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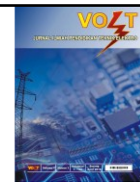

ANALYSIS AND DESIGN OF OBSTACLE AVOIDANCE ON ROBOT DETECTION OF PIPE CRACKED

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Abstract

Pipe robot is a robot capable of moving inside the pipe. The function of the pipe robot is to monitor pipe defects. The pipe robot is designed to move steadily in the center position inside the pipe. HCSR-04 distance sensor required as input to give distance value on microcontroller so that robot keep running stable and ballance, for movement of robot using DC motor. This robot is made with the aim to move autonomously following the pipeline in detecting pipe cracks. Programming on this robot using Artificial Neural Network algorithm with Backpropogation method of network structure, consist of 3 input layer, 3 output layer and 20 hidden layer. Conducted experiments on inputs, hidden layers and outputs with varying amounts to obtain robust network structure of efficient and precise movement of robots in detecting pipe cracks. The result of movement in the robot in the application of Artificial Neural Network algorithm with Backpropogation method is able to move well and more stable. In this case, it uses 2 ultrasonic sensors and 2 motor outputs. The average robot speed movement is 10 cm / sec.

Keywords : backpropogation, HCSR-04, autonomous, artificial neural network

INTRODUCTION

Robot comes from the language of robko Cheko which means workers who are tireless or bored. While in terminology, the most appropriate meaning of the term robot contains a sense system or tool used to replace human performance automatically. While autonomous robot is a robot capable of moving independently or automatically.

Along with the development time of robot the use of robot becomes one of the most important thing. Almost all human work can be done by robots. One is the use of autonomous robots to check for defects in the inside of the pipe that are very difficult or even impossible for humans to enter and check for pipe defects.

The movement of the robot requires input as a robot control either manual or automatic (autonomous). Automatically controlled robots can use sensors as distance detectors for robots or can also be referred to as navigation on robots.

The detection of boundaries in the pipe space and the positioning of the positions are two important and fundamental roles of navigation. Boundary detection is required so that the robot does not collide with the pipe wall, while position estimation is required in order for the robot to get the position to fit its environment (Crawley, 1989).

The distance sensor on the robot serves to detect the boundary and to know the location of an object that is around the robot with an ultrasonic senor by utilizing ultrasonic waves as the distance detector.

Artificial Intelligence (AI) is one part of computer science that learns how to make machine (computer) can do work like and as good as done by human even better than human. According to John McCarthy, 1956, AI: to know and model human thought processes and design machines to imitate human behavior. Being intelligent means having knowledge plus experience, reasoning (how to make decisions and taking action), good morals (Dahria, 2008).

Artificial neural networks (ANN) is an information processing system that has characteristics for a particular work that resembles a biological neural network (Fausett, 1994). ANN has been developed as a generalization of mathematical models of the cognitive aspects of human or biological nerves, namely based on the assumptions that: 1) Information processing occurs on elements called neurons; 2) Signals propagate between neurons through interconnects; 3) Each interconnect has a corresponding weight that on most networks serves to multiply the transmitted signal. Each neuron implements an activation function (usually not linear) on the network input to determine its output signal (Widiastuti, 2014).

Avoider obstacle robot is a wheeled or legged robot that is programmed to be able to avoid if there are obstacles, such as a wall. The obstacle avoider robot requires at least three sensors to detect obstacles ie front, right and left sensors. In this case the sensor used is the proximity sensor. Robots need a lot of sensors due to better detection of barrier. This is due to the limited angle of sensor jets (usually around 15 degrees only). The angle of reflection that is too large will less accurate sensor readings. From its name it is clear that the obstacle avoidance robot aims to avoid collisions with obstructions. Called obstacle avoidance because this robot will move to avoid moving objects approaching in front of it by returning to its path to reach the goal.

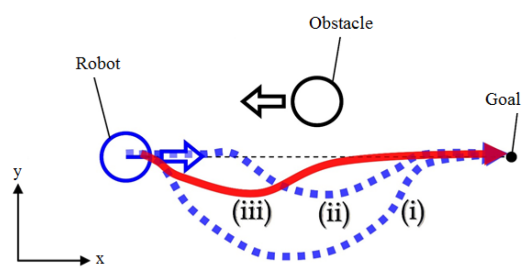

Figure 1. The concept of Obstacle Avoidance

The principle of obstacle avoidance work utilizes the output of the ultrasonic sensor to be processed by the microcontroller. The microcontroller sends to the motor to spin according to the pre-made program.

METHOD

ANN *backpropagataion or backtrack* (ANN-BP) is the simplest and most easily understood method of other methods. ANN-BP will change the weights normally to reduce the difference between network output and output target. After the training is completed, testing the trained network is done. Learning neural network algorithms require advanced propagation and followed by backward propagation. Both are done for all training patterns (Wiryadinata, 2005).

Artificial neural networks backpropagation consists of many layers (multilayer neural network), namely: 1) input layer, consists of neurons or input units, from input 1 to input unit n; 2) hidden layer, consists of hidden units ranging from hidden units 1 to hidden units p; 3) output layer, consists of units of output starting from the output unit 1 to the output unit m. The symbols n, p, m are each arbitrary integer numbers according to the artificial neural network artifacts (Widiastuti, 2014).

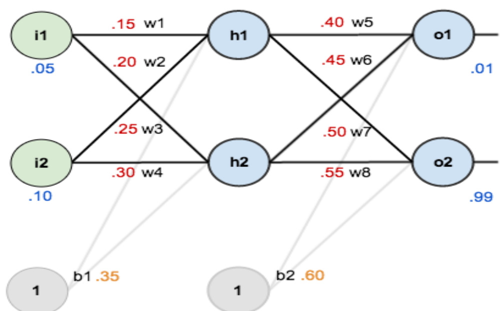

Figure 2. Backpropagation Architecture

This robot is designed with a form that can run on a flat surface so that it has stability when moving or maneuvering.

Figure 3. Robot Design

Block diagram can be seen in Figure 4.

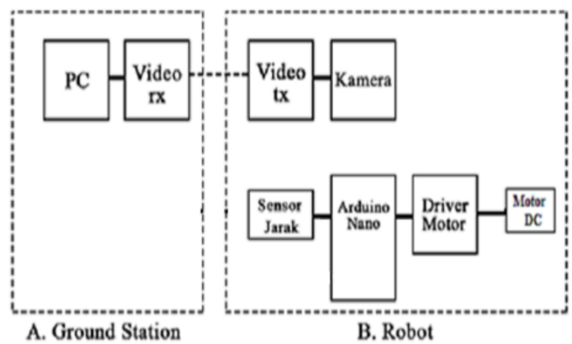

Figure 4. Block Diagram

Block Ground Station is a monitoring station for pipe defect robot detection consisting of: 1) PC is a tool for monitoring results captured by camera and image image processing and 2) Block Video Receiver as the data receiving device of the transmitter generated by the camera.

Robot: 1) Video Transmitter Block as a data sender device generated by camera; 2) Block Camera as the vision sensor of the robot; 3) Microcontroller Block as a robot system processing unit; 4) Motor Driver Block as controller for DC motor; 5) DC motor block as the driving force of the robot; 6) Ultrasonic sensor block as input distance value on robot

The method used in this research is to analyze the change of ultrasonic sensor distance value to motor output movement and movement of robot movement direction and analyze the result of effectiveness of using the method used. Sampling is done by running the robot on the track and processing the robot control.

Stages of system analysis is a very important stage because errors in this stage will cause errors in the next stage. The process of system analysis in system development is a procedure that is done to check the problem and the preparation of problem solving that arise and create a new system specification. Flow chart can be seen in Figure 5.

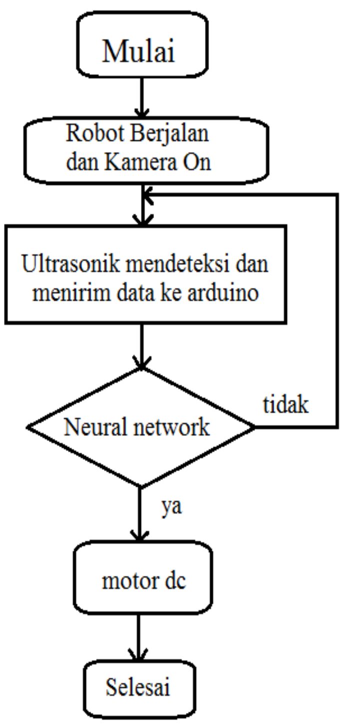

Figure 5. Flow Chart

RESULT AND DISCUSSION

Ultrasonic sensor testing performed to determine the accuracy of ultrasonic sensors on the right, left and center and the influence of each sensor on the movement of motor output on the robot when the sensor detects an obstacle.

Based on table 1 it is proven from the left ultrasonic sensor is smaller than the right sensor then the robot will move right while when the left ultrasonic sensor value is greater than the right ultrasonic sensor then the robot will move left, while at this time from the ultrasonic sensor part left and right are the same as robot grack will go forward. Robot motion is made so that the robot can remain in the middle position. The results of robotic demonstration can be seen in table 1.

Table 1. Distance measurement of robot movement without Neural Network

No	Distance			Motion Robot
	Left Sensor (cm)	Central Sensor (cm)	Right Sensor (cm)	
1	3	20	13	Turn right
2	4	23	12	Turn right
3	5	26	11	Turn right
4	8	20	8	Advanced
5	8	23	8	Advanced
6	9	26	9	Advanced
7	13	20	3	Turn left
8	12	23	4	Turn left
9	11	26	5	Turn left

Ultrasonic sensor testing of robotic movement using Neural Network is done to prove the comparison of robot movement with and without method. Based on the tests that have been done on the mobile robot results in the use of the method of Neural Net-work and without Neural Network on the program there is a difference in the stability of robot motion. In robots without Neural Network robots move very unstable while in robots with Neural Network move better and more stable. The length of time the robot takes without a neural network to cover a distance of 1.5 meters is 15 seconds while the robot with the neural network is 10 seconds. The measurement results are shown in Table 2

Table 2. Measuring distance to the movement of robots with Neural Network

No.	Distance			Motion Robot
	Left Sensor (cm)	Central Sensor (cm)	Right Sensor (cm)	
1	3	20	13	Turn right
2	4	23	12	Turn right
3	5	26	11	Turn right
4	8	20	8	Advanced
5	8	23	8	Advanced
6	9	26	9	Advanced
7	13	20	3	Turn left
8	12	23	4	Turn left
9	11	26	5	Turn left

Ultrasonic sensor testing in this study aims to determine the ability of sensors in detecting objects (walls) of the system and to determine the level of accuracy of the sensor. To obtain accurate data, the test is done 10 times with the distance level varies with the object (wall) measurement in the form of a flat iron plate surface. The test result is the value of time taken by ultrasonic waves, from the time data is converted into units of centimeters (cm) and units of microseconds (μs) and then displayed on the serial monitor arduino that is installed on the pc below is a distance measurement table detected by the sensor against the travel time, which is shown in table 3.

Table 3. Ultrasonic Sensor Measurement Against Distance and Sensor Time

Distance (cm)	Sensors 1 (μs)	Sensors 2 (μs)	Sensors 3 (μs)
3	207	190	209
4	256	251	261
5	325	320	300
6	366	367	380
7	431	415	411
8	490	515	500
9	524	525	527
10	608	615	590
11	648	660	657
12	749	729	705
13	798	790	800

The result of measuring the distance and traveling time of the ultrasonic wave using HCSR04 sensor proves that the available distance depends on the travel time of the ultrasonic wave, the further distance of the object (wall) the longer the travel time of the ultrasonic wave or the greater the time value required by the ultrasonic sensor to reflect and recover the reflected wave from the object (wall). It can be concluded that the distance value is directly proportional to the ultrasonic wave travel time.

Based on the test in Table 3 it is known that there is difference of travel time difference with the same distance. Based on the test in Table 3 it is known that there is difference of travel time difference with the same distance.

$$S = t \times ((340 \text{ m/s}) / 2) \quad (1)$$

Table 3 with distance 3 cm got results:

Left distance sensor

$$S = ((207 * 340) / 2) \quad (2)$$

$$S = 35.190 \ \mu m \text{ or } 3{,}5 cm$$

Right spacing sensor

$$S = ((190 * 340) / 2) \quad (3)$$

$$S = 32.300 \ \mu m \text{ or } 3{,}2 cm$$

Right spacing sensor

$$S = ((209 * 340) / 2) \quad (4)$$

$$S = 35.530 \ \mu m \text{ or } 3{,}5 cm$$

In this research the output devices tested include motor driver circuit and DC motor. Testing and analysis is intended to determine whether the DC motor driver circuit can serve as a control direction of DC motor rotation in accordance with the logic provided by the pin microcontroller, and know the direction of DC motor rotation, Motor Driver used in this mobile robot using L298N module which is supplied by a 12 Volt DC lithium battery as a power supply for a DC motor.

Once the arduino nano module gets the distance value data from the ultrasonic sensor then arduino nano will give the pwm signal command to the motor driver as the output of the mobile robot which will then move the two dc motors.

When the robot moves right, the left motor will be active or worth 1 (High) and the right motor is off or 0 (Low). When the robot moves left, then the right motor will be active or worth 1 (High) and left motor is off or 0 (Low). When the robot moves forward, the left and right motors will be active or worth 1 (High) simultaneously. The speed at each motor is set at a speed of 50 pwm.

Below is the data of dc motor current and voltage on the mobile robot at run time, it can be seen the output of motor robot generate voltage 3,14 and current equal to 0,20 A. In the left motor, test point out 1 and out 2 in the motor driver module while the right motor, the test point is done in out 3 and out 4 on the motor driver module. Based on the above data, it can be concluded that the output voltage on the DC motor is 3.14 volts and the current is 0.20A or 0.200 mA. Here is the measurement table.

Table. 4. measurement of voltage and current at dc motor output

Left Motor		Right		Direction Motion Robot
Voltage (V)	Current (A)	Voltage (V)	Current (A)	
3,14	0,20	3,14	0,20	Advanced
3,14	0,20	0	0	Turn right
0	0	3,14	0,20	Turn left

In Table 5 prove that the results of the tests performed get stable results. Can be explained at input for left distance = 8 cm front = 20 cm and right = 20 cm produce ouput in the form of value 0,0,1 which is robot move forward with speed of right and left DC motor equal to stable value. For left-distance input = 6 cm, front = 21 cm and right 10 cm produce output of value 0,1,0 which is robot turn right with stable. Then at the input for the left distance = 12 cm, the front 20 cm and the right 4 cm produces ouput in the form of 1.0.0 which is the robot turn left with stable.

For the left-hand distance value smaller than the right distance value without being affected by the front-range sensor will always produce 0.1.0 output. As for the value of the left distance is greater than the value of the distance to the left tanpe influenced by the distance sensor will always produce output 1.0.0. And for the value of the right distance and the value of the left distance is equal value without being affected by the distance of the future will always produce a value of 0.01.

The test was done using medium diameter 30 cm, the distance of the left wall to the robot 8 cm and the distance of the right pipe wall against the 8 cm robot.

Table 5. Table Testing Input and Output Neural Network on Robot Motion Stability

Input (cm)			**Output**	**Stable / Unstable**
Left	**Front**	**Right**		
8	20	8	0;0;1	Stable
8	21	8	0;0;1	Stable
7	20	9	0;1;0	Stable
6	21	10	0;1;0	Stable
10	20	6	1;0;0	Stable
12	21	4	1;0;0	Stable

The robot's effectiveness in avoiding obstacles is affected by the number of hidden layers. This is related to the number of hidden layers used the more number of hiden layer the better the robot in moving. But in the experiments that have been done by using some hidden layer with different amounts obtained hidden layer with the number of usage 20 hidden layer. It is said to be effective testing in the movement of the robot is smoother in moving as well as more stable.

Table 6. The robot's effectiveness results in avoiding obstacles

number of hidden layers	**effective / ineffective**
10	ineffective
20	effective
40	ineffective

After the operation of mobile robot movement with the test material used by the track that is 30 cm wide and 185 cm long. Figure 6 shows the initial position of the robot, while Figure 7 shows the position at a distance of 95 cm with a travel time of 9 seconds and figure 8 shows the end position of the robot at a distance of 185 cm with a travel time of 18 seconds.

The total time required for the robot is 18 seconds with a length of 185 cm obtained the average speed of the robot is 10cm / sec. The speed of the robot in the move is determined at the PWM speed set in the Arduino program, to accelerate the robot then the PWM can be supplemented with a maximum value of 255. Mobile robot is set at the PWM speed 50.

CONCLUSION

Obstacle Avoidance system in defect detection robot able to work well and stable enough in its movement.

Artificial Neural Network method used to work as expected with some advantages such as easy in programming and easy to implement in robots.

The distance sensor HCSR-04 in detecting distances has a frequent shortage of occurrence of inaccurate distance value readings

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