Design Of Deep Learning Model Applied For Smart Parking System

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Abstract. *This article proposes and introduces a smart parking system using RFID technology incorporating a Deep Learning model to identify license plates. It tries to simulate the ability of the brain to recognize, differentiate and learn patterns from data. The employed algorithms are mainly based on neural network models where neurons are organized in stacked layers. The system is designed to manage incoming and outgoing vehicles by collecting and processing images and data on passenger information to update parking status with the news of empty lots. Another function of the parking system also designed is a fully automatic method of paying the parking fee by the user. The deep learning model for the smart parking system is implemented using the Raspberry PI 3 embedded system and sensors. Experimental results with the plate identification rate in the worst condition, up to 80%, have proven the reliability of the proposed smart parking system. In terms of quantity, the percentage of the worst plate identification down to 10% has established the stability of the proposed smart parking system.*

Keywords

Deep learning, Smart Parking System, RFID, Raspberry.

1. Introduction.

Advances in engineering and technology are the basis for developing a parking management system to meet the growing need for parking lots in large cities and busy shopping malls. A common characteristic of these places is the large number of vehicles entering and exiting the parking lot. This makes the management of the overall parking situation more and more complicated. Currently, the lack of a parking system has a function that can send out a warning of the number of vacancies left to users, resulting in congestion, especially in large companies, shopping malls, universities or other large parking lots.

There are many solutions for the smart parking system [1], which usually uses RFID to manage and control parking [2, 3]. Some studies have combined RFID technology with other technologies such as GSM [4, 5], WSN [6], IR [7], Zigbee [8], and image processing [9, 10] to increase control and management effectively. Other studies also combine with the wireless sensor network [11, 12, 13], Internet of Things (IoT) [14, 15, 16] or create graphical user interface apps [17, 18, 19] for users searching for their desired parking location in terms of low cost and convenience. Users can manage their parking by knowing available parking lots, estimating parking fees and extending parking time. They can save time and money parking in big cities [20]. Research [21] combined Python and Deep Learning Framework (DLF) to create a smart parking application. This application helps shorten the time needed for information gathering and operator decision-making based on the information supplied and raises the likelihood of successful machine-automated outcomes. To lessen the issue of looking for parking spaces, a brand new cloud-based and deep-learning mobile smart parking application was created in the research [22]. A binary Support Vector Machine (SVM) classifier was combined with an image classifier trained using a Convolutional Neural Network (CNN) to determine if vehicles are present in parking spaces proposed in research [23]. Research [24] The author combined AI technology and a multi-camera system for smart parking lot management. Using YOLO technology, the deployed system will track the vehicle and detect its number, using it as the object ID. The multi-camera system is responsible for detecting collision incidents that may occur when cars are moving in the parking lot using images from surveillance cameras. As the test results show, the parking and accident detection system becomes more accurate as training images increase. However, other standard conditions of parking operation have not been fully solved. This article proposes a deep-learning model to deal with other common parking operation conditions that have not yet been solved in the studies above. A design of an intelligent parking system employing a proposed model is implemented by utilizing a Raspberry Pi 3 embedded system to recognize license plates. This system automatically helps users enter and exit parking lots, identify the license plate, and collect users' information to recommend the parking fee payment method. The designed parking system is fully automatic by the users, has no human labour required and fixes some errors during operation that are difficult for conventional parking spaces, such as wrong check-out due to human mistakes.

The remainder of the article is organized as follows: Section 2. Materials and Methods describes a design of smart parking system. Experimental results by the proposed method are in the Section 3. Results and Discussion. Finally, Section 4. Conclusion concludes the article contribution.

2. Materials and methods

2.1. Smart parking system

An overview of a user-friendly model smart parking system is shown as in Fig. 1.

The proposed smart parking system is implemented by utilizing the Raspberry PI 3 embedded system. Fig. 2 shows RFID Sensors and Fig. 3 shows cameras. They are installed at enter gates.

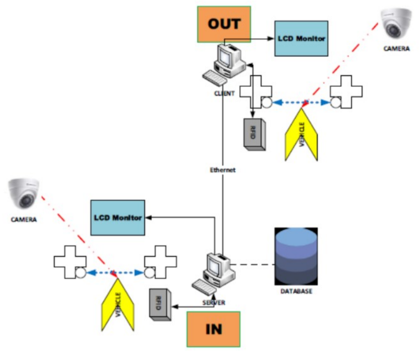

Fig. 1: Smart parking system.

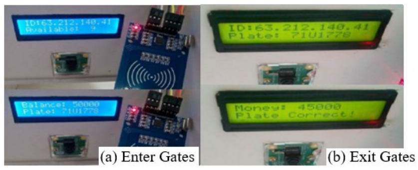

Fig. 2: RFID sensors at gates. (a) Enter gates (left). (b) Exit gates (right).

They are used to collect and store vehicle information when entering the parking lot, such as license plate, balance, and time to join the parking lot, and similar information when the vehicle exits the parking lot, such as license plate, compensation, and time to leave the parking lot. This information helps users self-check-in and self-check out the parking lot.

In addition, the proposed system is designed based on the structure diagram shown as in Fig. 4. It is transformed from the traditional one by using image processing employed Deep Learning Model and Algorithm (DLMA), then combined with RFID tag swipes. This system helps users to self-identify the capacity of the parking lot and users also perform themselves in order to access in and exit out the parking site. The proposed smart parking system consists of two central sensor systems and a network of computers for communication and database. The sensor system utilized RFID and camera technology.

The vehicles with the yellow label in Fig. 1 go through the sensor system at the Entrance and Exit Gates. When a car runs into the parking site, the related information of empty lots, fees, etc., will be shown on an LCD monitor, and the numbers on the plate, entrance time, and card information are read

Fig. 3: Camera Raspberry pi V2 8MP.

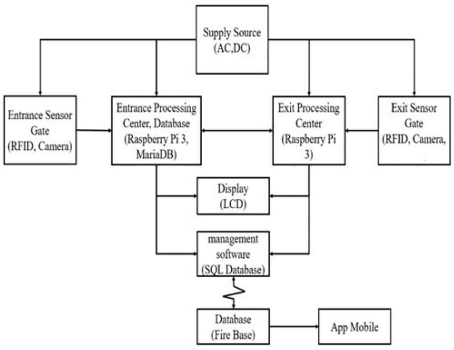

Fig. 4: System diagram.

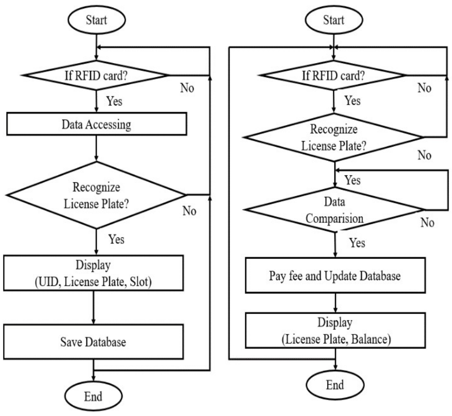

Fig. 5: (a) Entrance algorithm flowchart (left). (b) Exit algorithm flowchart (right).

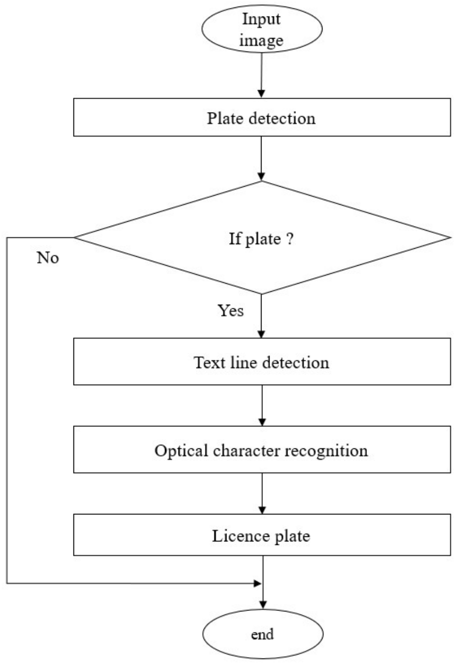

Fig. 6: Deep Learning flowchart.

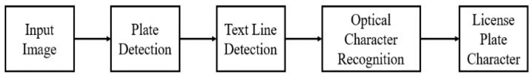

Fig. 7: Flow of license plate recognition by DLMA .

and recorded by the sensor system located at Entrance Gates if the driver has performed check-in action. The driver, using many types of cards such as private cards, debit cards, credit cards, etc... will check in the car. When a vehicle runs out of the parking site, its numbers on the plate, exit time, and card information are read and recorded by the sensor system located at the Exit Gates. The calculated results of parking time, charged fee, etc., will be shown on an LCD monitor. The driver will be asked to perform payment by both cash and card before exiting the parking site.

The Entrance/Exit sensors include a Camera and RFID. They will perform the following operations: capture the license plates by Camera and get RFID tag information. Data will then be sent to the Processing Centers and transmitted to the Display Block for showing. Simultaneously, the data is synchronized with the Exit Processing Center block data. The entrance data will be synchronized with the exit data. Display Block is responsible for receiving data from the Processing Center and displaying the required information. All these operations are summarized in the algorithm for controlling the smart parking system shown as in Fig. 5.

2.2. Deep learning model and Algorithm (DLMA)

Deep learning originates from the neural network algorithm, a tiny branch of machine learning. Neural Networks and Deep Learning are based on algorithms that attempt to model highly abstracted data using multiple-layer perceptron with a complex structure or encompassing many nonlinear transformations. The deep Learning Algorithm applied for the smart parking system in this research work is modelled according to the flowchart that is depicted in Fig. 6.

Similarly, the license plate is recognized according to steps that is depicted in Fig. 7.

The Tensorflow framework provides an API for Object Detection that can be retrained to identify desired objects. In this paper, object detection is used for training to determine the number plates accurately. Due to the number of computational parameters, the SSD network architecture [25] (as shown in Fig. 8) is used as a real-time training model for fast processing and high accuracy. SSD training model requires data to be labelled before training. For the problem of determining the number plate, label a single object class the number plate, then divide it into a train/validation at the rate of 80/20, adjust the learning rate parameters (speed learning/training speed), the number of types

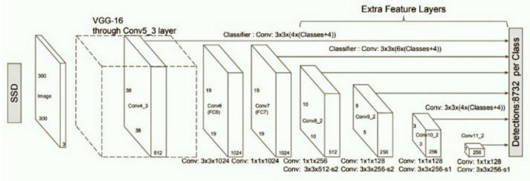

Fig. 8: SSD network architecture.

Layer Type	Parameters/Dimensions
Input	$C_{in} \times H \times W$ feature map
Convolution	# $C_{out}/4$ 1x1 stride 1
Convolution	# $C_{out}/4$ 3x1 strideh=1, padh=1
Convolution	# $C_{out}/4$ 1x3 stridew=1, padw=1
Convolution	# C_{out} 1x1 stride 1
Output	$C_{out} \times H \times W$ feature map

Fig. 9: Small basic Block.

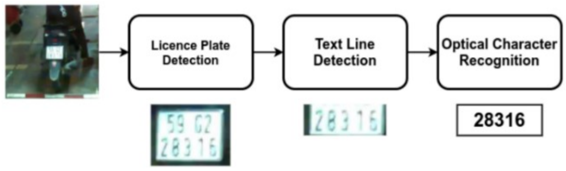

Fig. 11: Actual photo after identifying blurred license plates image using DL.

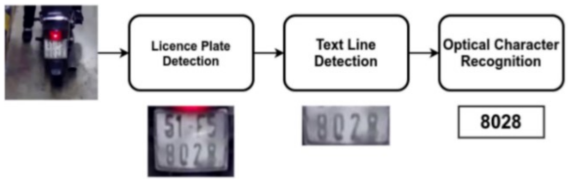

Fig. 12: Actual photo after identifying noise license plates image using DL.

of subjects to be trained,... In addition, other information will be edited after training getting the best results.

After delineating which image portion the number plate is and which image portion the character area on the license plate is, the character area is cut out of the plate image and labelled again. However, it will be marked with the same characters now. The algorithms for recognising textures combine Convolutional Neural Network (CNN) and Connectionist Temporal Classification (CTC). The basic CNN model is built on a small CNN architecture called SqueezeNet and Inception blocks [26], as in Fig. 9. This method is one of the most popular deep learning algorithms for optical character recognition. It has been partially stripped to fit the license plate recognition problem.

Most Deep Learning Models focus on accuracy. However, the CTC used model's performance is determined by both the accuracy and the error, whereby the lower the error, the higher the accuracy.

The labelled image will be encoded and then given to CNN to extract important characteristic areas, which can be considered to remove each character's curve and angle and t, sent to the CTC to decode the characters taken from the image.

Layer Type	Parameters
Input	100x25 pixels RGB image
Convolution	#64 3x3 stride 1
MaxPooling	#64 3x3 stride 1
Small basic block	#128 3x3 stride 1
MaxPooling	#64 3x3 stride (2, 1)
Small basic block	#256 3x3 stride 1
Small basic block	#256 3x3 stride 1
MaxPooling	#64 3x3 stride (2, 1)
Dropout	0.5 ratio
Convolution	#256 4x1 stride 1
Dropout	0.5 ratio
Covolution	# class_number 1x16 stride 1

Fig. 10: Training Deep Network architecture for OCR.

Most Deep Learning problems focus on accuracy, but with the issue of using CTC, in addition to determining the goodness of the model through precision, it can also be determined through the error of CTC; the lower the error, the higher the accuracy.

After successful training, the system can be considered an End-to-End model. From identifying the number plate area, separate each line of characters and then re-identify those characters correctly.

The LPRNet in [26] with CTC loss was fine-tuned to recognize the characters on the license plate. In this study, however, the raw RGB input size is (100x25), and the kernel size of the last broad convolutional layers is modified to (1x16). The layers and their parameters are shown in Fig. 10.

Tab. 1: Some results with accuracy.

Heading 1	Heading 2
71U-1778	100%
63H-1508	90%
80A-6008	80%
72K-3720	90%
51F-8082	95%
59G-28316	95%
59B-43764	90%
94H-4693	90%
69B-3941	90%
59C-2109	90%

3. Results and Discussion

The entire model is trained on an Nvidia 1080 Ti hardware configuration and 32 GB RAM. The trained

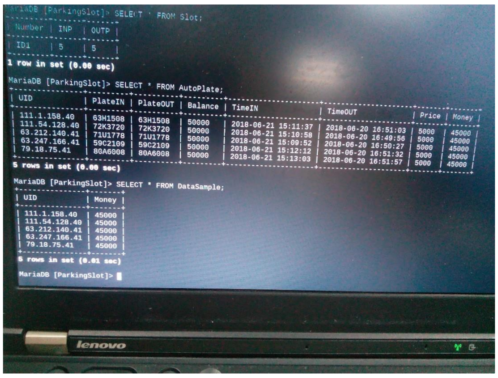

Fig. 13: Parking data Management System.

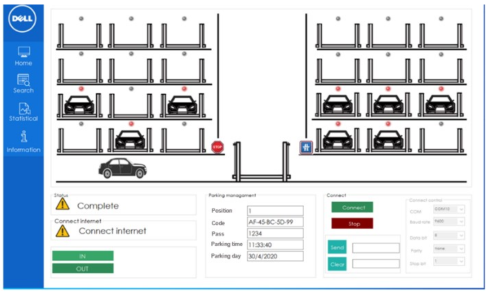

Fig. 14: Smart parking monitoring interface.

model can handle a speed of 0.003 seconds per image on the GPU and 0.02 seconds per image on the CPU.

The model was tested and evaluated on the same "private" data set with an accuracy of 96.62% compared with the current traditional model of 90.24%. This End-to-End model is being tested for the company's parking system.

The proposed smart parking system is applied for vehicles with license plate as follows: 63H-1508; 59C-2109; 80A-6008; 71U-1778. A user who drives these vehicles is tasked to enter and exit the parking lot up to 10 times. Cases of blurred images and noise images are also considered and solved by DLMA. Fig. 11 shows the experimental result with a blurred image, while Fig. 12 shows the practical result with a noise image.

The experimental results are summarized in Table 1 and prove that the proposed smart parking system worked well. The vehicle data parameters were put into the computer's data management system, as shown in Fig. 13. The numbers on the license plate are recognized well in any case. DLMA can handle common problems in the standard parking system, such as blurred number plates, dot noise, wrong identification of number plates, etc... thereby improving management and control.

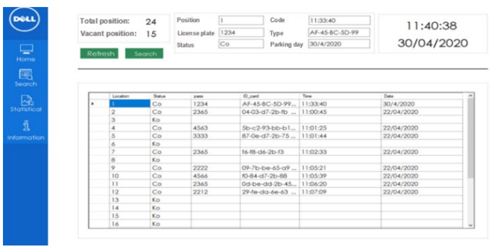

Fig. 15: Functions of Software record vehicle information.

The monitoring system with software has an interface as shown in Fig. 14. Monitored states include:

- Parking lot operation status: parking, picking up, waiting status.
- The lots status contained in the garage.
- Operation status of sensors, limit switches.

Monitoring Algorithm:

- Monitoring software with main interface as Fig. 14 is logged in by an employees. After logging in, the software will connect to the control circuit.
- After connecting, the parking lot will be in a state of waiting for customers to park in and park out the car.
- When a customer park in/out the car: the control circuit sends data to the software. Then the software separates the data, compares it with the database and sends the control signal down to the control circuit. The control circuit relies on that signal to take the appropriate action.
- When an error occurs, the software notifies employees for timely handling. User-related errors can be easily handled at the interface of the control board, but the "UPLOAD" error is a system asynchronous error that needs to be checked more carefully.
- Employees can also proceed to IN/OUT the vehicle at the monitoring software interface via Groupbox IN/OUT.

The lookup function of the software searches for existing vehicles in the parking lot. Components include:

- Refresh button: update parking status.
- Search button: search for cars.

Textboxes as depicted in the upper part of Fig. 15 are used to display the lots information according to the selected position.

The DataGridView as depicted in the lower part of Fig. 15 and in Fig. 16 contains the following information:

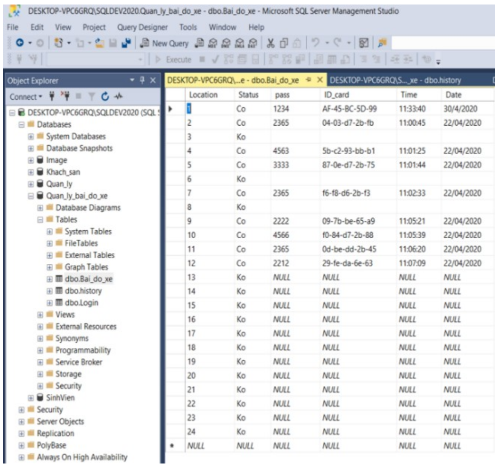

Fig. 16: The table contains information about the vehicle in the parking lot.

- Sequence number: ordinal number of the lots in the parking lot.
- Status: the status of that lot (Yes/No).
- Id_card: the password that the user enters (If the lot has a car).
- Pass: user's card code.
- Time: the time of the vehicle when entering that lot.
- Date: the date on that lot is occupied.

Moreover, the software also has the function of recording employee login history as depicted in Fig. 17 and Fig. 18 in order to control and trace responsibility when there is a problem, including:

- Click button Reload: reload
- Delete button: delete activity history
- DataGridView: contains information that includes:
  - Action: action (login/logout)
  - Name: the name of the employee performing the action
  - Time: execution time
  - Date: Date of execution.

Our research team built and tested the application software to find the nearest parking lot. Parking search application software to help users quickly find parking in the area and find the shortest route to the parking lot. It is depicted in Fig. 19.

In order to use the software, users need to do the following:

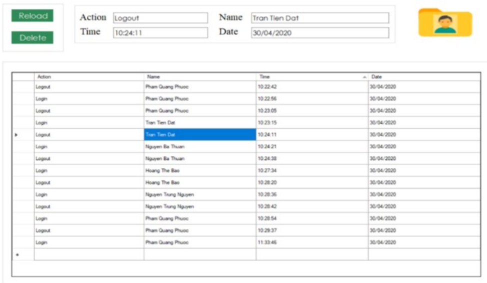

Fig. 17: Smart parking log history.

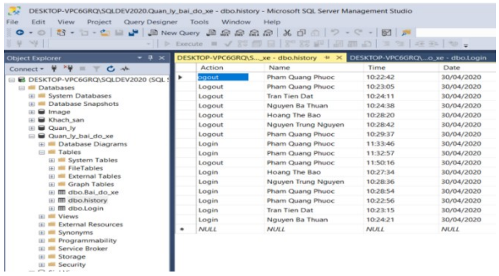

Fig. 18: The table contains the employee's activity history.

- Proceed to install the software and register an account to use.
- In the interface of the software, each marker on the map is equivalent to 1 parking lot, above the marker there is a name depicted in Fig. 20 and 1 quick information for the user about the parking lot, to see other information the user just needs to "Tap" into the marker and so on, one by one, the quick information will be forwarded to the user (Empty, Total, Address, ...).

To find the way to the nearest parking, users need to have the Google Maps app on their smart mobile devices such as smartphones, tablets, etc... as depicted in Fig. 21. These steps are: a) First, tap on a parking lot destination, b) next tap on the direction button in the lower right corner of the screen, c) then the application will automatically link and switch to the google map application to find and show the shortest path.

The comparison results in Table 2 show that the proposed parking system, which uses deep learning models, has relatively low prices compared to some basic

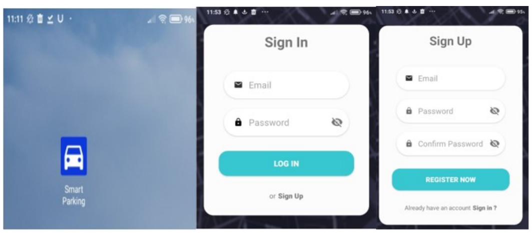

Fig. 19: Activities in the application.

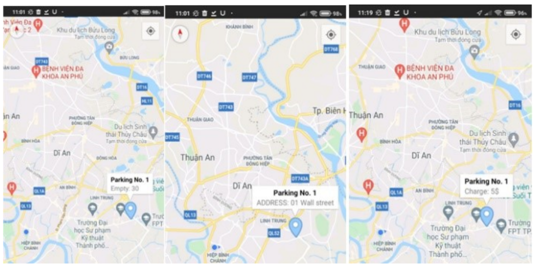

Fig. 20: Information smart parking.

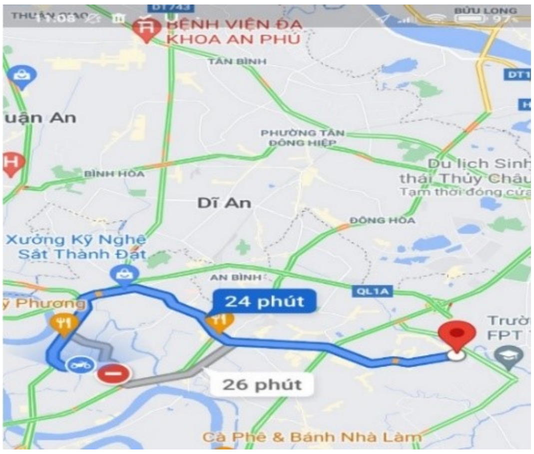

Fig. 21: Map showing directions to the smart parking.

parking systems on the market. Both parking systems [27] and [28] mainly use high-resolution cameras. Hence, the recognition of license plates in and out is greatly improved. Still, if the camera has a problem or fault, the license plate image is difficult to identify, making the system stall and challenging to manage the parking lot. Meanwhile, the proposed deep learning model increases the efficiency of detecting and recognizing license plates with greater accuracy without using high-resolution cameras. In addition, the proposed method also integrates a parking search function through a mobile app to meet the needs of users who want to find an empty parking lot when in an unfamiliar place/area.

4. Conclusion

This paper discusses a proposed model for a smart parking system that combines RFID technology and a Deep Learning algorithm. The proposed system is designed with low-cost electronic components to reduce manufacturing costs compared to existing commercial products while ensuring essential features and stable operation like other systems. Our research team has implemented a proposed algorithm based on deep learning artificial intelligence on the Raspberry Pi 3 embedded computer hardware platform. Experiments have demonstrated the proposed system's ability to

Tab. 2: Some results with accuracy.

Systems	Function	Price
2 lane Vin-parking system[27]	RFID technology. Support software on PC for management. License plate detection and recognition based on high resolution camera.	1900USD
SDT parking system [28]	RFID technology. Support software on PC for management. License plate detection and recognition based on high resolution camera.	1500USD
Proposed DL-based parking system	RFID technology. Support software on PC for management. License plate detection and recognition based on high resolution camera with embedded deep learing-based algorithm. Automatic searching for information of empty plots, price, adrress, etc... in near by parking areas by apps in mobile devices such as smartphone, tablet, etc...	1300USD

accurately recognize license plate numbers of vehicles such as motorbikes, cars, trucks, etc. The experimental results also show that the proposed smart parking system has been well designed to achieve an overall solution with low cost, satisfactory system performance, and help users save time while reducing the workforce in the parking lot. Furthermore, the price announced by our research team shows that this is a highly feasible solution that can be fully applied to public parking lot models. Finally, our research team will research to improve the algorithm so that the proposed system can recognize many types of license plates with different background colours, such as blue and yellow, compared to currently only recognizing license plates with a white background colour.

Acknowledgment

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Author Contributions

Both V.A.Vo and V.M.Bui perform computational analysis, model design, and experimental runs. Both V.A.Vo and V.D.Phan wrote the entire article, while T.N.Do checked the simulation results and built the interface on the computer and the app on the phone, as well as grammar and spelling errors.

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