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Legal analysis of implementation of the traffic accident monitoring system

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ABSTRACT

Purpose. The study aims to establish positive changes after the introduction of traffic accident monitoring systems implemented by government agencies in China, India, Germany, the United States, the United Kingdom, Finland, Beijing and Sweden. Methods. The research was carried out in stages, based on the logical presentation of the material. The following methods were implemented in the study: direct observation, comparison and analysis of the content and the form of advanced traffic accident monitoring systems. Results. The study of international best practices and experiments about the implementation of various options for traffic accident monitoring systems gave preference to an intelligent system. A study conducted in the United States, India and Portugal shows the effectiveness of different approaches to use mobile applications on smartphones to transmit reliable information to the traffic accident registration system. Accident data collection should be standardized and structured, and police officers should benefit from the statistical reports they complete for each traffic accident.

KEYWORDS: Education; transport policy; justice; dignity; responsibility; schoolchildren.

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Análisis legal de la implementación del sistema de monitoreo de accidentes de tránsito

RESUMEN

Propósito. El estudio tiene como objetivo establecer cambios positivos después de la introducción de sistemas de monitoreo de accidentes de tránsito implementados por agencias gubernamentales en China, India, Alemania, Estados Unidos, Reino Unido, Finlandia y Suecia. Métodos. La investigación se llevó a cabo por etapas, en base a la presentación lógica del material. En el estudio se implementaron los siguientes métodos: observación directa, comparación y análisis del contenido y la forma de los sistemas avanzados de seguimiento de accidentes de tráfico. Resultados. El estudio de las mejores prácticas y experimentos internacionales sobre la implementación de varias opciones para los sistemas de monitoreo de accidentes de tránsito dio preferencia a un sistema inteligente. Un estudio realizado en Estados Unidos, India y Portugal muestra la efectividad de diferentes enfoques para usar aplicaciones móviles en teléfonos inteligentes para transmitir información confiable al sistema de registro de accidentes de tránsito. La obtención de datos sobre accidentes debe estar estandarizada y estructurada, y los agentes de policía deben beneficiarse de los informes estadísticos que completan para cada accidente de tráfico.

PALABRAS CLAVE: educación; política de transporte; justicia; dignidad; responsabilidad; escolares.

Introduction

Every year, almost 1.3 million people in the world die as a result of road accidents, and another several million are injured or disabled. At the same time, most road accidents (90 percent) occur in low- and middle-income countries (Kitamura et al., 2018). The fact that the death rate in high-income countries decreased between 2000 and 2015, but increased in low-income countries, indicates the seriousness of transport problems in developing countries. If government action is not taken, the number of people injured in road accidents in most parts of the world will increase exponentially over the next two decades.

The fact that the death rate in high-income countries decreased between 2000 and 2015, but increased in low-income countries, indicates the seriousness of transport problems in developing countries (World Health Organization, 2009). If governments take no action, the number of people injured in road accidents in most parts of the world will increase exponentially over the next two decades (Government of Nepal, 2015).

In 2004, the World Health Organization and the World Bank identified the importance of collecting accurate and reliable data that determine the extent and problems of road accidents. In particular, the need to create data systems to collect information on the state of traffic on the roads and implement them primarily in countries with a large number of accidents was emphasized. Based on the accumulated data on the monitoring of accidents, it is proposed to implement appropriate road safety practices for.

An automated monitoring system is created to mitigate the consequences and reduce the number of accidents. Such a system can be useful for the timely provision of emergency care, which can increase the chances of immediate treatment to save the victims of a road accident.

The introduction of the road accident monitoring system is urgent at the national level as well, it corresponds to the 2024 State Strategy for Improving Road Safety (Cabinet of Ministers of Ukraine, 2020). According to the statistics of the National Police for 2019 and 2020, there were approximately 450 accidents on the roads every day (Patrol police, 2021). In this regard, by 2023 it is planned to introduce and improve the analytical system of registration and analysis of accident data based on the European Common Accident Data Sets (CADAs) (Ministry of Infrastructure of Ukraine, 2020).

The correct scientific approach to the registration of accidents and their analysis is important for the implementation of effective countermeasures for road safety. Information about the accident location is important for engineering improvements to road infrastructure. Accident monitoring reports can provide the information not only about the total number of accidents, but what accidents, where and when they occur, objective circumstances about the condition and cause of people's behaviour in a particular place and on all roads, their injuries and deaths. Besides, road accident data can help develop generalized road safety theories (Abdulhafedh, 2017).

Data collection at the accident scene is crucial (Wach, 2013), because the subsequent stages of the accident rely on these data: investigation (reproduction of the circumstances of the event), insurance, compensation for material damage and other legal aspects (Padua et al., 2020). In the event of an accident, the driver is obliged to stop (Cabinet of Ministers of Ukraine, 2001) and provide his/her data (or information identifying the vehicle) to another driver who is involved in an accident to compensate for material damage (Legal Services

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Commission, 2021). However, irresponsible drivers do not always do as required by law and leave the scene arbitrarily.

Therefore, further research on the implementation of road accident monitoring systems is necessary and relevant to take into account and reduce the factors and consequences arising from road accidents.

The aim of this study is to conduct a legal analysis of international experience and the results of the introduction of road accident registration and monitoring systems in China, India, Germany, USA, UK, Finland, Beijing, and Sweden.

The aim of the study involves a number of objectives that will help to understand the features and difficulties that exist in the implementation of road accident registration systems, in particular: study the international practice and best practices on technical and legal significance of road accident monitoring system; identify problems that arise during the interpretation and use of data accumulated in the database of the accident monitoring system; try to develop a functional diagram of a modern accident monitoring system; outline the advantages and disadvantages of different types of accident monitoring systems.

1. Literature review

At the national level, the Centre for Road Safety and Automated Systems at the Ministry of Internal Affairs (2008) analyses the causes and state of road accidents in the country based on statistics or accident databases, monitors and proposes measures to control the road traffic situation, prevent accidents and mitigate the severity of their consequences. The results of studying such statistics of Ukraine allow identifying the shortcomings that exist in road traffic conditions. By studying the causes of road accidents, it is possible to identify dangerous areas of their location and reasonably develop a strategy to eliminate such shortcomings (Oznyuk, et al., 2019).

In 2018, India ranked 1st in the number of fatalities in road accidents among 199 countries, which is 11 deaths per million people, that is less than in Iran (20), the Russian Federation (14) and the United States (12) (Ministry of Road Transport and Highways of India, 2018). A study conducted in India showed that the country's rating is the worst in the world, each year about 150 thousand people die as a result of road accidents, and 80% of victims of accidents in India do not receive timely emergency care. In this regard, it is

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proposed to introduce a smart accident registration system. However, the peculiarity of this system is that it consists of a database and a module that is installed on the car. Such a module includes GPS, GSM transmitters and an impact sensor that can be activated during an impact, vibration or the airbag deployment. Bluetooth technology is used to activate the module. In the event of an accident, the information contained in this module (full name of the driver, blood type, telephone number, e-mail, medical history, date of birth) is automatically sent to the appropriate telephone number and downloaded to the database of the main monitoring system (Sharma et al., 2020). In this case, the experimental work and suggestions of experts were taken into account in this system in terms of troubleshooting. It has been found that the proposed system will work well in a variety of situations. The detection hardware can detect an accident and a collision and accurately send a message to the rescue service with the help of three sensors and a software application (Parmar et al., 2019). With the development of wireless technologies in their mobile applications, motor transport is being transformed into smart vehicles that can be accessed through intelligent traffic applications (Rath, 2018). Another group of Indian researchers proposed an algorithm for registering accidents only for cases in which there are any victims (Sharma & Shoney, 2019).

Research conducted in Beijing is worth mentioning. The spatial analysis of road accident data based on the WaveCluster system showed that the entire road accident area in Beijing is divided into 5 categories: hotspot space (high traffic area), space with different quality of drivers or intersection of urban and rural roads, and information system about vehicles. It has been found that accidents usually change in stages as they are dealt with. However, the adoption of laws and establishment of mechanisms for accidents can improve the ability to anticipate new cases (Zhang & Shi, 2019).

Modelling the number of road accident data is of particular importance for road safety analysis, and over the past few decades a significant number of tools have been proposed for the analysis of road accident data (Abdulhafedh, 2016), but the choice of the necessary monitoring system depends on the specifics and financial capabilities of the country.

The CADaS system is considered as a recommendation for the collection of road accident data for the police of the EU countries in a common database. The list of variables for CADaS should be comprehensive and concise, and the level of their detail is chosen by

each EU country. The list of CADaS variables is divided into four main categories: A — for accident-related variables, R — for the road-related variables, U — for variables related to the traffic unit, P — for variables related to a person (for example, A-2 Date of the accident) (Petros Evgenikos National Technical University of Athens, 2009).

2. Methods

The research involved the following methods: direct observation helped established the opinion of modern scientists and researchers on the implementation of accident monitoring systems; the method of comparison was used to identify the difficulties faced by public authorities of different countries during the implementation of the accident monitoring system; the main international trends and advanced technical experience on this issue were identified using the content analysis.

So, the main sources of input data generation are established, which are transmitted to the accident monitoring system, and the main parameters of accident data in all types of road accidents are outlined through the direct observation.

The method of comparison helped reveal common trends among developing countries (Ukraine, India, China) and developed countries (USA, Germany, UK) in the use of devices and software to transmit statistics and receive them from the accident monitoring system.

The experience of the implementation of the accident monitoring systems in Europe and the world was studied: RADMS (in India), WaveCluster (in Beijing), CADaS (for European countries), TARS (in the UK), NASS (in the US), STRADA in Finland and Sweden), CrashMape (in Germany), CVIS (in China).

A total of 50 sources and references were used: statistical reports on the state of road accidents.

3. Results

Since 1979, the United States has implemented a National Automotive Sampling System (NASS) for collecting data about road accidents which occurred during the year. NASS provides an effective and useful resource to collect data necessary for society. Over the past 10 years, the basic set of NASS components on road accidents has created a reliable resource for a number of departments and agencies. Personal information about individuals, names, addresses, driver's licenses, vehicle registration certificate and even specific places of the

accident are not contained in publicly available NASS files. The NASS consists of two parts: the Crashworthiness Data System (CDS) and the General Estimates System (GES). Both systems collect information from police accident reports in randomly selected regions of the country (National Highway Traffic Safety Administration, 2020). One of the disadvantages of NASS-GES data is that they use an aggregate data element that provides overall national estimates that may differ from true values at the state level because they are based on the probable choice of accident in the country and cannot provide accurate estimates at the state level, which reduces the reliability of the data. Another disadvantage is that NASS-GES data is obtained either directly from the police accident report (PAR), or by interpreting the information presented in the PAR, by viewing the accident diagram or a combination of data elements in the PAR (National Highway Traffic Safety Administration, 2021).

An empirical study conducted in the United States shows the effectiveness of different approaches to the use of mobile applications on smartphones to transmit reliable information to the accident registration system. So, built-in accident reporting systems are not available in all vehicles, and they are expensive to upgrade for older vehicles. Alternatively, smartphones can automatically detect accidents using accelerometers and acoustic data, immediately notify the central emergency server after an accident, and provide situational awareness through photos, GPS coordinates, VOIP communication channels, etc. (White et al., 2011). The results of the experiments show that the microphones in smartphones are not able to distinguish sounds such as screaming from the airbag deployment (White et al., 2011). Therefore, the use of various sensors can help in more accurate detection of accidents (Bhatti et al., 2019).

In the UK, the TARS system is used to assist in the management, review, analysis and display of accident information. Anyone can request TARS for information about the accident and, using the TARS2 software, see the accident sites on the map, as well as a detailed report on accidents. The information obtained from TARS is useful for policy development, monitoring and evaluation of road safety efforts in the country (CDR Group, 2020).

The Indian state of Himachal Pradesh has launched its first Road Accident Data Management System (RADMS) for data management, analysis and evaluation. This system was developed by a research laboratory in the UK. RADMS optimizes and centralizes

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accident data management, making it easier to detect and take action to reduce the number and severity of accidents (ITS International, 2021). In Greece, a web geographic information system (webGIS) has been introduced since 2004 to register, store, visualize and analyse road accidents (Vaitis et al., 2019).

The German Statistics Office has also solved the problem of accident registration using a web application, which is public and shows only accidents in which people were injured and the police arrived on call. Assessment of the condition of the motor road for the absence of accidents is calculated by the number of accidents on one section of the road. It is planned that the map will have information on accident statistics from all 16 federal states of Germany, not from 9 as it is currently the case, as not all states register geographical data on accidents (European Transport Safety Council, 2018). In the Czech Republic, there is a website created in collaboration with the Transport Research Centre and the police. The CrashMape map shows accidents from 2007 to date and is updated monthly. Compared to England and Germany, it has the widest filtering of accidents by identification number or criteria. Criteria that have not been indicated in previous versions are: blood alcohol content, substance use, visibility during the accident, the cause of the accident, information about the road (highway) and many others (Kmet & Kvet, 2021).

A group of German researchers also proposed a different and inexpensive accident monitoring system. This system uses a multi-level IoT-based automotive environment through V2X and Edge/Cloud Computing. A video camera is built into the vehicle for reliable detection of accidents together with the GPS module. As soon as an accident occurs, the vehicle sends a notification to the receiving device. The receiving device, in turn, finds the nearest hospital and immediately makes a request to send an ambulance to the scene of the accident. A dynamic interface visualization, which is hosted on the server, is also proposed in order to assist the relevant authorities in conducting a full analysis of the road accident. The generated charts help the police officers to make the corresponding legal decisions on their basis. Besides, when an accident occurs and the accident monitoring system registers it, it can ensure that relevant data is passed to rescuers and doctors, which can improve the likelihood of survivors. Accumulated accident data is sent to a central database for long-term storage. These data can later be obtained for analysis. Data stored in the cloud can allow

relevant authorities to develop policies and take effective measures to reduce the number of injuries and deaths caused by road accidents (Abdul Khali et al., 2019).

A smartphone that contains inertial sensors can be used as an additional data source to better understand the events of the accident. These are the results of a study using sensors in smartphones to detect the acceleration of the torso associated with the risk of falling in the elderly who have suffered a stroke (Isho et al., 2015).

The comparative analysis of accident statistics in the system of Finland and Sweden (STRADA, Swedish Traffic Accident Data Acquisition) for 2009-2013 is also noteworthy. A study of the causes of fatal accidents has shown that the use of detailed data provides more opportunities for analysis than computer programmes on accidents across Europe (Peltola & Luoma, 2017).

That is, the main parameters of all types of accidents can be reduced to the following categories (Table 1).

Table 1. The main parameters of all types of accidents (author's development).

General information	Date, week, hour, working day or day off, etc.
Accident location	Street number, intersection number, geographical (GPS) coordinate, number of kilometres from the settlement, name of the district, etc.
Participants in the accident	Age, sex, type of road user, signs of alcohol consumption, use of seat belts, placement of passengers inside the car, category of driver's license, date of issue, driver's medical data, etc.
Details of injuries	Volume, number of injured, data on injured, ambulances and evacuations, etc.
Traffic conditions at the time of the accident	Road type, road category, weather conditions, lighting conditions, type and condition of the road surface, availability of means of control and video recording of traffic, etc.
Vehicle	Vehicle type, age of the vehicle, etc.
Information about the mechanism of the accident	Accident type, type of manoeuvre, causes, etc.

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Video surveillance systems that receive data through video mining can provide additional information about the causes of accidents. In this way, it is possible to better understand which sections and infrastructure of the road are dangerous or those that cause accidents (Battiato et al., 2018). At the same time, it is proved that the use of unmanned aerial vehicles (hereinafter — UAVs) as a video surveillance camera for traffic condition provides accuracy of 80%, and the use of stationary video cameras for traffic control has 50-75% accuracy. Besides, UAVs combine the capabilities of both stationary and mobile traffic detectors (Shan et al., 2021). With good visibility from above (without clouds, high-voltage cables and good lighting), UAVs provide the ability to collect more data, with greater accuracy and speed in relation to traditional approaches to recording/registering accidents. Therefore, in real conditions, a group of Portuguese researchers proposed to use a full set of tools to obtain data on the accident. In particular, they include: UAVs, terrestrial video cameras, tacheometers, artificial lighting units and photogrammetry, measuring tape, receivers of the Global Navigation Satellite System (GNSS).

However, CVIS methods were the most effective in collecting data on road accidents. The CVIS system is not cheap, it consists of a set of intelligent devices of road infrastructure, which showed the shortest time of detection of a car accident, namely, 0.0461 seconds with a probability of 90.02%. The accident detection model is based on the use of a deep neural network (YOLO-CA) based on a set of auto image data (CAD-CVIS) and self-learning algorithms (Tian et al., 2021). Given the high cost of intelligent road devices, it is proposed to use them on the most dangerous intersections of smart streets of the city (Iqbal and Khan, 2018). Taking into account the above, the author proposes to use the following functional diagram of a smart accident monitoring system for analysis (Figure 1).

At the same time, the collection of data on road accidents should be standardized and structured in practice. For completeness and objectivity, the procedure for obtaining data on an accident should be synchronized with the process of its investigation, reconstruction and simulation of the circumstances of the events. It is advisable to fully computerize and automate the data accumulation procedure in the monitoring system. It is also proposed to conduct a survey of victims about their health in 1 month. In turn, police officers who receive primary accident data should benefit from reporting work (European Commission, 2019).

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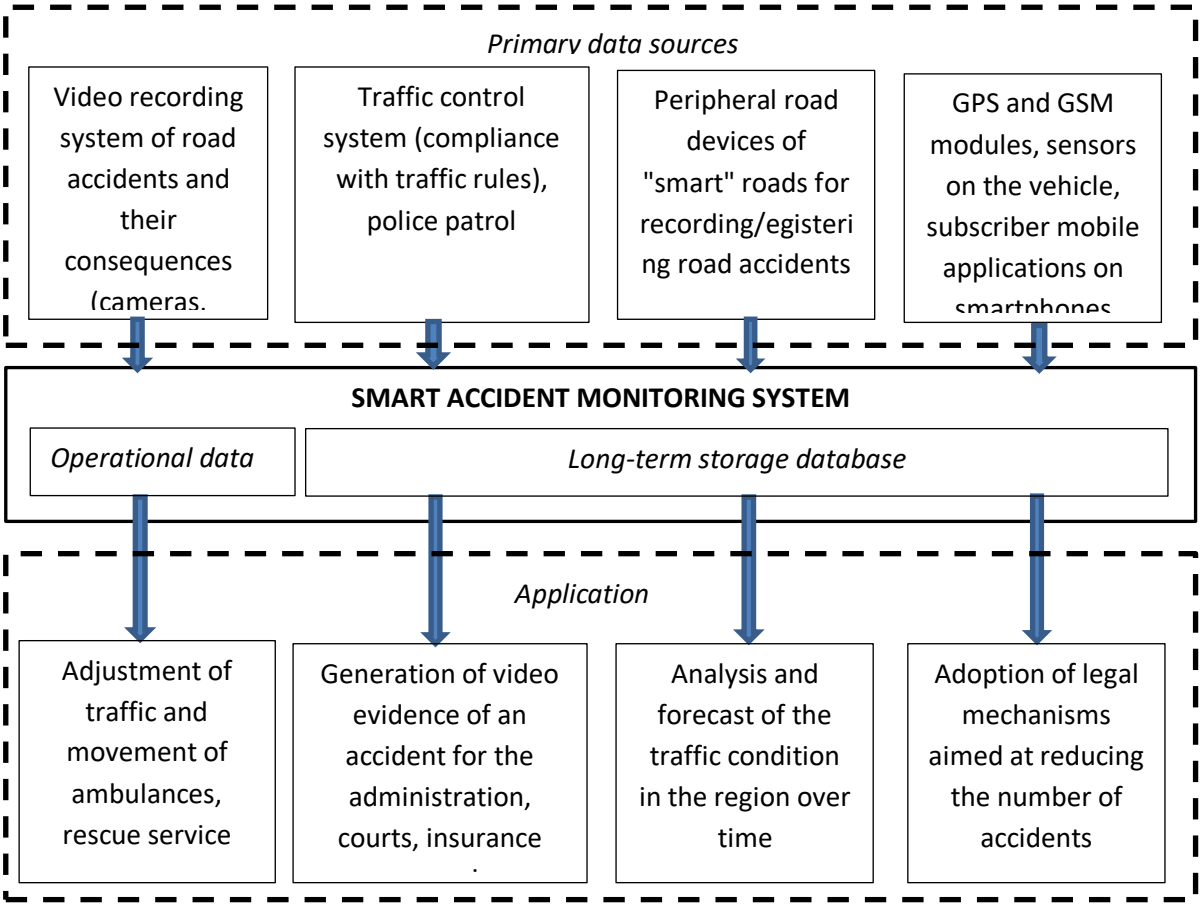

Figure 1. Functional diagram of a smart accident monitoring system (author's development).

Road safety analysis, based only on registered accidents, often suffers from underestimation of data, which can lead to biased conclusions and an ineffective accident prevention strategy. An additional method of obtaining information about the accident is to send accident reports yourself. The combination of the two methods can provide a more accurate idea of how safe a driving should be (Kamaluddin et al., 2018). Common problems in the use of consolidated statistics obtained from the database of accident monitoring systems are given in Table 2.

4. Discussion

An overview of the current situation and practice in Abu Dhabi, as well as in the Kingdom of Bahrain, UAE, UK, Sweden, Australia, New Zealand, USA contains other information that is worth noting. With the exception of the Persian Gulf, most countries require only the presence of the police when injuries or serious material damage are caused

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at the scene of an accident, whereas all accidents in the Persian Gulf must be reported to the police.

Table 2. The main problems in the use of consolidated statistics obtained from the accident monitoring system (author's development).

Excessive or insufficient variance	When the data is excessively scattered (excessive variance), the estimation of the accident model may lead to a bias in the estimation of the parameters. As a result, there will be incorrect conclusions about the factors that determine the frequency of accidents. When there is a lack of data (insufficient variance), the accident forecast will be incorrect.
Small sample size	Given the fact that the process of collecting data and collecting a sample of accidents can be financially costly, the calculation and forecast of accidents is often not comprehensive and incomplete.
Changing the time interval	The period for collecting data on accidents is usually one, three and five years. Instability of the time interval can lead to incorrect estimation of parameters and forecast of road accidents. The accuracy of the forecast directly depends on the duration of the time interval: the longer the time interval of the obtained sample, the more accurate the forecast.
Temporal and spatial dependences	Roadway objects may be mistakenly taken into account several times in a few years or not taken into account at all because they were near the scene of the accident.
Skipping variables in the forecast	Modelling of accident forecasts according to the methodology with insufficient number of variables can lead to simplification of models and incorrect conclusions.
Not complete reporting	Because of minor accidents, police reporting is incomplete.

One of the priority areas for reducing the number and severity of accidents is to improve road infrastructure. To this end, it is necessary to improve the organization of road traffic and develop measures to improve road safety. Statistics on accidents should be used to eliminate the shortcomings of traffic condition. Therefore, the introduction of a modern and intelligent system of accounting and monitoring of accidents remains more relevant than ever.

The smart monitoring technology includes the processing of streaming data (photos, videos, telemetry data, user information), data mining, machine learning, processing and forecasting, and the implementation of existing traffic models in practice. At the same time,

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a comparison of time characteristics showed that changes in traffic conditions and the concentration of accidents in controlled areas are highly dependent on weather conditions (Finogeev et al., 2018).

Given the constant growth of the number of road vehicles owned by citizens, the existing system is difficult to ensure road safety for all its participants. Therefore, a long-term strategy to improve road safety must be implemented (Gurzhiy, 2012). One of the directions of such a strategy should be traffic optimization. The proposition of alternative routes to avoid accidents significantly increases the overall efficiency of traffic. However, the main problem is how to do it in the shortest time and with the least financial cost (Souza et al., 2017).

Monitoring of traffic violations significantly affects the drivers' behaviour in the control area. Monitoring traffic violations can effectively reduce the likelihood of accidents. Therefore, monitoring of traffic violations has a positive effect on road safety (Zhu et al., 2012). In order to maintain order on the roads and reduce the number of accidents on high-risk roads (for example, on school and main road sections), it is advisable to install traffic violation monitoring systems (Pan et al., 2020).

Besides, the ability to use artificial intelligence to analyse and provide information about the situation in the event of a road accident significantly increases the efficiency of road accident response operations. The analysis and reporting module should be further improved to adjust the information and images obtained from other possible sources about the accident site and to create one final agreed report (El Barachia et al., 2020). When analysing statistical data from the database of accident monitoring systems, it is necessary to take into account the problems in their use.

Conclusion

The introduction of accident monitoring systems is an urgent need for middle- and low-income countries. The best option is a smart monitoring system with a focus on smart city, smart street and so on. Such a system can increase the chances of the necessary treatment of persons injured in an accident, to adjust traffic. Besides, data from the long-term storage database can be used to generate video evidence of an accident for the administration, courts, insurance companies, analysis and forecast of accidents on a particular section of road and the adoption of legal mechanisms to reduce the number of accidents.

There is no doubt that a promising area for the development of monitoring systems are systems based on artificial intelligence with the possibility of machine learning.

Experiments conducted in India, Germany, USA, Sweden, Finland, Portugal and China have shown high efficiency from the use of databases of long-term and operational storage of accident data based on data obtained from various sources: GPS and GSM modules, sensors on the vehicle, mobile subscriber applications on smartphones, UAVs, radars, photo and video recording systems. The most effective accident data collection system was CVIS (proposed in China), which consists of a set of smart road infrastructure devices.

Based on the results of evaluation and analysis of statistical data, it is logically correct to implement an adequate policy and strategy to reduce the number of accidents and mitigate their consequences.

Although the CADaS system is part of the 2024 State Strategy for Improving Road Safety, CADaS is seen only as a recommendation to collect accident data for the police of the European Union into a common database. Therefore, taking into account international best practices on this issue will not be superfluous. However, the question of time and financial costs for the implementation of a smart accident monitoring system arises in such a case.

It will be useful to further study the features of the introduction of a smart monitoring system for road accidents into the legislation of Ukraine.

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