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# An Unconditional Smart Mobile-Based Model for Finding Parking Lots in Urban Cities

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**Abstract**

***Urban cities are frequently affected by heavy traffic issues. One of these significant daily issues includes searching for existing parking lots in different regions across these cities can lead to increase fuel consumption, energy waste, pollution emissions, and can impact people's health. Moreover, as the number of vehicles is increasing, searching for an existing parking lot during peak hours is considered a major issue that puts an impact on drivers and the city government. Hence, the issue of finding a method that can search for available parking lots in different dense cities, especially during busy hours is considered a major concern. The paper aims at building a smart mobile-based model to support drivers in searching for available parking lots in public parking areas with no limitations to indoor or private parking. It is found to be proven from the obtained results that the proposed mobile model achieves a rapid method for finding available parking lots. Furthermore, there are no special requirements for this model. It is found to be proven from the obtained results that all main target goals are achieved with 95% of accuracy.***

**Keywords**: *Smart System, IoT, Real-Time Monitoring, Parking Lots.*

# 1 Introduction

Recently, modern cities deal with several critical traffic problems, one of which is based on rapidly finding an available parking slot (e.g. in crowded areas) [1]. The United Nations (UN) reported that by 2050, the world's population for people residing in urban areas is expected to reach 66% [2]. Moreover, the number of private cars has continuously been increasing, and the reduction of the need for public transportation has made the process extremely difficult in finding available parking lots especially public parking lots [3]. Therefore, enabling the driver to find an available parking lot rapidly during peak hours is a critical issue for the driver's and the city government [4, 5]. Accordingly, using a smart parking guidance system is important for detecting available parking lots.

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Searching for a suitable parking space in a crowded city is extremely difficult for the driver and may cause many issues. First, searching for an available parking lot is time-consuming. According to [1, 3], the average time needed to search for a parking lot is up to 10-20 minutes, and the percentage of the overall travelling time could reach up to 45%, which is time-consuming when searching for an available parking spot. Second, as the number of drivers increases during busy hours, the city experiences lack of a availability of parking lots, and thus, the inefficiency of traffic management would lead to serious traffic jams around the parking area [6].

According to the work conducted in [7, 8], an average of 40- 45% of the total traffic area is occupied by vehicles that are searching for parking lots every second. Additionally, parking a vehicle can lead to excessive driving in search of a space in traffic dense environments, which can increase fuel consumption, energy waste, pollution emissions, which directly affect the environment, and the possibility to increase the number of accidents due to the decrease on the drivers' focus [9-11]. According to [12], it was reported in the USA (Los Angeles) that drivers consumed a total of 47000 gallons of fuel while they are searching for available parking lots with a total consumption of 95000 hours, and an average of 20 minutes per driver. Additionally, a further study including 100 different countries reported that 17 hours are spent by drivers yearly searching for an available parking lot that cost up to $345 per driver, with a total of 3.6 billion hours and 1.7 billion of fuel wasted yearly in the USA only [13]. Moreover, millions of fuel barrels are consumed daily, and it was found that total worldwide consumption is forecast to reach 102.14 million barrels per day by the end of 2023 as illustrated in the statistics (see Figure 1) [14]. A previous Intelligent Transport Systems (ITS) study reported that vehicles, which are racing for narrow and crowded parking lots exacerbate traffic issues and impose unnecessary high costs on drivers and cause about 30% of the traffic issues [15]. An early study showed that 20% of the entire congestion in streets is caused by stressed and unsatisfied drivers who are searching for available parking lots across the near block [16].

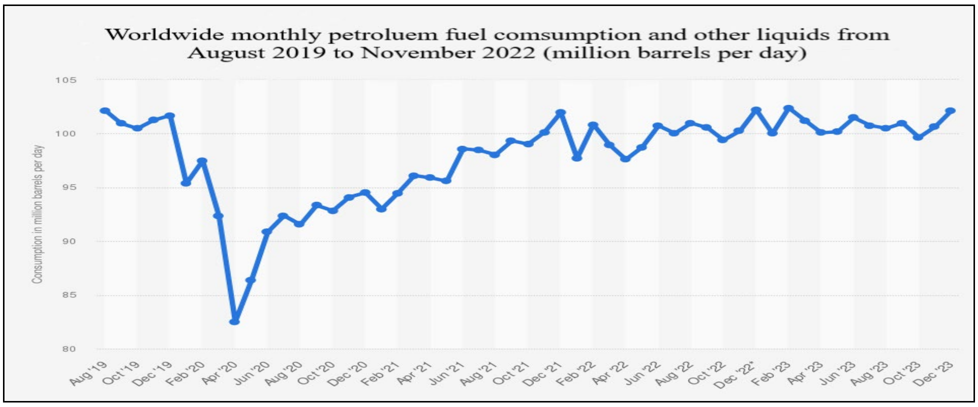


Fig. 1. Worldwide monthly fuel consumption [14].

There is a significant amount of research progress that proposes solutions for solving the problem of finding parking lots, counting the number of vacant spaces, and monitoring the changes in the parking lot status over time. For instance, the number of proposed solutions are based on sensors technology such as magnetometers, and ultrasonic sensors with vehicles to find parking lots in a specific parking area [17, 18]. Sonars are widely used as a commercial solution for detecting available lots and labeling them as available parking slots. However, this solution requires human monitoring [19-21]. Furthermore, many other proposed solutions are devoted to the development of smart parking systems, such as Wireless Sensor Network (WSN), Radio Frequency Identification (RFID), Near-field communication (NFC), Bluetooth, Wi-Fi, and ZigBee [4, 22, 23]. Moreover, computer vision and image processing-based solutions can be deployed over visual sensor networks to find parking lots in predefined areas [24, 25]. Additionally, recognition-based image processing and appearance-based image processing are accurate but complex solutions for parking systems [17]. In other approaches, empty parking lots can be detected from satellite images by enabling the tracking of real-time parking [26, 27].

Internet of Things (IoT) adoption has been growing exponentially in academia and industry. Recently, IoT development is of utmost importance to the creation of smart cities that can improve the management and quality of public services, such as public parking lots [28]. Therefore, researchers have made many efforts in the field of IoT to solve different traffic issues such as parking management systems [21, 24]. Additionally, integrating the cloud with smart parking management systems has shown interest in many approaches due to the great capability of storing, processing, and information distribution [29, 30]. In [31], a summary of the advantages of combining the technology of IoT with cloud computing is given for instance, providing online, unlimited and reduced cost storage capacity when storing IoT-generated data. Moreover, cloud computing enables IoT systems with unlimited processing power where IoT cannot stand alone with high-demand computations. Because cloud computing is scalable, data stored in a cloud system can be accessed from remote locations and can be edited or controlled [31].

The objectives of this research paper are given as follows:

- To build a smart and efficient mobile-based model with minimum cost and hardware requirements that supports drivers to find parking lots in public parking areas with no limitation to indoor or private parking.
- To produce a smart solution with the ability to build an up-to-date map system for all available parking lots in public areas by collecting a real-time data from a large number of drivers.
- To reduce the time consumed by drivers while searching for available parking lot and guide the drivers along the shortest route to find the available parking lot.

The contribution of this paper is to produce a smart model for supporting drivers to find available parking lots in public areas with no constraints to the location, and with minimal solution requirements. In particular, this solution is implemented by combining multiple approaches, which are IoT, cloud system, and mobile applications that entirely aim to assist drivers in searching for a parking lot efficiently and rapidly. The proposed solution can automatically build and update a real-time parking lots map on an integrated google map where it can learn about any new parking lots based on the real-time drivers' location. The outlines of the paper are organized as follows: Section 2 presents the related research of different solutions that aim at searching for available parking lots. Section 3 presents the proposed solution in detail. Further, the implementation and results discussion is provided in Section 4. The conclusion of this research is provided in Section 5.

# 2 Related Research

Several research papers aim to propose solutions for the problem of finding available parking lots, particularly, in crowded time slots. In [1], crowd-sourced data is generated by vehicle sensors, which is used as a method of reliable detection and forecasting of on-street parking availability in cities. Many researchers use in-vehicle sensors to identify free parking lots by using ultrasound, radar, or cameras that monitor both sides of streets when passing by cars and act as floating detectors. They determine and map three residential study areas with parking facilities and collect parking data manually and use equipped test vehicles as part of their evaluation of the proposed approach. As a result of the data analysis, each parking lot in the three identified areas is analyzed for occupancy and non-occupancy time gaps. In light of this, the occupancy and non-occupancy time gaps are used as input parameters for available future parking lot estimation and further validation of the proposed methodology [1].

In [6], a real-time automated parking management system for smart cities is proposed to keep track of the occupancy status of parking places. By integrating an android application that is installed on the driver's phone for making reservations of parking predefined spots online in a secure manner, the parking management system also enables the automatic collection of parking charges from drivers by the city authorities through an electronic payment gateway [6]. A similar Automated Parking Management System (APMS) is proposed to enable drivers to find and reserve parking lots in real-time on a secured basis over a server that manages available parking lots throughout the city. Further, the proposed system searches for an automatic collection of parking charges that are arranged via the city authorities [32]. The parking facility area is monitored by the surveillance system. It manages the parking lots' record by communicating with the Parking Meter (PM), which is installed at each parking space to keep track of its status, which can be empty, reserved, or occupied [32].

In [4], an elaborate discussion on a vision application for detecting vacant parking lots in outdoor parking areas is conducted by using the Structural Similarity Index Measurement (SSIM). By enhancing the availability of parking lots' information in real-time, this study is aimed at assisting drivers and supporting parking control systems by continuously updating vacant parking lots' positions in public spaces. In this solution, a vision-based method for identifying parking spaces that are occupied by vehicles is divided into two parts, which comprise configuration and object detection [4]. In [10], the parking space detection solution is proposed based on the usage of the vision-based system. In each parking lot, the coordination is manually entered into the system where a camera is used to provide the system with an image of the overall parking space. Additionally, the system processes the image and generates individual parking lot images, which are sent along to the pre-trained ResNet50 algorithm pertaining to the parking lot status (empty or occupied), and finally, all of the parking lots' status on a shared screen to drivers [10].

In [25], the parking space detection solution is presented based on the usage of the Conventional Neural Network (CNN) under hazy conditions. In this context, the vision-based parking slot detection system, which contains an end-to-end dehazing and a parking slot classifier (CNN) network is proposed with different training procedures to improve the system's accuracy under hazy and non-hazy conditions [25]. In [33], a decentralized and efficient solution is produced for visual parking lot occupancy detection that is based on deep CNN), which is particularly designed for smart cameras. Two visual datasets are used in this study to compare them with other related methods, such as the PKLot method, which has already been investigated in the literature, and the CNRPark-EXT method. Smart cameras have circuitry for capturing images and computing power for processing and extracting the application-specific information from the captured images. Intelligent and automated systems use smart cameras to derive event descriptions or generate decisions. CNNs are designed for smart cameras, which are employed as part of the system. Several parking lots can be monitored simultaneously by a single smart camera, which is far less expensive than putting sensors on each of them [33].

In [5], the authors propose an indoor private parking method for identifying parking lots and obstacles by installing laser transmitters on cars and using visual sensors and laser devices recognition techniques. By using laser transmission, the laser transmitter forges a checkerboard-shaped laser grid (mesh) that varies with the terrain conditions. After that, the camera captures and uses the grid as a region of interest for processing multiple images [5]. In [34], a method for detecting parking space by using Yolov2's target detection algorithm is presented. In this method, a camera is used to collect the required images of the parking space area and vehicles followed by using the indicated algorithm for building and obtaining the required coordination details, and by calculating the contour of parking space and vehicles, and finally, by determining the status of the parking space [34].

In [15], a new method of automatic outdoor parking lot detection is presented by using a camera system, which consists of four fisheye cameras that are arranged around the vehicle based on the Around View Monitor (AVM) system. According to the edge information, a Line Segment Detector (LSD) detects parking lot markings with a pair of parallel lines and a fixed distance in an AVM image and then uses stereo vision and image segmentation to calculate the height of small objects within the parking mark [15]. In [35], multiple cameras and artificial intelligence techniques are applied, and a smart parking management system is also proposed. In this system, a vehicle number is detected at the entrance of the parking space by using the Optical Character Recognition (OCR) technique and is used to track and record the parking lot's location of that vehicle. Additionally, surveillance camera images are used to keep monitoring the parking lot space and detect collision that is caused by encountered incidents based on the use of the YOLO along with the CNN deep learning process [35]. Further, a similar solution is proposed using for parking space detection and management that use the Recurrent Neural Network (RNN) and the Long Short-Term Memory (LSTM) model [36].

In [16], the authors present an ultrasonic parking detector system along with the use of the IoT to transmit information about parking lots. This application allows the user to see which parking spaces are empty in any part of the world and where to park. By using ESP8266 as a Wi-Fi module, they can send data from ultrasonic sensors to any IoT open-source app that supports HTTP to display the data (thingspeak.com in this example). In [23], the RFID-based technology with the Arduino Uno board is proposed for the smart parking system. In this system, the RFID tag is attached to the vehicle, including all required details such as vehicle number, owner details, and amount balance. The card reader is used for data extraction from the attached tag, and the IoT module is used to reflect real-time information about the free and occupied parking lot on the website [23]. In [37], a smart parking system is proposed by using IoT technology, IR sensors, and RFID tags In this system, users access the parking space and book a specific parking lot by using their mobile phones. The RFID tag that is attached to the vehicle is used for security checks, which reads the vehicle's details and records the arrival time at the cloud server. In the end, the IR sensor is used to detect the vehicle at the booked parking lot [37].

In conclusion, the current literature investigates several proposed solutions for providing drivers with different ways that can be used to search for available parking lots. However, since these solutions apply image processing or hardware-based solution, they are limited to different pre-defined areas. This paper suggests a mobile application model that enables drivers to find free parking lots by using their real-time locations with no constraints on the location of the parking lots, and with the ability to build a map containing dynamic parking lots.

# 3 The Proposed Solution

This section describes the proposed model. An overview of the proposed framework is shown in Figure 3. This section is divided into the following three subsections: Subsection 3.1 demonstrates the initial requirements and the overall working procedure of the proposed solution. Subsection 3.2 and 3.3 highlight detailed explanations about the learning procedure and daily usage procedure of the proposed solution.

### 3.1 Initial Requirements and Overall Working Procedure

The proposed solution begins with an initial configuration of three dynamic variables (see Figure 2). The value of these variables is configured dynamically by the administrator user and is declared from the settings option with different values according to the users' needs and country/city regulations. The input values of the first and second variables are provided from the integrated Google map in this solution.

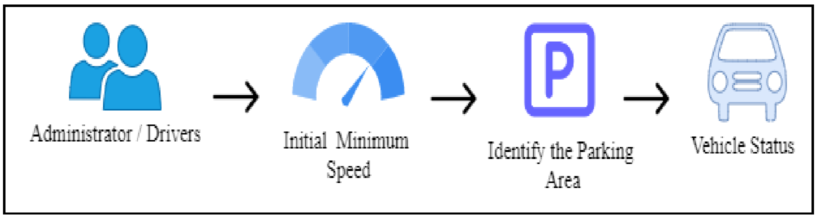


Fig. 2. Initial dynamic variables configuration.

The first variable is used to declare the optimum car minimum speed, and in most cases, the value of this variable is assigned to be 12 km or more if preferred. This variable is used to identify the moving object as a car. For example, if the speed in the proposed solution reaches 12 km or more, then the moving object is identified as a car, otherwise, in case the speed is less than the minimum declared value, it will not be considered a moving car.

The second variable is used to detect and identify the parking lot area/space, which generally can be up to 4 meters of space area. For instance, after the car stops in the parking lot, the proposed solution reads the current location value as the center of the parking lot. This center value is used to identify the parking space by adding two meters before and two meters after the location center as the parking lot area.

The third variable is used to make a decision about the status of the car as to whether it is completely stopped or not. In many scenarios, drivers might get stuck in different crowded areas, which implies that the car is still moving and has not stopped at the target parking lot. For the previously mentioned scenario, a minimum stop time variable is declared by the administrator to avoid any incorrect parking lot detection cases. In general, the initial value of this variable is dynamic and can be modified according to the emerging needs, its value can fall within the range of 2-3 minutes, and in this case, if the car does not move for that declared minimum time, then the solution considers the status of the car as a full stop status in this case.

Referencing to Figure 3, the overall working procedure of the proposed solution is started by declaring the three dynamic variables, which are discussed above. To start using the solution, a set of processes could be repeated based on the driver's use. The first step is to read the current location of the car automatically. After the location of the car is determined, the solution updates the current parking lot status from occupied status a lot to available lot status. This allows for any other drivers to use this lot since it is represented as available to be used by any other drivers who are using this solution. After searching operation for another parking lot in different areas, drivers will have the ability to select the new destination from the integrated Google map or through the manual search by the destination's location name that can be obtained. After this step, the proposed solution highlights all available lots on the map by using green pins, and the driver can select any to start the real-time navigation. The final step after selecting the destination target is to keep monitoring the status of the selected lot. If the driver arrives at the destination and the status of that slot remains available, the driver can use it accordingly, and the solution updates the status to an occupied lot (red pin). If the selected parking slot is occupied by other drivers before their arrival, the solution automatically presents all available lots, and the drivers can select any new free parking lot that is provided by the solution. Once the destination parking lot is used by the driver, the system updates the status to an occupied lot either.

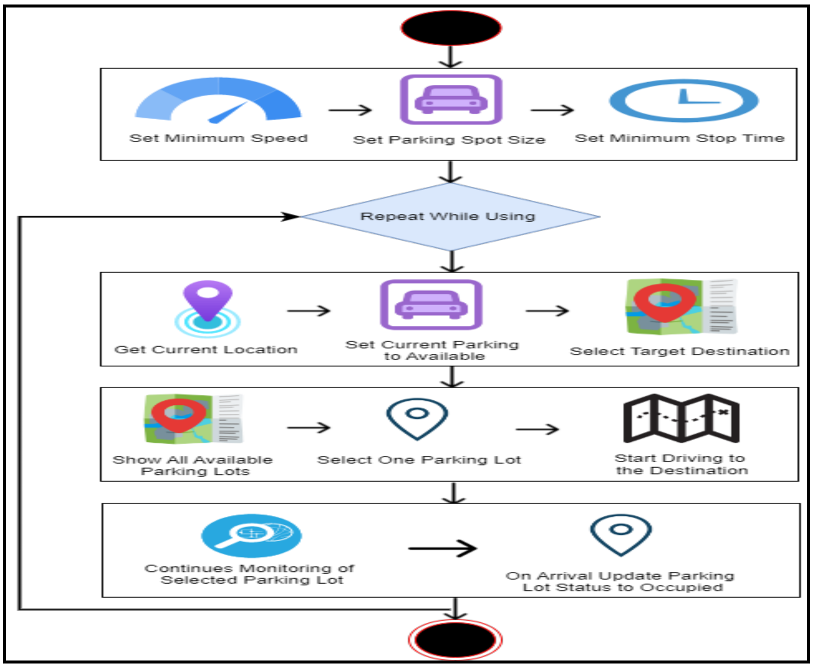


Fig. 3. The general working procedure.

## 3.2 The Procedure of the Learning Process

The proposed solution working scenario is divided into two main operations, namely learning and daily usage operation. The first operation is the learning operation, which refers to the first time when starting to use the proposed solution. In this operation, it is assumed that there are no parking lots identified in the system and it can be considered a process of building parking lots for a database on the central server. This procedure is used frequently to learn and add any new parking lot to the systems' database. The following codes represent a summary of the pseudocode of the learning procedure and performed operations:

Algorithm 1: Learning

***Start***
***Set the parking lot status to available***
***Get the current location automatically***
***Select the destination's location***
***Start the navigation process***
***If it arrives and all conditions are satisfied, then:***
***Identify the new location as the parking lot***
***Update the parking lot status***
***Add the new parking lot to the database***
***End***

In the learning operation, the working procedure of the proposed solution aims to build and learn about the parking lots within a city, which can be used and summarised as follows:

- Initially, the solution considers all the parking lots' status as available lots, which implies that there are no occupied parking lots added to the data solutions based on the integrated Google map, which is stored in the centralized high-performance server.
- By using the integrated map, the proposed solution automatically reads the current location of the car followed by asking drivers to select the destination location, which can be identified manually by dropping a pin on the map, or by using the navigation search option when using the destination's location name.
- After the destination target is selected, the real-time navigation on the map starts. Upon arrival, and after the driver stops the car in an available parking lot, the exact current location coordinates (the latitude and longitude) are automatically read as a central point of the parking lot. This center value is used to identify the parking lot area/space based on the above second indicated variable configuration setting. Finally, after declaring the parking lot in that selected area, the solution automatically drops a red color pin on that center value that is considered as an occupied parking lot and that can update the parking lots into the database accordingly.
- The solution decides on the status of the car, and then adds the parking lot to the previous step based on a condition that should be satisfied. The conditions indicate that the total stop time of the car should be greater than the minimum value declared on the minimum time variable, and the car speed must be less than the minimum speed. Consequently, the status is completely stopped, and the parking lot is added to the database.
- By repeating the previously mentioned steps, the proposed solution can build a map for the parking lot system, including all parking lots along with the ability to continuously monitor the status of each parking lot individually (occupied, which is represented by red color pin / available which is represented by green color pin).

## 3.3 Daily Usage Procedure

The second solution operation is the regular usage or the daily used operation by drivers to search for an available parking lot, navigate to the destination, park at

the available parking lot, and finally update the parking lot status to occupied and continue to monitor its status. The following codes represent a summary of the pseudocode of the daily usage procedure and performed operations:
Algorithm 2: Daily Usage

***Start***
***Select the destination location***
***List all available parking lots at the selected destination***
***Select one parking lot***
***Start the navigation***
***Continue monitoring the parking lot status***
***If it arrives and the condition is satisfied, then:***
***Update the parking lot status***
***End***

On the daily usage scenario, the working procedure is summarised as follows:

- The car driver searches for the destination target area on the integrated Google map. After that, all available parking lots are represented on the map with green color pins where the driver can select any available parking lot. In the end, the navigation process can be released.
- The solution keeps monitoring the status of the selected parking lot during the navigation along to the target. If the parking lot is occupied by another driver before arriving, the solution can automatically update the status of this parking lot to occupied /red pin), and all the other available parking lots are represented to the driver as (green pins) to select a new available parking lot.
- Upon arrival, the proposed solution update the status of the parking lot to occupied followed by monitoring the status of this lot if the above-mentioned full stop condition is satisfied and the location of the car is determined on the selected parking lot.

# 4 Results and Discussion

In this section, a comprehensive detailed discussion on the implementation requirements, finding and achieved results discussion, overall solution evaluation, and limitations are all provided and discussed in detail.

## 4.1 Implementation Requirements

In this section, the environment that is used for the implementation process and the proposed solution related to the process of searching for and managing parking lots are presented in detail. The main goal of this solution is to provide a smart mobile-based model that assists drivers to search for different available parking lots in a simple manner. The proposed solution is built with the ability to maintain and continually update an integrated Google map used to present all available and occupied parking lots. The main contribution is that the proposed solution can be used in any location (parking area) with no location-based restrictions.

The implementation requirements of the proposed solution are simple and are taken into consideration by achieving the main goal with minimal cost. Moreover, the proposed solution consists of three components, which are a smartphone device, a centralized server, and an Internet connection for the communication between the drivers' phones and the central server. The smartphone at the driver's side is acting as a client that is used to send its requests to the central server and includes an integrated Google map within the solution's interface. The current driver location is required to be accessed by the proposed solution during the usage time of the mobile application to maintain the best battery consumption and reduce it to the minimum. The solution is active and can access the location in the foreground only i.e. during the usage time only, which means that once the user opens the application, the current location will be automatically detected, which is one of the main essential requirements to achieve the main solutions' goal. The centralized server is used to control and process the received requests, and most importantly, it manages and builds different database solutions that are used to present the parking lots on the integrated map, keep monitoring the status of these lots, and updating their status as either available or occupied. The last required component is the Internet connection between the driver's side and the server's side with an acceptable download speed that is supported by the 4G mobile network connection.

## 4.2 Proposed Solution Finding and Achieved Results

The proposed solution achieves the main objectives that represent the ability for collecting real-time data from all drivers by using the solution in building and learning about the location of the parking lots to create a centralized database that represents all of these lots. The solution can support drivers by finding an available parking lot in different public parking areas with no limitations to indoor or private parking. Furthermore, the status of the parking lots are monitored and updated by representing the status of these lots. The proposed solution takes less time during its process, which improves the maintainability and usability by providing a user-friendly, simple, and easy use of user interface with minimum costs and hardware requirements. As depicted in Figure 4 from left to right, all drivers are requested to start by one-time registration to validate the mobile number of the drivers. At this stage, simple details are requested from the drivers such as name, password, e-mail address, and mobile number.

The proposed solution allowed drivers to select some favorite categories from a list of categories that are provided to the driver i.e. restaurants or cafes. If the driver selects a specific category, voice based-advertisement messages can be received to the driver from nearby shops during the navigation in case the driver passes through their location. Favorite locations are presented on the integrated map as yellow. As depicted in Figure 4. The current location is detected automatically and superimposed on the map. After detecting the current location, the driver can now select the destination target either manually and drop the pin on the destination's location, or the driver can use the provided searching facility by the solution and search for the destination's by using its name to start the real-time navigation to the selected destination location after selecting one of the available parking lots.

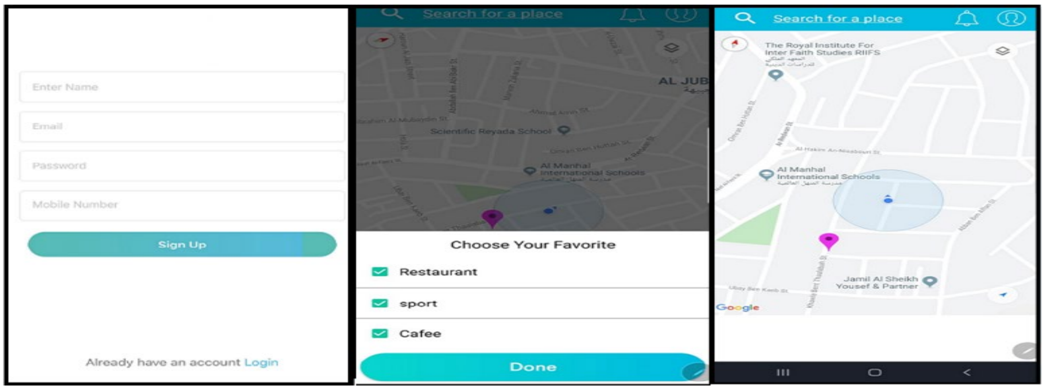


Fig. 4. Solution registration, favorite selection, and location search screens.

Furthermore, Figure 5, illustrates an example of generated available and occupied parking lots after performing the search process by using the destination location's name, which is in the provided example of the University of Jordan. As shown in Figure 5, all available parking lots are imposed automatically by using green pins, while the occupied lots are provided by using red pins. Once the driver selects an available parking lot in the destination area, a real-time navigation can be launched, and in this case, the solution will keep monitoring the status of the selected lot and all other parking lots that are to the destination by using the above-mentioned daily usage procedure. The availability of the parking spaces are automatically updated if any of the available parking is occupied before reaching the destination, which is indicated in red color.

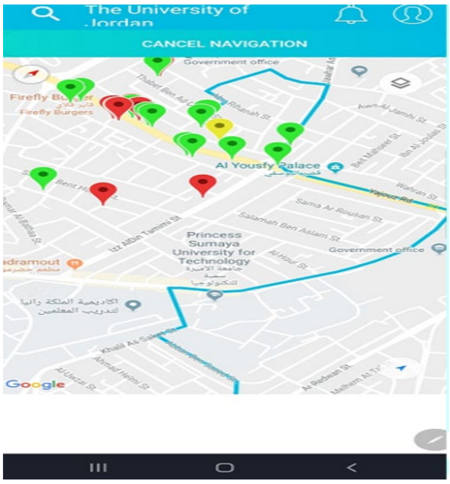


Fig. 5. Available parking lots after the search process.

## 4.2 Results and Discussion: Overall Evaluation and Limitations

The proposed solution aims at achieving the entire targeted main goals, which are efficiently provided. In order to improve the level of users' convenience, usability and simplicity are taken into consideration during the development of the proposed solution.

The testing process of the proposed solution is implemented in Jordan for one month, which is considered an acceptable duration needed to get an acceptable indication of the main functionality of the proposed solution and present any limitation that might be faced during that time. Moreover, according to the available testing resources, a team with a total of 25 cars was used for testing with communication among the members i.e. (WhatsApp group) for organizing purposes, which allowed for the ability to test 25 different parking lots at the selected testing area.

Additionally, during the testing period, the most crowded areas are selected to test the learning and daily usage scenarios such as the city center and the area of the University of Jordan. The testing day-time slot is taken into consideration during the testing starting from 7:30 AM till 10:00 PM representing the most active hours of the day in addition to the testing day type i.e. working day or weekend day.

It was noticed that different results are obtained according to different cases, for instance, it was noticed that the accuracy level varied according to the day type where the accuracy of the proposed solution decreased on Thursday and Saturday. This decrease is due to Thursday's day, which is the last working day of the week while Saturday is a non-working day. The testing area was crowded on these mentioned days, which means that during the testing it was found that some parking lots were occupied with cars which their drivers are not using the proposed solution application, which was identified as available during the testing process. Additionally, it was found that the accuracy level increased during the testing in the area where most of the cars are using the solution i.e. no drivers who did not use the solution are located at that time.

The proposed solution achieves the main goals by building and learning about the database of the centralized parking lots. The accuracy level reaches 95% in the middle of the week i.e. on Monday and Tuesday, and in the case that all the available lots at the testing area were occupied with the cars that using the proposed solution which is 95%. The 5% loss can be arisen due to some issues such as GPS signal loss, Internet connection loss, or driver mistakes in the situation the driver is moved from the parking lot without activating the solution. Figure 6, illustrates an example of accuracy calculation for two weeks, note that the starting Day 1 represents Saturday.

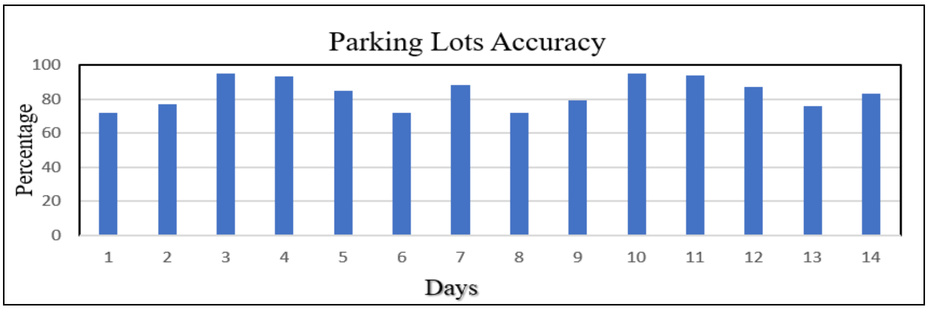


Fig.6. Parking lot Accuracy

During the testing period, different types of scenarios are noticed and an action solution is implemented to minimize its effects for maintaining the performance and accuracy level to the utmost. The first scenario indicates that the driver arrives at the parking lot and its status is updated to occupied, and the driver moves after that without running the application, where in this case, the current location is not detected and the status of the parking lot is not be updated. As a solution for the previous scenario, the proposed solution assumes that 10 hours are considered the maximum duration for using the parking lot as an occupied lot. If the maximum time exceeds and the location of the car is not updated, the system automatically resets the status of the parking lot to available lot status. One more solution for the same scenario is that once the driver opens the application, the occupied lot is updated automatically to an available status in one condition, which is that this lot is not used by any other driver at the application activation time.

The second scenario is to select the parking lot if an overlap is detected between two previously identified parking lots. In this case, the solution cancels the previously identified parking lots and considers the new location as a new parking lot. Furthermore, the solution adds new parking lots in terms of speed, which is less than 12 km. The location is not changed for 10 minutes. Further, if the parking area is a multi-level area, this case is considered the worst testing case and leads to different overlaps among multiple parking lots that are located at different parking levels. For instance, let us assume that three cars are using the same parking lot when, however each one is located at different parking level.

In the scenario that two or more users sharing the same car with an activated mobile client, or in the case the different drivers with different cars have selected the same destination and the same parking lot. In this case, the solution will start the real-time navigation to the destination normally on arrival i.e. in full stop status at the selected parking lot. The first GPS signal received from any of the mentioned activated mobile clients by the central server will be considered as the parking lot occupied by that activated client. However, some limitations are observed during the testing stage. When the driver uses the indoor location in the first case, this type of parking area can accordingly reduce the strength of the GPS signal and can affect the accuracy level of the location's calculation process. Further, if the parking area is a multi-level area, this case is considered the worst testing case and leads to different overlaps among multiple lots.

Table 1: The main functions of the proposed solution.

| **Key points** | **Is supported by the proposed solution?** |
|---|---|
| Can be implemented and used in any public parking zones? | Yes |
| Special hardware is required | NO |
| Simple and user-friendly interface | Yes |
| Voice-based advertisement | Yes |
| Overall cost | Low |
| Accuracy achieved | Acceptable level |

The main functions of the proposed solution are provided in Table 1. This table provides a summary of the proposed solution in contrast with other provided solutions, which can be implemented in predefined parking zones only by using the hardware solution (sensors), image, or video processing algorithms.

# 5 Conclusion

Searching for available parking lots is one of the main traffic problems that add an impact on drivers and the government. During peak hours, finding available parking lots, for instance, in public parking areas, is not simple and rapid as is thought to be. Searching for available parking lots causes several issues such as being time-consuming, traffic jams, fuel consumption, energy waste, pollution emissions, and many more, which can directly affect the surrounding environment. Consequently, this paper proposes a new model that can be used for improving the process of finding an available parking lot with no area restrictions, including simple hardware requirements.

The proposed model provides a solution that can build, monitor and update parking lots within an integrated real-time map that can be used to assist drivers in searching for an available lot more rapidly. The implementation of the proposed solution along with testing the experimental results over the designed mobile application implementation is provided. Additionally, it is found to be proven from the obtained results that all the target objectives are achieved, and the proposed model achieves an accuracy level of 95% with a minimum cost and hardware requirements.

In future research, the machine learning method can be integrated with the proposed solution in the context of improving the process of detecting the parking lots. For example, it can be used during the process of building a parking lots map by detecting any incorrect parking scenario i.e. long stop because of accredited at the middle of the road.

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