Smart parking for an ecological type of transport - electric scooter

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Abstract. The advantages and disadvantages of using one of the environmentally friendly modes of transport - an electric scooter - are considered. It was noted that one of the constraining factors for the development of this type of transport is the poorly developed infrastructure (convenient and reliable parking lots, places for charging batteries - the range of the electric scooter is no more than 40 km, etc.). One of the options for solving this problem is presented. A universal small-sized parking for electric scooters for 4 places with a battery charging system has been developed. To identify the parking user, a new version of the logical system of interaction between the user and the parking module is presented. This allows the user of the electric scooter to save time searching for a parking space, not waste extra battery power and increase the mobility of employees and students moving between university buildings (the campus consists of 54 buildings). Reduces the load on the air by reducing exhaust emissions.

1. Introduction
The deterioration of the ecological situation, especially in cities, requires the search for new solutions to various problems [1-14]. The problem of operative movement of people with a decrease in the technogenic load on the environment is one of them [13-20]. In addition, there is a decrease in fuel reserves, an increase in the cost of its production, etc. [17, 18, 21-25]. On the other hand, the development of nuclear energy, especially in the areas of large cities, has provided the population with a large amount of electrical energy, which must be spent [26-30]. The ecological component of the load on nature during the operation of nuclear power plants is lower than that from burning gasoline in a car engine, if we compare it on a global scale [31-33]. Air condition monitoring by various devices confirms this [33-42]. One of the options for solving this problem is the introduction of electric scooters and other small vehicles into people's lives.

The rapid development of two-wheeled electric vehicles among the population, especially in large cities, is constrained by the problem with the placement of these vehicles. Unlike bicycles and simple scooters, electric vehicles (electric scooters) require different maintenance and temporary storage. The existing infrastructure is not ready for these changes, as its basic components are missing. Therefore, it is still difficult for electric scooters to compete with environmentally harmful modes of transport, for example, cars.
The installation of smart parking lots located on the territory of institutions is a very urgent task (for example, for students and university teachers, or on the territory of a company for its employees). As the number of use cases for electric scooters has increased (from last mile transport to several miles a day), there is an urgent need to recharge the scooter in the parking lot.

In our work, we offer one of the options for smart parking for universities, taking into account the requests of teachers and students. Figure 1 shows the dynamics of the increase in the number of users of private electric scooters at the Polytechnic University. It can be concluded that the number of users is increasing every year, which means that the need for parking spaces for electric scooters is increasing.

![Figure 1. The dynamics of the increase in the number of users of electric scooters at the university](image)

It should be noted that the measurements of air quality in the area of some buildings of the university with optical devices [43-46] during the active use of electric scooters showed a decrease in harmful gases.

2. Description of the construction of smart parking

In our proposed smart parking design, in addition to solving the problems under consideration, it is taken into account that it must be made universal (adapted for parking all models of modern electric scooters). A feature of this parking is the presence of four parking spaces. This makes it compact and can be placed at the entrances of public buildings close to power supplies. This, on the one hand, increases the safety of the parking lot, on the other, it allows you to recharge the battery of the electric scooter at a lower cost.

The developed parking includes a building and a control system. The control system can be adapted to suit any need. Our work demonstrates authorization through a corporate roll-up of an organization. For commercial use, monetization scenarios are possible with hourly rental of a parking space, similar to a car park. The appearance of the developed parking lot is shown in Figure 2. The parking lot conditionally consists of two parts: the upper one, where the main structural elements are located, and the lower one, consisting of the scooter front wheel holder. and a scooter tray to keep dirt and moisture in.

Let's take a closer look at the upper part. The system consists of a set of parking spaces. One parking space is a cutout for the steering wheel of the scooter, a compartment for storing the charger and a cover - a lock. The cell has a 220 V - 50 Hz socket. A lockable lid when closed further locks the charger storage compartment. A spring is installed next to the latch to prevent any accidental closing of the cover-blocker. It holds the cover 1 to 2 cm above the latch.
A fundamentally new system has been created that allows you to leave the scooter for safe storage. At the same time, it is suitable for all types of scooters and allows you to charge the battery. Additionally, there is the possibility of fast charging.

The modules are connected using the technology of the universal asynchronous receiver / transmitter (UART). These modules allow using the application to determine the availability of free parking space so as not to waste extra energy and time. One of the models of such scooters is shown in Fig. 3.
3. Conclusion
The results of operation of the prototype parking lot for four electric scooters installed in the research building of Peter the Great St. Petersburg Polytechnic University (the prototype was implemented at the expense of the university grant for the practical implementation of the project) showed the following. The developed system is universal (it can be installed on the street or in a building). When installed outdoors, a roof is required for the convenience of users, ensuring the stable operation of various radio systems, chargers, etc. The design of the developed parking lot is mobile enough and, if necessary, can be easily rearranged to another place.

The presence of this parking lot has increased the number of employees and students who started using the electric scooter as a vehicle. Among them, two people stopped using a private car to come and move around the university. This has reduced the amount of vehicle exhaust fumes on campus. An additional territory was freed up (two machine spaces at the hull). Gradually, the traffic on campus began to decrease. People's interest in purchasing electric scooters has increased for solving various problems, especially those related to mobile travel.

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