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POLYTECHNIC UNIVERSITY OF THE PHILIPPINES

ParKo: IoT-BASED SMART PARKING SYSTEM

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Bachelor of Science in Degree Program

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CERTIFICATION

This thesis, ***ParKo: IoT-BASED SMART PARKING SYSTEM*,** prepared and submitted by IRIS MAE B. LIMBO, DANICA BEA B. NERI, and GABRIEL M. VILLEGAS in partial fulfillment of the requirements for the degree BACHELOR OF SCIENCE IN COMPUTER ENGINEE has been examined and recommended for Oral Examination.

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CERTIFICATION OF ORIGINALITY

This is to certify that the research work presented in this thesis entitled *ParKo: IoT-BASED SMART PARKING SYSTEM* for the degree Bachelor of Science in Computer Engineering at the Polytechnic University of the Philippines embodies the result of original and scholarly work carried by the undersigned. This thesis does not contain words or ideas taken from published sources or written works that have been accepted as basis for the award of a degree from any higher education institution, except where proper referencing and acknowledgement were made.

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ABSTRACT

Title	:	*ParKo: IoT-BASED SMART PARKING SYSTEM*
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The research addresses the problem of traffic and car parking, which is one of the issues of more traffic and how the driver's attitude towards the use of the ParKo System. The purpose of the research is to reduce the time of finding parking slots in buildings and further the efficiency of it. In this study, the researchers will utilize statistical tools to examine and interpret the data once they have gathered it all. What the researchers found out is that the reason why people don't get to their destinations quickly is because of people's inability to find slots that are free for them to take and they have to look for one for minutes to hours or just wait for one car that leaves their slot.

The researchers, based on their findings with the prototype, said that having to understand the problem of car parking would help the system greatly and could improve it further with a couple of adjustments in terms of materials used in the model and improvements in the design.

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Chapter 1

THE PROBLEM AND ITS SETTING

Introduction

Metro Manila, the capital of the Philippines, can be one of the busiest road traffic in the world. It is estimated that 36% of Filipino households own a single car and some 16% own more than one. This leads to severe traffic congestion during peak hours of the day which is estimated to be a 20 minute to an hour for a commuter and car owner to wait. Considering the many advancements in technology that are available and are being utilized in the country, traffic is still one of the most prevalent issues that are yet to be resolved. Increasing car ownership accompanied by the lack of parking space can cause intense traffic. On average, 34 percent of traffic was cruising, and the average time it took to find a space was eight minutes. These results are selective because researchers study cruising only where they expect to find it: on downtown streets where traffic is congested and all the curb spaces are occupied. (Hampshire & Shoup, 2018) these findings are subjected to certain locations, times, and road types that are believed to have most critical traffic.

In a 2016 study called Smart Parking System Based on Embedded System and Sensor Network it shows that based on surveys they have conducted, the researchers have found that in one year, car cruising for parking created the equivalent of 38 times trips around the world, burning 1.7 liter of fuel and producing 730 tons of Carbon Dioxide (Ibrahim et al., 2016). Meaning parking search traffic can not only affect road traffic but also the environment, producing unnecessary byproducts such as Carbon Dioxide. The authors have suggested to broaden the scope of the device since they focused on private parking lots with a much lesser space.

Based on the analysis of the interactions among the parking lot, the central server, and the vehicular drivers, an algorithm of appropriately assigning the parking spaces was proposed. The results indicate the parking lots were utilized efficiently and the traffic congestions were alleviated. (Ni & Sun, 2017). This study proved that parking reservation can lessen traffic and parking spaces are much more utilized than before. Unfortunately, this study mainly focused on the aspect of replying to reservations and not so much in the simulation of steps. The limitation of this study is authors only focused on the aspect of replying to the reservation requests, seldom presenting the simulation steps explicitly. As a result, investigating the reservation process and providing a useful analytic tool is crucial.

Another study called A City Parking Integration System Combined with Cloud Computing Technologies and Smart Mobile Devices concluded that Cloud computing technology obtains information at low costs via convenient ways, causing it to become the focus of the technology industry today. Nevertheless, the impact, influence, and integration of the different platforms that cloud computing technology brings have provided the direction for the current study (Yeh et al., 2016). The research utilized the use of Cloud computing technology and the use of Radio-Frequency Identification (RFID) and how it can affect the user's convenience.

The main feature of ParKo: IoT-BASED SMART PARKING SYSTEM will be the generation of unique QR-Codes to the user, the purpose of this feature is to ensure secured parking lots, fast entry, and less contact between people. The QR code will be for reservation slot guarantee, this will ensure that those who enter will be only those who has a unique QR-Code.

Theoretical Framework

This research is based on Managing parking spaces in vehicular networks which states that through maximizing the use of all the available parking slots by avoiding a parking space to remain available if there are vehicles searching in its vicinity (Delot et al., 2013). By advertising a single parking slot, it is imperative that the slot will only be sent to a single driver to ensure that there will be no overlapping of reservation.

From the Survey of Smart Parking Systems Mathias, they have compiled different types of Smart Parking Systems (SPS) based on the survey conducted from January 2012 to December 2019 from 274 publications. These systems are as follows; Parking Reservation System, Parking Guidance and Information Systems, Crowdsourcing in Intelligent Transport Systems CITS, Centralized Assisted Parking Search Here, Agent-Based Guidance Systems, and Electrical Vehicle Parking Systems Currently (Ogás et al., 2020). Since this study employs some type of reservation feature the Parking Reservation System will be the model.

Conceptual Framework

In this research, the conceptual framework was built on the theory and concepts provided. The conceptual model in the figure below depicts how the system functions and how the technology for the research is related to one another.

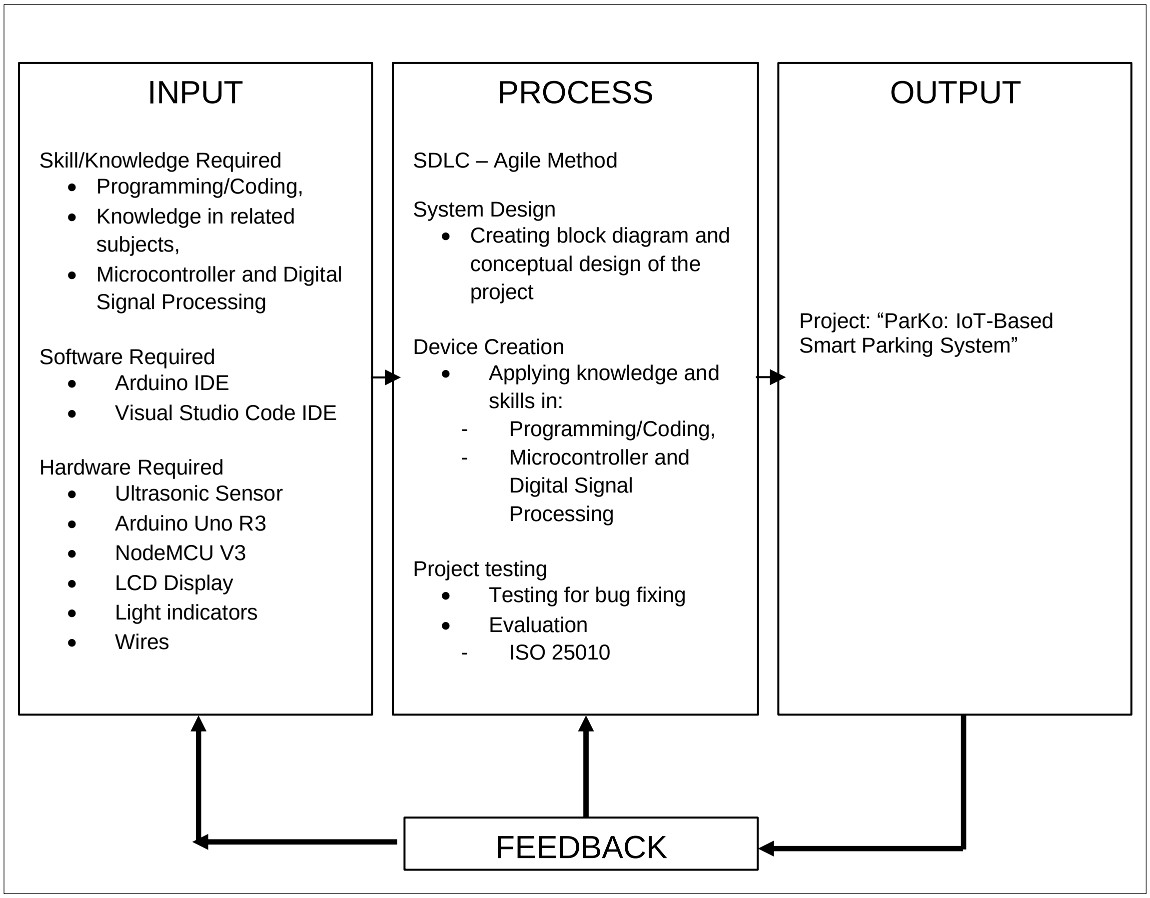

Figure 1. Conceptual Framework Paradigm

To create the prototype, the Researchers need to have knowledge in Python Programming and since this will be the primary language that will be used. Knowledge about microcontrollers specifically Arduino UNO and digital signal processing is also required. The list of important components such as Ultrasonic Sensor, Arduino Uno R3, NodeMCU V3, LCD Display, Light indicators, and Wires are also shown in Figure 1. along with software applications that were used. After completion of the prototype, the prototype will undergo a small-scale testing to ensure that the device is functioning properly.

Statement of the Problem

The goal of this study is to create a device that can reduce the time that motorists spend in searching a parking space, additional to that is to help maintain less contact as well as reduce parking search traffic. The researchers are particularly interested in answering the following questions:

1. What is the status of the parking and traffic condition Paranaque City?
2. What are the stages undertaken in the development of ParKo: IoT-BASED SMART PARKING SYSTEM using AGILE Model?
3. What is the effectiveness of the system prototype in terms of;
   3.1. Notification Speed; and
   3.2. Detection Speed
4. Evaluate the difference between the effectiveness of these two parameters.
5. What issues and challenges are encountered by the Users in using the proposed system?
6. What is the training that can be implemented for the use of ParKo: IoT-BASED SMART PARKING SYSTEM?

Hypothesis

The hypothesis of the study is expressed in different ways as shown below to provide a general idea of the expected relationship between the major variables of the study. The study aims to prove that implementing a smart parking system can help lessen the traffic in Paranaque City by reducing the number of motorists that are looking for parking spaces.

Scope and Limitation

The primary objective of this study is to create a software that can help reduce traffic congestion by reducing parking search traffic with the help of OpenCV, Python, Microcontrollers, and sensors.

The ParKo: IoT-BASED SMART PARKING SYSTEM is a mobile application that will be implemented in Parañaque City Hall located at San Antonio Ave, San Antonio, Parañaque, 1700 Metro Manila. In addition, a software web-based app will be developed as a platform for both administrators and users. The prototype will be tested in Polytechnic University of the Philippines – Paranaque Campus and will be produced in a total of nine(9) months, beginning in October 2021, and ending in July 2022, whereas the definition of requirement stage will last just three (3) months, from October 2021 to December 2021. The initial estimation will be two months beginning on December 2021 and ending on January 2022, High-Level planning will then take three(3) months, this will be done together with the initial estimation both starting at December but High-level planning will take a month longer ending on February 2022. The Iterative Development will be done for at least four(4) months, starting from February 2022 and ending on May 2022. Lastly, the Final Evaluation will begin during the end of the Iterative Development which is on May 2022 and will end on July 2022. With respect to COVID-19 protocols the researchers will conduct the data gathering with the use of Surveys and coordinated Interviews to authorized personnel. Third-party survey applications will be used to reduce contact between the researchers and the respondents.

Significance of the Study

One of the main importance of this study is that we can determine why traffic can be very problematic and how parking search traffic can directly affect this issue. The ParKo: IoT-BASED SMART PARKING SYSTEM aims to, if not to solve, reduce traffic congestion specifically parking search traffic. The following people will benefit substantially from the outcomes of this project:

Motorists/Drivers. Motorists or Drivers will be the main benefactor of this system since they will be the first ones to be affected. Users will be able to see available spaces and will not be limited by distance. Since it is a mobile application, it can be accessible by most Motorists.

Paranaque City's Local Government. If the results meet the expected outcome of the system this can provide useful information and the foundation for future researchers that are looking for solutions regarding traffic management.

Public places. Shopping malls such as SM Supermarket and Robinsons Supermarket can one of the most populated areas during weekends. Since most Filipino go to supermarket to either eat, bond, and cool off from the burning heat it can be quite crowded resulting in traffic congestions and lack of parking space. If this system will be utilized by this Supermarkets, motorists will be able to see if there are available parking spaces in those areas.

Private Company Parking. Private companies can also utilize this system mainly for information it can provide for the employees to see the available parking spaces.

Future Researchers. The Researchers will be able to set the ground for parking systems here in the future be able to add additional improvements to the project.

Definition of Terms

Provided here are the list of used words and phrases, used in the study, that will be given clarification for how it was used in the study:

Application. Application is a type of software that carry out specific task when called or activated.

Kiosk. Kiosk is a small device with a built-in scanner that can scan specific code to allow entry.

Parking search traffic. Parking search traffic is a kind of traffic that is mainly composed of individuals who are looking for parking space around the area.

QR Code. A two-dimensional barcode that carries information that can be translated by the scanner.

Sensor. Sensor is a device that can detect and read certain information and transfer the data into the main device.

CHAPTER 2

REVIEW OF RELATED LITERATURES AND STUDIES

This chapter will cover four significant topics: Parking System Designs, Effects of implemented parking systems in other countries, Implementation, and Synthesis of the Review of Related Literature and Studies.

Data Statistic of Traffic Congestion in Metro Manila

According to the most recent TomTom Traffic Index data, the annual traffic congestion in Metro Manila has dramatically dropped from 71 percent in 2019 to 53 percent in 2020. This indicates that a 30-minute commute in Metro Manila will take 53% longer than it would in normal. Despite an improvement in annual traffic congestion following the implementation of COVID-19 community lockdowns, the Philippines remains the world's fourth most congested city, having risen from second place in 2019. As per TomTom's 2020 Traffic Index, Metro Manila (in percent) has the same traffic congestion level as Mumbai, India, and Bogota, Colombia

Metro Manila suffers from traffic congestion, which results in time and energy waste, air pollution from increased car emissions, and large financial losses because of traffic accidents. The key to resolving these traffic concerns is to utilize current road resources effectively and efficiently rather than relying solely on road infrastructure developments or improvements to meet increased traffic volumes. Intelligent

Transportation Systems (ITS) has been investigated and proposed as a feasible option. approach and prospective solutions to perceived problems Following a thorough examination of the ITS framework, the identified ITS application that can be utilized to alleviate traffic congestion is traffic surveillance or a long-term data collection system. (Reigna et al., 2021)

Parking System Designs

The Smart Parking System (SPS) is made up of primary and secondary components that serve various objectives. The following are the main characteristics of SPS: In a multilevel parking lot, determine whether each space is occupied. Display directional signage for each aisle, indicating which direction has open spaces for drivers. When a vehicle park is empty, SPS employs ultrasonic sensors to detect it. The sensor sends out a sound that is reflected by the sensor after hitting a solid object (such as a car or the ground). Ultrasonic sensors work on the principle of echolocation, which means that the delay between emitted sound and reflection is longer in unoccupied space than in occupied space. Ultrasonic sensors, LED indicators, network switches, telephone wires, and administration software are all part of the SPS design. The prototype depicts a four-story parking lot with 100 spaces on each level (Kianpisheh et al., 2012)

This research develops and examines the performance of a multi-objective optimization model for optimal node placement in wireless sensor networks, based on preemptive topology management. Two algorithms based on the XPress-suite are described and contrasted in the Mosel language. The findings show that simulating the multi-objective optimization problem with a single-step method is rather efficient, but they also suggest trade-off issues that will require further examination in future work. In comparison to random topology generation, they also demonstrate the importance of using optimal sensor placement in smart parking. With the rise of hybrid networks that use unmanned aerial vehicles (UAVs) as communication backbones or relays for ground-based sensor networks, a 3D version of our model can be used as a first step toward simulating coverage in hybrid UAV/sensor networks. (Bagula et al., 2015)

In Hong Kong, parking reservations for public car parks do not yet exist or are not currently publicly accessible, according to their research and data collecting. They developed a prototype consisting of a web-based management front-end as well as a mobile client to assist the entire flow for car park reservation from member registration, car park searching, making reservations, vehicle check-in and check-out, and reservation logging with a strong sense of the win-win situation in mind. Based on the trial run they conducted, they saw a 6 percent increase in utilization when the car park was initially empty, and a maximum of 9 percent increase with a 5 percent, 10 percent, and 15 percent overbooking rate for gold, silver, and bronze users, respectively, while revenue increased by 6 percent when the car park was filled in advance and vehicles were (Cheung, 2012). Furthermore, users can reserve a guaranteed car park space in advance for a minimal fee, receive membership discounts and benefits, and use a convenient system for searching and making reservations to avoid unnecessary queueing and cycling time issues when looking for an available car park space anywhere.

Effects of implemented parking systems in other countries

While parking shortage problems are well recognized, the cost of providing additional capacity is frequently prohibitive. Smart parking may provide a sensible means to effectively increase parking capacity. The findings of this case study on London's smart parking service are presented and discussed within their paper (Peng et al., 2017). The primary data collection method was a questionnaire completed by 212 local drivers in London. This was supplemented by the gathering and analysis of 470 user comments submitted for the service on the internet.

The parking system is designed in such a way that it is applicable for covered parks, open parks, and street-side parking. The cloud based IoT architecture for smart parking system which contains cloud service provider which provides cloud storage to store information about the status of parking slots in a parking area, etc (Bagula et al., 2015). The centralized server manages to store entire smart parking systems information such as the number of slots, availability of vehicles, etc. This information will be accessed through some secured gateways through the network. This smart parking system consists of several components such as a Centralized server, Raspberry pi, Image capture, Navigation system, a Display device, User device.

Due to advancements in technology, drivers are demanding easier and less time-consuming parking facilities. Various methodologies of smart parking have been implemented to provide better services to the end-users and improve the overall management of the existing parking system. The real-time monitoring of available parking lots and allotment of the suitable parking area by advanced reservation (Lotlikar et al., 2016). After examining the various options, it was discovered that each system has some disadvantages, such as excessive usage of expensive sensor modules, trouble detecting precise parking availability data owing to vehicle speed limits, and so on, use of certain modules, such as Bluetooth, that are only effective over short distances, inefficient user authentication procedures, and centralized management of parking lot databases across multiple regions.

As Ali et al., 2020 stated in their study, “IoT based smart parking system using deep long-short memory network”, The development of IoT based smart parking information systems is one of the most demanded research problems for the growth of sustainable smart cities. It can help the drives to find a free car parking space near to their destination (market, office, or home). It will also save time and energy consumption by efficiently and accurately predicting the available car parking space. In this research, we have developed an IoT-based smart car parking framework (Ali et al., 2020).

The average time of users parking their vehicles is effectively reduced in this system. The optional solution is provided by the proposed system where most of the vehicles find a free parking space successfully. This smart parking system provides better performance, low cost, and efficient large-scale parking systems (Patil et al., 2021). The study showed that the proposed Automatic Parking System has proven to be effective when implemented near shopping centers and other comparable areas. The system does not require observable operation making it efficient and economical.

The smart parking system is considered beneficial for the car park operators, car park patrons as well as in environmental conservation. For the car park operators, the information gathered via the implementation of the Smart Parking System can be exploited to predict future parking patterns. Pricing strategies can also be manipulated according to the information obtained to increase the company's profit. In terms of environmental conservation, the level of pollution can be reduced by decreasing vehicle emissions (air pollutants) in the air. This can be attributed to the fact that vehicle travel is reduced as fuel consumption is directly related to vehicle miles traveled it will be reduced as well.

To help with the situation the smart parking system was developed. Smart parking systems help people find vacant car parks hassle-free and make them convenient. This study was conducted to investigate the effect of smart parking systems (SPS) on parking search times (PST) in large parking lots. SPSs are systems that disseminate real-time parking spot availability to drivers searching for parking (Surpris et al., 2013). The study has concluded that indeed implementing a smart parking system has improved in utilizing the capacity of parking lots. Smart parking system also shows potential in improving looking for vacant parking spaces.

Challenges of Smart Parking System

The challenges we can see are that typically, such systems are intended to aid motorists in locating available parking spaces so that they can choose the best one for their specific needs and such is that it may take longer in choosing their specific space in a kiosk type. The second challenge we see is that owners of car parks are needed to join a City Parking System that the researchers made and must negotiate it. The third challenge is when money is involved owners of car parks would want compensation on installing the system and that it should benefit them when it is installed, so parking fees may change depending on the owners of those car parks. (Nocera et al., 2014)

The type of sensor technology to use is determined by the project's goal and scope. This research looks at two forms of detecting technology: vision-based and sensor-based. Closed-circuit television or CCTV is used in vision-based approaches. One camera is normally responsible for monitoring multiple parking spaces if it is within the camera's view, and image processing software is used to detect parking space status. Sensor-based solutions employ a single sensor for each parking place. (Kianpisheh et al., 2012) Monitoring parking lot vacancies is a useful tool for directing vehicles to available places and making efficient use of parking spaces. There are two types of monitoring and detection technology. The first method counts incoming and outgoing vehicles to estimate the number of remaining vacant parking spaces for the entire parking lot. The second checks the status of each parking space and can be used to direct a vehicle to a free spot. To help the drivers find unoccupied spots a smart system is needed for them to find it faster and easier and that it will provide them the location where they are supposed to go.

RFID stands for Radio Frequency Identification, which uses radio waves to identify animate and inanimate objects. It enables data transmission across a wireless network. RFID technology improves company productivity and gives benefits to both the company and the client. (M. Patil & Bhonge, 2013) Compared to other networks, RFID technology is much more secure. The car identification system uses RFID technology, and there is no need for employees in this procedure. Vehicles are automatically detected, and parking payments are collected through this method. The RFID system allows vehicles to check-in and out in less time while maintaining security and convenience.

One of the most difficult aspects of creating big parking spaces for companies, office buildings, malls, and other structures that demand vast parking spaces is telling visitors of occupied and unoccupied parking spaces. Most visitors may spend up to 45 minutes looking for an empty parking space. In modern technology, certain parking lot systems included a system that could automatically count when a car entered an empty parking place and blocked an infrared signal, alerting the system to count for it. This form of sensor, on the other hand, requires an increase in budgeting to install and maintain. (Suleiman et al., 2013)

Implementation

Smart city applications and services are increasingly being viewed as strategic tools for dealing with rising global concerns like climate change, pollution, population getting older, and energy scarcity. Smart parking is a category of smart services that helps cities reduce traffic congestion and pollution. Nonetheless, while improved information technology drives smart city services, their success is primarily dependent on user involvement, which has historically been a concern. The paper talks about the results of questioning people in London on their experience in smart parking. The questionnaire's result was that the smart parking system may help the drivers to save an average of £68 (62.2 l) on petrol annually and reduce CO_2 emissions by 238.14 kg per car per year (Peng et al., 2017). However, public awareness, actual usage, and user happiness with this smart service are currently at an all-time low.

Iparker is a new smart parking system that objectifies the utilization of parking spaces, improved driver experience, and increased park revenue. The suggested system addresses today's parking issues by providing assured parking reservations at the lowest possible cost and time for drivers, as well as the greatest possible income and re-source utilization for parking managers. New equitable pricing regulations that can be applied in practice are also proposed. The new approach is based on mathematical modeling utilizing mixed-integer linear programming (MILP), to lower overall monetary costs for drivers and increase parking resource usage. The software used to solve the MILP problem is IBM ILOG CPLEX (CPLEX). To evaluate the system effectiveness, sets of data are first randomized to represent the data of parkers, resources, destinations, and pricing. Using Microsoft Excel, the parkers' arrivals are generated following Poisson distribution, and the rest of the parameters are generated following an exponential distribution. A database is then created to store the random data and act as the storage node for the CPLEX program. The CPLEX program inputs the random data generated earlier and updates the database after the parkers' allocation (Kotb et al., 2016).

Synthesis of the Review of Related Literature and Studies

Parking search traffic not only contribute to traffic congestions, but it also emits unnecessary carbon dioxide (CO_2) emission, inconvenience to drivers, and unable to utilize parking lot efficiently. Smart parking systems have one of the greatest potentials in reducing these challenges. With the use of ground-based sensors such as Ultrasonic sensors and wireless sensor networks, RFID technology, and MEMSIC IRIS sensor.
Although there are still some drawbacks in some of the designs such as expensive sensor modules, use of components that are only effective over short distances, trouble detecting precise parking availability data owing to vehicle speed limits, lack of adequate authentication procedures, centralized management of parking lot databases across multiple regions.

The system also varies in implementation depending on the location such as Off-street parking and on-street parking. Off-street parking implementation is much more straightforward compared to the latter since most of them have checkpoints where a kiosk can be placed. This is to ensure that only those people who have a code can enter. On the other hand, on-street parking can be much more complicated since most of them do not have checkpoints to check the codes. One solution for this is to include wireless technology that only the driver who has reserved the spot can access. By achieving this using “folding barriers” or other forms of obstacle can be implemented. The problem with this solution is that it can be very expensive.

Chapter 3

METHODOLOGY

This chapter will cover the different methods that will be used in Smart Parking System, this will be including numerous topics on study design, research instruments to be used in data collection, and use of statistical treatment to be used in project development. Furthermore, several diagrams will be presented for a better understanding of the subject. Block and schematic diagrams, as well as architectural and prototype design, are examples.

Research Design

The research design that will be used in this study is Applied Research. Applied research aims to provide solution to a particular issue or problem an individual, group, or society is facing. It is also referred to as Scientific Method of Inquiry or Contractual research because it uses the scientific method to produce a particular solution to everyday problems.

Exploratory research, a type of mixed research, will also be used in the study. The qualitative data collection and analysis will be done first, followed by quantitative data collection and analysis on the first half of the research. This method is used to answer the research questions such as the status of the parking and traffic condition in Paranaque City, then, include the qualitative types (narrative analysis through interview and observation) and quantitative type.

The systematic study of creating, producing, and assessing instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness has been classified as developmental research, as opposed to simple instructional development. In the realm of instructional technology, developmental research is especially essential. The most prevalent types of developmental research are those in which the product development process is investigated and explained, and the product is assessed. The impact of the product on the learner or the organization is the focus of the second type of developmental study. The third form of research focuses on a broad examination of design creation or evaluation processes as a whole or as individual components. Reports of actual developmental research (practice) should be distinguished from explanations of design and development procedural models (theory). Although it is commonly misinterpreted, developmental research has made a significant contribution to the field's overall progress, frequently providing a foundation for model design and thinking. (Richey, 1994)

Process Flowchart

In this part, the researchers will discuss the process flowchart that will be used in the software development preparation. The researchers will follow the framework of the agile development method. In addition, the group will create a systematic approach and timeframe for the prototype's construction using a Gantt chart for it.

System Development	Oct 2021	Nov 2021	Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022
Define Requirement										
Initial Estimation										

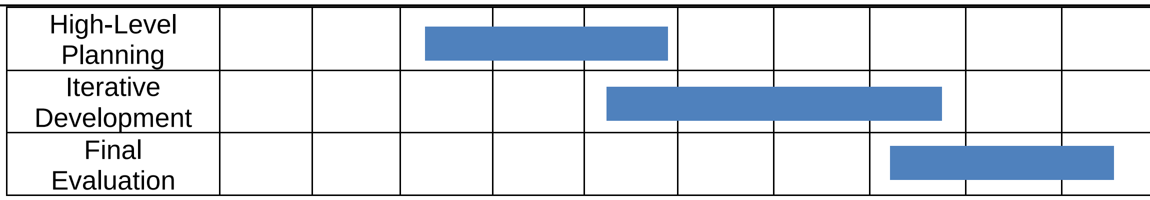

Figure 2. Gantt Chart of the Establishment of the Prototype

Description of Research Instrument Used

The use of the research tools in this study will serve as a guide for how each topic is addressed or resolved by the researchers. In the first section of this study, descriptive and qualitative methods were used to assess the present state of the traffic management system in use in the city of Paranaque as well as the system documentations that were crucial for ensuring the system's high level of quality. Furthermore, the focus of the second section is mostly on quantitative techniques using testing and experimentation.

1. **The current status of Parking and Traffic Management in Paranaque City.** To determine the current parking and traffic management in Paranaque the researcher will have to set an interview with the Traffic and Parking Management Office (TPMO). The researcher will provide a letter of invitation for interview about the said matter. The letter will contain the draft interview question so that the TPMO will be able to prepare for the initial interview. The list of inquiries is created in accordance with the goals of this research: about the current parking management system in the city of Paranaque, how they implement these said systems, issues that were being encountered while implementing the said system, and how they conduct training programs to enforce the said system.

2. **The development stages of the System Prototype.** Agile development techniques are used to create the system prototype. Prior to the actual building of the system, the researchers employ the construction of numerous requirements and documentations to prepare for this. The said requirements will be divided into 4, namely: Business Requirements, User Requirements, Functional, and Non-Functional Requirements. During the iterative development phase, documentations like real screenshots of the prototype development will also be provided.
3. **Evaluation of Prototypes based on Various Parameters.** The parameters for the Application and the Prototype will all be tested to determine the time intervals for each sensor and notifications received. The testing will be conducted at two different times, day and night, and each condition will be tested 30 trials. The data will be gathered by the researchers based on (1) notification speed and (2) detection speed. The Microsoft Excel Data Analysis tool will be used to analyze and interpret the data using the z-test. The information will then be presented as follows in Chapter 4:

Table 1

Sample Presentation of Results for Prototype Parameters

Trial No.	Parameter	Measurement	Remarks
1			
2			
. . .			
N			
Average			

4. **Difference between the Two Parameters.** The hypothesis will also be examined and interpreted using the Data Analysis tool of Microsoft Excel and the z-test formula

utilizing the data acquired from the testing of the prototype's effectiveness depending on the parameters. The following information will be given on the testing of the hypothesis:

Table 2

Sample Table for Results of Hypothesis Testing

Parameters	z-score	Decision
Parameter 1		
Parameter 2		
Parameter 3		
Overall	**-**	**-**

5. **Issues and Challenges on the Prototypes.** The researchers will use the observation approach while running several experiments to accomplish the prior goals in order to overcome this issue. Three (3) major themes, hardware requirements, real-world performance, and parameter efficiency, will be used to group the problems, and these themes will typically deal with the prototypes.

6. **Preparation of the Training Programs.** The researchers are fulfilling the requirements completed from the previous phases of the agile methodology in order to prepare for the training programs that will be implemented once the system is deployed in the actual application. System documentation, project management documentation, and user documentation must be the three (3) key clusters identified in the presentation and interpretation of the training programs. However, the Project Management Documentation also includes the schematics necessary for creating the prototype as well as the Business Requirements. The User Documentation then

displays the User Acceptance Test (UAT) findings from the User Requirements paper.

Statistical Treatment of Data

After gathering all the data, the researchers will use statistical tools to analyze and interpret it. The researchers will use the Weighted Mean, Standard Deviation, and T-Test statistics to organize the obtained data to solve the study's problem.

To compute the central tendency of a data set, the researcher will utilize the Sample Mean formula. In terms of the respondent's evaluation.

$$\overline{X} = \frac{\boldsymbol{\Sigma f x}}{\boldsymbol{n}}$$

Sample Mean Formula

Where: $\overline{X}$ = sample mean

$\boldsymbol{f}$ = individual frequency

$\boldsymbol{x}$ = individual score

n = total frequency

The Z-test will be used to examine the significance of the difference between the Notification speed and the Detection speed.

$$z = \frac{(\overline{x_1} - \overline{x_2}) - \mu}{\sqrt{\frac{{s_1}^2}{n_1} + \frac{{s_2}^2}{n_2}}}$$

Z-Test Hypothesis Testing for Two Samples Formula

Where: $\overline{x_1}$, $\overline{x_2}$ = means of samples 1 and 2, respectively

μ = population mean

s_1, s_2 = standard deviations of samples 1 and 2, respectively

n_1, n_2 = size of samples 1 and 2, respectively

By considering the gathered values from the experimentation of the testing of the hypothesis and the parameters of the prototypes, the test will accumulate significant level of 0.5. It will also implement the two-tail critical value of 1.960. The sample mean shall be used to distinguish the mean of the trials done for the experimentation.

Design Project Flow

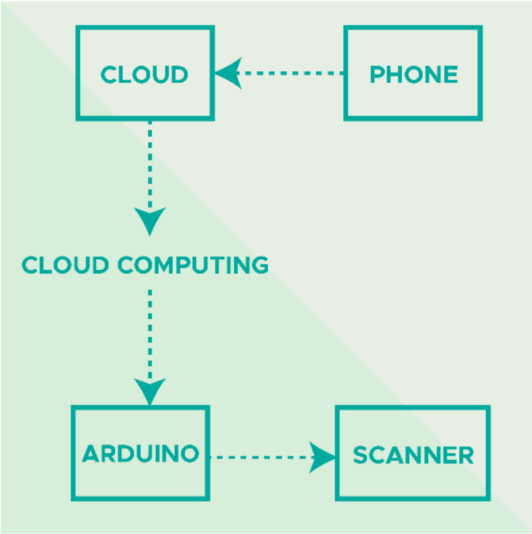

Figure 3. Block Diagram

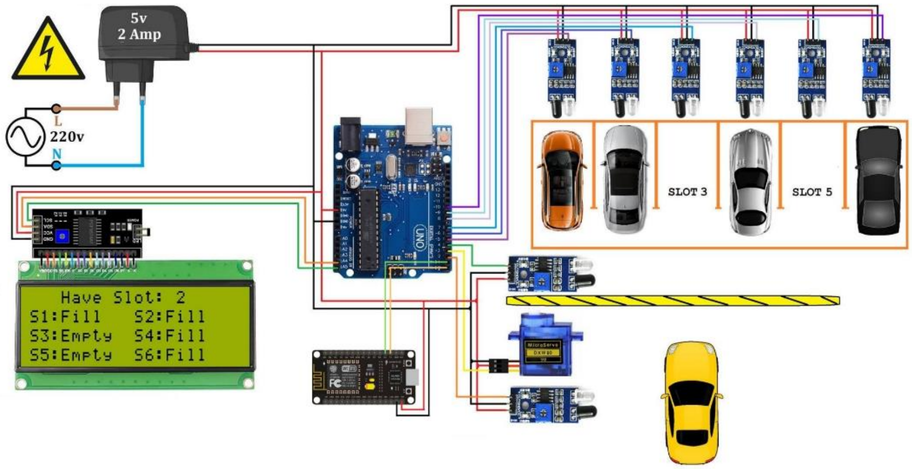

Figure 4. Schematic Diagram

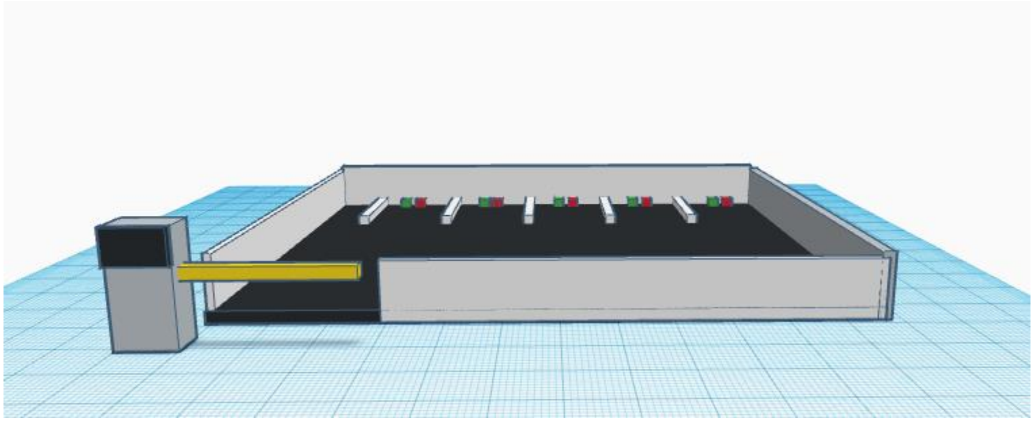

Figure 5. Prototype Design

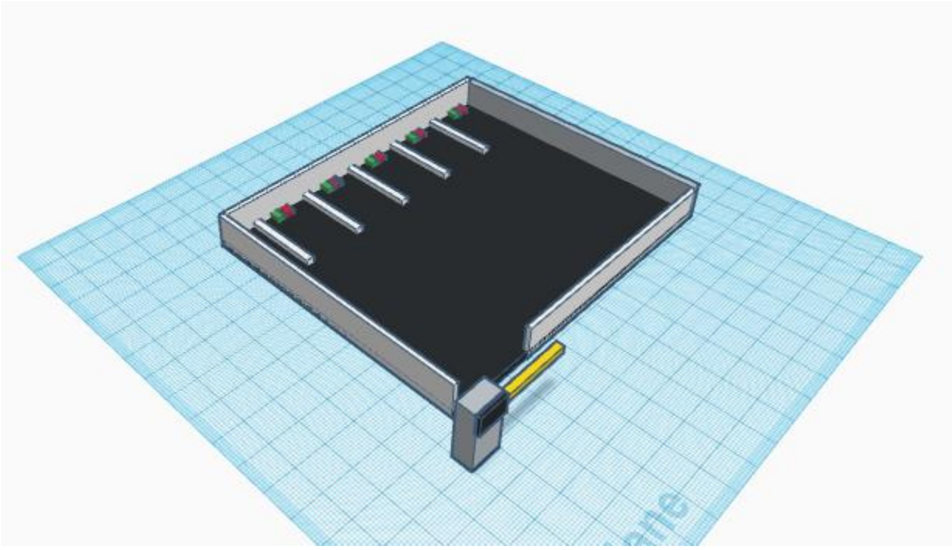

Figure 6. Prototype Kiosk

Chapter 4

RESULTS AND DISCUSSION

In order to solve the various issues and goals of the ParKo: IoT-Based Smart Parking System, the findings obtained will be discussed in this chapter. The researchers used a variety of qualitative and quantitative approaches to gather and display the data. The findings of the study are analyzed, presented, and interpreted in this chapter.

1. **The current status of Parking and Traffic Management in Paranaque City.** The Traffic and Parking Management Office (TPMO) has discussed that the city issues notice to not tolerate illegal parking and also have plans on constructing parking areas. There is also the consideration of the Proof of Parking Space act which requires the buyer to show proof that they own parking space at home before they are permitted to buy a car.
2. **The development stages of the System Prototype.**

   The researchers used agile methodology, following the steps and processes as they created the prototype for the proposed Smart Parking System (Parko). The researchers go through a process of planning, carrying out, and evaluating the progress in the beginning. There were five (5) distinct stages in the creation of the whole system. Definition of needs, preliminary estimates, high-level planning, iterative development, and final evaluation are some of these.

2.1 Stating the Requirements The researchers use four (4) system requirements documents at this stage to guarantee that the system's foundational criteria will be met. It comprises non-functional, business, and functional requirements as well as user and functional requirements. To identify the community needs that must be addressed and handled, the researchers develop the business requirements. The researchers have made sustainable arrangements in this study, such as the acquisition of having access to information, instructions, and notifications on the system's usability that are both plain and intelligible. It also entails effective functioning with little human involvement and proven assistance rather than burden to traffic operators. All of these conditions are essential for the system.

2.2 Estimations for the Prototype The researchers calibrated their findings with diagrams and show how the systems will be visualized. These diagrams may be used to plan out a new system for implementation or to map out an existing system and enhance it. The procedure through which the system will function successfully is described in the Context Data Flow Diagram.

3. **Evaluation of Prototypes based on Various Parameters.** The prototype was tested on two (2) distinct parameters that are critical to the system's operation: notification speed and detection speed. Data for these parameters were collected using 30 trials per parameter during daytime and nighttime.

3.1 Notification Speed. The prototype's initial start time when it identified the automobile and the time the notice was received were initially noted in order to calculate the notification speed. The time interval was then calculated by subtracting the latter from the beginning time. Each of the six sensors in the prototype was tested five times, for a total of ten trials.

During daytime testing the average time interval based on the mean of the 30 trials is 2.870533333s at its fastest time and 5.7413s at its slowest time. On the other hand, during nighttime testing the average time interval based on the mean of the 30 trials is 3.453866667s at its fastest time and 6.907966667 at its slowest time. Making the overall average of 3.1622s for the fastest time and 6.324633333s for the slowest time.

3.2 Detection Speed. The detection speed was calculated by noting the initial start time when the car was put in front of the sensor and subtracting the time when the car was detected by the sensor. This was done with the help of the Arduino IDE. The prototype was subjected to two different scenarios, daytime and nighttime, to test the detection speed and notification speed. All the data that was gathered was then compiled to get the average time each sensor can detect.

During daytime testing for the average time interval based on the mean of the 30 trials is 2.870533333s at its fastest time and 5.7413s at its slowest time. On the other hand, during nighttime testing the average time interval based on the mean of the 30 trials is 3.453866667s at its fastest time and 6.907966667 at its slowest time. Making the overall average of 3.1622s for the fastest time and 6.324633333s for the slowest time.

4. **Difference between the effectiveness of two parameters.** As test results have shown, the two parameters with relation to the time that they were tested have yielded mixed results. Notification speed proves to have a significantly longer time, about a minute, to be received by the user, while the detection speed is about seven seconds before it will be reflected to the app. Despite the fact that the result time may look fast enough, it still does not reach the expected level for a real-world situation.

5. **Issues and Challenges on the Prototypes.** The issues and challenges the researchers encountered is that there were various problems and difficulties when the researchers tried to test or experiment with the prototype. Some of these issues could come up, particularly when a parameter's consistency is being looked at. Researchers identified three (3) problems in this study: hardware requirements, real-world performance, and parameter efficiency.

   5.1 Hardware Requirements. The prototype had potential but in terms of hardware capabilities it is lacking in that department. the prototype used Arduino Uno for the brains of the system and software used was python and the application is the Blynk app, it is a free python-based software that uses Arduino boards.

   5.2 Real-world Performance. The performance was good but not the expected outcome the researchers had in mind.

   5.3 Efficiency in Parameters. The parameters used by the researchers are the speed in detection and the speed of which the notification is received by the driver using the application. As stated, both the detection speed and notification speed are about average or even slow in the test but is consistent it may be because of the sensors used why these are the results.

6. **Preparation of the Training Programs.** When the planned Parko has been accepted and made available to the possible customers, the development for its actual implementation should be accompanied by documentation focused on educating and instructing the system's intended users with all the information they require on its capabilities. These training program documentations should go through rigorous

quality control, systematic implementation, and thorough design. The three most important parts of it are the system documentation, user documentation, and project management documentation.

6.1. System Documentation. Smart parking technologies are beginning to provide answers for urban transportation. The systems goal is to ease the trouble of finding parking slots for the intended users of the system. To develop the system the researchers had to use hardware that are only available for the researchers so that they can make a prototype. The foundation of smart parking is knowing precisely how many cars are present in a parking lot at any one moment and system did exactly that but with little room for improvement when it comes to hardware used in the prototype.

6.2. User Documentation. Smart systems combine sensing, actuation, and control capabilities to describe and evaluate a condition, make judgments that are predictive or adaptive, and take smart actions as a result. The sensors will sense the incoming cars then relay the data gathered to the system where the users that are connected will receive the data and the users will decide what to do with the said information for an optimal outcome for them.

6.3. Project Management Documentation. The project of the researchers was intended for others to experience the smart parking system that other countries have, and make use of the smart aspect of it. The prototype has sensors that will sense objects that come near it in a certain range and send the information to the system so that others will know which is occupied and vacant. The researchers will examine the initial needs, early estimates, high-level planning, iterative development, and final assessment phases of this proposed system. The researchers will gather information for the user, business, functional, and non-functional needs during the requirements formulation process.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter, which serves as the study's final one, contains information about the research, including restated are the research problem, methods, and findings. Additionally, it contains data that readers, in particular future researchers, will find the information pertinent and beneficial for the aim of project development.

Summary of Findings

This study was carried out to deliver meaningful and useful information to help determine if the planned prototype Smart Parking System (Parko) is feasible. The results are obtained and reported as follows through the use of mixed method research, which includes both quantitative and qualitative procedures:

1. **Present day parking system in the Philippines.** The status of parking lots in the Philippines is that they are removing obstructions in roads and sidewalks to lessen the traffic and illegal parking in some cities and ease the conditions. The Office of Parking and Traffic Management (TPMO) will start removing impediments from the sidewalks and roads. This applies to "No Parking" streets as well as busy thoroughfares. The goal of this method was to put the city's traffic management code into practice. Residents were also told that anyone breaking this law will be fined and have their cars towed.

2. **Stages of Prototype Development for the Proposed System.** The creation of a prototype design that would mimic and depict the real system is taken into account. The stages of the agile approach are followed during the development. The following are a few of them: (1) the specification of needs, (2) preliminary estimates, (3) high-level planning, (4) iterative development, and (5) final evaluation. The first part of the research period is when most of the requirements are finished. The first three (3) stages of the agile approach have been completed. On the other hand, the development of the prototype and experiments with the system's characteristics, as well as evaluations to further gauge its quality, take up the second half of the study time.
3. **Effectiveness of the prototype using parameters.** The researchers conducted an experimentation to determine the effectiveness of the prototypes speed in detecting the object that is in coming and the speed in which the notification will be received by the people using the app. The prototypes are evaluated over the course of 30 trials depending on the system's speed in detection, and the speed of the notification. By using the z-test function in Microsoft Excel's Data Analysis tool, all the data are evaluated. What the researchers got in the results is that in the day time interval they got 7.3 secs and at night time they got 7.3 secs as an average of the effectiveness of the sensors in terms of detecting the object.
4. **Issues and Challenges Encountered in the Use of the Prototype.** The findings the researchers got in the development of the prototype is that the problem with the sensors not sensing the cars when entering the toll booth quick enough to let the drivers in parking lot area. Since the researchers only used one prototype and that is the Arduino Uno, they did not test other devices that can be a better system than the Uno. Even though the testing was successful, the development of the

application was not that exceptional by all means because of the lack of applications flexibility to modify it, the researchers used Blynk app because it uses python for coding the application.

5. **Training Program for the Implementation of the Proposed System.** Documents for the system's training programs are developed via the examination of the system requirements and the findings of the experiments. Documentation from the Project Management, System, and Users is included in the training program. It will be utilized for future references for the next researchers in line for the prototype as well as potential operators or users of the system prototype. A copy of the training manual for the prototype is included in the appendices.

Conclusions

For the system, the researchers have collected enough data. The researchers have drawn the following conclusions from the findings presented:

1. Using other Application One of the problems with the system is that the application for mobile and desktop was not flexible enough for the researchers to add the important parts of the application which are the mapping system for the drivers to know which location they are trying to park on.
2. Adjustments on the prototypes hardware the researchers lack the necessary materials for a better system to test it on let alone afford a better system. The prototype can be upgraded for better time intervals on the speed of detection and the speed of receiving the notification.

Recommendations

The researchers have consequently determined the following recommendations to be significant based on the results and conclusions of this study:

School Faculty and Students. The results on the prototype that the researchers gathered, the prototype seems to work as it is intended although it is not the recommended speed the researchers wanted. It did work and the researchers recommend that other students that will come before them would try to modify or upgrade the current status of the prototype and encourage the new generation to carry on this research and continue the capabilities of the said prototype.

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APPENDICES

APPENDIX A

Project Name: ParKo: IoT-BASED SMART PARKING SYSTEM

Hand over by: Limbo, Iris Mae B. Neri, Danica Bea B. Villegas, Gabriel M.	Taken over by :PUP - Parañaque

HAND OVER

Subject matter of handover:	Sytem prototype for proposed smart parking system
Handover method:	Physical discussion and demonstration, email of documents, training program.

End of Documentation

APPENDIX B

	NOTIFICATION SPEED (seconds)						
	DAY		AVERAGE	NIGHT		AVERAGE	OVERALL
	FASTEST	SLOWEST		FASTEST	SLOWEST		
Trial 1	3.268	6.536	4.902	2.725	5.45	4.0875	4.49475
Trial 2	1.306	2.612	1.959	3.313	6.626	4.9695	3.46425
Trial 3	2.497	4.995	3.746	2.521	5.041	3.781	3.7635
Trial 4	3.036	6.072	4.554	3.59	7.181	5.3855	4.96975
Trial 5	2.215	4.431	3.323	2.798	5.595	4.1965	3.75975
Trial 6	2.081	4.163	3.122	4.017	8.033	6.025	4.5735
Trial 7	5.003	10.007	7.505	3.444	6.889	5.1665	6.33575
Trial 8	3.317	6.634	4.9755	4.234	8.469	6.3515	5.6635
Trial 9	1.414	2.829	2.1215	3.193	6.386	4.7895	3.4555
Trial 10	3.987	7.975	5.981	3.923	7.846	5.8845	5.93275
Trial 11	2.896	5.792	4.344	3.393	6.787	5.09	4.717
Trial 12	2.632	5.265	3.9485	3.346	6.692	5.019	4.48375
Trial 13	2.689	5.379	4.034	3.393	6.786	5.0895	4.56175
Trial 14	3.921	7.842	5.8815	3.301	6.602	4.9515	5.4165
Trial 15	2.873	5.746	4.3095	3.414	6.829	5.1215	4.7155
Trial 16	3.51	7.021	5.2655	3.365	6.731	5.048	5.15675
Trial 17	3.01	6.019	4.5145	3.418	6.837	5.1275	4.821
Trial 18	2.434	4.868	3.651	3.35	6.701	5.0255	4.33825
Trial 19	3.608	7.216	5.412	3.448	6.896	5.172	5.292
Trial 20	3.694	7.388	5.541	3.352	6.703	5.0275	5.28425
Trial 21	2.216	4.432	3.324	6.327	12.654	9.4905	6.40725
Trial 22	2.288	4.576	3.432	3.34	6.681	5.0105	4.22125
Trial 23	2.883	5.766	4.3245	3.319	6.638	4.9785	4.6515
Trial 24	2.493	4.986	3.7395	3.314	6.628	4.971	4.35525
Trial 25	1.892	3.783	2.8375	6.335	12.67	9.5025	6.17
Trial 26	3.251	6.502	4.8765	2.929	5.859	4.394	4.63525
Trial 27	2.991	5.981	4.486	3.35	6.7	5.025	4.7555
Trial 28	3.426	6.852	5.139	3.396	6.792	5.094	5.1165
Trial 29	2.73	5.461	4.0955	3.358	6.717	5.0375	4.5665
Trial 30	2.555	5.11	3.8325	0.41	0.82	0.615	2.22375
AVERAGE	2.870533333	5.7413	4.305916667	3.453866667	6.907966667	5.180916667	4.743416667
SD			1.162927994			1.50849742	0.898602244

Figure 3. Effectiveness of the System Prototype in Terms of Notification Speed

	DETECTION SPEED (seconds)						OVERALL
	DAY		AVERAGE	NIGHT		AVERAGE	
	FASTEST	SLOWEST		FASTEST	SLOWEST		
Trial 1	7.31	15.337	15.337	7.277	12.01	9.6435	12.49025
Trial 2	7.317	17.739	17.739	7.291	7.659	7.475	12.607
Trial 3	7.289	12.927	12.927	7.272	12.582	9.927	11.427
Trial 4	7.289	7.945	7.945	7.292	10.833	9.0625	8.50375
Trial 5	7.313	15.059	15.059	7.281	15.906	11.5935	13.32625
Trial 6	7.322	11.93	11.93	7.303	16.916	12.1095	12.01975
Trial 7	7.367	14.188	14.188	7.286	8.009	7.6475	10.91775
Trial 8	7.332	12.024	12.024	7.325	15.33	11.3275	11.67575
Trial 9	7.297	13.086	13.086	7.324	11.336	9.33	11.208
Trial 10	7.317	15.388	15.388	7.341	10.375	8.858	12.123
Trial 11	7.291	7.849	7.849	7.324	12.301	9.8125	8.83075
Trial 12	7.207	18.132	18.132	7.305	12.872	10.0885	14.11025
Trial 13	7.288	11.019	11.019	7.311	15.749	11.53	11.2745
Trial 14	7.329	15.595	15.595	7.268	15.116	11.192	13.3935
Trial 15	7.286	15.858	15.858	7.292	16.956	12.124	13.991
Trial 16	7.309	15.386	15.386	7.281	10.513	8.897	12.1415
Trial 17	7.336	12.219	12.219	7.338	12.081	9.7095	10.96425
Trial 18	7.298	10.871	10.871	7.296	13.654	10.475	10.673
Trial 19	7.279	17.363	17.363	7.34	7.595	7.4675	12.41525
Trial 20	7.33	19.403	19.403	7.275	7.842	7.5585	13.48075
Trial 21	10.293	13.495	13.495	7.314	15.536	11.425	12.46
Trial 22	7.309	17.211	17.211	7.295	9.465	8.38	12.7955
Trial 23	7.294	14.165	14.165	7.311	7.464	7.3875	10.77625
Trial 24	7.325	17.822	17.822	7.271	12.08	9.6755	13.74875
Trial 25	7.307	19.699	19.699	7.332	17.097	12.2145	15.95675
Trial 26	4.335	20.016	20.016	7.3	12.46	9.88	14.948
Trial 27	7.296	12.296	12.296	7.304	11.544	9.424	10.86
Trial 28	7.298	9.899	9.899	7.309	9.132	8.2205	9.05975
Trial 29	7.29	11.295	11.295	7.303	10.48	8.8915	10.09325
Trial 30	7.29	19.322	19.322	7.281	7.787	7.534	13.428
AVERAGE	7.304766667	14.4846	14.4846	7.3014	11.956	9.6287	12.05665
SD			3.38890461			1.540480202	1.744521744

Table 4. Effectiveness of the System Prototype in Terms of Detection Speed

	A	B	C
1	z-Test: Two Sample for Means		
2			
3		*Variable 1*	*Variable 2*
4	Mean	4.305917	14.4846
5	Known Va	1.35	11.48
6	Observatio	30	30
7	Hypothesi	0	
8	z	-15.5646	
9	P(Z<=z) or	0	
10	z Critical o	1.644854	
11	P(Z<=z) tw	0	
12	z Critical tv	1.959964	
13			

Table 5. Z-Score of Experimentation Results in Terms of Notification Speed

	A	B	C
1	z-Test: Two Sample for Means		
2			
3		*Variable 1*	*Variable 2*
4	Mean	5.180917	9.6287
5	Known Va	2.28	2.37
6	Observatio	30	30
7	Hypothesi	0	
8	z	-11.2974	
9	P(Z<=z) or	0	
10	z Critical o	1.644854	
11	P(Z<=z) tw	0	
12	z Critical tv	1.959964	

Table 6. Z-Score of Experimentation Results in Terms of Detection Speed

	A	B	C
1	z-Test: Two Sample for Means		
2			
3		*Variable 1*	*Variable 2*
4	Mean	4.743417	12.05665
5	Known Va	0.81	3.04
6	Observatic	30	30
7	Hypothesi:	0	
8	z	-20.4145	
9	P(Z<=z) oı	0	
10	z Critical o	1.644854	
11	P(Z<=z) tw	0	
12	z Critical t\	1.959964	

Table 7. Z-Score of Experimentation Results in Terms of Overall Effectivity

APPENDIX C

ParKo: IoT-BASED SMART PARKING SYSTEM

Through Supervisory Control and Data Acquisition

July 2022

Project Evaluation

(Users Acceptance Test)

Date: June 2022

Venue: PUP Paranaque Campus

UR ID	As a…	I want...	So that…	Remarks
UR1-01	Driver	to use a platform that will be able to assist me by showing the available parking slots in the establishment	I can spend much less time on navigating a free slot in the parking lot I want to visit	PASSED
UR1-02	Parking Lot Owner	To be able to monitor my parking slots.	I can ensure the safety in my establishment.	PASSED
UR1-03	Traffic Management Officer	the drivers to see the available parking slots in an establishment before they go there	traffic, possible road accidents, and carbon footprint in the area can be minimized.	PASSED
UR1-04	System admin	to use the system to provide access to the users of the car park.	only valid users can access its features.	PASSED
UR2-01	Parking Lot Owner	the sensors to be properly positioned in each parking slot.	it will provide accurate results at a reasonable maintenance cost	PASSED
UR2-02	Drivers	my car to be detectable by the car park sensors	it will change the parking slot status from “vacant” to “occupied”	PASSED
UR2-03	System admin	the sensors to accurately detect cars	the system will be reliable enough with respect to its	PASSED

			intended features	

Project Timeline

WBS ID	ACTIVTY	START	END	DURATION	BUDGET
01-00	**Define Requirements**	Oct 6, 2021	Oct 18, 2021	2 weeks	0.00
01-01	Business requirements	Oct 20, 2021	Oct 27, 2021	1 week	0.00
01-02	User requirements	Oct 27, 2021	Nov 1, 2021	1 weeks	0.00
02-00	**Initial Estimations**	Nov 2, 2021	Nov 8, 2021	1 week	
02-01	Process modeling	Nov 9, 2021	Nov 20, 2021	10 days	
02-02	Data modeling	Nov 26, 2021	Dec 3, 2021	8 days	
03-00	**High level Planning**	Dec 4, 2021	Dec 17, 2021	2 weeks	
03-01	Scope Management	Dec 19, 2021	Jan 3, 2022	16 days	
03-02	Cost Management	Jan 16, 2022	Jan 29, 2022	2 weeks	
04-00	**Iterative Development**	Feb 3, 2022	Feb 21, 2022	19 days	
04-01	Begin Iteration	Feb 25, 2022	March 8, 2022	11 days	
04-02	Detailed Design and Plan	March 15, 2022	April 5, 2022	3 weeks	
04-03	Development and unit tests	April 6, 2022	May 6, 2022	4 weeks	
04-04	Development and integration tests	May 12, 2022	May 30, 2022	3 weeks	
05-00	**Final Evaluation**	June 2, 2022	June 30, 2022	2 weeks	
05-01	System test	June 23, 2022	June, 31, 2022	1 week	
05-02	User Acceptance Tests	July 9, 2022	July 11, 2022	5 days	

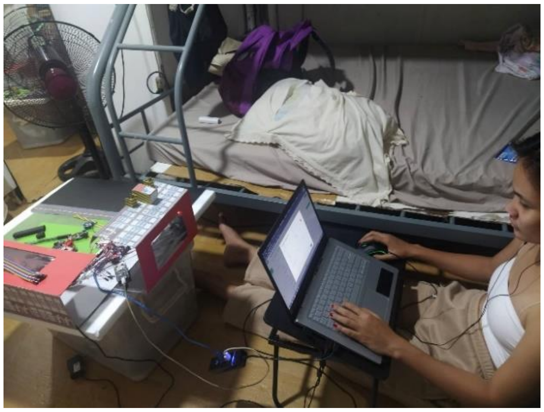
Research Timeline

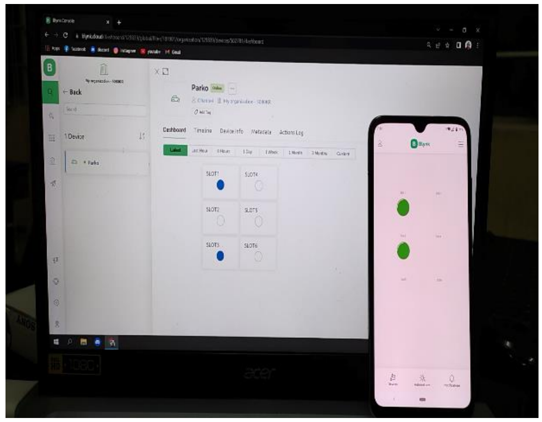
System Development	Oct 2021	Nov 2021	Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022
Define Requirement										
Initial Estimation										
High-Level Planning										
Iterative Development										
Final Evaluation										

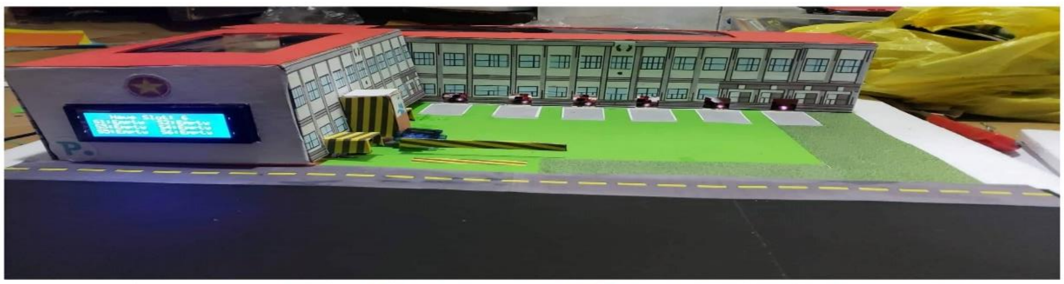
Project Cost

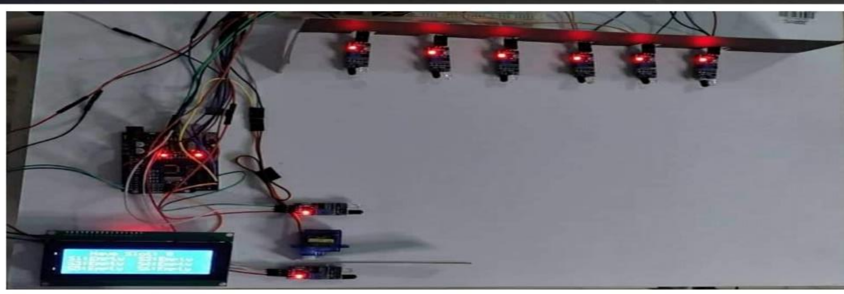
Image	Product Name	Model	Quantity	Unit Price	Total
	NodeMCU V3 ESP8266 12e Development Board CH340	2390	1	₱279	₱279
	Breadboard MB102 830 Point Clear / Transparent	2759		₱109	₱109
	Jumper Wires Male - Female 10cm 20PCS	AJ184	2	₱59	₱59
	Servo Mini Tower Pro 9g SG-90	AF001	1	₱127	₱127
	Uno R3 Starter Kit with LED Resistor Wires Arduino Compatible	AH008	1	₱630	₱630
	LCD Display Module I2C 20x4 Blue Arduino	2412	1	₱305	₱305
				Sub-Total:	₱1,509
				Total:	₱1,509

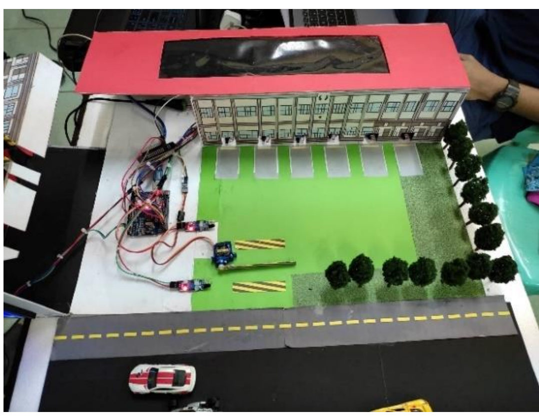
Implementation and Testing Activities



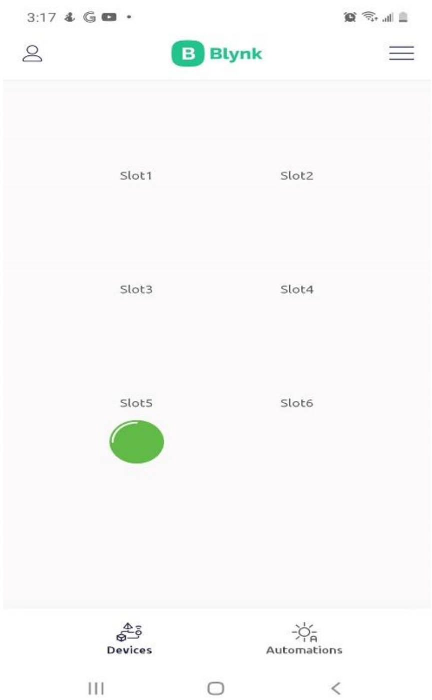




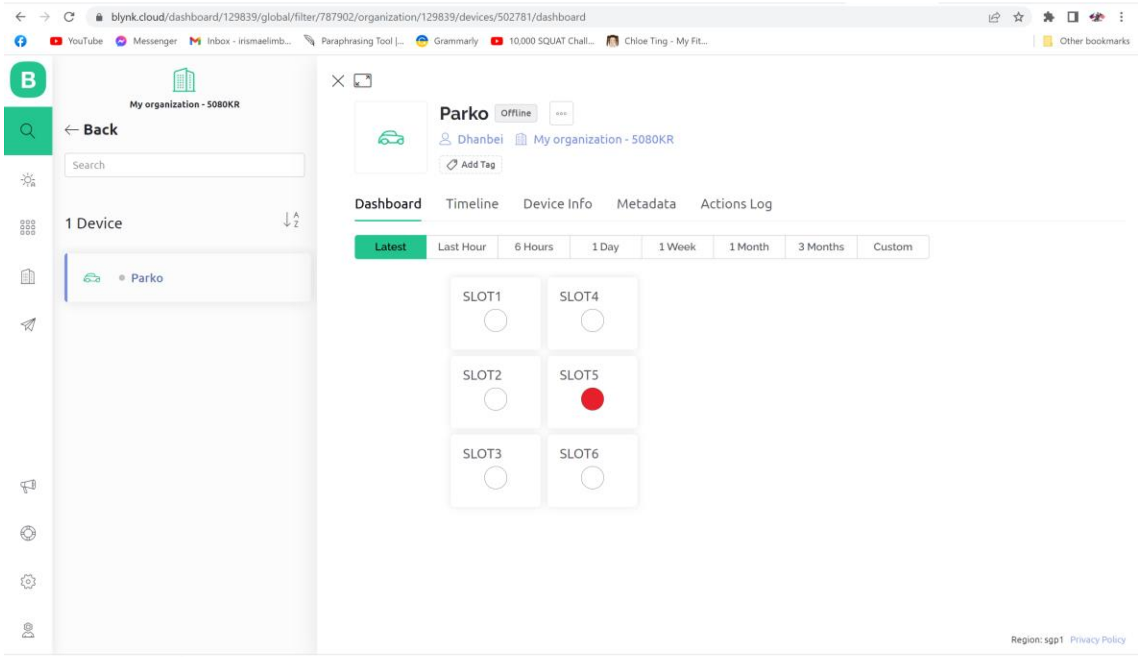




Blynk App

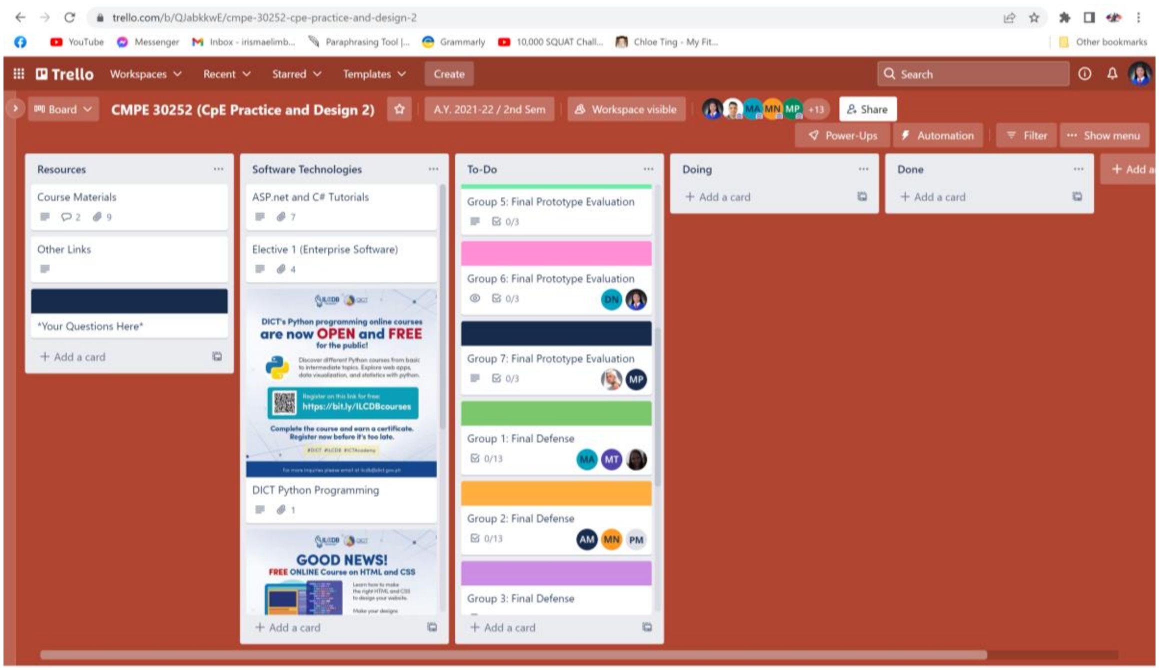


Mobile Application



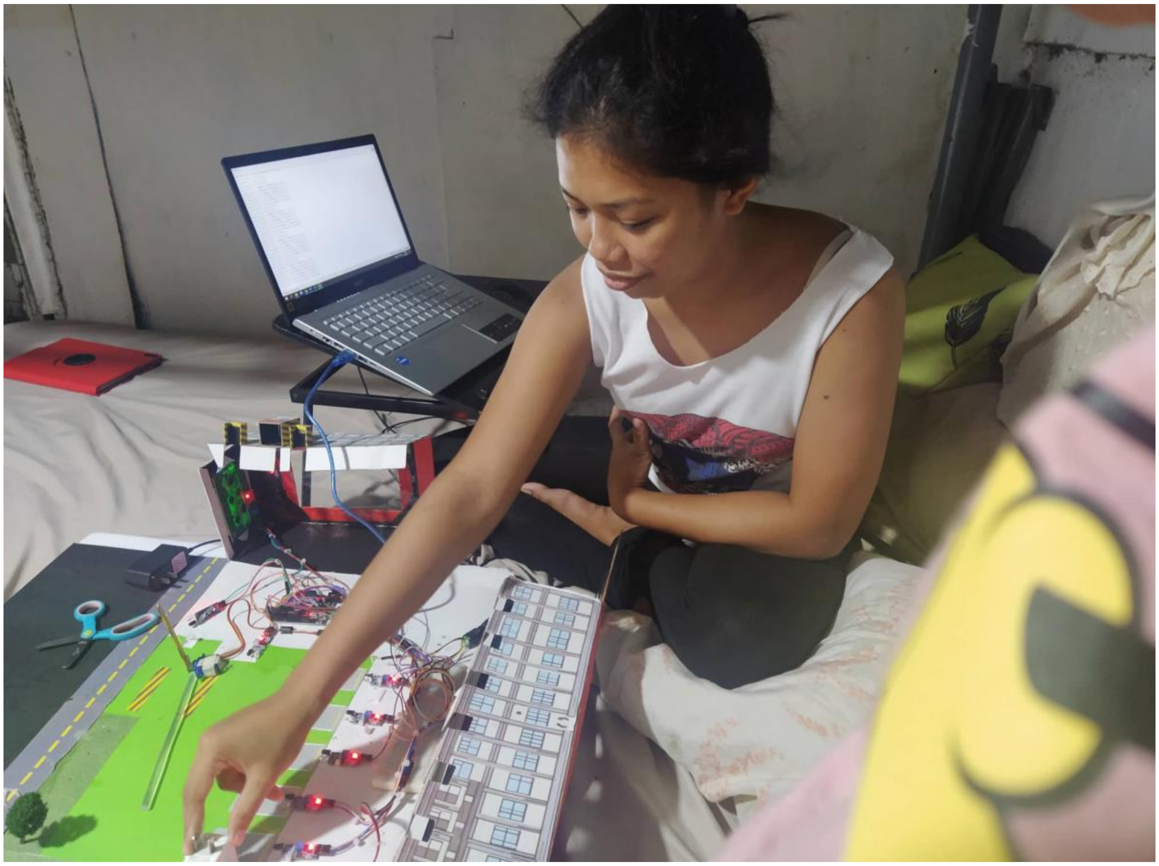
Desktop Application

Trello



Google Workplace

Evaluation of Prototype



Curriculim Vitae

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Father name: Richard E Villegas

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Senior Hight School: APEC Schools Las Piñas City

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