DESIGN AND DEVELOPMENT OF AUTONOMOUS GUIDED VEHICLE (AGV)

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ABSTRACT

The technologies running fast we ever imagined before. The implementation of computer chip can be seen anywhere in every parts of this world. Humans are looking for automatic system that will make their life easier. This paper describes a project of design and development of autonomous guided vehicle (AGV). An AGV is a vehicle that uses no operator to drive that often used in material transportation in an automated production line or in automatic storage and retrieval system. This AGV running through the electronic programmed to drive the material or parts product to the specific destination. Sometimes this vehicle programmed to move to follow the line on the floor. This project required the student to build a prototype of an AGV in smaller scale but have the basic function as the real AGV where this prototype of AGV are able to move to the specific workstations and waiting for the task to accomplished. This project requested to complete the process of technical study, design, analysis, parts machining, assembly as well as testing and refinement of an AGV in the two-semester course. The four-wheeled AGV is driven by a stepper motor, move and steered by a different rotation of the motor. This AGV controlled by PIC microcontroller and ULN2803AG integrated circuit. Through this project, students are able to learn how to innovate the technological product through the small scopes of project.

ABSTRAK

Teknologi hari ini bergerak sangat pantas tanpa kita sedari. Penggunaan cip komputer boleh dilihat di mana-mana sahaja di setiap pelosok dunia. Manusia mencari sistem automatik yang boleh memudahkan kehidupan mereka. Thesis ini menerangkan projek mereka dan membangunkan kenderaan pacuan automatic (AGV). Kenderaan ini bergerak tanpa pemandu yang kerap digunakan untuk pangangkutan bahan dalam baris pengeluaran automatik atau dalam bahagian peyimpanan dan pengagihan barang-barang. AGV ini akan bergerak mengikut program elektronik untuk membawa barang-barang kepada destinasi yang spesifik. Kadangkala kenderaan ini telah diprogramkan untuk bergerak mengikut garis panduan yang dilukis pada lantai. Projek ini mengkehendaki pelajar untuk membina prototaip AGV yang boleh bergerek ke hentian kerja and menunggu sehingga selesai kerja. Projek ini meminta pelajar untuk menyelesaikan kajian teknikal, mereka, analisis, proses pembuatan juga pemasangan termasuk pencubaan dan penambahbaikan dalam dua semester ini. Kenderaan automatik empat roda ini di jana oleh motor stepper yang mana belokan ke kiri dan ke kanan dikawal dengan perbezaan putaran rodanya. AGV ini dikawal dengan mikro kawalan PIC dan litar sepadu ULN2803AG. Melalui projek ini, pelajar dapat mempelajari bagaimana untuk menginovasikan produk teknikal melalui projek yang kecil skopnya.

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cm	-	centimeter
DC	-	direct current
PM	-	permanent magnet
PWM	-	Pulse Width Modulation
'+'	-	positive current flow
'-'	-	negative current flow
V	-	Voltage
CAD	-	Computer Aided Drawing
CAM	-	Computer Aided Manufacturing
mm	-	millimeter
h	-	hour
min	-	minute
s	-	second
%	-	percentage
X	-	vertical axis
Y	-	horizontal axis
x	-	multiple
/	-	divide
kg	-	kilogram
RM	-	Ringgit Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Prologue

The creations of a truly autonomous and intelligent system - one that can sense and interact with its environment, one that can integrate much more into lives of human from day to day - has ever been the motivating factor behind the work on artificial intelligent, control theory and robotics, autonomous vehicle.(Shuzhi Sam Ge, 2006) The technology involve is highly complex. Autonomous systems are little by little becoming a part of our way of life. There are huge improvements of intelligent of robotic systems in current indoor and outdoor application ranging from factory transport systems, public transport systems, security systems to military application.

This project is focusing mainly on development of autonomous guided vehicle for manufacturing especially for factory transport systems generally called an AGV. The benefits are that we can learn the fundamental of sensing, control, decision-making and application. Sensing is supplementary to how AGVs can perceive the environment such as destination, obstacle detection and its own current state. Control of AGVs is about how AGVs can react to the environment, tracking maneuvers - forward tracking, backward tracking, driving and steering - and actuator for higher level decision-making mechanism. Intelligent control is all about the autonomous, thus the most important part is how AGV's ability to manipulate the information. This is more to the automatic control which require feedback control.

This information is used to execute tasks through the actuation and feedback control. (E. Grant) The application of AGVs can be seen in big factory such as DaimlerChrysler, Procter & Gamble, Mactac Europe and others big company.

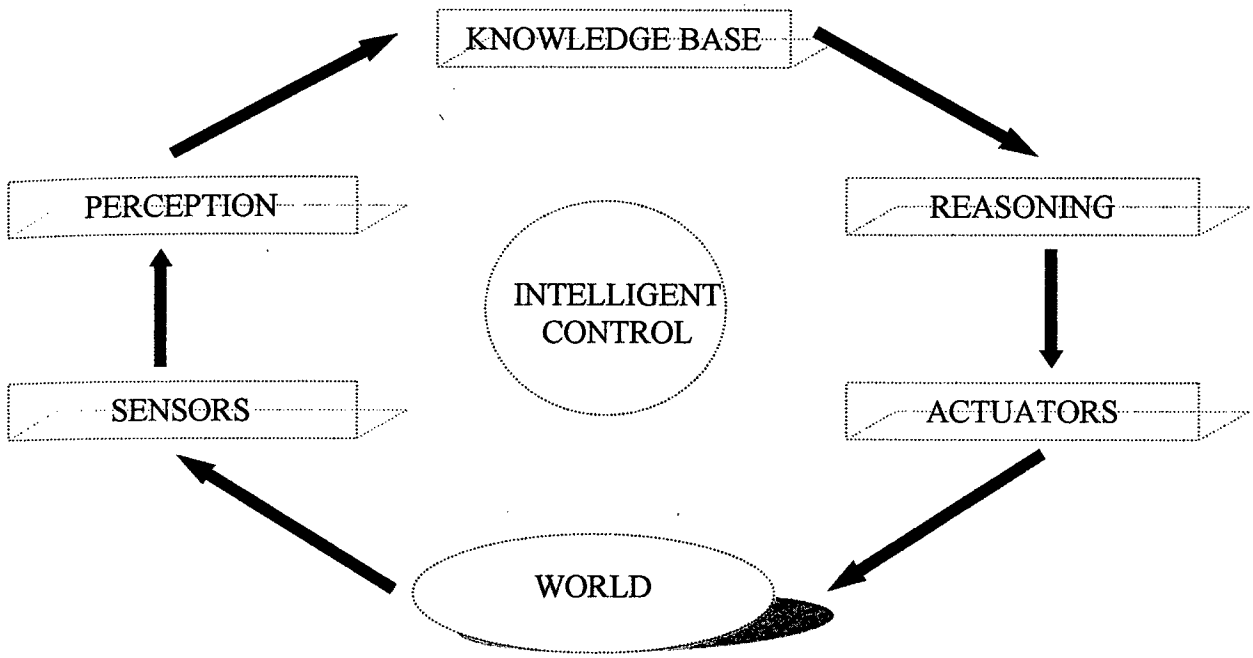

Figure 1.1 Architecture for intelligent control. *Source*: Advance Robotics & Intelligent Machines

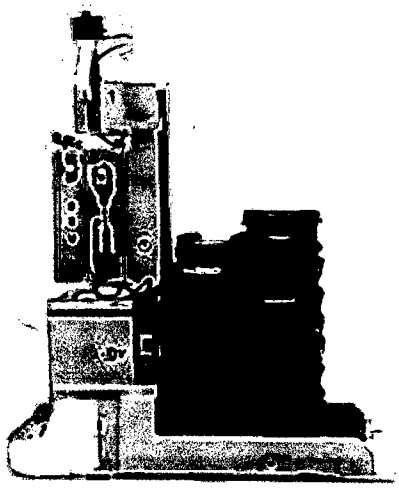

Figure 1.2 *Vennootschap Mechelse Veilingen(VMV)* Unit Load type of AGV *Source*: Egemin Automation Global

1.2 History of AGV

Automated Guided Vehicles (AGVs) are driverless industrial trucks, usually powered by electric motors and batteries (Amerdeen, 2006).

The first AGV system, a modified towing tractor with trailer following an overhead wire, was built and introduced in 1953 in a grocery warehouse. (Frog, 1984) By the late 50's and early 60's towing AGVs were in operation in many types of factories and warehouses. This type of AGV, a tugger, is still applied today. (Frog, 1984)

Modern AGV technology began back in 1962 when Goran Netzler and Anders Dahlgren founded NDC Sweden, a Swedish company focuses on the new technology on designing and standardized the modular industrial electronic solutions and control components to satisfy the need for efficient maintenance and ease of interface between operator and machine (Transbotics, 2006). The birth of modern-

day technology of Automatic Guided Vehicle Systems (AGVS) can be accredited to the pioneering efforts of the two men brought to the material handling industry.

Today AGVs expands in virtually every major industry such as in the aerospace, apparel, automotive, beauty product, books and library systems, communication, electronics, healthcare, mail order fulfillment, pharmaceuticals and health care, retail, toys, warehouse and storage facilities. (Bastian, 2006)

Most AGV-systems have system management computers in which AGV utilization is optimize, transport orders, tracking history material in transfer and system direct to control the AGV traffic. (Bastian, 2006) Most AGVs sold today are however special made machines, special designed for special purposes. AGVs today can be equipped with robot for examples arms and grippers and can perform robotic handling functions. AGVs are also used as storage machines equipped with forks, handling loads in storage racks. (Bastian, 2006)

Overall, the objectives of using AGV are to reduce operating cost and requirements of the human operator in a process. AGV is a part of flexible manufacturing system (FMS). During 1960-1970, operation cost was the primary concern. So, a new strategy was formulated. The more customizability, mean more flexible in their operation. The main advantage of FMS is its flexibility in managing manufacturing resources like time and effort in order to manufacture new product. Different FMSs levels and an example for each is stated below,

ii. Flexible Manufacturing Module (FMM): a numerical control (NC) machine, a pallet changer and a part buffer.
iii. Flexible Manufacturing Assembly (FMA): four FMMs and an AGV.
iv. Flexible Manufacturing Group (FMG): two FMCs, a FMM and two AGVs which will transport parts from a loading area through machine, to a part unloading area.
v. Flexible Production System (FPS): a FMG and FAC, two AGVs, an automated tool storage and automated part/assembly storage.
vi. Flexible Manufacturing Line (FML): multiple stations in a line layout and AGVs.

Flexible manufacturing systems can benefit from the linkage with AGVs. AGVs are often highlighted as saving billon in production plant and material handling. Today, there are hundreds of instances of computer-controlled systems designed to handle and transport materials, many of which have replaced conventional human-driven platform trucks. The advantages of AGVs as a part of FMS are that it can reduce the number of damages to in-process materials, simplified inventory tracking & production scheduling, increasing safety and fewer personnel than in conventional systems.

1.3 Project Problem Statement

In our local country, the implementation of AGVs is very rare to see in the industry. But for the establish industry such as Toyota, BMW that mostly from big manufacturer, they already use AGVs on their production. In order to make AGVs as the main transportation, we must understand the existing performance without AGV compare to the used of AGV. The general comparisons are stated below,

ii. The variety of production can be made with AGV as it flexibility can be controlled.
iii. Manual operation are limited to hourly shift, contrast with the use of AGV, it can be used in multi-shift environment or 24-hour operation.
iv. Rearrangement of production floor area always to be made as there is new retrieval or when there is a change of layout. AGV make the works more easier as AGV's system can be reconfigure quickly and easily.
v. Manual operation always making some mistake, but AGV system operation are more precise and automatic can lead to a significant reduction in the incident of damage to the materials.
vi. The maximum material load by manual operation are much more less than AGV operation as it can tow or lift to thousand kilos more than human does.

1.4 Project Objectives

The project objective is to build one model of AGV that function as a transport. It must have control panel for programming input and work as the program written. The case study is to be created. Then the analysis to be made based on its performance. The specific objectives are as below:

i. To design the AGV that meet the basic requirement of the real AGV that will follow a path as navigation and stop at the station to complete the specific task.
ii. To analyze the performance of the AGV, the movement, and the intelligent it has based on the structure fabricate.
iii. To fabricate the prototype AGV.
iv. Testing the AGV

1.5 Project Scopes

This AGV is built based on the following aspect:

i. This project is to make the prototype AGV. Thus the scale is much smaller. It only can lift only the small weight approximate less than a kilogram.
ii. Powered by using DC battery. It could be Nickel Cadmium (NiCad) or Lithium Polymer (LiPo).
iii. The motor used is stepper motor.
iv. Flexible scheduling with different route by different programs written. It should be less than three programs.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of AGV

Autonomous guided vehicle can be classified as a robot as the AGV behaviors is intelligent. It is capable of performing many different tasks and operations precisely and do not require common safety and comfort elements humans need. There are various ways of defining AGVs.

Autonomous Guided Vehicles are used to consistently and predictably transport loads of material to places that might otherwise be serviced by fork lift trucks, conveyors, or manual cart transport (Bastian, 2006). They are typically used where high volumes of repetitive movement of material is required, but where little or no human decision making skill is required to perform the movement (Bastian,2006). For example, when the conveyor is undesirable, this type of transport is useful for processing task.

AGVs as driverless, computer controlled vehicles that are programmed to transport materials through designated pickup and delivery routines within a particular facility usually a manufacturing, warehousing or distribution facility(Brian Keiger, 2004). AGVs can be used throughout the entire process from starting delivery of raw material all the way through to loading the trucks at the dock with finished product.

In a flexible manufacturing system, a driverless computer-controlled vehicle equipped with guidance and collision-avoidance systems and used to transport workpieces and tools between work stations (www.Answer.com/FMS).

Autonomous Guided Vehicle (AGV) is an intelligent machine that has 'intelligence' to determine its motion status according to the environment conditions. For an AGV to operate it must sense its environment, be able to plan its operations and then act based on this plan (Ming Cao and Ernest Hall, 1998).

2.2 Type of AGVs

Based on the application, AGVs can do certain things, but not others things. As they are designed properly for special purpose, they are useful and will continue to be used. The application of AGVs today can be anywhere. It much related to robots and computer system. For example they may be use in the nuclear industry, in surgery, aerospace, food industry even as public transportation. Thus, AGVs is classified based on their task. In this chapter, the type of AGVs is focus on handling of flexible materials in automation. Basically there are about 3 tasks that AGV does, towing, fork lift and unit load, but as time goes on; their performances are upgraded to do more complicate tasks. These are the general types of AGVs used in industrial for material handling process.

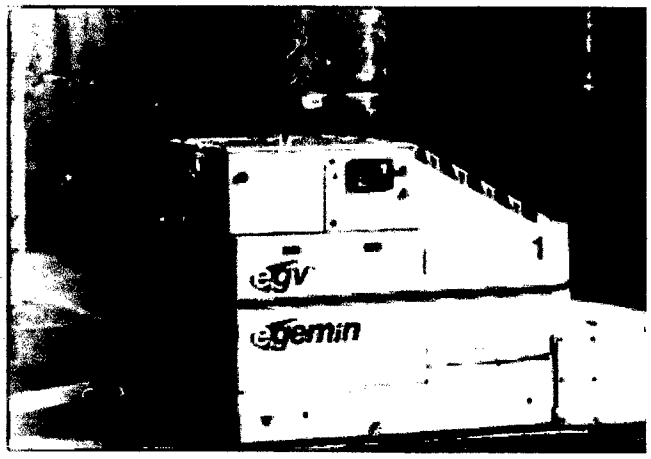

Figure 2.1 Towing type of AGV. *Source*: Egemin Automation Global

i. ***AGVs Towing Vehicles*** were the first type introduced and are still a very popular type today.(http://en.wikipedia.org/wiki/AGV) Towing vehicles can pull a multitude of trailer types and have capacities ranging from 8,000 pounds to 60,000 pounds or approximately 28,000 kg.

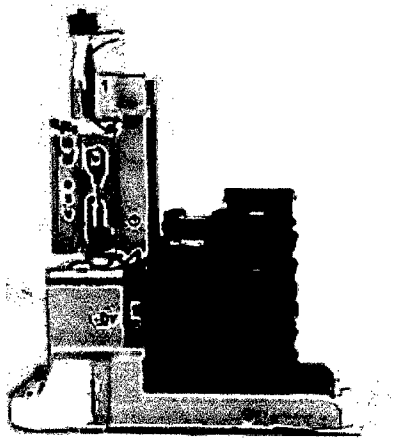

Figure 2.2 *Vennootschap Mechelse Veilingen(VMV)* Unit Load type of AGV. *Source*: Egemin Automation Global

ii. ***AGVs Unit Load Vehicles*** are equipped with decks, which permit unit load transportation and often automatic load transfer. The decks can either be lift and lower type, powered or non-powered roller, chain or belt decks or custom decks with multiple compartments. (http://en.wikipedia.org/wiki/AGV)

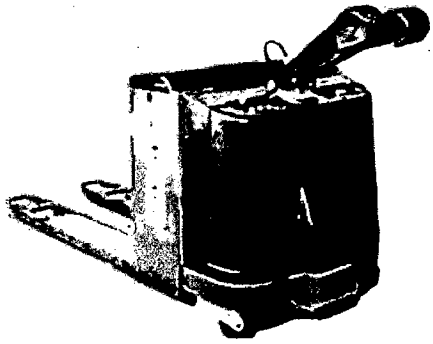

Figure 2.3 Pallet truck type of AGV. *Source*: Egemin Automation Global

iii. ***AGVs Pallet Trucks*** are designed to transport palletized loads to and form floor level; eliminating the need for fixed load stands. (http://en.wikipedia.org/wiki/AGV)A seemingly good method of moving material panels by place them in pallets, restraining them with clamps while the pallets are moved.

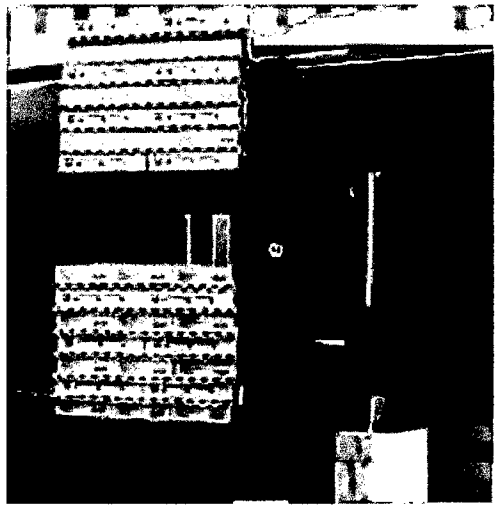

Figure 2.4 *Leen Menken* AGV fork truck type. *Source*: Egemin Automation Global

iv. ***AGVs Fork Truck*** has the ability to service loads both at floor level and on stands. (http://en.wikipedia.org/wiki/AGV)In some cases these vehicles can also stack loads in rack.

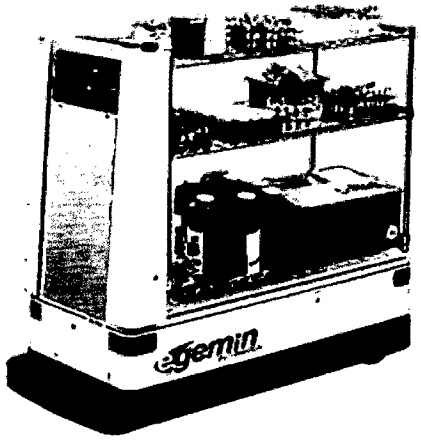

Figure 2.5 Light load type of AGV. *Source*: Egemin Automation Global

v. ***Light Load AGVs*** are vehicles which have capacities in the neighborhood of 500 pounds or less and are used to transport small parts, baskets, or other light loads though a light manufacturing environment (www.egemin.com). They are designed to operate in areas with limited space.

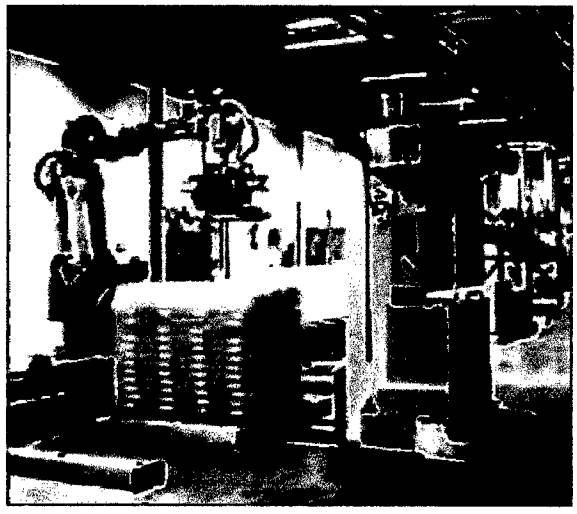

Figure 2.6 AGV Assembly Line type used by *Pharmacia & Upjohn. Source*: Egemin Automation Global

1) *AGVs* ***Assembly Line Vehicles*** are an adaptation of the light load AGVs for applications involving serial assembly processes.