RFID based on-the-spot navigation system for car parks

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***Abstract*—People spend a significant amount of time in their life finding parking whenever they visit shopping malls or travel to various places of their interest. Malaysia is known for its huge number of vehicles travelling every day during the morning rush and after work. Although many existing systems are in place to solve the parking problem, most of these systems lack coordination and on-the-spot navigation. Most of the time, the parking system is not well maintained, which sometimes leads to misleading information about the number of available parking spaces at the given time. This research aims to change how the current "smart parking system" works by implementing on-the-spot navigation based on RFID, which will always lead the user to the nearest parking space. As a result, it will reduce the time spent finding vacant parking lots.**

Keywords*— *IoT based car parking, RFID based car parking, smart carparking, intelligent car parking system

I. INTRODUCTION

RFID is an acronym for Radio-frequency Identification and is a technology that can be found at almost all the toll stations around Malaysia. RFID works are similar to the barcode system found in supermarkets, shopping malls, and any other shops that sell any products where a barcode is attached to a product and can be scanned using a barcode scanner to retrieve the particular information product. The advantage of RFID over the barcode system is the distance whereby the barcode needs to be close to contact to read the barcode. The RFID reader can read the tag a few meters away. Hence, Malaysia is starting to implement the RFID system into the toll station in collaboration with Touch & Go.

The navigation system is a system that aids the user to get from one location to another without the need of memorizing the road. Many navigation systems users can download using either Apple App Store or Android Play Store, and the most famous among them was Google Maps and Waze. On-the-spot navigation, on the other hand, works similar to a traditional navigation system. However, instead of displaying the direction on your mobile, a screen will display the direction instead so that the user is not required to keep looking at their phone while trying to drive. The proposed system combines RFID and on-the-spot navigation to improve the current parking system for shopping malls. This system should be implemented into any parking system in Malaysia to improve the existing system. Users are not required to download any application since the navigations shown on-the-spot using the display [1].

IoT is the most innovative resource in manufacturing, commercial, and residential structures every day, playing a critical role [2-3] The only thing users are required to use this system is to register for an RFID tag. The proposed system's aim is to enable the users to enter and exit the mall faster and allow users to locate an available parking lot before they enter the parking area. With the current parking systems, users often spend a lot of time getting the parking ticket when entering the mall and paying the ticket before exiting. In addition, the amount of time users spend finding an available parking lot is ridiculous. The proposed system solves this problem by locating a parking lot for the users before they enter the parking lot.

The purpose of the proposed system is to reduce the time taken for users to line up at the gate when entering the mall and when making payments before exiting the mall. Other than that, the system intends to remove the need for parking tickets altogether where users usually forget where they put it. Furthermore, it helps to save users time to drive around the parking area to search for an available parking lot.

II. PROBLEM STATEMENT

A typical car parking system usually consists of a multi-level garage or multi-level underground garage, which has multiple floors to park and accumulate many cars within a small space [3]. Malaysia is using the same car parking system because a multi-level parking system is the only way to contain the sheer number of cars due to the high growth in the car population in Malaysia. Although the existing parking system has been implemented for quite some time, problems are starting to pop up, especially in universities such as Asia Pacific University (APU). The reason is that many students have different timetables based on their intake; hence students constantly go in and out of the university's parking all the time. This results in the inconsistency of available parking space since students often have their parking location preference, which leads to the parking garage getting filled unequally.

When the next batch of students came to the university, it will be very difficult for them to find any available parking location. Therefore, they usually spend a lot of time going around the parking garage. In addition, the current parking system used by APU uses student cards to pay for the parking before they exit the parking garage, which sometimes leads to students accidentally trying to exist without sufficient funds in their student cards. When this happens, the student will need to go from the parking garage to the top-up kiosk located in

the center of the facility and usually takes some time to resolve. Occasionally, the kiosk machine will break down. Students will be forced to go and top up their student card at the payment counter, and other students paying for other things such as fees or buying assignment submission forms.

According to the problems stated above, a carpark payment system with RFID and a on-the-spot navigation system allows students to locate a parking location without any hassle by using sensors. Moreover, RFID, a contactless payment method powered by Touch & Go, enables students to pay for their parking without opening their car's window. Therefore, it is very convenient, especially on a rainy day. In addition, this system will be using Arduino for the computer. Consequently, it will significantly cut down the cost since Arduino is inexpensive and powerful hardware and very suitable for a parking system. The following shows the benefits of this system.

The car park payment system with RFID and on-the-spot navigation system allows people to quickly enter the building's parking garage without opening the car window by using the RFID tag. After they passed through the gate, the system will locate an available parking location and guide them to the area with on-the-spot navigation on the wall. The display will show the user to the nearest available parking location rather than randomly provide a location.

The main problem when developing an on-the-spot navigation system is the connectivity. Because this system uses multiple sensors located in the whole parking garage, every single sensor will need to be connected using either Bluetooth or Wi-Fi to send the data to the computer, an Arduino board. Although connecting all the sensors and the Arduino using cable is an option, it will be a messy solution. In addition, all the students, lecturers, and staff will need to have an RFID tag stick to their car to use the RFID payment system.

III. LITERATURE REVIEW

RFID mainly used for capturing data such as serial numbers, positions, data, etc., which are stored inside RFID tags. The process of data collection of RFID is possible by exchanging electromagnetic waves between the RFID tags (usually carried by the user) and the RFID readers [5]. The concept of RFID has been around since 1970 but it is not widely used until recently due to the high manufacturing cost to be used on large-scale projects or activities [6]. In fact, due to the high cost of manufacturing RFID tags, they were initially used to track large items such as airline luggage, cows and railroad cars, and the tags are made out of a combination of the complex pattern of metal coils antennas and glass.

RFID has been improving and evolving every year and now many industries are starting to use RFID for logistics purpose such as warehouse management system where they check the status and location of their stocks throughout the whole warehouse. In addition, RFID also started to be used in consumer products like highway toll payment system which cutdown the time of each transaction compared to the traditional method such as Touch&Go or by cash.

There are mainly two types of RFID tags, passive tags and active tags. A passive tag won't transmit radio waves on its own; instead, they need to get power from the electromagnetic energy from the RFID reader's antennas [5].

The maximum range between passive RFID tags and the RFID reader is six meters, and any distance further than that, the RFID tags won't be able to receive any power. Passive tags are commonly used in small projects because of their lower production costs which means less expensive [6].

Fig. 1. Rate of Passive RFID inlays [4]

Active tags, on the other hand, get their power by an on-board battery and provide sufficient energy that allows independent communication capability for 90 meters. Because active tags have internal batteries that power the circuit, they can broadcast radio waves continuously and are common as beacons or trackers to track items in real-time [7]. However, because active tags can broadcast radio waves continuously for a long-distance, they tend to be very expensive.

Fig. 2. An extremely rugged active RFID tag [4]

The way ultrasonic sensors work is by constantly emitting sound waves at a very high frequency where humans cannot hear at all [8]. The sensor will then calculate the distance between the object and the sensor based on the time required for the sound wave to reflect. Most of the consumer-grade ultrasonic sensors combine both sound emitter and receiver, which reduce the size of the sensor itself and maintain a lower price for accessibility

Fig. 3. Ultrasonic sensor

Fig 4. shows a consumer-grade ultrasonic sensor, and each silver tube represents the emitter and the detector.

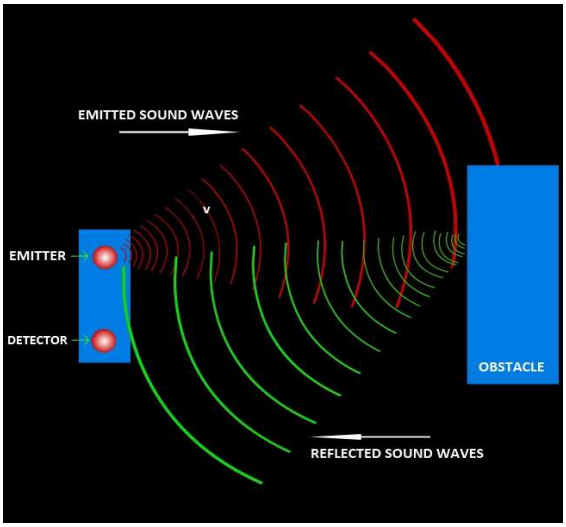

Fig. 4. How ultrasonic sensor works

IV. SIMILAR SYSTEM(S)

Insufficient parking area here in Malaysia is not a newly discovered problem, and it has been the same for many years. However, due to the recent advancement of Information Technology, many researchers have tried to develop a system to solve the issue. One of the famous solutions is the navigation system. One of the previous researches done by [9] created a Smart Urban Parking Detection system. They use Raspberry Pi and Ultrasonic sensors to detect any empty parking lot found in a parking area. This can be done by using the Ultrasonic sensor to detect the distance between an object and the sensor itself to determine whether there is a car in a parking lot or not. In addition, they are using a smartphone application to show the user the current available space and navigate the user to the assigned parking lot.

Another research was done by [10], where they created a parking system that combined Wireless Sensor Networks, Parking Management System, Guidance System and Entrance Display System. They use wireless sensor networks (WSN) as the main system to detect available parking lots by using sensor technology and store them in a database. Next, the user will be able to use the Guidance System to locate

An available parking lot indicates the available parking lot in the parking area using a display. The display will indicate any available parking lot by showing three directions: Left, Right or Ahead for the user to follow. Furthermore, at the parking area entrance, a display indicates the current total number of available parking lots left by fetching the data from the database through the Parking Management System.

Although navigation systems integrated, parking systems are getting more common nowadays due to the advancement of Information technology. Of course, there are many types of research done based on the concept of an intelligent parking system, but few improvements can be made to increase the quality of life for the user. For example, in the system created by [9] and [10], there is room to improve the current parking system, and the navigation system used in their system is not perfect. In the case of [9], the user had to install an application on their smartphone to use the navigation system. Furthermore, the user needs to stare at their phone to navigate around the parking area, and it is hazardous since the user might get distracted and causes an accident. The system done by [10], on the other hand, uses a navigation system that shows very little information. Their Guidance System only offers the three directions of a possible available parking lot, and the user might not be able to find it if other cars are coming in before them.

Furthermore, [11] research suggests four different approaches for Smart Outdoor Parking Systems (SOPS) that exist today. The four different approaches were Computer Vision, GPS, and Wireless-based SOPS. Computer vision uses image processing technology to analyze the CCTV footage to determine the availability of a parking lot and detect all the entering and leaving vehicles by identifying the location of the vehicles. On the other hand, GPS uses satellites to capture the currently available parking lot and send it to anyone who requests parking from the server. After the driver parked at the parking lot, the system will update the server, indicating that the parking lot was occupied. Another approach was Wireless-based, where it connects wireless devices, business networks and applications using radio waves. This approach uses a technology called LowPAN, which stands for Low-power Personal Area Network. This technology had an advantage over others that low power consumption and long-range communication.

Research is done by [12] to create a Parking Bay Allocation and Management System Using LoRaWAN. They use a technology called LoRaWAN that consumes less power while providing long-range communication, which is very suitable for a parking system. This parking system also uses a sensor to detect the vehicle in the parking area. This system also allows motorists the ability to find a parking space without wasting any time. The purpose of the research done by them is to find out why there are many parking space wastages and the difficulty of searching for an available parking space.

In addition, [13] has researched Smart Parking System and its Technology, where they discuss the categories of the smart parking system. The categories include the Parking Guidance and Information System (PGIS), Smart Payment System, and Vehicle Detection Technology which is the necessary technologies required for the proposed system. Because the technologies above were mentioned in other several conference papers indicate that these technologies are not new and there are many solutions deployed successfully. Even though they might be some limitation or flaw about the system but because the advancement of the technology recently will get improve throughout the years

Research done by [14] on the integration of RFID and WSN Technology in a Smart Parking System shows the use of Radio-Frequency Identification and Wireless Sensor Network (WSN) has been found in another Smart Parking System. This indicates that these two technologies were the standard technologies used to create a smart parking system, leading to the stable integration of both technologies. Adding some additional function like navigation system will improve the system and enhance the usability of the overall system.

Furthermore, [15] researched Enhanced Vehicle Parking Monitoring System, created and implemented in their university. This conference paper compares two technologies used in vehicle parking monitoring systems: Vision-based and Sensor-based.

Vision-based technology detects the number of available parking spaces using the surveillance camera, while Sensor-based technology detects through various sensors such as Ultrasonic sensors. Although Vision-based technology has improved a lot due to the advancement of image processing technology, using a sensor to see available parking space is the most reliable solution since surveillance cameras might not work so well during bad weather conditions.

Research done by [16] has shown many types of sensing technology to detect the number of available parking spaces and vehicles. The three mentioned in their research were Induction Proximity sensors, Active Ultrasonic Sensors, and RFID sensors.

The induction Proximity Sensor works by detecting the earth's magnetic field change when a vehicle passed by. This sensor can be buried under the parking lot ground and will detect any vehicle parked on top of the sensor since the sensor is good at detecting metal objects (vehicles). Next is Active Ultrasonic Sensors which can be mounted on the roof of the parking area and detect any vehicles by sending out a pulse of high-frequency sound. These sensors can detect vehicles because once a vehicle is parked at the parking lot, the time taken for the echo pulse to bounce back will be different compared to the ground.

Last but not least, an RFID Sensor requires an RFID tag and reader to function. This sensing technology uses a passive RFID tag which will be placed in a vehicle, and once it is in the range of an RFID reader, the tag will be detected and will send out a signal. Of course, the disadvantage of this sensing technology is that RFID tags are required in every vehicle to work.

V. PROPOSED SYSTEM ARCHITECTURE

Based on the details mentioned in the previous sections, the main function of the car park payment system with RFID and on-the-spot navigation system or CPS, in short, is to improve the current parking system in most of the shopping malls, universities, open-air car park, etc.

One of the main features of CPS is finding the nearest available parking space whenever a car has entered the gate and guild the user to space. This feature removed the user's need to drive around the parking area to find available space every time they enter the gate, which saves their time. This is made possible by using ultrasonic sensors to detect the presence of cars based on the distance of ultrasonic waves that bounced back after hitting the car. After knowing which parking space is available by the value to bounce back by the ultrasonic sensors, the system will indicate which parking at which row and which side of the whole place is available. This works by scanning and retrieving the data collected by the ultrasonic sensors so that once an ultrasonic sensor gets a value above a certain amount, it will recognize it as available space. Using this system, users only need to enter the gate and follow the screen on the ceiling to their designated area without any hassle.

Other than that, the way user enters the parking area is by using RFID. In Malaysia, we have a widely used payment method by using Touch & Go cards, a card that holds money and is commonly used at train stations, convenient stores, and some restaurants and shops that have started implementing it. Touch & Go is brought up here because they have a thing called RFID payment where users can pay using their Touch & Go card with RFID when travelling through toll. By using this technology, users will be able to pay for their parking fees with RFID and remove the need to carry an extra card or, even worst, take a physical parking ticket, which sometimes will be replaced by users. With RFID payment, users need to top-up their Touch & Go card with an e-wallet tied to an RFID payment method that makes their life easier instead of keeping track of all their cards. For example, in Asia Pacific University, the students are using their ID card as a payment card to access the university's parking area. Although students can check their remaining balance of the card using an apps created by the university, the kiosk machines to top-up the card are located in the centre of the entire university. This causes inconvenience to the students, especially when they only notice they don't have enough balance to exit the parking area because they need to walk back to the university and the kiosk machines, which takes a long walk.

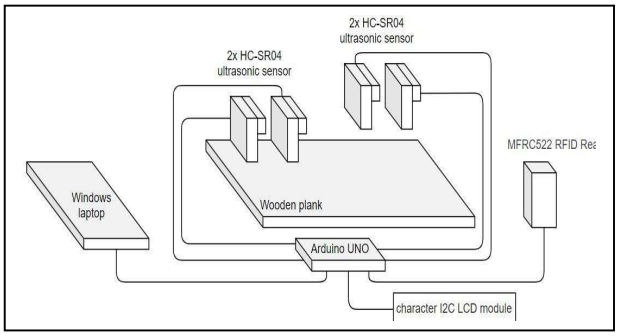

Fig. 5. Overall layout for the CPS prototype

In case of a shopping mall, for instance, users will avoid few problems by using a RFID payment instead of a physical parking card. First of all, users will avoid losing their physical tickets, as mentioned in the previous point. Many users tend to forget where they put their parking ticket when they try to pay for it before exiting the mall. Sometimes even worst, the user will accidentally leave the ticket inside their car, walk to their car and go back to the mall to pay for their ticket. In addition, when users try to pay for the ticket during the closing of the mall where everyone is trying to leave the area, they will end up required to queue up for it. If they are using RFID payment, queue up to pay for their ticket or lose the parking ticket can be avoided since the payment will be made at the gate after they scanned with the RFID, which will deduct money from their Touch & Go.

VI. CONCLUSION

The authors analyzed the different RFID tags to determine which is suited to be used in the existing system. Even though this research is done during the challenging phase since a series of a pandemic is happening worldwide, luckily, research work was managed to be conducted without any obstacle.

In addition, the authors also managed to further enhance their knowledge of the various IoT related concepts and applications. Last but not least, at the end of this report, the authors are satisfied with the findings and the knowledge obtained throughout this research. Furthermore, they believe that the implementing phase will be less stressful with all the information on hand.

A perfect system never exists, so does this proposed system. Any system will have some limitations to it. The limitation of the system is that users will not know the current total available parking lots left, before they enter the parking. There won't be any display indicating the number of available parking lots left, so the user might need to drive out the parking area if the system can't find any parking lot. Furthermore, the user will need to stop and wait in front of the parking area to find an available parking lot, and it might take some time to browse through the whole system.

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