

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

I hereby declare that this work has not been previously submitted to any other institution of higher learning. To the best of my 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.

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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

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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 its proximity to Nairobi County. However, it faces the same challenge, since managing parking spaces in Kiambu is becoming increasingly problematic owing to the usage of manual parking spot distribution. 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. This study focuses on using machine learning to discover neighboring parking spaces, hence boosting current understanding of the importance of parking lot placement in parking management.

This study examines parking placement trends in Juja using a comprehensive analysis of relevant literature. A user-friendly smartphone application will be developed that will make use of advanced algorithms to assist drivers in finding nearby parking slots.

The study's findings may have consequences for parking management in Kenya. This project intends to give evidence-based suggestions to parking lot operators and county government by locating available parking spots. The purpose 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.

This study's endeavor recognizes several constraints, including real-time processing, variability in parking structures, data availability and quality, shifting demand, and the generalizability of findings outside Juja constituency. Throughout the investigation, ethical aspects such as data protection and confidentiality will be given proper attention.

INTRODUCTION

Background study

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 its proximity to Nairobi County. However, it faces the same challenge, since managing parking spaces in Kiambu is becoming increasingly problematic owing to the usage of manual parking spot distribution. 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.

Statement of the problem

Since the building of the Thika super highway, inadequate parking management and enforcement has been a problem in Juja. As a result, disruptive parking behavior, such as double parking or occupying several spots, occurs. This mismanagement has the potential to significantly lower the total capacity of available parking places. According to (Joan, 2016), 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. As a result, the goal of this study is to address a research gap by assessing the impact of available parking spot location on automated parking management using machine learning.

Furthermore, the findings of the study will be utilized to create a system that will give drivers accurate and up-to-date information on available parking places, allowing them to make educated decisions and maximize their parking experience in both new and familiar regions to the customer. The parking assistant (IPA) smartphone app addresses these issues by providing real-time parking availability data as well as directions to the nearest available parking places.

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

The objectives of this project can be classified into software-based and client-based goals.

From a software perspective, the focus is on obtaining data, creating algorithms and an machine-learning model to help determine parking slot availability, integrating Google Earth and Google Maps to offer accurate directions to the parking slots and creating a user-friendly interface using ReactJS and.

Additionally, the integration of payment methods such as M-PESA, a mobile money service widely used in Kenya, to allows for convenient payment options. On the client side, the objectives include reducing time spent finding parking, providing navigation to available parking areas, saving on fuel costs and providing information on parking area distribution.

### General Objectives

The general objective of this project is to develop an intelligent parking assistant that will guide the user to a parking slot that is unoccupied and close to where they are with ease and reduce the general time they take to find the parking areas.

### Specific Objectives

#### Software-based

1. Create and populate a database to be used by the application i.e obtain data on the various parking slots available.
2. Develop the model for the intelligent parking assistant i.e
3. Implement the model using python.
4. Verify and validate the implemented method
5. Create a friendly user interface and experience – should be easy to navigate i.e., develop a user-friendly mobile application.

#### Client-based

1. Reduce time spent finding parking area.
2. Provide direction to the available parking area by integrating google maps.
3. Save on fuel cost.
4. Acquire information on distribution of parking areas and on how parking payments are made.

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. Economic Impact: The software can positively impact the local economy by attracting more visitors to business districts and commercial areas. By providing accurate parking availability information, it encourages people to visit establishments and facilitates economic growth.
7. 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:

* The availability and reliability of real-time parking data may vary, as it relies on data from sensors, parking lot operators, and user reports.
* 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.
* User adoption and engagement are also potential limitations, as the success of the software depends on user acceptance and active usage.
* Connectivity issues and technical limitations may impact real-time functionality and navigation experiences.
* Furthermore, the actual availability and accessibility of parking slots may be subject to external factors such as demand fluctuations and parking restrictions.

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.

1. Adki and Agarkhed:"Cloud assisted time-efficient vehicle parking services," The proposed work introduces a complete framework that solves the urban vehicle parking problem. 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)

1. Aydin and Karakose: "A navigation and reservation based smart parking platform using genetic optimization for smart cities," In this study, 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)

1. 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.
2. 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.
3. Macharia and Otieno (2018) 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.

Methodology

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:

1. **Model Formulation**:   
   The proposed parking assistant (IPA) mobile application utilizes a model-based approach to provide drivers with real-time information on available parking slots and navigation guidance. The model integrates data from Google Earth, Google Maps, and M-PESA to deliver accurate parking information and convenient payment options. The car parking assistant software utilizes a predictive model to estimate parking availability based on historical data and real-time inputs. The model incorporates various factors such as parking lot capacity, historical parking patterns, time of day, day of the week, and external data sources to make accurate predictions. The model is designed to continuously update and refine its predictions based on new data inputs.
2. **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.
3. **Governing Equations**: The Parking Assistant (IPA) application does not rely on specific governing equations, as it utilizes existing data sources and APIs to provide accurate parking information and navigation. The model focuses on data processing and user interaction rather than explicit mathematical equations.
4. **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.
5. **Methods of Solution**:
   1. Requirement Analysis: Conduct a comprehensive analysis of user requirements, desired features, and integration possibilities with Google Earth, Google Maps, and M-PESA.
   2. User Interface Design: Develop a user-friendly interface using ReactJS and tailwindcss, ensuring an intuitive and seamless user experience.
   3. Backend Development: Utilize Django and Django Rest Framework to set up the backend infrastructure, handling user accounts, authentication, membership management, and database integration (MongoDB).
   4. Integration with Google Earth and Google Maps: Integrate the application with Google Earth to triangulate parking slot locations accurately. Utilize the Google Maps API to provide navigation directions to the available parking areas.
   5. Payment Integration: Incorporate M-PESA integration to provide users with convenient and secure payment options for parking fees.
   6. Feature Engineering: Extract relevant features from the data that may influence parking availability, such as historical parking patterns, time of day, day of the week, assuming external factors like weather or special events are negligible.
   7. Model Training: Utilize machine learning algorithms, such as regression, classification, or time series analysis, to train the model in predicting parking availability using the pre-processed data and engineered features. The model learns from the historical data to establish correlations and make predictions.
   8. Model Validation: Evaluate the performance of the trained model using validation techniques such as cross-validation or hold-out validation. Assess the accuracy, precision, recall, and other relevant metrics to ensure the model's reliability.
   9. Testing and Quality Assurance: Conduct rigorous testing to ensure the functionality, accuracy, and reliability of the application. Perform quality assurance checks to identify and resolve any issues or bugs.
   10. Deployment: Prepare the application for deployment by configuring servers, ensuring scalability, and optimizing performance. Deploy the IPA application to relevant app stores for user accessibility.
   11. Continuous Improvement: Gather user feedback and monitor the application's performance to identify areas for improvement. Regularly update the application with bug fixes, feature enhancements, and security updates based on user feedback and emerging technologies.

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 software's performance is assessed through validation techniques, and user feedback is used to drive iterative improvements. 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.

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.

Conclusion

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.

**WORK PLAN**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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** |  |  |  |  |  |  |  |

**BUDGET**

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

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APPENDICES

APPENDICE 1: Work plan

Data Collection: Gather parking availability data from different sources, including parking lot operators, IoT sensors, and user-generated reports. Establish partnerships with parking facilities and explore open data initiatives to gather a comprehensive dataset.

Data Preprocessing: Clean and preprocess the collected data to remove any inconsistencies, outliers, or missing values. Transform the data into a suitable format for analysis.

Data Processing: Develop algorithms to process and analyse the collected data. Implement machine learning techniques for predicting parking availability based on historical patterns and real-time data.

Application Development: Design and develop a mobile application Android platform. Ensure an intuitive user interface, incorporating features such as real-time parking availability, navigation, reviews, and payment integration.

Testing and Validation: Conduct rigorous testing to validate the accuracy of the parking availability predictions. Solicit user feedback and make iterative improvements to enhance the application's usability and functionality.

Deployment: Release the car parking assistant software on relevant app stores and promote its usage among the target audience. Collaborate with parking lot operators and local authorities to increase the coverage and accuracy of parking data.

APPENDICE 2: Work Schedule

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

Table: Work schedule

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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 |  |  |  |  |  |  |  | |