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Neural networks and behaviour based control for education botanical robot navigation

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Abstract. The development of robots began when the military needed it as war equipment, and then it was used by some industries to develop production until now widely used for education and agriculture. Educational robots are usually more universal and simpler than industrial or military robots because robots for education are made only for simulations or prototypes. In this study, the authors surveyed prototypes of Educational botany robots, namely robots used to distinguish fruit maturity. In this journal, the behaviour-based control (BBC) algorithm will continue implemented into mobile robots. The movement of the mobile robot prepared in advance, and then actually the mobile robot is wheeled compared to the desired path. Besides, both kinematic and dynamic smelling mobile robots are derived and considered. In this study, only focused on mobile robots three-wheel differential drive, which will explore in a circular and straight path. In this journal, it can be found that image processing techniques can be used to determine the maturity of watermelons which are shown in different average values in each image obtained by the camera. The best models are generated by layer 32 hidden with an accuracy value of 87% at the training dataset level 60:10:30. The Behaviour Based Control Method has directional movements. But there was an error in each test so that I couldn't take the watermelon correctly. The error rate reaches 25% from 40 tests or about ten failures in the form of deviating from the object point.

1. Introduction

The science of robotics comes from the development of automation technology [1]. Until now, researchers have not kicked off the exact definition of a robot. Even in the relevant research domain, the classification of robots ranges from "programmable automation" [2] to definitions and approaches to human characteristics and morphology, such as complex motion and anthropomorphic features [3]. Automation can be interpreted as work carried out by machines from work previously done by humans [4].

The definition of robots from other studies suggests the importance of the environment as a factor in the classification of robots. A robot is a very complex and very dynamic system that shows a degree of autonomy and cognition when performing actions in a real environment [5]. Robots will be able to understand the situation through input from sensors that do not require direct human relations. The



sensor allows robots to be placed in an unstructured state with task-oriented goals and oriented to human safety.

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2. Method and Design

2.1. Method

In this study, an experimental research method used because the use of botanical robots as educational aids was new so that no research has referred to the topic

2.2. Design

The design of the robot classified into three main parts, namely the design of algorithms, mechanical design, and electronic design. Designing algorithms includes designing algorithms in the control system and designing algorithms on sensors.

2.3. Behaviour based control

Behavior-Based Control does not use clear representation when every detail of robotic behavior included in the program. However, for this type of control, it collects all information from the sensor, so that each stage has its program so that later it will be collected into one unit and run gradually according to changes in the nearest environment. Behavior-based robots often display biological actions that appear at each stage of computing; this can have an impact on the repetition of these stages so that the robot will become confused. But there is a tenacity where the program at that stage repeated many times. Thus, the emergence of an Artificial Intelligence on the robot. In Figure 1 it can be seen that the sensor as input into the environment so that the situation has a stage of the problem. These stages have been arranged by the work steps of a robot.

When the sensor has a specific value, the environment sees whether the first stage or stage A is successful if it has not succeeded, the situation will run the early stage directly to the actuator. When the first stage fulfilled, the environment will carry out the next step by inputting the sensor and output in the form of an actuator, just like the early stage when it is not fulfilling, and the program will continue, this applies at the next step. Behavior does not depend on the complex model but rather on a continuous blend of sensor values and motor activity[6].

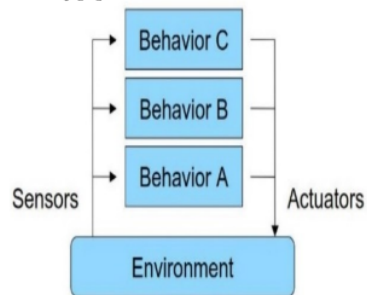


Figure 1. Behavior-Based Control Algorithm Design

This control certainly has advantages and disadvantages, and it seems that the lack of control is that it is challenging to see what the robot will do, but there is no guarantee that when running not only that

bug will always come up and it will be challenging to solve. But for the advantages of this control is the making of modules or easy stages and the performance performed by robots looks natural or not rigid[7]. Research conducted by Yulianto on robot control systems has implemented Behavior-based Control as the architecture of robot soccer navigation control systems, while Fuzzy Logic Controller is used as a control algorithm for each behavior[8]. Other research develops fuzzy behavior based control for robot navigation by using omnidirectional robot (TWOMR) to track static or dynamic targets while avoiding obstacles in accordance with predetermined areas, the results of which are effective for use as robotic navigation systems[9].

In designing behavior-based control, there are decisions on each behavior that can adjust according to the level of the response. The coordinator that regulates the intervention in one of these behaviors.

2.4. Algorithm artificial neural network

The artificial neural network is a computing system that has an architecture and operation similar to biological neural networks of living things. The process of processing information as well as in the human brain, the way this system works is to learn through examples[10][11]. Artificial Neural Networks and Pattern Recognition emphasize probabilities and statistics. The average of the experiments produced has evidence that approaches the natural or original value. At the application layer, the emphasis is on pattern recognition. Most of the examples or cases that occur are from real world problems[12]. ANN is an adaptive system that can change its structure to solve problems based on external or internal information that flows through the network. It is like fuzzy logic which only allows membership values between 0 and 1, gray level as well as black and white, and in linguistic terms, uncertain concepts such as "few", "not bad", and "very"[13].

Artificial neural networks are model on mobile neural networks in the brain of an organism. The basic unit of mobile neural networks is neurons. The neurons receive input from one or more different neurons. The strength of each information on the neurons depends on the neuron that collected the data. If the combined value is strong enough, the neuron receives these signal outputs. When neurons connect with many other neurons (there are about 1011 neurons in the human brain) to form a network, an organism can learn to think and make decisions.[10,11,14,15].

2.5. Mechanics design

Figure 2 is the main drive design uses tricycle with Omnidirectional system. The position of the robot wheels is on three parallel lines so that each axis forms an equilateral triangle. This will make it easier to determine the center of the robot and will get an accurate and precise navigation motion.

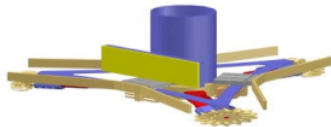


Figure 1. Wheel Position on Robot

2.6. Electric design

Figure 3 describes the Botany Robot diagram block, namely the parts of the electronic circuit connected to one system on botany robots using the Behavior-Based Control method. In making wheeled robots with Behavior-Based Control, the method is divided into three parts, namely Input, Process, and Output.

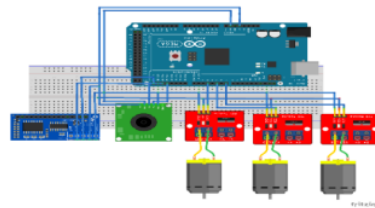


Figure 3. Electrics Design

3. Result and Discussion

3.1. Test result for artificial neural networks

The next stage of this research is the implementation of artificial neural network algorithms that are used for the learning process of watermelon images. The results of this learning will make the reference or comparison for the camera installed on Arduino so that later the robot will recognize the types of watermelons captured through the camera. The next stage is data collection, namely image capture from several watermelon samples that will become primary data. During the training process, backpropagation has 3 phases. The first phase is the forward phase. The input pattern will be calculated forward from the input layer to the output layer using a predetermined activation function. The second phase is the backward phase; the difference from the output at the forward phase to the desired target is called an error. The errors obtained will be propagated backward, starting from the line that corresponds directly to the units at the output layer. The third phase is the process of modifying the weights that have been obtained previously to reduce errors. These three phases will be repeated continuously until the goal condition is fulfilled.

Figure 5 shows process row image became grayscale image with histogram equation algorithm. This test is carried out on processes at the image processing stage. The test aims to find out that the processes in the Image Processing stage are correct so that the data presented from this stage can certainly be input in the next stage. The image obtained has a different image size. So, image cropping is done by taking the best part of the image. From the results of cropping, the image size is 650×650 pixels.

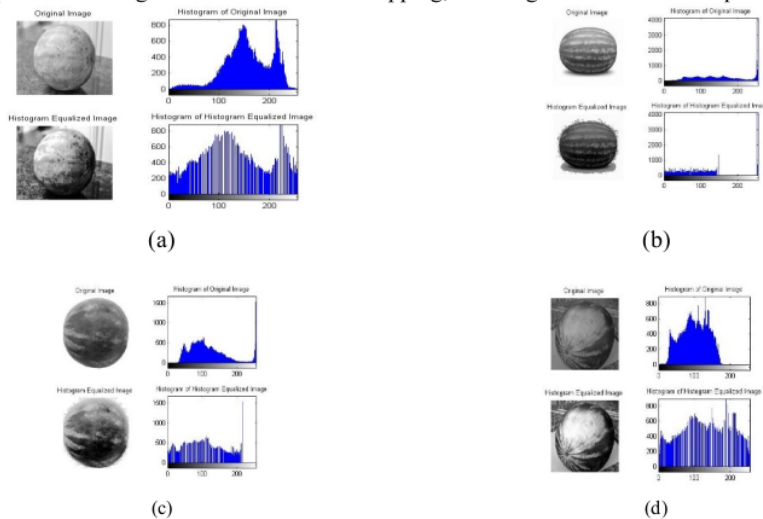


Figure 4. Pre-processing Image and Sample Histogram

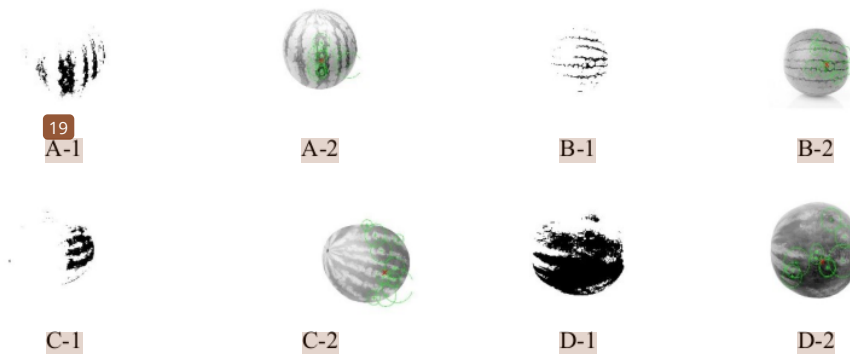


Figure 5. Color and Pattern Identification Process on Watermelon with ANN

Figure 5 shows that the color identification process is done by eliminating image color segmentation to find the best image clusters before continuing the feature extraction process. The intended image area of coffee is the area that separates the color object of the foreground image and its background, leaving a transverse pattern on the watermelon. The letters A - 1 and B - 1 show good and mature fruit quality because the evenly distributed bright green color and pattern are indicated by the identification of patterns in letters A - 2 and B - 2. The letters C - 1 shows bright colors but patterns uneven, and the letter D - 1 shows watermelon that is bad because of the dark color and uneven pattern. This was caused by the fact that the watermelon was rotten. Table 1 is the test results obtained from data obtained from human experts who use ANN. the results obtained showed that the average accuracy was 87%.

Table 1. Percentage of testing between human experts and ANN

Number of Testing	Result of Human experts Testing	Result of Neural Network Test	Error %
1	0.65	0.846	0.20
2	0.7	0.702	0.9
3	0.75	0.742	0.107
4	0.8	0.897	0.88
5	0.85	0.842	0.94
6	0.9	0.909	1.00
7	0.95	0.954	0.42

3.2. Robot Navigation with Behavior-Based Control

By using a camera located on each robot to detect the presence of objects. Retrieving data from the camera gets two outputs, namely post, and Value, the post is the degree of slope of the robot towards the camera, while value is the pixel information of the watermelon. From the information obtained, the calculation is carried out as follows:

Figure 6 shows distance between robots and watermelons is obtained from post information = r. To find the position of x and y, the object of the year is use by the formula:

$$x_object = r \cdot \cos \Theta \text{ and } y_object = r \cdot \sin \Theta$$

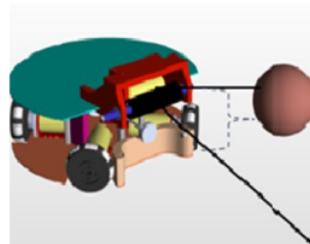


Figure 6. Calculate the distance of the camera with objects

This experiment aims to calibrate the camera so that it can adjust to the actual environment. The method that is done is by giving several colors that will cause a change from the RGB value then this value will be changed into the hue format to simplify the calculation, so to detect the colors RGB and Hue values are in Table 2. Retrieving data from camera sensors has a large error value because the pixels obtained by the camera cannot be used for distance calculations, the pixel value on the camera changes irregularly, when the camera is far from the object the value changes slowly, when the camera is close to the object of change can occur quickly so that the data obtained is not stable.

Table 1. Calibres of camera

COLOR	COLOR DATA	HUE
RED	255. 0. 0	42
GREEN	0. 255. 0	126
BLUE	0. 0. 255	210
YELLOW	255. 255. 0	84
ORANGE	255. 145. 0	65
BLACK	0.0. 0	0

Unstable data makes the calculation method using a camera as a sensor will be difficult to use to calculate distances but is used to detect watermelon objects as presented in Table 3.

Table 2. Calculate the distance of the camera with objects

Robot	Object Potition (cm)		Error (%)	
Training	x	Y	X	y
1	2700	1200	24.26	8.17
2	2700	1200	2.30	33.33
3	2700	1200	0.56	0.83
4	2700	900	26.44	11.11
5	2700	900	21.04	33.11

Much research on ANN and BBC is used for robot navigation systems. studies have been conducted using the ANN algorithm as a ball color detector or face recognition. in this study and the results of various tests show that the robot that is made can recognize watermelon. so that in this study the robot can be used to educate the public to choose a good watermelon and eliminate bad watermelon. In this research there is a disadvantage that the robot is not stable when it has done several times the detection of watermelon, sometimes the accuracy of wheel navigation will be significantly reduced so that the robot can be developed better.

4. Conclusion

In this study, it can be found that image processing techniques can be used to determine the maturity of watermelons which are shown in different average values in each image obtained by the camera. The best models are generated by layer 32 hidden with an accuracy value of 87% at the training dataset level 60:10:30. The Behavior Based Control Method has directional movements. But there was an error in each test so that I couldn't take the watermelon correctly. The error rate reaches 25% from 40 tests or about ten failures in the form of deviating from the object point.

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