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PUBLIC OPINION POLL ON THE PARKING SYSTEM IN PIŁA AND THE POSSIBILITY OF INTRODUCING THE SMART PARKING SYSTEM IN PIŁA

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A b s t r a c t

The aim of the article is to find out about the public opinion of the inhabitants of the city of Piła about the functioning of the parking system, in which residents have problems finding a parking space. The most important issues in this field were reviewed. On the basis of the survey, car parks were designated, where it was proposed to modify the existing parking system by introducing intelligent parking systems. The results of the research, after analysis and summary of observations in the form of conclusions, are presented in the table and in the form of graphs.

Introduction

The technological development of the world causes the development of the automotive industry to a large extent. This is related to the constantly growing number of vehicles traveling on roads, which has more than doubled over the last 17 years (Fig. 1), and the number of parking spaces is not growing at such a pace. The problem of finding a parking space in urban areas has always been a problem for drivers living in developed countries.

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For years, solutions have been sought to ensure the largest possible number of parking spaces while using the minimum area of land, especially in large urban agglomerations, where there is no more space for additional parking spaces. A growing number of vehicles that go literally wherever possible. We can find cars not only on highways and streets, but also on well-worn roads and paths. Such a number of vehicles necessitates the creation and provision of a safe place to stop the vehicle. One of the main problems is that parking is possible not only in typical car parks, but also in non-urbanized areas.

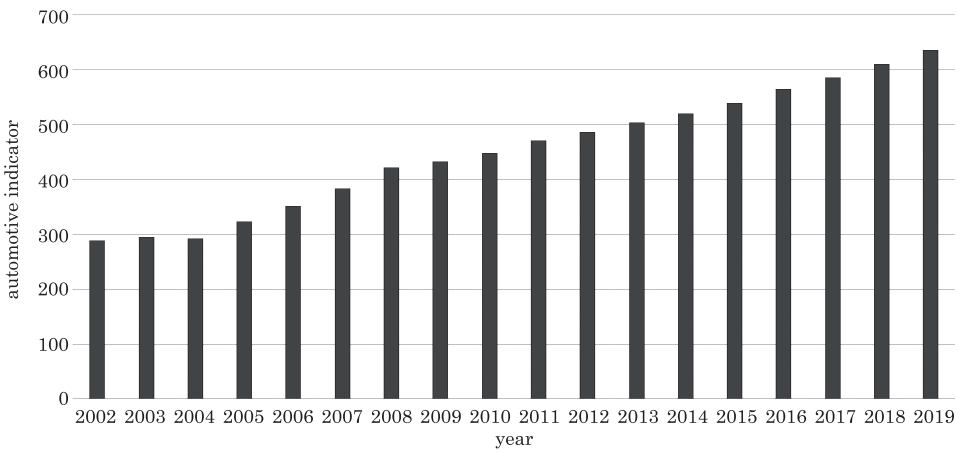

Fig. 1. Automotive index in 2002 ÷ 2019
Source: based on Statystyki CEPiK (2019), GORZELANCZYK (2020), Eurostat (2020).

Finding a parking space, especially in large urban agglomerations, is a time-consuming process. Some of the negative effects of the parking space search process include, for example, unplanned costs, harmful social interactions, and decreased employee productivity. An important factor is also the fact that many vehicles with "larger dimensions" cannot fit in most parking spaces.

In order to determine the dimensions of parking spaces for individual types of vehicles, the announcement of the Minister of Investment and Development of April 8, 2019 on the publication of the consolidated text of the ordinance of the Minister of Infrastructure on technical conditions to be met by buildings and their location (Obwieszczenie Ministra Inwestycji i Rozwoju z 8 kwietnia… 2019). The British Parking Association (BPA) (BPA 2020) analyzed the time spent by drivers looking for a free parking space. The BPA study also presents the driver's feelings when looking for a parking space, as well as the criteria used by drivers looking for a parking space. Research shows that the average British driver spends almost 4 days (91 hours) a year finding a free parking space. In the United States, the situation is different. The average time it takes to find a parking space is 17 hours per year.

The research conducted by IRNIX was similar. The study analyzed not only the time needed to find a free parking space, but also the related costs. Two types of incurred costs were included in the analysis. Costs to drivers for wasting extra fuel looking for a parking space and overheads that take into account not only fuel costs but also factors such as environmental impact and driver time. According to an INRIX study (McCoy 2020), searching for a free parking space costs $ 345 per year per driver.

Based on the report of the European Automobile Manufacturers Association (ACEA), it can be concluded that 66.2% of households declared that they owned at least one car (Okurowski 2020).

The report of the European Statistical Office (Eurostat 2020) was used to check the degree of motorization not only in Poland, but also in all European Union countries. The report shows that Poland is one of the most motorized countries in the European Union, next to such countries as: Liechtenstein, Luxembourg, Italy, Cyprus and Finland.

Many authors have addressed the subject of the limited number of parking spaces resulting in congestion, air pollution and frustration for drivers. The article (Gongjun et al. 2008) presents how the time needed to find a parking space has changed before and after the introduction of an intelligent parking system and how this system influenced the use of the parking lot.

Intelligent parking is a system based on a special infrastructure that allows the driver to quickly and accurately locate a free parking space. This system allows for comprehensive management of parking lots and provides users with information about the availability of parking spaces in given parts of the city and within its territory. In a specially prepared application, users can check whether there is a free parking space at the airport, cinema or other popular city venues. There are two main factors in the intelligent parking system: a transport infrastructure using smart cameras, sensors and algorithms. systems and applications for mobile devices. The image from cameras installed in strategic places from the point of view of communication is analyzed using algorithms and sent to a database connected to a free mobile application. The application will not only indicate the free space, but also suggest which one is best for a specific vehicle, taking into account the free space and dimensions of the vehicle. Additionally, this system allows to increase the safety of parking lots by constant monitoring of the parking space (Kirci et al. 2018).

Smart Parking is part of Intelligent Transportation Systems (ISP). This gives the opportunity to develop newer and newer parking improvements. This system not only controls the processes taking place in the car park, but also takes into account other aspects related to parking facilities (Kirci et al. 2018). ISP includes several systems, the most popular are such systems as: expert and agent systems, system based on fuzzy logic, systems based on wireless sensors, systems based on GPS navigation, road communication systems and systems based on vision

The intelligent parking system should enable the driver to book the selected parking space and facilitate movement around it. The continuous "entry/exit" system is designed to automatically scan all vehicles entering and exiting the parking lot. These systems not only increase the protection of our car through its constant monitoring, but also allow for additional activities related to the parking process, such as, for example, the purchase of a parking ticket. The full automation of these systems means that the driver does not waste time looking for a parking space and does not care where he should pay for parking. As these systems monitor the traffic in the car park, this leads to a reduction in congestion and an overall improvement in road traffic (SZMIDT 2017). The benefits of implementing an intelligent system are described in (MUFAQIH et al. 2020).

The issues related to the systems used in intelligent parking systems are also described in the article (FAHEEM et al. 2013) which describes in detail: expert systems, systems based on fuzzy logic, wireless systems, road communication systems and vision systems.

The topic of using intelligent parking systems based on the use of intelligent real-time cameras was discussed in (ALAM et al. 2018). The work describes the principle of operation and construction of a system based on the use of intelligent cameras, examples of system applications and the correct arrangement of the entire infrastructure included in the system. The topic of intelligent parking lots was also included in (STANCZYK, PYREK 2013, SKRZYNIOWSKI et al. 2018, PARKITNY 2010).

Intelligent parking solutions have been implemented in Gdańsk, where parking spaces located on the streets in the city center are monitored, and the steering wheel in the application can check where there is a free parking space. Similar solutions exist in Warsaw, Gliwice and many other Polish cities.

Materials and Methods

The main goal of the work is to find out the opinion of the inhabitants of the city of Piła on the functioning of the parking system, where residents have problems with finding a parking space. The study conducted a survey aimed at finding out the opinions of residents and people coming to the city of Piła about the transport infrastructure related to parking lots in Piła, and the city does not plan to improve the parking situation in the city of the future and there are currently no intelligent parking solutions in the city.

The first step in the study was to use a pilot study. The interviewers were assigned 10 questionnaires, the purpose of which was to express an opinion on the method of implementation and its clear image. Based on the conclusions reached through this procedure, the final version of the questionnaire was prepared. The next step in conducting the survey was to encourage the survey participants

to complete the final version of the survey in electronic form. The drivers survey asked, inter alia, o: the purpose of the trip, the time needed to find a parking space, whether they had previously encountered the Smart Parking concept and many other questions related to public transport. infrastructure. The research was conducted in the form of a questionnaire from March 2020 to the end of May 2020. The research involved randomly selected 286 people. The study was conducted on various social groups in order to thoroughly learn the opinions of the city's inhabitants.

The next step was to calculate the sample selection.

1. From a practical point of view, the maximum error is δ = 2%, based on surveys conducted within the city of Pila in most of them the maximum error was estimated δ = 10%.

2. The significance level assessed in most studies is 90%.

3. The standard variation of the population in Pila is 52% female and 48% male.

Then the sample was calculated using the following formula:

$$n = \frac{Z^2 \cdot p(1-p)}{\delta^2},$$

where:

n – sample size number,

Z – significance level dependent coefficient, 90% – 1.65,

p – proportion in the population, (52% – 0.52, 48% – 0.48),

δ – estimation error, 5% – 0.05.

$$n = \frac{1.64^2 \cdot 0.52(1-0.52)}{0.05^2} = \frac{2.69 \cdot (0.52 \cdot 0{,}48)}{0.0025} = 268.57.$$

The minimum sample size took a value of approximately 269, but the number of people during the study increased to 286 people.

Results

The highest percentage of respondents (39%) came from the age group of 18 to 25 years old, which is due to the fact that people in this age group have driving licenses and are active on the Internet. People in this age group are mostly students, who don't have many obligations and can afford to "waste" more time than other age groups. In the 26-50 age group the number of people taking part in the survey is 40%. The smallest percentage of respondents 21% are people over 50 years old.

Regarding their place of living 40% of the respondents stated that they live in the city of Piła, and a small number of people 13% live in areas between

5 and 10 km from the city center. A significant part of respondents (38%) live in places located more than 20 km from the city center (Fig. 2). Respondents mostly live in urban area (53%) and 47% live in rural areas. A vast majority of 73% of respondents states that they are the driver of the vehicle while driving. Only 27% of the respondents identify themselves as a passenger.

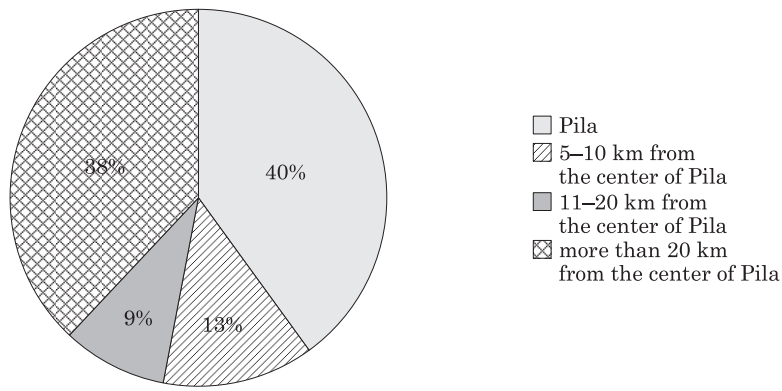

Fig. 2. Place of residence
Source: own study.

Most of the respondents (over 50%) come to the city for education or work. 13% of respondents say they come to the city for shopping, 7% for a visit and only 3% of them choose the city as a leisure time destination (Fig. 3). Among other purposes of their visit, respondents most often cited visiting a specialist doctor or getting tests done in city health facilities as the reason.

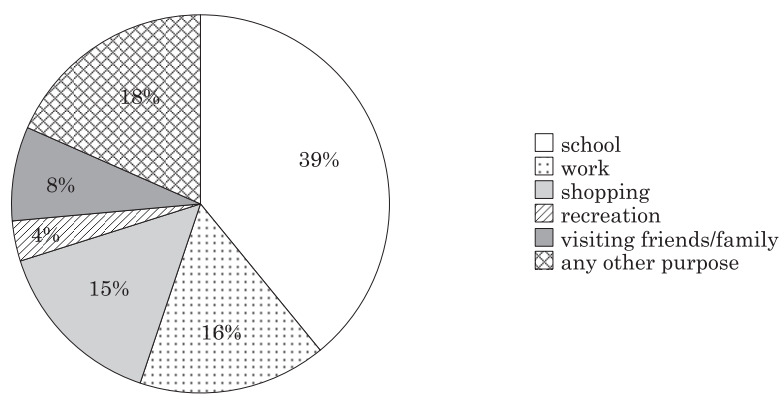

Fig. 3. Destination
Source: own study.

The vast majority of respondents (61%) consider the city's transportation infrastructure to be at a good or very good level. Such a high result could be influenced mainly by renovations carried out over the years. 20% of respondents think that the city's infrastructure is at a neutral level, and only 15% see it as negative. 4% of respondents could not express their opinion on that (Fig. 4).

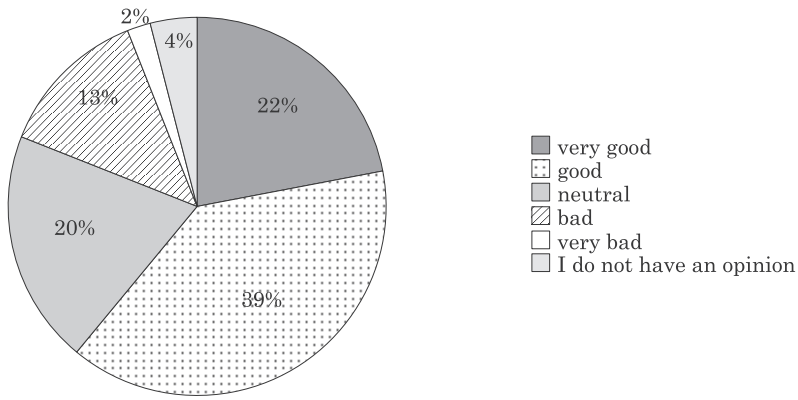

Fig. 4. Assessment of the city's transport infrastructure
Source: own study.

38% of respondents state that the location of Pila's parking lots in relation to the places they visit is good, and 12% believe that parking availability is very good. 27% of respondents have a neutral approach to the subject. 16% of respondents think that the location of Piła's parking lots is bad and 7% think that the location is very bad (Fig. 5).

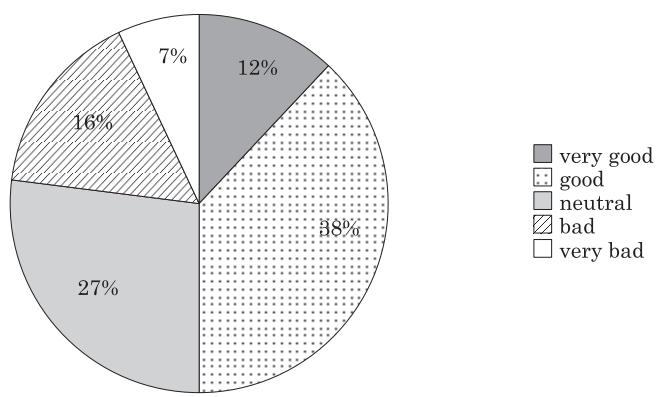

Fig. 5. Availability of parking in relation to places visited
Source: own study.

The time spent finding an available parking space varies widely. This is most likely due to the different destinations and personal feelings of the respondents. Nevertheless, 44% of respondents find a parking space within a time range of up to 3 minutes. 24% of respondents need 4 to 6 minutes to find a free parking space and 32% of respondents spend 7 to even more than 10 minutes (Fig. 6). 64% of respondents admit that they have not encountered the concept of smart parking before. This may be due to the fact that the concept is relatively new and the technologies used in Smart City are rare. 36% of respondents state that they have encountered the concept before. The vast majority of 63% of respondents think that the introduction of smart parking is a good solution. 26% of respondents say they are indifferent to the idea and 11% are against it.

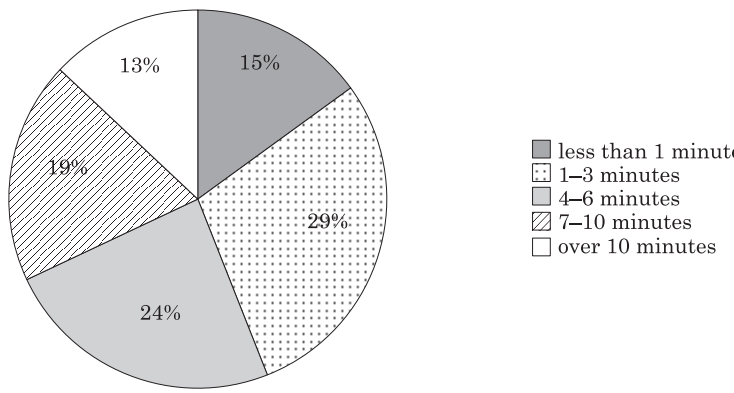

Fig. 6. The time it takes to find a free parking space
Source: own study.

The vast majority of respondents state that they would use smart parking systems often 40% or very often 18%. 17% of respondents think they would use this solution from time to time, 11% of respondents think they would rather never use this solution and 5% of them declare they are not interested in such solution. 9% of respondents did not express their opinion (Fig. 7).

A significant number of respondents, as many as 37%, said that a smart parking system should appear at the Vivo shopping mall. 15% of respondents were in favor of Chestnut Gallery, 12% thought that a good place for a parking system would be a parking lot by the market square, and only 9% believe that the ideal place to introduce intelligent solutions is the Signify parking lot. A large number of respondents (27%) would choose other locations for such solutions (Fig. 8). The most frequent answers were: city center, Piła City Hall, Stanisław Staszic Specialist Hospital, Biedronka supermarkets and railway station.

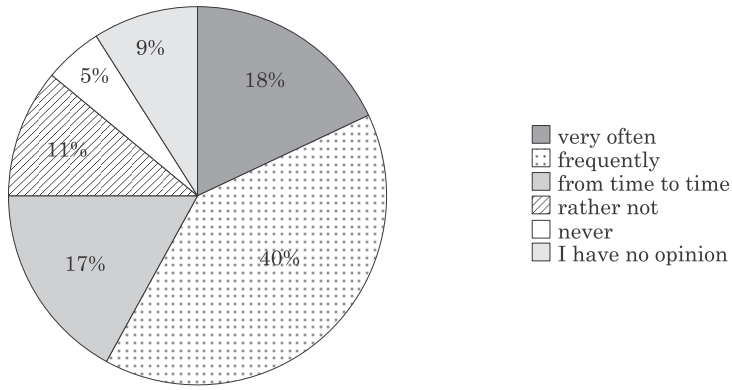

Fig. 7. How often would you use a smart parking system?
Source: own study.

A significant number of respondents, as many as 37%, said that an intelligent parking system should appear by the Vivo shopping mall. 15% of respondents supported a parking lot next to a hospital, 12% said that a good place for a parking system would be a parking lot next to a pedestrian zone, and only 9% said that the ideal place for intelligent parking solutions is a parking lot next to a railway station. A large number of respondents (27%) would choose other places for such solutions (Fig. 8). Among respondents' answers there were: city center, Piła City Hall, Biedronka supermarkets and Galeria Kasztanowa.

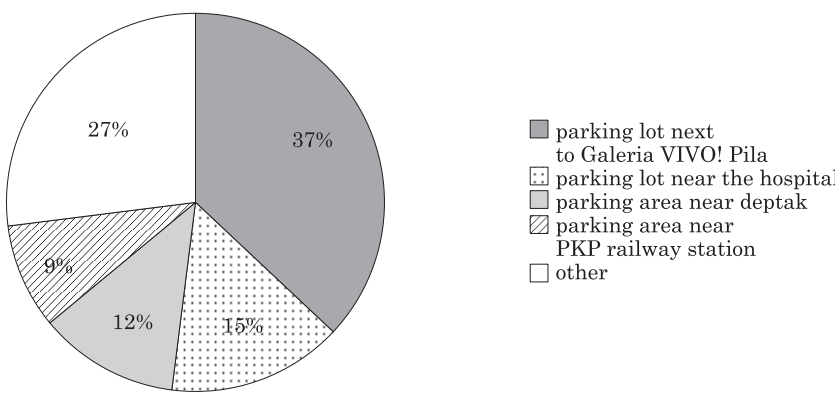

Fig. 8. Where do you propose to introduce Smart Parking
Source: own study.

Almost all respondents, up to 98%, confirmed the use of payments with mobile devices such as smartphone and smartwatch. Only 2% of respondents said they do not use this form of payment. Poland is one of the leaders in mobile

payments in Europe, according to Visa Digital Payments research (PARKITNY 2010) as many as 86% of Poles expect to use mobile payments by the end of 2020.

For the last additional, open-ended question "How do you feel about the introduction of smart systems related to city management?" a significant number of respondents unanimously agreed that the introduction of smart systems to improve city management is needed and required. The respondents were unanimous in their willingness to support and use all the facilities provided to them by the smart systems in the Smart City project. A large number of respondents also pointed out that the urban environment should not have a significant impact on the natural environment, and the implemented solutions should be pro-ecological.

Based on the author's observations, confirmed by respondents' surveys (Fig. 8), places were selected where residents have a problem with finding a parking space:

– Parking lot next to Galeria VIVO! Pila;
– Parking lot near the Stanislaw Staszic Specialist Hospital;
– Parking area near Deptak (Pila Pedestrian Street);
– Parking area at the PKP railway station.

The technical data of the above-mentioned facilities are presented in Table 1.

Table 1

Technical data of selected car parks in the city of Piła

Car park parameter / Name of the car park	Parking lot next to Galeria VIVO! Pila	Parking lot near the Stanislaw Staszic Specialist Hospital	Parking area near Deptak (Pila Pedestrian Street)	Parking area at the PKP railway station
Total parking lot surface area	18,850 m^2	7,250 m^2	5,100 m^2	1,600 m^2
Total number of parking spaces	480	230	144	54
Number of parking spaces designated for passenger cars	434	224	134	50
Number of parking spaces designated for people with disabilities	20	10	10	4
Number of parking spaces designated for mothers with children	16	1	0	0

Source: own study.

In the analyzed car parks, the number of parked vehicles was examined during rush hours, and then the arithmetic mean was drawn. The research in all car parks was carried out from Monday to Friday from 5:00 p.m. to 7:00 p.m. and on weekends from 11:00 a.m. to 1:00 p.m. and from 3:00 p.m. to 6:00 p.m. in the period May – June 2020. The relevant data is presented in the Table 2.

Table 2

Parkings lot utilization analysis

Car park parameter / Name of the car park	Parking lot next to Galeria VIVO! Pila	Parking lot near the Stanislaw Staszic Specialist Hospital	Parking area near Deptak (Pila Pedestrian Street)	Parking area at the PKP railway station
Occupancy rate of parking lot	$W_{orp} = \frac{363}{480} = 0.76$	$W_{orp} = \frac{149}{230} = 0.64$	$W_{orp} = \frac{102}{144} = 0.71$	$W_{orp} = \frac{38}{54} = 0.7$
Parking occupancy rate during peak hours	$W_{po} = \frac{417}{480} = 0.86$	$W_{po} = \frac{172}{230} = 0.74$	$W_{po} = \frac{129}{144} = 0.89$	$W_{powp} = \frac{47}{54} = 0.87$
Percentage of vehicles parked illegally	$P_{pvp} = \frac{39}{480} \cdot 100 = 8.1\%$	$P_{pvp} = \frac{9}{230} \cdot 100 = 3.9\%$	$P_{pvp} = \frac{39}{144} \cdot 100 = 27\%$	$P_{pvp} = \frac{6}{54} \cdot 100 = 11\%$

Source: own study.

Based on the layout of the first of the analyzed car parks, the car park at Vivo, it is proposed to install a system based on intelligent cameras. The solution with cameras is expensive, but taking into account the number of parking spaces, this solution seems to be a better solution than the use of individual sensors responsible for each individual parking space. An alternative solution that could be used to improve the functioning of the car park is the construction of a multi-storey car park.

The structure of the hospital car park resembles a square. The square structure of the car park suggests that the optimal way to improve the functioning of the car park would be to install a smart camera system. This system would not only have a navigation and protective function, but would also inform drivers about which zones the car park is divided into. The use of the intelligent camera system would allow assigning an individual number to each vehicle entering the hospital parking lot. Not only would this automate the ticket collection process, it would also automatically cause hospital patients to be charged.

Another of the discussed car parks are the Promenada car parks. This is a place frequented by many people. There are not only many shops and eateries here, but it is also the perfect place to spend time together with family or friends. Such a large number of frequently used facilities means that the number of people and vehicles in this area is large, and the number of parking spaces is limited. The key factor in finding a free parking space is that there is no single large parking lot in the area that can accommodate all vehicles. A large number of small parking lots and the presence of the main Piła roads in this area only increase the problems related to the effective flow of vehicles, which results in the formation of traffic jams in the city center.

The introduction of a system based on Smart Parking technologies would significantly relieve drivers, but would also have a positive impact on traffic in the city. As this area is characterized by a large number of small parking lots and high vehicle rotation in parking lots, the ideal solution would be to install an intelligent parking system based on the use of parking sensors connected to the application. The simple concept of the sensor operation makes it the most optimal solution. Each individual parking space is equipped with a sensor that is able to show us the current state of the parking space in real time.

The last of the considered car parks is the train station car park with a limited number of parking spaces. The solution to the problem of a small number of parking spaces seems to be the automatic modular car park (Car Towers). Car towers are ideal where a large number of parking spaces are required and parking is small. The car park is fully automated and does not need to be operated by any employee. The only person who takes an active part in using the car park is the driver of the vehicle.

Conclusion

The article uses a questionnaire to conduct a public opinion poll on the parking system in Piła and the possibility of introducing the Smart Parking system in Piła. The research clearly shows that people take an active part in the life of the city and support the introduction of intelligent solutions. A large part of the respondents expressed their willingness to use modern technological solutions and stated that the systems that are elements of Smart City are the basis for a more comfortable life not only in large urban agglomerations.

In the comments provided in the survey, respondents indicated that the city is often impassable during rush hours and that the streets are often congested. Intelligent parking systems would enable some drivers to find a free parking space more efficiently, which would significantly reduce the number of vehicles in traffic.

The article also presents proposals for the implementation of the project of intelligent parking lots in the city of Piła and other modern parking solutions based on a study conducted on the inhabitants of Piła and the surrounding area. Proposals for the implementation of the project of intelligent parking lots in the city of Piła and other modern parking solutions based on a study conducted on the inhabitants of Piła and the surrounding area were also described. After talking to the city authorities, there is a chance to introduce the described solutions in the analyzed city.

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