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A Smart Parking System, Case Study

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ABSTRACT

The Gaza Strip in general, and the Islamic University of Gaza (IUG) in particular, are plagued by a lack of parking places, a lack of management and efficient usage of parking spaces, and illegal vehicle parking. This resulted in lost time and effort, besides traffic congestion. The study's goal is to provide a plan for implementing a Smart Parking System, which manages the parking spots on the IUG campus. To accomplish this goal, the researchers have identified the parking problems that face drivers at IUG, and then they have studied the impact of implementing the Smart Parking System. Researchers have used questionnaires to collect the raw data as one of the important tools in the field of survey. The data were analyzed using the Statistical Package for the Social Sciences (SPSS), as a useful tool for statistical analysis. The first results was the number of parking spaces is 300, which is greater than the number of potential vehicles occupying the university parking spaces at peak hours. Therefore, the issue is not the number of parking places, but how they are used. The result of the questionnaire presents that a large majority of respondents agreed that the IUG campus suffers from a lack of parking spaces, especially in rush hour from 8-10 am. The results indicate that 65.7% of the respondents park their cars near their workplace/study at the campus parking spaces, and 72.6% of the respondents do not use parking spaces with modern technology before. While 92.6% of the respondents encourage parking with modern technologies. Smart Parking System has assisted to resolve the issue of locating a parking spot on the IUG campus, resulting in less traffic congestion and a better flow of traffic. The Smart Parking System can be applied to all of the IUG's parking spaces and in the Gaza strip cities in the future.

1. Introduction

Intelligent Transportation Systems (ITS) include smart parking systems, which are defined as a system that uses modern technology to provide parking spots and improve its management efficiency(Idris et al., 2009). Parking is any space, building, or portion thereof, with or without a roof, utilized or constructed for car parks or storage (Gómez-Bravo et al., 2001).

The purpose of the Smart Parking System is to direct vehicles to the most convenient available parking space with a short time and less effort.The problem comes from a mismatching between availability and demand for parking spaces, as well as growing vehicle ownership in regions of business, administrative operations, services, and buildings (Hodel-Widmer et al., 2004), in addition to a lack of a public transportation, messy parking, and illegal parked vehicles. All these reasons causes a traffic congestion.

The lack of parking places on the IUG campus wastes time and effort, and causes traffic congestion. Furthermore, there messy parking on the campus, particularly illegally parked cars.

The study's goal is to provide a plan to implement the Smart Parking System, which controls parking spots on IUG campus. To achieve this goal, some stages was accomplished. Firstly, identify the parking problems that facing the drivers at IUG campus. The second stage is for studying the impact of installing the Smart Parking System to solve the parking problems. Finally, installation of a practical application for the Smart

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Parking System at the campus of IUG.

The study was carried out at the Campus of IUG, which consists of fourteen buildings, besides a mosque and a stadium. There are three hundred parking spaces on the campus. A field survey of vehicle parking and knowing the daily flow of vehicles on campus was conducted. Method of counting has been determined for the number of available and occupied parking spaces of the Islamic University of Gaza campus. The campus parking spaces were divided into 7 parking lots and each parking was counted every hour during the work hours in the university.

As an example, Figure.1 shows the parking lots on the campus of the Islamic University of Gaza (IUG), which is suffered from mismanagement and a lack of parking places. Therefore, staff and students consume the time and effort spent looking for suitable parking places. As a result of this problem, a system for efficiently managing parking spots is developed.

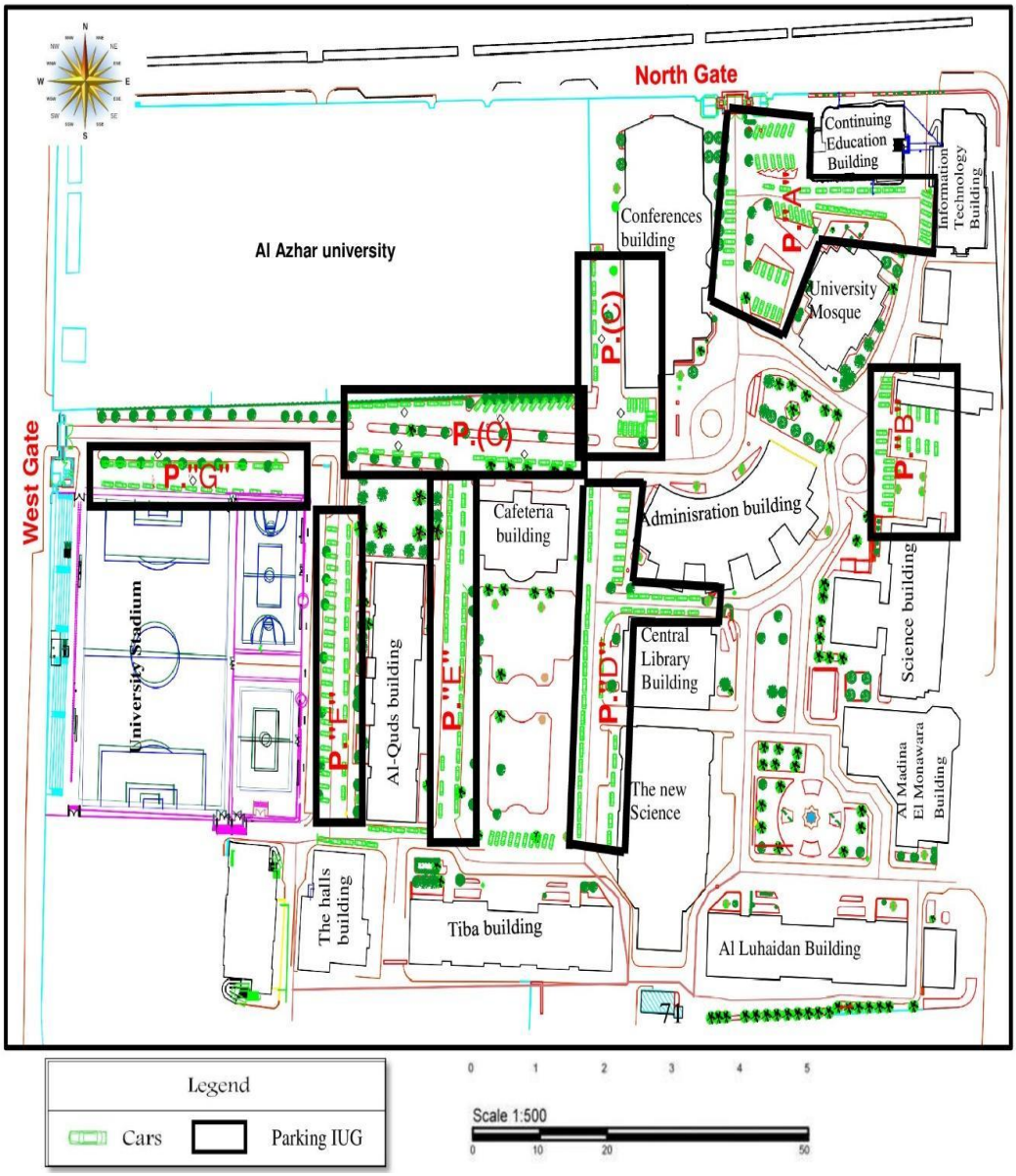


Figure 1. Parking lots at Campus of the Islamic University of Gaza (IUG)

2. Related work

2.1 Smart car parking system

A driver in a vast parking lot must search the entire area for a parking space, Gandhi research (Gandhi et al., 2016) seeks to address this issue. A microcontroller-based smart parking system is a smart car parking system. It is divided into two stories, with access and exit gates for cars on each story. On Display Screen, the system's output, which is the number of available parking spaces, is displayed. To get the number of vehicle in the parking area, the team utilizes a push button to switch sensors and connect this sensor to the microcontroller. The entry gate's Display Screen panel displays if the park is full or has available parking spaces. It also displays the number of available parking spaces as well as their location on each floor, allowing the vehicle to proceed directly to them.

An 8051 microcontroller, micro-switch sensor, motor, Display Screen to lead cars to available parking spaces, a wire to connect all the components, and a gate with a motor to open and close it was used in the study. This study is expensive because of all of these factors.

Instead of using an 8051 microcontroller, which requires new software technologies, the team used a parallel port in a PC (Personal Computer) to communicate data from the switches to the PC. They failed in some component connections, causing internal damage in some devices. Furthermore, the project's cost was extremely high, owing to the study's team's failure to select the appropriate hardware components (Gandhi et al., 2016).

this study differs by employing multiple drivers in a vast parking lot must search the entire area for a parking space, Gandhi research (Gandhi et al., 2016) seeks to address this issue. A microcontroller-based smart parking system is a smart car parking system. It is divided into two stories, with access and exit gates for cars on each story. On Display Screen, the system's output, which is the number of available parking spaces, is displayed. To get the number of vehicle in the parking area, the team utilizes a push button to switch sensors and connect this sensor to the microcontroller. The entry gate's Display Screen panel displays if the park is full or has available parking spaces. It also displays the number of available parking spaces as well as their location on each floor, allowing the vehicle to proceed directly to them.

An 8051 microcontroller, micro-switch sensor, motor, Display Screen to lead cars to available parking spaces, a wire to connect all the components, and a gate with a motor to open and close it was used in the study. This study is expensive because of all of these factors, and visual basic interfaces, Gandhi's study employs an Android application to display available parking spaces. Instead of utilizing wires to link the screens to the microcontroller, this study employs wireless communication to send data to the android application. In addition, instead of using an 8051 microcontroller or PC parallel ports, this study uses a micro webserver to collect all data from a sensor.

2.2 Wireless operated parking system

Many studies (Geng et al., 2012; Khanna et al., 2016; H. Wang et al., 2011; Yan et al., 2011) allow drivers to connect with the controlling center, which operates the gates and collects money from cars as they exit the parking lot. In this study, the process is performed automatically, which cuts down on parking time, improves payment accuracy, and lowers the need for human management at the park.The driver contacts the administration center and requests access to the garage using this technology. Meanwhile, the controlling center verifies the driver's identity and the status of the parking lot before signalling the gate to open.

The research includes the software that manages the controlling center, gates, sensors, and a mobile station. This system controls the Bluetooth communication between the driver's mobile station and the administration center, as well as an electrical circuit that connects all of the components.

There are some differences between this study and other studies, where this study only guides the driver to the appropriate floor, whereas this study detects the precise location of the nearest available parking space because each parking space has a sensor. This study uses an Android application to guide the driver to the available parking space, but this study counts the cars on each floor and closes the gate if the floor is full or opens it if there is a space.

2.3 Smart parking

(Zhou et al. 2014) the system is comprised of a user interface at the parking garage's entry that lets the driver at the gate view all available parking spots. Although the system advises the best floor, the driver is free to choose any open parking place. When a parking place is picked, red LEDs embedded into the slots direct the driver to their destination. In addition, a ticket with directions will be issued, which may be used to lead drivers back to their vehicles when they return to the parking garage.

The PC's visual interface must deliver and receive information from the microcontroller. To monitor several cars around the garage, the microcontroller must be able to multitask and execute multiple threads at the same time. The sensors on the road and in the parking spots must be precise enough to detect each car in the garage (Fazelpour et al, 2014).

There are some differences between previous studies and this study, which employs a visual interface and employs an Android application. This work uses a loop detector, which was directly connected to the microcontroller, whereas the investigation makes use of sensors and Wi-Fi technology. One problem of the prior study is that the driver interacts with the central computer, which is not ideal for use as an android application on a smartphone.

Each parking place has a smart parking system based on presence sensors. This makes it easier for drivers to locate available parking spots. The user launches the mobile application on his/her smartphone and selects the relevant parking lot icon. A new screen appears, displaying all of the parking spaces covered by this parking lot. The sensors, which were installed in each parking area, provide signals to the "Raspberry-Pi" control devices, which were spread around the university campus.The Raspberry Pi receives sensor signals, transforms them to a programming language (0 and 1), and delivers them to the main server. The server is linked to an Android application, where this data is presented as (ON and OFF), allowing the driver to proceed immediately to the selected parking place.

3. Methodology

3.1 Data collection

Data are gathered through interviews with field specialists including academic and administrative staff, engineers, engineering club organizers, and university security officers, as well as field visits to the IUG campus. This phase also involves a field study of the seven parking lots at IUG campus, which requires counting the vehicles on the campus during working hours for five consecutive days.

3.2 Vehicles count

Vehicles were counted at the IUG campus during working hours (from 7:30 a.m. to 3:30 p.m.) for five consecutive days to collect statistics on the number of cars in each of the IUG campus's seven parking lots. During working hours, the number of available parking spots and the number of occupied parking spaces were determined. However, many cars were discovered to be illegal. Figure (2) shows that the number of available parking spaces more than the number of occupied parking spaces.

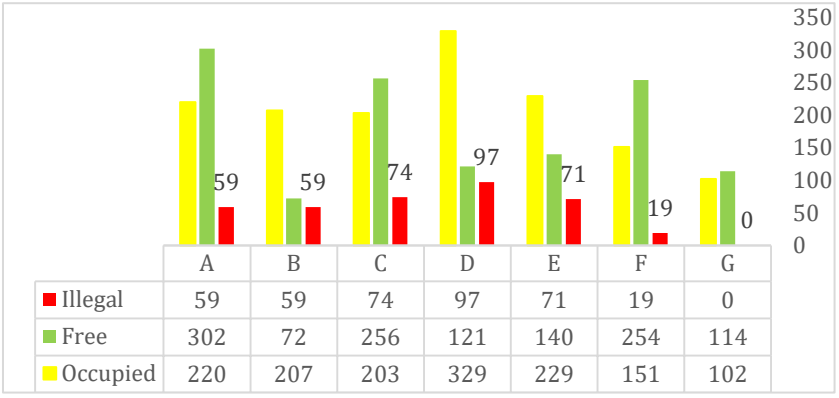
3.3 Questionnaire

To assess the feasibility of establishing a Smart Parking System on the IUG campus, an electronic questionnaire was delivered to all university personnel, and 30 hardcopy questionnaires were distributed to university students and visitors randomly. The findings were then analysed using a descriptive-analytical approach.

The Study population includes the academic and administrative staff, students, and visitors. The sample size is 151 questionnaires according to the following question (Thompson et al., 1994):

$$\text{Sample size} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

Z = Z value (e.g. 1.96 for 95% confidence level).
e = Margin of Error (usually 0.05 or 0.1).
P = percentage picking a choice expressed as a decimal (0.50 used for sample size needed).
N = population size**.**



	A	B	C	D	E	F	G
Illegal	59	59	74	97	71	19	0
Free	302	72	256	121	140	254	114
Occupied	220	207	203	329	229	151	102

Figure 2. Vehicles Count at the parking's lots of the IUG campus

3.4 Smart Parking System installation

Many actions should be taken based on data gathered by car counts to begin the first stage of the Smart Parking System installation at the IUG campus. It covers the research's requirements as well as a basic practical application on the IUG campus demonstrating how the proposed study operates, Figure. 3. The system contains;

Hardware equipment Sensors: devices that detects the physical motion. The output is generally a signal that is transmitted electronically over a network for reading or further processing.

USB dongle for Wi-Fi: a USB Wi-Fi adapter. It is used to make the raspberry-pi access to the wireless network.

Wireless USB.

Raspberry-Pi (microcontroller): used in automatically controlled devices.

Smartphone: The new-generation high-featured and multi-function cell phone, contains android applications and has Wi-Fi communication (Yang et al., 2011).

Software requirements

Android application: It is used to display information about parking spaces status that received from micro web server to the user's smartphone.

Micro web server: It stores the data in a database (Jeffrey et al., 2012).

4. Analysis

According on statistics gathered from the counting of vehicles during working hours for five consecutive days, can be note that on Saturday at 11:30 a.m., the IUG campus parking spaces were occupied by the greatest number of cars that reached 287 cars. On the other hand, according to information from the engineering club,

The IUG Campus has 300 parking places. This indicates that the number of parking spots is more than the number of cars parked at the IUG Campus during rush hour. However, a number of cars were illegally parked, which were 68 cars.

Based on the data gathered, it has been concluded that the number of parking spots at the IUG campus is enough for the cars accessing the campus. The major issue is that these parking spots are mismanaged. As a result, a Smart Parking System has developed that regulates the parking of cars within these parking spaces.

In addition, the questionnaire was designed to gather information regarding the problem of overcrowding and a lack of available parking spots on the IUG campus, as well as to identify the perspectives and suggestions of parking space users. The information played an important role in enhancing the scientific study process and determining the causes of the problem of overcrowding and a lack of parking places.

From the statistical analysis of the questionnaire data, most of the respondents of the IUG are males aged between 40 and 60 years. The largest proportion of cars exist in the campus for university personnel whose working at IUG and most of them are highly qualified. Therefore, their opinions are more confident to be accurate.

By analysing the data, can be found that:

69.1% of the respondents occupy parking spaces for 4 hours or more and the largest percentage need parking daily, and the majority find it difficult to find a parking space.

The vast majority agreed that the IUG campus lacks parking spaces and parking spaces for disabled people.

The campus suffers from a lack of parking spaces especially from 8-10 a.m.

The majority agreed that the existing parking spaces and illegally parked cars affect the width of the street and traffic negatively.

38.3% of respondents find that there are other places that can be used as car parks.

65.7% of the respondents park their cars near their workplace/study at the campus parking spaces.

61.1% of the respondents do not accept to locate a dedicated parking space relatively far from their work inside the campus.

61.1% of the respondents do not park their cars illegally to stand close to their place of work, and 86.9% prefer to park their cars and walk

22.9% of the respondents think that the losses resulting from the lack of parking spaces are delays and loss of time, stress, and fuel waste.

26.9% of the respondents think that lack of car parking spaces and frequent visitors within the campus are the factors causing the problem of parking spaces.

72.6% of the respondents do not use parking spaces with modern technology before.

16.0% of the respondents think that the reason why smart parking techniques are not used are lack of sufficient awareness of the need to use Smart Parking System, lack of equipment to implement smart parking techniques, and the difficulty of installing the system of paid smart parking spaces within Gaza.92.6% of the respondents encourage parking with modern technologies.

The researchers developed a mobile parking, application for parking at university campus as.It provides five parking places as a prototype for the practical implementation of study. Two cars were utilized to clarify the practical component of the study.

Installation of the Smart Parking System yielded the following results: The smart parking system has developed to save time, effort, and fuel. The technology directs cars to the most available convenient parking place. The IUG's Smart Parking System helps to mitigate traffic congestion on campus, increase the road size, and improve traffic flow by reducing the number of illegally parked cars on both sides of the campus roadways.

5. Conclusion

By implementing the prototype and based on the data collected and analysed, some conclusions were obtained. In addition, the results were helped to offer good suggestions and some ideas and directions for future efforts.

The Counts findings revealed that the IUG campus has an adequate number of parking spots, while the problem is a lack of parking management, which motivated the authors for installation of a Smart Parking System.

The Smart Parking System has helped to solve the problem of finding parking spots on the IUG campus, which has resulted in less traffic congestion and a better flow of traffic. It is based on two axes: Reducing traffic associated with the search for parking spaces by providing up-to-date information on parking conditions to help accessing to available parking spaces; Reducing the number of vehicles parked illegally on both sides by accommodating them inside parking spaces.

It is recommended that the Smart Parking System be installed for all of the IUG's parking spaces. It is also recommended that the Smart Parking System can be installed in places where there is traffic congestion, such as universities, streets where hospitals, wedding halls, bus stops, and shopping centres are located. When the driver returns to get his car, the system can be modified to display the location of his car by his smartphone via an Android application. The Smart Payment System can be integrated with the Smart Parking System and all of its features, allowing the new system to perform a variety of tasks: It will direct drivers to parking spaces that are available.

It will accept remote payments to collect revenue after each parking space use or even monthly. The money can be paid for some services like maintenance and development. This can be used in the most congested parking spaces on campus, such as parking D, to reduce traffic congestion and increase revenue. Another feature that can be added to Smart Parking Systems is the ability of drivers to reserve a parking space at a desired location ahead of time, saving time and effort, especially for those who need to get somewhere quickly. Different modes of public transportation are being developed, as well as their availability at specific times. At the end, The Smart Parking System can be generalized to all the parking spaces of the campus of IUG and Gaza strip cities.

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