

Design and Implementation of an Intelligent Parking System (ISPS) With Laser Security System (LSS)

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Abstract

In order to solve one of the most important problems, especially in a large and crowded city like Baghdad, is finding an empty and secure car parking space. In this work, an intelligent Smart Parking System (ISPS) has been investigated and developed by providing information about the empty lots and helping the driver to get to his parking spot with a rotary parking system to reduce the traffic in the parking area. The ISPS Park implements a car number plate recognition system as a security system for car identification. Moreover, for increased security, a fence with a Fiber-Optic vibration system has also been used to prevent any object from entering a parking space without a license. The ISPS was run with the pre-programmed controller to make minimum human involvement in the parking system to ensure access control in restricted places. Matlab with Arduino tools has been used for the car plate number recognition process and car entering control. The system shows that using RFID for entering and leaving is so fast and informative. A Fiber SenSys program has been used with the Alarm Processing Unit (APU) to prevent any unlicensed person from trying to cut, climb or crawl under a fence.

Keywords- Smart parking system, Fiber-Optic vibration system, laser trigger circuit, rotary parking system, car plate number recognition.

I. INTRODUCTION

Car parking is a significant issue on the level of both national and local planning of small and large cities. In the last recent years, many cities have had many difficulties in parking and take a long period to find space, especially in large and busy [1][2]. These difficulties have great mayhem to drivers in our society because of wasting time, fuel consumption, air pollution, and crowding inside the garage [3]. In smart cities, this problem can be solved by helping the driver to find the empty lot, which reduces the traffic jam and consumes less time. However, these parking provides the “informative parking system” but didn’t solve the whole problem like the “smart parking system (SPS)” [2]. The SPS was implemented mainly in the Europe, Japan and United States, this progress was done by incorporation of researchers and advanced technologies from different academies [4]. In 2010 a smart parking system was proposed and developed in such a way that the driver can choose their parking spot using short message services (SMS), sent and processed by using a wireless communication, instrumentation ((Remote Terminal Unit or “micro-RTU”)) which is used to reply the confirmation of the chooses lot by providing the details of reservation including password and lot number [5]. While in [6] a wireless sensor network (WSNs) was used in a smart parking system by using the light sensor to determine the empty parking lot automatically in the parking area with billable parking time. Another way used to find and detect the empty parking lots in [7], was an ultrasonic and magnetic sensor that helps in detecting vehicle’s indoor and outdoor parking fields, with a high accuracy. However, in [8] it was focused on car parking detection mechanism by the ultrasonic sensor module, that is ESP8266 in combination with Internet of Things to send the status of the parking lot through Internet.

In this paper a new design has been implemented for parking lots “Intelligent Smart Parking System (ISPS)”, which is a smart parking with a rotation system, with high security using “Laser Security System (LSS)” or fiber-optic vibration system and car license plate recognition for preventing any unlicensed person from trying to cut, climb or crawl under a fence. The rest of this paper was organized as follows: Section 2 presents a description of the proposed system design and its performance, while in Section 3 the system results and discussion has been presented, and in Section 4 for conclusions.

II. SPS System Components:

An intelligent Smart parking system (ISPS) is a new effective way of using limited space and achieving updated information around the parking spot. The design, shown in figure (1), requirements are set as functionalities and constraints to be an effective system for the end user. These requirements were gathered and analyzed to have an efficient parking system which is made by using rotary parking embedded in the smart parking system [4][9]. This system consists of:

- 1) Arduino Mega: which was used as a microcontroller based on the ATmega2560,
- 2) Servo Motor: for entrance and leaving the parking lot, which moves either in the anti-clockwise or clockwise direction to allow the driver to in or out of his car.
- 3) Two LCDs: for looking out the available parking lot, by the LCD monitors. It helps to identify the empty lots in less time (20 x 4). And the other is for display parking empty or full (16 x 2).
- 4) Line tracking sensor: deployed in the parking lots to sense the vehicle's availability.
- 5) Webcam for plate recognition.
- 6) Laser trigger circuit: to trigger the camera to take a picture of the car license plate.
- 7) RDFI: for driver authentication, this will help to give an identification with a prior paying and for car counting.
- 8) RFID MFRC522 internal transmitter, for driving a reader/writer antenna designed to be able to communicate with ISO/IEC 14443A/MIFARE cards and connected to transponders,
- 9) MQ135 Gas Sensor, Flame Sensor Module, with a webcam connected to a PC has been implemented. Laser trigger circuit: is a circuit used to capture images remotely and controlled by the laser circuit. The laser trigger circuit consists of a laser sensor, relay, webcam, and Arduino UNO.
- 10) Fiber–Optic Vibration system.

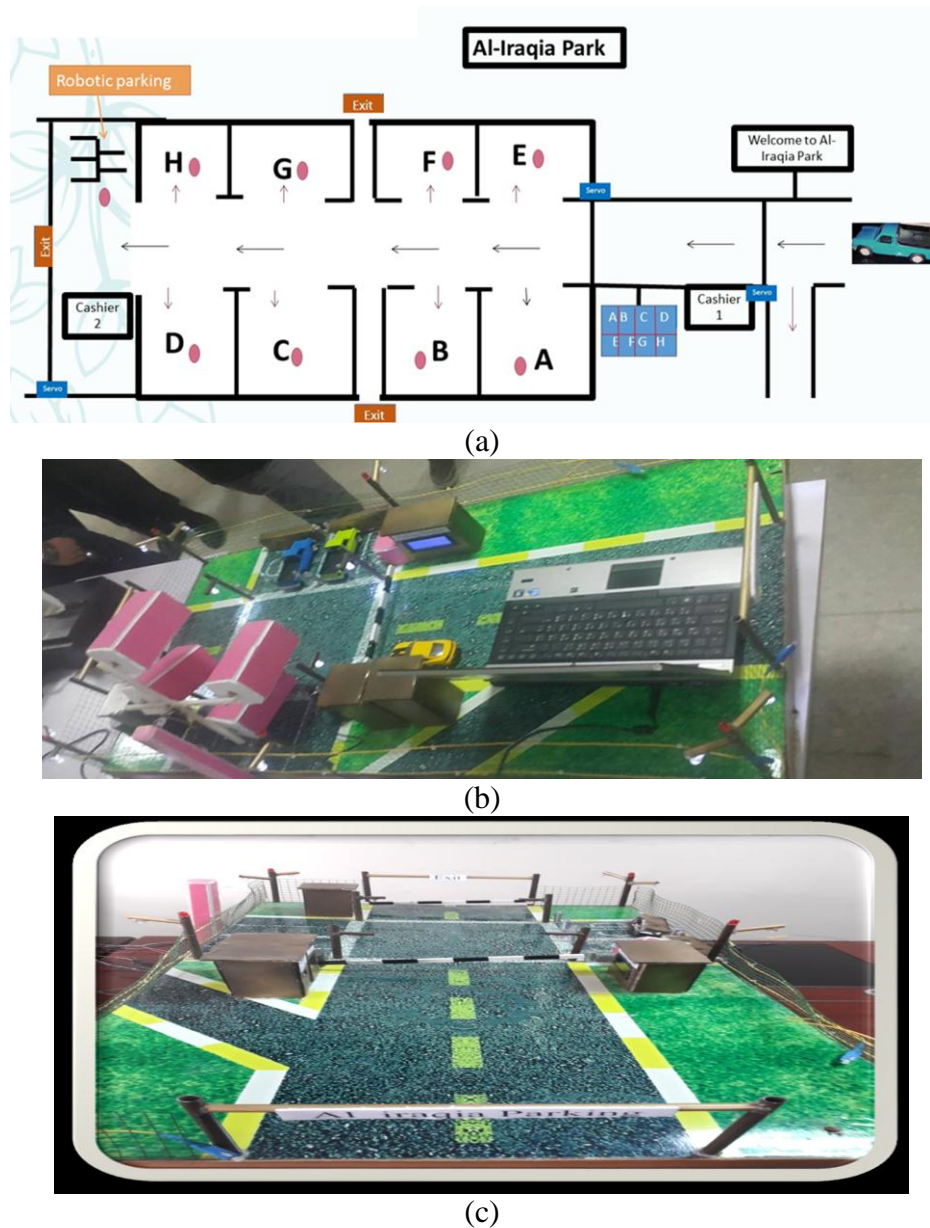


Figure (1): (a) Schematic picture of the experimental arrangement; (b) is the top view and (c) is the side view of the experimental arrangement

Figure (2) explain the interaction between ISPS system components. When cars are in front of parking area and before entering, it will look out for an empty lot by checking the LCD monitor, at the same time the plate number will be processed, analyzed and checked it with a database. The data then will be sent to Arduino, if the customer doesn't have any legal problem and he is from the existing user then Motor will open automatically the gate and line tracker will guide him to the parking lots. In case of new user then the data will be entered to the database and then will be serviced as an existing user. Another checking has been made with RFID identification card for a pre- paying service. On other hand Arduino was connected to an ultrasound sensor for checking the car availability, gas and flame sensor as a security system, Fiber optic vibration sensor. Another Arduino has been installed in the garage for controlling the mechanical rotary system.

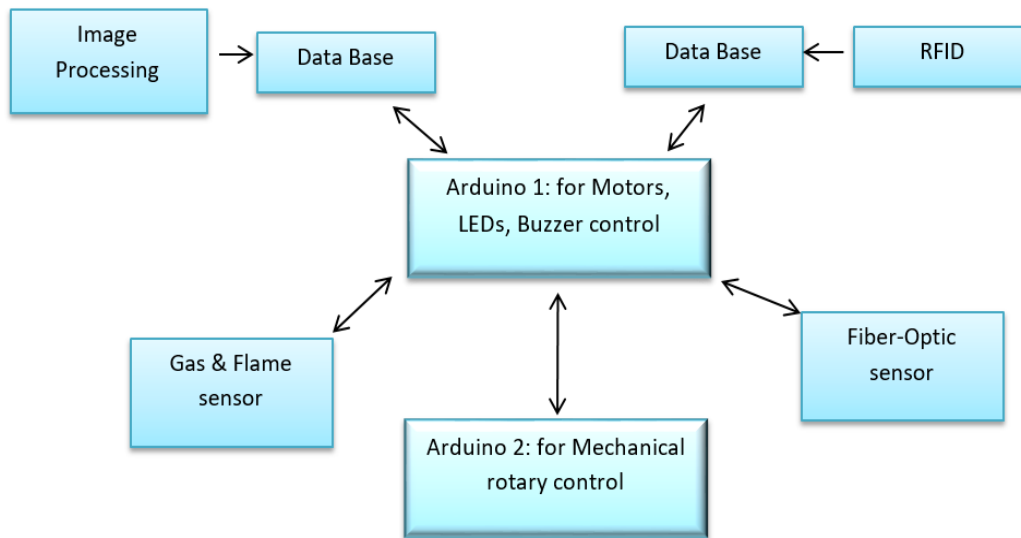


Figure (2): ISPS components interaction

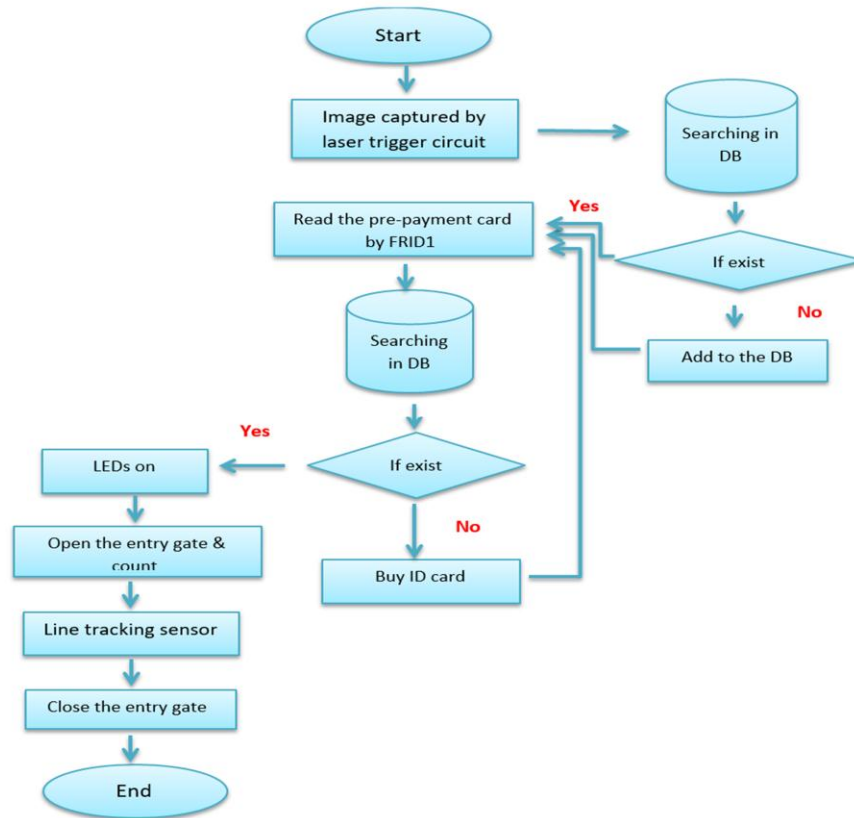
III. ISPS SYSTEM ALGORITHM:

Most developments these days were focused on providing better people's services[10]. The Smart parking system is one of the most important services used to decrease jam traffic and difficulties in finding a parking space within a restricted parking area[4]. This system helps in [11]:

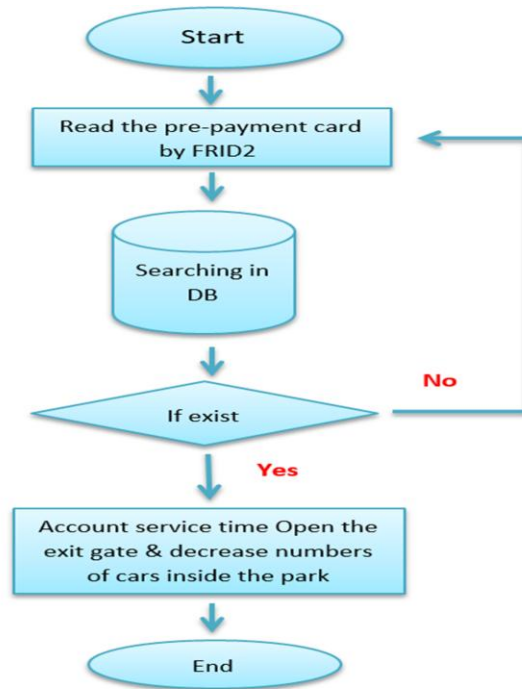
- 1) Reduce the time of finding parking lot with less fuel consumption.
- 2) It's also used to provide a guideline for empty parking lots easily.
- 3) Provides secured data transferred to the system and checks the parking time.
- 4) It is appropriate, time-saving, and easy to book the parking space.

The flow of ISPS (Figure 3):

- Initially, each driver will register and book his parking lots using a specific mobile application like Customer Relation Management and Enterprise Resource Planning.
- The driver will be provided with identification by database hosting services which are provided by the hosting providers. The provider services will enable the running of database-supported applications. The driver registration information will be stored in the database.
- When the driver is in front of the parking gate looking out for an empty lot by checking the LCD monitor, a breaking out laser line will be made by the vehicle causing resulting in triggering the capturing system (Laser Trigger system). The captured image will be cropped, scaled, filtered from noises, and made a morphological process in it for solving the problem of preserving edges by Matlab2014. Finally, the image data will be sent to the database for recognition.
- If the driver is from the existing customer, the checking identification will continue with an RFID card for a pre-paying, if not, then check whether it's from the suspected plate number, if not then add it to the existing list.
- When the driver entered into parking area the LEDs will be on and the line tracker sensor will guide the driver to the chosen empty lot by closing the parking gate.



(a)



(b)

Figure (3): flow chart processing of the (a) entry gate (b) exit gate

IV. ROTARY OR MECHANICAL PARKING ALGORITHM

Parking demand a large parking area to include a great number of cars and the availability of land. The mechanical parking system has a great solution, because it depends on small areas with numerous parking lots[9]. The idea behind the use of rotating parking is for increasing the number of car parking in the same parking lot space. The rotary parking system is a new and a powerful type of parking system with an electrical source power used to minimize parking area with a maximized number of car parking as shown in figure (4)[12].

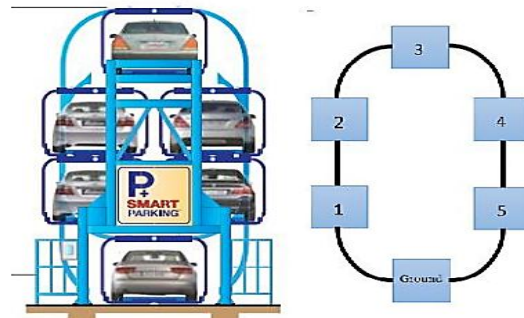


Figure (4): the rotary parking mechanism [13]

The advantages of the rotary parking system [9]:

- 1) Small footprint which helps to be installed anywhere.
- 2) Lower cost than the conventional one by using small area with higher number of parked cars.
- 3) Instead of 3 cars in conventional parking, it can hold 6 to 24 cars depending on the location and requirements.
- 4) Flexible and easy to use.
- 5) Easy to configure, relocate and install.

This system is implemented with Arduino for controlling the rotating motor with less power consumption. Any customer after choosing the location of parking areas near or far the exit gate in registering stage, then he can put his car in any pallet of the chosen lot area. Each lot was designed with 5 pallets, if the driver went to take his car, then the motor will rotate in clock or anti clock wise depend on which pallet is in the ground.

V. PARKING SECURITY SYSTEM ALGORITHM

For keeping parking, car from thieves Laser Security System (LSS) with special sensors had been used:

A. Fiber-optic vibration system Algorithm

It is a mechanical system based on LSS which is used as a security system with different sensors and cameras, as shown in figure (5).

The system based on using optical fiber (MMF) surrounding the fences, housed in a channel in touch with the fence by a stainless-steel wire tie. The two ends of the channel were terminated by ST-type connectors, which one side connected to the optical input and the other side to the optical output (sensor). This system will be applied to optical fiber (MMF) and appropriate optical sensor, which is consisted of optical detector to convert the signal to electrical form., Low noise amplifier, triggered by disturbance, noise, temperature change or low vibration changes such as from wind, these interface noise will keep the mode of sensor at zero level [13].

The fiber-optic sensor specification is [15]:

- Reliability,
- Durability to E/M interference,
- High sensitivity,
- Real-time
- Fast response,
- Compact and environmental resistant

This system was designed and implemented as shown in figure (5), the MMF optical fiber intrusion with a PME sensor on the car parking fence. The system was installed unaffected to wind vibration to give an alarm, by controlling the frequency response, the sensor will be responded at 200Hz and above. This system consisting of two major components: Alarm Processing Unit (FD322-APU)

with its tuning software) and a 3mm cable of optical fiber sensor, which is a thin Multimode fiber, housed inside by a half-inch gray conduit which attached to the fence by a stainless-steel tie wire. This conduit has two main purposes; first, it protects the cable from direct cutting and threats like UV exposure, second, it gives a capability of free moving when a stranger or intruder shakes the fence. This system was with a 1310nm APU laser transmitter and a sensor cable in a coherent pattern. The sensor was diffused as a chain on the park fence, when the laser light is exposed to confusion or interruption through the sensor chain due to any vibration from intruder trying to climb or cut through [14]:

- The alarm will be triggered on.
- And the image from the outcome will sent to the recorder for to record and sent to security officials.

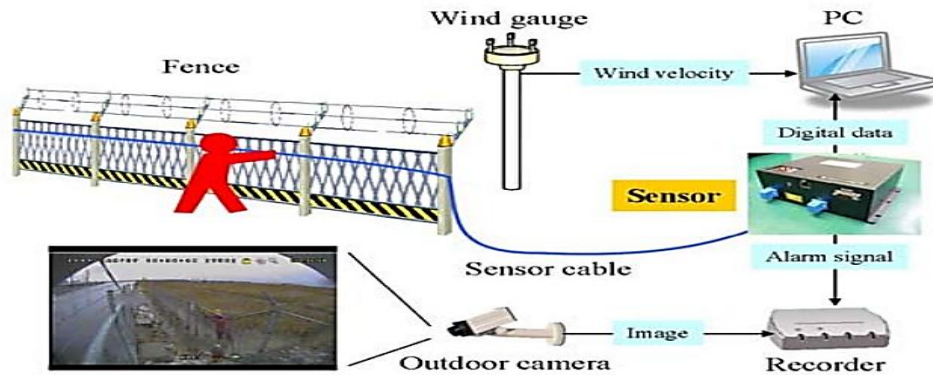


Figure (5): Fiber-optic setup system [15]

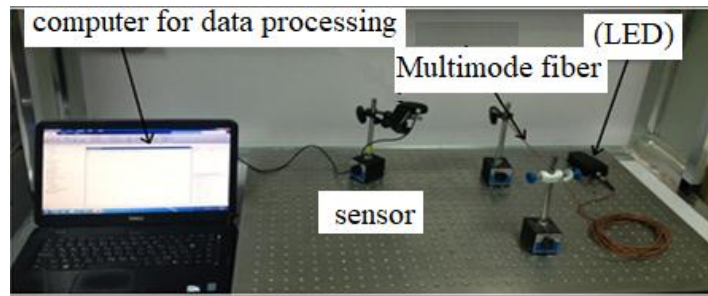


Figure (6): Experimental setup of Fiber-optic vibration system

B. Fire-gas alarm system Algorithm:

Fire or gas leakage is a very common problem with car parking as shown in figure (7):

- MQ135 gas sensor was employed with an audible alarm to alert people for any dangerous gas has been detected if more than 10 ppm was detected for NH₃, Benzene and Alcohol [15].
- Also, a flame sensor is implemented in the system with sensitivity range from 760nm to 1100 nm and 100 cm detection distance [16].

VI. IDENTIFY, RE

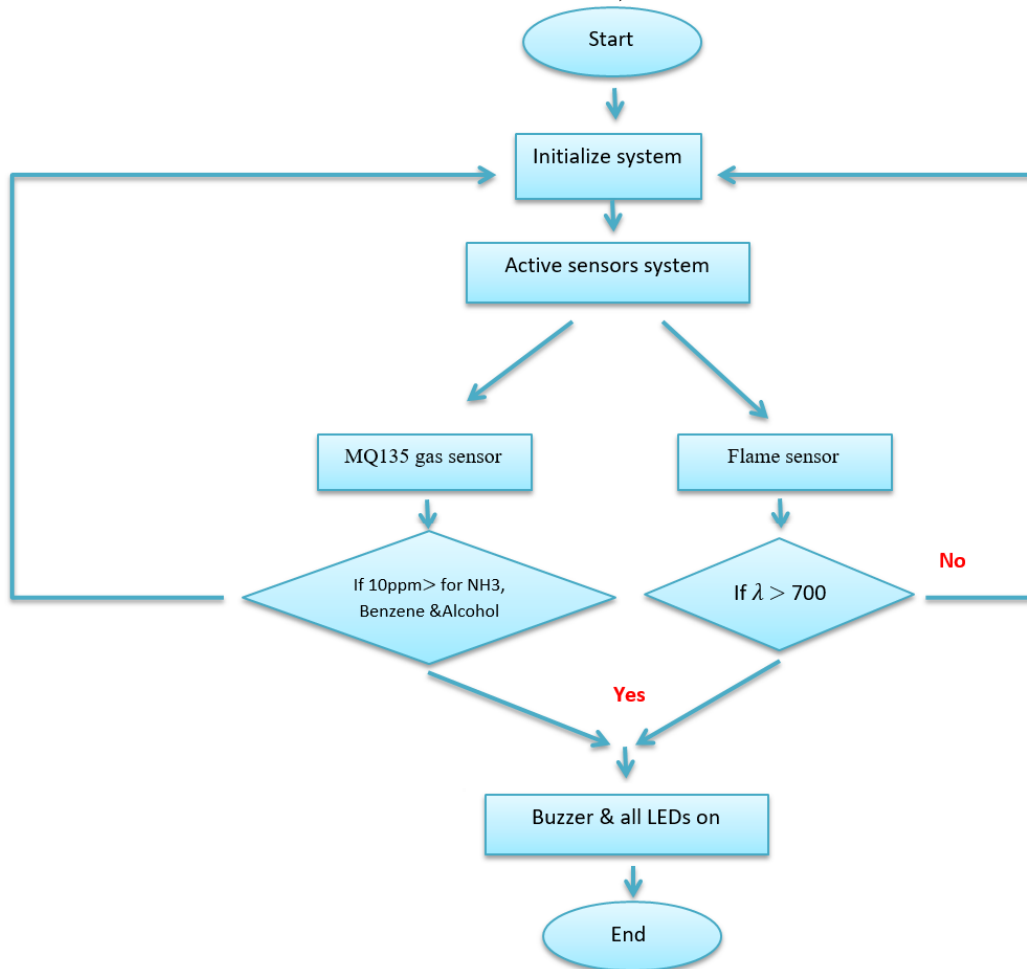


Figure (7): Working Mechanism of MQ135gas sensor

C. Car plate licenses number recognition algorithm

To increase the security of the car parking system, the car's license plate was extracted and saved using LSS, to protect the car from stealing or to prove the car driver for a lawsuit if any theft has been made [17].

Working algorithm (Figure 8)

- Since the license plate normally has a rectangular shape with an aspect ratio [18]. After the image is captured by a laser triggering circuit, the image will be filtered by a Sobel filter for both vertical and horizontal detection, for representing both vertical and horizontal lines of the image.
- Image thresholding was then implemented to isolate the plate from the car background by converting the high grayscale image to a lower level based on the OTSU method
- Vertical and horizontal dilation and erosion morphology was used for analyzing the geometric structure ingrained with an image [19]
- The number will be extracted and recognized and converted to a text. Then it will be compared with the stored database. If it's recognized by the existing user, then Matlab will send a signal to Arduino for opening the gate using a spatial Matlab-Arduino toolbox.

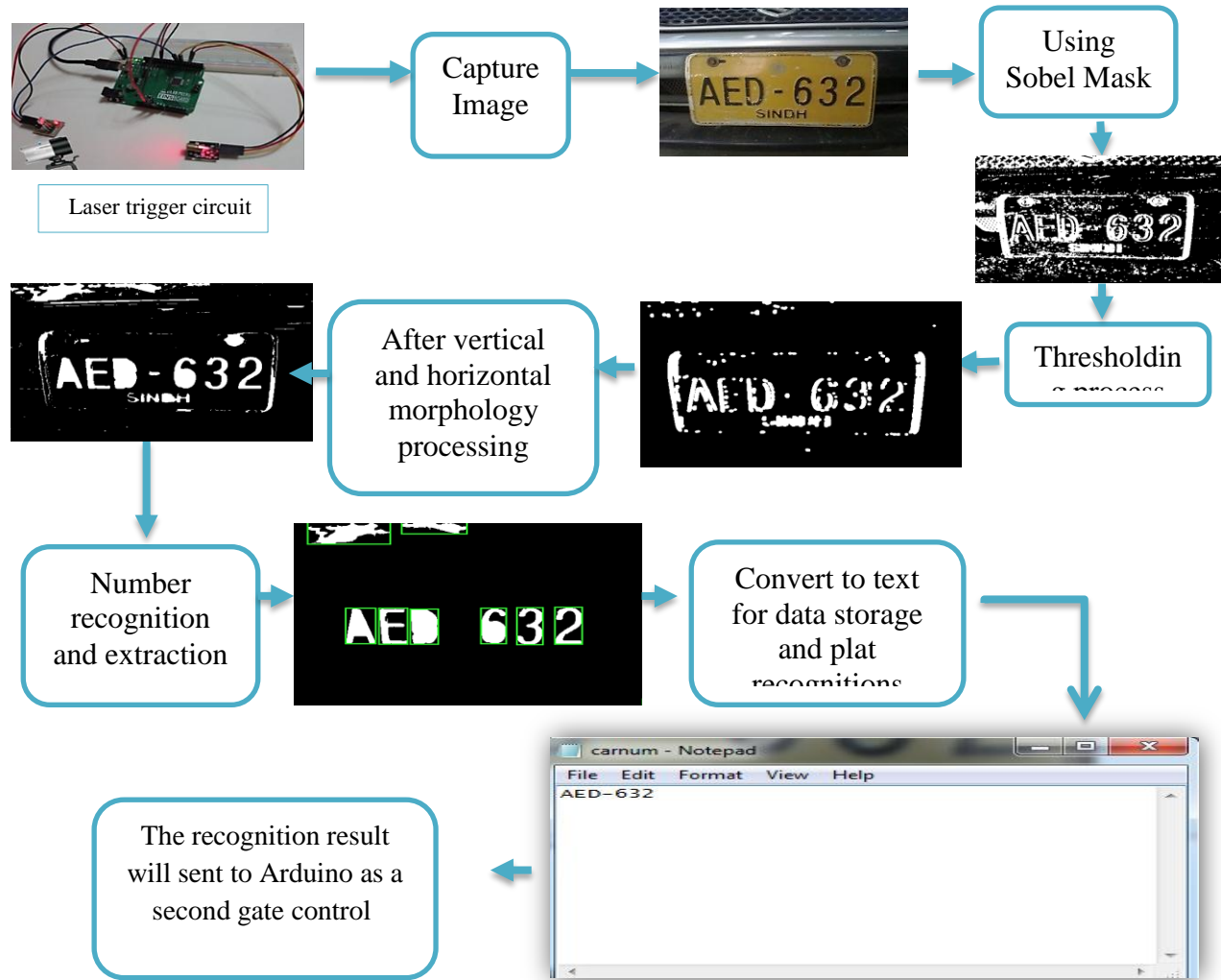


Figure (8): Recognition process using Matlab 2014 and Arduino toolbox

VII. RESULTS

Using the mechanical rotary parking system, increase the efficiency of the parking area by increasing the number of cars in same area in comparison with a smart or regular parking system as shown in figure (9)

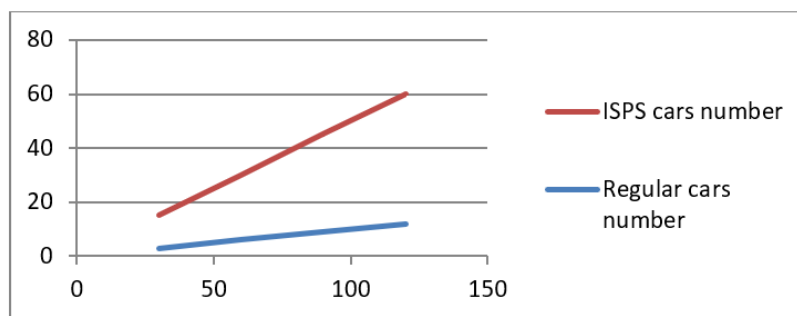
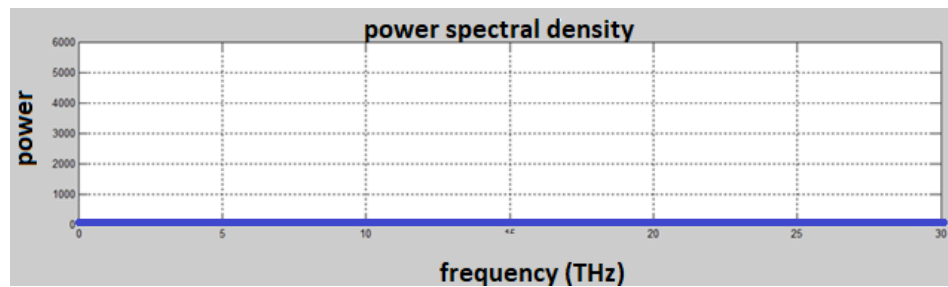


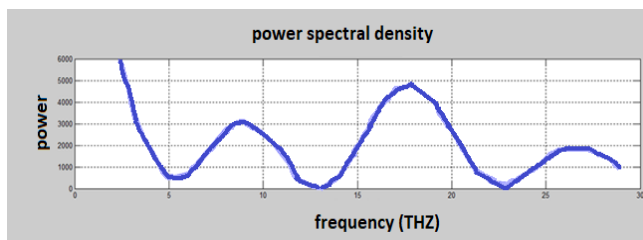
Figure (9): Illustration the efficient area with different number of cars

Three cases have been recorded by a fiber-optic vibration system using a FD232-APU perimeter security system with a Fiber SenSys program. **First**, Steady state case or no event, as shown in figure (10a), in this case the peak power of the power spectral density instrument was equal to zero. In the **second** case which is shown in (10b), without alarm, due to weak presented signal (Speckle) of weak vibration, or repeated events such as wind frequency, which cause a little laser deviation from the sensor and no alarm signal.

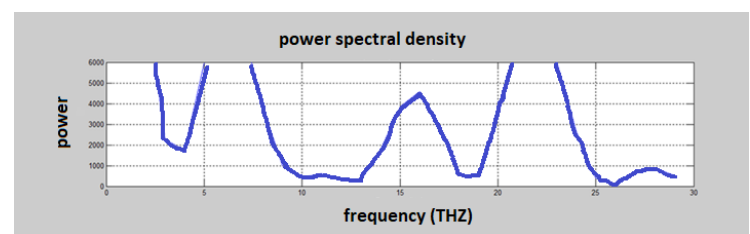
Note: the neglected frequencies are determined by the calibration process so that frequencies such as wind frequency are calculated and placed within the neglected frequencies. In the **third** case, hard alarm signal, as shown in figure (10c) where a strong signal (Speckle) was presented when a strong vibration or Jump over the park fence, strong signal (Speckle) up to 5200 a of power amplitude occurred, a warning alarm will be released to inform the security men.



(a)



(b)



(c)

VIII. CONCLUSIONS

This paper proposed an efficient way of utilizing limiting parking spaces, by using mechanical rotary parking lots. The ISP's system shows an intelligent parking way that depends on using the service mobile application to speed up the picking process with novel system security relies on LSS. The LSS was used in fiber-optic vibration systems and in-car plate recognition systems. The results show that using the ISPS in parking makes it easy to access, less power consumption, and optimal parking space usage.

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