Journal of Modern Technology and Engineering
Vol.9, No.3, 2024, pp.217-224
https://doi.org/10.62476/jmte93217

WEB DESIGN OF INTELLIGENT PARKING SYSTEM IN TRAFFIC CONTROL

Aida Mustafayeva[1,2*], **Elmira Israfilova**[3]

[1]Department of Information Technologies, Mingachevir State University, Baku, Azerbaijan
[2]Institute of Control Systems, Baku, Azerbaijan
[3]Department of Information Technologies, Mingachevir State University, Mingachevir, Azerbaijan

Abstract. The rapid growth of modern cities has significantly increased vehicle numbers, exacerbating parking-related challenges in traffic control. Drivers frequently spend excessive time searching for parking spaces, causing inconvenience, worsening congestion, and increasing environmental pollution. According to IBM research, approximately 30% of urban traffic congestion stems from parking searches, highlighting the severe impact of parking issues on urban life. This paper explores UX/UI design principles in developing web applications for intelligent parking systems, emphasizing their importance in addressing these challenges. Web-based intelligent parking systems provide real-time parking information and allocation, reducing congestion and emissions while enhancing driver convenience. Effective design aims to create intuitive, user-friendly interfaces, incorporating interactive city maps, dynamic markers, simplified parking allocation, secure payment systems, and robust data protection. Integrating navigation with public transport further enriches the user experience by offering optimal routes. As urbanization and vehicle numbers surge globally, optimizing parking processes is essential to alleviate congestion, reduce pollution, and minimize driver stress. Advances in technologies like sensors and real-time systems enable efficient parking solutions. Additionally, adherence to advanced UX/UI standards ensures user satisfaction, promoting the widespread adoption of these technologies. The creation of secure, intuitive parking applications is crucial for improving urban environments and traffic efficiency.

Keywords: intelligent parking systems, UX/UI design, web application, traffic control, smart cities, sustainable transportation.

Corresponding author: Aida Mustafayeva, Department of Information Technologies, Mingachevir State University, Baku, Azerbaijan, e-mail: *aida.mustafayeva@mdu.edu.az*

Received: 19 September 2024; Revised: 29 October 2024; Accepted: 10 November 2024; Published: 25 December 2024.

1 Introduction

Implementing web-based smart parking systems is a crucial step in addressing modern traffic control challenges in cities. With the increasing number of vehicles, the efficient utilization of parking spaces is becoming increasingly important. Drivers spending considerable time searching for available parking spots contribute to overloaded roads, frequent traffic jams, and a rise in exhaust gas emissions, which not only deteriorate the ecological situation but also lower the quality of urban life. In large cities, it can take 10–15 minutes to find an available parking space, with a significant portion of traffic congestion resulting from this process. Modern technologies

How to cite (APA): Mustafayeva, A., Israfilova E. (2024). Web design of intelligent parking system in traffic control. *Journal of Modern Technology and Engineering*, *9*(3), 217-224 https://doi.org/10.62476/jmte93217

offer effective solutions to these problems through the development of intelligent parking systems that use advanced equipment and mobile applications to provide real-time information on available parking spaces. The success of such systems largely depends on their ability to help drivers quickly locate parking spots and on the design of user-friendly and intuitive interfaces for booking and paying for parking spaces (Ali et al., 2020). An intuitive UX/UI design plays a central role in the successful implementation of these solutions by ensuring seamless and secure user interactions with the system. A well-designed interface reduces the number of steps needed for parking allocation, enables easy navigation, and ensures secure payment processes. Moreover, integrating navigation systems and public transportation options not only helps users find parking solutions but also provides optimized routes, enhancing the overall user experience. Another critical factor is adherence to security and privacy standards, ensuring that the systems are safe and trustworthy for users. Given the growing challenges in urban environments and the increasing demand for efficient, secure, and user-friendly parking solutions, the development of UX/UI design for intelligent parking system web applications remains a highly relevant and significant area of focus.

2 Formulation of the Problem

The accelerating urbanization processes and the increasing number of vehicles in cities have exacerbated parking control issues. Finding available parking spaces has become a difficult and time-consuming task, resulting in additional traffic congestion and an increase in harmful emissions released into the atmosphere. Research shows that in major cities, drivers spend up to 30% of their time searching for parking spots, which contributes to the growth of traffic jams and increased stress for those behind the wheel. With the limited availability of spaces and the rising number of vehicles, the problem of efficient parking control is becoming more acute.

Traditional parking methods (such as issuing paper tickets or simple registrations at parking spots) no longer meet the demands of modern cities. The lack of automated and smart solutions leads to inefficient use of parking spaces, forcing drivers to spend a long time searching for empty spots or to turn to other locations, which creates new problems in traffic flow. Poorly organized parking control ultimately lowers the quality of the urban environment, leading to wasted time, increased fuel consumption, and a rise in pollution levels.

The development and implementation of smart parking systems based on modern web technologies and user-friendly UX/UI designs have become critical to solving these problems. These systems automate and simplify the processes of searching for parking spaces, allocating them, and making payments, ensuring the efficient use of city resources. International experience with the implementation of intelligent parking systems demonstrates significant progress in traffic control in cities. Major cities such as Singapore, Amsterdam, and San Francisco have become successful examples of using modern technologies to optimize parking space allocation. In Singapore, the primary goal of the intelligent automated system for parking space control is to encourage drivers to choose when and where to park their vehicles based on population density in different areas, effectively managing parking demand. In Amsterdam, using sensors and mobile applications providing real-time information on available parking spaces has reduced the number of cars searching for parking, leading to fewer traffic jams and lower emissions. San Francisco, with its "SF park" intelligent system, has achieved significant progress in the distribution of parking resources by implementing dynamic pricing and automating the search process for parking spots. These examples emphasize the importance of a comprehensive approach considering user convenience, transparent pricing, and integration with existing transportation systems.

A key element of success is an intuitive and functional UX/UI design that makes interacting with these systems simple and accessible. Mobile applications play a vital role by providing information about available spaces and allowing drivers to pre-allocate parking spots, thus

minimizing the search process. In Azerbaijan, parking control has also become an increasingly important issue, especially in large cities like Baku, where the growing number of vehicles causes traffic congestion and parking challenges. In recent years, steps have been taken towards the implementation of intelligent solutions, such as parking payment systems through mobile applications. However, the widespread deployment of integrated systems using sensors and real-time data is still in its early stages. One of the challenges is the lack of infrastructure and coordination between municipal authorities responsible for parking spaces and private companies. Additionally, mechanisms for dynamic control of parking spaces have not yet been developed, and there is no full integration with public transportation. International experience shows that solving these issues in Azerbaijan requires the creation of a comprehensive parking control system that focuses on user experience, technological integration, and sustainable development. Investment in infrastructure and technological platforms that connect parking and traffic flows will help reduce vehicle congestion, improve the environment, and enhance the quality of life in cities.

3 Functional Analysis of the Intelligent Transportation Control System

The proposed methodology for addressing parking control issues is based on the implementation of a comprehensive intelligent parking system using modern web technologies and UX/UI design principles. The main objectives of this methodology can be outlined as follows: increasing the efficiency of parking space control, reducing the time spent on finding parking spaces, and minimizing traffic congestion and emissions through the use of real-time data by the system's users (Mustafayeva et al., 2021).

The first step in solving the problem is conducting a detailed analysis of the current situation in the city, including existing parking areas, their occupancy, and traffic flow patterns at different time intervals. The proposed study highlights the main areas with high demand for parking and those that are frequently overloaded. At the same time, it is important to identify user needs and focus on requirements such as search functions, allocation and payment for parking spaces, integration with navigation, and consideration of individual preferences. After collecting and analyzing the data, an intelligent system should be developed using sensors to determine the real-time status of parking spaces (whether they are available or not) and create mobile web applications to interact with users.

The application should feature a simple, intuitive interface that provides quick access to information about available parking spaces, allocation options, and an easy payment process through various payment systems. A key element is the development of a GPS map system that allows users to easily find accessible parking spaces and filter them by price, distance, or other criteria (Ata et al., 2020).

Integration with other city transportation systems, such as public transport and navigation programs, also plays a crucial role in improving overall mobility. In addition to finding suitable parking, drivers will be able to plan an optimal route, considering the time needed to reach the destination, as well as explore nearby public transportation routes.

To ensure user security, it is necessary to implement encryption for payments and personal data, along with two-factor authentication mechanisms. Continuous updates and system monitoring will enable quick resolution of arising problems and maintain the relevance of the solution. Regular system testing with users is essential to identify shortcomings early and improve the performance of the applications.

The introduction of dynamic pricing for parking based on demand and supply will help optimize the use of parking spaces and encourage drivers to utilize parking during times of lower demand. Thus, the developed methodology combines situation analysis, the use of modern technologies, and user-friendly UX/UI design to offer comprehensive solutions that improve parking control, enhance user convenience, and reduce the negative impact of transportation on

the urban environment.

The proposed intelligent parking system consists of several interrelated components designed to optimize the search and use of parking spaces in urban traffic conditions (Figure 1).

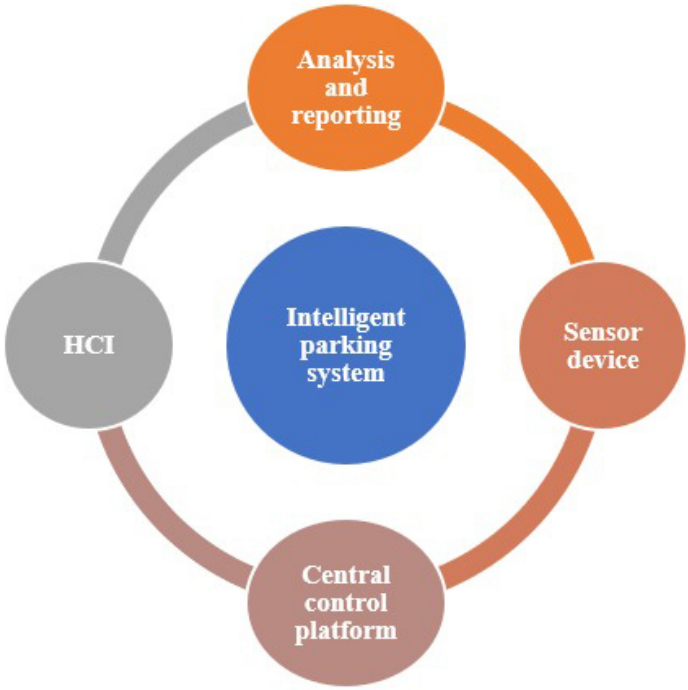

Figure 1: Diagram of the intelligent parking system analysis

As seen in the diagram, the main structural elements include the following: sensor devices, the central control platform, the user interface, and integration with external systems. The first element is the sensor infrastructure responsible for collecting data on parking space occupancy (Israfilova & Heydarova, 2023). These can either be sensors installed directly in parking spaces or cameras equipped with vehicle recognition functions. The sensors record real-time information about the availability of vacant parking spaces and transmit it to the system's central server. This component provides the system with the latest data needed to make decisions regarding parking availability.

The central control platform forms the core of the system, processing the data received from the sensors and overseeing the operation of all processes. It is responsible for storing, analyzing, and transmitting data, as well as distributing parking spaces among drivers. The platform also communicates with external services, such as payment gateways and navigation applications. One of the key advantages of this platform is its scalability, allowing the system to adapt to changes in the road network and the number of users.

The user interface, implemented through a web or mobile application, serves as the primary means of interaction between the system and drivers (Figure 2).

It provides users with information about available parking spaces, facilitates the allocation of spaces, and enables payment for parking services. A key feature of the interface is its simplicity and intuitiveness: users should be able to easily locate available spaces by using the city map, which displays dynamic markers of accessible parking spots. The interface should also support customizable parameters, such as filtering parking spaces by price, distance, or other criteria, as well as integration with navigation systems for route planning.

To improve the efficiency of parking control, the system ensures integration with external services, including navigation programs, public transportation systems, and payment platforms. Such integration allows users not only to find and reserve parking spaces but also to immediately

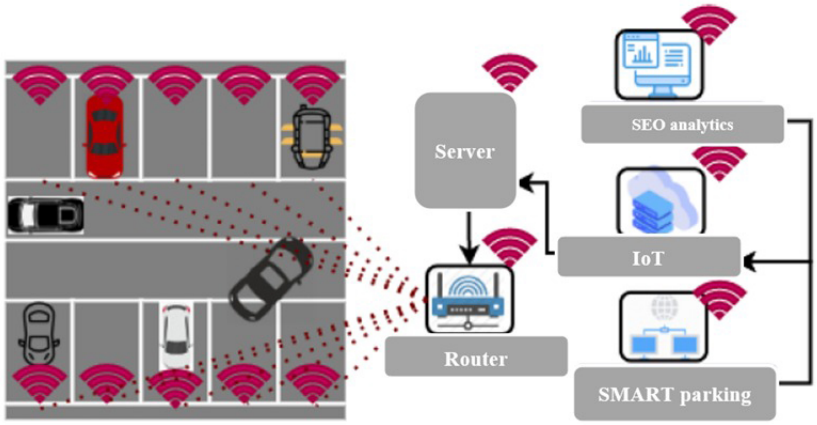

Figure 2: Functional structure diagram of the intelligent parking system implemented via Web or Mobile Application

access references and make parking payments using bank cards or electronic wallets. Ensuring the security of payments and users' data is crucial, and the system must support modern data protection methods, such as encryption and two-factor authentication.

Additionally, the system's important component is its analytics and reporting module. This module enables city authorities and parking zone operators to access information on space usage, conduct analysis, and optimize infrastructure based on the collected data. It helps align parking zones with the real needs of drivers and supports well-informed decisions aimed at improving the city's transportation network.

In conclusion, the structure of the intelligent parking system consists of several components, ranging from sensors installed in parking areas to web interfaces that ensure the continuous operation of the entire system.

4 Structure and Stages of Web Design

Web design and the implementation of the intelligent parking system play a crucial role in ensuring the convenience and efficiency of utilizing this technology. Several aspects must be considered when developing a web application for such a system (Dogan et al., 2016). Initially, it is essential to create an intuitive and user-friendly interface that allows users to easily find information about available parking spaces. The main screen of the application should feature a city map with dynamic markers displaying real-time occupancy of parking spaces. Users should be able to use filters to search by price, distance, and other parameters, facilitating the quick identification of suitable options.

To simplify the allocation process, the number of steps required during the selection and confirmation of parking spaces should be minimal. It is advisable to ensure the availability of detailed information related to the selected parking, including operational hours, service prices, and user reviews.

The security of users' personal information is a crucial aspect of system implementation. Utilizing modern security methods such as encryption and two-factor authentication will help ensure the safety of payments and personal data. Regular software updates and system monitoring are also necessary to prevent potential vulnerabilities. Integration with other services, such as navigation programs and public transportation systems, allows users to organize comprehensive services together. For example, the option to enter route coordinates directly from the application to the parking location would provide additional convenience.

Moreover, it is vital to test the interface with real users at various stages of the application

development. This will help identify potential issues and support improvements in functionality before the final version is released. After the application is operational, feedback and regular updates will ensure its relevance and alignment with user requirements.

Thus, the proposed intelligent parking system consists of three main components: hardware, software, and communication infrastructure. Hardware includes sensors, cameras, and communication devices. The software encompasses user interface design,frontend, and backend systems. The communication infrastructure consists of the Internet, networking devices, and cloud computing (Figure 3).

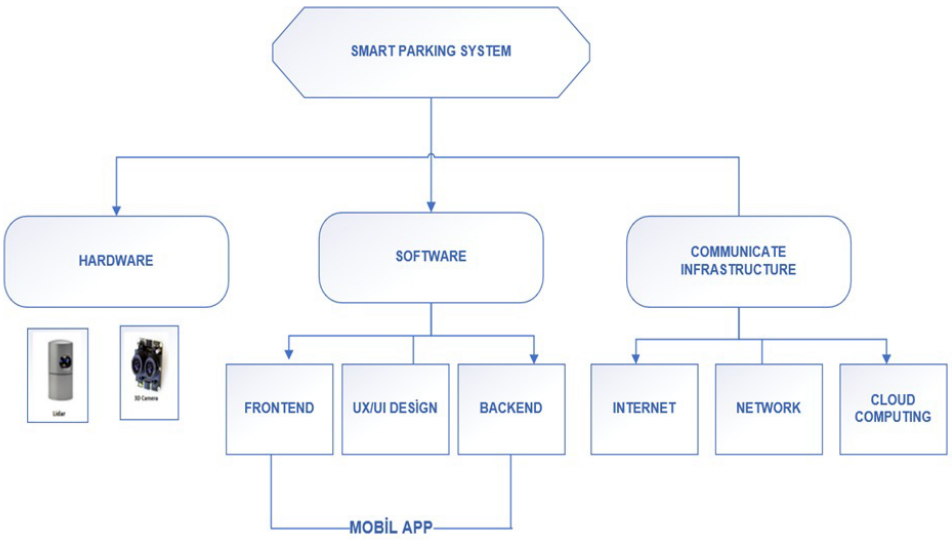

Figure 3: Intelligent Parking System Architecture

The system's user interface is designed to provide real-time data on available parking spaces. Users can access this data through a mobile application or web interface. The user interface also allows users to allocate parking spaces and make payments for services.

The backend system is responsible for processing data collected by sensors and cameras. This system utilizes machine learning algorithms for data analysis and provides information on available parking spaces in real time. The backend system manages transactions related to allocations and payments made by users.

The system's communication infrastructure is designed to ensure a reliable and secure connection between the sensors, cameras, and the backend system. The system uses cloud computing for storing and processing the data collected from the sensors and cameras. Internet access is utilized to provide remote access to the system.

The web design of the intelligent parking system should focus on creating convenient, secure, and functional tools that contribute to the efficient control of parking spaces and the improvement of transportation conditions in urban areas. Thus, the development of the web application encompasses the following stages:

- **Stage 1:** Sensors and cameras are installed in the parking area. Sensors are mounted on the ground to detect vehicles, while cameras are installed on poles to capture the license plates of vehicles.
- **Stage 2:** Creation of the communication infrastructure. The communication infrastructure is established to ensure a reliable and secure connection between the sensors, cameras, and the backend system. This includes setting up network connections between devices and configuring communication protocols.
- **Stage 3:** The user interface is designed to present real-time data on available parking

spaces, allocate spaces, and facilitate payment for services. The backend system is responsible for processing, analyzing, and presenting data on available parking spaces in real-time based on the information collected from sensors and cameras.

- **Stage 4:** The system undergoes testing for compliance with project requirements. This stage involves testing the accuracy of the sensors and cameras, the reliability and security of the communication infrastructure, and the functionality and performance of the user interface and backend system.
- **Stage 5:** The system is deployed in the parking area. The user interface is made available to users through mobile applications.

5 Conclusion

Thus, the implementation of intelligent parking systems will provide significant progress in urban transportation control by addressing the growing problems associated with the increase in the number of vehicles and limited parking resources. The integration of real-time data collection, user-friendly interfaces, and advanced technologies enhances the efficiency of parking solutions while reducing congestion and negative impacts on the environment. International experiences demonstrate the effectiveness of various strategies, such as dynamic pricing models and seamless integration with public transport systems, in several major cities, including Amsterdam, San Francisco, Singapore, and Barcelona. The successful implementation of intelligent parking systems in these cities shows that they can optimize the use of parking areas and improve the overall experience of vehicle control.

A key factor in their success is the focus on delivering an intuitive and responsive user experience, providing essential information and services seamlessly. Furthermore, attention to security measures, such as data encryption and two-factor authentication, is crucial for maintaining user trust and protecting personal information. Regular updates and monitoring of the systems are also necessary to adapt to the changing dynamics of the city and technological advancements.

In conclusion, intelligent parking systems contribute not only to improving urban mobility efficiency but also to achieving broader sustainability goals by promoting responsible use of urban spaces and resources. As cities continue to evolve, the application of smart technologies in parking control will play a vital role in shaping the future of urban life, creating a more organized, accessible, and environmentally friendly urban environment.

References

Aliyev, R.A., Jafarov, S.M., Babayev, M.C., & Huseynov, B.G. (2005). *Principles of Construction and Design of Intelligent Systems.* Baku: Nargiz.

Ali, G., Ali, T., Irfan, M., Draz, U., Sohail, M., Glowacz, A., Sulowicz, M., Mielnik, R., Faheem, Z.B., & Martis, C. (2020). IoT-Based Smart Parking System Using Deep Long Short Memory Network. *Electronics, 9*(10), 1696.

Anjankar, S.C., Zalke, J., Pandey, S.R., Misal, N., & Jawarkar, P. (2020). Vehicle Monitoring System Based on Internet of Things (IoT) for Smart Cities. *Helix, 10*(01), 222-227.

Ata, K.I., Soh, A.C., Ishak, A.J., & Jaafar, H. (2020). A Smart Guidance Indoor Parking System Based on Dijkstra's Algorithm and Ant Colony Algorithm. *International Journal of Integrated Engineering, 12*(2), 1-9.

Israfilova, E.N., Heydarova, A.S. (2023). Digital Transformation of Parking. In *Proceedings of the VII International Scientific-Practical Conference on Applied Systems and Technologies in the Information Society*, Kyiv, 319-323.

Mustafayeva, A.M., Israfilova, E.N., Aliyev, E.M., Khalilov, E.O., & Baxshiyeva, G.S. (2023). Analysis Based on UX Design of Mobile Platforms Applied in Agricultural Sectors. *Journal of Modern Technology and Engineering*, Special Issue — IECHCI2022, 59-64.

Mustafayeva, A.M. (2021). Development Prospects of Artificial Intelligence Technologies. In *Proceedings of the International Scientific Conference on Sustainable Development Strategy: Global Trends, National Experiences, and New Goals*, Mingachevir, 47-53.

Dogan, A., Calp, M.H., Ari, E., & Ozkose, H. (2016). A Review on Brain-Computer Interfaces Within the Scope of Human-Computer Interaction: Features and Working Principle. *Journal of Management Information Systems, 1*(2), 1-10.

Lin, L. (2021). Low Power Consumption and Reliability of Wireless Communication Network in the Intelligent Parking System. *Journal of Ambient Intelligence and Humanized Computing, 12*(1), 1305-1313.

Mackey, A., Spachos, P., & Plataniotis, K.N. (2020). Smart Parking System Based on Bluetooth Low Energy Beacons with Particle Filtering. IEEE Systems Journal, 14, 3371-3382.

Natarajan, P.B., Ghosh, S.K. (2018). Design and Implement Smart Car Parking System Using Lab View. *International Journal of Pure and Applied Mathematics*, 6, 329-338.