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VISUAL BASED CART FOLLOWER USING ARTIFICIAL NEURAL NETWORK

MOHAMAD FAIZ BIN AHMAD JOHARI

UNIVERSITI SAINS MALAYSIA

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VISUAL BASED CART FOLLOWER USING ARTIFICIAL NEURAL NETWORK

by

MOHAMAD FAIZ BIN AHMAD JOHARI

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF SYMBOLS

μ	Micro
Φ	Phi
σ	Standard deviation
$\sum$	Summation
θ	Theta
σ^2	Variance

LIST OF ABBREVIATIONS

ACK	Acknowledge
AC	Alternating Current
ADC	Analog Digital Converter
AN	Analog Input
A/D	Analog/Digital
ALU	Arithmetic Logic Unit
AI	Artificial Intelligent
ANN	Artificial Neural Network
AGV	Automated Guided Vehicle
BW	Bandwidth
CPU	Central Processing Unit
CW	Clock Wise
CCW	Counter Clock Wise
DC	Direct Current
EXT	External
FOV	Field of View
FPGA	Field-Programmable Gate Array
FPS	Frame Per Second
GPS	Global Positioning System
GUI	Graphic User Interface
GND	Ground
HPS	Hard Processor System
HIS	Hue Saturation Intensity
HSV	Hue Saturation Value
IR	Infrared
I/O	Input/Output
IDE	Integrated Development Environment
INT	Internal
LED	Light Emitting Diode
LR	Learning Rate
MSE	Mean Square Error

MLP	Multilayer Perceptron
PTZ	Pan Tilt Zoom
PC	Personal Computer
VCC	Positive Power Supply
VDD	Positive Supply for Logic and I/O pins
PD	Proportional Derivative
PI	Proportional Integral
PID	Proportional Integral Derivative
PWM	Pulse Width Modulation
RF	Radio Frequency
RFID	Radio Frequency Identification
RAM	Random Access Memory
ROM	Read Only Memory
RX	Receive
RGB	Red Green Blue
RMSE	Root Mean Square Error
TX	Transmit
USB	Universal Serial Bus
VIN	Voltage Input
VOUT	Voltage Output

PEDATI PENGIKUT BERASASKAN VISUAL MENGGUNAKAN RANGKAIAN NEURAL BUATAN

ABSTRAK

Pengecaman berasaskan penglihatan bagi pedati pengikut boleh memberi manfaat sebagai robot penolong. Ia mempunyai keupayaan untuk mengesan dan mengikuti pengguna kerusi roda tanpa mempunyai sebarang sambungan fizikal di antara mereka. Di samping itu, keamatan cahaya yang kurang baik juga boleh menjejaskan prestasi penjejakan. Pedati pengikut yang dilengkapi dengan semua komponen pengesan telah dibuat. Sistem ini juga digabungkan dengan Rangkaian Neural Buatan (ANN) untuk navigasi visual yang lebih baik. Kaedah penjejakan warna digunakan untuk aplikasi tugas mengikut dengan kamera Pixy CMUcam5. Kamera mengumpul maklumat lebar, ketinggian, luas, sudut, koordinat x dan y pada papan corak warna yang terletak di belakang kerusi roda dan menterjemahkan maklumat ini ke maklumat kedudukan relatif yang membolehkan kereta itu mengikuti kerusi roda. Fungsi pengaktifan yang digunakan adalah linear tepu (satlin). Bidang Pandangan (FOV) Pixy CMUcam5 adalah dari 69.98^{o} hingga 76.83^{o} dengan jarak menegak 20cm hingga 150cm. Saiz warna sasaran optimum untuk jarak maksimum 150cm adalah 98.07 cm^{2}. Jarak dari pandangan atas menunjukkan bahawa ralat jarak minimum dan maksimum ialah 0.40cm dan 2.30cm manakala ralat sudut maksimum dan minimum ialah 5.30^{o} dan 21.30^{o} dari titik P0 hingga P1, P2 dan P3 masing-masing. Keadaan pengesanan yang paling unggul adalah pada 205 Lux kerana kadar ralat bagi setiap nilai R, G dan B adalah yang terendah. Ujian simulasi ralat akhir menunjukkan bahawa terdapat 0.65% dan 4.27% ralat dalam jarak minimum 20cm dan sudut -15^{o} sementara 1.93% dan 5.57% ralat dalam jarak maksimum 69cm dan sudut 30^{o}. Ujian prestasi

keseluruhan menunjukkan ralat pada jarak ialah 1.62% manakala 5.39 pada sudut. Kesimpulannya, sistem pengesan untuk pedati pengikut telah dibuat dan penyepaduan ANN telah mencapai ketepatan yang pantas dengan ujian simulasi ralat terakhir.

VISUAL BASED CART FOLLOWER BY USING ARTIFICIAL NEURAL NETWORK

ABSTRACT

A visual based cart follower can benefit as a helper robot. It can track and follow a wheelchair user without having any physical attachment between them. In addition, the low intensity of the surrounding light can affect the tracking performance too. In this study, the cart follower that equipped with all tracking component has been developed. The system was also integrated with Artificial Neural Network (ANN) for good visual navigation. A colour tracking method being used for following task application with Pixy CMUcam5 camera. It gathered the information of the width, height, area, 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. The activation function being used is saturating linear (satlin). The Field of View (FOV) of Pixy CMUcam5 is from 69.98^{o} to 76.83^{o} with vertical distance of 20cm to 150cm. The optimum target colour size for maximum distance 150cm is 98.07cm^{2}. The distance from the top view shows that the minimum and maximum distance error is 0.40cm and 2.30cm while the maximum and minimum angle error is 5.30^{o} and 21.30^{o} from point P0 to P1, P2 and P3 respectively. The most ideal tracking condition is at 205 Lux since the error rate for each R, G and B value is the lowest. The final error simulation test shows that there is 0.65% and 4.27% of error in minimum distance 20cm and -15^{o} angle while 1.93% and 5.57% of error in maximum distance 69cm and 30^{o} angle. The overall test performance shows that the error occurred in distance is 1.62% meanwhile 5.39% in angle. As a

conclusion, the tracking system for cart follower has been developed and integration of ANN has achieved its deserved accuracy with the final error test.

CHAPTER 1

INTRODUCTION

1.1 Overview

In the development world now, the growth of autonomous mobile following robot increases rapidly in various field and industries. The mobility concept which is versatility of the mobile robots being applied in an environment which can contribute for multi-purpose usage. The transition of mobile robot technologies kept on evolving from the first generation only for single usage to various civil usage such as in modern offices, airport, hospital and factories. The innovation of the automated robot following technology begins with a manual remote control of a machine which helps in factories and industries. Now with the advancing technology, there is no limit in the futuristic technologies where everything goes automatic. Today's trend evolves to small mobile robots equipped with microcontroller which controls numerous sensors and actuators. The robot platform itself can be controlled via wireless connection without having any physical contact which can save space and ease to carry everywhere (Bräunl, 2008).

Mobile robot needs a good vision like human vision perception as it influences the movement efficiency of the robot. Thus, an established navigation system is required. The relationship between mechanical and electronics are also needed not just a stable software logic solution (Chen *et al*. 2011). An ideal navigation system that comes from combination of vision camera and several sensors is also one of the mobile robot requirement. A stable connection between software and hardware is needed to perform following tasks (Chen *et al*. 2013).

Visual tracking widely being used in robotic field that required the localization of target tracking like machine learning and robot navigation. It performed the tracking

task based on edges, colour or feature templates detection with several limited condition (Taylor, 2008; Xu *et al*. 2013; Wu *et al*. 2014; Hertenstein *et al*. 2015; Ismael *et al*. 2016; Rahmani *et al.* 2017).

Artificial Intelligence (AI) is an ability to learn and understand before making decisions to solve problems. The intention of AI is to duplicate intelligence from human beings to machines. There are various types of AI which is Artificial Neural Network (ANN), Genetic Algorithms (GA), Fuzzy and Hybrid systems. ANN is a computational model that consists of a complex interconnection of the neurons in human brain and ANN is useful for data prediction, pattern recognition and classification (Negnevitsky, 2011). Most of the Personal Computer (PC) based simulation model came from ANN implementation (Artrith *et al*. 2016; Kaur *et al*. 2016). It can be said quite slow compared to hardware implementation type of ANN (Ramanaiah *et al*. 2014). Therefore, a research on hardware implementation of ANN model should be increased to multiply the portable ANN application product.

ANN technically is a learning and decision making process of a machine. It consists of data analysis, data collection and decision making with different method in every stage (Pascual *et al*. 2017). ANN is useful to command the actual actions of a mobile robot which allow it to navigate through surroundings. The ANN production can be determined as a search engine to obtain the correct sequence of rule as control technique with sufficient information to construct database that meet the final output of a product (Nilsson, 2014). Machine learning is a group of techniques that can automatically detect the data pattern and predict the future output or performing decision making tasks (Murphy, 2012).

A Wheelchair user needs free movement while moving around. Any attachment to the wheelchair in the form of luggage will reduce the performance in

navigating the wheelchair. Thus, a visual based cart follower with a good navigation system is useful to overcome this situation (Sani *et al*. 2012). The current existing method to solve the cart navigation system has been proposed by Xu *et al*. (2013). They came up with target tracking control of a mobile robot with a low cost CMUcam3 tracking camera.

1.2 Problem statement

A cart follower losses the tracking sight when the wheelchair makes a hard turn because the camera has a limitation where it is unable to track colour pattern at certain angle. In addition, low intensity of surrounding light affects tracking performance. Thus, a tracking loss can occur. Existing cart followers are not robust due to its inability to provide important information about the colour pattern to be determined and cannot predict the output from the unseen data. A system that can enable navigation of cart follower that is able to predict the output for unseen data is needed.

1.3 Research objective

The purpose of this study is to develop a tracking system of cart follower. The details are listed as follows:

- To identify suitable environment of data acquisition using camera.
- To apply data from first objective to ANN for navigation system.

A cart follower equipped with vision based sensor than can fulfil the following task need to develop. A suitable environment with ideal light intensity need to identify

with RGB extraction method from colour pattern. The obtained data was applied to ANN for a navigation system.

1.4 Scope of research

The scope of the research covered studies of embedded system for cart follower that is applicable for wheelchair user. It covers the study of vision sensor and ANN application.

- Tracking system includes object tracking and cart turning directions. It covers the usage of PixyMon software in determining the colour pattern through Pixy CMUcam5.
- The obtained preprocessing data has been applied to ANN for cart navigation system. Arduino MEGA ADK used for raw data collection and MATLAB in analyzing the performance of ANN for navigate the cart. MLP type of ANN is used as a default in MATLAB.

1.5 Thesis organization

This thesis is classified into five chapters. They are introduction, literature review, methodology, result discussion and conclusion. The short explanation for each of the chapters has been summarised into this section.

Chapter one described about the overview of the research being conducted based on the summary of the developed cart tracking system integrated with ANN for a better performance. The problem statement, main objective to achieve from the research and scope of the research also concluded in this chapter.

Chapter two presents the previous invention by the other researches that is related with this research in view of concept and method being used for various mobile robot following system. The literature of tracking technique and ANN learning

algorithm also being described. The best method being selected to handle this research is also stated in this chapter.

Chapter three discussed about methodology, which presents the design platform, development of tracking system and integration of the system with ANN. The description of hardware and software being used are well explained. The approach for overall research and experimental setup also being described in this chapter.

Chapter four come out with the results and discussions of the cart with visual sensors respond to find out the best tracking performance of the cart follower when integrated with ANN. All the data taken throughout whole project being plotted and tabulated in term of graph and table. The analysation of the data also being discussed in this chapter.

Chapter five give a conclusion toward all approaches and feedback about the research. Future work to improve the ability and efficiency of the cart tracking system in upcoming research also described in this chapter.