the energy modeling is the following equation:

$$E_{\text{in}} = \Delta E_{\text{store}} + E_{\text{out}}. \tag{1}$$

Equation (1) describes that the energy reaching the system covers the energy stored in the system and leaving the system [8, 9]. Figure 1 shows the theory of modeling.

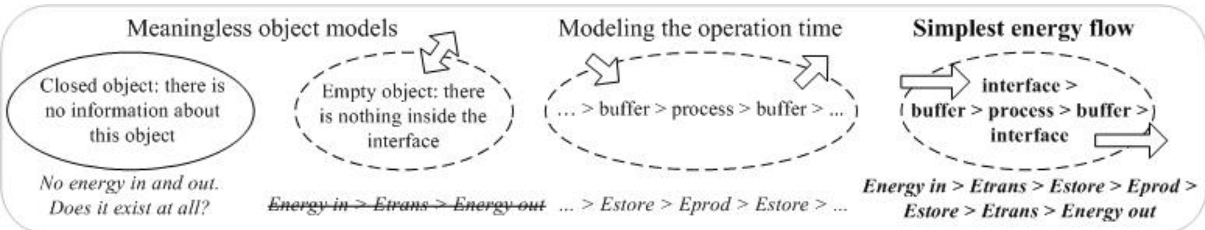

Figure 1. Energy modeling [8].

SOCIAL ENGINEERING

The function of the cybernetic loop is to ensure the temporal operation of the system. This mechanism allows system maintainers to adjust the operation of the system as needed. In addition to functionality, the goal of most systems is sustainability. This is ensured by the control system [20-26].

System interference is included in the system cybernetic loop model. This interference affects the processes of the system. The disturbance can be of natural origin and can be initiated by the human mind. The disturbance initiated by the human mind is usually hidden and is not intended to sustain the system in the long run. Such covertly directed disturbance serves an unknown purpose for system maintainers by exploiting system resources. This phenomenon is called Social Engineering [10, 12].

In terms of the mechanism of action of Social Engineering, it operates on the same principle as the model of cybernetic loop. The three phases of the Social Engineering process are information gathering, processing and preparation, and intervention. These correspond to the three phases of the cybernetic loop [12]. Figure 2 shows the parallels between the two models.

Based on what has been described, Social Engineering can be considered as a hidden control mechanism. The combined operating model of Social Engineering and the cybernetic loop was developed [12]. Figure 3 shows this model.

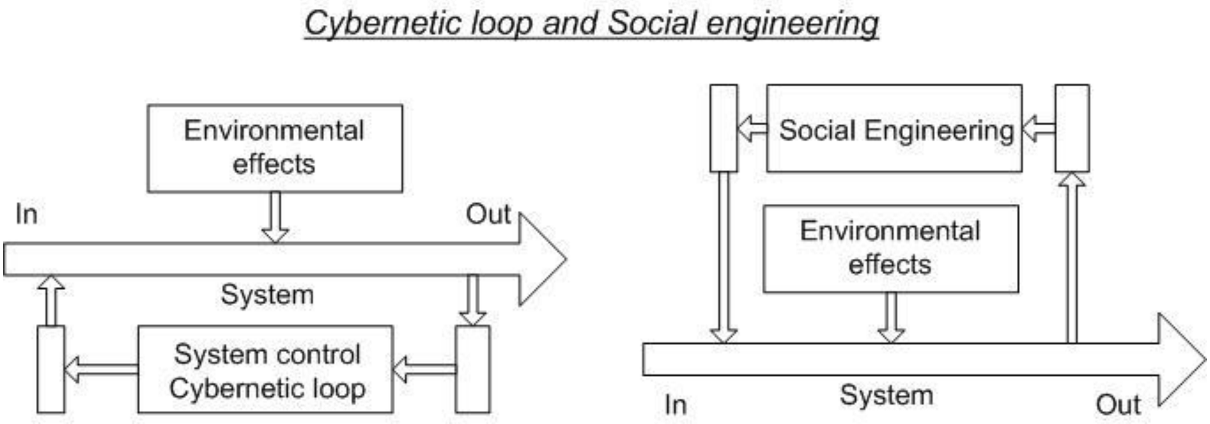

Figure 2. The parallel between the cybernetic loop and social engineering [12].

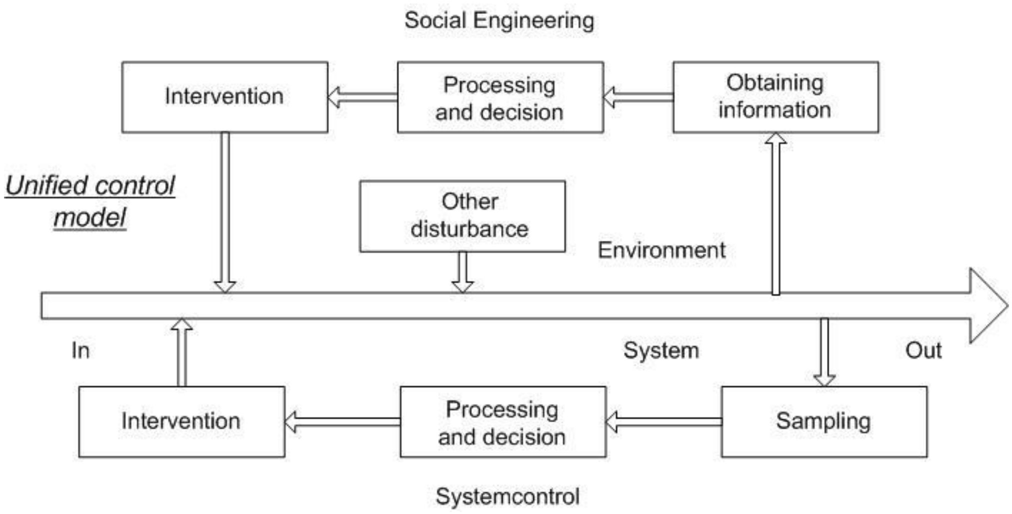

Figure 3. Unified model of cybernetic loop and social engineering [12].

ENERGETIC IMPACT

The energy impact of Social engineering can be modeled using the combined model of the cybernetic loop and Social Engineering and the energy balance model of the systems.

Using the traditional model of disturbance in the system, the energy balance of the system is described by equation (1). That is, the amount of energy reaching the system is equal to the sum of the change in stored energy and the amount of radiated energy.

Using the unified model, one can write the fpllowing equation:

$$E_{\text{in}}' = \Delta E_{\text{store}}' + E_{\text{out}} + E_{\text{SocEng}}. \tag{2}$$

Combining:

$$E_{\text{SocEng}} = [E_{\text{in}}' - E_{\text{in}}] - [\Delta E_{\text{store}}' - \Delta E_{\text{store}}]. \tag{3}$$

From (3) it can be red that the energy entering and stored in the system must balance the impact of social engineering.

Comparing the two cases: achieving the same amount of useful work requires more energy investment in the presence of social engineering. Respectively, in the case of the same energy investment, the system's reserves are reduced. Both effects worsen the energy balance. Therefore, it is not only worthwhile to protect the system from the effects of Social Engineering in terms of information security, but also to protect it from an energetic point of view.

SUMMARY

The main challenge for current systems is to ensure long-term sustainability. To this end, new sustainability concepts are being developed. Such concepts include Industry 4.0 and the smart city concept. Implementing new concepts requires identifying and addressing sustainability issues. Efficient energy management is one possible solution to the problems of sustainability.

One way to examine energy management is to review the energy balance of the system. The general energy balance equation is derived from the modeling of the energy balance. Improving energy balance can be achieved by improving the control system. Disturbances of the system can be both random and directed. Social engineering is one such directed disturbance. Due to its mechanism of action, Social Engineering can be paralleled with cybernetic loop. This is how the unified operating model of the cybernetic loop and Social Engineering was created.

The present study examines the energetic role of directed perturbation using the unified cybernetic model and the energy balance model of systems. According to the results of the modeling, the energy entering and stored in the system must balance the impact of social engineering. This induces the conclusion that protecting the system against Social Engineering can reduce unnecessary energy consumption. This promotes sustainability.

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THE ROLE OF ADDITIONAL INFORMATION IN THE CONTROL SYSTEM

Edina Albininé Budavári* and Zoltán Rajnai

Óbuda University, Doctoral School on Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

As a result of rapidly evolving technology, the energy hunger of the world is also increasing. Depletion of fossil resources is also a problem in addition to growing energy hunger. Climate change also presents us with ongoing challenges that also affect energy supplies. These problems and challenges must be answered and solutions must be found. Mankind needs to switch to the use of climate-neutral resources and to the operation of energy-efficient models. Increasing efficiency also requires the development of an effective control system. The basic element of system control is the cybernetic loop. The present study examines the efficiency of the first phase of the cybernetic loop, the efficiency of sampling.

KEYWORDS

additional information, control system, cybernetic loop, energy model, energy importance

CLASSIFICATIONS

ACM: H.1.1, J.4, K.4
APA: 4010
JEL: D81, L86
PACS 01.70.+w

*Corresponding author, η: abepubkut@gmail.com; +36 20 425 4605;
OE-BDI office, Nepszinhaz str. 8, 1081 Budapest, Hungary

INTRODUCTION

The base of the smart city concept is to preserve long-term sustainability. The use of complex systems goes hand in hand with the development of the industry. Unfortunately, the energy efficiency of complex systems is not yet ideal. In this way, the development of the industry entails an increase in energy demand [1, 2].

Satisfying humanity's energy hunger is facing serious problems these days. The excessive use of fossil resources has also contributed to global climate change. In addition, the process has reached the limit of fossil resources depletion. For these reasons, past energy use patterns cannot be maintained either. This affects both industrial production and households[3-5].

Solutions to the problem may include switching to climate-neutral resources, more flexible energy use methods and more efficient energy use. Energy efficiency also requires efficient system control. Theoretical study and modeling of system control has also become an increasingly important area of education [6-10].

The present study examines the efficiency of system control. The basis of the study is the energetic background of the control theory cybernetic loop model. The efficiency of the sub-processes of the cybernetic loop determines the efficiency of the entire cybernetic loop. The first sub-process of the cybernetic loop is the sampling method from the operation of the system. The study models the impact of sampling efficiency across the entire cybernetic loop.

CONTROL SYSTEM

Each system serves a purpose. There are several factors that can affect operation. Controlled operation of the system includes checking the correct operation of the system and any adjustments to the operation. Thus, the control also ensures the sustainability of the system. A continuous version of this management is the control system. System regulation is essential to the operation of the system. The expected operation of the system cannot be ensured without regulation [11-14].

In control theory the cybernetic loop is a fundamental element of the system control model. The cybernetic loop model includes a time-negative feedback process that can be broken down into three major subphases. Interactive sampling takes place in the first phase. A snapshot of operating parameters of the system is taken. The analysis of the parameters, the comparison with the required state, and the intervention decision are the elements of the second phase. Then the interactive intervention takes place in the third phase [15-18]. The model of the cybernetic loop is shown in Figure 1.

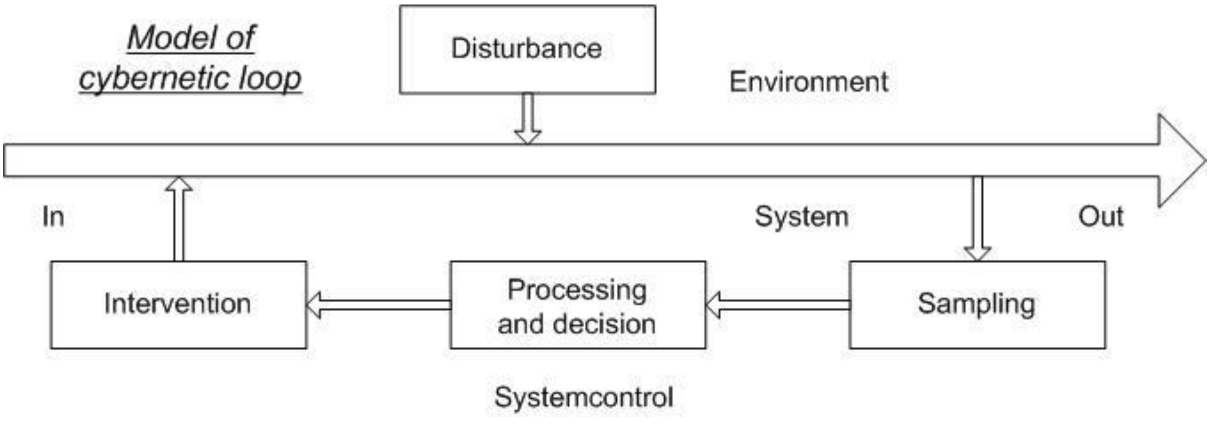

Figure 1. Model of cybernetic loop [13].

ADDITIONAL INFORMATION

The purpose of communication is to transfer information from one entity to another. In the course of communication, the sender usually sends not only the necessary information, but also additional data content in addition to the useful information. This can be caused by intentional redundancy and unintentionally sent data. However, unintentional extra data may carry significant additional information that may provide additional information to the communications receiver [19].

A multi-round online game has been created to model the additional information: Guess where the doll is! In a given round, photos were taken as if a toy doll had taken selfies in a particular location. It was up to the players to guess the location using the additional information in the background. The surprising result of the game was that the players could not only decode the information that the organizer was thinking. Players were also able to decode additional information about the doll's manufacturer and clothing [19]. A mix of images from the game is shown in Figure 2.

Figure 2. Mix of pictures from the game, based on [19].

EFFICIENCY OF SYSTEMCONTROL

Additional information is a natural part of communication. In the cybernetic loop model, one form of communication is sampling. Thus, the model of the cybernetic loop should also be examined in order to model the effect of the additional information.

The initial assumption is that additional information is coupled with useful information during sampling. In this case, sampling contains more than just useful data. The test of the usefulness of the data and the sorting of the useful data take place during the non-interactive data processing.

For all these reasons, in the case of additional information appearing during sampling, the useless data must also be transmitted to the place of processing. The useless data must stored at the place of processing. This useless data should then be processed to determine the need. Consequently the appearance of additional information in the sampling procedure results unnecessary energy consumption. Information technological implications of this are:

- energy of transmitting unnecessary data,
- energy of processing unnecessary data,
- energy of storing unnecessary data.

Figure 3 shows a version of the cybernetic loop model supplemented by sampling with additional information.

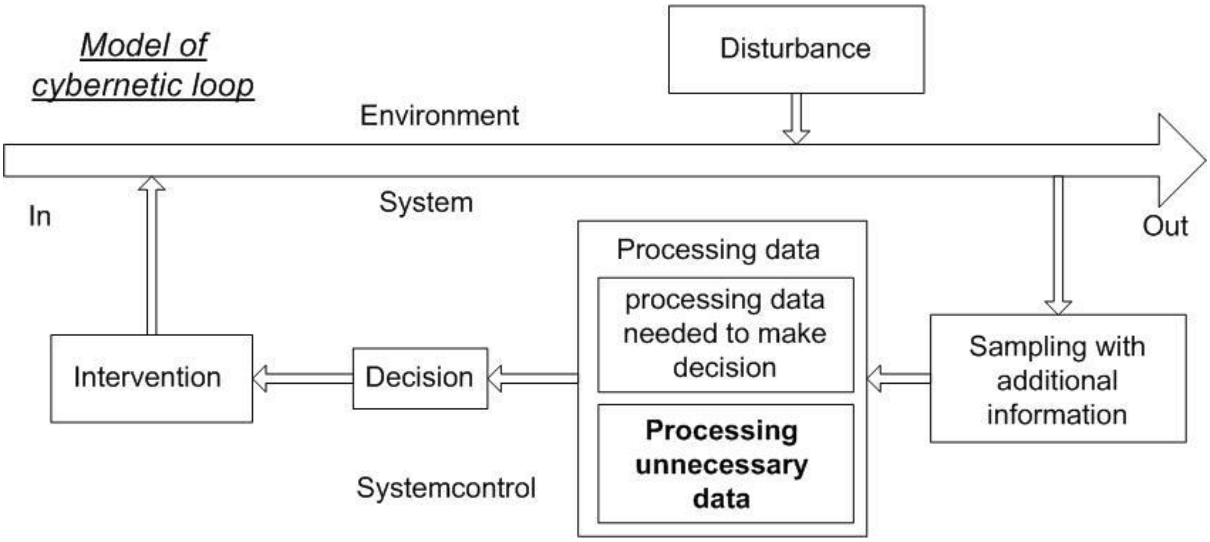

Figure 3. Cybernetic loop – sampling with additional information, based on [13].

SUMMARY

The need for long-term sustainability has brought with it the industry 4.0 concept and the smart city concept, among others. The motto of the models is sustainability. One of the pillars of ensuring sustainability is energy efficiency. Energy efficiency also depends on the efficiency of the control system.

The cybernetic loop is a basic element in the modeling of the control system. The sub-processes of the model are sampling, the processing process with the decision, and the intervention. The efficiency of these sub-processes strongly influences the efficiency of the entire control system. The data content of the sampling sub-process determines the energy requirements of the processing process.

The present study is based on the cybernetic loop model. The study complements this model with additional information that appears during sampling. Modeling the role of additional information in the cybernetic loop has shown that the presence of additional information generates unnecessary energy consumption. This occurs in storage, processing and transmission of energy, too. Thus, the additional information present in the regulatory system can significantly reduce the efficiency of the system.

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AUTONOMOUS VEHICLES FROM ANOTHER PERSPECTIVE – A LITERATURE ANALYSIS

László Berek*

Óbuda University
Budapest, Hungary

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ABSTRACT

Autonomous vehicles are part of our everyday lives, but with the rapid development of technology, this will become more and more common. Research on self-driving cars will replace conventional vehicles not only in passenger transport but also in the transport of goods and industrial materials. Car companies and research institutes are conducting more and more research in the face of serious economic interests. This study analyses published papers on self-driving vehicles and their security issues. A more detailed analysis of the publication output of the last six years is also included. The analysis of the publications by country shows that the Asian region has invested considerable efforts in the research and development of self-driving cars and their safety issues in the last three years.

KEY WORDS

autonomous vehicle, self-driving car, safety, behavior, literature review

CLASSIFICATION

JEL: Q55

*Corresponding author, η: berek.laszlo@uni-obuda.hu; +36 (1) 666-55976;
Óbuda University, Bécsi út 96/B, H-1034 Budapest, Hungary

INTRODUCTION

The mass emergence of self-driving cars will transform how we live and work. Related research suggests several positive consequences: shorter travel times, improved fuel economy, reduced traffic accidents and deaths, and fewer emissions. The world of self-driving cars is already here; only mass deployment is still to come. The world's leading car manufacturers are investing heavily to get this technology on the road as soon as possible. Of course, this expenditure is mainly in research and development, the results of which can be tracked in the publication of research results and publication output.

Self-driving cars and related fields have made significant progress in recent years. An increase in publications and a widening spectrum of research results have naturally accompanied this continuous development. By examining and analysing the scientific output on the subject, we can get an objective picture of the direction of research on autonomous cars and the importance of the topic. Research on self-driving vehicles examines the potential impact of the phenomenon from different angles and the consequences of the spread of autonomous cars.

The following change in research forecasts illustrates the evolution of technology and the pace of autonomous vehicle deployment. Prognoses in 2018 predicted sales of 8 million semi-autonomous (SAE Level 3, 4, and 5) vehicles by 2025 [1]. Statista's 2022 report predicts 10,5 million autonomous vehicles at Level 3 or above will be sold by 2025. Figure 1 shows Statista's forecast for the period 2019-2030. The report forecasts 58 million autonomous vehicles sold by 2030 [2].

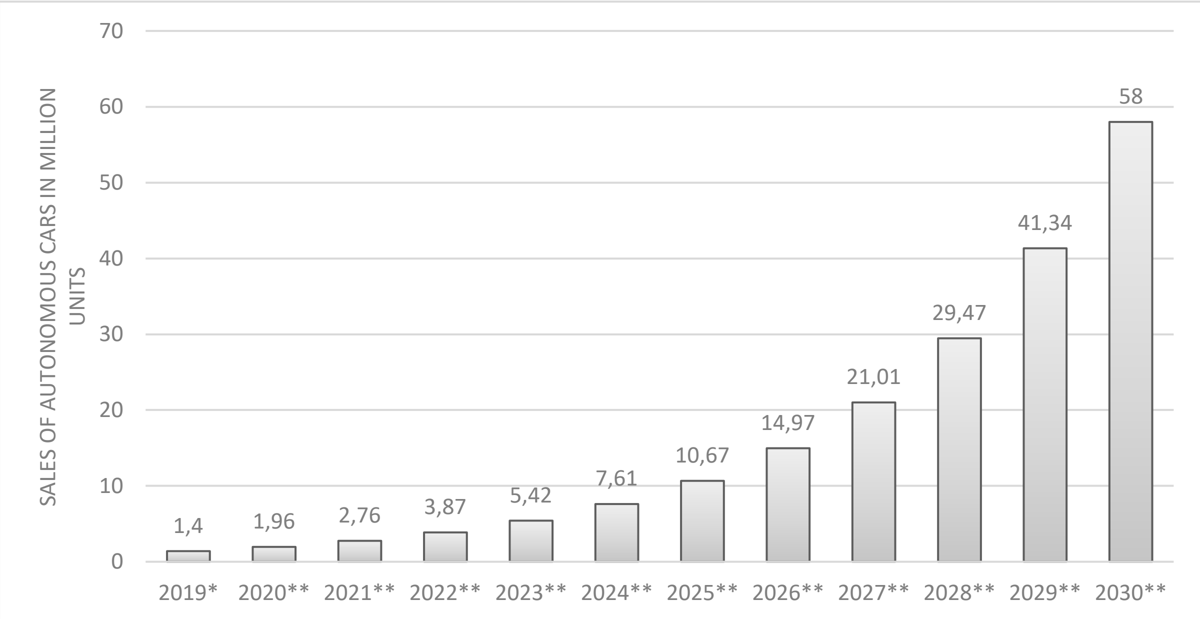


Figure 1. Projected sales of autonomous vehicles worldwide from 2019 to 2030 [2].

Several studies are looking at the issue of autonomous vehicles for transport and public transport. In this area, mass deployment of self-driving vehicles would make all aspects of transport much simpler and less polluting. In public transport, driverless subways, trains, and trams are already in operation in many countries, and an increasing number of city buses also carry passengers without drivers. The research has raised the following questions [3, 4]: Who are the current manufacturers of such vehicles? Is it possible to completely abandon traditional modes of transport? Where are driverless vehicles used today?

There is a growing amount of research into the development and evolution of autonomous vehicles, not independently but linked to each other and the related technologies. Cooperative driving uses vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies to implement cooperative functions such as sensing and manoeuvring. Researchers in this area are investigating the feasibility and development opportunities for the safe implementation of intelligent car parking, route changing and connecting, and crossroad management in the context of self-driving car cooperation [5, 6].

In recent years, several studies have focused on the potential impact of the spread of autonomous cars on the urban environment. These research directions are not only related to the effects on urban traffic rules or pedestrian traffic but also to urban planning, car sharing, or possible changes in the daily life of urban citizens. Autonomous vehicles are expected to revolutionise urban mobility with their improved sensing and navigation capabilities. Despite the expected benefits, this emerging technology has some implications for their use in mixed traffic flows in cities. A systematic literature review has also been published to map the research field. Some researchers have examined the impact of the spread of autonomous cars on urban planning, urban infrastructure and through this, the daily lives of people living in cities [7-9].

Research is being carried out in some related areas to assess the public perception of self-driving vehicles. The results of a 2018 survey showed that autonomous cars are perceived as a low risk means of transport. However, autonomous cars were also perceived as riskier than autonomous trains already in use. The research looked at how gender and age affect attitudes toward self-driving cars [10]. Attitudes toward self-driving vehicles were also examined in a survey in 2021. The outcomes showed that around 47 % of respondents would be willing to use a semi-autonomous car, while around 44 % of respondents expressed a willingness to use a fully autonomous car, Figure 2 [11].

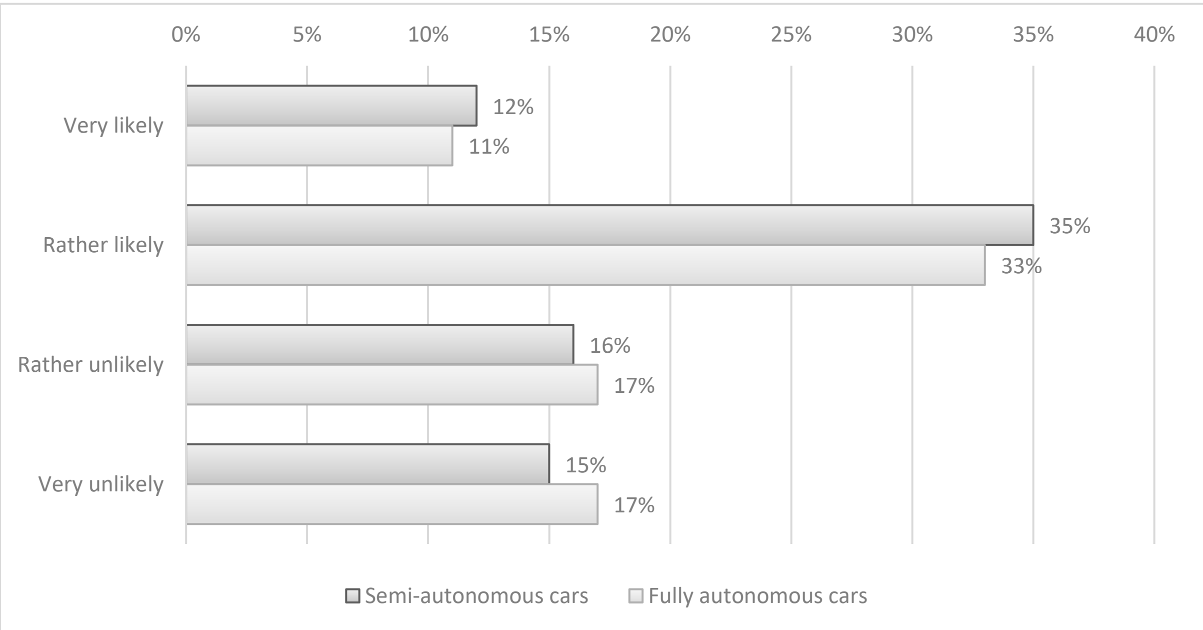


Figure 2. Willingness among customers worldwide to use fully autonomous or semi-autonomous cars in 2021 [11].

Several research projects have been launched to address the problems faced by some segments of society concerning self-driving vehicles. Some research in the field of autonomous vehicles, including self-driving cars, addresses the travel problems of people with disabilities. One example is a systematic literature review in which the authors examined the grey and academic literature on autonomous vehicles for people with disabilities [12].

MATERIALS AND METHODS

The research is based on a bibliometric analysis of the literature using scientific and statistical database and the Zotero reference management software. The primary data source used in the study was the Scopus database, where two search queries were conducted.

CRITERIA AND LIMITATIONS

The search was conducted in Scopus, one of the largest scientific bibliographic databases. For further analysis, the related data analysis platform SciVal was used.

As a first approach, the entire literature was examined, regardless of publication date. The following comparisons have been conducted for the last six years. Data for 2017-2019 and 2020-2022 were queried and analysed. The search queries were conducted on 9 February 2023.

The search in Scopus did not exclude conference proceedings or book chapters. All content indexed in Scopus was included in the analysis.

Several keywords (autonomous car, autonomous vehicle, unmanned vehicle, self-driving, and vehicle-to-vehicle) were defined to obtain relevant publications for this study. Additional keywords (car, cars, automobile) have been used to exclude possible erroneous results. In the second search query, keywords (safety, security, risk, data privacy, accident, pedestrian) related to safety and security were added to the term..

SEARCH QUERIES

The structure of the search queries was started by mapping the keywords most frequently used in the literature. The following search queries were used to conduct the analysis.

Scopus search query #1
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) PUBYEAR < 2023

Scopus search query #2
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data privacy OR pedestrian* OR safet*) PUBYEAR < 2023

The Scopus queries have been filtered into two more periods for institutional and country/region analysis. The two periods examined were 2017-2019 and 2020-2022.

Search query for SciVal #1
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data AND privacy OR pedestrian* OR safet*) PUBYEAR < 2023 AND PUBYEAR > 2012 AND PUBYEAR < 2022 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re"))

Search query for SciVal #2
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR

"Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data AND privacy OR pedestrian* OR safet*) PUBYEAR < 2023 AND PUBYEAR > 2011 AND PUBYEAR < 2023 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch"))

OBJECTIVES

The following objectives have been identified when examining the data collected:

- to explore the growing literature on autonomous cars,
- to examine the volume of literature on self-driving cars related to safety and security,
- to examine the national and regional distribution of authors involved in research on autonomous cars,
- to analyse changes in the publication output over the last six years in representations of country/region.

RESULTS

The first defined search query (#1) from the Scopus database returned 16 854 results. The earliest record dates back to 1967, but only the last 15 years have seen a significant annual publication volume. Subsequently, the second search query (#2) was run in Scopus, which resulted in 3041 records. These data were used to analyse the distribution of published papers by year, country and affiliation.

Analysing the data on a yearly basis, it can be seen that the number of publications on the subject has been steadily increasing over the past 20 years. This is also true when looking at the results of the query on self-driving cars and the results of the query on the safety of self-driving cars. Figure 3 also shows the annual distribution of the two sets of results. The number of publications in 2012 has increased significantly by 2022.

The figure shows the percentage of publications on self-driving cars (#1) and the percentage of publications on the safety of self-driving cars each year. It can be clearly seen that the percentage of publications related to safety, protection, accidents, and risks of self-driving vehicles has risen to over 20 % in the last 10 years. To summarise, one in five publications on self-driving cars also deals with related safety issues.

An analysis of the results of the first query by country showed the nationality of researchers on self-driving cars in the period under review. This gives an insight into the countries where intensive research and development work on self-driving vehicles is ongoing. Figure 4 shows that American, Chinese and German researchers published most publications.

Figure 4 shows an interval of several decades. It is well known that a large amount of research has focused on self-driving cars in the last ten years, so it is worth looking at the country-specific approach in recent years. The changes have been analysed over two 3-year periods: 2017-2019 and 2020-2022. Figure 5 shows the distribution of publications on self-driving cars by country over the two periods. It can be clearly seen that there has been a significant change in the publication output in the Asian region over the last three years compared to the 2017-2019 period. While US researchers registered the highest share of publications between 2017 and 2019, 2020-2022 was dominated by publications from Chinese researchers.

The figure shows that the number of publications by Chinese researchers (*from 816 to 1831*) has increased by more than 120 % in the last three years, with much lower publication numbers, but the figure for Indian researchers shows an increase of more than 150 % (*from 286 to 740*). For US and German researchers, there is no significant difference in publication numbers between the two periods.

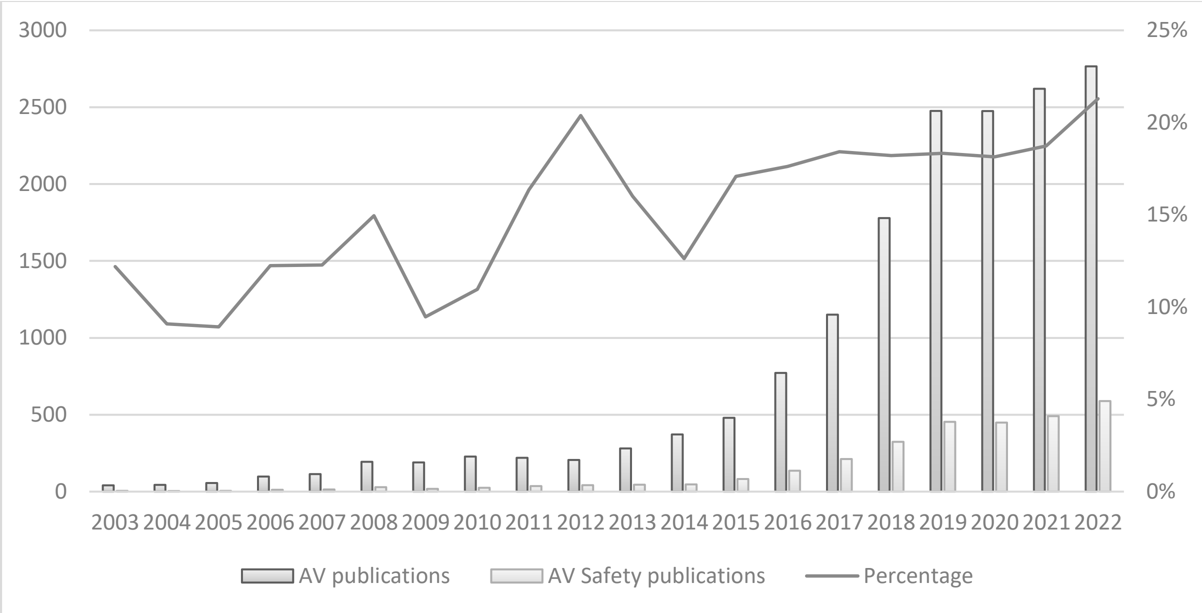


Figure 3. Number of publications / Comparison of the two search queries.

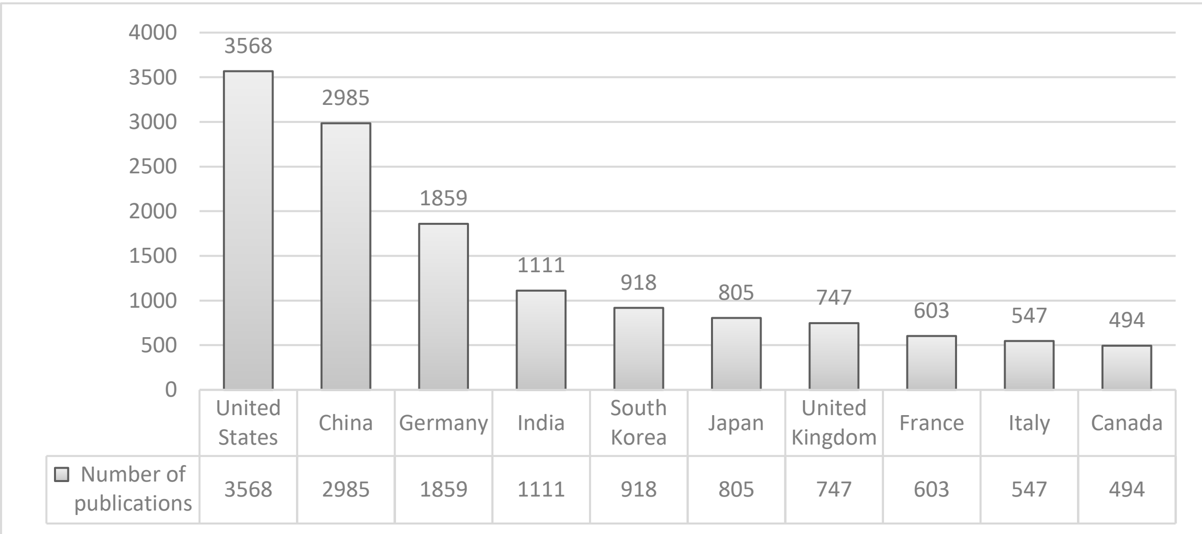
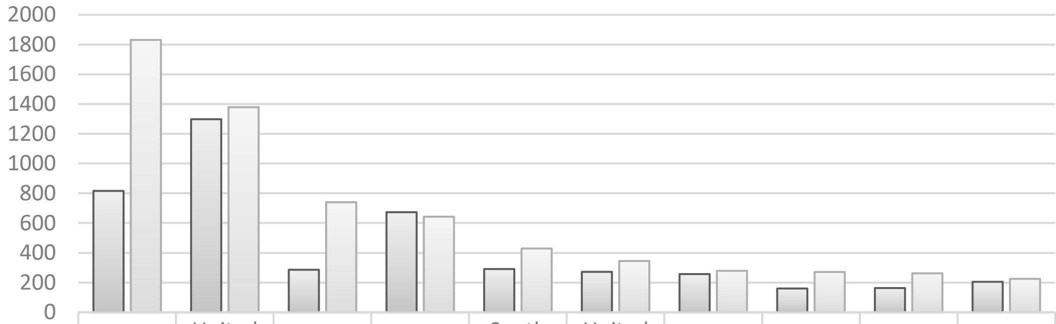


Figure 4. Number of publications by country (*search query #1*).

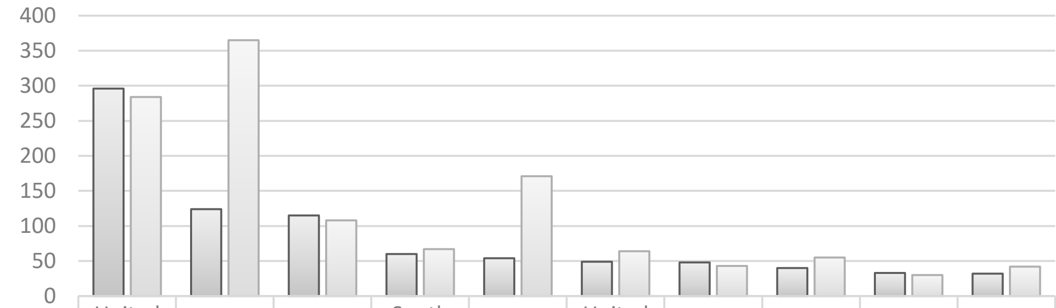
Figure 6 shows the second set of results (#2) from the same perspective. This figure shows even more clearly the trend already illustrated in Figure 5. The publication rates of Chinese and Indian researchers have increased significantly over the last three years compared to the 2017-2019 period. Similarly, to the results of the first search query (#1), no change in the publication numbers of US and German researchers is visible.

This study did not attempt to analyse the quality of publications, the only quality criterion being that the publication was indexed by Scopus.



	China	United States	India	Germany	South Korea	United Kingdom	Japan	Italy	Canada	France
Publications 2017-2019	816	1298	286	673	291	272	257	160	163	205
Publications 2020-2022	1831	1379	740	643	429	345	279	271	262	225

Figure 5. Number of publications by country / 2017-2019 and 2020-2022 (*search query #1*).



	United States	China	Germany	South Korea	India	United Kingdom	France	Italy	Spain	Canada
Publications 2017-2019	296	124	115	60	54	49	48	40	33	32
Publications 2020-2022	284	365	108	67	171	64	43	55	30	42

Figure 6. Number of publications by country / 2017-2019 and 2020-2022 (*search query #2*).

CONCLUSIONS

In this article, some research trends on self-driving cars are presented. The bibliometric analysis included an overview of publications on self-driving cars by year and by country. By analysing the publication data of the last six years, Asia is making significant efforts in the field of self-driving cars. China and India's research – in terms of numbers – has increased significantly in the last three years. Further analysis of the data from these two surveys is needed. The following research direction is to examine the publications by topic and to analyse and compare the published papers qualitatively. Since the Scopus database is the primary data source, the further scientometric analysis will be performed on the SciVal platform.

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INTERNET OF THINGS IN SELF-DRIVING CARS ENVIRONMENT

César Bautista* and Gyula Mester

Óbuda University, Doctoral School of Safety and Security Sciences
Budapest, Hungary

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Regular article

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ABSTRACT

The development of Self-Driving cars has had two main approaches, the vehicle as an individual object, allowing it to perceive the environment and react to it, and seeing it as part of an autonomous system (smart city) where the environment is responsible for identifying all components and providing timely activation. Internet of Things technologies can drastically improve the capabilities of the autonomous vehicle to better understand its environment with the interconnection of the surrounding elements. The findings from the development of the Internet of Things in autonomous cars are more intelligent mobility with higher levels of safety (for passengers and pedestrians), efficiency (allowing drivers to avoid traffic congestion and facilitating their search for parking), and sustainability (through reduced fuel consumption.). This article reviews advances on the Internet of Things and how it has changed the industry. Aspects in the development of intelligent cities result from implementing the Internet of Things.

KEY WORDS

cloud computing, Internet of Things, safety, self-driving cars, smart city

CLASSIFICATION

ACM: H.1.1, J.4, K.4
APA: 4010
JEL: L86
PACS: 01.70.+w

*Corresponding author, η: cemike.bautista@gmail.com; +36 (1) 666-5605
Népszinház utca 8, Budapest, H – 1081, Hungary

INTRODUCTION

The Internet of Things (IoT) is a system of interconnecting devices, which could be digital and mechanical devices, objects, animals, or people that are provided with unique identifiers [1]. The devices should have the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. An IoT ecosystem consists of web-enabled intelligent devices that use microprocessors, sensors, and technology to store, processing and act in their environments. The concept of Cloud Computing is used in IoT systems, consisting of computer programs for receiving Big Data, analysing, processing, and managing it; Big Data means all information can be transferred from any device to the cloud. In the last years, the development of wireless sensors, help to create the intelligent terminal for controlling remotely extensive systems. For example, security systems in airports, intelligent parking lots, intelligent homes, and more, the main goal is alerting and protecting people, giving users the confidence to use these systems [1]. IoT is also very present in the automotive world. Our cars are becoming more intelligent (Connected Car) thanks to intelligent sensors that go far beyond calculating a route: they save fuel, they notify emergency services, our geolocation in case of accident or breakdown, they receive and interpret incidents or safety notices that affect our trip and communicate it to us in real-time [2].

For smart cities, the role of IoT is essential. The benefits are addressing population growth in urban areas, reducing resources, cost savings, more accurate services to citizens and organizations, and more efficient transportation, all of which far outweigh the cons or risks of a connected city. In the same way, the security and protection of critical infrastructure, applications, identities, and sensitive data (personal information, medical details, vehicle routes, financial information, etc.) must be increased, maintaining the confidentiality of the data collected [3]. A single security vulnerability in one sensor could compromise the entire network segment where the sensor resides.

INTERNET OF THINGS

Refers to connecting everyday objects with the network, digitalizing the physical world, Figure 1. Some examples would be if the refrigerator notifies you of the expiration date of the products or the toothbrush alerts you to caries and asks for an appointment with the dentist [4].

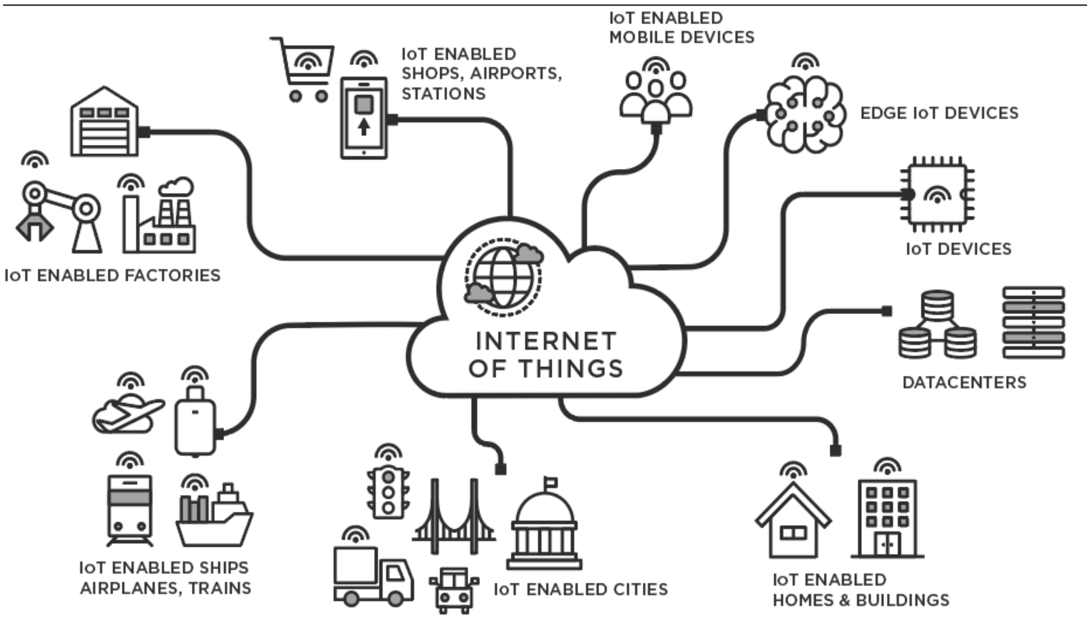


Figure 1. IoT.

To connect the devices to the Internet of Things, you need sensors, a Central Process Unit, and an Internet connection. IoT depends on an integrated set of technologies such as application programming interfaces connecting devices to the internet.

Connected objects and networks that, thanks to the information they receive from millions of sensors, store and interpret millions of data in seconds (Big Data) and launch orders that make it possible to streamline and automate processes that, until now, were based solely and exclusively on the human interaction.

The definition of the Internet of Things leads us to sensors or objects that, through interconnected networks, send, in real-time, millions of data to interpretation and analysis centers for study and decision making. Still, it is much easier to think about day to day and see examples of the Internet of Things that we already use daily that make our lives a little easier and have been integrated into our daily reality and that of our cities. In-home (Domotics), Figure 2, the intelligent refrigerators can order directly to the supermarket when there is a lack of food. Automotive systems allow saving electricity according to the real needs of the house, devices for irrigation and wise water consumption, intelligent garages, etc. Figure 3 [5].

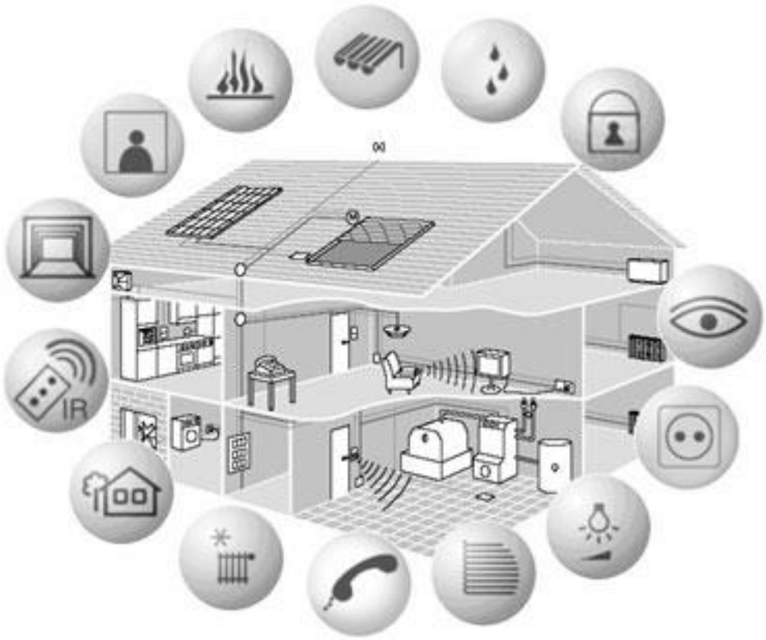


Figure 2. Example1 of IoT – Domotics [5].

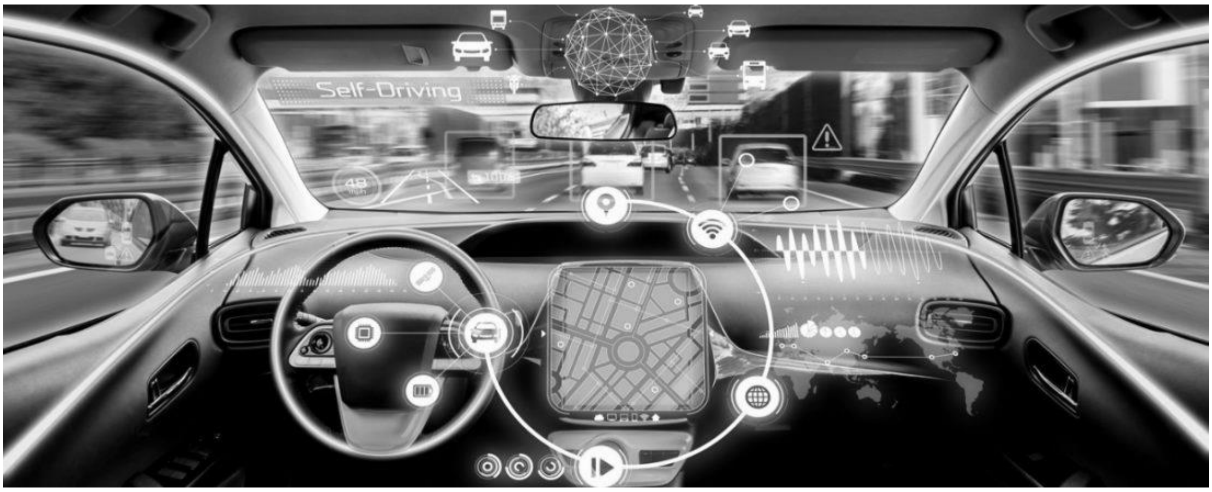


Figure 3. Example 2of IoT – Car Automation [6].

THE CLOUD AND CLOUD COMPUTING

Cloud computing is a technological and business model that allows ubiquitous, adapted. On-demand network access to shared configurable computing resources can provide information infrastructure, services, platforms, and applications that come from the cloud to users, as requested and through a network [6]. Clouds are groups of virtual resources coordinated by management and automation software. The users can access them as requested through self-service portals supported by automatic scaling and dynamic resource allocation. Cloud computing allows Information Technology departments not to waste time expanding custom implementations by giving business units the power to request and implement their resources, Figure 4.

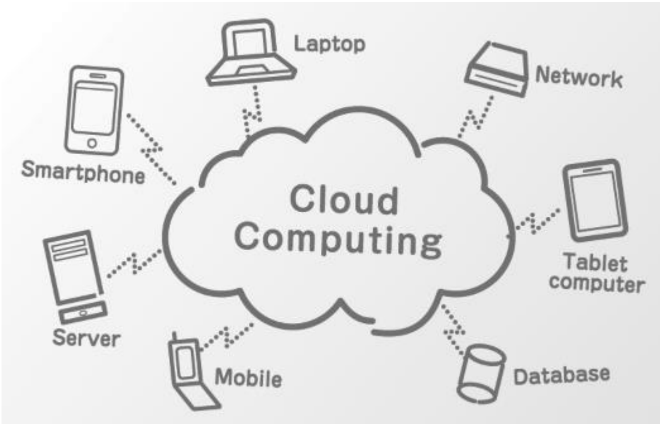


Figure 4. Cloud Computing representation.

Clouds and cloud computing are not technologies in themselves. It would help if you had operating systems, virtualization software, and automation and management tools to use them. The operating systems configure the host user interfaces and networks; virtualization extracts resources and groups them in the clouds; the automation software allocates those resources, and the management tools provide new environments.

The basic idea is that all information is stored distributed in servers, being accessible at any time by the user without the worry of anything; the system of the "cloud" is responsible for always keeping the information available [1]. The system distributes the computing capacity and memory of the applications stored in the cloud; depending on its use, its capacity is delegated, and data processing is distributed to the servers.

ADVANTAGES OF CLOUD COMPUTING

- Change of capital expenses for variable expenses: Paying consumes computing resources and how long.
- Benefits from massive economies of scale: With Cloud Computing, hundreds of thousands of customers are registered.
- Stop guessing capacity: With Cloud Computing is not necessary to think in infrastructure, and this problem is eliminated. Additionally, the users can access as a need for the information.
- Increase speed and agility: The response in Cloud Computing is faster because the resources are available all the time.
- Save money in managing data centers: In Cloud Computing, the projects can focus on customers without infrastructure.
- Go global in minutes: This kind of system lets the developers build applications and distribute them worldwide without difficulty, which means global applications.

CLOUD COMPUTING DEPLOYMENT MODELS

PUBLIC CLOUDS

This model, Figure. 5, allows the entire public to access its services through free accounts.

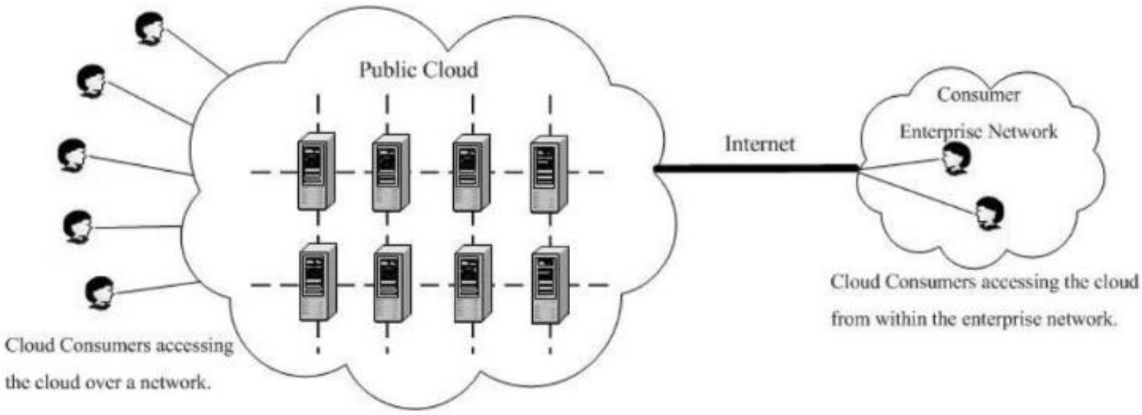


Figure 5. Public cloud structure [8].

Key aspects of public cloud:

- the access to innovative business apps for management and data analytics,
- flexible, scalable for storage and compute services,
- enables power for cloud-based application development and deployment environments.

PRIVATE CLOUDS

Usually is reserved for specific businesses and is provided on a private network, Figure 6.

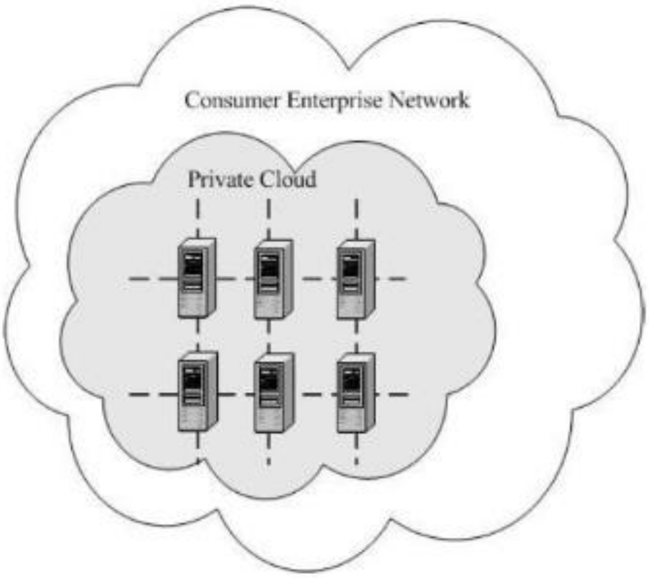


Figure 6. Private cloud Structure [8].

Key aspects of a private cloud:

- self-service interface controls services,
- automated management of resource pools,
- sophisticated security and governance.

HYBRID CLOUDS

A combination of public and private services is more flexible and helps optimize the user's infrastructure and security, Figure 7.

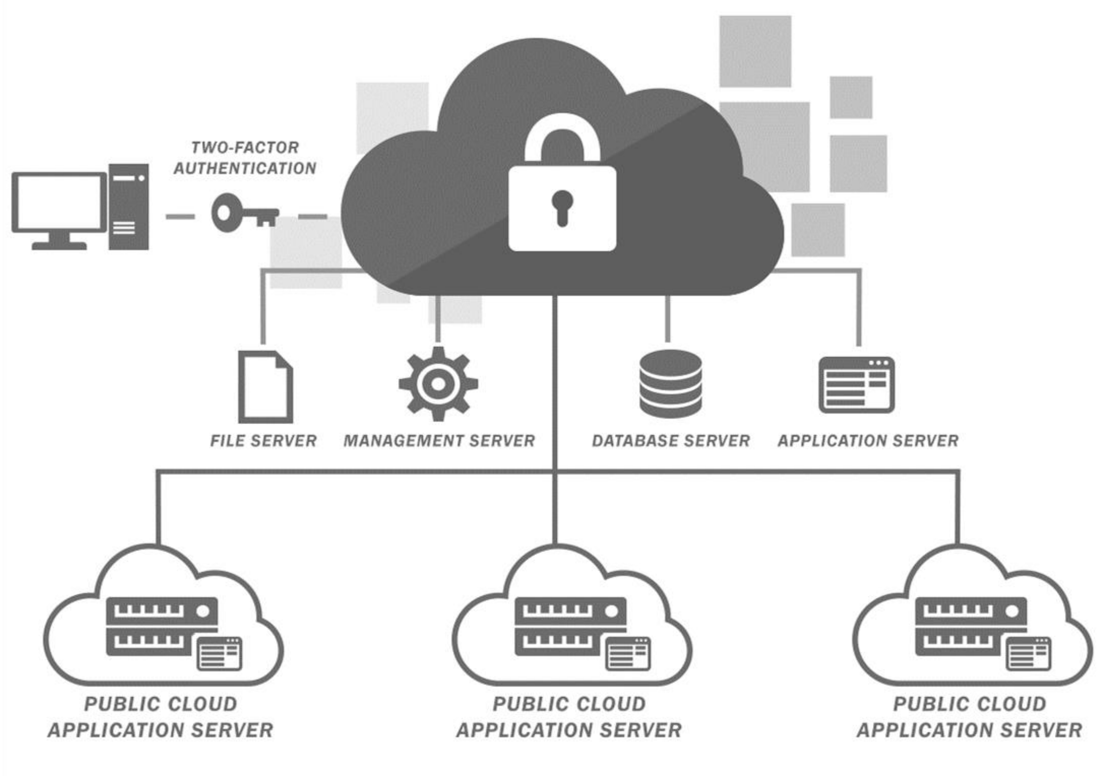


Figure 7. Hybrid Cloud Structure [8].

Key aspects of hybrid cloud:

- allows companies to save a critical application and sensitive data,
- the advantage in public cloud resources like Software as a Service (SaaS) for the latest applications and infrastructure as a Service (IaaS) for flexible virtual resources,
- facilitates portability of data, apps and services and more choices for deployment models.

VIRTUALIZATION

Virtualization is one of the technologies that allows cloud computing. However, virtualization is not cloud computing [8]. The main difference is that virtualization is an abstraction of computer resources, typically virtual machines. Virtualization is unnecessary to create a cloud environment, but it allows for rapid scalability of complex resources in non-virtualized environments.

A virtualized infrastructure is the basis for most high-performance clouds. Virtualization has been a successful strategy for consolidating data centers [9]. It is widely used to pool the resources of the infrastructure and can also provide the essential elements to improve the agility and flexibility of a cloud system. The servers continue to be the main focus of virtualization [10].

TYPES OF CLOUD COMPUTING

SOFTWARE AS A SERVICE

SaaS involves the licensure of a software application to customers, Figure 8 [8]. These applications are accessible from various client devices through client-light interfaces, such as a web browser.

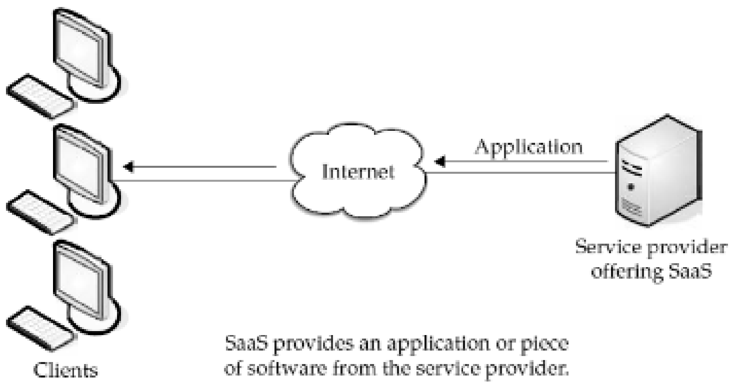


Figure 8. SaaS [8].

Benefits of SaaS:

- you can sign up and fastly start using innovative business apps,
- apps and data are accessible from any user,
- the data is never lost because all is in the cloud, dynamically scale to usage needs.

Some of these applications:

- customer resource management,
- video conference,
- administration of IT services,
- accounting,
- web analysis,
- web content management.

INFRASTRUCTURE AS A SERVICE (IAAS)

This method, through IP-based connectivity, is capable of distributing from operating systems to servers and storage, Figure 9 [8].

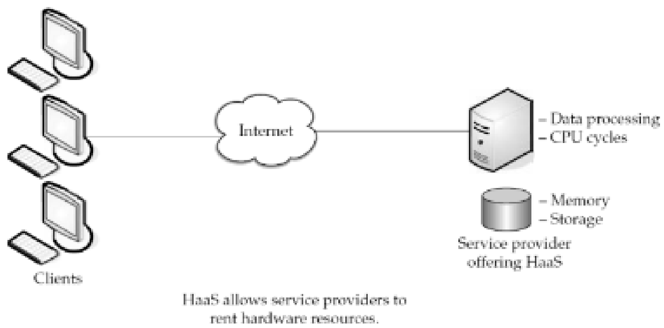


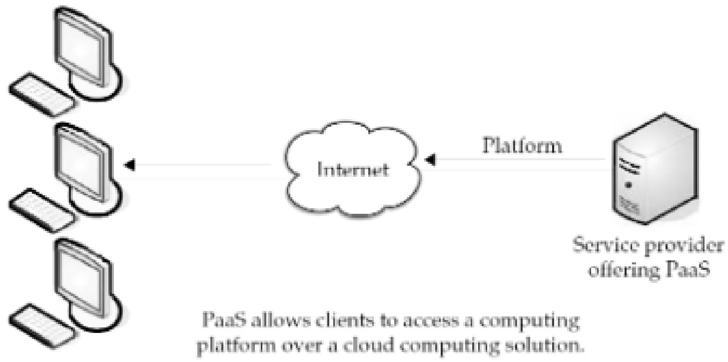
Figure 2. Infrastructure as a Service (IaaS) Structure [8].

Benefits of IaaS:

- no need to invest in your hardware,
- infrastructure scales on-demand to support dynamic workloads,
- flexible, innovative services available on demand.

PLATFORM AS A SERVICE

The main difference with SaaS is the delivering software online; the platform allows creating software delivered by Internet [8]. The consumer can deploy applications in the cloud infrastructure, developed by or acquired, programming languages, services, libraries, and tools supported by the provider.



aas

Figure 10. Platform as a Service (PaaS) structure [8].

Bepnefits of Platform as a Service (PaaS):

- develop application and get to market faster,
- upload new web applications to the cloud in minutes,
- reduce complexity with middleware as a service.

INTERNET OF THINGS – AREAS OF APPLICATION

The importance of IoT lies in the change that it will mean in our society since it is one of the fundamental elements of digital transformation whose presence is essential for sectors such as: Industry 4.0 or Connected Industry. The Internet of Things will automate processes and connect machines and production centers anywhere in the world to respond to a demand in real-time. There is talking about a new industrial revolution. Industry 4.0 refers to the introduction and application of digital technology to all production systems and processes in factories and customers, Figure 11.

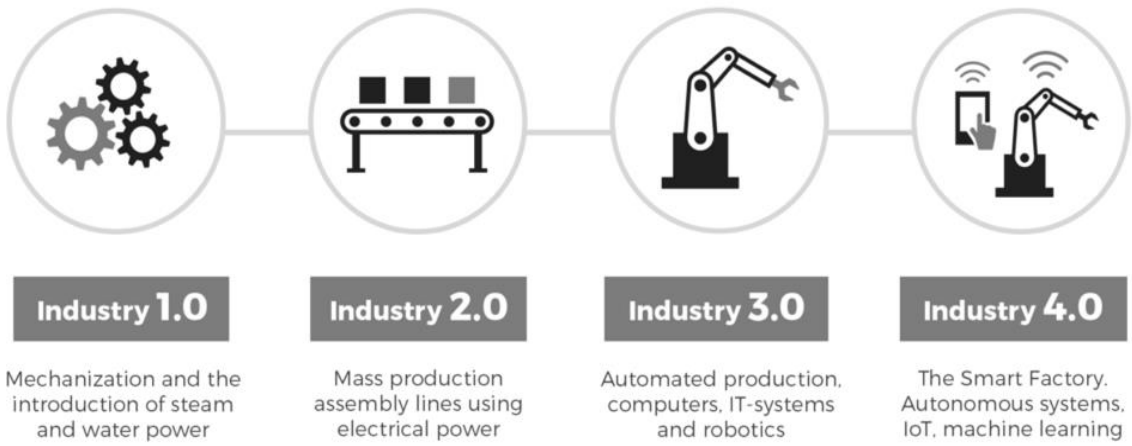


Figure 3. Industrial Revolution [10].

SMART CITY OR INTELLIGENT CITY

Smart cities apply Information and Communication Technologies to manage and provide their different services, such as governance, economy, social affairs, mobility, security, energy, culture, environment, and others [13-21]. For Citizens, this means a better quality of public services, greater administrative efficiency, greater accessibility, more transparency, and better access to public information. Smart City can also mean better economic, social, and environmental quality for the City and Citizens. At the same time, a growing number of private companies provide services of Smart Cities complementary and integrated to those of the public administration, Figure 12. Citizens interact with the ecosystems of intelligent cities in various ways using smartphones and mobile devices and connected vehicles and homes. Pairing devices and data with the physical infrastructure and services can reduce costs and improve sustainability.

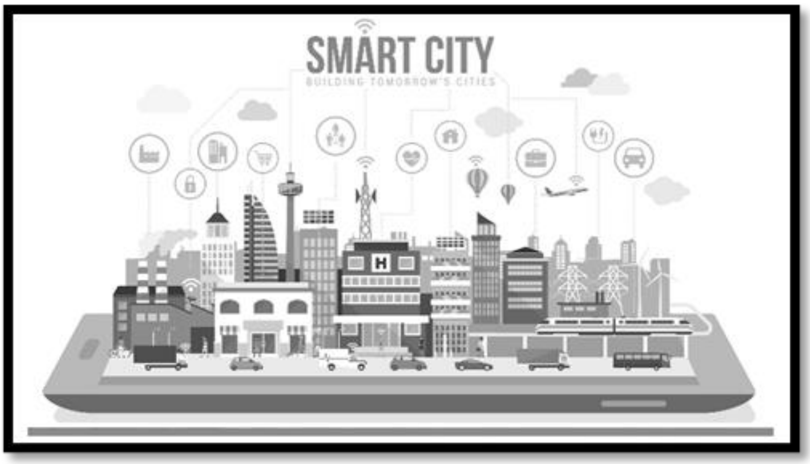


Figure 12. Smart City [21].

E-HEALTH

It is one of the aspects in which the Internet of Things revolution has already begun and whose advances go much further thanks to the real-time interpretation and data that facilitate wearable devices for better and effective service of patients, among many other possibilities, Figure 13.

Figure 13. E-Health [21].

EDUCATION

Not only talking about new formulas or educational systems based on the interaction with objects but the application of the Internet of Things to improve the access and integration of thousands of people who, otherwise, would have much more limited access and your opportunities.

CYBERSECURITY

Security technologies are needed to protect devices and platforms from the two significant dangers they face, attacks on information and physical manipulation of devices. The big problem is that many connected 'things' are elementary and use processors and operating systems that do not support sophisticated security approaches.

Also, the IoT security specialists will have to make an effort there since the solutions are currently very fragmented. There will be new threats because hackers will find new ways to violate protocols and devices. Therefore, considering that they are 'objects' with a long lifespan, they would have to have hardware and software updated during their operation period.

CONCLUSIONS

The virtual and physical joint between infrastructure components and sectors are becoming increasingly permeable as IoT systems become networked and remotely accessible. Increased connectivity, faster speeds, and multi-directional data flow access points into critical infrastructure, changing and stretching the borders that Smart Cities must secure. IoT development depends on different factors such as resource availability, user preferences or scale, and accessibility. Migration to these new technologies will present a significant security challenge for users, industries, and the government. In some areas, merge older and newer infrastructure. There will be points where older equipment continues to dominate but lacks the same – new equipment's ability to report operational status, problems, or efficiency opportunities. More generally, such adaptation challenges developing consistent security policies for cities at different stages or approaches to Smart City development.

One of the goals of the IoT infrastructure is to migrate the control of people to digital systems based on algorithms. This process presents new challenges to be considered. The increase in access points increases the points of attack to the system, due to the size of the system, the complete monitoring becomes complex, cascading failures, automatic response to emergencies (leaving aside the humanity in decision making), involuntary removal of manual overrides.

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UNDER-ESTIMATED FACTORS IN THE ADOPTION OF SELF-DRIVING CARS

Dalma Zilahy*

Óbuda University, Doctoral School of Safety and Security Sciences
Budapest, Hungary

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ABSTRACT

Automated vehicle acceptance is needed to improve road safety, reduce congestion, reduce pollution and to meet a number of higher-level goals. To date, little is known about the factors that actually influence drivers' acceptance or rejection of Self-Driving technology. Acceptance is critical to the widespread uptake of Self-Driving vehicles. This article focuses on the factors that have been underestimated in the adoption of Self-Driving cars. The article is organized as follows: in Section 1 the Introduction is given, in Section 2 Adoption models are presented, in Section 3 Social relationships, subjective norms, impact of cultural milieus are presented, in Section 4 The indirect impact of social media is presented, in Section 5 The interaction between social media, subjective norms and self-efficacy is presented, in Section 6 Future objectives are presented, Conclusions are given in Section 7.

KEY WORDS

automated vehicle, road safety, adoption, self-driving cars, under-estimated factors

CLASSIFICATION

ACM: H.1.1, J.4, K.4
APA: 4010
JEL: L92, Q55
PACS: 01.70.

*Corresponding author, η: zilahydalma@gmail.com; +36 (1) 666-5605;
Népszinház utca 8, Budapest, H – 1081, Hungary

INTRODUCTION

Automated vehicle acceptance is needed to improve road safety, reduce congestion, reduce pollution, and meet a number of higher-level objectives. To date, little is known about the factors that actually influence drivers' acceptance or rejection of self-driving technology.

Economic and technological developments in the 5th generation wireless network further cloud the degree of confidence in these innovations. Acceptance is critical to the widespread adoption of self-driving vehicles. This paper focuses on the factors that have been under-appreciated as having an impact on the adoption of Self-Driving Cars. Theories of adoption, the perception of self-efficacy, mass media, the way information is accessed, and the impact of the social environment are underestimated.

Through experiencing the efficient operation of Self-Driving Cars, the personalizing effect of the social norms system, and appropriate mass communication channels, we can increase the widespread use of Self-Driving Cars.

Investigating the human-specific factors behind the intention to use Self-Driving Cars has become the basis for several models.

Who, when, why and for what reason would use self-driving technology will be of great importance in the future. Given that the respondents in previous studies currently have minimal personal experience of self-driving, the results rely mainly on the results of responses that the respondent imagines or is currently thinking about.

The article is organized as follows: in Section 1 the Introduction is given, in Section 2 Adoption models are presented, in Section 3 Social relationships, subjective norms, impact of cultural milieus are presented, in Section 4 The indirect impact of social media is presented, in Section 5 The interaction between social media, subjective norms and self-efficacy is presented, in Section 6 Future objectives are presented, Conclusions are given in Section 7.

ADOPTION MODELS

According to the Technology Acceptance Model, the main factors influencing intention to use are "perceived usefulness" and "ease of use". The question of utility is complex, what is useful for society, the economy, the environment, is not necessarily useful for all users, i.e. it may not pay off in the present life. Utility in this sense varies from one individual to another.

The "simplicity of use" can be better defined in technical terms. The easier it will be to access a self-driving car through an app, and the easier it is to operate, the more attractive it will be for the user. However, we should not forget the generational and infrastructural differences in this respect.

In addition, research has also identified a number of variables – trust, perceived security risk, personality factors, social norms – that influence the intention to use.

The Automated Vehicle Adoption model summarises the mental process that most users go through in 4 steps. The first level of the 4-stage model of automated vehicle acceptance is based on positive and negative attitudes, i.e., the attitudes, behaviours, and mental attitudes towards self-driving.

The second level is the decision phase, where the choice to accept or reject self-driving cars is made.

At the third level, the practical implementation takes place, i.e., personal experience is gained, and at the fourth level, the criteria of 7 acceptance classes are considered based on the model.

At the micro level, they mainly measure socio-demographic, personality, and travel behaviour variables. At the micro level, they list the variables of AVs on individuals, which consist of asset-specific, normative, and affective factors.

At the meso-level, they classify into separate classes those factors that are exposed to AVs and already have personal experience, vehicle domain-specific characteristics – performance, safety, efficiency, service – and separate factors with symbolic meaning and moral values. In total, the model classifies 28 acceptance factors into 7 classes.

This alone shows how difficult it is to predict who will ultimately decide to use self-driving cars and on what basis.

The factors that are under-appreciated in terms of self-driving adoption and based on existing models include self-evaluation, the effects of communication and innovation, and the way information is accessed [1, 2].

SOCIAL RELATIONSHIPS, SUBJECTIVE NORMS, IMPACT OF CULTURAL MILIEUS

An individual's behavioural intention is influenced by several factors. According to Bandura's Social Cognitive Theory, the immediate physical environment, peer relationships, cultural milieus, social norms and values, and the influence of peers determine how we think about the world and ourselves [3-5].

A 2016 study examined the acceptance of self-driving cars after reading idealised and realistic representations. Before taking the test, which consisted of 24 items, participants were randomly assigned to read short stories that contained realistic or idealistic descriptions of a friend's experience of using a self-driving car for the first six months.

Reading the idealised portrayal resulted in greater acceptance of Self-Driving Cars. The question then arises as to what is the most effective way of gaining acceptance of self-driving: gaining the trust of a good friend through experience or promoting the increasing range of cars and the expansion of driving features in trade publications.

I wonder on what basis and facts the next generation will choose self-driving, and what are the main factors that drive current drivers to adopt self-driving.

THE INDIRECT IMPACT OF SOCIAL MEDIA

According to Social Cognitive Theory, media is one of the most influential environmental influences. Self-esteem is most influenced by a sense of self-efficacy and subjective norms; behaviour is most influenced by trust in technology and the intention to use self-driving vehicles. Today, trust in technology and vehicle use are most influenced by mass media. Mass media includes broadcasts, movies, video games, audio recording, reproduction, internet, blogs, RSS-news feeds, podcasts, mobile media, and print media [6].

In a 2016 survey by Fraedrich and Lenz, 57 % of respondents said they were generally interested in autonomous driving and 78 % of them obtained information on the topic mainly through mass media [7]. Social media such as Facebook, Twitter or WeChat influence the willingness of the public to operate Self-Driving Cars.

Kohl et al. concluded, based on an analysis of 642 033 tweets, that communication strategies need to be rethought due to the bias of pros and cons. Overestimating the benefits leads to misuse and then disappointment, while overestimating the risks leads to resistance. People were found to be more accepting after they had used prototypes, but increased safety features led to an experience of loss of control [8-11]. The positive or negative bias broadcast by mass media plays a large role in consumers' perceptions of self-driving cars and in their behavioural fluctuations. In the case of new emerging technology, there is no personal experience, so the media plays a greater role in product purchase preferences.

The mass media also has a significant impact on consumer confidence in self-driving cars and helps to promote understanding of innovative technologies. The media play a key role in reducing uncertainty about new products by providing information in an understandable form. Otherwise, consumers will doubt whether they can learn to use self-driving cars. The opinions of others – family, friends, colleagues, etc. – will also influence consumer behaviour. Subjective norms have a strong and positive impact on perceived usefulness and attitudes towards use.

THE INTERACTION BETWEEN SOCIAL MEDIA, SUBJECTIVE NORMS AND SELF-EFFICACY

Subjective norms change evaluations and affect behaviour, and this can change their trust in the product [12]. Mass media have an impact on subjective norms. Norms are beliefs, about the behaviour of others and their evaluation of it, which influence our judgements and opinions. Mass media also affect self-efficacy. Self-efficacy [13] can be defined as an individual's beliefs about his or her ability to perform in a way that influences the events that shape his or her life. Individuals with a high sense of self-efficacy treat difficult, complex tasks as a challenge, while a low sense of self-efficacy tends to lead to an avoidance attitude.

A sense of self-efficacy comes from a variety of sources, the most important being practical experience, but it can also be developed through other vicarious experiences and learning. If we see the example of others like us, our own personal sense of self-efficacy may increase or decrease as a result of success or failure as a result of persistent work.

Therefore, if the mass media portray the use of self-driving cars in a positive light, and the user's judgement and evaluation of it is positive, it has the potential to influence behaviour. Behaviour can be reinforced by a sense of self-efficacy, the practical personal or others' positive experience of being able to use a Self-Driving Car effectively and not failing in this experience.

The impressions of the passengers of a self-driving shuttle were investigated in an interview study at the EUREF (Europeanises Energieforum) campus in Berlin-Schöneberg by 30 users. The research confirmed that the participants had idealised expectations of the technological capabilities of the automated shuttle, which may have been fostered by the media.

Less than a quarter of respondents would prefer an external control room or an on-board cabin attendant to unattended automation. A US study found that men showed a greater willingness to hand over control of driving. Women and greater conscientiousness were associated with greater anxiety about AV, while prior knowledge about AV helps reduce anxiety about self-driving. Emotional stability and openness to experience were positive predictors of willingness to accept AV, while conscientiousness had a negative effect. And extroversion was negatively associated with willingness to transfer leadership [6-9]. Subjective norms have a strong and positive effect on perceived usefulness and attitude towards use [14, 15].

Subjective norms change evaluation and behaviour, and this can change trust in the product [16, 17]. The opinions of family, friends and colleagues influence the consumer's opinion. Mass media, subjective norms, and self-efficacy combine to influence consumer trust and behavioural intentions. Information through Facebook, Twitter, chat and other social media, as well as peer influences and the experience of being able to challenge the use of self-driving cars, i.e., to experience the impact of a major event in one's life, combine to influence the future use of AVs [18-24].

FUTURE OBJECTIVES

Based on the research so far, the prototypical future user is a less conscientious, introverted male with prior knowledge of AV. He or she is informed through social media (e.g. Facebook, Twitter, WeChat) and believes that self-driving vehicles are easy to use. He is emotionally stable, open to new experiences, has family members, friends and colleagues who find or use self-driving vehicles useful, and has heard idealised stories about self-driving vehicles.

CONCLUSIONS

The study focuses on the factors that have been underestimated in the adoption of Self-Driving Cars. In the future, companies wishing to promote Self-Driving Cars should use social media to describe self-driving in a way that is as clear and simple as possible. Information should be communicated mainly through Facebook, Twitter, WeChat, YouTube. Self-management should be linked to emotional stability and openness. Women should be given the opportunity to be cautious and understand the benefits of giving up driving. The controllability of vehicles should also be communicated. In order to increase self-efficacy, the user should experience the simplicity of use and understand why it is useful in their lives. The use should be linked to a community experience, a community of community, because of the impact of social norms, and personal experience should be enabled through open days, test tracks, test drives.

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METHODOLOGICAL AND HEALTH REASONS FOR UNSUCCESSFUL BIOMETRIC IDENTIFICATION

Andras Pallagi[1, *] and Aliz Persely[2]

[1]Óbuda University, Doctoral School of Safety and Security Sciences
Budapest, Hungary

[2]Semmelweis University Doctoral School of Theoretical and Translational Medicine
Budapest, Hungary

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ABSTRACT

Nowadays, the use of biometric identification procedures is becoming increasingly widespread making our lives more convenient and safer at the same time - due to their uniqueness.- from mobile phones through access control systems to the official use of biometric identifiers.

However, proper identification can be hampered by a number of errors, when either an incorrectly chosen method or even the health condition of the person may cause a problem.

Our research examined the main causes of failed identification procedures through examples. The obtained result can provide guidelines for the selection of the optimal identification methodology and determine their development directions.

KEY WORDS

biometrics, identification, twin research

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*Corresponding author, η: pallagi.andras@uni-obuda.hu; +36 703837237;
OE-BDI office, Nepszinhaz str. 8, H – 1081 Budapest, Hungary

INTRODUCTION

Biometrics, as a term, derives from the combination of the Greek words “bio” – life and “metric” – i.e. the measurement of the physiological characteristics of an organism. In our present case, this living entity is a human, whose biometric characteristics are the basis of determining their identity. Thus, biometric identification is a process that requires an automatic technique that measures and records a person’s unique physical characteristics and behavioural traits, and uses them for identification and authentication purposes. Biometric recognition may be used for the purpose of personal identification, where the biometric system identifies the person by searching for a match in the whole registered data file, and it may be used for verification purposes, when the system authenticates a person based on previously recorded and stored samples.

BIOMETRIC IDENTIFICATION

Biometric identification methods can be divided into two groups based on the individual biological or behavioural characteristics that differ from person to person:

BIOLOGICAL CHARACTERISTICS

- skin pattern: fingerprint, palm print, footprint,
- hand and face geometry (2D, 3D),
- vascular/vein network (typically: palm, wrist, finger),
- facial features, facial thermal image,
- iris and retina pattern,
- fragrance, the combination of body fluids,
- heart rate,
- DNA genotype, white blood cell antigen.

BEHAVIOURAL CHARACTERISTICS

- voice,
- walking, posture,
- handwriting,
- typing dynamic, habits.

The identification and measurement process consists of the following steps:

1) The sensor detects the required biometric sample from the person.
2) From the whole sample, the program highlights the characteristic (identifiable) features.
3) The comparison algorithm compares a detected sample with samples pre-recorded in its database and evaluates it.
4) The comparison generates an identification response, i.e., a match or no match.

Four specific characteristics can assess the efficiency and reliability of identification systems:

- False Rejection Rate (FRR),
- False Acceptance Rate (FAR),
- Crossover Error Rate (CER),
- Failure to Enroll Rate (FER).

An erroneous denial is when the access control system denies access to an authorized user. There are several possible reasons, such as incorrect sampling or even a timeout for sample evaluation. In case of false acceptance, the algorithm identifies unauthorized persons as authorized, which may be due to sample tampering or incorrect algorithm assessment. The same error rate has been introduced for the objective comparison of different types of identification systems. The crossing error rate describes the point where FRR and FAR are equal, thus describing the overall accuracy of the biometric system. Below the probability of a coverage error, it shows us the number of chances that someone will fall out of the biometric measurement.

The most important of the above mentioned four characteristics is the FAR index, which shows us the proportion of wrongly identifying an unauthorized person as eligible.

FAR indicators of some biometric systems (informative, device-specific data) [1]:

- voice identification, voice analysis: 200 … 1 000: 1;
- face recognition (2D, 3D): 2 000 … 10 000: 1;
- hand geometry analysis: 10 000 … 100 000: 1;
- vein network identification: 100 000 … 1 000 000: 1;
- fingerprint identification: 100 000 … 1 000 000: 1;
- iris, retinal examination: 10 000 000: 1.

In addition to the aforesaid, the efficiency of biometric systems can be measured by the following seven essential criteria [2]:

1) Universality: Every individual accessing the application should possess the trait.
2) Uniqueness: The given trait should be sufficiently different across individuals comprising the population.
3) Permanence: The biometric trait of an individual should be sufficiently invariant over a period of time with respect to the matching algorithm. A trait that changes significantly over time is not a useful biometric.
4) Measurability: It should be possible to acquire and digitize the biometric trait using suitable devices that do not cause undue inconvenience to the individual. Furthermore, the acquired raw data should be amenable to processing in order to extract representative feature sets.
5) Performance: The recognition accuracy and the resources required to achieve that accuracy should meet the constraints imposed by the application.
6) Acceptability: Individuals in the target population that will utilize the application should be willing to present their biometric trait to the system.
7) Circumvention: This refers to the ease with which the trait of an individual can be imitated using artifacts (e.g., fake fingers), in the case of physical traits, and mimicry, in the case of behavioural traits.

TECHNICAL AND METHODOLOGICAL REASONS FOR IDENTIFICATION FAILURE

Most biometric identification systems in use today typically use a single biometric feature to establish identity (i.e. they are unibiometric systems). It is essential to know the vulnerabilities and limitations of these systems. Below are some of the challenges that biometric systems often face.

THE DETECTED DATA IS NOISY, INCORRECT

The scanned biometric data will be noisy due to inadequate data collection or minor differences in the biometric feature. Such a discrepancy could be a damaged or bloated fingerprint. Due to extreme weather conditions, the evaluation of the venous map may also be incorrect.

INVOLVEMENT ERROR

There may be cases where the identification system is unable to obtain the biometric data required for identification from the user. For example, lesions in the iris or fingerprint due to disease cannot be identified. The conditions and rules must be established under which these persons may also be included in the identification system.

UPPER LIMIT OF IDENTIFICATION ACCURACY

The matching performance of a one-factor authentication system cannot be improved indefinitely. During identification, it compares templates made from predefined sample parts with the perceived biometric feature, but there is also an upper limit to using a sample that can be recognized based on the templates.

The number and complexity of each sample depend on the biometric feature. For example, fingerprints have far fewer template patterns than irises.

ATTACKABILITY

Many physical and behavioral biometric features are attempted to be falsified and copied. Fingerprints and palm prints are reproduced on a silicone-based surface. An IR photo can be used to create a device that deceives venous scanners. Behavior, gait, and speech imitation may also be part of the attacks.

To minimize the challenges outlined above and the associated errors, and to maintain the trust of those involved in the identification, we should strive to select the appropriate identification system. The following parameters must be considered when choosing the optimal biometric identification system:

- operating temperature, humidity, dust content,
- number of users, religious, ethnic composition,
- identification time,
- the working environment of the persons to be identified,
- simple integration with existing systems,
- the cost of the system.

It is essential to consider the operating temperature and humidity range specified in the manufacturer's instructions to use the identification devices properly. In some cases, environmental dust limits are also set. Ignoring the operating parameters, in most cases, increases the identification time and the FRR.

The number of individuals to be identified and their religious and ethnic composition are essential considerations in selecting the appropriate system. The throughput of the identification system should be designed depending on the number of people. The religious habits of some individuals may make biometric identification impossible. For example, Muslim women wear the niqab and burqa, which partially or wholly cover the face.

Identification time is also an important parameter when selecting a biometric identification method.

Rapid identification is not required in cases where individuals need to be identified infrequently or in small numbers. Where a large group needs to be identified, identification time can be a very important consideration to avoid congestion. For example, when changing shifts in large companies, the goal is to direct the crowd to the exits at the same time as fast as possible. In such cases, a palm vein scanner or facial recognition system may be a good solution.

The last parameter contains a description of the user's work environment. There are a number of work environment parameters that can impair the efficiency of biometric identification. This can be the case with a wet work environment, which causes the fingers and palms to become damp and swollen.

For example, the fingerprints of people who fold paper temporarily disappear, as the folds wear off. There are chemicals that also temporarily destroy fingerprints (instant glue, acids).

HEALTH REASONS FOR IDENTIFICATION FAILURE

Our research also examined biometric identification errors deriving from the users going through identification procedures. In addition to individual behaviour, we have identified health reasons that make clear or impede clear biometric identification. The list does not include injuries caused by accidents.

HEALTH CAUSES THAT IMPEDE RECOGNITION OF IRIS AND RETINA

- Aniridia, i.e. an eye without an iris. It occurs in one in every 50 000 to 100 000 newborns.
- Ptosis is known as the sagging of the upper eyelid and the patient usually complains of visual and cosmetic damage. It may be congenital or acquired, or it may be of neurogenic, myogenic, aponeurotic, mechanical, or traumatic origin.
- Endophthalmitis is defined as an inflammation of the inner coats of the eye. If not properly treated or neglected, it may even require the surgical removal of the eyeball.
- Cataracts, also known as cloudy lens. The lens is positioned behind the iris.
- Trichomegaly, i.e. abnormally long eyelashes. Eyelash trichomegaly can have several different causes. These causes can include both genetic inheritance and environmental causes (such as side effects of certain drugs).

HEALTH REASONS THAT MAKE FINGERPRINT RECOGNITION IMPOSSIBLE:

- severe hand eczema, also known as hand dermatitis, is a common disease. Genetics o contact allergens or irritating substances play a role in "triggering" this form of eczema [3].
- fingerprint smoothness. One of the side effects of paclitaxel and capecitabine for the treatment of cancer is the smoothing of fingerprints [4].

HEALTH REASONS THAT MAKE FACIAL GEOMETRY AND VEIN RECOGNITION MORE DIFFICULT:

- facial nerv paralysis, such as stroke or Bell's palsy,
- side effects of Botox treatments.

HEALTH REASONS FOR THE UNRECOGNIZABILITY OF SPEECH/VOICE:

- changes in sound characteristics due to Parkinson's disease [5],
- speech may change due to diseases affecting the sound-producing organs (throat, mouth, nose).

CAUSES OF DNA IDENTIFICATION ERRORS

- after a bone marrow transplantation, the sequence of the donor DNA will also be detectable, distorting identification,
- nearly identical DNA sequence of monozygotic twins (the difficulties with monozygotic twins are covered in the next section) [6].

ANOMALIES IN THE BIOMETRIC IDENTIFICATION OF TWINS

Authentication of identical twins might be the most challenging area in the biometrical field Therefore, the number of twins studies have been increased to achieve better methods. It is well-known that monozygotic twins share almost 100 % of their genetical background, but not only their genes are closely the same, they also have great similarity in phenotypical appearance. However, there are differences between them, which are mostly caused by epigenetics and environmental factors [6]. A previous study revealed that false accept rate for the recognition of monozygotic twins might be 2-6 % [7].

Literature data in biometrical identification of the monozygotic twins is mostly about face recognition, fingerprint and palmprint matching, iris and retina recognition, speaker recognition and handwriting. However, the need of proper detection initiated more studies to be conducted about multimodal matching systems [7-9].

Fingerprints are known to be personally unique, the ridges are formed during fetal development and they remain the same across the whole lifespan, unless skin damage occurs. Previous studies confirmed that fingerprint class, ridge width, depth and separation are significantly shared by monozygotic twins. Although they show huge similarities compared to fraternal twins, they also have minor differences, and this way, monozygotic twins can be distinguished by their fingerprints, especially when they are using and rotating both thumbs [8, 10]. It was observed by Kong et al. that the palm print of identical twins have correlated characteristics, and the discrimination is possible [8].

The patterns of irises were also found to be similar and reliable sources of identification [8].

The voice recognition of twins has also been studied, because the sounds are assumed to be same due to for example their anatomical resemblance [8].

The accuracy of recognizing images of monozygotic siblings is the most problematic part, because by manual face detection it was around 78,82 %, in a study where features like moles, scars, freckles were used for the correct answers. Currently, however, automatic face detection processes are quite promising and show better results. [8]

Multimodal studies are emerging in the field of biometric twin examinations. Sun et al. observed the recognition of iris, fingerprint and face patterns. They found that only some or none degradation in performance was shown when using the iris and the fingerprint, but there were difficulties when only the face matchers were regarded [8].

Priya et al. found in their multimodal study that the accuracy of matching was 93,62 % using only fingerprints, 95,2 % using only lip prints and 91,27 % using facial patterns, while the combination of these three methods altogether meant 93,36 %. [9] Combining facial recognition and skin surface texture analysis can increase the accuracy by 20 to 25 % [8].

MULTIMODULAR IDENTIFICATION SYSTEMS

Multimodular identification systems have been developed to increase the level of security. However, the individual parameterizability and fine-tuning of the system identification methodologies can eliminate the identification difficulties associated with technical or health reasons in one-factor identification systems. Using properly defined rules, individuals who have been excluded from single-factor systems can also be included in the identification.

The multimodular identification system can use:

- only biometric identification,
- biometric and knowledge-based identification
- biometric and object-based identification.

The most common multimodular identification systems based on biometric characteristics only:

- fingerprint and finger vein recognition system,
- hand geometry and hand vein network recognition system,
- facial geometry and facial venous recognition system,
- face and write recognition system,
- face and ear geometry recognition system.

Biometric identification and knowledge-based combined identification systems:

- finger or palm print and pin code,
- voice and password phrase (for example, telephone-based authentication),
- face/iris and pin code.

In the case of biometric identification and object-based combined identification systems, the object is typically an access card or token. In many cases, the HASH code generated from the holder's biometric characteristics is stored in the access card's chip portion. Typically, the following combined systems are developed:

- fingerprint or palmprint and access card,
- palm vein and access card (e.g., in stadiums, in sports facilities).

Many other combinations are possible, but in most cases the above combinations are used to reduce the cost of installing the system.

CONCLUSION

According to our research, the majority of misidentifications were due to a poorly chosen biometric identification system. Neither the health status of the user group nor the installation environment of the system was taken into account. In the examined one-factor access control systems, there were identification points where the system operator preferred to turn off biometric identification because of the high reading time. We have experienced a loss of trust in the identification system due to a series of false rejections.

Where multimodular identification (both biometric or biometric-card) is used, it is possible to define and/or rules. This will allow better parameterization of the identification system and reduce the rate of false rejections.

Observations on monozygotic twins have highlighted that most one-factor identification systems are not able to adequately handle nearly identical biometric features. In this regard, we recommend the development of detection resolution.

The present research will be continued in two separate directions. It will further investigate the biometric identification anomalies associated with monozygotic twins, and determine the basic system requirements that will help to select the optimal access control system.

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