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Solutions of Problems Related to COVID-19 Pandemic with Application of Selected Logistic Technologies

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Abstract: Covid-19 has brought about the development of the use of technological applications and initiatives to control the situation. The aim was to effectively monitor and eventually treat patients and facilitate the efforts of medical staff. This paper is the result of research into the possibilities of solving the problems caused by the Covid-19 pandemic by applying selected logistics technologies. The paper provides a new perspective on technologies and discusses possibilities for future research. The goal of the study is based on relevant existing research which examines in detail how five selected technologies can help in the fight against the pandemic. It defines the potential practical application of these technologies in the context of threats to public health. The main findings of this paper concern the application of logistics technologies considering these essential factors. The research characterizes the problems associated with using the proposed technologies, such as costs, time, legislative constraints, safety, and ethics. Proposals for the practical application of logistics technologies in solving pandemic-related problems must accept not only the legal framework but also the socio-ethical dilemmas that these technologies present.

Keywords: Covid-19 pandemic, logistics technologies, internet of things, drones, virtual reality

1. Introduction

Logistic technologies are relatively stable sets of information, handling, warehousing, transport, and other operations that guarantee the desired relation between logistic outputs and costs. However, many of these technologies can be used to solve a lot of problems related to the pandemic. As the coronavirus pandemic evolves, technological applications and initiatives are developed as well in the effort to stop the spread of the pandemic [1]. Technologies can directly or indirectly provide for

better information, make a model of crisis situations, monitor people in quarantine, or ensure maintaining social distance, all with an emphasis on promoting public health. Logistic technologies are usually closely related to automation and robotic automation in manufacturing, warehousing, or distribution [2,3]. Many of them have already become part of everyday production and distribution, such as automated guided vehicles (AGVs), virtual reality, drones, internet of things, etc. These technologies can be also used to monitor the evolution of a pandemic, enforce restrictive measures, distribute drugs, or monitor risky areas. Some other logistic technologies are still under development and are yet to be widely used in practice, e.g., artificial intelligence [4,5]. The tools of these technologies can considerably help with solving many problems related to the Covid-19 pandemic [6].

The paper presents an analysis of selected logistic technologies. The selection was based on relevant research [1,7-10], mainly those implemented by the European Parliamentary Research Service [8,9]. Based on this analysis and a comparison of advantages and disadvantages of the technologies, the paper presents proposals and possible applications for solving problems associated with the Covid-19 pandemic. From the perspective of health, it is crucial to reduce physical contact to a minimum during a pandemic, but it is also necessary to address public mobility [8,9]. As for the national economy, it is very important to maintain production and distribution on adequate level [9,10]. An integral part of designing applications for solving a specific problem is evaluation of possible application of technologies on the basis of set criteria. For this reason, the result of this proposal is a comprehensive overview of solutions to specific problems that can occur in a pandemic situation with the help of logistic technologies.

2. Analysis of Selected Logistic Technologies

Technologies suitable for addressing or eliminating the problems associated with the Covid-19 pandemic will be selected based on several relevant studies [8,9], one of them being the Gartner analysis (Gartner IT Symposium in Orlando), which lists the Top 10 Strategic Technology Trends for 2019 [8]. Another research study conducted by the Scientific Foresight Unit's 2020 for the European Parliament and the European Parliamentary Research Service (EPRS), entitled "Ten technologies to fight coronavirus", mentions the application of 10 technologies, which are partly different from the previous study [9].

Based on the above research studies [8] and [9], as well as other relevant sources [1,10,11], five technologies were selected, partly on the basis of relevant research. There were selected mainly those that correspond with the research area, i.e., those than can be applied in addressing Covid-19 pandemic problems.

The technologies to be analysed are listed below:

1. Internet of Things (IoT) [1,8].
2. Artificial intelligence (AI) [8,9].
3. Automated guided vehicles (AGV) [9,10].
4. Drones [11].
5. Virtual reality (VR) [10,11].

2.1 Internet of Things

Internet of Things represent a technology that connects individual devices (machines, objects) via the Internet without human involvement. The basis of the technology is collecting data from many locations, which is carried out through various sensors or transducers. The next step is to process and share the data via the Internet. The data is evaluated and then used for a specific purpose [12,13]. The Internet of Things finds application in all links of the logistics chain. In distribution, it involves processing and evaluation of volumes of data related to optimizing the delivery of goods.

In times of pandemics, the IoT helps to prevent the spread of a virus by reducing direct contact between downstream subsystems of the logistics chain, or even direct contact within a subsystem [14]. In the distribution subsystem, IoT enables distribution without the necessity of direct contact between supplier and customer. As an example, a parcel vending machine system can be mentioned, which enables non-stop distribution. Parcel vending machines are easily accessible, secure, and flexible [15].

In the context of a pandemic, IoT can passively ensure that all infected individuals are quarantined. The monitoring system ensures that all, but especially high-risk patients, are monitored via the Internet network. The monitoring tracks all important biometric measurements such as blood pressure, heart rate, and glucose levels [16]. Part of the problems that arise with IoT applications are the scope for cyber threats, data loss or theft, or inadvertent data sharing. From the above analysis of advantages, and disadvantages of IoT, it is evident that this technology has an important role in dealing with the problems related to a pandemic [10,16]. However, the technology is also applicable in logistics processes such as distribution, manufacturing, warehousing, transportation etc. [17].

2.2 Artificial Intelligence

Artificial intelligence is the ability of a device to exhibit human-like abilities such as learning, reasoning, planning, and creativity. AI enables technical systems to distinguish the environment in which they are operating and solve the problems they recognize [18]. A computer receives data prepared or collected by its sensors (e.g., cameras), processes it and responds to it to achieve a specific goal. Based on the collection of relevant data, AI systems can operate autonomously and adapt their behaviour to some extent on the basis of the analysis of previous actions [18,19]. The

goal of AI is not to replace humans, but only to increase their capabilities and usefulness in any environment. The main target areas of AI applications are shown in the following Figure 1.

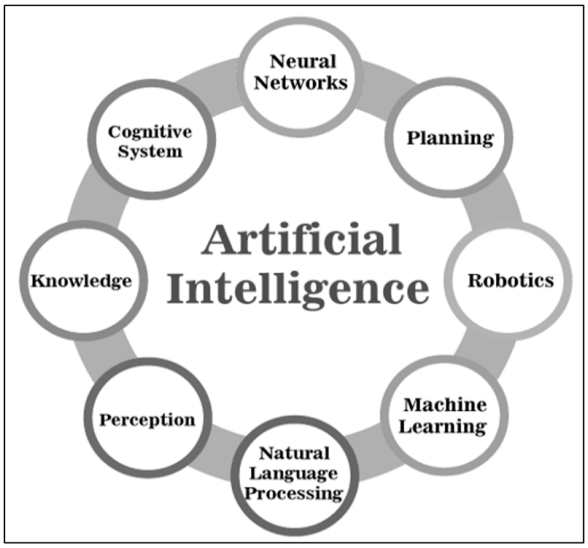


Fig. 1 Goals of Artificial Intelligence. Source: [19]

Artificial intelligence is used to transform logistics processes through the predictive analysis of big data, robotics, or autonomous vehicles. Another application of artificial intelligence in logistics is the analysis of vast amount of structured and unstructured data generated throughout the logistics process. Artificial intelligence has become an integral part of almost all logistics processes and is primarily used for forecasting and planning, warehousing, robotics and automation, operational efficiency of systems, and customer service [19,20]. The indisputable advantages of AI in combating pandemics include high speed decision making, cybersecurity, reliability, monitoring of endangered entities and objects, impartial intelligent decisions, and autonomy. Aspects such as high accuracy with a minimal error rate, the possibility to use a digital personal assistant (Mob, PC, etc.), online processes can also be crucial in problem solving. Partial disadvantages may be relatively high investment and operational costs and legislative barriers in the case of subject monitoring [21].

2.3 Automated Guided Vehicles

Automated guided vehicles are devices that do not need a human to drive them but are controlled automatically by a control and navigation system. They are mobile robots that can be used mainly for transport and handling operations such as intra-company transport, warehouse operations, loading operations, etc. It is advantageous for applications where frequent repetitive handling of material flows with higher frequency is required and for such processes where material flow monitoring is important. AGVs facilitate material handling and, by their independence, increase efficiency and reduce the cost of human operators in logistics processes [22]. The use of AGVs in

logistics has many advantages, such as eliminating human errors, more accurate work, higher efficiency, and reliability compared to humans [23].

In the context of dealing with pandemics, the following benefits of AGVs can be highlighted: reducing the need for human labour, reducing operating costs, increasing productivity and reliability, increasing safety at work, and reducing direct contact of workers to a minimum. In times of a pandemic, AGVs, their autonomy and application in automated processes in production and warehousing ensure the elimination of personal contacts and thus contribute to reducing the risk of transmission of the disease. Like other robots, AGVs do not require any "personnel care" and they can work in the event of operational workers being hospitalized, even in environments with an increased risk of infection. However, AGVs can also be used to distribute goods in the public sphere in addition to intra-company logistics. However, the vehicles must be equipped with AI features. By using object recognition together with a navigation system (usually GPS), the trucks can deliver parcels without the presence of a driver [24].

2.4 Drones

A drone is an unmanned aircraft or an unmanned aerial vehicle (UAV) with a variety of shapes, sizes, and features. It can fly autonomously based on pre-programmed flight plans, or with the use of more complex dynamic autonomous systems [25,26]. Autonomous drones' function like flying robots where a task is programmed and performed autonomously by the drone. Remotely controlled drones are manually operated by a human operator who sends commands to the drone via radio waves. Drones are usually equipped with a camera or other tracking and data collection system. In logistics, drones find applications in warehouse management (e.g., inventory), transportation (for shipment distribution), but also in manufacturing. In recent years, also due to the pandemics, the application of drones has expanded to a wide range of activities, from the disinfection of premises to monitoring private and public spaces to the delivery of food and medicine to quarantine areas. Advantages of using drones include ensuring the serviceability of hard-to-reach areas, ease of deployment, simple automation, high quality aerial imagery, accuracy, and safety. Disadvantages include limited payload capacity, undefined flight paths, or privacy-invasive misuse of drones [26,27].

In the context of preventing the spread of the Covid-19 pandemic or to protect the population and prevent possible danger, drones can be used for [28]:

- Humanitarian aid and disaster relief - locating victims, monitoring damage, preventing disasters.
- Disease control - monitoring locations, capturing, testing, and evaluating risk areas.
- Healthcare - rapid distribution of medical aid to hard-to-reach areas.

- Urban monitoring - collecting data on population mobility in densely populated areas.
- Food ordering and delivery - fast food delivery reduces physical effort and direct contact with customers, while making deliveries faster, more hygienic, and cheaper.

The use of drones during the Covid-19 pandemic facilitates the implementation of tasks and control of the regulations in the enforcement of the relevant measures [27,28]. Drones allow for minimal human physical intervention, reducing the likelihood of contracting the virus. It appears that the systematic deployment of drones for the purposes such as monitoring, reconnaissance, delivery, search, etc. can be crucial in managing the Covid-19 pandemic [26,27].

2.5 Virtual Reality

Virtual reality is a computer-generated environment with scenes and objects that simulate reality [28]. This environment can create a representation of the real world (e.g., when practicing combat, learning to pilot) or be very different from it (e.g., when playing games). Virtual reality has a wide range of applications. In addition to logistics processes, VR can be used, for example in healthcare, logistics, and other sectors. Virtual reality is divided into simple and immersive. Simple virtual reality is used, for example, in computer games, where the player observes the virtual environment on a monitor and interacts using a mouse and keyboard. The players see the virtual world and perceive the real world they are in. In immersive virtual reality, the users find themselves fully in the virtual environment thanks to the headset [28,29]. Users' movements interact with the movement in the virtual environment. The headset is supplemented with haptic gloves that can track pressure or create resistance and allow the users to grasp virtual objects as if they were real [29].

Augmented Reality (AR) combines real and virtual environments, where a virtual object is embedded in a real space. The headset allows users to scan an actual real space and insert a virtual element into the scanned space. Augmented reality can also be used for scientific and medical purposes where it helps to simulate various phenomena or surgical procedures. The main advantages of VR include cost and time savings, increased level of knowledge and information, as well as the ability to share real-time data over long distances [30].

During the Covid-19 pandemic, VR features could be effectively used to address or solve many of the problems currently occurring in healthcare. VR technology can provide useful information to healthcare personnel and improve the efficiency and accuracy of healthcare services during this pandemic [21,29]. Virtual reality has emerged as a current invention in the digital domain and is rapidly changing the traditional medical education methodologies and approaches to case management [29]. The concept of VR uses computer engineering and techniques to create a virtual work environment [30].

There are various important applications in the context of the COVID-19 pandemic [31]:

- physical therapy,
- pain management,
- mobile application for Covid-19,
- physical rehabilitation,
- treatment of psychological disorders,
- assistance in complex surgeries,
- training of healthcare professionals.

3. Research Outcome and Recommendations

The Faculty of Operation and Economics of Transport and Communications, University of Žilina, is currently (year 2023) implementing the second part of the research "Identification and possibilities of implementation of new technological measures in transport to achieve safe mobility during a pandemic caused by COVID-19". The research is co-funded by the European Regional Development Fund and one of its goals is to propose innovative technological measures and safe mobility with the support of automation. The application of selected logistics technologies to address the problems related to the Covid-19 pandemic is part of one of the research areas.

Logistics technologies can play an important role in the fight against the Covid-19 pandemic. However, it shall be noted that the outcome of the action must be consistent with values such as transparency, accountability, interpretability, auditability and traceability, and neutrality or fairness. In the absence of EU legislation on the deployment of certain technologies (drones, AI) or their components (automation, robotics), particular attention must be paid to the need to establish a system for ethical management of these technologies [32-34]. The wider application of some technologies is hampered by general data protection.

It follows from this research that the application of logistics technologies in times of a pandemic is essential. Appropriate logistics technologies can solve a significant part of the problem areas related to the Covid-19 pandemic. It shall also be noted that logistics technologies can largely increase efficiency when appropriately combined [10,11]. For example, combining artificial intelligence with drones or AGVs appears to be highly effective. When implementing these selected technologies to solve a specific problem, the basis should be a thorough analysis of the problem area, followed by a design of an appropriate technology or combination of technologies, and finally evaluation of the effects of this implementation.

The technologies contribute to increased performance, efficiency, and automation of processes [14,16]. The evaluation of some of the selected criteria are presented in Table 1 below.

Table 1 Evaluation of logistic technologies. Sources: authors

Technology Criterium	Cost reduction	Shortening time	Increase security	Legislative issues	Application to subject/object
Internet of Things	N	N	N	Y	S
Artificial intelligence	N	N	N	N	S / O
Automated guided vehicles	Y	Y	Y	N	S
Drones	Y	Y	N	Y	S / O
Virtual reality	Y	Y	N	N	O
Y - Yes, N - No, S - Subject, O - Object					

Proposed criteria:

Cost reduction – the introduction of any technology entails investment and operating costs. Each criterion was evaluated in relation to the reduction in process-related logistics costs in the short term.

Shortening time – this was evaluated in relation to the demonstrable reduction in overall process time.

Increase security – issues related to data protection and data leakage or misuse.

Legislative issues – legislative issues related to a wider deployment of the technology or its application in specific cases.

Application to subject/object – evaluation of the application (impact) of the technology on the subject and object.

The research outputs presented in the paper are based on the first part of the project conducted within the Operational Programme Integrated Infrastructure mentioned in the acknowledgments and serve as the subject of the implementation of the second part of the project focused on safe mobility during the pandemic caused by Covid-19.

All of the logistic technologies analysed can be used to address the problems associated with the Covid-19 pandemic. However, each technology has different benefits for application in this area [10-12,15,33,34]. The areas that each technology can focus on during the pandemic are summarized below:

- Internet of Things - Tracking of persons in quarantine, monitoring of persons, biometric measurements of basic functions of infected persons.
- Artificial Intelligence - Thermal imaging of people in public places, identification of people at risk, tracking the movement of people, predicting the spread of disease, regulation of misinformation on social networks.
- Automated Guided Vehicles - Elimination of personal contacts, working in a risky environment, monitoring of kissing contacts [34].

- Drones - Humanitarian aid, monitoring sites, locating people, assessing risk areas, distributing medical aid, delivering food, monitoring population movements.
- Virtual Reality - Solving health problems and healthcare issues such as pain management, therapy, rehabilitation, assistance in complex surgeries.

Although many of the accepted measures that control the use of certain logistics technologies (e.g., drones, AI, etc.) are based on emergency powers to be used only temporarily in emergencies Special rules should be introduced that could be used only temporarily in emergencies so that full protection of personal data is ensure once the emergency is lifted [33,34]. These five logistics technologies have been selected and can address pandemic-related issues under certain conditions. Each of these technologies can be used in specific areas to solve problems related to the Covid-19 pandemic.

4. Conclusion

With the spread of the Covid-19 pandemic, the number of technological applications and initiatives is increasing in the effort to control situation and stop the spread of the pandemic. The analysis presented in the paper takes an in-depth look at how five selected logistic technologies can help to fight the pandemic. It also highlights important legal aspects and key socio-ethical dilemmas that represent different ways of use of these technologies when applied in the context of threats to public health. Logistics technologies have recently become extremely desirable due to their contribution to the implementation in logistics processes. The paper presents the possible use of logistics technologies during the Covid-19 pandemic. Five logistics technologies have been selected that can solve pandemic problems under specific conditions.

Technology cannot replace or make up for other public policy measures, but it does have an increasingly important role in emergency response. Based on the analysis of individual technologies and their advantages and disadvantages, various uses have been proposed that can solve specific problems to some extent, not only in logistics chains, but also in crisis situations which pandemic undoubtedly is. With the spread of the coronavirus pandemic, technological applications and initiatives are proliferating to manage the situation, effectively treat patients, and facilitate the efforts of health professionals. Logistics technologies cannot replace medical and political measures, but they play an important role in emergency situations such as the Covid-19 pandemic. Paradoxically, this epidemic presents an excellent opportunity for policy and regulation makers to reflect on the current legislation, the ethical soundness, and the effectiveness of the deployment of logistics technologies in times of crisis.

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