Model Design of Tomato Sorting Machine Based on Artificial Neural Network Method Using Node MCU Version 1.0

PREFACE

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The 2018 International Conference on Engineering, Technologies, and Applied Sciences (ICETsAS 2018) was held in Bandar Lampung, Indonesia, October 18-10, 2018. ICETsAS 2018 was organized by Faculty of Engineering, University of Lampung, Indonesia in the supports from Cooperation Agency–Public Universities in Indonesia (BKS PTN) in West Region of Indonesia for Engineering Section (BKS PTN in West Region of Indonesia for Engineering Section). This conference was also held in conjunction with Annual Meeting of BKS PTN in West Region of Indonesia for Engineering Section and a global smart city workshop which was a part of BLESS U project, a joint newton fund project between University of Lampung–Indonesia and University of Bradford–United Kingdom. This conference aims to provide a platform for researchers, practitioners and decision makers from academia, industries, and government to share their excellent works in wide range of engineering and applied sciences. The conference invited four keynote speakers: Professor Yim Fun Hu (University of Bradford, United Kingdom), Professor Yoshihiro Narita (Hokkaido University, Japan), Mr. Yunus Mousa Mayat (City of Bradford Metropolitan District Council, United Kingdom) and Mr. Ali Mundakir (Pertamina Geothermal Energy, Indonesia). The success and prosperity of the conference is reflected high level of the papers received. The proceedings are a compilation of the accepted papers and represent an interesting outcome of the conference. This proceeding covers in the fields of Civil Engineering, Mining and Geophysics, Electrical Engineering and Informatics, Mechanical and Material Engineering, and Chemical Engineering. We would like to acknowledge all of those who supported ICETsAS 2018. Each individual and institutional help were very important for the success of this conference. Especially we would like to thank the organizing committee for their valuable advices in the organization and helpful peer review of the papers. We sincerely hope that ICETsAS 2018 will be a forum for excellent discussions that will put forward new ideas and promote collaborative researches and friendship between the delegates. We are sure that the proceedings will serve as an important research resource of references and the knowledge. And hence, our hope that the proceedings will lead to not only scientific and engineering progress but also other new products, processes and innovations.

It gives us a great pleasure to publish the proceeding in the Journal of Physics: Conference Series. The proceeding consists of 45 peer reviewed research papers selected from the manuscripts received for consideration for publication, all of which were presented in the conference. The editors take this opportunity to thank all authors of research articles; irrespective of their articles being published or not in the proceedings for their contribution and the reviewers who helped us by sparing their valuable time to review the manuscripts; without which publication of this proceedings could not have been accomplished.

Dr Misfa Susanto and Dr Shirley Savetlana
The Conference Proceeding Editors

Peer review statement

Peer review statement

All papers published in this volume of *Journal of Physics: Conference Series* have been peer reviewed through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

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Model Design of Tomato Sorting Machine Based on Artificial Neural Network Method Using Node MCU Version 1.0

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Abstract. *Tomatoes have different quality and maturity, this is a problem in sorting because it is often wrong on put the grade of tomato marketing and takes a long time in sorting. One solution offered to overcome this problem is a tomato sorting system based on artificial neural network method that can minimizes the sorting time and also places the tomato according to grade. In this research, the model of artificial neural network system backpropagation method on microcontroller NodeMCU Lua version 1.0. The artificial neural network method is used to process the image of tomato objects moving through conveyor in the form of RGB value and captured by color sensor TCS 3200, the image obtained can classify the grade of tomatoes into unripe, half ripe and ripe. This research compared the results of training and testing of artificial neural networks between Matlab R2015a and NodeMCU Lua version 1.0. The outputs or decisions of artificial neural networks will be forwarded to the control system in the form of hardware and software used in this research. The results showed that the tomato sorting model successfully classified the tomato grade, and was able to control motor servo & DC motor automatically based on RGB value with processing time about 5 seconds and error 8.3%.*

1. Introduction

One of application on the image processing is the assessment of the maturity of tomatoes to help determine the grade / marketing of products according to the distance of market share from the location of the garden to be right on target. Conventional processes using human vision, it have many limitations and disadvantages so that often occur errors [1]. Based on statistical data from the BPS and the Directorate General of Horticulture, tomatoes which produced in Lampung reached 23,600 tons per year by 2016. The high amount of production requires a grade level, one of it is based on fruit skin color [2].

Grading or class distribution of tomato quality, devided into grade 1, grade 2 and grade 3. In grade 1, the target of marketing tomatoes is for the local market. In grade 2, the marketing target for tomatoes is further from grade 1, the market between districts / cities. Whereas in grade 3, the marketing target is the furthest, the inter-provincial market.

Based on that reasons, in this research was create a model design of tomato sorting machine, which is equipped with artificial neural network. The software was using are Arduino IDE and Matlab R2015a. The results of the training and testing are compared, so that the best device can be known for processing this artificial neural network.

2. Literature

In the previous researches about the identification of fruit maturity has been carried out, one of them is research on the identification ripeness of tomato using backpropagation method. The difference of this research compared to the research that has been done is that in the previous research it was only carried out in the form of identification and image retrieval using a webcam, then the image will be processed using the Matlab, whereas in this research a fruit sorter was made based on its maturity level, for the object image will be detected its RGB color composition value using TCS3200 color sensor and then will be processed using node MCU [3].

In the another previous research, by Natalia Sitorus, in determining the maturity of tomato based on image classification method using Matlab 7.0 as an application in processing images of tomatoes. Retrieval of object image as input using Microsoft LifeCam VX-1000 Webcam installed on capturing device with a distance of 10 cm to the object. The object image will be processed by Matlab 7.0 to determine the distribution of the RGB index on the image of the tomato. There are 3 kinds of maturity levels of tomatoes, are raw tomatoes, broken tomatoes and ripe tomatoes. The difference between this research and the previous one is the using of Lua NodeMCU version 1.0 as color processing and sensors TCS3200 to determine the level of each RGB color (red, green and blue) with ranges from 0 to 255. In addition to this, this research made a design a tomato sorting machine and equipped with a conveyor and also with artificial neural networks as a system in making decisions that will determine the tomato grade [4].

The other previous research was to construct a sorting machine and check the maturity of fruit using a color sensor. This research use AVR8535 microcontroller and color sensor to detect fruit maturity, the processing results will be displayed on the LCD and the conveyor will move forward if the fruit is ripe, while if it is still immature, the conveyor will move backwards (reverse). In the this research, NodeMCU as microcontroller and TCS3200 as color sensor are used to detect maturity, the processing results will affect the conveyor valve according to the grade of the fruit that will open or close the container [5].

In this research, a model design of tomato sorting machine can be function as a fruit sorter based on the grade which determined according to marketing, equipped with artificial neural network methods. The software used is Arduino IDE and Matlab R2015a. The results of the training and testing of the backpropagation neural network method in Matlab R2015a and Lua NodeMCU Version 1.0 will be compared so that it can be known in order to obtain the best device to process the artificial neural network.

3. Methods

3.1. Methods

In this research, the RGB values of tomato was obtained by the TCS3200 sensor, can be found in the black box on the conveyor facing the upper of tomato with a distance of 2 cm above the tomato. Furthermore, it is processed using programming in the MCU node where the ANN method has been programmed to determine the grade of fruit maturity. This is so that the determination of tomato's grade can be precisely.

This process must be real-time so that tomatoes can be sorted immediately, an effective and efficient ANN is needed so the tomato sorting process can run correctly, so that no occur error in sorting and can deliver the output to the box provided.

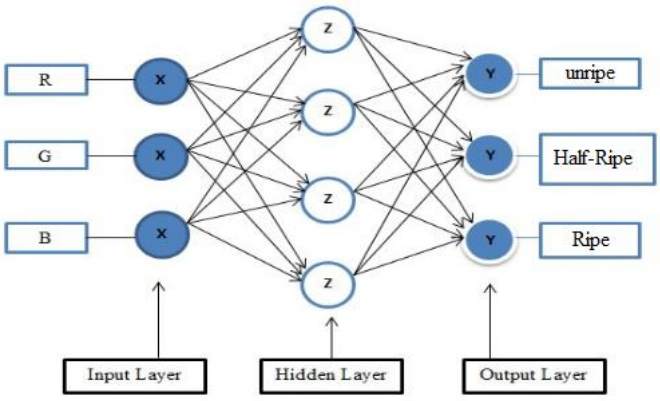


Figure 1. The architecture of Backpropagation

This following is a block diagram that explains how the system work in this research, as follow:

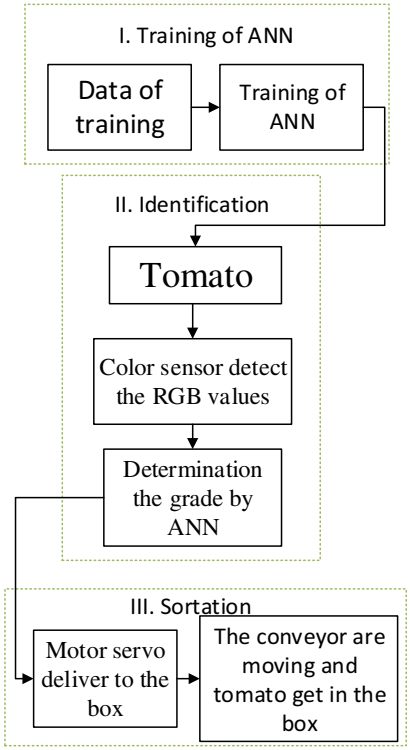


Figure 2. Block diagram of system

3.2. The planning of system

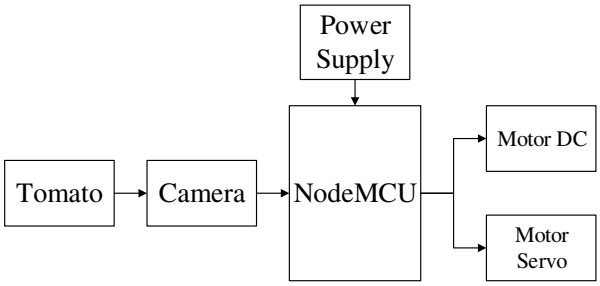


Figure 3. Block diagram of the planning

How the system work is divided into two stages, first stage is the tomato identification system, TCS3200 sensor is used to read the RGB values on the fruit skin, afterward it's processed by NodeMCU. On the second stage, the tomato sorting system. The conveyor is driven by a motor DC. Motor servo will move the track to separate the fruit according its grade to each box provided.

4. Results And Discussion

4.1. The Result of training

Specifications of the training process on NodeMCU :

1. The number of neurons in the hidden ANN layer is 7 neurons
2. The number of neuron output in ANN is 1 neuron
3. The goal parameters are 0.001 and 12000 iterations

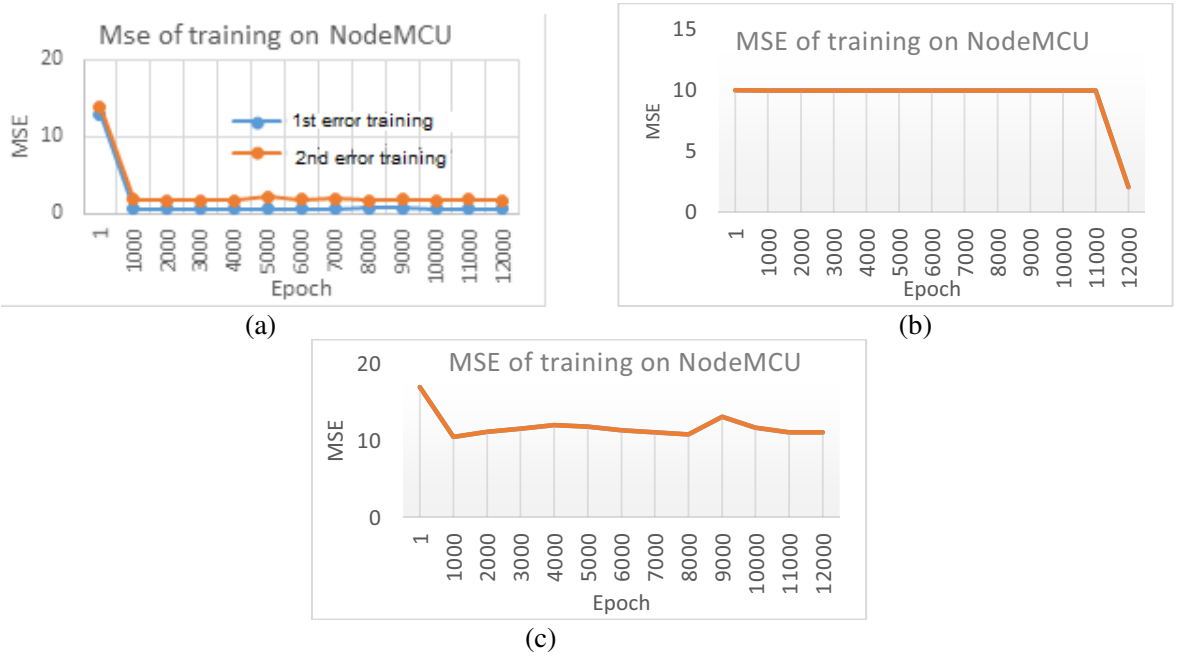
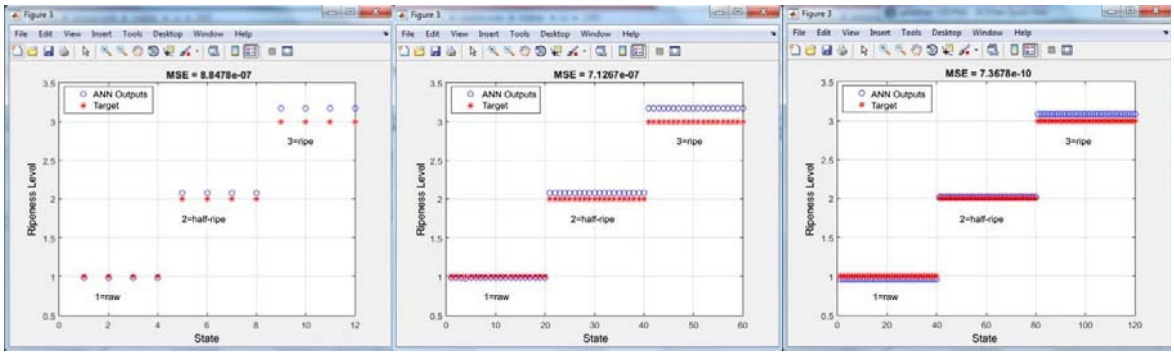


Figure 4. The results of training using (a) 12 tomatoes, (b) 60 tomatoes & (c) 120 tomatoes

Specifications of the training process on Matlab:

1. The number of neurons in the hidden layer of ANN consists of 4 sigmoid functions and 1 neuron linear function
2. The number of output neuron is 1 neuron
3. The goal parameter is 1 x 10^{-7}



(a) (b) (c)

Figure 5. The training result on Matlab R2015a using (a) 12 tomatoes, (b) 60 tomatoes, and (c) 120 tomatoes

The results of data's training on the NodeMCU obtained MSE on 12 tomatoes at 0.67301, using 60 tomatoes at 2.04105 and using 120 datas at 11.03337. The required epoch is 12000 iterations. Whereas in Matlab R2015a, there were 12 tomatoes training obatained MSE at 8.8478 x 10^{-7} in epoch 512, using 60 tomatoes 7.1267 x 10^{-7} when the epoch was 128 and using 120 tomatoes were 7.3678 x 10^{-10} in the 17th epoch.

4.2. Hardware

The description in Figure 6. as follows:

1. NodeMCU
2. Color sensor (TCS3200)
3. Motor Servo
4. DC motor
5. Roller of conveyor
6. Belt of conveyor

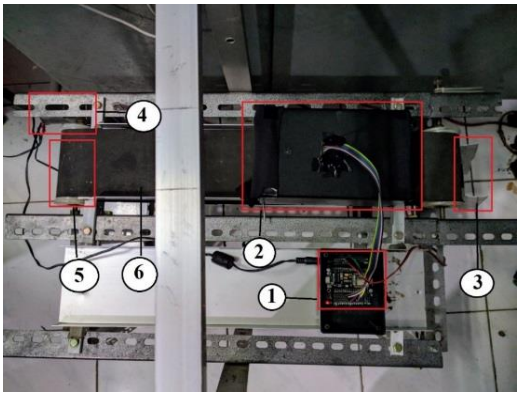
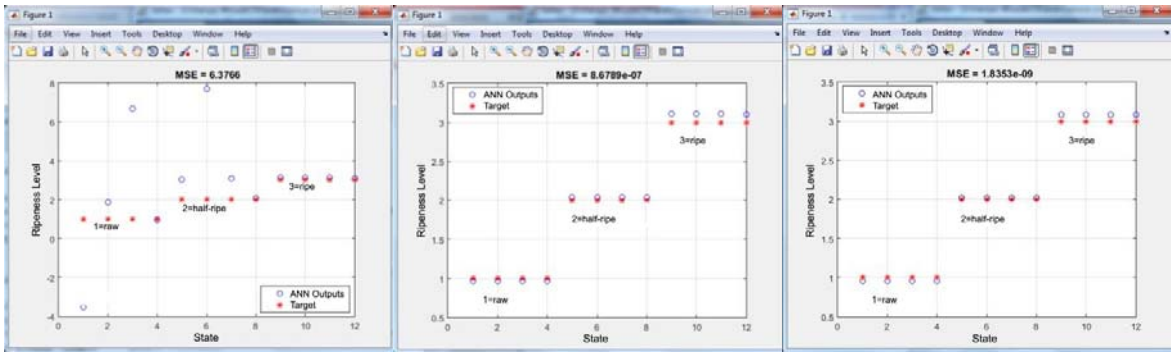


Figure 6. Tomato sorter machine

All of the above subsystems are assembled into a unified system that can be function in accordance with what was previously planned.

4.3. The Test of System

This following is a test using 12 tomatoes which are used as training data and new of 12 tomatoes which do not include training data:



(a) (b) (c)

Figure 7. The test results on Matlab R2015a using (a) 12 tomatoes, (b) 60 tomatoes and (c) 120 tomatoes

Based on the Figure 7, the test results on Matlab R2015a produce an output like the following, in testing using 12 tomatoes obtained an error of 41.6% with MSE 6.37 then at 60 tomatoes obtained an error of 0% with a MSE of 8.67×10^{-7} and in training with 120 tomatoes the output is obtained with an error of 0% and MSE of 1.8×10^{-9}. There are black boxes that function to minimize outside light so that the measurement of RGB values is consistent and not affected by outside light.

TABLE 1. The test results on Matlab R2015a

No	Training data	MSE	Error (%)		Testing time (s)
			Tomato of training	Tomato of test	
1	12 data	8.8478×10^{-7}	0	41.6	3—6
2	60 data	7.1267×10^{-7}	0	0	3—6
3	120 data	7.3678×10^{-10}	0	0	3—6

TABLE 2. The test results of tomato sorter machine

No	Training data	MSE	Error (%)		Testing time (s)
			Tomato of training	Tomat of test	
1	12 data	0.67	0	8.3	04.38 – 12.17
2	60 data	2.04	0	16.6	04.48 – 12.14
3	120 data	11.03	8.3	33.3	04.22 – 12.11

The testing of Artificial neural network use data of 12 tomato's training and data of 12 new tomatoes. In testing the sorting machine using tomato's training, the results obtained were in accordance with the wishes when the artificial neural network system used 12 and 60 tomato's training, while using 120 tomato's training obtained error 8.3%.

Based on TABLE 1 and TABLE 2, we can make conclusion that the artificial neural networks are best applied to using 12 tomatoes for training. This is because it has the smallest amount of 0.67 and also the

smallest device output error of 8.3%. Whereas for the use of 60 and 120 tomatoes for training, it has a greater error because the MSE is much larger than using of 12 datas. This is due to the limitation of the 12,000 epoch so that the NodeMCU does not overheat because the training process is slow and requires much time. The using of Matlab R2015a on a laptop is better because the resource is much better so the training process run faster and can load more training data so that the epoch does not need to be limited to 12,000 and smaller results and errors.

5. Conclusion

Tomato sorting machine has been realized which includes the artificial neural networks, reading RGB values by TCS 3200 color sensor and sorting tomato using NodeMCU Lua version 1.0 with an error rate of 10.6% with an average sorting time of 5 seconds. This tomato sorting machine provides good results and in accordance with the plan, it's seen from the RGB reading process by TCS 3200 color sensor that can function as a sensing to get the RGB values of tomato. As well as the results of the decision of the backpropagation artificial neural network in sorting tomatoes according to its grade. The error in the identification of the tomato ripeness pattern for tomato sorting machine is influenced by the reading of the RGB values by the TCS 3200 color sensor which is sensitive against the changes of light intensity.

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