UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Robust Automated Guided Vehicle (AGV) Controller Design Method For Uneven Terrains Application

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

by

ADI KHAIRI BIN ABDUL LATIF

B071210551

870330566189

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: Robust Automated Guided Vehicle (AGV) Controller Design Method For Uneven Terrain Application

SESI PENGAJIAN: **2014/2015 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (JTKM) (Hons.). The member of the supervisory is as follow:

………………………………

(Project Supervisor)

ABSTRAK

Kenderaan berpandu automatik (AGV) tidak boleh melakukan dengan baik di tanah yang tidak rata kerana banyak AGV mempunyai pengawal yang ditetapkan untuk sistem linear. Dalam dunia sebenar sistem berada dalam keadaan bukan linear. Dari ini, terdapat satu persamaan yang boleh membantu untuk mengira masalah ini dengan mereka bentuk pengawal AGV berdasarkan Kestabilan Lyapunov Analisis untuk membina fungsi kawalan Lyapunov (CLF). Kaedah reka bentuk Servoing Visual telah dicadangkan untuk AGV dengan dua roda digerakkan. Dalam pendekatan Servoing Visual, pengawal berasaskan imej telah direka dengan menggunakan CLF. Pengawal mengawal dan mengurangkan beberapa data yang tidak diperlukan oleh pengawal yang tidak memberi manfaat, dan sistem yang mempunyai stabiliti minima supaya dapat membuktikan kejituaan dengan berdasarkan ketidaktentuan input. Keteguhan AGV adalah isu yang amat penting dalam permukaan yang tidak rata. Eksperimen telah dijalankan ke atas kawalan berasaskan Imej untuk mengkaji keupayaan dan ketepatan pengawal CLF. Analisis CLF telah dibuat untuk membuktikan ketepatan dan keteguhan pengawal dengan membandingkan dua eksperimen yang telah dibuat di permukaan rata dan permukaan halangan (luar). Keputusan menunjukkan bahawa data pengawal berasaskan imej lebih stabil dan tepat di atas permukaan rata dan bukannya pada permukaan halangan.

ABSTRACT

Automated Guided Vehicle (AGV) can't perform well in uneven terrain because many AGV have controller that are set for linear system. In the real world the system is in non-linear. From this, there is an equation than can help to calculate for this problem by designing an AGV controller based on Lyapunov Stability Analysis to construct a Control Lyapunov Function (CLF). A design method of Visual Servoing was proposed for AGV with two actuated wheel. In the Visual Servoing approach, an image based controller was designed by using CLF. The controller control and minimizes some significant unimportant cost on the controller which was not given in any advance, and the system with a minimum stability which hopefully proving robustness with respect to input uncertainties. The robustness of AGV is very important issue for uneven terrain applications. Experiments was conducted on Image-based control to examine the ability and accuracy of CLF controller. Analysis on CLF were made to prove accuracy and the robustness of the controller by comparing the two experiment that were made on flat surface and obstacle surface (outdoor). The results shows that the image based controller data more stable and accurate on flat surface rather than on obstacle surface.

DEDICATION

Dedicated to my father, Abdul Latif bin Taha and my mother, Saripah binti L Mahamud. To my supervisor, Mr. Muhammad Zaidan bin Abdul Manaf, co-supervisor, Mr. Mohd Suffian bin Ab Razak, lecturers and friends for all of their help and friendship.

ACKNOWLEDGEMENT

Assalamualaikum w.b.t, first of all, I would like to take this opportunity to thanks to God's blessing for giving me a chance to finish my report for Projek Sarjana Muda (PSM). First and foremost, I would like to express my heartily gratitude to my supervisor, Mr. Muhammad Zaidan bin Abdul Manaf and my co-supervisor, Mr. Mohd Suffian bin Ab Razak for the guidance, enthusiasm and also motivation given throughout the progress of this project. My appreciation also goes to my family who has been so tolerant and supports me all these years. Thank you for the encouragement, love and supports that they had given to me. I will never forget about this. Nevertheless my great appreciation dedicated to my best friend Syairah binti Salleh and BETA member's batch 2012 who had given me the valuable supports. Finally, I want to appreciate to a person that involved directly or indirectly that helped me and much forgiveness on my mistakes during my period for finishing my PSM. Good things come from ALLAH SWT and bad things come from my own self.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AGV	-	Automated Guided Vehicle
CLF	-	Control Lyapunov Function
IMU	-	Inertial Measurement Unit
LTI	-	Linear Time Invariant
PID	-	Proportional Integral Derivative
MV	-	Manipulated Variable
FL	-	Fuzzy Logic
DFM	-	Describing Function Method
SIDF	-	Sine Input Describing Function
MIMO	-	Multiple Input Multiple Output
SPR	-	Strictly Positive Real
LPDF	-	Locally Positive Definite Function
PDF	-	Positive Definite Function
DF	-	Decrescent Function
VS	-	Visual Servoing
t	-	Time
v	-	Velocity
K	-	Gain
α	-	Alpha
β	-	Beta
ϵ	-	Epsilon variant
$\in$	-	Element of
ψ	-	Non-linearity
ω	-	Omega
$\approx$	-	Almost equal to
$\forall$	-	For all
∞	-	Infinity

CHAPTER 1

INTRODUCTION

1.1 Background of study

Automated Guided Vehicles (AGV) growth productivity and condense costs via assisting towards mechanise a manufacturing facility. AGV is Computer-controlled wheel-based cargo transporters that travel alongside the floor of a facility without a worker. They are typically battery powered. Their movement is engaged via arrangement of software and sensor-constructed control systems. Computer-based software uses wireless networks to gather information about each element's present, formerly edges using software intended for end point and map-reading logic. The first inventor of Automated Guided Vehicle (AGV) are Barrett Electronics in 1953.

Figure 1.1 : First AGV invented
(http://www.egeminusa.com/pages/agv_education/education_agv_history.html)

AGV pull substances behind them in trolley or trailers for which they can independently attach or can be mounted onto as unit load type. Trailers container exist used to transport resources or complete product. AGV been hired in approximately all industry, generally manufacturing. Conveying resources such as wood, steel, medicine, linen or food. Throughout the years, AGV has become more urbane as it is programmed to interconnect with additional machines to guarantee the merchandise are been moved smoothly from end to end production line and the warehouse for storage or sent directly to shipping areas. There are many types of AGV navigation as well be discussed in this chapter.

1.1.1 Wired AGV

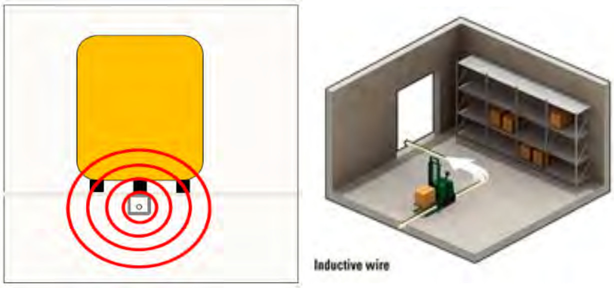

Figure 1.2 : Wired (http://www.transbotics.com/learning-center/guidance-navigation/)

Wire are to be found about 1 inch beneath the surface right in middle of the slot. AGV is to follow the slot stands alongside the line. The cable is used to transfer a wireless signal. A device is mounted beneath of the AGV close to the ground. The device detects the qualified location of the wireless signal being transferred from the cable and collected data is being process.

1.1.2 Guide tape AGV

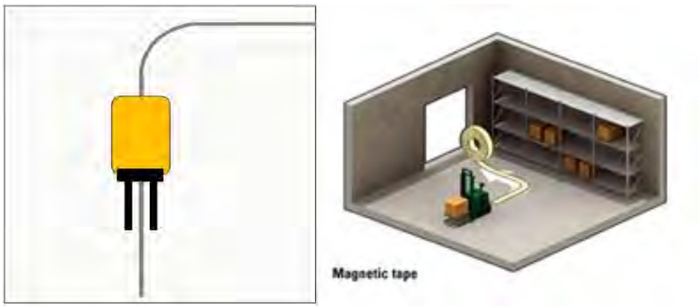

Figure 1.3 : Guide Tape (http://www.transbotics.com/learning-center/guidance-navigation/)

Some Automated Guided Vehicle (AGV) use duct tape for the direction. The duct tape can be magnetic or coloured. The Automated Guided Vehicle (AGV) is built-in with the suitable controller sensor to monitor the path of the duct tape. Main benefit of sticky tape over wired direction is that it can be simply detached and moved if the path changes. Coloured duct tape is primarily fewer expensive, but if the area of duct tape is always got moving the tape may become ruined or dirty. A flexible magnetic bar can also be implanted in the ground like wire but workings the same as magnetic tape. An additional benefit of magnetic conductor duct tape is the double polarity. Minor fragments of magnetic duct tape may be positioned to alteration conditions of the AGV based on polarization and arrangement.

1.1.3 Laser target navigation AGV

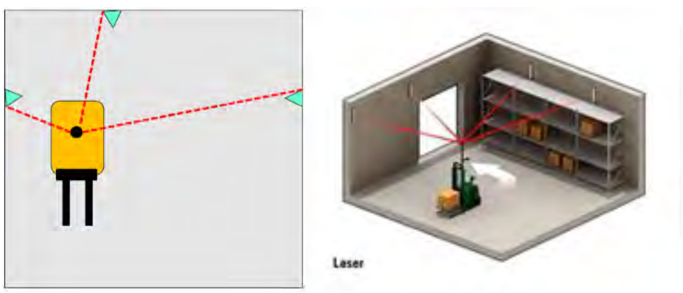

Figure 1.4 : Laser target navigation (http://www.transbotics.com/learning-center/guidance-navigation/)

The course plotting is completed by mounting tape on dividers, rods or machine. The AGV transmits a laser transmitter on a turning turret. The laser is transferred and received by the similar sensor. The angle and distance to any indicators that in reach are repeatedly calculated. This data is matched to the plot of the indicator plan kept in the AGV's memory. This lets the direction-finding system to triangulate the present location of the AGV. The present location is matched to the automated route in to the mirror design map. The navigation is attuned therefore to keep the AGV on track. It can then pilot to a wanted mark using the continuously renew position.

- Modulated lasers provides more noteworthy reach and precision over beat laser frameworks. By producing a non-stop modified laser, it can attain an uninterrupted image as soon as the scanner reaches line of range by a reflector.
- Pulsed lasers produces beat laser light at a rate of 14,400 Hz which gives a most extreme conceivable determination of ~ 3.5 mrad (0.2°) at 8 scanner cycles for each second. Towards attain a practical navigation, the evaluations must be exclaimed based on the concentration of the mirrored laser light, to recognize the core of the reflector.

1.1.4 Inertial (Gyroscopic) AGV

Figure 1.5 : Inertial (Gyroscopic) (http://www.mhi.org/agvs)

Inertial navigation means a CPU controller system leads and allocates errands to the vehicles and transponders are implanted in the floor are magnets. The AGV customs transponders to confirm that vehicle is going on course. Position points are sensed by a sensor on the vehicle as it move over the position point. Gyroscope on the vehicle measures vehicle's and wheel encoder on the vehicle analyses the range travelled. Vehicle uses response from all manoeuvres to define location. Gyroscope is capable to sense the least alteration in the route of the vehicle and modifies it in order to retain the AGV on its route.

1.1.5 Vision guidance AGV

Figure 1.6 : Vision guidance (http://www.mhi.org/agvs)

Vision-Guided AGV mounted with no changes to the environment. It's run via cameras to record geographies alongside the path, letting the AGV to repeat course by using the recorded geographies to steer. A conventional type of vision guided AGV is using processed image of colour marker as features on floor to navigate. This system can be implemented using sensor and open source microcontrollers which are generally cheap and easier to program.

1.1.6 Natural features (natural targeting) AGV

Figure 1.7 : Natural features (natural targeting) (http://www.mhi.org/agvs)

Steering deprived of retrofitting of the working area is called Natural Features. The technique practices individual and additional range sensors. By Markov/Monte- Carlo localization methods to realize where it is as it vigorously strategize the direct pathway to destination. The benefit is that they are extremely flexible for on-time distribution at all places. It's manage miscarriage deprived of shut down the whole engineering operation, since AGVs be able to design pathways everywhere the miscarried device. Fast to mount in a smaller amount of time for the factory.

1.1.7 Geo guidance AGV

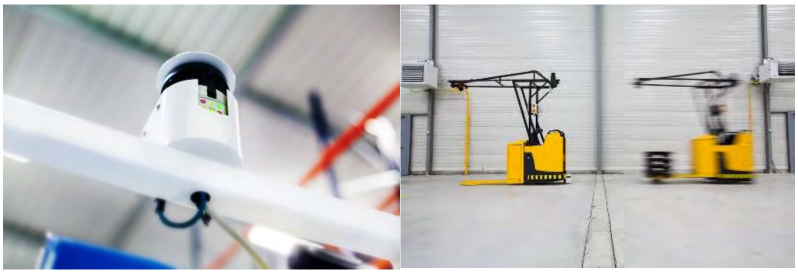

Figure 1.8 : Geo guidance (http://www.balyo.com/en/Solution/Geoguidance)

A geo guided AGV identifies its situation to begin its way. The forklift armed with geo guidance senses and classifies racks, brackets and barriers within production line in the factory. It is same as the natural targeting AGV but the algorithm is more complex because it can detects the contour of structure from map. By these static references, place itself in actual period and decide its pathway. It is limitless on spaces in drop-off and pick-up places and paths substantially can change.

1.2 Problem Statement

AGV are more efficient, consistent and productive than human operator but AGV are facing problem in maneuvering on slippery surface and cannot perform really well on uneven terrain or broken floors. This is due to AGV controller design that were using linear system, where in the real world the system is in non-linear (Hedrick & Girard, 2005). The problem faced by most AGV application in the industry are;

1. AGV design is sometime bigger and heavier than the product it is carry, which is not good in the term of energy efficiency and its moving speed.
2. Some AGV cannot perform well on rough terrain condition such as uneven terrain, slippery or broken floors.
3. Some AGV can only perform in controlled, indoor position while there are situation of using AGV at outdoor for transportation between plant.

Therefore, a robust controller should be designed and meet this requirement. An experiment was conducted using CLF controller on a mobile robot and good result was achieved (Hiramatsu, Fukao, Kurashiki, & Osuka, 2009). So, in this project, an experiment using CLF controller will be conducted on AGV and the robustness of their design will be evaluated. Microcontroller will be programmed with CLF that process the input data that from internal and external sensors and component such as camera, IMU, ultrasonic sensor and other components in order the AGV to perform. Assuming that a line (marker) can be detected on the floor through image processing method, the CLF controller will be applied to two visual servoing approach, image-based and position-based control. Experiment will be conducted and the robustness will be evaluated.

1.3 Objective

1) To fabricate AGV body based on design given.
2) To design AGV controller for uneven terrain application.
3) To conduct experiment using the image based CLF controller.

1.4 Scope

Overall scope of this project are stated as below:

1) AGV design using Space Claim (CAD software).
2) AGV body fabrication using pipe joint system.
3) Camera and other components functions programming and calibration.
4) CLF controller implementation in AGV.
5) Experiment will be done on flat and obstacle surface, location area within the Kampus Teknologi, UTeM.
6) Gathering the experimental data of CLF controller with suitable gain parameter.

1.5 Structure of project

Chapter 1 will be the Introduction of Automated Guided Vehicle (AGV), the ongoing research to explain more deeply the meaning of AGV system and fragments found in AGV system. This chapter also states the problems of the AGV system and project objective that are clearly stated in this chapter to gain data the data from experiment at the end of the research. Other than that, project scope are described in detail in order to help the research on going in limited time.

Chapter 2 will describe about background or literature review that are related to the AGV. It contains the journal of control theory, different kind of controller, method that are been use in analyzing non-linear system and a detailed description of CLF controller based on Lyapunov stabilization analysis.

Then chapter 3 will explain more about the methodology design of the AGV by showing the flow chart process and describe it in detail. The method flow from CAE generated conceptual design of AGV structure, CAD design of AGV, procedure of bodywork AGV fabrication, procedure of components and fabrication as well as programming CLF controller and experiment to be conducted.

Result and discussion of experiment findings are described in chapter 4. Discussion about the result analysis that are collected from the experiment are plotted in graph. The data that are collected during experiment need to be discussed and evaluated whether the objectives are achieved.

The last chapter that is chapter 5 describe the conclusion from this research project. From this conclusion, there will be some suggestions will be made that are important for further studies development on Robustness AGV for uneven terrain or outdoor application.