EMBEDDED ARTIFICIAL INTELLIGENT (AI)

TO NAVIGATE CART FOLLOWER

TANG KHAI LUEN

UNIVERSITI SAINS MALAYSIA

2018

EMBEDDED ARTIFICIAL INTELLIGENT (AI)

TO NAVIGATE CART FOLLOWER

by

TANG KHAI LUEN

Thesis submitted in partial fulfillment of the requirement for

the degree of

Bachelor of Engineering (Electronic Engineering)

June 2018

ACKNOWLEDGEMENT

This dissertation is dedicated to everyone in the field of artificial neural network in embedded system who embarks the journey of expanding the collection of knowledge and transcendent passion for artificial neural network in embedded system.

First of all, I would like to thank my final year project supervisor Dr. Syed Sahal Nazli Alhady Syed Hassan for his guidance and advices throughout the process of my Final Year Project. His continuous effort and precious advice is key factor for me to complete my final year project. His caring and considerable characteristics gives me strength and ease me throughout the research. I really appreciate and feel thankful to have such a great supervisor as my final year project.

Besides, I would also like to thank the Master student, Mohamad Faiz Bin Ahmad Johari who doing researh study under Dr. Syed. He is kind and wills to sacrify his time to provide me precious advices, guide and support for my final year project. He shares his experiences and knowledges to me and gives me advices about the final year project and research.

In addition, I would also like to deliver a special thanks to Dr. Wan Amir Fuad Wajdi Othman who advices me so that my research can fulfill the requirement set for the final year research and introduce me to some latest technologies. Another special thank reach out to Dr. Junita Mohamad Saleh who gives me advices in order to have greater insight about the Artificial Intelligence theory in order to choose the correct method for my research.

Last but not least, I would also like to thank my friends and seniors for their kindness and moral support for me to complete my research especially for those friends and seniors from Mechatronic engineering courses. As I’m a eletronic engineering student, topics about AI was new to me and they really wills to sacrify their time to share me some basics knowledge about topic although they are busy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS/ACRONYMS

AI	Artificial Intelligence
ANN	Artificial Neural Network
EEPROM	Electrically Erasable Programmable Read-Only Memory'
FPGA	Field Programmable Gate Array
IO	Input and Output
LED	Light Emitting Diode
SDRAM	Synchronous Dynamic Random Access Memory
SPI	Stateful Packet Inspection
UART	Universal Asynchronous Receiver/ Transmitter
USB	Universal Serial Bus
Verilog HDL	Verilog Hardware Description Language

ABSTRACT

The concern of the societies in creating a quality life for everyone without laying aside of the right of disable person leads to research on designing and fabricating autonomous robot. Wheelchair user usually faces the problem of carrying luggage along during travel as they need both of their hands to navigate their wheelchair. One of the solution for the problem is to create an Artificial Intelligent (AI) cart follower. Therefore, this research is to create an AI system for the AI cart follower with a visual based sensor. The visual based sensor gathered the information of the width, height, angle, x and y coordination of the colour pattern board which situated behind the wheelchair and translate this information into relative position information which enable the cart to follow the wheelchair. This translation can be done in neural network. However, the data needs to be collected in such a way that the output distance is manipulated between 20cm to 69cm and the output angle is manipulated between -30 to 30 with its restriction for each case. The test MSE value is used to evaluate the performance of NN and validation MSE value is used to prevent overfitting. The weights and biases generated through the training process is depended on the training algorithm, initial weights and biases for training and the dataset used in the process. The training algorithm may also vary with different sets of parameters, number of neurons and activation function. The set of parameters used in traingd are lr, max_fail, min_grad, goal, time, and epochs. The final weights and biases generated with the minimum MSE performance after several run is used to train NN in the FPGA together with the structure of NN obtained in Simulink. The implementation of neural network on the FPGA can be done through software or hardware configuration. However, the floating-point operation circuit needs to be built to ensure the NN on FPGA is functioning.

ABSTRAK

Usaha masyarakat dalam menwujudkan kehidupan yang berkualiti setiap individu tanpa mengetepikan hak orang kurang upaya mendorong kewujudan penyelidikan mengenai reka bentuk dan fabrikasi robot autonomi. Pengguna kerusi roda biasanya menghadapi masalah membawa bagasi semasa perjalanan kerana mereka memerlukan kedua-dua tangan mereka untuk menavigasi kerusi roda mereka. Salah satu penyelesaian untuk masalah ini adalah untuk mencipta pengikut troli Artificial Intelligent (AI). Oleh itu, penyelidikan ini adalah untuk mewujudkan sistem AI untuk pengikut troli AI dengan sensor berasaskan visual. Sensor berasaskan visual mengumpul maklumat mengenai panjang, tinggi, x dan y koordinasi papan corak warna yang terletak di belakang kerusi roda dan menterjemahkan maklumat ini ke dalam posisi relatif yang membolehkan kereta itu mengikuti kerusi roda. Terjemahan ini boleh dilakukan dalam rangkaian saraf. Walau bagaimanapun, data perlu dikumpulkan dengan memanipulasikan jarak kerusi roda dan troli antara 20cm hingga 69cm dan memanipulasi sudut kerusi roda dan troli antara -30 hingga 30 dengan had yang wujud bagi setiap kes. Nilai ujian MSE digunakan untuk menilai prestasi NN dan nilai pengesahan MSE digunakan untuk mencegah overfitting. ‘weight’ dan ‘bias’ yang dihasilkan melalui proses latihan bergantung kepada algoritma latihan, ‘weight’ awal dan ‘bias’awal dan data yang digunakan dalam proses. Algoritma latihan juga boleh berbeza-beza dengan set parameter yang berbeza, bilangan neuron yang berbeza dan fungsi pengaktifan yang berbeza. Set parameter yang digunakan dalam ‘traingd’ adalah ‘lr’, ‘max_fail’, ‘min_grad’, ‘goal’, ‘masa’, dan ‘epochs’. ‘weight’ dan ‘bias’ akhir dihasilkan dengan prestasi MSE minimum selepas beberapa percubaan digunakan untuk melatih NN dalam FPGA bersama dengan struktur NN yang diperoleh dalam Simulink. Pelaksanaan rangkaian saraf pada FPGA boleh dilakukan melalui konfigurasi perisian atau perkakasan. Walau bagaimanapun, litar operasi ‘floating-point’ perlu dibina untuk memastikan NN pada FPGA berfungsi.

CHAPTER 1

INTRODUCTION

1.1 Research Background

The concern of the societies in creating a quality life for everyone has become prevalent. Therefore, lots of research on creating infrastructures and tools to ease the daily activities are fostered. In conjunction, the research on designing and fabricating Autonomous robot arises.

In the technologies evolving era, the world is making a great stride towards autonomous system. Autonomous system is referred to the system that capable to operate in real world environment without any external control. It can maintain its internal structures and processes for extended periods and capable to adapt toward environmental change. The overall architecture of the robot consists of sensors, actuators and intelligent processors [1].

Autonomous robotic vehicle is vehicle that capable of intelligent motion and action without guidance or teleoperator control. It is used to remote repair and maintenance, handle system for office and factory and even intelligent wheelchair for handicapped [2]. It is also known as mobile robot or embedded robot. After a long way of research, the mobile robot today is smaller with numerous actuators and sensors controlled by inexpensive embedded computer system as processor [3].

Visual tracking is commonly employed in variety robotic application that require the localization of dynamic target like mobile robot navigation, human machine interaction and machine learning. It proposes object tracking through the literature and algorithm based on the detection of particular cue like colour, edges, feature templates. Each of the cue can provide reliable tracking under limited condition [4].

Machine learning is a set of methods that can automatically detect the pattern in data and either to use the uncovered patterns predict the future data or to perform other kinds of decision making [5]. ANN is part of the machine learning.

ANN is related to learning and decision making of a machine. It comprises of data collection, data analysis and decision making with different approach in each stage [6].

ANN can be used to control the physical actions of a mobile robot which enable it to navigate through the environment and manipulate items and solve other. The production of ANN can be characterized as a search process to search for the correct sequence of rule as control strategy with enough knowledge to produce database that satisfy the termination condition [7].

AI is a future development system toward a more advance machine learning. It is in the sense that the system can train the model or update its learning and decision-making process by itself if any diversity encounter. It acts like an intelligent human being.

1.2 Problem Statement

Wheelchair user might face difficulty of carrying their luggage along especially when travelling around from one place to another. This is because they need to use both their hand to control their wheelchair. This is considerably hard for them to carry along their luggage. Moreover, if the luggage is heavy, it will affect the smooth movement of the wheelchair if they carry along the luggage. Hence, AI cart with embedded ANN is proposed. ANN is used to enable the navigation in cart follower as it able to predict the output for unseen data. This enhance the usage of the controller. Furthermore, training process in ANN can be readily used with just manipulating the parameter to suits the data.

1.3 Objective of Research

- To identify the changes in information data of colour pattern board (object) when the relative position between the colour pattern board and the sensor is manipulated
- To develop neural network which translate the information data of colour pattern board to relative position information data

The ANN for AI cart follower is created to enable the cart to navigate according to the wheelchair user and able to response intelligently without any external control. The ANN able to translate the information data from image to relative position information data to allow the cart to identify the position of the wheelchair user. In this project, the visual based CMUCAM5 is used to gather information data from the environment. Then the data is analysed through ANN in Altera DE0 Nano FPGA. ANN helps the AI cart follower to make decision upon each different situation and ease the difficulty of wheelchair user when travel

1.4 Scope of Research

This research has covered the studies of developing an ANN for the AI cart follower which ease the wheelchair user. It covers the usage of Pixymon in determining the colour pattern through CMUCAM 5, Arduino in collecting the data for ANN training, MATLAB in analysing the performance of ANN and Altera DE0 Nano FPGA in implementing the ANN. The ANN is analysed and retrained to develop an optimum AI system for the cart.

1.5 Thesis organization

This thesis consists of five chapter. They are introduction, literature review, methodology, result discussion, and conclusion.

Chapter 1 is about the introduction of the research on developing an ANN for the AI cart follower. It reviews the purpose of the research and the focus of the project.

Chapter 2 is about the approach of the research. It is the literature review about the research field. It provides information about the study related to the research.

Chapter 3 is about the methodology to create an AI system for AI cart follower. It makes use of the research of study to develop the AI system which is the output of the project.

Chapter 4 is about the result of analysis to find the suitable parameter for the training process of the neural network. It also shows the simulation of developed neural network.

Chapter 5 is about the conclusion of parameter that suitable to be used when traingd algorithm is used. It also tells about the future improvement that can be done

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Wheelchair user faces harsh time when travelling. The situation becomes worst when it involves carrying luggage. Hence, the mobile robot which can track or follow the user is introduced. It helps to carry the luggage of the user and navigate to follow the user. Therefore, to enable the robot to perform the task, the robot must able to collect information data from the surrounding environment and process the data to come out a decision action to accomplish the task as mentioned. In executing the task, the robot also needs to consider about the safety of the user. It needs to maintain a safety distance with the wheelchair during the navigation.

2.2 Following mobile robot

There are several mobile robot-based localization methods present which can roughly divided into 2 general classes. The first class is without its local position information. The mobile robot considers its beginning point as the coordinates origin and moving along the sensor network domain. It keeps track the robot's position to enable localization. The second class is with its local position information. It uses the global position estimation to enable localization. For the mobile robot in the second class, it is normally equipped with GPS for localization and radio wave strength measurement to estimate the distance (indoor positioning tracking) [8]. For the mobile robot in the first class, it can be describe as following mobile robot as keep track or follow object. Example of the robot are leader following, human following, line or path following and sound following. The method to achieve the task of following might vary in the hardware or sensor used.

2.2.1 Leader following

Leader following robot is mobile robot that follows the command of the leader robot. It can use an active signal positioning device to locate and track the position of the leader [9]. The leader robot works together with all its following robot to move the box.

AI follower forces will synchronize to the direction of the force applied by the one leader robot although there is no communication between the follower robot [10].

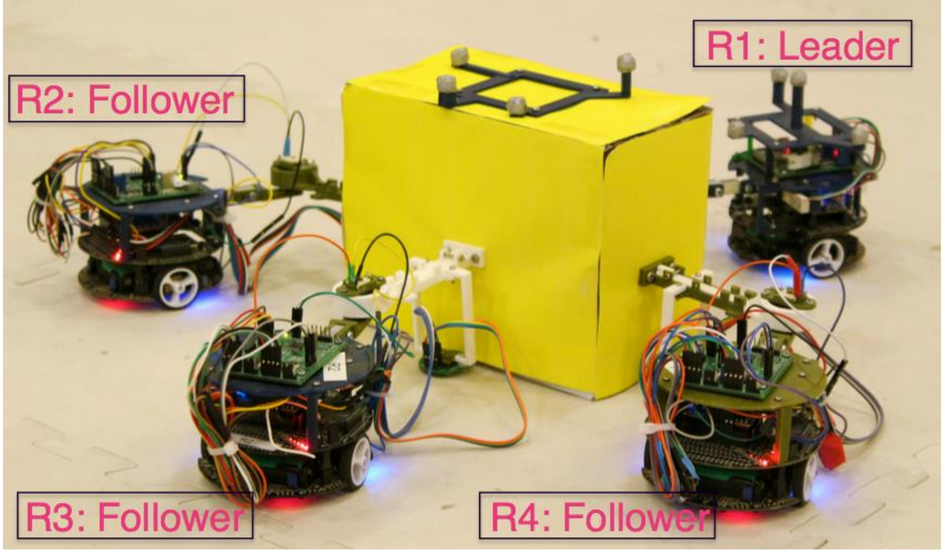


Figure 2.1: Leader Following Robot [10]

2.2.2 Human following

Human following robot is a mobile robot that can coordinate the motion of a human in a populated, continuously changing, natural environment.

For Erwin Prassler, Dirk Bank and Boris Kluge model, Velocity Obstacle approach is used for motion planning amongst moving obstacles. Besides, the model also tracks the virtual target to manipulate the direction and velocity of the robot's movement according to the person it follows [11].

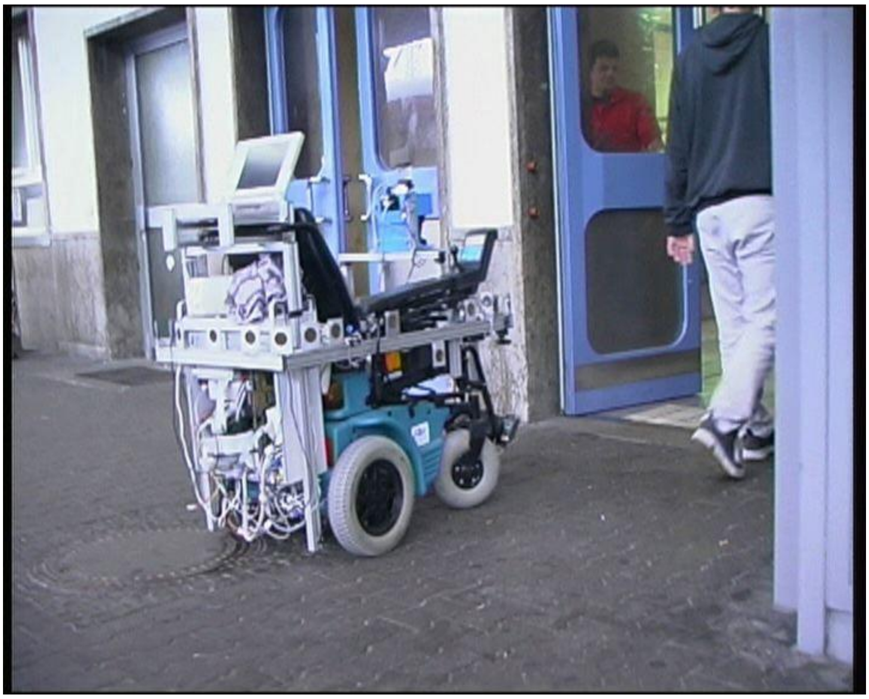
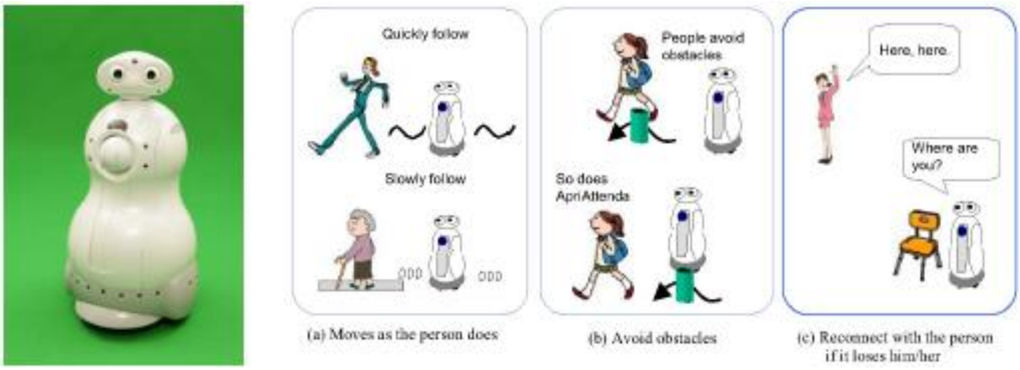


Figure 2.2: Prassler Human Following Robot [11]

For ApriAttenda model by Yoshimi, it uses the image processing to define region of interest. Then it recognizes the texture and colour of the subject. The specific person is then detected from the specification and his position is calculated. Stereo vision with systemizing visual and motion control helps to extract the information on the distance to each feature point, speed of target, colour and texture of clothes for a stable tracking in many situations [12].



(a) Moves as the person does

(b) Avoid obstacles

(c) Reconnect with the person if it loses him/her

Figure 2.3: ApriAttenda Human Following Robot [12]

2.2.3 Line following

Line or path following robot is route-based following robot. It uses line tracking method with the implemented Infrared Ray sensors. The IR sensors will be set up and distributed according to its place and signalling the present of the line for controlling the direction [13].

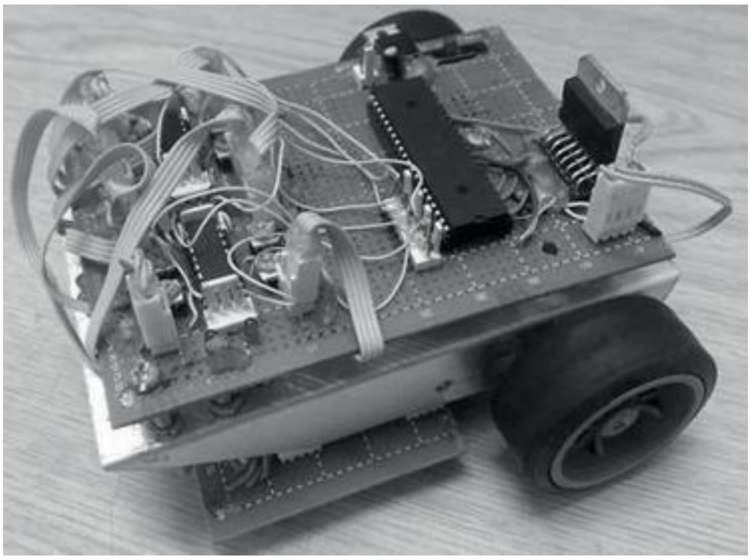


Figure 2.4: Line Following Robot [13]

2.2.4 Sound following

Sound following robot is the mobile robot that trace the existence of human based on sound made. For mobile assistive companion robot by Luo, it uses vision sensor and laser sensor to track and follow the targeted person. However, it also consists of sound source detection and speech system to establish speech interaction between robot and its user. This helps to relocate the user if the robot gets lost. The robot is equipped with a laser range finder, pair of microphone, a speaker and a tracking camera. The collected sound wave in TDOA (Time-Delay of Arrival) are collected by pairs of microphone meanwhile the camera to trace the human upper part and the laser range finder to search for the human lower part [14].

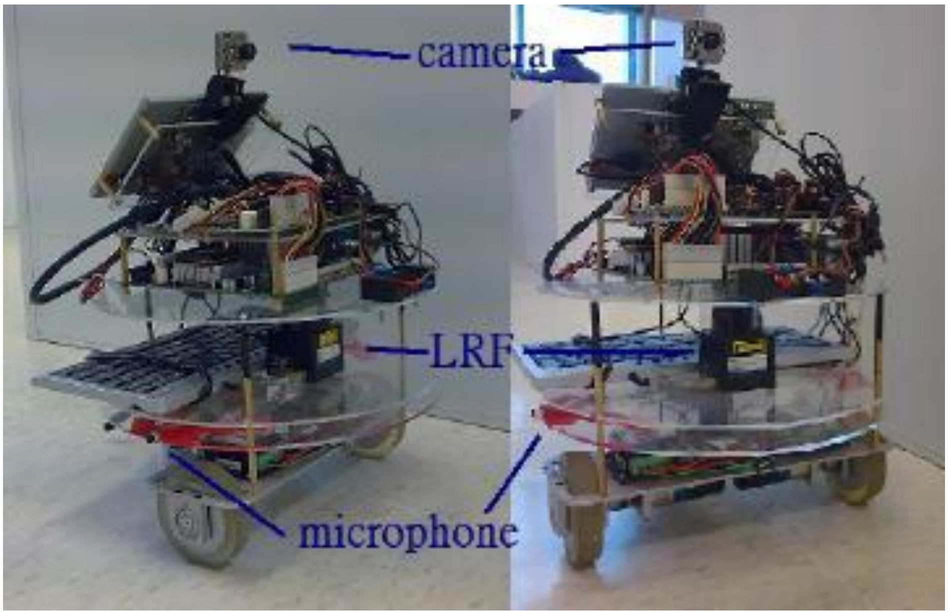


Figure 2.5: Sound Following Robot [14]

2.3 Visual-based sensor

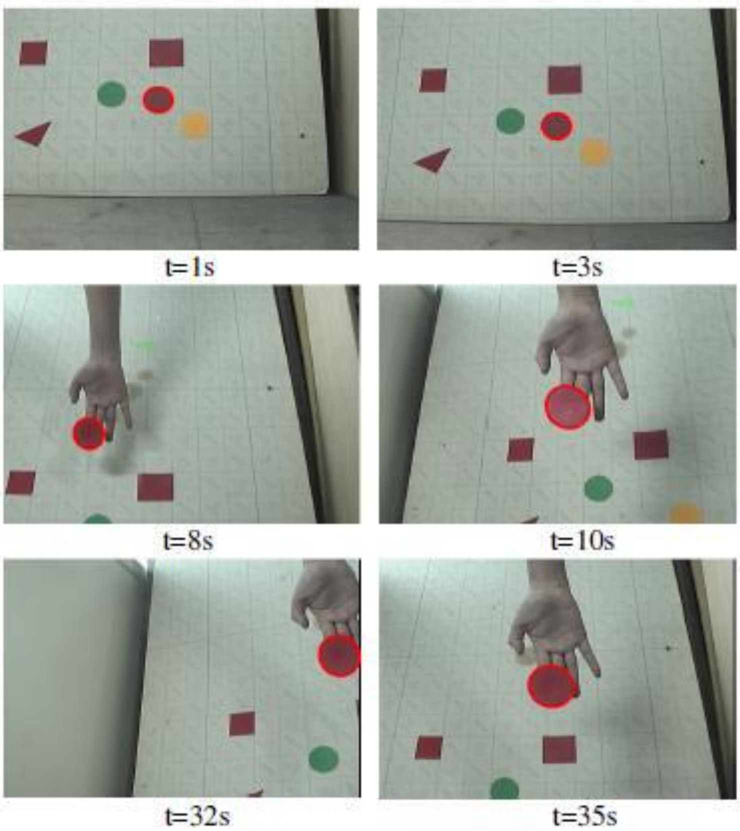
A visual-based sensor like camera is used to detect the colour, contour, position, shape, edge, etc. through analysation and comparison on the image capture in the camera.

2.5.1 Colour detection

Colour detection is used to detect colour of image. The image captured in the camera are RGB channel image with difference colour format. One of the common colour model is HIS (Hue, Saturation, Intensity) as it is one of the best model to define colour. H and S component have a relationship to human colour perception meanwhile I component is the brightness of colour [15]. Each colour is defined by code in colour model.

2.5.2 Position tracking

Position tracking is used to track the position of the object. At first it needs to select the targeted object and adjusts so that the tracked object is always at the centre view of the camera screen. [15]



t=1s t=3s

t=8s t=10s

t=32s t=35s

Figure 2.6: Object Detection and Position Tracking in Real Time [15]

2.4 Machine Learning

Machine learning include ANN can be produced through rule or knowledge extraction which can summarized into Initial Design of Experiments, Accuracy-Aware Supervised Learning, Reinforcement Learning, Model Building Learning, Self-Verification, Knowledge Extraction. [16]

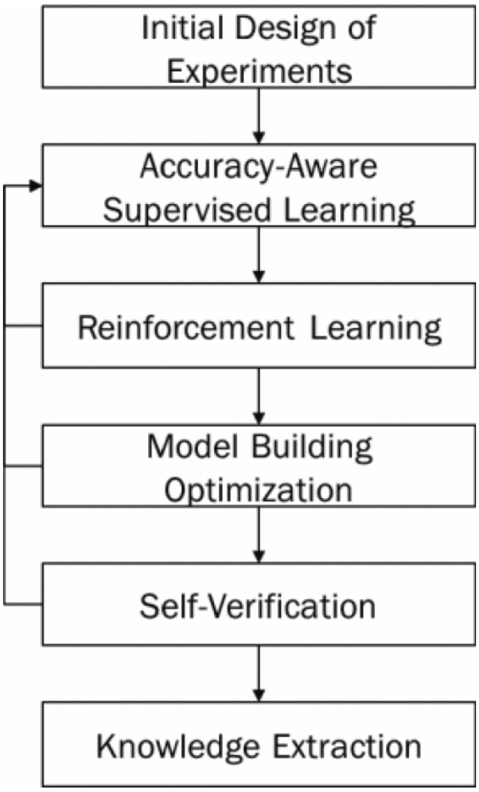

Initial Design of Experiments
Accuracy-Aware Supervised Learning
Reinforcement Learning
Model Building Optimization
Self-Verification
Knowledge Extraction

Figure 2.8: Machine learning Architecture [16]

2.4.1 Initial Design of Experiment

The data information is required before the learning. Hence, a design of experiments method needs to build to achieve the entire goal of the machine learning. For some cases, the raw data needs to be pre-processed before it is feed into the machine learning.

2.4.2 Accuracy-Aware Supervised Learning

This stage a regression and classification models are build. The method that often use to determine the optimized NN architecture is cross validation which compare 2 or more learning models [17]. The different model has different ability to extract the information about the model structure and different relationships between input and output from the trained network.

2.4.3 Reinforcement Learning

The value of interest predicted might not be accurate enough to support design decision. Hence, the points that can better identify the area of interest with perfect accuracy is simulated through statistical sampling.

2.4.4 Model Building Optimization

Although the model created can predict all values for all points anywhere in the space, but there are still areas that have more sparse data and area that are less which lead to inaccuracy upon response change. Hence, it is necessary to optimize the model with removing unnecessary link. Prune algorithm removes unimportance connection of NN based on the magnitudes of the weights to simplify the NN. This can be related to sensitivity analysis. It is a method for calculating the output sensitivities to input variation from the trained ANN [18]. The ANN is retrained if necessary to achieve desired accuracy level.

2.4.5 Self-Verification

After the desired accuracy is reached, the ANN needs to be verified with different sets of data obtained through the experiment in order to demonstrate that the model is correct.

2.4.6 Knowledge Extraction

After that, the knowledge needs to be extracted into machine readable knowledge which enable for the machine to handle the data outside the range of training.

2.5 Artificial Neural Network

NN is a system to process information like biological system in human brain. It constitutes general mathematical representation of human reasoning. The information is processed by neurons. Each neuron communicates through link between them. Every connection between neurons is associated with weight. Hence, transmission of signal between neurons involved multiplication of weights. Every network neuron applies an activation function [19]. The architecture of feed-forward ANN is known as multi-layered perceptron with the first layer as the input layer and last layer as the output layer. Other layers are generally hidden layer [20].

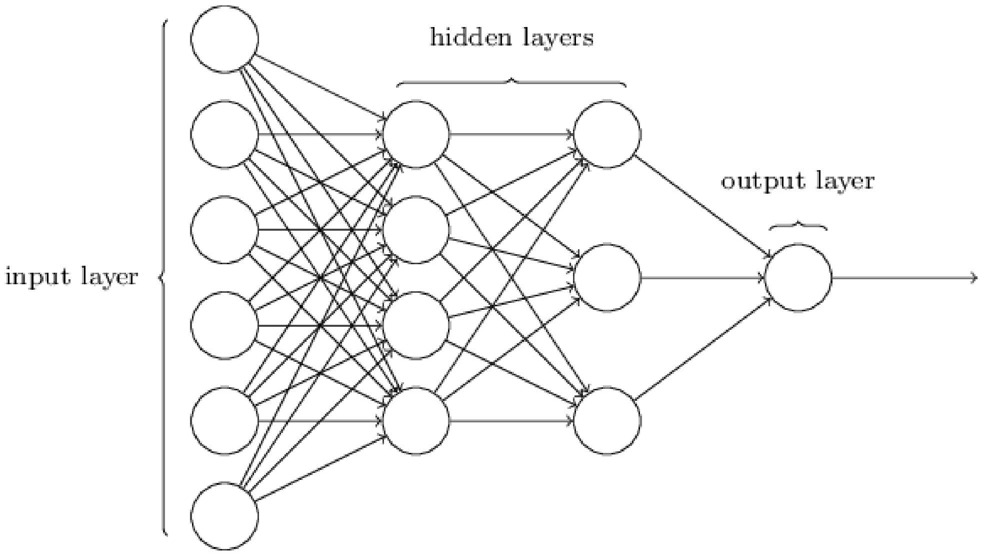


Figure 2.7: Multi-layered Perceptron Model [20]

2.6 Conclusion

The human following robot with visual based sensor is more applicable in the research as it does not require active signal, does not depends on signal that hard to be recovered and does not rigid route path. In the research, it is about to create a cart that follows the wheelchair user with pixy CMUcam5 as the sensor to collect input data. Then, the data is feed into an AI system in Altera DE0 Nano FPGA. The AI system enable the cart to navigate to follow the wheelchair user and maintains a safety distance from the wheelchair with colour detecting, object detecting and position tracking techniques.

CHAPTER 3

METHODOLOGY

3.1 Overview

In this chapter, the steps of developing the AI system for cart follower are explain in detail. The process of developing the NN for the AI cart is shown in the figure 3.1. The process of developing the system on Altera DE0-Nano FPGA required MATLAB tool as an intermediate tool to determine the suit model, the optimum weights and biases to train the NN. Then, the AI system is trained on Altera DE0-Nano FPGA with the spec determined.

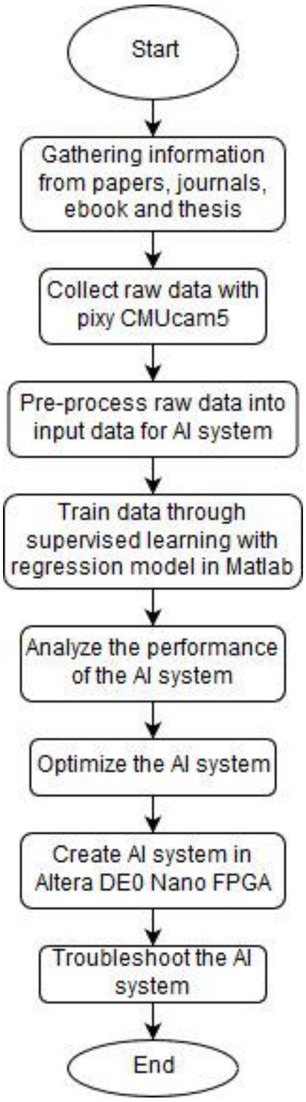

Start
Gathering information from papers, journals, ebook and thesis
Collect raw data with pixy CMUcam5
Pre-process raw data into input data for AI system
Train data through supervised learning with regression model in Matlab
Analyze the performance of the AI system
Optimize the AI system
Create AI system in Altera DE0 Nano FPGA
Troubleshoot the AI system
End

Figure 3.1 Research Flow Chart

3.2 Research Framework

The framework of the project is shown in figure 3.2. The project is separated into 3 stages. The first stage is to get the detect the colour of the image and track the position of the object with pixymon. The colour pattern of the colour board which is placed behind the wheelchair is detected by CMUcam5 through pixymon to allow cart to track the wheelchair position. Then, the data is pre-process to determine the width (w), height (h) and centroid (x,y) of the object through Arduino. The data that collected are the information data of the object. Hence, the designed experiment is carried out to map the object information data to relative positioning data which allow the AI cart to track the wheelchair position through NN. The final data allow the cart to check the perpendicular distance of the object from cart and the angle of the object to the cart. In direct method, the area of the colour board is used to determine the distance between the wheelchair and the cart, whereas in indirect method, the skew angle is needed to estimate the distance [21]. However, in the project, the experiment only covered the direct method. Basically, the centroid is used to determine the angle of the object to the cart in order to navigate the cart to enable it to follow the wheelchair. However, this data is used to compute the additional information data so that the weights and biases generated is more feasible. The additional information data, the lower x coordinate of the object (x1), upper x coordinate of the object (x2), lower y coordinate of the object (y1), upper y coordinate of the object (y2) and area are then generated in MATLAB. In stage 2, 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 Machine learning is about the data-based data analysis and modelling techniques [22]. It can be classified into unsupervised learning with clustering model, supervised learning with classification model and supervised learning with regression model. As the research is dealing with continuous variable and fixed decision output, therefore the regression model is used. The training model evaluate through MSE performance graph to select the best fit model. After the suitable model is selected, the weights and biases are then determined. The structure of the Neural Network is also generated. In stage 3, the NN is then implemented in Altera DE0-Nano FPGA with the structure, weights and biases determined to navigate the cart.

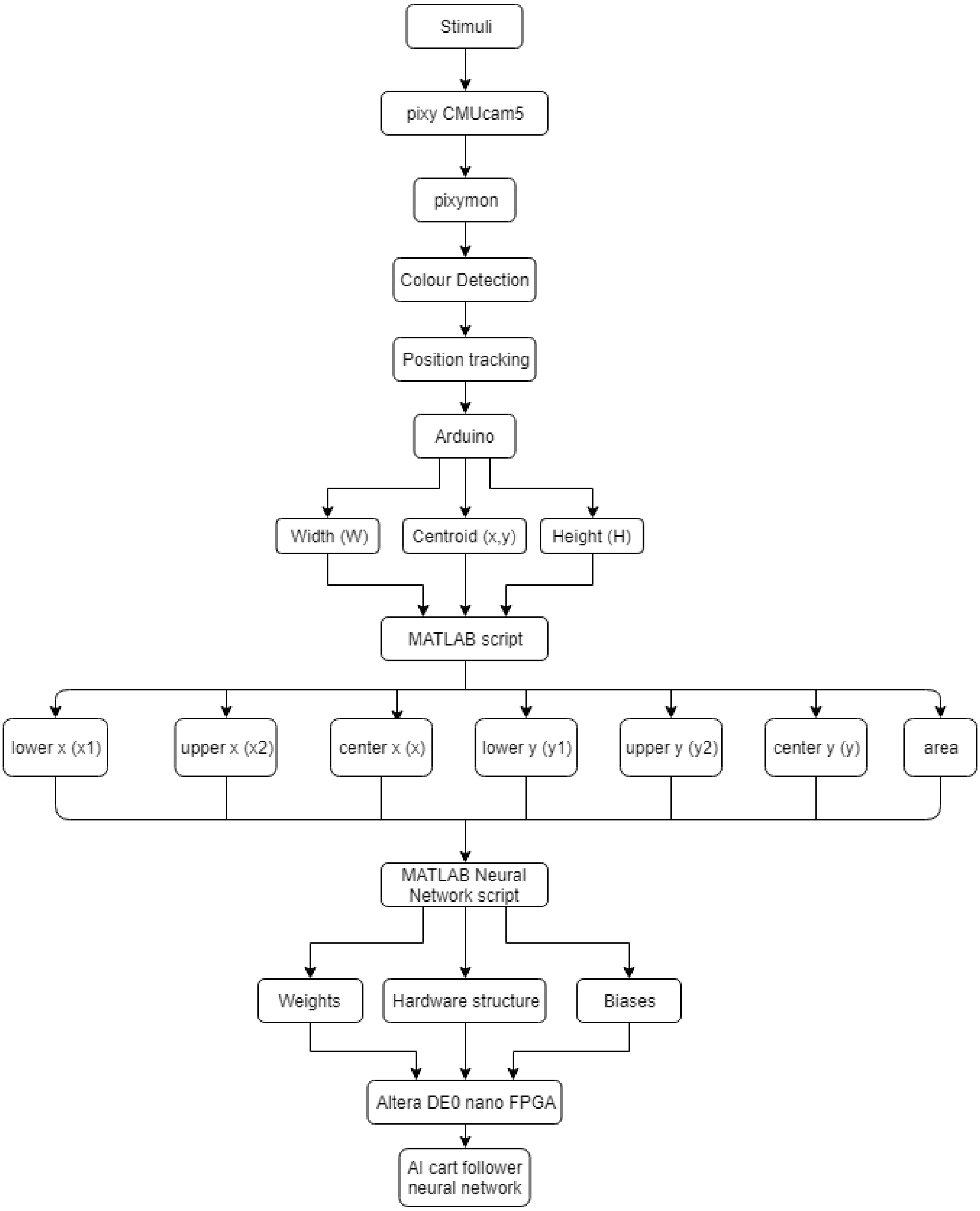


Figure 3.2 Research Framework

3.3 Neural Network in FPGA

Basically, the FPGA required the CMUcam5 to provide the width, height and centroid of the object to be fetched into the NN to determine the relative positioning information which is the distance and the angle. The response of the NN is shown in the figure 3.3.

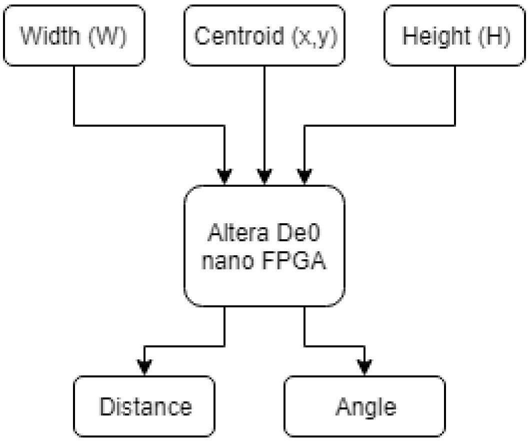


Figure 3.3 NN response in FPGA

3.4 Pixy CMUcam5

CMUcam5 is a small, fast, easy-to-use, low-cost, readily-available vision system which is used in the project. It learns to detect objects after we taught it. It can output what it detects 50 times per second. It able to connect to Arduino with included cable, Raspberry Pi, BeagleBone and other controllers. It supports C/C++ and Python language. It can also communicate via SPI, I2C, UART, USB or analogue/digital output at once. Figure 3.4 shows the pin configuration of the CMUcam5. However, only 5 pins are required to connect the CMUcam5 to Arduino and FPGA to gather the data. The pins that required are Serial Peripheral Interface Master In-Slave Out pin, Master Out-Slave In, Clock, 5V and ground.

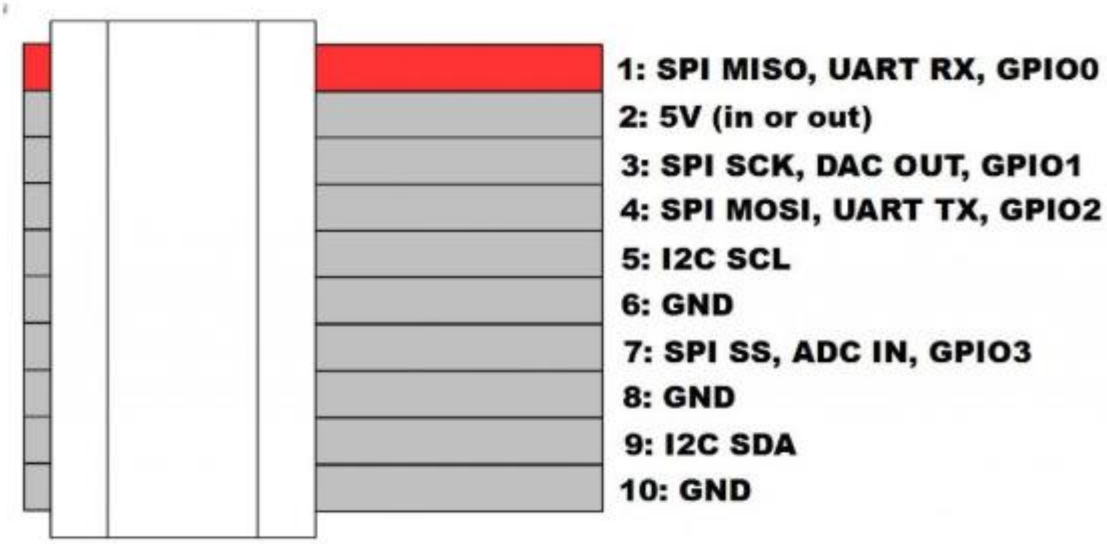
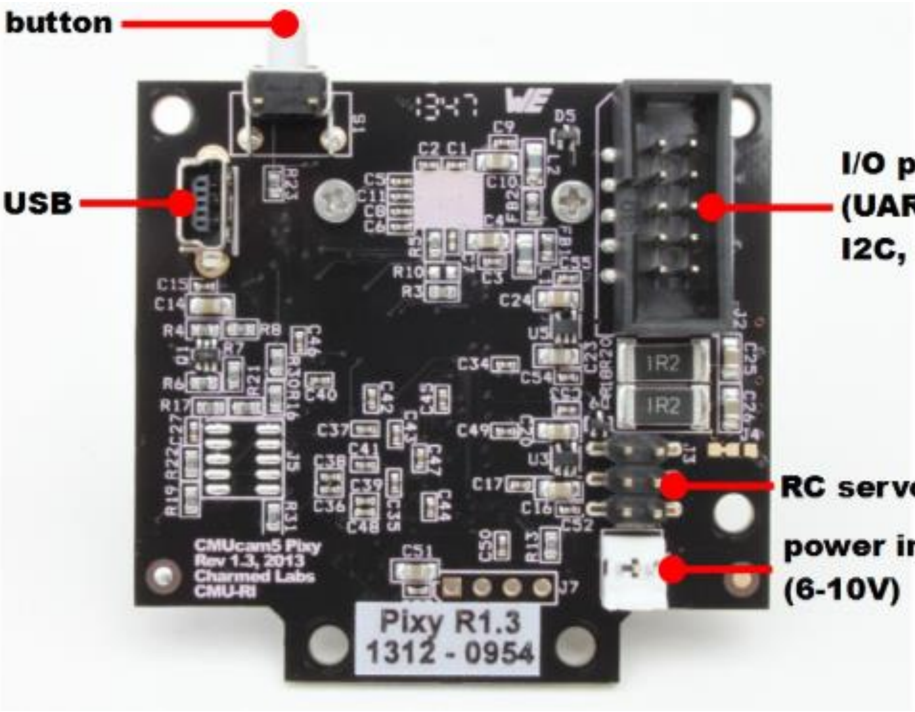
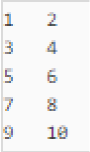

1: SPI MISO, UART RX, GPIO0
2: 5V (in or out)
3: SPI SCK, DAC OUT, GPIO1
4: SPI MOSI, UART TX, GPIO2
5: I2C SCL
6: GND
7: SPI SS, ADC IN, GPIO3
8: GND
9: I2C SDA
10: GND

Figure 3.4 Pin configuration of CMUcam5 [23]





1	2
3	4
5	6
7	8
9	10

Figure 3.4 cont. Pin configuration of CMUcam5 [23]

3.5 Data collection with Arduino

The CMUcam5 is connected to Arduino to collect the centroid, width and height of the object. Figure 3.5 shows the flowchart of Arduino program. The Arduino will initiate the pixymon program to enable the colour pattern to be set as the object. The colour pattern needs to be set separately. For example, if 2 colours are used as the colour pattern in the project, the first colour is set and followed by the second colour to enable the CMUcam5 to determine the object as a single object. Then, the Arduino will get the block data from CMUcam5 which contains the data of centroid, width, height, etc. and display it out. The data are then saved into Excel manually.

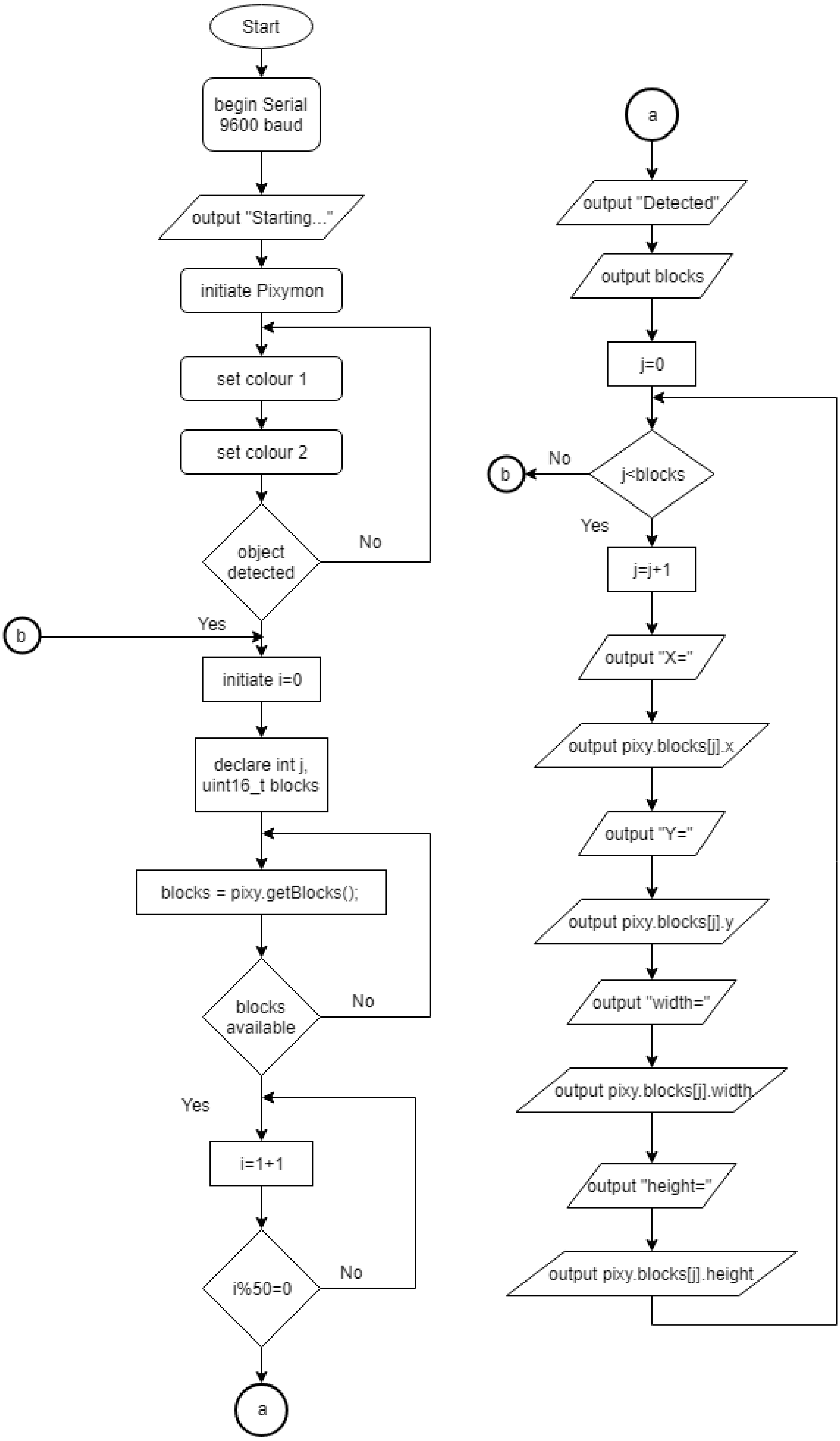


Figure 3.5 Flowchart of Arduino programming for data collection

3.6 Design of experiment

The experiment is designed in to gather the data as shown in figure 3.6. The object colour pattern position will manipulate along the track. However, assumption that the object and the CMUcam5 are at the same level which is 30cm above the ground level is made. The experiment is carried out by manipulating the perpendicular distance between the cart (illustrated by CMUcam5) and the wheelchair (illustrated by colour pattern) shown in the figure from 20cm to 69cm. The step size is 1cm. Another manipulated variable is the angle. For distance between 20cm to 29cm, the angle is manipulated from -15° to 15° with 5° step. For distance between 30cm to 39cm, the angle is manipulated from -20° to 20° with 5° step. For distance between 40cm to 49cm, the angle is manipulated from -25° to 25° with 5° step. For distance between 50cm to 59cm, the angle is manipulated from -30° to 30° with 5° step. For distance between 60cm to 69cm, the angle is manipulated from -30° to 30° with 5° step.

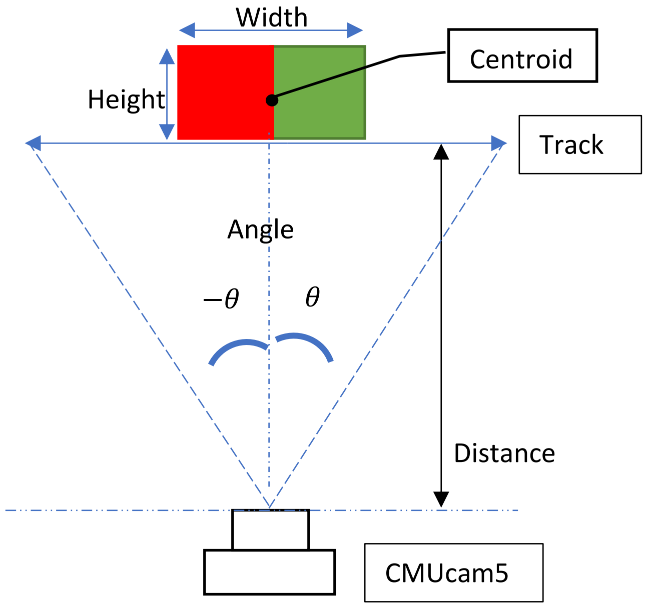


Figure 3.6 Design of experiment

3.7 MATLAB Data Variation

MATLAB is a tool to analyse and design the system and product. It uses the matrix-based MATLAB language to express computational mathematics. Moreover, it can also integrate with other programming languages. It contains built in graphics which make it easy to visualize and gain insights from data [24]. Figure 3.7 shows the flowchart of reading the data into MATLAB workspace and how to generate the secondary input data to create more weightage subjected to the NN training. It also separates the data into predictor array which contain the input data to the NN and output array which contain the output data to the NN.

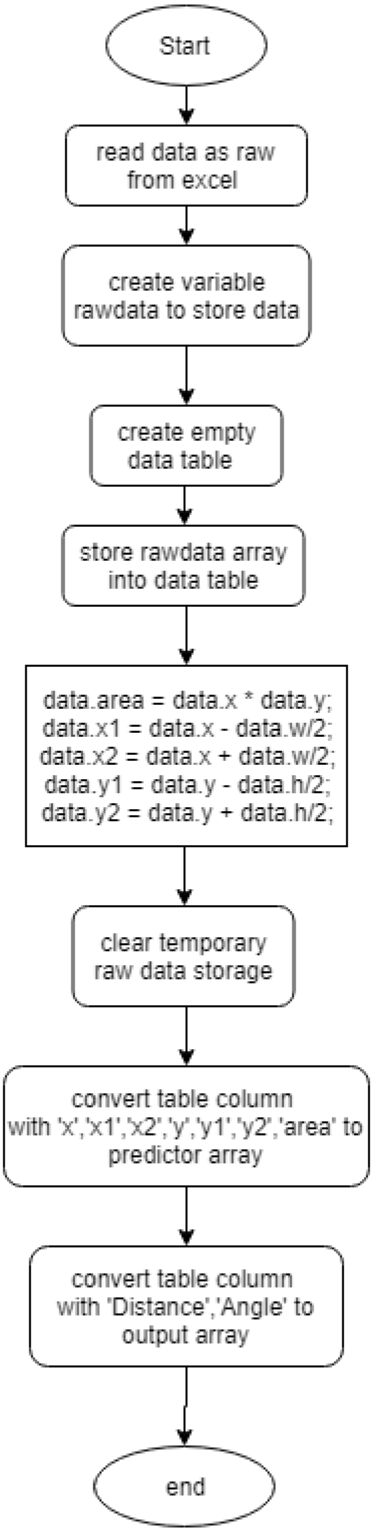

Start
read data as raw from excel
create variable rawdata to store data
create empty data table
store rawdata array into data table
data.area = data.x * data.y;
data.x1 = data.x - data.w/2;
data.x2 = data.x + data.w/2;
data.y1 = data.y - data.h/2;
data.y2 = data.y + data.h/2;
clear temporary raw data storage
convert table column with 'x','x1','x2','y','y1','y2','area' to predictor array
convert table column with 'Distance','Angle' to output array
end

Figure 3.7 MATLAB data variation flowchart

3.8 MATLAB Machine learning training algorithm

MATLAB do supports machine learning including shallow NN learning and deep learning algorithm. Machine learning can be classified into supervised learning and unsupervised learning. Unsupervised learning is to build up a look structure of perspective data set without reference to a response, while supervised learning is to build predictive model map input variable to response. Unsupervised learning uses the clustering model while supervised learning uses the classification model and regression model. Classification model is used to classify the data into a group which can give a specific output, while regression model is used to classify the data into a group which give a continuous output variable. Regression training model in NN that commonly used in MATLAB are Batch Gradient Descent, Batch Gradient Descent with momentum, Gradient Descent with Variable Learning Rate, Resilient Backpropagation, Fletcher-Reeves Update, Polak-Ribiére Update, Powell-Beale Restart, Scaled Conjugate Gradient, BFGS algorithm, One Step Secant algorithm, Levenberg-Marquardt algorithm. Regression can be assumed as putting the data into a form that fits function expectation.

3.8.1 Training model

Network is ready to be trained when the network weights and biases have been initialized. During the training process, the weights and biases are updated until an optimum weights and biases are obtained. One of the common method used to perform the update is called the backpropagation. It used the cost function to determine the error of the output and the predicted output and from that it determined the way to update the weights and biases itself. Neural Network can be trained for the function approximation, pattern association or pattern classification with network inputs and target outputs. The training process are iteratively adjusted to minimize the network performance with MSE as performance function by default in MATLAB. The gradient of the performance function is used to determine how to adjust weights to minimize performance. The gradient is determined through backpropagation which involves performing computation backward through network. A simple neural network system can be represented by $Y = W.X$ where Y is the output computed from calculating the scalar dot product of vector W with a given sample vector X. If the training is converged and the weights is stabilised, the neural network will perform the task correctly.

3.8.2 Steepest descent algorithm

The gradient descent algorithm can be implemented through incremental mode and batch mode. The gradient is compute and the weights are updated after each input is applied to the network in Increment mode. The gradient is compute and the weights are updated after the entire training set is applied to the network in Batch mode. This backpropagation technique uses the formula as shown in equation 3.1 to determine the following updated weight and bias

$$x_{k+1} = x_k - a_k g_k \qquad (3.1)$$

where $\mathrm{x_k, x_{k+1}} = \text{vector of current weights \& biases}, \mathrm{a_k} = \text{learning rate}$

$and\ \mathrm{g_k} = \text{steepest gradient}$

3.8.2.1 Batch Gradient Descent (traingd)

This is the backpropagation training in MATLAB. The weights and biases are updated in the direction of negative gradient of the performance function. There are 7 training parameters associated with Batch Gradient Descent, that is epochs, show, goal, time, min_grad, max_fail and lr [25]. Epochs is the parameter which set the number of