

ABSTRACT

The parking management at the TULT building faces challenges in efficiently locating parking spaces for users. Uncertainty about the availability of parking spaces results in wasted time for users and increases traffic congestion in the basement parking area. This problem is exacerbated by the lack of a system that provides up-to-date information on parking availability in real-time, hindering the optimization of parking space usage.

To address this issue, this project proposes a Smart Parking solution using a combination of Internet of Things (IoT) and Machine Learning technologies. This system is designed to provide real-time information about parking slot availability through the use of infrared and ultrasonic sensors connected to the Firebase platform. The E18-D80NK infrared sensor is used to detect vehicle presence, while the HC-SR04 ultrasonic sensor measures vehicle distance. Data from these sensors are then sent to Firebase and processed for display on an LCD screen and a mobile application. The mobile app not only displays real-time information from the four devices but also predicts basement parking congestion using Machine Learning algorithms.

The test results demonstrate that the Smart Parking solution effectively meets various parameters such as aesthetics, ease of maintenance, cost-effectiveness, broad development prospects, low system complexity, and ease of operation. Signal testing was conducted by analyzing average delay values, throughput, and data loss from data transmission using Wireshark. Additionally, application testing was conducted through functional evaluation and the User Experience Questionnaire (UEQ) method, while Machine Learning evaluation utilized Mean Squared Error (MSE). With these results, the third solution that combines IoT and Machine Learning proves to be the most suitable choice for optimizing parking management at the TULT building.

Keywords: *Internet of Things (IoT), Machine Learning, Firebase, User Experience Questionnaire (UEQ), Mean Squared Error (MSE).*