

AN INTELLIGENT PARKING SYSTEM

By

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A Research Proposal Submitted to the Department of Pure and Applied Mathematics in the School of Mathematical and Physical Sciences in Partial Fulfillment of the Requirement for the Award of the Degree of Bachelor of Science in Mathematics and Computer Science of Jomo Kenyatta University of Agriculture and Technology

2023­­

DECLARATION

We hereby declare that this work has not been previously submitted to any other institution of higher learning. To the best of our knowledge and belief, the project contains no material previously published or written by another person except where due reference is made in itself.

Signature………………………………                                    Date …………………....................

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This research project has been submitted for examination with my approval as the university supervisor.

Signature ………………………………                                   Date……………………………….

Name:

DEDICATION

We dedicate this work to the institution of Jomo Kenyatta University of Agriculture and Technology for its invaluable contribution towards our education, our families for their steadfast support during this crucial period and our classmates for walking this journey with us hand in hand.

ACKNOWLEDGEMENTS

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ABBREVIATIONS

|  |  |
| --- | --- |
| IPA | Intelligent Parking System |
| API | Application Programming Interface |
| REST-API | A web service that governs interactions between the client and server to  retrieve data and send data to the database. |
| Mongo DB | This is a non-relational database that provides support for JSON-like storage. |
| CNN | Convolutional Neural Network. |
| ML | Machine learning |
| GUI | Graphical user interface |

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ABSTRACT

Car parking management in Kenya is crucial to urban development and achieving Vision 2030. Juja, a town in Kenya's Kiambu County, has grown immensely due to many factors, one of them being the presence of Jomo Kenyetta university of agriculture and technology. Consequently, a challenge of poor parking management has arisen, since managing parking spaces in Kiambu is becoming increasingly problematic owing to the usage of manual parking spot allocation. It may be difficult to locate enough parking spots in Juja, especially during busy hours. This study will look at how machine learning may be utilized to find an available parking spot, in turn boosting current understanding of the importance of parking lot placement in parking management.

A complete investigation of parking patterns in Juja will be done, followed by the creation of an application that will assist drivers in finding nearby parking slots.

The purpose of the study is to determine the most efficient and effective solutions for parking slot positioning, therefore aligning with the rising trend of innovative city projects and contributing to Kenya's sustainable urban transportation.

Throughout the investigation, ethical aspects such as data protection and confidentiality will be given proper attention.

CHAPTER 1

INTRODUCTION

Background study

As Juja continues to expand and urbanize, various parking issues occur as a result of increased population density and commercial activity. Inadequate parking management and enforcement, in particular, can result in disorderly parking behavior, such as double parking or occupying numerous spaces. This mismanagement has the potential to significantly lower the total capacity of available parking places. As a result, the demand for automated parking management emerges.

Fortunately, software development is everchanging and we propose to use ML to locate the free parking slots by using CNN to process and analyze images of the parking areas and identify open parking slots. In addition, these images will be provided to use by corroborating firms nearby. All the data collected will then be stores in the MongoDB database for ease of processing later on. This data will be accessed from the application by use of REST-API built by Django Rest Framework. For the GUI, Figma would be used to design and ensure it if clear thereafter ReactJS would be used to create the application user interface. It would also inco-operate a payment functionality that gives the users all-in one application feeling. The backend development will link our REST-APIs to M-PESA API, which provides API endpoints for accessing M-PESA services, to enable ease payment of parking. Furthermore, users will be prompted on their location and on their concent, the application would use this information to locate the nearest parking slot at that given time using google maps API and google places API, which will help in any calculation involved.

Statement of the problem

The construction of Thika super highway, provision of cheaper living standards and provision of education facilities has a major impact on growth of Juja. However, with time, it has brought a major challenge in the parking management. As a result, the county has resorted to manual allocation of parking. Researchers have been able to identify the difficulties in searching for parking space lead to wastage of time and fuel. High-stress levels experienced due to the random search for parking spaces and its impact on economically productive activities is wanting. However, there has been minimal study on the influence of machine learning on parking management in Juja and other big cities in Kenya. As a result, the goal of this study is to address the research gap by assessing the impact of available parking spot location on automated parking management using machine learning. Consequently, create an application that will give drivers accurate and up-to-date information and directions to the nearest available parking places

1.3 Justification

Drivers encounter difficulty in finding parking areas and mostly have to rely on the residents of a given area for information on where to park. However, this may be dangerous and inconvenient, in the case that they get misleading information or they cannot get the opportunity to stop and ask. In other cases, drivers do not know how to get to the parking locations. IPA will be able to provide directions to the client. Additionally, it can sometimes happen that drivers make their way to a known parking area only to find it is at capacity and therefore have to reroute to a different location, wasting both time and fuel. IPA would solve this problem by directing them to a sure vacant slot, thereby helping drivers save on both. Drivers also tend to break traffic rules, while trying to get directions to a parking area. IPA would assist in minimizing such traffic regulations. By developing this software, we can make significant strides in mitigating parking-related issues and improving the overall quality of urban transportation systems in Kenya. The general time takes to obtain a free parking space will be reduced significantly, we will provide reliable information that will be crosschecked to ensure that it is accurate. Another added advantage is that the model will have a payment system integrated to make user experience seamless. It will provide a bridge between the user and the various services that he or she will require, considering they will need information on the location of the parking space given their location, the app will serve as an interface to determine the various parking that are available.

Objectives

### General Objectives

To develop an intelligent parking assistant.

### Specific Objectives

1. Develop the model for the intelligent parking assistant
2. Create and populate a database to be used by the application
3. Implement the model using python.
4. Create a user-friendly interface
5. Verify and validate the implemented method

Significance of study

The significance of the proposed study on developing a car parking assistant software for locating free parking slots lies in its potential to address several important issues and provide numerous benefits:

1. Improved Parking Efficiency: By providing real-time parking availability information, the software enables drivers to locate free parking slots more efficiently. This reduces the time spent searching for parking, leading to improved traffic flow, reduced congestion, and decreased fuel consumption.
2. Enhanced User Experience: The software aims to improve the overall parking experience for drivers. Features such as navigation guidance, user reviews, and parking spot reservation streamline the process and reduce the stress associated with finding parking. This enhances user satisfaction and convenience.
3. Optimal Resource Utilization: By efficiently directing drivers to available parking slots, the software promotes the optimal utilization of parking resources. It helps prevent overcapacity at popular parking areas while also directing drivers to lesser-known parking options, thus distributing parking demand more evenly.
4. Data-Driven Decision Making: The project involves collecting and analysing parking data, which can provide valuable insights into parking patterns and trends. This data can be utilized by urban planners, parking lot operators, and local authorities to make informed decisions regarding parking infrastructure planning, pricing strategies, and policy development.
5. Environmental Benefits: Efficient parking assistance reduces the time spent driving in search of parking, thereby reducing carbon emissions and contributing to environmental sustainability.
6. Scalability and Adaptability: The developed software can be scaled up and adapted to different cities and regions, addressing the unique parking challenges of various urban areas. It has the potential for wider adoption and implementation in multiple locations. By addressing these issues, the car parking assistant software can make a significant and meaningful contribution to urban mobility and quality of life.

Scope of study

The study focuses primarily on the organization of the parking system along Thika road, and around Nairobi town. The study will analyse how drivers find parking in these areas, the challenges they face and aims to provide feasible solutions. It will involve the development of a user-friendly mobile application for Android platforms. Data integration will be conducted to gather parking availability information from various sources, including parking lot operators, and user reports as well as information and functionality attained from google earth and google maps.

The proposed solution may not be able to solve errant driver behaviors or limited parking space due to lack of infrastructure or government restricted parking zones.

Some limitations are expected to be encountered during the project study. Some limitations to consider will be:

1. The availability and reliability of real-time parking data may vary, as it relies on data from sensors, parking lot operators, and user reports.
2. The study's coverage will be limited to the areas along Thika Road and Nairobi town, which may not represent the entire parking landscape in Kenya.
3. User adoption and engagement are also potential limitations, as the success of the software depends on user acceptance and active usage.
4. Connectivity issues and technical limitations may impact real-time functionality and navigation experiences.
5. Furthermore, the actual availability and accessibility of parking slots may be subject to external factors such as demand fluctuations and parking restrictions.

CHAPTER 2

LITERATURE REVIEW

Car parking management and the development of smart parking systems have been areas of growing interest globally, including in Kenya. Several studies have been conducted, examining various aspects related to parking efficiency, technology adoption, and user experience. This literature review provides an overview of relevant research conducted in Kenya, highlighting key findings and their implications for the proposed car parking assistant software.

Adki and Agarkhed:"Cloud assisted time-efficient vehicle parking services," The proposed work introduces a complete framework that solves the urban vehicle parking problem in Turkey. This work helps the end users to efficiently find nearby parking lots along with the available parking spaces with the aid of navigational directions. The system consists of smart phone applications, cloud services, sensing and communication technologies.

(P. R. Adki and J. Agarkhed, 2016)

Aydin and Karakose: "A navigation and reservation based smart parking platform using genetic optimization for smart cities," In this study conducted in India, a navigation and reservation based parking proposal system was developed for smart cities. The proposed method involves the development of small devices that send data to the internet using the internet of things (IoT) technology. The free parking space closest to the current location is found by genetic algorithm. (Aydin, M. Karakose and E. Karakose, 2017)

Wainaina et al. (2020) investigated parking patterns and demand in Nairobi Central Business District. The study analysed parking data from various sources, including parking lot operators, and examined the influence of factors such as time of day, day of the week, and special events on parking availability. The findings underscored the need for predictive models and real-time information dissemination to optimize parking resource utilization.

Ndirangu et al. (2017) proposed a cloud-based parking management system for Nairobi. The research focused on developing a platform that integrates parking lot operators, drivers, and local authorities. The system aimed to provide real-time parking availability, online reservation, and payment options to enhance user convenience and reduce congestion. The study highlighted the importance of collaboration among stakeholders for effective parking management.

Macharia and Otieno (2021) investigated the perceptions and acceptance of smart parking technologies in Nairobi. The study explored user attitudes towards adopting mobile applications for parking guidance, payment, and reservation. The findings emphasized the importance of user-centric design, ease of use, and trust in the technology for successful adoption.

The reviewed literature provides insights into the challenges and opportunities related to car parking management in Kenya. It underscores the significance of developing innovative solutions that leverage real-time data, IoT technologies, and user-friendly interfaces. In conclusion, the literature review demonstrates the relevance and timeliness of the proposed car parking assistant software project in Kenya. The findings from previous studies emphasize the need for efficient parking management systems, real-time information dissemination, and user-friendly interfaces. By building upon and expanding upon these existing studies, the project aims to contribute to improved parking efficiency, reduced congestion, and enhanced user experiences in Kenyan urban areas.

**Point of Departure**

As indicated by these studies, further optimization of the parking system is a vital requirement to the general transport system which is still lacking in efficiency. This project aims to provide better solutions for this current problem using different methods and techniques.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The efficient utilization of parking spaces in urban areas has become a pressing concern due to the escalating number of vehicles and limited parking infrastructure. To address this issue, our research proposal aims to develop and implement an Intelligent Parking Assistant Model that leverages Google Maps, webcam images and machine learning algorithms to assist drivers in locating available parking spaces in real-time. This section outlines the methodological approach we intend to employ to design, implement, and evaluate the effectiveness of the PAM system.

The primary objective of this study is to create a user-friendly and accurate parking assistant tool that optimizes the process of finding vacant parking spaces within Juja Constituency. We will employ a multi-faceted methodology that encompasses data collection, model training, and performance evaluation to achieve our research goals.

The proposed methodology begins with an extensive data collection phase, where we will gather real-time parking availability data from various Juja using Google Maps API. This data will include information on parking lots, parking garages, and on-street parking spaces. Additionally, we will collect historical parking data to identify patterns and trends in parking space availability over different time periods and days of the week.

Once we have amassed a substantial dataset, we will proceed to the model development stage. Machine learning algorithms, such as support vector machines (SVM), random forests, convolutional neural networks and deep neural networks, will be employed to train the Parking Assistant Model. We will explore various feature engineering techniques to extract relevant information from the data, such as parking occupancy rates, time of day, weather conditions, and local events. By combining these features, the model will learn to predict the likelihood of finding an available parking space at a given location and time.

To evaluate the efficacy of IPA, we will conduct a series of simulations and tests using images obtained from Google Maps API. During the simulation phase, we will use historical parking data and compare the model's predictions against the actual parking availability to assess its accuracy and performance. Furthermore, we will deploy IPA in Juja to conduct real-world field tests. A group of participants will be provided with the IPA application on their smartphones, and we will collect data on their experiences while searching for parking spaces. Post-field test surveys and interviews will also be conducted to gather user feedback and assess the practicality and user-friendliness of the IPA system. Additionally, we will address potential limitations of the methodology, such as the reliance on Google Maps data and potential biases in the training dataset.

In conclusion, this methodology aims to develop a cutting-edge IPA that utilizes machine learning techniques and Google Maps data to aid drivers in locating available parking spaces efficiently. By adopting a comprehensive approach that includes data collection, model training, and real-world evaluation, we anticipate that the IPA system will make a significant contribution to alleviating parking-related challenges in urban areas and enhance the overall driving experience for users.

3.2 Proposed solution

To solve our problem, we propose creating a mobile application. It will be integrated with a machine learning model, Google Earth and Google Maps to offer the directions required to get to the parking slot. Google Earth helps triangulate the location of the parking slot and offer the co-ordinates to Google Map, also providing real time images of parking space.

We will also create a friendly user interface using reactJS for the front-end. The pages will include sign in, and a landing page to start the search. For the backend we will use Django and Django Rest framework to setup accounts for the users and facilitate membership.

In addition, we will use MongoDB to setup the database to ensure efficient online data storage and retrieval. The project will follow the following methodology:

3.3 Model Formulation

In order to achieve the set objectives, we’re going to have a Mongo db database to store all the user’s information, their login credentials, and the history of the parking spaces they have ever occupied, the database will also store coordinates of parking spaces we know and this will be provided by the machine learning model as per the input provided, this will aid in the general search for parking spaces in future and also to analyze trends in Juja.

We will then construct a machine learning model that will leverage on deep neural networks and convolutional neural networks to study and obtain meaningful insight from the data provided which in this case will be images. We will also harness the power of computer vision to aid the machine learning model function more efficiently and save on time it takes to determine whether the provided areas are free on not.

The source of the images to be provided will be google maps API, we will gather satellite images and the history of the patterns of parking in Juja and use it to the machine learning model. And from the training we will subject a few test cases to it to evaluate its functionality.

We will then construct the REST-API to handle the requests from the user and communicate with both google maps API and the machine learning model. This will require functions to login, get the location of the user, send co-ordinates to the model and receive back results of free parking slots.

In conclusion, we will develop a user-friendly user interface with the aid of tailwindcss and reactJs. With all of these in place, we will integrate them together to form the complete product.

1. **Assumptions**:
   1. Reliable Data Sources: The model assumes that the data obtained from Google Earth and Google Maps is reliable and up-to-date, providing accurate parking slot locations and navigation directions.
   2. Effective Payment Integration: The model assumes successful integration with M-PESA for secure and seamless payment transactions.
   3. Parking Slot Independence: The availability of parking slots is assumed to be independent of each other. This assumption allows the model to treat each parking slot as a separate entity and make predictions based on individual slot availability.
   4. Stationary Parking Demand: The model assumes that the parking demand remains stationary during the prediction interval. It does not account for sudden changes in demand due to special events, emergencies, or other unpredictable factors.
   5. Reliable Data Sources: The accuracy and reliability of the data from various sources, such as sensors and user reports, are assumed to be sufficient for making parking availability predictions. The model relies on the availability and quality of data to provide accurate results.
2. **Boundary Conditions**: The application operates within the boundaries of the integrated data sources (Google Earth, Google Maps) and the availability of M-PESA payment services. The accuracy and availability of parking data depend on the coverage and quality of the data obtained from these sources and additionally on the data collected from parking lot operators and user reports.

3.3 Model Formulation

1. Develop a model for the intelligent parking assistant: To achieve this objective, we ae going to come up with a model for the whole system. The model will comprise of a machine learning model, database, rest- API and finally the user interface for the user to communicate with the system. The machine learning model will be constructed using convolutional neural networks to facilitate images as input, deep neural networks to further study the images and the trends that will be provided by the pattern obtained from the images as well and finally computer vision to determine the objects in the images. Several algorithms will be implemented as well to account for factors such as events and open-parking areas. The ML model will not only take images as input but the data from the database to study the pattern of parking within Juja as well to aid in hastening the location of available parking slots. The model will then be connected to google maps API and the rest-API to facilitate communication between these three modules of the system. The model will receive input from google maps API and then give an output of the parking areas that are free to the rest API which will then relay to the user the location of available parking spaces.
2. Creation and population of the database: We will use mongo db to create the database. The database will compose of several tables such as the users table to store the details of the user, a visits table to outline the areas that are known and have been visited by specific users and finally we will have a table to store records of parking spaces that are known in Juja. Population of the database will be specific to the table that is being populated. The users table will be populated by the users themselves and this will be through a registration form, the visits table will be filled automatically when the user gets to their destination, this will guide the future searches of other users. The table containing the locations of parking spaces will be populated by the machine learning model after the training and the data will be verified.
3. Implementation of the model using python: We will create the machine learning model using TensorFlow specifically using python programming language. We propose that in addition to this we could come up with a tinyML, that is a light weight machine learning model that can be hosted on the mobile application and this will in turn reduce the time complexity of operation of the system. The rest API will also be created using python, specifically Django rest framework that will be facilitate the communication between these components of the system.
4. Creation of user-friendly user interface: The user interface will be created using Reactjs which is a javascript framework. We will use it to create several pages, these pages will be the landing page, the search page, the registration page, the login page and finally the page to list the results of the search, a page to view the directions to the designated location and finally a page to return reviews on their experience in using the application. In addition to this we could also include a page to view all the previous visits to different places. This will be the comprehensive outline of the pages to be used in the system.
5. Verification and validation of the model: The verification of the system will be conducted by testing the site and the directions given by the applications and actually visiting the location. We will as well check the coordinated of the parking areas provided by the machine learning model and making necessary modifications in the machine learning model and the general system.

In summary, the car parking assistant software utilizes a predictive model based on historical data and real-time inputs. It incorporates data preprocessing, feature engineering, and continuous model refinement. The user will provide their location by logging in and this will be passed to the rest API and the search for the available parking spaces, this will be subjected to the database to return parking spaces within 500-meter radius, the calculation will be done by a custom build algorithm to determine the results that are within the radius. The coordinates will finally be subjected to the machine learning model to determine if there is an available space. The model will finally return if the coordinate of an available parking space that will be passed to the user interface. By following this methodology, the Parking Assistant (IPA) mobile application can provide drivers with accurate parking information, navigation guidance, and convenient payment options, as well as predict parking availability. The model formulation focuses on data integration, user interaction, and seamless user experience, ensuring a reliable and user-friendly solution for parking management.

3.4 Expected Outcomes

Upon completion of the project, the following outcomes are anticipated:

1. A fully functional car parking assistant software that provides real-time parking availability information and navigation guidance.
2. Increased awareness and utilization of available parking slots, leading to reduced congestion and optimized parking resource usage.
3. Improved user experience through features like user reviews, payment integration, and parking spot reservation.
4. Valuable insights into parking patterns and trends, which can be used by urban planners and authorities to optimize parking infrastructure and policies.

3.5 Our Contribution

The development of a car parking assistant software has the potential to revolutionize the parking experience and alleviate parking-related issues in urban areas. By combining real-time data, intelligent algorithms, and user-friendly interfaces, this project aims to empower drivers with the necessary tools to locate free parking slots efficiently. The project's outcomes can have significant positive impacts on traffic flow, resource utilization, and user satisfaction.

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APPENDICES

APPENDICE 1: Work plan

This research study will cover a period of seven months. Table below shows the various activities that will be undertaken during the research and their respective timelines.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2023** | | | | | | |
| **Month** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | |
| Literature review |  |  |  |  |  |  |  | |
| First semester report preparation |  |  |  |  |  |  |  | |
| First semester presentation |  |  |  |  |  |  |  | |
| Research and data collection |  |  |  |  |  |  |  | |
| Application and model development |  |  |  |  |  |  |  | |
| Testing |  |  |  |  |  |  |  | |
| Data collection and analysis |  |  |  |  |  |  |  | |
| Final year report preparation and submission |  |  |  |  |  |  |  | |
| Final year presentation |  |  |  |  |  |  |  | |

APPENDICE 2: BUDGET

|  |  |
| --- | --- |
| **ITEM** | **COST** |
| **SERVERS** | $135 (19000 KES) |
| **DOMAIN NAME** | $14 for a one year subscription |
| **COLLABORATIVE EFFORTS** | $40 per month |
|  |  |
|  |  |
| **TOTAL** | $349 |