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Implementation of License Plate Recognition Monitoring System Using Neural Network on Solar Powered Microcontroller

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Abstract
One automatic system for monitoring the presence of vehicles in a parking zone is an indispensable mean of an area such as services building, institutions, and other organizations, which accommodated many vehicles. A tracking record is the most important matter when the vehicle leaves the parking area. Manually, one parking officer will be needed to do the job. However, when using such an automated parking system, then this officers' job can be replaced. The vehicle license plate recording system is designed to use electronic-vision devices as a fundamental device for detecting the presence of vehicle. Vehicle license plates are detected using a digital camera which captured by the camera module on the Raspberry-Pi mini-pc microcontroller device, in addition to the detection of ultrasonic sensors that capture the position of vehicle objects. The process of reading vehicle numbers in an intelligent system of artificial neural networks to extracts each character of the license plate so that each number and letter can be recognized. Meanwhile, the detection of the ultrasonic parking sensor is a complementary confirmation indicating the presence of a vehicle object being monitored. The combination of solar power as the power supply for this automatic system is an important set-up that makes the system's electricity able to run independently. This monitoring system is prepared to help increase vehicle security automatically.

Keywords: character recognition; vehicle license plate; image processing; convolution neural network; solar powered supply

1. Introduction

The design of license plate monitoring system includes some high technology of computation techniques that has been used recently in many application or system, which concern of image or optical processing method and classification. This software technologies can be loaded in one modern microcontroller, which plays important part as a microcomputer, of a Raspberry Pi micro-pc so then some of devices such sensor, camera, leds, and dc motors would be well controlled. Beside software and hardware implementation, the system will also to be supported by an efficient supply power from a solar panel system.

1.1. Raspberry Pi with Camera Module

The software or programmed application in Raspberry Pi microcontroller commonly developed in Python language program that has many of improved program library such image processing and artificial network for classification procedures. This compact device has the ability of modern computer to process medium data so that a digital camera can work well in this device system.(Ziemann, 2018)(*Raspberry Pi Documentation - Raspberry Pi Hardware*, n.d.)

Figure 1. Raspberry Pi microcontroller.

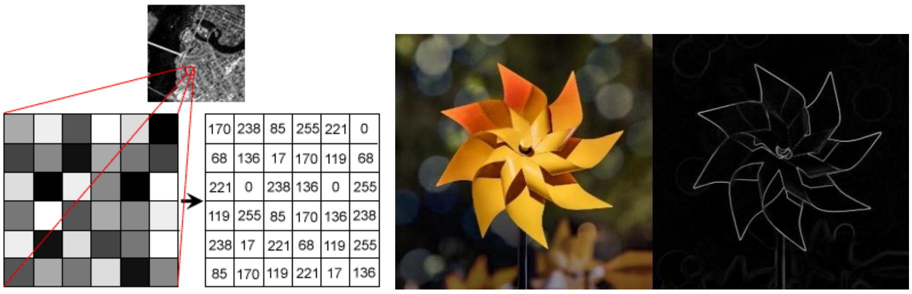
Another component of Raspberry Pi camera module in Figure 1 has a specification of 8 MP fixed-focus camera that supports 1080p30, 720p60 and 480p90video modes, and image mode at a maximum resolution of 3280 × 2464 pixels.(Barsocchi et al., 2018)

1.2. Optical character recognition technology

The technology of optical character recognition has many usefulness when people being accessing through documents conversions into computer data or text. Developers can use two principal of OCR algorithm, the matrix comparison of image processed and feature extraction which decomposes lines of character image. OCR technology is used to read the text included in an image, typically a handwritten or a printed document that has been captured or scanned.(Darshan et al., 2015; Shu et al., 2022)

1.3. Digital Image processing

Digital image processing to support the character detection is by changing the color image to grayscale and also the process of image edge detection that showed in Figure 2.



(a) (b)

Figure 2 (a) Bit grayscale pixels (b) Edge detection conversion

These two stages cannot be separated because it is usual that the image environment and condition consists of many objects and colors, so they must be removed and only use shapes and background colors for this segment/part to be not interfered with any other process to be used as character object recognition.(Maksimovic et al., 2021; Musaddid et al., 2019)

1.4. Artificial neural network algorithm

The main process for recognizing license plate characters is the neural network algorithm (Shan, 2010; Sowmya et al., 2020)(Ardiansyah et al., 2018). Neural network algorithms that are often used for character detection include RBF (Radial Basis Function) and CNN (Convolutional Neural Network) (Ma & Zhang, 2021). If the two are compared, the convolutional neural network algorithm as a derivative of the Deep Learning algorithm has a lower computational speed, but the accuracy is quite high because it uses more layers of neurons.

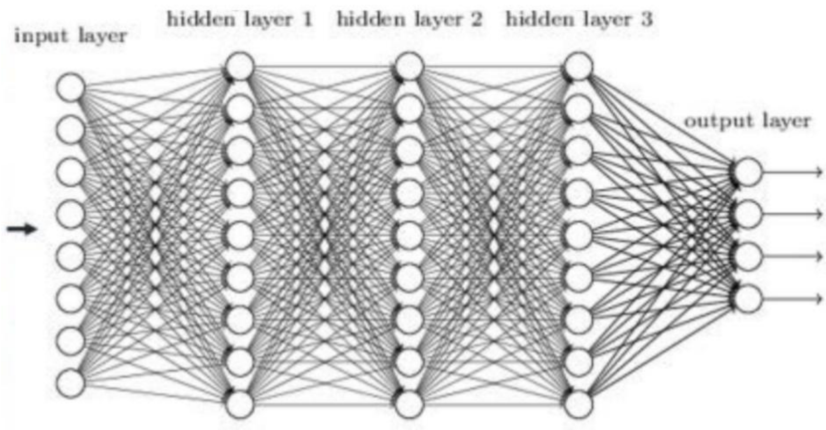


Figure 3. Deep learning network chart on visual recognition.

RBF neural networks generally have 3 layers: an input layer, a hidden layer with a non-linear RBF activation function, and an output layer shown in Figure 3. The input can be modeled as a vector of real numbers (x), while the output is used as a scalar function (φ) of the input vector, becoming an activation function:

$$\varphi(\mathbf{x}) = \sum_{i=1}^{N} a_i \rho(||\mathbf{x} - \mathbf{c}_i||)$$

Where N is the number of neurons in the hidden layer, c_i is the middle vector for neuron i, and a_i is the weight of neuron i in the linear output neuron. So a function that depends only on the distance of the central vector must be symmetric about that vector, so it is called the radial basis function.

1.5. Solar panel powered supply

A solar panel, or solar cells panel, or photo voltaic (PV) module or panel is the compound of some photo-voltaic solar cells which sensitive to explosion of light, that common combined into rectangle device can be called PV or solar array of the Figure 4a. The solar panel which exposed to sunlight will capture the light energy and then converts into electrical energy to be used as power supply.

(a) (b)

Figure 4 (a) Solar Panel Sectional (b) VRLA battery / accumulator

The electric current can be stored in a battery to create a portable power system.(A'Ffan et al., 2022; Dallard et al., 2017; Fraas et al., 2011; Thapa et al., 2019) The VRLA (Voltage Regulated Lead Acid) batteries in Figure 4b widely compatible for a portable or remote powered system since this device lead cells component can be leave unmaintained to work properly and it has adequate discharge capacity averagely for used by electronic devices.

2. Research Method

The purpose of this research is to build an accurate license plate monitoring system that can be independently works by the solar panel powered supply DC electric. The importance of monitoring system more inevitable when the system environment is unreliable to electricity.

2.1. Hardware design

The system is designed for situation seen in Figure 5 where the entrance and exit gates using only one door.

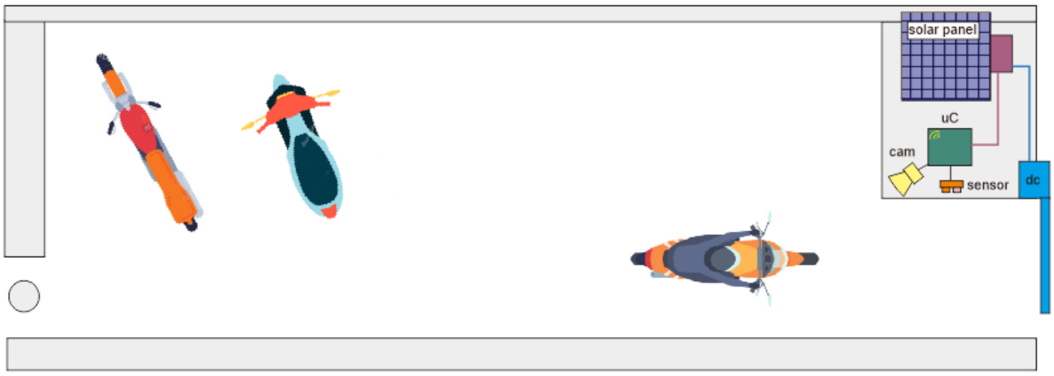


Figure 5. Monitoring System Set-up

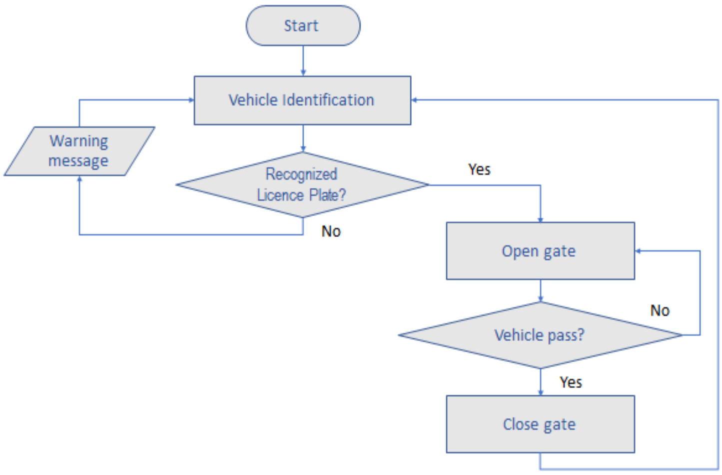


Figure 6. Working Diagram of Monitoring System

The system work flow diagram can be shown in the Figure 6 where the system will continue to read the results of camera detection in the identification process. If the ultrasonic sensor detects the presence of a vehicle that has passed, then the system will re-identify from the new image capture of other license plate.

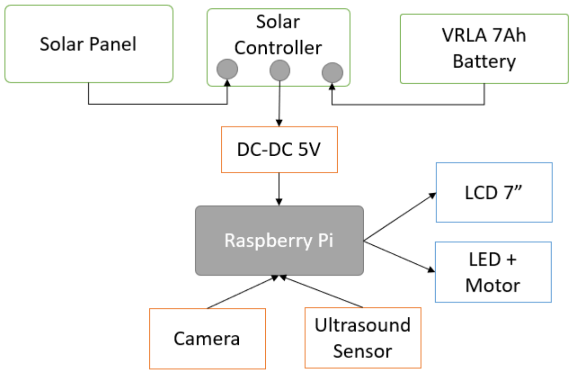


Figure 7. Hardware Connection of Monitoring System

The battery capacity used is 7 Ah / 12 Volts with the assumption that 84 Watts of power is obtained per hour. While the power consumption of the Raspberry Pi 3B + is 2.75 Watts (5 Volts x 0.55 Ampere).(Zubi et al., 2020)

2.2. Software design

The monitoring system software loaded in the raspberry pi microcontroller is organized into 3 process sections.

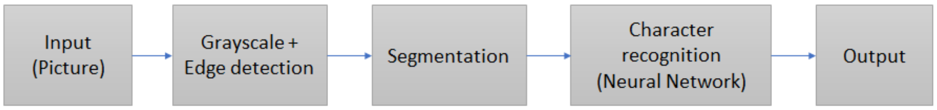


Figure 4 Software Flow Chart

The first part is the process of converting the image to gray color and then processing edge detection to clarify the difference in the image containing the character. This part is using software library OpenCV and also adds implementation of noise reduction filtering. After that, the separation of each character obtained so that it can be recognized in the Neural Network section as the testing data.(Ma & Zhang, 2021; Silva & Jung, 2020)(Wang et al., 2021). The Neural Network section is inside of the software library PyTesseract with some data training modification. (Smith, 2007; *Tesseract OCR in Python with Pytesseract & OpenCV*, n.d.; "Train Your Tesseract," 2018)

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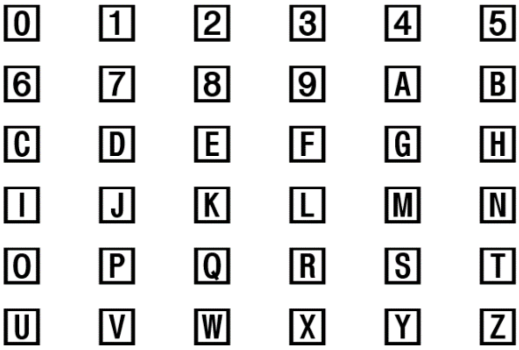

Figure 5. Character Data Set

The data set prepared for character recognition in the neural network for the classification process has enough of 20 training data each character preferably showed in Figure 5.

3. Result and Discussion

The research resulted from combined solar panel supply system and optical character recognition monitoring system.

3.1. Power supply solar panel

The power supply stored in the VRLA battery is 8.4 Watts.

Table 1. Comparison of Battery Power with Raspberry Pi Power Consumption.

Time	Battery power	Current	RPI power
08.00	8,40	0,87	4,35
09.00	6,72	1,20	6,00
10.00	6,72	1,02	5,10
11.00	5,04	1,06	5,30
12.00	5,04	1,10	5,50
13.00	5,04	1,09	5,45
14.00	5,04	1,14	5,70
15.00	6,72	1,02	5,10
Average	6,09	1,06	5,31

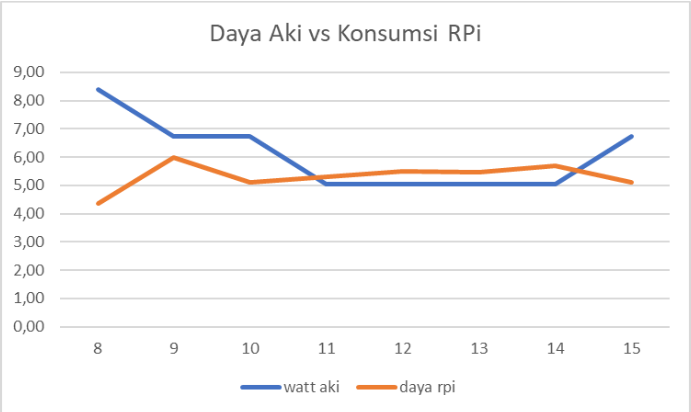

Figure 8. Comparison Chart of Battery Power with Raspberry Pi Power Consumption

Power supply devices from solar panels and VRLA batteries look quite capable of supplying current to raspberry pi devices where the average available power is 6.09 Watts while the raspberry pi power requirement is 5.31 Watts.

3.2. Vehicle license plate character recognition

The first step for image processing is the conversion of gray images into black and white contours using an edge detection process by using OpenCV library which resulted in Figure 9 below.

Figure 9. Edge Detection Process

The convolutional neural network method of character recognition in this study has successfully recognized a number of vehicle license plates from the data set that has been trained.

Table 2: Percentage of Character Recognition

No.	Extract		Character	
	Quantity	Percent	Quantity	Percent
1	48	96	45	90
2	47	94	42	84
3	43	86	40	80
4	45	90	41	82
5	46	92	41	82
6	45	90	44	88
7	49	98	47	94
8	48	96	46	92
9	50	100	48	96
10	50	100	48	96

A total of 50 vehicle license plates showed in Table 2 can be recognized with a maximum ratio of 100% and a minimum ratio of 90% character extraction. Meanwhile, the recognition of each character has been successful up to a maximum ratio of 96%.

Table 3. Vehicle Detection Distance

No.	1	2	3	4	5	6	7	8	9	10	Average
Distance (meters)	2,3	3,0	1,4	1,9	3,7	2,6	1,8	1,5	3,5	2,8	2,5

And lastly by means of ultrasound sensor, the distance measurement for monitoring system was obtained at 2.5 meters of average as noted in Table 3.

4. Conclusion

From the research that has been done, a vehicle license plate monitoring system which equipped with an independent power supply from solar panels has been successfully build. This monitoring system can work with an average vehicle number plate recognition rate of 98% up to an average distance of 2.5 m, and this system has helped increase vehicle security automatically.

5. Acknowledgment

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6. References

A’Ffan, M. I., Arbai, A. A., & Pazil, A. F. M. (2022). *Photovoltaic (PV) Watering Plant System With Internet of Things (IoT)*. 30–35. https://doi.org/10.1109/ICSIMA55652.2022.9929199

Ardiansyah, H., Rivai, M., & Nurabdi, L. P. E. (2018). Train arrival warning system at railroad crossing using accelerometer sensor and neural network. *AIP Conference Proceedings*, *1977*. https://doi.org/10.1063/1.5042999

Barsocchi, P., Calabrò, A., Ferro, E., Gennaro, C., Marchetti, E., & Vairo, C. (2018). Boosting a low-cost smart home environment with usage and access control rules. *Sensors (Switzerland)*, *18*(6). https://doi.org/10.3390/S18061886

Dallard, M., Forest, A., & Shabani, A. (2017). Design of a portable smart connected solar-powered charger for consumer electronics. *Canadian Conference on Electrical and Computer Engineering*. https://doi.org/10.1109/CCECE.2017.7946781

Darshan, H. Y., Gopalkrishna, M. T., & Hanumantharaju, M. C. (2015). Text detection and recognition using camera based images. *Advances in Intelligent Systems and Computing*, *328*, 573–579. https://doi.org/10.1007/978-3-319-12012-6_63/COVER

Fraas, L., Avery, J., Minkin, L., Huang, H. X., & Uppal, P. (2011). Portable concentrated sunlight power supply using 40% efficient solar cells. *IEEE Journal of Photovoltaics*, *1*(2), 236–241. https://doi.org/10.1109/JPHOTOV.2011.2172576

Ma, L., & Zhang, Y. (2021). Research on vehicle license plate recognition technology based on deep convolutional neural networks. *Microprocessors and Microsystems*, *82*, 103932. https://doi.org/10.1016/J.MICPRO.2021.103932

Maksimovic, V., Petrovic, M., Savic, D., Jaksic, B., & Spalevic, P. (2021). New approach of estimating edge detection threshold and application of adaptive detector depending on image complexity. *Optik*, *238*, 166476. https://doi.org/10.1016/J.IJLEO.2021.166476

Musaddid, A. T., Bejo, A., & Hidayat, R. (2019). Improvement of Character Segmentation for Indonesian License Plate Recognition Algorithm using CNN. *2019 2nd International Seminar on Research of Information Technology and Intelligent Systems, ISRITI 2019*, 279–283. https://doi.org/10.1109/ISRITI48646.2019.9034614

Raspberry Pi Documentation - Raspberry Pi hardware. (n.d.). Retrieved December 19, 2022, from https://www.raspberrypi.com/documentation/computers/raspberry-pi.html

Shan, B. (2010). License plate character segmentation and recognition based on RBF neural network. *2nd International Workshop on Education Technology and Computer Science, ETCS 2010*, *2*, 86–89. https://doi.org/10.1109/ETCS.2010.464

Shu, L., Al-Anbuky, A., Fischer, S., Rodrigues, J. J. P. C., Alves, M., Patil, S., Varadarajan, V., Mahadevkar, S., Athawade, R., Maheshwari, L., Kumbhare, S., Garg, Y., Dharrao, D., Kamat, P., & Kotecha, K. (2022). Enhancing Optical Character Recognition on Images with Mixed Text Using Semantic Segmentation. *Journal of Sensor and Actuator Networks 2022, Vol. 11, Page 63*, *11*(4), 63. https://doi.org/10.3390/JSAN11040063

Silva, S. M., & Jung, C. R. (2020). Real-time license plate detection and recognition using deep convolutional neural networks. *Journal of Visual Communication and Image Representation*, *71*, 102773. https://doi.org/10.1016/J.JVCIR.2020.102773

Smith, R. (2007). *An Overview of the Tesseract OCR Engine*. http://tesseract-ocr.googlecode.com/svn/trunk/doc/tesseracticdar2007.pdf

Sowmya, P., Karuna, G., Shanmuka Shalini, R., & Suneetha K, C. (2020). An exploratory study on image edge detection quality evaluation using various algorithms. *Materials Today: Proceedings*. https://doi.org/10.1016/J.MATPR.2020.09.511

Tesseract OCR in Python with Pytesseract & OpenCV. (n.d.). Retrieved December 18, 2022, from https://nanonets.com/blog/ocr-with-tesseract/

Thapa, P., Park, G. C., Lee, J., & Kwon, S. G. (2019). A Comparative Study on VRLA and Li-ion Battery for Use in Frequency Modulation (FM) Station. *IEEE Green Technologies Conference*, *2019-April*. https://doi.org/10.1109/GREENTECH.2019.8767162

Train Your Tesseract. (2018). *Train Your Tesseract*. http://trainyourtesseract.com/

Wang, X., Li, C., & Song, J. (2021). Motion image processing system based on multi core FPGA processor and convolutional neural Network. *Microprocessors and Microsystems*, *82*, 103923. https://doi.org/10.1016/J.MICPRO.2021.103923

Ziemann, V. (2018). A Hands-On Course in Sensors Using the Arduino and Raspberry Pi. In *A Hands-On Course in Sensors Using the Arduino and Raspberry Pi*. CRC Press. https://doi.org/10.1201/9781351188319

Zubi, G., Adhikari, R. S., Sánchez, N. E., & Acuña-Bravo, W. (2020). Lithium-ion battery-packs for solar home systems: Layout, cost and implementation perspectives. *Journal of Energy Storage*, *32*, 101985. https://doi.org/10.1016/J.EST.2020.101985