Smart Parking System based on Improved OCR Model

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Abstract. Smart parking system becomes essential nowadays specially in urban area because it can reduce the time and the fuel wasted in searching for an empty parking slot. The aim of this paper is to develop smart parking system based on improved Optical Character Recognition (OCR) model. The proposed system consists of three stages: 1) OCR based parking slot detection, 2) User notification based on IoT approach, 3) Smart parking meter based on Simple Mail Transfer Protocol (SMTP). In this system, the vacant parking slots are detected using improved OCR model by labeling the parking slots with specific characters. The system identifies empty parking slots by detecting these characters with installed camera above the parking slots, otherwise the parking slots are occupied. The performance of the proposed OCR model in detecting these characters is enhanced by considering two stages of advanced morphology filter to remove unwanted small/large objects from the image. The accuracy of the proposed OCR model is tested by eight images having different parking street textures as a background and characters written with seven font styles. The idea of detecting empty parking spaces is to share the number of vacancies on a website for the drivers searching for a parking space. However, a time-controlled parking system with different charge rate each hour can be considered to make the best utilization of parking spaces available in urban areas. Therefore, a smart parking meter is proposed to notify the user through Email about the time left that allowed to be parked and the change in charge rate. The proposed system is developed and implemented using vision assistant of LabView.

Keywords: Smart parking system; Optical Character Recognition (OCR); Parking slot detection.

1. Introduction

The increase in number of vehicles especially in urban areas makes finding an empty parking slot very
difficult nowadays. The analysis of traffic congestion shows that the main reason of traffic congestion in city center is due to 70% of drivers are slowing down their speed while they are searching for empty parking slot (Athira, Lekshmi, Vijayan, & Kurian, 2019). This will increase the wastage of fuel, air pollution caused by vehicles and the time wasted in finding vacant parking space. Besides, in most of big cities, more than 31% of the land were wasted for parking coverage due to the large population (Lin et al., 2017). Several research papers are working on developing smart parking system to overcome these problems. Most of the current solutions are focused on developing empty parking lot detection using different type of electronic sensors or image processing methods with IoT approach to inform the drivers about vacant parking spaces through website or smart phone application. These research papers will be discussed in related work section.

The proposed approach of solving parking space problems in urban areas consists of three stages. The first stage is focused on developing empty parking slot detection based on improved optical character recognition (OCR). The second stage is to share the number of vacant parking slots on a website for drivers looking for empty parking space using IoT approach. The last stage deals with the smart parking meter system which notify the user about time-limit left of parking through an Email. This system is based on Simple Mail Transfer Protocol (SMTP).

2. Related Works

Most of the recent smart parking systems are based on detecting the vacant parking space using IR sensors or ultrasound sensors. In the work (Seth, Ashritha, & Namith, 2019), IR sensors with IoT approach are considered to develop smart parking system. The data from IR sensors about the status of parking spaces are sent to the cloud web services to inform the users about the number of available parking spaces that updated continuously. This approach has the disadvantage of complexity in installation since each parking slot requires IR sensor. In (Patil, Kadam, & Kaushal, 2018), smart parking system based on reservation service is proposed to allow the driver to pre-reserve the parking space online with mobile application. The drawback of reservation system is not efficiently utilizing parking lots due to the wasted time of empty reserved parking space because the driver is able to reserve the slot online from long distance.

Smart parking systems based on image processing method proposed by (Yusnita, Norbaya, & Basharuddin, 2012), (Athira et al., 2019) (Jain, Choudhury, & Kashyap, 2017). Different image processing techniques were used to develop parking slots detection instead of electronic sensors. Parking space detection using image processing was proposed by (Yusnita et al., 2012) that based on detecting brown rounded circles which are not hidden by parked car. In (Athira et al., 2019), OCR based smart parking system was developed that identify the empty parking spaces by detection the numbers which are not covered by parked car. However, most of these proposed OCR models were developed using one street texture background and one font style of park slot label. Since each garage may consider different street texture and different font style for labeling parking slots, it is important to consider the impact of the background texture of the garage on the performance of the OCR model.

An improved OCR model is considered in this paper because it is very efficient and simple method to identify empty spaces, beside it requires couple of installed cameras to cover the parking lot. Sharing the number of vacant spaces to drivers through IoT approach is also considered in this work. Moreover, a smart parking meter based on SMTP protocol is proposed to inform the user through Email about the time-limit left for parking. Moreover, a time-controlled parking system is proposed that based on increasing the charge rate each hour. This approach may make the utilization of parking lot more efficient.

3. Proposed Smart Parking System

The proposed smart parking system consists of three stages as shown in figure 1. In the first stage, the empty slots are detected by image processing technique known as OCR. The second stage shares the number of vacant parking spaces on a website. This will allow the user to track the nearest parking lot with the number of available spaces. In the last stage, a smart parking meter is considered to alert the user about the time-limit left of parking and the changes in the charge rate. This approach will help the
user to define the limit of money to be spent by getting an Email about the time-limit left for parking. Figure 2 illustrates schematic model of the proposed system.

![Figure 2. Proposed model of a smart parking system](image)

### 3.1 OCR based Parking Slot Detection

Optical Character Recognition (OCR) is an advance image processing technique that able to convert the characters in the images captured by digital camera to digital characters. In this paper, the vacant slots are identified using modified OCR model. This can be achieved by labeling all parking slots with unique code in white color which consists of two digits as shown in figure 4 (the first digit is a character, and the second digit is a number). Considering such a complicated labeling of two digits is to avoid the wrong detection of a number printed over the vehicle. The camera is fixed in a position to capture the maximum number of slots in one frame. Depending on the design of the parking lot, it is possible to make the camera rotating and continuously capturing images of the entire garage with one camera only. The proposed OCR model is based on several of image processing phases as illustrated in figure 3. The first phase is capturing images of the whole parking garage, then the captured images are converted to grayscale image and improved by Math-lookup processing based on exponential operation. The process of Math-lookup is based on replacing the pixel values with defined values from lookup table (National Instruments, 2003). The use of exponential operation is to extend the contrast of large pixel values and reduce the contrast of small pixel values. The histogram phase is used to estimate the threshold value which is the sum of the standard deviation and the mean value. This threshold value will be considered in the segmentation phase. The image segmentation phase is based on thresholding the images to
separate the characters. Before identifying the characters with OCR model, two stages of advanced morphology filters are considered to remove the unwanted large and small objects. The two advanced morphology filters are basically high-pass and low-pass filter which remove the particles with width greater $K_1$ pixels or less than $K_2$ pixels respectively (National Instruments, 2003). These two stages of advanced morphology filters have removed most of the large and small particles resulted from parking texture and the parked vehicles (see figure 5). Moreover, a lookup table with equalize function is considered to make the image having evenly distributed grayscale levels. Before applying OCR algorithm, a median filter with size of 2x2 is considered for further smoothing from salt and pepper noise. Then, the OCR algorithm is applied to identify the characters. This algorithm is based on template matching approach. Therefore, the algorithm of OCR model should be trained with a data set of numbers and characters. The detected characters from the processed image are compared with predefined vector of all unique codes of the parking slots, then missing code is denoted as an occupied slot. This is because the parked vehicle covered the code of that slot as shown in figure 5D.

![Figure 3. phases of OCR based parking slot detection](image)

![Figure 4. Labelling the slots of parking garage with white color unique code](image)
3.2 User Notification System

The main aim of smart parking system is to share the number of empty slots for the drivers searching for the nearest garage with vacant space. The approach of internet-of-thing (IoT) is considered to send the data acquired from parking slot detection method to web-enabled without any human intervention. The ‘ThinkSpeak’ website which is free access for IoT project is used. Two channels for two different...
garages are designed, and each channel has the number of empty slots and the location of the garage at google map as shown in figure 6. This will help the drivers to find the nearby garage which has empty slots.

![Image](image1.png)

**Figure 6.** User notification website interface that shows number of vacant and the location of the park on google map. (Left) first channel “Duhok-Garage of Zariland”, (Right) second channel “Duhok-Garage of Malta”

### 3.3 Smart Parking Meter

A time-controlled parking system is proposed in this paper, where the charging rate is increasing with respect to the parking duration as illustrated in table 1. Therefore, a smart parking meter based on SMTP protocol is developed to alert the user through Email about the time-limit left for parking and the change of charge rate (see figure 7). The system allows the users to set their time-limit of parking duration for Email notification by writing their email, the parking duration and the unique code of the slot that is occupied by the user as shown in figure 7 A. The technical interface helps the user to see the actual location of the empty slot. This can reduce the time wasted searching for the location of empty slot inside the garage as shown in figure 7 B. This system notifies the client with an Email ten minutes before the end of the time-limit parking duration, and each time the charge rate is changed (see figure 8). This approach will improve the utilization of parking lots specially in city center of urban areas by controlling the average parking duration through increasing charge rate with respect to parking duration. The proposed charge rate in this paper can be adopted with respect to the regulations of that city and it can be limited to specific number of hours.
Table 1. Charge rate with respect to parking duration

| Parking Duration       | Charge rate  |
|------------------------|--------------|
| < 60 minutes           | 0.25$ per 10 minutes |
| > 60 minutes & < 120 minutes | 0.5$ per 10 minutes |
| >120 minutes & <180 minutes | 1$ per 10 minutes |
| >180 minutes           | 1.5$ per 10 minutes |

![Image of sign in and sign out interface for parking garage](A)
Figure 7. User interfaces at main gate of the garage. (A) this interface shows Sign in/out of smart parking meter system and the code of the vacant slots (B) the technical interface gives the real-time images of the actual location of the vacant slots

Figure 8. Email notification from smart parking meter
4. Results and Discussion

The proposed OCR based parking slot detection is developed using vision assistant tool in LabView 2018. A data set of images is generated using Microsoft office to train and test the proposed OCR model. The training image consists of eight numbers and eight English characters of seven different font styles and white color font with black background as shown in figure 9. The testing images are similar to the training image, but each testing image has a specific parking street texture as a background (see figure 10). Besides, the images of parking slots with/without parked vehicles from (Athira et al., 2019) are also used. The accuracy of OCR model is calculated by following formula (Samann, 2018):

\[
\text{accuracy}\% = \frac{\text{No. of correctly detected characters}}{\text{Total No. of characters}}
\]  

Table 2

| Font style             | Training image | Output after training OCR model |
|------------------------|----------------|---------------------------------|
| Agency FB              | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| ALGERIAN               | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| Arabic Typesetting     | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| Arial Rounded MT Bold  | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| Andalus                | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| CASTELLAR              | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |
| Courier New            | 1 2 3 4 5 6 7 8 ABCDEFGH | 1 2 3 4 5 6 7 8 ABCDEFGH |

Figure 9. Training image and the output of OCR model after training

The most common parking street textures (see figure 11) are considered to measure the performance of the proposed OCR model in different environment. The accuracy in detecting the characters for different parking street textures are illustrated in table 2. In general, the results show that the smooth parking street textures (see texture 6 & 7 in figure 11) has excellent accuracy in detecting characters. Moreover, the results in table 2 indicate that font style plays significant role in the accuracy of the proposed OCR model. For example, the following font styles, Arial bold and Courier New, have excellent accuracy with most of parking textures.
Figure 10. Testing images are used to test the performance of the proposed OCR model
Figure 11. Eight different parking street textures

Table 2. Accuracy of the proposed OCR model

| Front style        | Texture 1 | Texture 2 | Texture 3 | Texture 4 | Texture 5 | Texture 6 | Texture 7 | Texture 8 |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Agency FB          | 100%      | 100%      | 100%      | 100%      | 93.75%    | 100%      | 100%      | 93.75%    |
| Algerian           | 100%      | 93.75%    | 100%      | 100%      | 93.75%    | 100%      | 100%      | 75%       |
| Arabic Typesetting | 100%      | 81.25%    | 100%      | 100%      | 87.5%     | 100%      | 100%      | 93.75%    |
| Arial Rounded MT Bold | 100%     | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 93.75%    |
| Andalus            | 100%      | 100%      | 100%      | 100%      | 93.75%    | 100%      | 100%      | 81.25%    |
| Castellar          | 87.5%     | 87.5%     | 87.5%     | 87.5%     | 87.5%     | 100%      | 100%      | 87.5%     |
| Courier New        | 100%      | 100%      | 100%      | 100%      | 93.75%    | 100%      | 100%      | 100%      |
While not smooth textures like texture 8 & 5 have the worst accuracy due to the high salt and pepper noise resulted from the remain of the textures itself. This can affect the performance of OCR algorithm in identifying the characters. On the other hand, Castellar font style has the lowest accuracy comparing with other fonts. This is because their characters consist of two sides with line in the middle. Table 3 shows the average accuracy of proposed OCR model in comparison with OCR model developed in LabView by (Zhang, Cui, & Yang, 2015)

| OCR model developed in LabView | Average Accuracy |
|--------------------------------|------------------|
| OCR model proposed by this paper | >90%             |
| OCR model proposed by (Zhang et al., 2015) | >80%             |

The following scenarios are considered as the main drawbacks of the proposed smart parking system: 1) The label of slot is covered by an obstacle, so the slot is considered occupied, but smart parking meter will be inactive because it requires Sign-In, 2) Label is not covered by the vehicle, the slot is considered not occupied and the user will be notified by User interface at main gate of the garage, when the user is trying to Sign-In.

5. Conclusion

Smart parking slot detection based on improved OCR model is proposed with efficient utilization approach of available slots through smart parking meter notification system. The information about the number of vacant parking slots and the location of the park on google map are available on a website which can be accessed by drivers. In this paper, the accuracy OCR model is improved by considering several image processing phases. Where the threshold value for segmentation phase can be calculated automatically by adding standard deviation and mean values from histogram phase, then two stages of advanced morphology filter are used to remove the unwanted small and large particles from the image. A median filter with 2x2 kernel is also used for further salt and pepper noise reduction before applying OCR algorithm. To evaluate the performance of the proposed OCR model, eight parking textures and seven font styles are considered as a testing data set. The results indicate that the accuracy of the OCR model is reliable specially in case of having smooth texture and clear and bold font style.

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