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IoT for Smart Parking

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***Abstract*—Nowadays, technology has become more reliable that allowed human interaction to decrease while the machines have started to take over in many fields of interest. The Internet of things (IoT) represents the idea of machines ability to control entire systems without any human interactions. This paper proposes an IoT system that takes a picture of parked cars in a garage, extract the plate number and the location of the car, and places these information in a database. At the garage entrance, a terminal linked to the system allows the user to locate the parked car using the license plate no.. The system is tested for reading license plates several times, and is shown to perform with a low probability of error. The proposed IoT parking system is an integrated system combining the RPi operating system Motion Eye, with MATLAB segmentation code for character recognition, database tools, as well as web services all in order to make the user interface as friendly as possible.**

***Index Terms*—IoT, Smart Parking, Smart Cities.**

I. Introduction

As urban areas endeavor to become noticeably more intelligent, the use of Automatic License Plate Recognition (ALPR) is rising and so is the number and quality of different applications it can be utilized for. For example, it can be used for designing and controlling modern cities, for public safety and security, for surveys and statistics of speed calculations which can be used to eliminate the rate of accidents on the long run. Furthermore, it can be used in issuing fines for traffic violations automatically for drivers which allows cities to have more traffic control and to be in better realization. And that is why the need for innovation in this topic became essential. There is a great amount of work in this hot topic because of its many gains through different applications. For example, there is a dilemma in almost every huge garage, many people get disoriented and start to wonder where did they park, or even trying to make sure during the day that their car is safely standing. The proposed system tries to answer all these questions.
The objectives behind this work are summarized next.

- The system has to be a standalone system which can function without any interference from humans.
- The system is required to capture the movement of the car getting in and out from the parking lot and help with monitoring the traffic inside the parking area.
- It must be able to perform the image processing for different types of cars independent of dimensions of the car.
- It has to save the license plates of each car entering the garage in system database which can be used for security issues later.
- It needs to allow the user to search for their car from a computer terminal instead of having to for it physically.
- And Finally, it gives the user an interactive user friendly application at the terminal positioned in the garage entrance.

The rest of the paper is organized as follows. Section II gives a brief background on the topic. Section III gives a detailed description of the system architecture. SectionIV shows the system operation and presents the results. Section V gives some ideas for future work. And Finally, Section VI concludes the paper.

II. Background

This sections gives a brief background on the topic showing example from both the literature and the state of the art.

A. literature Review

In [1] Chittode J S et al. created a system that is deployed on the car park structures to screen and manage parking services. Morphological operations were used for the algorithm. Optical Character Recognition (ORC) is used to read the license plates of cars entering the garage.
Peng H et al. in [2] offered an algorithm called Document Image Recognition (DIR). DIR is one of the best operative approaches which uses a database to correlate the plates with the saved pictures. In [3], Chunyu C et al. proposed a procedure for recognition of plate number from vehicle image which is executed using MATLAB and the prediction of characters is done through using edge detection segmentation and preprocessing of image.
Lekhana G.C et al. in [4] has implemented a recognition system by NPR algorithm which is an effective real time online technique. Singh M et al. in [5] developed a well-organized methodology that works on morphological operations, first step is to know the place of plate in image then skew correction is performed for segmentation process of alphanumeric characters. The Recognition is done by pattern equivalency [6].

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B. State of the Art

*1) **IOT automated parking system**:* In this system, cars are monitored with intelligent sensors at the entrance of the garage. The dimensions of the car are measured at the entrance and the license plate picture is taken for the parking database. The system automatically takes the dimensions of the car then searches in the database for the suitable vacant place for it. The customer is requested to drive their car in the elevator and leave it there as the system will take charge of the rest of the parking steps. Moreover, a simple application installed on the user phone can be used for monitoring the time left in the parking zone and the location of the parking tower. Figure 1 shows the operation the system.

The entire system is controlled by a Programmable Logic Controller (PLC). Which represents a closed system based on a unique programming language. The IOT system comes in action when the PLC connects to the cloud with the control panel in the garage entrance. As a result in this innovation, smart parking cities can be established to give the users the ability to know the vacant spots using GPS/web-based mobile device [7].

Fig. 1. Car detection at the garage entrance.

*2) **RFID Parking**:* The RFID parking system is shown in Figure 2. It operates by installing RFID tags per each car registered in the system. At each entrance of the garage there is a RFID reader which can read the tag remotely from 3 to 10 meters. After that the validity of entry and available balance is in the e-card [8].

Fig. 2. RFID system.

*3) **Parking in the smart City**:* This system is composed of sensor positioning and communication channels for each car to detect the vacant places for the cars to park. This smart solution is needed to lessen the traffic in the city and help the drivers to find their parking places efficiently. The system must have power management methods to control the power usage for the sensors for the whole system. The risk of having any break down in any of the sensors, due to environmental effects reduces its possibility of being a valid and sustainable option. Also, the number of gateways must be set to minimum. So, the servers must communicate on a technology with a long reach. The system parking are are shown in Figure 3.

The system aim is that each gateway will take the readings

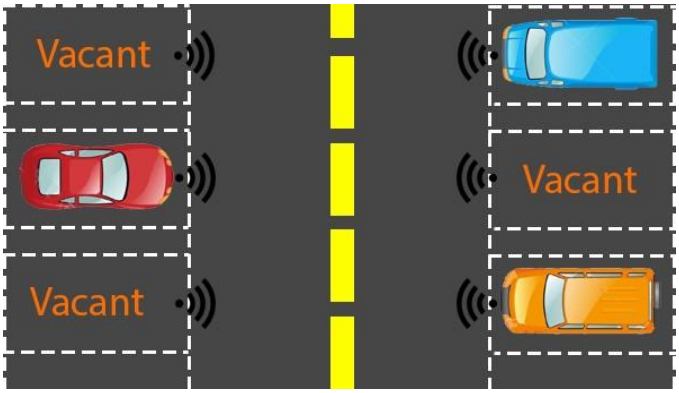

Fig. 3. System Parking Areas.

form multiple of sensors. It is considered a good solution if one gateway is connected to 500 sensors. It is important to ensure constant power supply to gateways, using the best possible hardware components, voltage protectors and enclosures to withstand extreme conditions like heat, cold and dust. The server is required to get readings form several gateways, while the server is communicating with the users mobile application guiding the user to the empty space for parking by using GPS [9].

C. Analysis of the proposed system

- In the previously mentioned systems, the motion is detected by hardware sensors. The proposed project uses the motion eye software frames per second difference to detect the picture when numbers of frames per second increase, which implies that there were motion. This will help in the cost reduction as it will eliminate the need for installing motion sensors in each parking lot.
- In most of the systems, the image capture is done by security cameras using propriety algorithms that are unknown to the user. Even though the plates can be recognized with different angles and in difficult environmental conditions. The cost is increased because these algorithms will have to be acquired. On the other hand, the proposed system uses basic webcams and open source image processing

segmentation technique on MATLAB to detect the license plate characters with a very satisfying results.

- The access point for the user is a mobile application that presents the car's position through GPS. The proposed system has the ability to find the position by using the default garage markers and the ID of the camera that took the photo, which again reduces the cost of the system.

To summarize, the proposed IoT parking system is intended to be a low cost integrated system when compared to the equivalent systems. it is a flexible one thus, it can be modified easily whenever needed to match the requirements. The idea proposed here is the parking system itself as it is a recent needed application that can be used in any smart city as in building, mall, compound or whatever place that has a garage. Since this low cost system is in its early stages, only the English plates were tested.

III. System Architecture

This section describes the architecture of the system in details.

A. Image Processing

The Image Processing in this system is performed by MATLAB, because it provides real time environment and very fast computation which makes the overall system more reliable. However, the drawback of the system because of this processing technique is that there will be manual changes within the code itself to upgrade or troubleshoot the code. Moreover, a new version will have to be made for each country because each country has its style in font and in the size of the plate.

The main methodology of license plate recognition is pattern recognition. Pattern recognition is the act of differentiating input data into objects based on key features. Accordingly, there are two ways of differentiation; supervised and unsupervised classifications.

Supervised pattern technique: Supervised learning algorithms are used which create classifiers depending on a training data from different object classes. Those classifiers receive the input data and assigns the appropriate object or class for them. This technique can be used for face detection and recognition, for optical character recognition and any classification [10].

Unsupervised pattern technique: this one works through the concept of finding hidden objects in unlabeled data using segmentation or clustering concepts. This method can be achieved through Gaussian mixtures, hidden Markov models or K-means clustering. This technique is best used for object detection and image segmentation [11]. In the proposed license plate recognition system, supervised technique is used due to its reliability and easiness in addition to performing less errors during operation.

Simply, the image processing used in this system starts by getting the required image, filtering and then comparing regions of the image with the templates saved. Afterwards, a string of the number plate characters is obtained.

Preprocessing section includes the three steps of resizing,having gray image and then removing the noise through a filter, usually a median filter is used. Afterwards, dilation and edge enhancement are performed, and then comes the morphological operation. The morphological operation is then applied and the image goes through the three steps; filling (for holes) then thinning (for character isolation) and then grabbing the connected characters together. At last, template matching is done which represents the easiest classification method in pattern recognition, and then correlation to have the output and match between the license plate and the template. Figure 4 shows the algorithm steps in details.

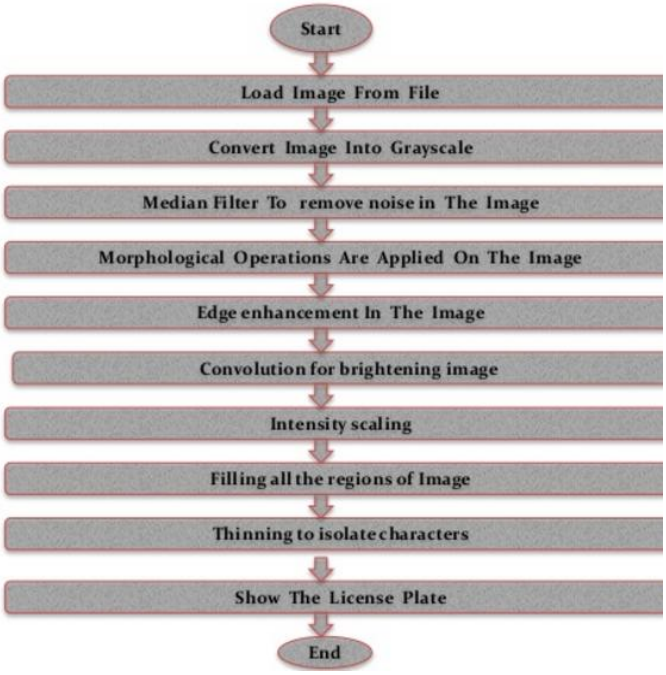

Fig. 4. Image Recognition flow of events.

B. System Circuitry

The system components are shown in Figure 5.

The Raspberry Pi serves as a client in an intranet, acting as both a video recorder and a motion detector. A memory card of more than 50 MB is used for the Operating system. There are two on-board serial RPi camera inputs and three remaining USB inputs for extra devices. For WIFI connectivity, a WIFI USB stick/adapter is used. EDUP is the most commonly used adapter. For the future work, one of the new models of Raspberry Pi that have the WiFi adapter built-in can be used. Moreover, up to 3 additional USB cameras can be connected simultaneously into the three remaining USB ports. For the sake of testing reliability, two different cameras (VGA VX-800 and HD HD-3000) were used simultaneously. And Finally, a wireless router is needed to connect the Raspberry Pi to the terminal which performs the OCR and stores the result in the database.

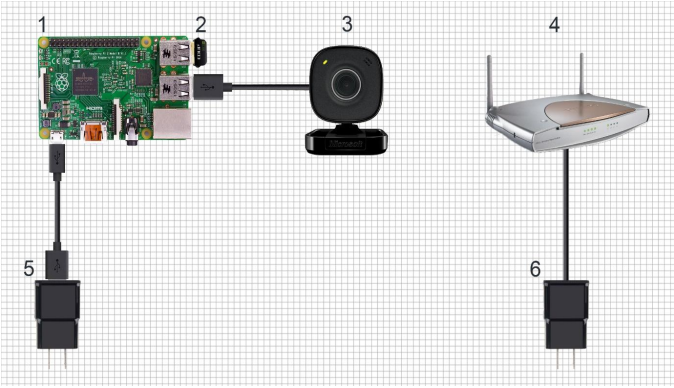

Fig. 5. System Connection Diagram.

The Network topology can be easily changed whenever needed, however for now, the used topology is a wireless router, all the Rpis used and the computers are connected to it. Moreover, the folder used where all the images captured is a shared folder, to have the ability to check new images through the network from any other computer and therefore, any computer can perform the image processing phase. The Raspberry PIs act as clients, they send and receive the commands whether saved ones or any other sudden commands.

IV. Operation and Results

This section shows the operation of the system and presents the results.

As soon as a motion is detected, the camera captures a picture after the motion stops. This picture is stored on the Rpi with a time stamp and a name based on which camera took the picture.Then, the Rpi sends the captured images directly to a destination folder on the terminal where Matlab is installed and running the algorithm. Once the algorithm detects that there is new information through the number of pictures that the shared folder in this network has. It grabs the new images, process them and then writes the extracted number along with the location of the car "which is known from the filename" in an excel file.This excel file is accessed by the web server. Whenever the user wants to search for the location of their car, they only need to write the number of his license plate in the website which is then directed to the excel file to search for the number and returns the parking location.

The motion detection is part of the operating system, there is a certain threshold added and whenever a change occurs in the frames within the chosen rate, it detects the change and the processor begins its operation to capture and send the image. The sensitivity of the system can be changed through the frames/sec chosen in the settings at the start of the operation. There is no memory in the camera, it stays on and whenever a motion is detected, the Rpi saves the image after the motion ends and sends it to the main terminal where the image processing starts. Nevertheless, the operating system installed on the Rpi (Motioneye) checks the overall performance every 20 seconds, and if there is no motion detected, it reduces the frames/sec used and therefore, reduce power consumption. This standby mode uses lower power and allows less congestion in the network. Figure 6 shows an example setup that was used for testing.

The example plate numbers are moved in frot of the camera

Fig. 6. Test Setup.

to simulate a car entering the parking lot. Once the image is captured, it is sent to the terminal for image processing.

Figure 7 shows the image used for testing while figures 8 to 11 show the processing itself through steps. After many trials through many pictures for training, it was concluded that this technique is efficient and valid for the system requirement. Using the accuracy as a performance measure; the accuracy of the proposed system is $(n - numberoferrors)/n * 100$. 70% of the trials were correctly extracted and saved in the database.

Once the text is extracted, it is stored in a database along

Fig. 7. Test Image.

with the location of the car. An example of an excel file that hold these information is shows in Figure 12.

The only thing that remains at this moment is for the user to access the excel file through a local website and search for their plate number to find where it is parked.

V. Future Work

The following points will be implemented to upgrade and develop the Parking IoT system to fulfill the requirements and

Fig. 8. Convert to Black and White.

Fig. 9. Extract White only.

Fig. 10. Characters Segmentation.

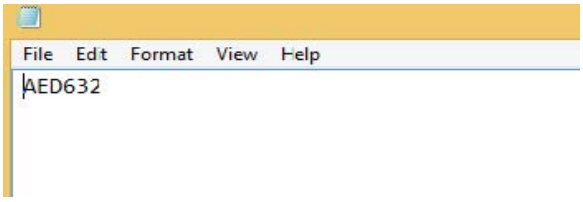

Fig. 11. Extracted Text.

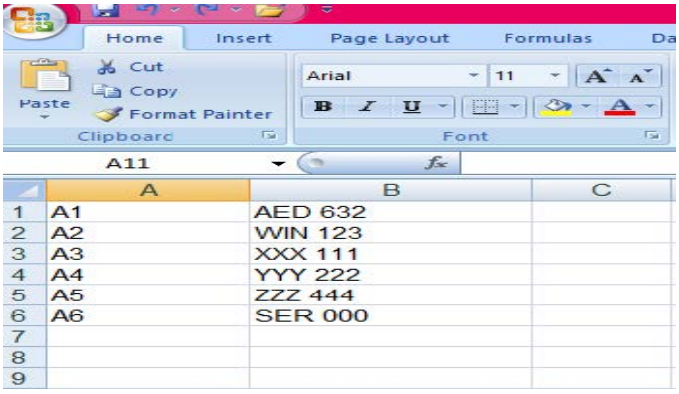

Fig. 12. Excel File.

the needs of the user and make the system more reliable.

- **License plate recognition algorithms**: Up till this point, English image processing was used to implement the system since it can function with less errors and high reliability. In the future work, an Arabic License plate recognition system will be implemented with the same segmentation technique that was used through the English license plate recognition, thus it can be used in the country of origin (Egypt). Moreover, the neural network technique can be used to give the system higher efficiency and higher artificial intelligence.
- **System scalability**: The main goal of the future work is widening the IP-based network, so more RPi devices are going to be used thus they can communicate with each other. The captured image will cover at least two cars to save memory, power, cost and the image processing execution time. Also, the used cameras will be duplicated and added to the system to increase the coverage of the parking areas.
- **Terminal**: An online application for the system will be released, so the user can install it on their mobile phone. This will save more time, ease the traffic on the terminal and will avoid the single point of failure in the terminal.
- **Parking Mapping**: The application which will be installed on the mobile phones will include a map which route the user from the gate to their car. This will be related to the position of the cars which are saved in the database.

VI. Conclusions

IoT has proven itself to have great potential in many fields of interest, their main goal is to operate and control systems independently unbounded with the user distance from the system's core of operation. The proposed system uses the IoT concept and image processing to help users identify the location of their parked cars in a smart parking lot. When a car enters the parking lot, its license plate is captured using camera which is connected to a raspberry pi. The Raspberry pi stores the image with a time stamp and the ID of the capturing camera and sends it to a computer which processes it using

Matlab to extract the plate number. Once the plate number is extracted, it is stored in a local database along with the location of the car which is implied from which camera took the picture. The system was tested with multiple license plates is different environments and was shown to work with very low rate of error.

REFERENCES

[1] J.S. Chittode and R. Kate, Number plate recognition using segmentation, International Journal of Engineering Research and Technology, Vol. 1 Issue 9, November- 2012.

[2] H. Peng, F. Long and Z. Chi, Document image recognition based on template matching of component block projections, IEEE transaction on Pattern Analysis and machine Intelligence, Vol. 25, no. 9, pp 1188-1192, sep 2003.

[3]] C. Chunyu, W. Fucheng, C. Baozhi and Z. Chen, Application of image processing to the vehicle license plate recognition, International Conference on Computer Science and Electronics Engineering, published by Allantis press, pp 2867-2869, 2013.

[4] G. C.Lekhana and R.Srikantaswamy, Real time license plate recognition system, International Journal of Advanced Technology and Engineering Research, Vol-2, Issue-4, pp 5-9,July 2012

[5] C N Paunwala and S Patnaik,A novel multiple license plate extraction technique for complex background in Indian traffic conditions, International Journal of Image processing, Vol-4, Issue-2, pp 106-118.

[6] M. Rathore and S. Kumari, "Tracking Number Plate From Vehicle Using Matlab", International Journal in Foundations of Computer Science and Technology, vol. 4, no. 3, pp. 43-53, 2014.

[7] Iot-Based Automated Parking Systems - ADLINK Technology". Adlinktech.com. N.p., 2017. Web. 3 June 2017.

[8] Bashraheel, Mazen. "Smart Parking". Hackster.io. N.p., 2017. Web. 3 June 2017.

[9] Kulkarni, Devavrat, and Devavrat Kulkarni. "Parking In The Smart City". Internet of Things blog. N.p., 2017. Web. 3 June 2017.

[10] "Supervised Learning Workflow And Algorithms - MATLAB and Simulink - Mathworks United Kingdom". Mathworks.com. N.p., 2017. Web. 3 June 2017.

[11] "Pattern Recognition - MATLAB and Simulink". Mathworks.com. N.p., 2017. Web. 3 June 2017.