Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Managing Sustainable Smart Parking System

Ghazi M. Magableh [1*], Sajeda Alharahsha [2], Haneen Alazzeh [3], Ruaa Derbas [4]
[1, 2, 3, 4] *Industrial Engineering Department -Yarmouk University, Irbid, Jordan*
**Corresponding Author: ghazi.magableh@yu.edu.jo*

ARTICLE INFO

Received: 14 Dec 2024

Revised: 18 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

Smart cities are one of the forms of the fourth industrial revolution, and one of its applications is smart parking. In this study, a model was designed and developed for efficient car parks in Jordan with the aim of managing the parking lots smartly using emerging technology. The system detects and counts the cars entering and leaving the car park, and when the car park becomes full, the system prevent cars from entering the parking lot. The developed system guides the drivers to the free spaces and suggest nearby alternative parking lots for the entering vehicles. Furthermore, it displays the environmental measurements inside the park. Simulation is used to evaluate the system and the system was developed and applied to a case study to demonstrate its effectiveness. The developed system helps reduce the waiting time, cost, pollution, and improve the safety. The system is designed to be scalable and affordable for different sizes enterprises.

Keywords: Smart City, Smart Parking, Simulation System, Sustainability, Park Management and Safety.

INTRODUCTION

The interests of citizens - their comfort, mobility and safety are at the heart of the concept of the Smart City. An important aspect of smart city development plans is the establishment of effective sustainable urban parking management systems. Sustainable Smart Parking System (SSPS) is a unified specialized system for managing parking spaces using modern technologies for quick and convenient search for parking spaces, ensuring security and automating the parking process. By reducing waiting time, the comprehensive and intelligent parking system also helps reduce emissions from vehicles.

Car parks, or car shelters, are permanent surfaces in cities where cars are common, such as shopping centers, hospitals, universities, shopping center, and sports stadiums. However, Jordan faces a significant parking problem due to insufficient space. There are no signs indicating empty slots, so the car driver is forced to enter the parking lot to search for a parking space, and usually if the parking lot is busy, the car gets stuck in the congestion while the driver tries to return. If a lot is full, drivers struggle to find parking, potentially leading to accidents, environment, and safety issues.

One of the current solutions to the garage issue is the use of vertical buildings to utilize limited ground spaces where the driver drives on a special platform and leaves the car. Then the platform transports the car to the predetermined place, the reserved or free parking place, and informs the driver of the number of parking slot. To get a car, the driver needs to log in and enter the specified number on a special screen, after which the system lowers the platform with the car to the entry level. Smart parking systems (SPS), like Mutrade, can reduce traffic congestion, vehicle emissions, fuel consumption, and pollution by optimizing lane usage and travel time. These compact, safe car parks not only improve safety but also positively impact the environment. By introducing smart parking, city administration can efficiently manage parking assets and accelerate the implementation of smart cities.

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Municipalities in old towns face challenges in allocating parking spaces due to high-density development. To solve this, optimizing existing parking lots and transitioning to modern technology-based resource management can be effective. Smart and efficient parking is crucial for a sustainable and smart city, as around 20% of urban traffic is driven by drivers looking for parking. Having enough parking near homes and workplaces also benefits the economy. The main advices of development of smart parking management system are the integration of digital systems, sensors, IoT, and intelligent automated parking management systems. The first stage is the accurate detection and identification of available parking spaces and provision of data on the availability of parking spaces designated for families, people with disabilities, and the cost of parking, etc.

The goal of creative solutions using advanced technology in crowded cities is to reduce the traffic parasite that is the time a driver spends driving a vehicle moving at the lowest speed in search of a parking space. Because of the time spent looking for parking the business meetings are frustrating, and the visitors of tourist and cultural sites, restaurants and cafes decreases. Major cities suffer from congestion in the transportation networks, which causes a lot of inconvenience to residents and tourists and harms the economy.

This study is based on the lack of studies concerned with smart parking lots and their use as solutions to the continuous increase in the number of cars and the limited number of parking slots available in public places and near shops, organizations, institutions and universities, city centers, and population hubs in Jordan. Studies have focused on smart and sustainable cities, reducing gas emissions, improving safety, and reducing the time spent searching for a suitable and nearby parking lot, taking into account the limited spaces available in crowded and congested areas. The study answers the following questions: How to solve the problem of parking lots in crowded and congested areas? How can modern technology be used to manage these parking automatically? How does the proposed system help drivers make the right decision quickly and accurately? Is it possible to obtain environmental solutions based on the sustainability of cities? And what is the relationship between the developed SSPS and smart cities?

The study contributes to helping drivers and works owners in crowded areas alike. It also provides technological and digital solutions to manage the parking in a fast, automated way, avoiding wasting drivers' time and reducing stress among those looking for a parking space. It is also considered environmentally friendly and increases sustainability in cities, as it reduces gas emissions and fuel consumption at acceptable and relatively low costs.

LITERATURE REVIEW

As vehicle numbers increase, parking issues and traffic congestion in urban areas increase. An automated smart parking management system is crucial to help drivers find suitable parking. Most existing systems lack real-time detection and automatic fee collection. Decision makers may use an integrated parking meter for smart parking management [2]. SPSs offer real-time parking information to drivers, reducing congestion and pollution. A consortium blockchain is used by these systems to guarantee availability, security, and transparency. Drivers' positions are concealed by cloaking technology, and validators provide offers for available parking. Direct reservations can be made with the parking lot, allowing drivers to select the best offer [1].

A smart parking system that utilizes spread cameras, edge computing, data analytics, and deep learning algorithms to capture license plate numbers and monitor large parking lots, can reduces costs and offers an adaptive solution, improving existing systems' efficiency [3]. A system with real-time navigation to parking spots and probabilistic emptiness values based on Estimated Time of Arrival, offer reroutes users to the nearest space if needed, potentially reducing traffic congestion, and improve system practicality and efficiency [4].

An IoT-based cloud-integrated SPS should be designed to address traffic congestion, limited parking spaces, and road safety. The system includes an on-site IoT module for monitoring and communicating parking availability, and a mobile application for users to check and reserve spaces. Such system provides potential in enhancing road safety [5]. The development of a smart parking system uses IoT technology and mobile applications to provide information about vacant spaces, assist users in parking, monitor vehicles, and use computer vision for security. Such system also features mobile payment for convenience [6].

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

City overpopulation and vehicle growth have made finding vacant parking spaces difficult, especially during peak hours. Despite traditional methods and technology, limitations exist in devices and implementation costs. Digitalize systems can optimize parking solutions with low-cost options [7]. Smart parking solutions should focus on optimizing parking options with low-cost options to ensure efficient and cost-effective solutions [8].

Traffic congestion in cities is a major issue, with cruising accounting for 10% of traffic. A system using IoT, cloud technology, and sensor can be used to anticipate parking availability to provide state-of-the-art prediction models, based on geography, days, and working hours [9, 10]. The Internet Engineering Task Force (IETF) advocates for the use of web services via Platform as a Service (PaaS) to accelerate the adoption of the Internet of Things (IoT). This strategy enables easy, quick, and less complicated application development, allowing for the integration of parking sensors with IoT middleware and the quick development of SPS [11].

Due to the lack of in-depth studies in sustainable smart parking management systems, this paper's primary goal is to design a model for smarter parking lots that can detect when a lot is full and identify free spots to make it easier for drivers to access them. Smart parking systems use IoT technology and mobile applications to provide parking information, assist users, monitor vehicles, and use computer vision for security. The proposed systems address city overpopulation and vehicle growth by optimizing options with low-cost options, predicting parking availability, and integrating parking sensors with IoT middleware. This will save time and make the parking safer by lowering the possibility of accidents occurring within the parking lot. The study contribute by proposing an SSPS that helps in parking lot management, cutting down driver waiting times, minimizing potential collisions within the lot, and enhancing public safety by lowering the risk of suffocating from poisonous gasses and oxygen deprivation.

RESEARCH METHODOLOGY

Figure (1) shows the method of designing and developing the system, where the appropriate idea was chosen and then data was collected by taking the opinions of the concerned parties by questionnaire, views of experts, and personal interviews with people with related experience. Information was also collected through literature reviews and solutions introduced locally and globally. Next, a prototype was made taking into consideration the requirements of different parties and the design for excellence considerations. The prototype was then examined, evaluated and reworked to meet the design requirements. Then the system was applied to one of the parking lots, outcome data was collected, analyzed, and results were extracted.

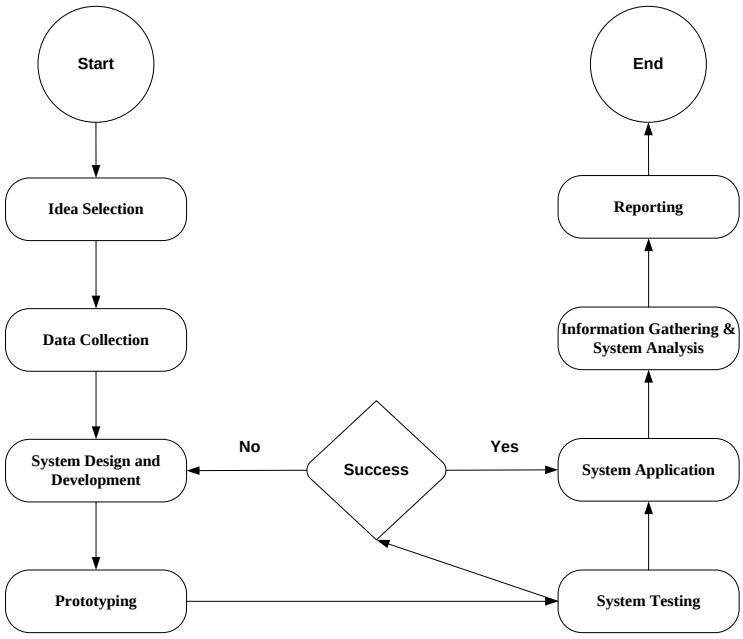


Figure (1) Design methodology

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

SSPS DESIGN AND DEVELOPMENT

4.1 System Description

To reduce the driver waiting and searching time and lower the chance of accidents within the parking lot, a model is being designed and developed to make parking lots smarter. It will determine whether the lot is full or not and identify any empty spots to make it easier for drivers to access them. Currently, parking lots are handled in a traditional manner, with drivers entering to look for a spot and leaving if the lot is full. As a result, pollution levels rise and safety levels decrease. In the proposed SSPS model, smart technology will be used in the management of car parks. If the parking lot is full, a message will be displayed on the parking gate indicating that the parking lot is full, and if there is room for cars to enter, a message will be shown indicating that the parking space is available for the car to park. The system determines the location of the unoccupied lots and also takes into account the number of cars that have entered and have not yet parked. The system considers the shortest path to the parking slots. There are internal screens that show the free slots as a result of cars leaving or those that are occupied as a result of cars parking while the car is entering. The system also shows nearby parking lots that the driver can go to and park if the specified parking is completely occupied. The system also includes a mobile application that enables the driver to reserve a parking space and view empty parking spaces, nearby parking, their occupancy rate and prices. SSPS provides a model that helps in managing car parks, reducing queuing time for the car driver, and reducing possible accidents inside the parking lot, also adding more safety to people lives by reducing the chance of suffocation due to toxic gases and lack of oxygen.

In an era of increasing digital transformation driven by rapid growth in technology, Jordan is witnessing a significant increase in the movement of people from rural areas to cities. With new areas constantly evolving, city-led innovations are increasingly focusing on developing transportation systems and services, enabling people to move more efficiently through existing road infrastructure. However, the region faces new challenges stemming from the rising urban population, heavy traffic congestion and pollution. Through the integration of transformative technology, decision makers seeks to address these major challenges by participating in building the future of intelligent transportation in the country, where the urban areas are constantly expanding.

The goal is to reduce congestion in the state, by introducing smart parking solutions and providing user-centered and data-driven smart transportation services and parking search method. To do this, the SSPS provide digital parking solutions and transportation services that provide cheap, reliable and seamless electronic parking experiences that include flexible and futuristic functionality, thus, enabling stability of development and enhancement to meet the changes and dynamic needs of communities across the cities for decades to come. The project targets all shops that have private parking, restaurants, universities, municipalities, and all governmental and non-governmental departments that have problems in their parking lots.

One of the barriers for such projects is the cost of as parties involved views the parking lot as a secondary or inconsequential capability and does not want to invest any money in its development. The required time to implement the project and the availability of experts to consult and assist in resolving certain problems present additional challenges. Along with the lack of maps that indicate the location of the parking in the specific areas.

To prevent accidents, a message will be displayed when a car enters a full parking lot, indicating that it is occupied before entering the vehicle. A Smart lighting system will be employed to enhance sustainability. The system will reduce congestions at the entrances, exists, inside the parking lots, and nearby streets. It will prevent road blocks and cars getting stuck inside the park. It will reduce the waiting, searching time, and improve the health and safety by minimizing the amount of time the car stay inside parking, It also alerts the driver to the amount of gases inside the garage to help people with allergies from being exposed to injury. The SSPS system will help reducing the pollutions and greenhouse gases by minimizing the waiting, moving, and searching time of the vehicles.

The design is based on customer requirements and inputs. The main specifications include: minimum cost, improving safety in the parking lot, reduce the waiting and searching time, easy to use, maintain, consider

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

ergonomics aspects like clear visibility from long distance & health related issues. Table (1) shows the performance metrics considered in the design and development of the system.

Table (1) Design and performance considerations

Performance Factors	Description	Design Consideration	Description
Accuracy	System will guide the driver to the available place accurately	Performance	Reduce the waste time and improve efficiency
Safety	The system will reduce accident in the parking and congestion by regulating the car entrances and exits and prevent cars from entering the parking when it is fully occupied.	Serviceability	Support the serviceability, usability, maintainability, and provide good service
Traffic regulation	The system will guide driver to the available spaces in systematic way and consider the traffic rules and regulations.	Economic	Reduce gas consumptions, and risks costs
Time	The system will reduce waiting and moving to search the available space.	Environmental	Less pollution and minimize gas emissions
Cost	The system is designed and developed with relatively low costs. It will reduce the gas consumption and minimize the risks.	Manufacturability	Minimum number of components, ease of assembly and installations
Responsiveness	The system is responsive and reactive by utilizing the automatic transfer of data and information directly to drivers looking for parking or to the reservation and payment systems in the organization.	Health and safety	Reduce number of accident, improve human health
Robustness	The system is designed to withstand different weather conditions and can be applied and implemented in different places of different sizes. It is applicable to closed and open parking lots and expandable and adaptable to different surrounding conditions.	Social	Reduce the tension and clashes among drivers

4.2. Main Components of the System

Figure (2) below show the main features of the developed system. The model components include Arduino Boards, Bread Boards, Wires, LEDs, Ultra-Sonic Sensors, and LCDs. The ultra-sonic sensor is used to detect any object placed by measuring the distance between the sensor and the object, then the sensor sends the distance to the Arduino board to process the distance, if the distance is lower than threshold value then there is a vehicle stand in parking slot, else there is nothing stand in the front of sensor, this information sent to the LCD screen from the Arduino board to provide a visual insight to the user to understand the system.

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

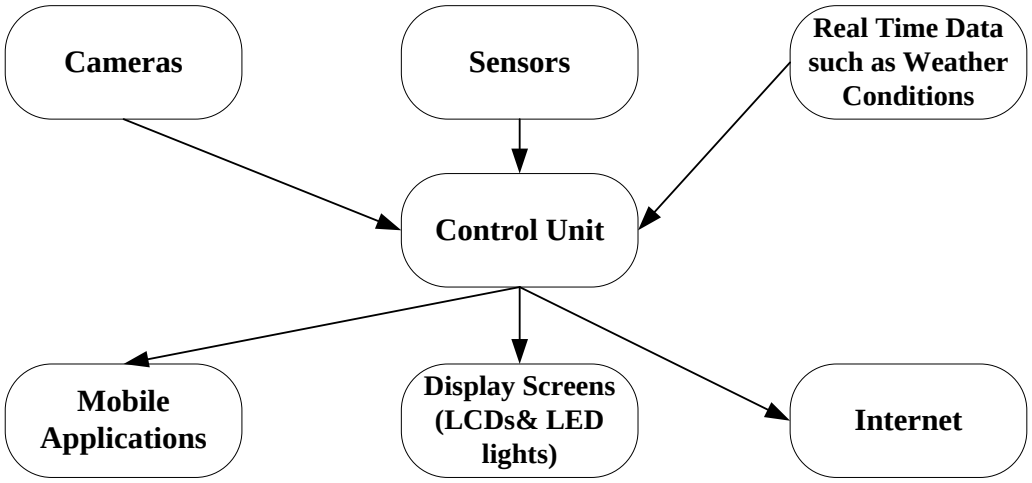


Figure (2) the main components of the system

- **Arduino** is an ATmega328P-based microcontroller board. A 16 MHz crystal oscillator, six analog inputs, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button are all included. It supports the microcontroller; to get it going, just plug it in via a USB cable to a computer or power it with a battery or AC-to-DC adapter.
- **A breadboard** serves as a foundation for electronic prototyping. The word was first used to describe a bread board, which is a sophisticated piece of wood used for bread slicing. The solderless breadboard is reusable and doesn't need to be soldered. This makes it simple to use for circuit design experiments and the creation of temporary prototypes. Solderless breadboards are therefore widely used in technological education.
- **LED**s is a semiconductor that uses electricity to create light. Unlike incandescent lightbulbs, LEDs are durable and don't break easily. They are efficient—the majority of the energy is converted to light rather than heat—and come in a wide variety of colors.
- **Jumper wires** are a long, thin, and multipurpose metal object. Wires serve a variety of functions and come in a wide range of sizes and metals. Electrical wire is wire that is used to transmit electricity and comes in a variety of colors.
- **LCD** is an electronic device that is used to display data and the messages.

4.3 Design Constraints

The cost of implementing the solution is the most important obstacle in such projects, as all parties consider that the car park is an unimportant or secondary facility and therefore, they have no desire to pay any cost to develop it. Another problem is the available time to implement the required infrastructure, and the availability of expertise to help solve installation issues and implement the system. In addition to lack of parking maps as there is no available maps shows the location of the parking in the Irbid Municipality-Jordan.

4.4 Safety Consideration

If the car enters the parking lot and it is full, there is a possibility of a stuck and high congestion leading sometimes to collision or driver nervousness inside the parking lot as the car tries to get out of the parking lot. Therefore, a message will be showed indicating that the parking lot is full before car entry to prevent clashes inside the parking lot. In addition to the sensitivity of some people to gases, especially in closed and dense places, the system will display data on the quantity and types of gases in garages to help people with allergies. The system also provides and illustrates slots for people with special needs. In addition, the SSPS indicates the presence of a stuck, accident or congestion inside the garage.

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

In general the system provides summary information about available slots, congestions, blocks corridors, accidents, stuck vehicles, incorrect parking, and pollution information. It improves sڑace utilizations, health and safety, sustainability, gas consumptions, the drivers' mode, data management, reduces the wasted time, accidents and chaos, and streamlining traffic and improving drivers' overall parking experience. Also, the system provide information about the nearby parking and available slots. It also provides those responsible for managing traffic in the city, such as the traffic police, municipality, civil society organizations, and researchers, with accurate information about these parking lots, which allows for studying, analyzing and finding appropriate solutions.

4.5 Development of the SSPS System

Congestion has made it extremely difficult for hospitals; banks, shopping centers, and other establishments provide enough parking lots due to the high rate of population inflation and the rise in number of automobiles. The main issue is that when a car enters a parking lot in search of an empty spot, it becomes trapped in the traffic, which can result in accidents and material losses for patrons.

After selecting the idea of SSPS and determine the mission statement, the first step is to determine the customer needs for the sustainable smart parking management system. Stakeholders include: business owner, drivers, employees, policemen, municipalities, and governments. The second step is to gather raw data using special designed surveys, and face-to-face interviews, the collected customer statements and customers need are as illustrated in table (2) below:

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Table (2) Concept selection phase 1

Selection Criteria	Smart Parking Management System	Additional Parking Spaces	Parking Space Management	Redesign the Parking Lot
Ease of use	+	+	+	+
Initial Cost	+	-	0	0
Running Cost	+	-	-	-
Accuracy	+	+	+	-
Sum+ Sum0 Sum-	4 0 0	2 0 2	2 0 1	1 0 2
Net Score	4	0	1	-1
Rank	1	3	2	4
Continue?	Yes	yes	yes	no

In order to choose the best tools to enhance the parking system, a set of criteria is established. Four options were identified: the smart parking management system, additional parking space, parking space management, and redesign of the current parking lot. The results of comparing these options based on the criteria, as shown in table (2), are used to rule out redesign of the current parking as a potential solution to the parking issue. In the next step, three alternatives were selected. The result of concept scoring shows the SSPS is the best solution of the problem. So, Sustainable Smart Parking Management System will be applied as shown in table (3).

Table (3) Concept Scoring

Selection Criteria	Weight	SSPS	Score	Additional Parking Spaces t	Score	Parking Space Management	Score
Ease of use	0.4	**5**	**2**	**5**	**2**	**5**	**2**
Maintenance Cost	0.1	**5**	**0.5**	**2**	**0.2**	**3**	**0.3**
Cost	0.2	**4**	**0.8**	**3**	**0.6**	**3**	**0.6**
Accuracy	0.3	**5**	**1.5**	**5**	**1.5**	**5**	**1.5**
Net Score			**4.8**		**4.3**		**4.4**
Rank		**1**		**3**		**2**	

The following summarize of the survey results which indicate the customers' requirements that should be considered in the design of the sustainable smart parking management system.

1. There is a sign warning drivers not to enter the parking lot if it is already full to avoid stuck risk.
2. The parking lot indicates the available parking space.
3. The system displays the congestions, blockings corridors, accidents, stuck vehicles, incorrect parking.
4. Presence of screens to display information in legible font.
5. Presence of indicators of jammed and crowded places.

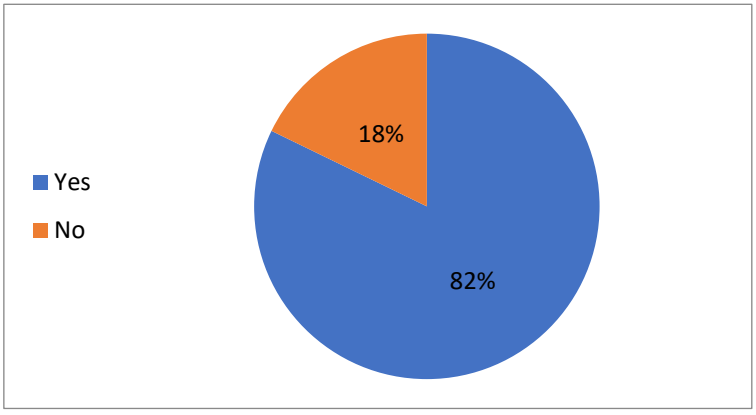
Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

6. The system provides accurate data and information of the parking lots for statistical analysis to help decision maker and researchers analyze the situation.
7. Presence of internal screens showing the unoccupied parking spaces and the shortest routes to available slots.
8. Presence of clear signs and enough parking spaces designated for special categories such as people with disabilities.
9. Clear indications of entrances and exits, which must be separated.
10. The system shows the dimensions of the parking spaces so that the driver can choose the appropriate parking space depending on the size of the vehicle.
11. There is a need to suggest nearby parking lots and the available slots.
12. The system is linked to mobile applications so that the driver does not have to approach the entrances and exits of busy lots.
13. The displayed data include the amount and type of gases and environmental conditions, especially in closed parking lots.
14. The system can display garage statistics such as the number of cars entering and exiting, as well as the time periods during which all the parking spaces were occupied, the highest and lowest gas percentage, and the average parking time.
15. Statement of the best times when parking spaces are available and there is less congestion.

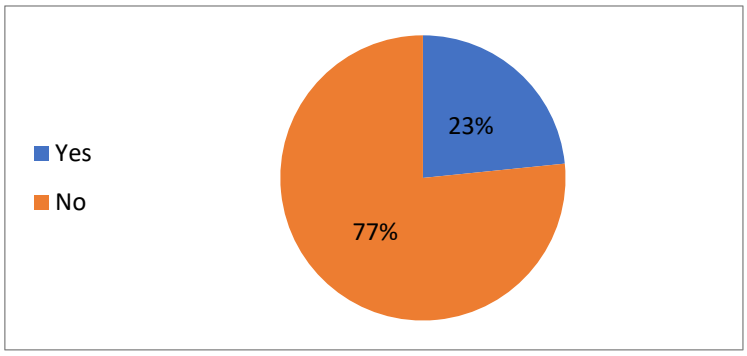
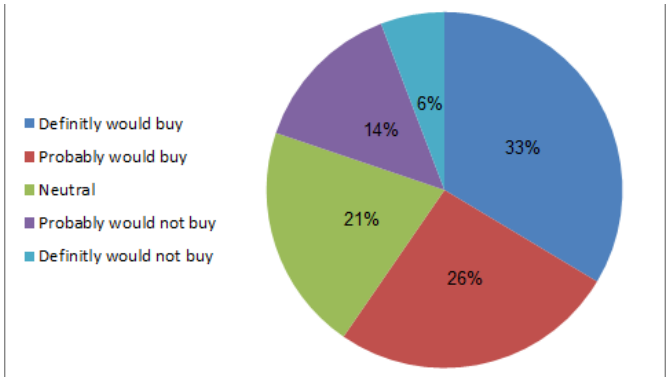
Using the survey, the concept acceptability by the customers was tested. The first question is about if the concepts are acceptable for the customer, the second question focus on the concept functionality and safety, the third question test if the customer would by the product with the new design. The questions and the stakeholders' response are shown in Table (4) below. The results demonstrate that 82.2% of respondent see the system is useful, 76.6% of the respondent see that the system is safe, and 62.6% will probably buy the system.

Table (4) Concept testing

Question	Illustrated figure
Do you think the new system will be useful and helpful for the users?	

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Question	Illustrated figure
Do you think the new system will improve the safety?	
Would you buy this system?	

4.6 Design for X

Considerations for the design for X are shown in table (57)

Table (5) Design for excellence considerations

Metric	Design
Design for ergonomics and safety	
User Analysis	All drivers from both genders and different ages
Task Analysis	The user can successfully do the tasks, completing all necessary mental and physical processes.
Usability	The system is simple to use, service, and maintenance and is successfully, efficiently, and adequately accomplishing specified purposes
User friendless	The system is user friendly and easy to understand and use
Multiple clients	System is flexible and easy to deal with and to change configuration and setting and it is design for multiple users simultaneously
Design for safety	
Use safe materials	The system use safe and environmental friendly and less hazardous material and it also improve the general safety
Use proper signs & switches	The signs for users and operators are simple, common, and properly designed.
Design for environment	

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Environmental friendly	Utilize recyclable and recycled industrial materials, natural materials that can be recycled back into biological cycles, processes that don't release harmful substances, avoid combining materials that aren't compatible with recycling, and label all of the recyclable components.
Design for assembly	
Easy to fabricate	The system is design for simple assembly, disassembly, maintenance, and packaging
Easy to maintain	Make it simple to disassemble into distinct material recycling streams and minimize size and weight for shipping that is more compact.

Based on the customer needs, the proposed concept main components include Smart Arduino System, Underground sensors, smart management system, and Android Application. Figure (3) below show the cluster analysis of the system, where the same colored represents the cluster of the same category.

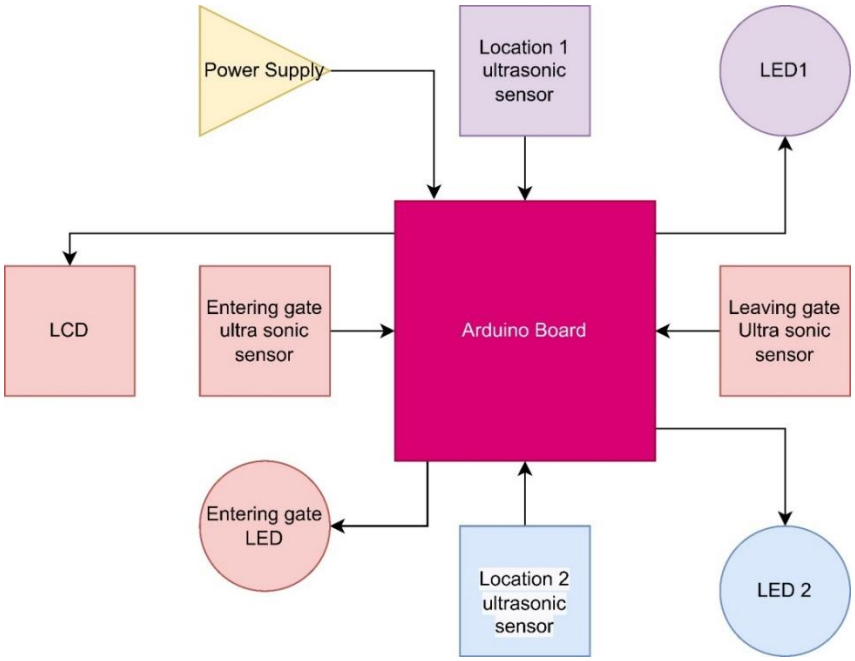


Figure (3) cluster analysis

4.7 SSPS Software and Hardware

The Arduino Nano microcontroller is in charge of managing other parts. The microcontroller has been programmed using the Arduino IDE, which is based on C or C++. This programming platform has been used to achieve efficient communication between sensors, actuators, and the microcontroller. The other sensors and actuators in this system can be controlled by programming the microcontroller. Every module, actuator, and sensor made use of a different software library. A software library is a group of codes that are used to control a sensor or actuator. Programmers and compilers who run software can benefit from the creation of software libraries.

Arduino is an open-source platform for building electronics projects. The Arduino platform consists of a programmable circuit board and the Arduino IDE (Integrated Development Environment) software. Programs can be written, compiled, and uploaded to a variety of physical boards using this computer-based IDE. The Arduino Platform has become very popular among hobbyists and developers. Arduino products are distributed under either the GNU General Public License (GPL) or the GNU Lesser General Public License (LGPL). They are offered as open-source software and hardware.

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Hardware infrastructure include electrical device and connections, cables and wires, sensors to be installed on the enter gate and out gate, sensors to be installed in each parking slots, and LCDs to be installed on the outer gates of the parking lot.

Based on the above analysis, the code is built for each function and activity. The code considers the inputs from variable sensors, cameras, and input platforms to setup the required libraries. The code illustrates the process, logic, variables, and calculations of the systems. The system is used to apply condition statements to manage the parking. Then the output of the system displays the required information on the screens and sends the information to the mobile phone applications. The code is used to initialize the interfaces to the LCD screen, and specifies the dimensions (width and height) of the display and defined the LEDs as output devices. Then the system will store specific data based on the system requirements. Massage, in the right from, will be sent to stakeholder for the current status of the parking.

DISCUSSION OF THE RESULTS

In light of the large population inflation accompanied by an increase in the number of cars, the search for a parking lot has become complicated as a result of congestion. The problem is when a car enters the parking lot to search for an free place to park, the car gets stuck in the congestion inside the parking lot, which may cause misfortunes that may cause losses.

Initially, a simulation model was developed to study and evaluate the system as well as to validate the system using real data from collected the case study. After that, the system was developed, the prototype was built and tested, and a beta model was developed and applied to one of the parking. The system and its performance were then monitored to ensure that it was working as intended. The system was tested according to the data shown in Table (6) and the results were consistent with what was decided.

Table (6) Results of the model experiments

Step	State	Counter	LCD	LED 1	LED2
1	Car entered and parked in 1	1	Slot 2 free Slot 1 occupied	off	on
2	Another car entered and parked in 2	2	full	off	off
3	Car left park 1	1	Slot 1 free Slot 2 occupied	on	off
4	Car left park 2	0	Slots 1&2 free	on	on

After that, the system was implemented and applied to one of the parking lots in Irbid city. The system was tested for a week, data was collected and analyzed, and the results were as follows. The system performance was as shown in table (7). The results indicate substantial reduction in searching time, emission gases inside the park, and no cars enter the parking while it is full. In addition the customer satisfaction was greatly improved.

Table (7) Performance Comparison

Metric	% Decease After SSPS Employment
Time to park	63%
Air pollution with CO2	38%
Number cars enter while park is full	100%

Journal of Information Systems Engineering and Management
2025, 10(44s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

A mobile application is utilized for users to check and reserve spaces and direct the drivers to the right parking lots. An SPS utilizes IoT technology and mobile applications to provide parking information, assist users, monitor vehicles, and use computer vision for security, with mobile payment features. City overpopulation and vehicle growth pose challenges in finding vacant parking spaces, prompting the need for digitalized systems to optimize parking solutions with low-cost options. Smart parking solutions should prioritize optimizing parking options with low-cost options to ensure efficient and cost-effective solutions. A system using IoT, cloud technology, and sensors can predict parking availability in cities, addressing traffic congestion and cruising, based on geography, days, and working hours. SSPS facilitates the swift development of smart-parking management, integrating parking sensors with IoT middleware, thereby reducing complexity.

The cost benefit analysis indicate the total costs required to implement the system is relatively low while the befits include the reduction in time required to park, congestion, environmental impact, gas consumption, increase safety, and a substantial increase in customer satisfaction. The system provides high accuracy and can reduce number of employees needed to manage the parking lot. In addition the system is equipped with several subsystems and features as follows:

- The application indicates the level of CO2 ,O2, humidity, and temperature inside the parking facility using different sensors. The SSPS display the measures at the entrance of the parking facility and update the information on the internet. This is to help preserve the environment and inform allergic people with asthma or other diseases to the environment inside the parking facility.
- The SSPS helps save time, reduce costs, and risks. The model helps in managing car parks, reducing blockage and queuing time for the car driver, and reducing possible accidents inside the parking lot, also adding more safety to people lives by reducing the chance of suffocation due to toxic gases and lack of oxygen in closed lots. Also it consider the amount of gas emissions in the park, even if there are a ventilation system in the parking facility, the system try to minimize gas emissions by reducing car waiting and searching time. Furthermore the system will send an alarm when the environment inside the park becomes risky.
- If the parking lot is full, a message will be displayed on big screen at the parking entrance gate indicating that the parking lot is full, and if there is a room for additional cars to enter, a message will be shown indicating the location and the routes of the available parking spaces.
- The system use sensors to detect the occupied parking lots based on the distance between the sensor and the object (car), then the sensor sends the a signal to the Arduino board to process the distance, if the distance is lower than threshold value then there is an object (vehicle) parking in the front of sensor, else the lot is not occupied, the information will be directly and continuously sent to the LCD screen from the Arduino board to provide a visual insight to the user.

Smart parking technology is a solution to the issue of parking scarcity, reducing frustration and traffic issues. It involves an IoT-based system that sends data about free and occupied parking spaces via web/mobile applications. E-Parking allows for electronic payment of parking charges, and Jordan has implemented off-street smart parking in malls and hospitals. This technology improves space utilization, safety, and overall cost by providing real-time information about parking availability. It also reduces pollution by drivers searching for parking spaces. Smart parking also allows for data management, allowing cities to gather and analyze real-time parking analytics, enhancing traffic flow management and optimizing space planning. This technology can be used in a variety of settings, including public parking lots, business buildings, residential complexes, and urban areas.

CONCLUSION

A model is designed and developed to enhance vehicle parking systems in Jordan with the aim of managing the parking lots smartly through emerging tools. The system detects and counts the cars entering and leaving the car park, and when the car park becomes full, the system prevent cars from entering the parking lot. System design and development is based on actual customer needs. To determine the customer requirements, tools were utilized such

as questionnaire, experts' interviews, direct data collections, and historical data from the related agencies. A Survey was distributed to the parking lots facilities, municipalities, traffic agencies, and traffic police department to determine the problem. The developed system guides the drivers to the empty spaces and suggest nearby alternative parking lots for the entering vehicles. By connecting the system with IoT technology, people can know if there is available parking location before coming to facility or while they are in their way to the target location. By the use of an application connected with the system that supports IOS and android, the driver can book a place in the parking facility before he comes to the site, and then directly go to the specified parking lot. Also the developed system can direct drivers to the nearby parking facility by suggesting close parking lots for the driver and guiding them using GPS system. The nearby parks are determined using specific developed algorithm based on the distance and time. The main interest behind the system design and development of SSPS is to improve the sustainability by:

- Providing new solution for parking systems with minimum cost and reduces chance of accidents occurrence in the parking lot.
- Solving real problem facing drivers and people who work or visit facilities by saving their time, health, and lives.
- Reduce the environmental impact by reducing and controlling the emission inside the parking facilities specially the indoor parking facilities inside big cites.
- The system use clean energy as it utilizes the solar energy to provide the electricity for the system.
- The system is scalable and can be developed and manufactured with robust design.
- The system reduce traffic congestions and blockage at the entrances, exists, and nearby roads.

This system benefits all parties involved in parking management, whether it is the owner of the lot, the traffic police, or municipal employees. In addition to drivers, as it provides smart solutions for parking and choosing the appropriate lots without wasting time. This system is expandable as it applies to small, medium and large parking lots alike. The solution provides a detailed user manual with illustrated figures, screenshots, or detailed diagrams. The study contribute to the smart city by offering a model that aids in parking lot management, cutting down on driver wait times, minimizing potential collisions within the lot, and enhancing public safety by lowering the risk of suffocating from poisonous gasses and oxygen deprivation.

There are limitations in the study, such as applying the system to one parking lot, where it can be applied in the future to a larger number of lots, integrated them and linking them with mobile applications of customers. No collected data on drivers parking incorrectly by leaving side spaces, and reducing clutter inside the garage. Future research should consider the connection of the system to additional applications of internet of things so that visitors can check the availability of parking spaces before arriving at the facility and set up the system to direct drivers to the closest parking lot showing walking distances and time required. Add more sensors and perform cost-benefit analysis of implementation, Future research could identify empty garages and allow drivers to reserve a spot and pay, if for a fee, through a mobile app.

REFERENCES

[1] W. A. Amiri, M. Baza, K. Banawan, M. Mahmoud, W. Alasmary and K. Akkaya. "Towards secure smart parking system using blockchain technology." In *2020 IEEE 17th Annual Consumer Communications & Networking Conference (CCNC)*, pp. 1-2. IEEE, 2020. doi: 10.1109/CCNC46108.2020.9045674.

[2] P. Sadhukhan. "An IoT-based E-parking system for smart cities." In *2017 International conference on advances in computing, communications and informatics (ICACCI)*, pp. 1062-1066. IEEE, 2017. doi: 10.1109/ICACCI.
2017.8125982.

[3] B., Harshitha, N. Lin, N. Kumar, S. M., S. Nagaraj, and K. Liu. "An edge based smart parking solution using camera networks and deep learning." In *2018 IEEE international conference on cognitive computing (ICCC)*, pp. 17-24. IEEE, 2018. 17-24, doi: 10.1109/ICCC.2018.00010.

[4] R. K. Lenka, R. K. Barik, N. K. Das, K. Agarwal, D. Mohanty and S. Vipsita. "PSPS: An IoT based predictive smart parking system." In *2017 4th IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics (UPCON)*, pp. 311-317. IEEE, 2017. doi: 10.1109/UPCON.2017.8251066.

[5] K. Abhirup, and R. Anand. "IoT based smart parking system." In *2016 international conference on internet of things and applications (IOTA)*, pp. 266-270. IEEE, 2016.

[6] L. Rachapol, K. Nambut, and S. Usanavasin. "Smart parking using IoT technology." In *2018 5th International Conference on Business and Industrial research (ICBIR)*, pp. 1-6. IEEE, 2018.

[7] D. Gopal, M. Ganesh, A. Jerlin, and M. Abirami. "A smart parking system using IoT." *World Review of Entrepreneurship, Management and Sustainable Development* 15, no. 3 (2019): 335-345, 2019.

[8] P. Ramaswamy. "IoT smart parking system for reducing green house gas emission." In *2016 international conference on recent trends in information technology (ICRTIT)*, pp. 1-6. IEEE, 2016.

[9] A., Ghulam, T. Ali, M. Irfan, U. Draz, M. Sohail, A. Glowacz, M. Sulowicz, R. Mielnik, Z. Bin Faheem, and C. Martis. "IoT based smart parking system using deep long short memory network." *Electronics* 9, no. 10 (2020): 1696.

[10] G. Magableh, and A. Mumani. "Simulation Based-MCDM Approach for Evaluating Traffic Solutions." *Promet-Traffic&Transportation* 34, no. 1 (2022): 117-133.

[11] S. Zeldi, G. Sinniah, S. Haseeb, M. Siddique, and M. Ezani. "Rapid development of smart parking system with cloud-based platforms." In *The 5th International Conference on Information and Communication Technology for The Muslim World (ICT4M)*, pp. 1-6. IEEE, 2014.