Mask-RCNN application on Web Based Smart Parking Management System

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***Abstract*— "This study presented a Smart Parking Management System that utilized deep learning algorithms for vehicle detection and license plate recognition, with the aim of providing an efficient parking system using technological advancements. The purpose of this project is to address common parking management problems such as inefficient resource utilization and manual payment systems. The experimental approach involved the replacement of traditional physical sensors with cameras to detect available parking spots in real-time. Masked Region-based Convolutional Neural Network (Mask-RCNN) was used for vehicle detection. The Mask-RCNN algorithm showed promising results in detecting vehicles and determining parking availability although the preliminary testing showed several factors that affect the accuracy of the algorithm. While the experimental results of this study were promising, it is important to validate the effectiveness of the proposed system under various conditions and scenarios. Hence, the Smart Parking Management System proposed in this study demonstrated the potential of deep learning algorithms in addressing common parking management problems. Further research and development are necessary to fully assess the system's effectiveness and optimize its performance for different real-world scenarios."**

Keywords— Smart Parking Management System, Mask-RCNN, web-based application.

I. Introduction

In most countries, parking areas are still manually managed which necessitates the presence of an operator to monitor incoming traffic and every user [1]. This struggle leads to the 10% to 15% waste of travel time of an average person looking for a parking space especially in the Metropolitan area [2]. In fact, Cookson & Pishue discovered that drivers from US, UK and Germany waste approximately $72.7 billion, £23.3 billion and €40.4 billion a year respectively looking for a parking spot [3].

Undeniably, this problem in the parking management system is also visible and prevalent in the Philippines. In fact, this is one of the issues which arise as a result of a developing metropolis, which is exacerbated by sustained economic growth. A study commissioned by Uber in 2017 revealed that on average, Manila drivers spend 24 minutes looking for parking every day. Consequently, an average of Php 100,000 is lost every year from being stuck in traffic or looking for parking space [4].

With this, different varieties of parking methods are currently being implemented today, according to the literature reviews. A study in 2016 proposed utilizing a cloud-based environment for a parking management system. Wherein, reserving an available parking slot, online payment, and cancellation of reservation is done using a web application. [5] Another study in 2018 also used a web application as well as a website for reserving a parking slot which is being operated by an admin in the parking lot. Moreover, it provides a forecast of parking availability in different parking areas. [6] Another technology being used in different parking systems is the Computer vision, minimizing the complexity of the setup. Other researchers were able to develop a parking system which uses image processing in detecting the presence of a car in a parking space and to be able to estimate the capacity of the parking area and provide useful information coming from aerial imagery. [7]

Hence, this study aims to look into the application of computer vision systems in plate recognition, determining the availability of parking slots, and the use of a web based application designed for both the users and establishment staff.

II. RELATED STUDIES

A. Parking Space Problem

In recent years, looking for a parking space has become a serious problem in big cities, especially in shopping centers where there is a lack of accurate information about the availability of parking spaces. With this, it is said by Farooqi [8] that this dilemma is one of the issues that needs to be addressed as it can put the economic assets in jeopardy as it causes congestion in the said urban areas.

A. Smart Parking Systems utilizing Computer Vision

Thus, Bachtiar et al [9] proposed a vision-based system to detect available parking space which utilizes CCTV cameras and the HAAR method to detect cars.

However, Dsouza et al. states that unavailable parking space is not the problem but the lack of information about the availability of parking space in different parking areas.
Thus, they proposed a system that utilized a computer vision algorithm which processes video feed from CCTV cameras placed in parking areas, to detect available and unavailable parking spaces, which is then reflected to a web application that is accessible to the user and/or drivers. [10]

B. Smart Parking System Using IOT

Consequently, this called for a specific action as these two aforementioned ideas can be merged. To address the problem of parking on commercial stretches in cities, Kanteti et al. [11] developed a Smart Parking System that enables the user to view the nearest parking area and the availability of the parking lots in that certain parking area. The system utilized IOT, electronic sensors, IP cameras, cloud storage, Raspberry Pi, and computers.

Moreover, it is agreeable that when smart parking management systems can indicate the available parking spaces near the drivers, it can also provide hassle free parking as long as it can also show potential achievement of high-efficiency and reliability rate [12].

III. METHODOLOGY

A. *Research Design*

This study focused on the development of an efficient smart parking management system to view available parking slots in advance. The following conceptual framework summarizes the input parameter, the processes done and the expected output of the system.

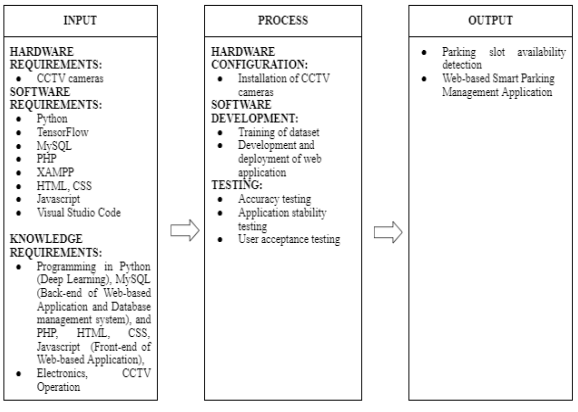

Figure 1. IPO diagram

Figure 1: *IPO Diagram*

B. *Mask-RCNN*

The researchers had developed a training model that is suitable for RESPARKMAN in identifying available parking spots. This includes data acquisition, data processing, and choosing of algorithms to build the model.

Gathering of Datasets

Datasets of various cars for detecting empty parking spaces in the form of pictures were collected and a possibility of having a main folder [*folder name: car*s] which would be accessed by the model when the training starts. This folder shall contain all possible four-wheeled cars available in the Philippines.

Data Wrangling

Datasets often come in large quantities that need to be organized. By segregating these data into different categories and by making their sizes identical, the data access would become easier especially if the data sources are rapidly growing. As for RESPARKMAN, the main folder has a subfolder which segregates the different models of cars available in the Philippines.

Model Training

Model training included finding the best fit of weights and biases used in an algorithm. This process aimed to reduce training loss and increase accuracy range. This shall predict the cars when the algorithm was deployed and would identify which of the parking spaces was occupied and available.

Algorithm Tuning

This process was a trial-and-error and can be achieved by comparing the original model against the adjusted model and getting the result that yields a much better output than the other.

Out-of-sample Testing

An in-sample period was used to create a parameter on which the model was expected to perform, while the out-of-sample testing was used to test the viability of the model in real life scenarios. A separate folder containing pictures of different models of cars which was not used to train the model was used to know if the model was accurate enough to identify the image. It was also at different angles to further test its accuracy.

C. *Web-based application*

In this section, the researchers have developed a web-based application for the users, customers and administrators of the establishment to see and monitor the real-time situation of the parking lots. This application also has an in-app payment system for the users and customers to be able to pay after reservation.

Building of the Web-based Application

The researchers followed the Model View Control architecture when building the web application. With this, the web framework shall provide (1) an abstraction model over the relational database through object relational mapper which transferred the programming language code into an SQL code which was used by the database, (2) routing for mapping URLs in the browser to the codes that shall run on the server; and (3)

a way of directly entering data from the database to the HTML for the user interface.

Considering this, the researchers chose PHP which is a free, open-source and battery-included web framework that has a lot of built-in features, libraries and packages.

Development of a Database Management System

The researchers created a relational database management system, and used MySQL which is a free and open source query language based on SQL used for communicating with the database.

D. *User Acceptance Testing*

Acceptance testing is a critical step in a software development process in which a user analyzes and ascertains other's work for the purpose of accepting it. It can be categorized in different ways such as User Acceptance Tests *(Internal Alpha Tests and External Beta Tests),* Operational Acceptance Tests, Regulatory Acceptance Tests and Contract Acceptance Tests. The objective of user acceptance testing is to seek reassurance for some reasons including presentation, demonstration, probing, usability and validation.

Method of Analysis

The researchers used the User Acceptance Test (UAT) to assess the software adapted from A. Abran, et.al., [13]. Consequently, a survey using Likert's Scale acceptability test was conducted in accordance with ISO 9126 standards for software quality models.

Participants and Setting

The respondents should fall under one of the four sub groups or categories which include (1) professionals in the field of technology such as Information Technology, Web Development, Computer Science, Software Engineering and other related fields pertaining to technology; (2) stakeholders who are working on the parking industry; (3) graduates and graduating students with course related to the field of technology, like Bachelor of Science in Electronics Engineering; and (4) owners of private vehicles who use their car for everyday life mobility such as going to work or school, going to the mall and other places.

Collection of Data

With the use of controlled quota sampling, the researchers distributed the survey questionnaires to the selected respondents corresponding to the given four categories in Metro Manila, Philippines. They were chosen based on the researcher's necessary target data for acceptability testing and convenience

Statistical Analysis

The researchers analyzed the results through determining the weighted mean of each item in every category to evaluate and analyze the data and/or result of the UAT adapted from the study of A. Abran [13]. Each range of the scale corresponds to the following interpretation:

RANGE	INTERPRETATION
1.00 - 1.79	*Strongly Disagree*
1.80 - 2.59	*Disagree*
2.60 - 3.39	*Neutral*
3.40 - 4.19	*Agree*
4.20 - 5.00	*Strongly Agree*

Table I. RANGE AND INTERPRETATION OF DATA

IV. RESULTS AND DISCUSSION

This section shall discuss the results of the aforementioned Mask-RCNN and web applications' user acceptance test.

Object Detection Result (Mask-RCNN)

Figure 2. *Sample image masked by the mask-RCNN.*

Figure 2 shows the image result when passed through the RCNN model. The images identified were put inside a bounding box and then masked out. The sample ensures that the model works and identifies subjects correctly. Upon preliminary testing using different camera footage from different parking areas, the vehicle detection system posed a promising 96.73% accuracy rate.

Figure 3. *IRTC parking footage.*

Figure 3 shows the result of Mask-RCNN on a sample footage; the green boxes indicate that the spot is available, while the red ones indicate occupancy

Evaluation of the Web Application

TABLE II. USER ACCEPTANCE TESTING RESULTS

Criteria	Total (N = 25)	Interpretation
	Mean	
Functionality	4.36	*Strongly Agree*
Reliability	4.36	*Strongly Agree*
Usability	4.58	*Strongly Agree*
Efficiency	4.43	*Strongly Agree*
Maintainability	4.4	*Strongly Agree*
Portability	4.41	*Strongly Agree*

Based on the given results above, the respondents showed a positive response as all of the given criteria for quality standards rooted from the ISO 9126 garnered a mean of 4.36 to 4.58 *(Strongly Agree)*. This suggests that the software quality can adhere to the need of standardized Smart Parking System as it has the potential to provide a comfortable ease of access as stated by Kanteti, D. et. al. [11] and shows good reliability that may help the drivers in parking their vehicles [12].

Consequently, as it earned a strong agreeability rate, the software has a tendency to address the issues of parking systems in the urban areas [10] and the congestion it brings in the busiest part of the community [8].

V. CONCLUSION

The system had successfully addressed the challenges in designing and implementing a smart parking management system that utilizes deep learning algorithms. Significant progress has been made towards achieving an efficient and automated parking management solution through YOLOv5 for license plate recognition and Mask-RCNN for parking availability detection.

The parking availability detection system, utilizing Mask-RCNN, provided a real-time monitoring of parking spaces, allowing users to easily identify available parking spots. This contributed to a seamless parking experience for drivers, reducing the time spent searching for parking spaces and optimizing the overall parking utilization. The results obtained from the comprehensive testing and evaluation provide valuable insights into the system's performance, accuracy, and efficiency. These findings did not only validate the effectiveness of the proposed solution but also paved the way for future enhancements and optimizations.

Moreover, by incorporating a web-based application, users can effortlessly navigate through various functionalities, make parking reservations, manage payments, and access personalized accounts. This gave the users greater control and flexibility, enhancing their overall parking experience. The application also ensured accurate and up-to-date information, enabling smooth coordination among different components of the parking management system.

ACKNOWLEDGEMENT

We would like to express our sincerest gratitude to the people who have helped us from the beginning until the end of this study. Your unwavering support, guidance, and encouragement were invaluable and priceless. Special thanks to God, our family and special loved ones, to our project adviser, Engr. Timothy M. Amado, to our Dean of the College of Engineering, Engr. Nilo M. Arago, to our panel members specially Engr. Edmund G. Monilar, to the ECE faculty, to Dr. Vicky Galiza, the University's Chief Administrative Officer, to Mr. Reggie Campomanes, the Chief of Civil Security Office, to Sir David Reyes and Sir Antoniño Orcine from CIT for their expertise and assistance.

Your contributions and guidance are of great significance in our study's success, and we are honored to have had you by our side.

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