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Integrating Smart Technologies and Mobile Applications to Enhance Shopping Mall Parking Experience

Luwe Li Long[1*], Juhwan Lee[2], Chan Shin Yee[3], Eng Ee Shen[4], Bryan Lok Yi-Jie[5]
[1]School of Computer Science, Taylor's University, Subang Jaya, Malaysia
[2]School of Computer Science, Taylor's University, Subang Jaya, Malaysia
[3]School of Computer Science, Taylor's University, Subang Jaya, Malaysia
[4]School of Computer Science, Taylor's University, Subang Jaya, Malaysia
[5]School of Computer Science, Taylor's University, Subang Jaya, Malaysia

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Corresponding Author
Luwe Li Long
0362330@sd.taylors.edu.my

ABSTRACT

Several studies found that Malaysian shopping malls have reported that traffic issues happen when entering malls. We have found out that the traditional car parking system is not fully utilised with advanced technologies. Here, we come out with a smart parking system called Smart Park. Smart Park is the evolution of the car parking system by integrating traditional parking systems, IoT devices and mobile applications together. Smart Park is important as it can overcome the traffic issue happening in car parks in Malaysian shopping malls. The goal of this study is to find a solution to save customers 'time and enhance customers' parking experience before entering the mall. We aim to solve public issues of wasting time in finding car parking in shopping malls and using advanced technologies to overcome the issues.

1.Introduction

The concept of smart parking systems, SmartPark comes with car parking systems and IoT devices working together. IoT devices can be controlled and connected to each other by using the Internet. IoT devices which will be used in the smart parking system include sensors, remote monitoring devices, IoT gateways, cloud platforms, etc. Smart parking systems are important in shopping malls nowadays. It is also one of the factors to overcome heavy traffic. The current situation which happens in various shopping malls is heavy traffic in the car park. People spend much of their time finding empty parking lots which leads to heavy traffic. Smart parking system is the evolution of traditional car parking systems which integrate with mobile applications and IoT devices. The purpose of this study is to optimise and streamline user parking experience. Smart parking systems benefit users as one of the most important factors is time saving. Users are able to save more time finding a parking spot as the mobile application is able to give correct directions to the available car parking. It is also able to help users to find the location of their parked vehicle.

2.Related Works

Firstly, we shall begin by taking a look at one of the local projects our government is attempting to achieve in Malaysia, specifically, the City Council of Penang Island & City Council of Seberang Perai (MBPP & MBSP). They are responsible for the planning and management of many infrastructure or community building aspects including preserving heritage, public hygiene, management of waste and traffic, environmental concerns, buildings, and more within the state of Penang. The Penang 2030 initiative is a vision enacted by them in an effort to bring about the state to improve all aspects of urban life with smart city integration. To achieve this, one of the things they needed to implement was a smart parking solution.

It is a no-brainer as to why a smart city would require smart parking, it is the very definition of utilising IoT and networks to increase efficiency and reduce hassle through smart systems. Bringing about many quintessential benefits such as streamlining the availability of parking, saving on time, reducing traffic jams and climate-damaging CO2 emissions or greenhouse gases, as well as optimising payment methods for security and convenience's sake. Using a contactless payment system greatly helps against the uprising of the COVID-19 pandemic. Furthermore, as they needed to transform a whole city, a lot more work needed to be done as opposed to smaller parking spaces like in a mall. Penang required a reliable smart parking solution able to resist the hot and humid tropical weather of Penang Island in 36,000 parking locations from Penang Island and the mainland.

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To meet these humongous requirements MBPP & MBSP employed HeiTech Padu Berhad (HeiTech) to develop the system. They have the strength of having a big enough workforce to accommodate such a huge amount of infrastructure in a timely manner. They also have a proven track record, accomplishing 1000 projects and over 800 clients. This improves stakeholder and employer confidence to take them on to complete the task, otherwise, MBPP would never have considered them as a realistic option. HeiTech developed their solution by connecting surface-mounted IoT devices in every parking space to the central dashboard via the Xperanti IoT 0G Network.
That brings me to my next point, the network operator chosen for this task was Xperanti IoT. They operate Malaysia's largest dedicated nationwide IoT 0G network, which is powered by Sigfox's global 0G Network technology. These attributes and being the only provider of exclusive access to Sigfox technology made them a suitable candidate for the Penang Smart Parking (PSP) system.
To elaborate more on the 0G association, it is a representative body of up to 70+ national 0G IoT solution providers globally, powered with the Sigfox 0G technology. Working in tandem to uphold the global 0G network supported by the 0G ecosystem. This network has many benefits that bode well for a large-scale system like this including low power usage, a wide area network functional enough to connect so many devices together, relatively low cost, and long connection range up to 20 km signal range.
The overall project was a success as they were able to achieve a quick surface mounting IoT-enabled device that only took less than 30 minutes for each parking space. Furthermore, they are painted yellow for increased visibility to the public. Each mounted device has been adapted to fit Penang's weather conditions as they are IP67 weatherproof certified, which includes dust and waterproofing. The devices are fitted with a long-life lithium battery with up to 10 years of battery life. All in all these attributes collaborating in harmony produced a durable sensor that can last long while requiring minimal maintenance.
The PSP application boasts an e-wallet that can be reloaded from a myriad of options including Boost, Touch 'n Go, Razer Pay, AliPay, credit/debit cards, as well as online banking; this makes payments extremely convenient. The application has attracted over 500,000 users since they started in 2018, a testament to the application and smart parking system's effectiveness.
However, it is not all rainbows and butterflies for the project as they had encountered a technical hiccup regarding the wallet balance display on January 10, 2022. Whereby the Penang Smart Parking (PSP) application had all users' eWallet balances locked at appearing to only have RM4.40 regardless of the actual balance. The PSP application is how the users' interact and pay the parking fees and summons in the Penang smart parking system, with this in mind it puts in perspective how abhorrent of a situation this would be. Made even more apparent by the countless users complaining about the technical issue on PSP's Facebook and Instagram accounts. Where PSP posted an official apology at around 1 pm the same day for any inconveniences that may have been caused. Some users even spread rumours about the possibility of weak cybersecurity in the system or an internal breach taking place.
The technical error was resolved the following day, as said so by the state executive councillor Jagdeep Singh Deo. He assured the public that the problem was not caused by a cyberattack or hacking, but an internal technical issue that did not affect users' e-wallet balance. Appropriately, the two Penang local government councils did not penalise users who could not pay their parking fees during the time of the technical issue. Although, this issue spiked users' frustration and the rumours of a hack likely damaged consumer confidence. The situation was handled professionally and fixed in a day. [10-17]

3.Materials and Methods: Design and Development of Smart Parking System

The design and development processes used to produce the proposed prototype of a smart parking system called SmartPark (Fig. 1) are described in this section. By providing navigation support, real-time availability data, and an intuitive mobile application, the system seeks to increase parking efficiency.

Hardware Prototyping

The hardware components chosen for the prototype prioritise affordability, ease of use, and scalability.

Microcontroller Board

The selection of the Arduino Uno and Raspberry Pi 4 Model B is supported by factors like affordability, ease of use, and accessibility to online resources. These are implemented to the microcontroller board to communicate with various sensors and actuators installed in the parking lot.

Identification of Parking Slots

To detect parking space occupancy, it is possible to track it with ultrasonic sensors. Green/red light indicators are integrated with Ultrasonic Sensors to contribute to efficient user guidance on the identification of whether the parking space is empty or occupied.

Software Tools and Techniques

Mobile App Development

The design of mobile app was designed using Figma, which it includes features like searching for parking space, real-time parking availability information, navigation assistance for finding the nearest parking as well as allowing users to check the details of their parked vehicles. These include the name, floor, parking space number as well as the fees of the parking lot.

Cross-platform frameworks like React Native or Flutter (additional) are also being used to save time and money during development by enabling the creation of mobile apps for both iOS and Android from a single codebase.

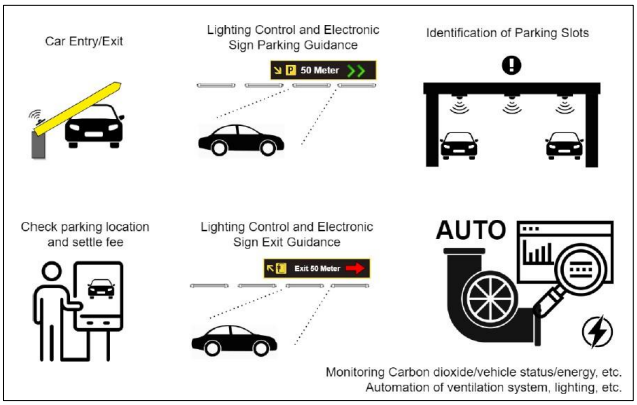
Microcontroller Programming

Python and C++ are selected for microcontroller programming due to their extensive libraries and resources as well as being suitable for sensor data processing and real-time control.

Cloud Platform Integration

Integrating with cloud platforms like Google Cloud Platform (GCP) or Amazon Web Services (AWS) can assist in user authentication, scalable data storage, as well as real-time communication between the mobile app and the backend system . Every parking space in the parking system has sensors installed to identify the presence of cars. The data collected from ultrasonic sensors is safely kept in the centralised cloud platform, which receives this information. The Cloud technology keeps track of available parking spots and differentiates between occupied and unoccupied spaces. Users can easily obtain real-time parking data using our mobile application connected to the cloud platform. This feature improves the entire parking experience by making it simple for users to obtain details on available parking spots.

Fig. 1. SmartPark Picture Description Diagram



Testing

The four primary testing phases essential before a program is approved for usage include unit testing, integration testing, system testing, and acceptance testing . To make sure the system operates as intended when it is isolated, unit testing involves verifying the functionality of individual units or components. To guarantee smooth communication and data sharing, integration testing focuses on examining how various modules interact with one another. System testing assesses the software system as a whole to make sure it satisfies requirements and operates correctly generally. Lastly, acceptance testing is putting the software through tests with stakeholders or end users to make sure it fulfils their expectations and is ready for deployment. Together, these testing phases find bugs, ensure the quality of the programme, and give consumers a reliable product.

Quality Assurance Techniques

Before a mobile app is released, quality assurance (QA) methods are essential to its success . One of these techniques is having skilled engineers analyse the code to look for errors, security flaws, and potential improvements [18-25]. Usability testing is the next step, in which users engage with the system to find usability problems and evaluate the user interface (UI). Next up is performance testing, which evaluates how well the application responds and can manage expected user volumes under various loads [26-31]. Last but not least, security testing seeks out and addresses security flaws to stop illegal access and data breaches. Developers that use these QA techniques can enhance the app's usefulness, security, and dependability. In the long run, this will lead to an improved user experience.

Methodological Framework for System Development

The methodical methodology used in the creation of the smart parking system is described in this section. Continuous improvement was a part of the iterative development process, which was driven by user testing and stakeholder feedback. Validating important features and resolving potential problems early in the development cycle were made possible in large part by prototyping. Collaboration techniques including frequent meetings and status reports made sure that team members were communicating effectively. Throughout the development lifecycle [32-37], tasks were coordinated, progress was monitored, and risks were managed with the use of project management tools. This section, taken as a whole, emphasizes the methodical approach used to guarantee the effective design, development, and integration of the various parts of the smart parking system.

4.Discussion

The main goal of the SmartPark system is to solve customers' parking-related problems and improve customer experience by utilising Internet of Things (IoT) technology. The system optimises managing parking space, and time consumption. This will reduce vehicle activity time in the parking lot. The result in reducing vehicle activity time in the parking lot will have a positive impact on the environment by reducing carbon dioxide emissions from vehicles. Not only that but improving the parking experience for consumers.

SmartPark offers solutions that use integrated sensors, mobile applications, and data analytics to address and enhance the aforementioned challenges. In detail, the system uses sensors such as ultrasonic sensors along with LED indicators to detect vehicles and deliver real-time information about parking availability to the customer's mobile application. It efficiently guides users to the nearest available parking spaces.

Compared to current smart parking systems that only display available parking spaces, this SmartPark solution system directly guides users to the nearest available parking space. These features save customers time looking for a parking space.

In addition, the app allows customers to easily find a parking space and receive navigation instructions by integrating real-time parking status data with mobile apps with user-friendly interfaces able to set smart parks apart from other solutions that lack interactivity and convenience.

Additionally, consumers can use our app to always monitor the location and costs of their parked vehicles once they have parked. This will address the problem of forgetting where the car is parked and enabling one-touch parking fee viewing.

The SmartPark system offers several key advantages and limitations.

Advantages

Firstly, Cutting-edge technology, utilised by monitoring and management systems, efficient management allows human resources to be minimised. Second, Directly guiding users to available parking spaces and providing real-time information, time-saving and stress-reducing for customers. This will significantly enhance user experience. Third, the modular design adopts various sizes and configurations of related facilities, expansion, and applications. Fourth, Traffic improvement, parking environment enhancement, and carbon emissions reduction, by optimising parking space utilisation and reducing time spent searching for parking. Lastly, through data analysis, parking operations are optimised using the data collected from SmartPark sensors and mobile applications via cloud platforms. This process provides valuable insights into customer parking patterns, peak hours, and behaviour, empowering operators to make data-driven decisions.

Limitations

However, there are also limitations to the implementation of the SmartPark system. First of all, this solution deployment requires an initial investment in IoT hardware, software development, and also in infrastructure upgrades, to prevent this, owners (projectors) must carefully measure the cost-benefit analysis. They may also have long-term limitations compared to the current traditional parking system. The IoT devices and sensors used in the system require regular maintenance. It may require periodic checks for technical issues or vulnerabilities and may also need software updates to ensure optimal performance. The success of SmartPark depends on customer adoption of the mobile application and trust in the system's guidance. Not only marketing efforts but also emphasising ease of use may be necessary to encourage widespread adoption. Finally, integrating SmartPark with existing traditional parking systems/infrastructure can pose challenges. Particularly for older shopping malls or related facilities using legacy systems.

5.Conclusion

Combining car parking systems with smart parking systems, such as sensors, remote monitoring devices, gateways, cloud platforms, and microcontrollers can improve traffic management in shopping malls. These traditional car parking systems are combined with mobile applications along with IoT devices to deal with the heavy traffic rush. To achieve this objective, it is crucial to optimise user parking experiences by helping them save time in directing them to available parking spots. The study aims at optimising and streamlining the users' parking experience reducing the time spent on finding empty parking lots in shopping malls.

This study aims to improve customer's experience with parking systems within the shopping mall. To be exact, SmartPark utilises the use of Internet of Things (IoT) devices such as sensors, gateways, Cloud Services, LED indicators, microcontrollers and many more. With navigation support, real-time availability data, and an intuitive mobile application, the system seeks to increase parking efficiency for customers. With the implementation, it reduces carbon emissions as Electric Vehicles (EVs) are not very common in the market yet, there are still many vehicles that are powered by petrol. With the reduction of carbon emissions, it aligns with the Sustainable Development Goal (SDG) 13, which is taking climate actions.

SDG 13's main objective is to decrease greenhouse gas emissions caused by carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases. One way in which this can be done, proposed by SmartPark, involves improving parking management and time spent when using vehicles. By doing so, it means that it will take less time to park a vehicle in the parking lot. Decreased period of vehicle activity in the parking lot leads to cutting down on CO2 releases from vehicles in the car park.

Utilising sophisticated technology in parking management, it saves the labour force and resultantly offers a better service to the user. Getting real-time information on which bays are empty helps reduce stress levels for drivers as they do not have to move from one bay to another in search of an empty one. The use of modular design styles has helped in creating a good traffic and parking environment hence reducing carbon emissions. Data analysis derived from SmartPark sensors and mobile applications offer valuable insights into customer patterns and behaviours, allowing operators to make decisions based on data.

In the world of intelligent parking systems, there lies a strong backbone built on thorough testing that offers users a great experience. It makes sure that technology meets the peculiar needs of users, operates smoothly and has user-friendly displays. Imagine yourself driving to an overcrowded city centre, desperately in need of a parking bay; this is just what the picture indicates. When equipped with such a system for smart parking, your journey becomes smooth as you don't even have to think about it and let it anticipate your needs to guide you without any hitches towards open space along your way. Every time we test, we get closer to ensuring all interactions are intuitive and stress-free so that our clients leave us with the impression that they can always count on us anytime they think of our services. Additionally, this evaluation process also goes beyond back-end checks into other areas such as performance improvement or better service delivery which can be realised through smart parking systems (Molina et al., 2015). By finding out possible areas of concern in advance so as to make improvements before deployment; thus having solutions that can withstand real-world usage more observably than other available options for use in such times like when many people are coming from work at almost similar periods. Last but not least, let's not overlook the fact that testing ensures that there will be no surprises or disappointments later on, when it would be too late to fix them.

6.Future Works

Other than the integration of IoT devices, smart parking systems can use advanced data analytics methods to assess parking data on a real-time basis which is useful for decision-making. These systems rely highly on predictive analytics, which makes use of historical parking data and external factors to predict future demand for parking accurately. By predicting the demand patterns, smart parking systems are able to proactively manage resources to optimise space allocation and minimise wait times for drivers. Moreover, anomaly detection algorithms quickly detect any anomalies or unauthorised activities within parking spaces thereby enforcing compliance with regulations and enhancing safety in the car parks. Furthermore, optimization algorithms help streamline traffic flow and ease congestion by dynamically adjusting the availability of parking lots based on real-time demand and traffic conditions. Smart Parking Systems can thus significantly improve efficiency as well as convenience and safety of users by leveraging evidence-based insights while supporting sustainable urban mobility ecosystems generally.

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