UTILIZATION OF SCIENTIFIC METHODS TO IMPROVE URBAN SAFETY

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Abstract. There are more than 6,000 municipalities in the Czech Republic, where concept of the municipality is understood as a territorial self-government unit.

Thanks to operation possibilities of the local government, it is possible to solve the local problems in these municipalities, including example: construction of various public spaces, transportation, security, etc. This solution is often better than would be in the case with the central management. However, this management has its limits associated with the budget parameters of the given municipalities and it is very closely related to the political struggle in the given locality. It is very common for the people who have no experience with the management of public spaces and finances to be elected to the new positions of representatives and mayors. This state of affairs may also lead to erroneous decisions that may have a long-term negative impact on the citizens of the given municipalities, in view of their efforts to identify against previous political competition.

The article makes extensive research into the application of scientific methods, approaches, experiments and their validation that can be used in the context of urban safety. The focus of these methods will be concentrated mainly on the municipalities (around 10,000 inhabitants). Applied methods will also be discussed with view of limited resources (budget, personnel, territorial, etc.). Part of the research article will be examples of good practice that have been used primarily in foreign countries. There will also be a discussion on the implementation and impact of these examples of good practice in cities in the Czech Republic. Implementation will be discussed in two examples of specific cities (Milevsko, Chotěboř) with regard to their budget constraints, state of roads and sidewalks and many other parameters. The aim of the article is to get a basic overview of possible ways of solving local problems with a view to maximizing the benefit for the citizen. The study was developed as part of the research project TL02000559 and will be followed by further research with application potential.

1. Introduction

Security can be understood from many points of view. The most basic view is the safety associated with human survival, or with the ensuring of basic living needs. Another point of view can be devoted to secure a property, or even in some sense we can talk about security in connection with investments. The investments can be safe (almost certain) or, conversely, high-risk. In all security categories, there are methods and systems that can increase the security or, at least, try to quantify it in some way. If we look at the safety with the point of view of self-government city, We will probably be concerned with the safety of human lives and the security associated with protecting property.

The ensuring of basic living needs is realized by infrastructures, which are gradually expanding and becoming more important with the development of humanity [1]. At the same time, these infrastructures are becoming progressively more interconnected, thanks to the information infrastructure [2]. Important infrastructures that ensure the basic living needs are called critical infrastructures [3]. These infrastructures must face a number of threats (like congestion, the environment, terrorism etc.) and therefore they are increasingly given attention. This leads to analyses of the risks associated with the downtime of these infrastructures [4].

The infrastructures can be physically, cybernetically, geographically and logically dependent on each other [5]. A number of publications are devoted to analyzing the risks associated with interdependence [6, 7]. The infrastructures must also evolve in today's world so they are not a static system. Yusta et al. [8] takes into account the dynamics of the development of this system in risk analysis. Murray a Grubesic [9] deal with the protection based on the worst possible scenario. This way may not be optimal, with regard to the operation of the entire infrastructure.

The safety of the inhabitant is influenced not only by the key infrastructure, but also by its interaction with the environment. In a number of interactions, the individual does not get into situations that could endanger his life. But in many cases, it is the other way around. First of all it is about transportation, which is used by most of the population every day. In this case, it can occur relatively easily to situations threatening human life. Other interactions are situations, where the common inhabitant meets a criminal offense.

2. Transport and safety

This issue is addressed in the study by the authors Pucher and Dijkstra [10], who examine how to improve the public health and safety of pedestrians and cyclists in American cities, according to successful policies in Germany and the Netherlands. Very important for cities is to improve conditions and reduce injuries or death of pedestrians and cyclists, thereby strengthening the fight against dangerous overweight of the citizens and achieving movement and overall healthier style in the everyday life of a person. In Germany and the Netherlands, the infrastructure used by pedestrians and cyclists has been strengthened. This includes wide and well-lit sidewalk on both road sides, clearly marked and raised pedestrian crossings with special lighting for good visibility. Cycling Transport has a real coordinated network that covers urban and rural areas. In addition, special bicycle lanes are built for bicycles leading directly to intersections that have bicycle traffic signals and separate driving signs.

The Most important impact was the reduction in the speed of motor vehicles in residential areas, which resulted in a reduction of the collision between the pedestrian or the cyclist with a vehicle. That ensured the greater likelihood of survival. City structures are also oriented so that the cyclists and pedestrians can easily and without problems get where they need to. Residential and commercial buildings have sidewalks and cycle paths, it also includes safe crossing over the transport ways like railway crossing or in case of highways a bridges only for pedestrian and cyclists. The next point of the study is the transport education, which must be passed not only by vehicle drivers, but it already started with children from 10 years of age. They learn traffic regulations, the right behavior for safe walking, cycling and anticipating dangerous situations, and how to react properly on it. Last but not least, it is about traffic regulations and penalties that benefit the cyclists and pedestrians, mainly in the Netherlands and Germany. In a traffic accident that is caused by the cyclist or pedestrian motorists are always partly guilty. In case of the accidents involving children or the elderly are totally guilty of the motorist who has to predict the dangerous behavior of the pedestrians or cyclists. The conclusion is that American cities should be more focused on strengthening the safety conditions for pedestrians and cycling. Further build an attractive non-motorised transport network and thus more entice and attract its citizens to greater movement and healthier lifestyles

The authors Vasilev, Pritchard and Jonsson [11] conducted research to test the lane for cyclists and changes in user behavior. The Project was implemented in Trondheim, Norway, and was aimed at encouraging the population to use publicly available and more mobility-active modes of transport. On the basis of the research, the number of lanes in this area has been reduced from four to two a two-way cycle path has been introduced. Research has shown that user behavior has changed significantly and has contributed to a reduction in motorized traffic to improve cycling conditions, which has led to greater interest in pedestrian and cycling.

Bicycle transport is used by more and more children and adults, and so the authors Zeuwts et al. [12] focused on the perception of dangers from the perspective of young and adult cyclists. The research depended on comparing visual search patterns and reaction times using a perception test for cyclists. The test is based on recorded video clips, where each contains a dangerous traffic situation that needs to be responded to. According to the results, it has been found that childhood perception has a delayed reaction time than an adult, which may be the cause of the immature visual system and the experience of a child. Therefore, a tailored educational program for children and young cyclists could help to improve the perception and understanding of road hazards.

In the study of the authors Anagnostopoulos et al. [13] regard of the safety of cyclists at crossroads, where the cyclists like to break the rules and often pass red, endangering not only themselves, but also drivers of motor vehicles, is represented the mechanisms by which traffic lights are able to perceive and react to cyclists. The Aim of the research is to give priority to cyclists in front of the automobile transport, thereby reducing the accidents caused by cyclists when crossing the red signal on traffic lights. According to the speed of the cyclist approaching the intersection and using the app on the smartphone, which sends a signal to the traffic light, in order to calculate the time of arrival of the cyclist, he could turn green. Cyclists would be the first to drive without waiting, and there would be no collision with the motor vehicle, and this would encourage people to use cycling more.

Cycling has many benefits from a more active way of living through a drop in motor traffic to reducing air pollution. Unfortunately, even this type of transport cannot do without the risk that is most often associated with the risk of injury to the cyclist or his surroundings. Teschke et al. [14] research route infrastructures and risks of cyclist injuries in Toronto and Vancouver. There were selected 14 routes, where cyclists are often injured. Routes have been observed and recorded data on their status, street type, street lighting, interroads, traffic volume or speed of operation. By using of the SAS analysis version 9.2; SAS Institute, Cary, NC and logistic regression model, it was found that it depends on the type of route and hence the risk of injury. The Results prove that the routes that are on larger and quieter streets without parked cars and with a bicycle path off the street indicate less risk of injury to cyclists than opposite street type. The aim of the study is to highlight the importance of a safe track infrastructure for cycling, reducing the risk of cyclist accidents and contributing to greater citizens' safety and activity. Other authors examining this issue are Reynolds and et al. [15], who conducted a study using articles and other published research on the impact of transport infrastructure on the safety of cyclists. They characterized two categories of infrastructure: the first category relates to crossroads (roundabout), and the other refers to roads, paths and alleys. Using these categories has been found, that a major impact on the reduction of the risk of injury have, not only well-built cycle paths, but also street lights, paved surfaces or proper traffic signs. It remains, of Course, that the increased risk of accidents occurs in the mass transport infrastructure of cyclists and motor vehicles, as well as in common terrain with pedestrians. The theme is related to the study by the authors of Panter and et al. [16], the impact of new transport infrastructure on pedestrians, cyclists and physical activity. The Study examines whether the issuance of new transport infrastructure for pedestrians, cycling and public transport will contribute to an increase in time spent walking, cycling and overall daily movement activity. The project depended on the construction of a new bus network and the adjacent pedestrian and cycling route. Using quasi-experimental analysis and recruitment of research participants, the authors evaluated the effects of the newly built transport infrastructure. The study showed increased use of bus transport, cycling and more walking activities after the construction of new transport infrastructure.

3. Limited Resources and Game theory

The economic reality of the self-governing units predicts that it has limited resources to implement security measures. In the case of resource constraints, the question is how to allocate these resources to maximize the effect. In other words, it is about to keep crime as low as it is possible, or to minimize the number of negative externalities.

Effective allocation of limited security resources is addressed by Pita et al. [17]. In their study, they examine the deployment of an algorithm for the allocation of security patrols to protect the airport, which are limited. They use game theory - based approach to allocation - specifically the Bayesian Stackelberg game [18]. The prerequisite is that the terrorists are watching the patrol and trying to attack the currently vacant place. Random allocation is the key to increasing security as it increases the risk to attackers. However, even this random allocation must be systematic so that the highest probability of attacking the place being guarded is as high as possible. This fact is being solved by the Bayesian Stackelberg game.

In order to solve the Bayesinan game using the Conitzer and Sandholm method [18], we have to perform Harsanyi transformation [19]. This will convert the Bayesian game (incomplete information) into a normal form game. An example of transformation is shown in the following figure 1. In the game we assume that there are two players. One player is the police, who has only one type of behavior. The other player is the attacker. However, he may be of a different nature (terrorist, thief, drunk,…). Each type of attacker has its own behavior pattern. In the example for simplicity, we assume two types of attackers.

	c	d
a	2,1	5,0
b	1,0	3,2

Figure 1: example

The Transformation assumes that an attacker of type 1 will attack with a probability of α. Striker 2 will attack with a probability of $1-\alpha$. The Transformation is then shown in the following figure 2.

	cc’	cd'	dc'	dd'
a	$2\alpha + (1-\alpha)$, 1	2, α	$5\alpha+(1-\alpha),(1-\alpha)$	$5\alpha+2(1-\alpha),0$
b	α, $(1-\alpha)$	$\alpha + 3(1-\alpha)$, $2(1-\alpha)$	3α, $2\alpha+(1-\alpha)$	3,2

Figure 2: transformation

The problem with this resolve lies in the range of strategic choices that are represented by a normal game. If I have n types of attackers with strategies, the resulting game is comprised of kn strategies. In the real world, we are getting into extremely large structures.

An alternative approach to the solution is decomposed optimal Bayssiaon Stackelberg solver (DOOBS). The key to the DOBSS decomposition is the observation that evaluating the leader strategy against a Harsanyi-transformed game matrix is equivalent to evaluating against each of the game matrices for the individual follower types [20]

The Bayssiaon Stackelberg game pilot Application for the airport safety management in LA has had extremely successful results after the pilot operation and continues its continued use [17].

4. Neural networks to detect risk behaviour and prediction of risks

Neural networks can be very useful and can be used in systems to help keep safety in citites. This issue deals with Murugan et al. [21] who examined inappropriate behaviour or anomalies in the pedestrian zone using a regional scalable convolution neural network called RS-CNN. For the calculation, the statistical model px (x) was determined for the distribution of the X measurement under normal conditions. Abnormalities are defined as measurements that are less than the threshold in this model. This is equal to the statistical hypothesis test:

- H0 : x is obtained from px (x)
- H1 : x is made out of a non-information separation px (x) α 1

Where px (x) < v, where v indicates the normalization constant of the non-informative separation with the rule of minimum probability of test failure and rejection of the null hypothesis.

The first phase of the process is a segmentation, which moves where the video footage is structured to identify area of anomalies. RS-CNN functions are calculated calculated for correlation filtering. In the second phase occurs to marking classes, when the market labels are assigned to each observed area in the video frame. Then the anomaly is detected. The detection level enters a set of images in the video sequence with the observed areas. The output will then be anomaly images with the appropriate label. To this end, the RS-CNN features were extracted, followed by the mapping process of the regions of interest and marking. When the observed areas were found within the frame, the relevant mark was allocated with the detection speed.

Anomalies are detected using this model, which are unusual or do not belong to the limitary zone for pedestrians, such as cars, cyclists or inappropriate or brutal behaviour of pedestrians. This technique can be utilized in systems to monitor abnormal activities in the video.

One of the most research parts is the movement of pedestrians using neural networks, which makes sense for a number of applications, and which play an important role in the automotive industry or robotics. Dai, Duan et al. [25] deal with infrared rays illuminated by pedestrians at night, which can be seen through the visible spectrum camera over longer distances, helping to identify pedestrians. The researchh uses a self-acting softmax with a 9-layer model of convolutionn neural Network (CNN).

The result of the research contributes to reducing the collision of a motor vehicle with the pedestrian at night, when the walker without the use of reflexive elements is not well visible.

The Same topic was examined by the authors Li et al [30], using a neural network to detect pedestrians, which can be used in car driving assistance systems. The method uses neural functions from fully convolution networks (FCN), detects pedestrians using the boundaries of green or red rectangles. Green point to pedestrians who are nearby and red rectangles show, so put on fake people, which means a poster with a character. The research uses three FCN models, which are trained on the PASCAL VOC Segmentation command.

FCN is softer and more structural than traditional convolphic networks. The advantage of using a neural network is to automatically learn the types of elements and thus achieve excellent performance in detecting pedestrians. Research exceeds most traditional methods that use hand-crafted functions.

Another author who dealt with the detection of pedestrians is Tome et al. [23], which proposes a deep learning system that is able to customize a conventional network for a given task It Performs a rigorous analysis and optimization of each step to achieve the accuracy of the task, approaching the most modern approaches, while also requiring a low computational time. The research was based on convolutional neural networks. These networks rely only on large-scale training data files and a link-based training practice, along with an optimization algorithm. The first layers of the network determine low-level concepts (edges, details), the final layers are able to combine low-level functions to identify complex visual concepts. The ultimate research system is a combination of LDCF region design algorithm and deep convolutional neural network.

The resulting system exceeds alternative approaches based on manual and learned functions, in reasonable computational complexity. The version is able to detect pedestrians in real time on modern hardware.

The topic of city security from the point of view of criminology was dealt with in the article by Andersson et al [26], who using the 4-Cardinal Siamese convolutional Neural Network (4-CSCNN), to investigated criminal behavior that is influenced by the environment where to criminal offences. The analysis works with street level images to classify low and high criminality.

Using Neural networks we can predict the magnitude of the earthquake, as Adeli and Panakkat [28] show in their article. They explore the class of neural networks used in the classification problems of probability neural networks to predict earthquake quantities. A Model of probabilistic neural networks provides good predicted precision for earthquakes between 4.5 and 6.0. Conversely, when the magnitude of the earthquake is greater than 6.0, it does not provide good results for the earthquake prediction. In an earthquake greater than 6.0 must be used model of the recurrent neural network, which was previously developed by authors significantly more successful in the prediction of earthquakes of magnitude between 6.0 and 7.5.

5. Industry 4.0 and safety

Smart City is currently a very popular Area of research. In some cases, even voices say that it is an overstated term. Smart City Solutions should ultimately bring benefits to the citizen in a given locality. The Author Alsarhan et al [31] deals with the traffic control safety management. In their analysis, they deal with the problem of limited available radio frequency spectrum. In the analyses, a paid spectrum was used to minimise traffic accidents and communications across transport participants. Numerical studies have shown that this approach could reduce accidents. Tokoda et all. [32] in its publication deals with the intelligent transport and intelligent vehicle system, which can improve both throughput and transport safety. The article deals mainly with methodological approach to the issue.

The Contribution of Adb-Elha Taha [33] introduces new short-term metrics for road safety assessment. The Metric uses machine learning in the core design of metric calculations using the new Hidden Markov models (HMM) application. The impact of the proposed architecture is demonstrated through a security planning application based on the current state.

Wan et al. [34] deals with emergencies that need to be effectively detected for their subsequent rapid resolution and removal. To this end, it proposes a structure composed of a central agent and three layers – layers of unmanned aerial vehicles (UAVS), layers of multiple robots and layers of sensor networks.

The authors Velladurai et al. [35] in their publication are dedicated to an intelligent system for detecting toxic gases. Microcontrollers would be equipped with a GSM module, which would send a monitoring report that could react quickly if a certain threshold is exceeded.

Srivastava et al. [36] In their overview map systems for security based on neural networks. The authors Lacinak and Ristvej [37] discuss what it means to introduce the smart cities concept. Then they are focused on the area of security, which is often underestimated in this respect. Finally, they accentuate the importance of simulations.

6. Conclusion

The article aims to perform a research of the current state and methods in the field of urban safety. To this end, documents have been analysed that define the key infrastructures that ensure basic human needs. In addition to the delimitation, approaches to their protection and interdependence were analysed. In addition, systems and measures in the field of transport have been analyzed, which can have a positive impact on increasing safety. Transport was chosen with regard to the number of external deaths according to the Czech Statistical Office.

The scientific methods have analysed neural networks that can predict or classify certain structures on the basis of identical parameters. This means that they can predict potentially risky situations and thus allow authorities to take appropriate measures with a proper priority. Another approach that has been analyzed is the game theory, which optimizes resource allocation while protecting certain infrastructure. In this case, analyses were used that are practically used in the protection of airports and which are inherently applicable to a number of criminal situations.

At least, the Smart city system related to urban safety, were analyzed. These systems often intertwined with neural network methods or game theory. However, these were practical applications related to the subject of the article.

The analyses will lead to the design of a safety city concept with regard to available of the local government resources. Proposals will be directed to the cities with a population below 10,000. citizens.

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