EMBEDDED ARTIFICIAL NEURAL NETWORK FOR CART FOLLOWER NAVIGATION

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ABSTRACT: Wheelchair users usually face the problem of carrying luggage along when traveling. This problem can be solved by an artificial intelligence (AI) cart follower where the cart carries the luggage for user. The colour code (CC) is placed behind the wheelchair to enable the tracking with Pixy CMUcam5. The tracked object is interpreted from the image received by the sensor. The data translation process is done through artificial neural network (ANN). The ANN created is able to predict the relative position of the wheelchair through regression method. However, to enable the training process, the image data needs to be collected with its known relative position distance and angle. The training process is repeated with training algorithm in MATLAB to analyze the optimum parameters, number of neurons and activation function required to generate weights and biases with mean squared error (MSE). The result shows that satlin activation function suits the best to the data provided with least MSE value at 0.2420. The final error simulation test shows that the larger the distance from the object, the higher the error would be.

KEYWORDS: *Pixy CMUcam5; Colour code; Wheelchair; Autonomous mobile robot; Artificial neural network.*

1.0 INTRODUCTION

An autonomous system is a system that is capable to operate in real world environments without any external control. The overall architecture of the robot consists of sensors, actuators and intelligent processors (Bekey, 2005).

Autonomous robotic vehicle is a vehicle that is capable of intelligent motion and action without guidance or tele-operator control (Perez, 2012). It is also known as a mobile robot or embedded robot (Bräunl, 2013).

Visual tracking is commonly employed in a variety of robotic applications that require the localization of dynamic targets. It proposes object tracking through the literature and algorithm based on the detection of particular cues like colour, edges and feature templates (Taylor, 2008; Ahmad et al., 2015; Ahmad et al., 2017).

ANN is related to learning and decision making of a machine. It comprises of data collection, data analysis and decision making with different approaches in each stage (Pascual et al., 2017). The production of ANN can be characterized as a search process to search for the correct sequence of rule as a control strategy (Nilsson, 2014).

2.0 RESEARCH METHODOLOGY

2.1 Research framework

The framework of the project is shown in Figure 1. Early stage is to detect the colour code (CC) and track the position of the object with pixymon. CC placed behind the wheelchair to obtain the pre-process data to determine the width (w), height (h) and centroid (x,y) of the object. Next, the MATLAB neural network tool is used to compute the centroid and the additional information data to determine the optimum model that suit the project. The training model evaluate through MSE performance graph to select the best fit model. The structure of the ANN is generated.

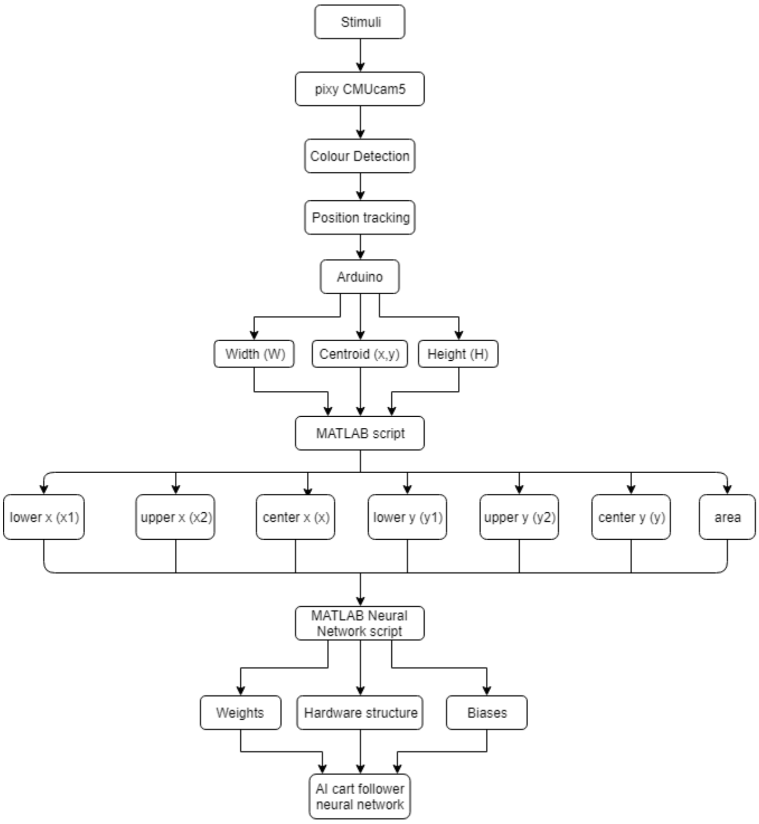

Figure 1: Research framework flowchart

2.2 Experimental setup

The experiment is designed in to gather the data. The experiment is carried out by manipulating the perpendicular distance between the cart (illustrated by Pixy CMUcam5) and the wheelchair (illustrated by CC) shown in the Figure 2 and range reading from 20cm to 69cm in Table 1. Angle is the parameter to be considered when the CC move to right or left.

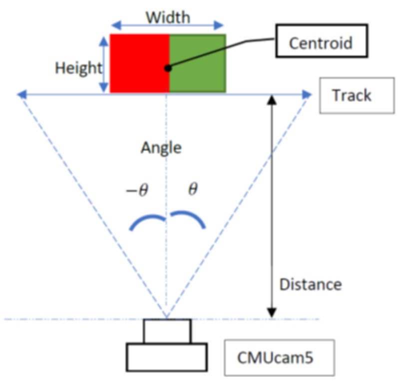

Figure 2: Experimental setup

Table 1: Range of angles according to distance

Distance (cm)	Angle (°)
20-29	-15 to 15
30-39	-20 to 20
40-49	-25 to 25

50-59	-30 to 30
60-69	-30 to 30

2.3 ANN block diagram structure

Figure 3 shows the neuron block. A simple neuron consists of multiplier, adder and activation function. At first the weights determined from the training process needs to multiply the input data. Then, all the result is added together with bias to generate a single value data. This data is used to generate a corresponding output data through the activation data.

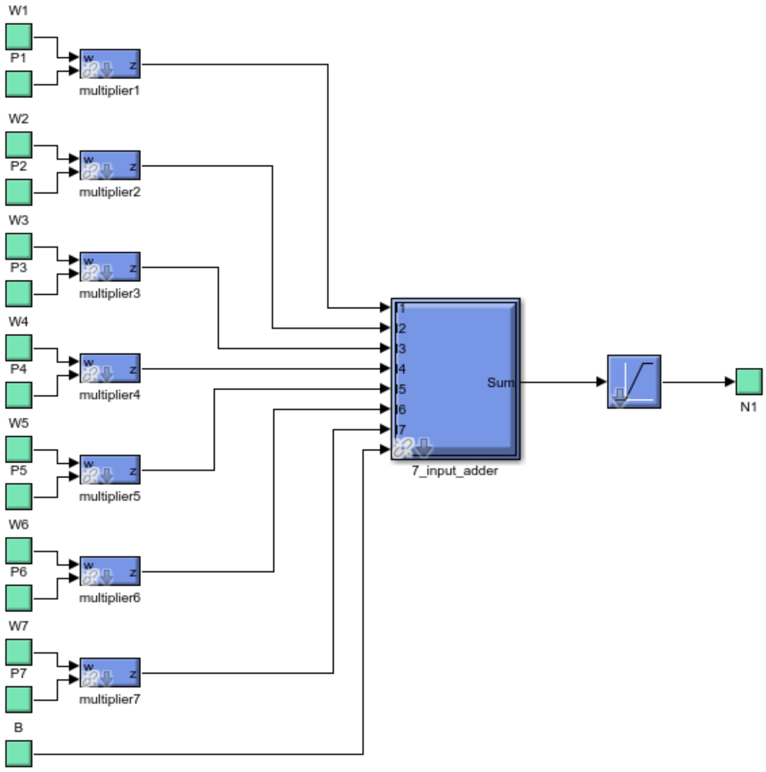

Figure 3: Neuron block for corresponding output generation

3.0 RESULT AND DISCUSSION

3.1 Input for ANN

Table 2 shows the data that collected from Pixymon. It detect the CC and generated information data which consist of centroid, width and height according to the position of the CC. There was more than 2000 samples data collected. Part of the data was selected to be shown as there are too much data to be contained. The overall data set was taken from distance 20cm to 69cm and angle of -30^o to 30^o with restriction of its detected limit. The data collected shown that the width and height of the CC decreases as the camera is further away from the object.

Table 2: Data collected from Pixymon software

Distance	Degree	x	y	w	h
20	-15	116	93	193	111
	0	163	93	208	112
	15	209	92	193	111
:	:	:	:	:	:
69	-30	44	105	46	32
	-15	103	100	62	34
	0	163	96	68	37

	15	223	92	64	35
	30	280	89	45	31

3.2 Final error simulation

The simulation from MATLAB is tested by applying the value of centroid, width and height into the neural network. This value is the raw data collected from CMU cam 5. The first test result is tabulated in Table 3 where the actual value of the distance is 20cm and angle is -15° whereby the second test result is tabulated in Table 4 where the actual value of the distance is 69cm and angle is 30°. This shows that the larger the distance from the object, the higher the error would be. Figure 4 and 5 shows the graph for first (minimum distance) and second (maximum distance) test respectively.

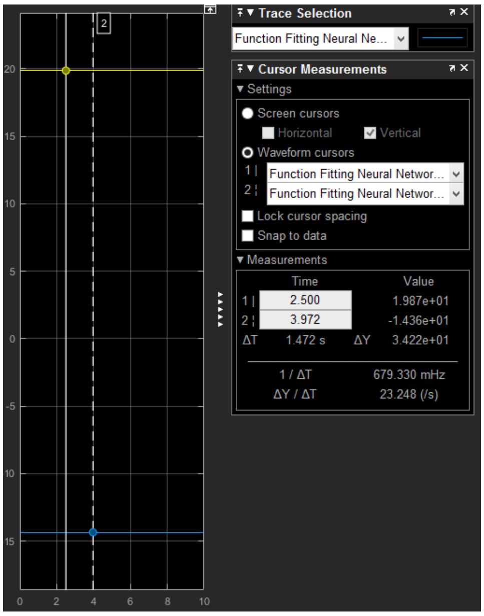

Figure 4: Minimum distance error test

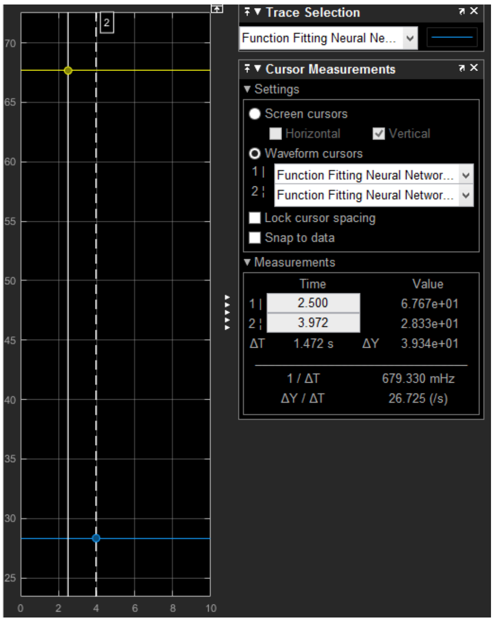

Figure 5: Maximum distance error test

Table 3: Final error simulation tests for 20cm

Measured value	Computed value	Error (%)
20cm	19.87cm	0.65
-15°	-14.36°	4.27

Table 4: Final error simulation tests for 69cm

Measured value	Computed value	Error (%)
69cm	67.67cm	1.93
30°	28.33°	5.57

4.0 CONCLUSION

The ANN cart follower uses the Pixy CMUcam5 as the visual sensor to gather the information from the CC. It enables the cart to track the CC as an object and collect the information like centroid, width and height in real time. The data determined is then translated into relative information which enable the cart to determine the position of the CC through ANN. Hence, a large amount of data is needed to train the ANN efficiently with less error.

In ANN training, the more number the input data, the better the training as all the data is considered. The validation and test performance MSE value is performed to reduce the overfitting and review the prediction in the network. However, the result based on several run shows that the satlin activation function suits the best to the data provided with fewest MSE value at 0.2420. The final error simulation test shows that the larger the distance from the object, the higher the error would be.

5.0 ACKNOWLEDGEMENT
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6.0 REFERENCES

Ahmad, M. F., Rong, H. J., Alhady, S. S. N., Rahiman, W., & Othman, W. A. F. W. (2017, November). Colour tracking technique by using Pixy CMUcam5 for wheelchair luggage follower. In 2017 7th IEEE International Conference on Control System, Computing and Engineering (ICCSCE) (pp. 186-191).

Ahmad, M. F., Alhady, S. S. N., Kaharuddin, S., & Othman, W. A. F. W. (2015, November). Visual based sensor cart follower for wheelchair by using microcontroller. In 2015 IEEE International Conference on Control System, Computing and Engineering (ICCSCE) (pp. 123-128).

Bräunl, T. (2013). Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems, Los Angeles: Springer Science & Business Media, pp. 434.

Bekey, G. A. (2005). Autonomous robots: from biological inspiration to implementation and control. MIT press.

Nilsson, N. J. (2014). Principles of Artificial Intelligence, Morgan Kaufmann, pp. 476.

Pascual, M., & Zapirain, B. G. (2017). Review of the use of AI techniques in serious games: Decision making and machine learning. IEEE Transactions on Computational Intelligence and AI in Games, 9(2), 133-152.

Perez, T. L. (2012). Autonomous Robot Vehicles, G. T. W. Ingemar J. Cox, Ed., Springer Science & Business Media, pp. 462.

Taylor, G., & Kleeman, L. (2008). Visual perception and robotic manipulation: 3D object recognition, tracking and hand-eye coordination (Vol. 26). Springer.