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The Development of LOHAS Automated Guiding Vehicle

Cheng-I Hou[1,2], Han-Chen Huang[1], Tian-Syung Lan*[3]
[1]Department of Leisure Management, Yu Da University, Taiwan
[2]Department of Leisure and Recreation Management, Chung Hua University, Taiwan
[3]Department of Information Management, Yu Da University, Taiwan
*Corresponding author, e-mail: tslan@ydu.edu.tw

Abstract

Automated Guiding Vehicle (AGV) is widely used in factories, hospitals, warehouses, and offices. It can also be controlled remotely to operate under hazardous environments that are unsuitable for human presence. On the other hand, medical advancement and the decrease of birth rate are pushing the world into population aging. For elderly or the physically/mentally-challenged patient, some of the common foot problem includes diabetic foot, myotenositis, having calluses in the soles of the foot, foot deformities, etc. This research is aimed at the design and the implementation of an automated guiding vehicle, which is controlled by PC. Once the input is received from optical sensors, it will pass the information to chip, which will process the information and output the decision to stepping motor to finish the process. The research includes understanding the mechanical design, optical sensor input, defining the control units, and initiating stepping motor. Using BASIC programming, the program is burned onto a chip, which works as the central of the AGV. The result can be applied in barrier-free facilities. This research analyzes the pros and cons of AGV based on its behavior under different scenarios.

Keywords*: automated guiding vehicle, lifestyles of health and sustainability, sensor system, stepping motor*

1. Introduction

During operation, sensors are installed on AGV (Automated Guiding Vehicle) [1]. A successful AGV is heavily relied on how well the sensors are implemented and whether the strength of each sensor is identified and fully utilized. In short, such an automated device can be seen as the integration of different systems [2]. The research on AGV carried out through modularizations, which are: power system, sensor system, guidance system, and actuating system [3]. The guidance system, being the most important of all four, must direct AGV to move on a reliable track to the destination [4]. By commanding the actuating system and sensor tracking special marks, the guidance system can direct the AGV to move along on the preset track.

AGV is an independent mobile vehicle; therefore its power comes from battery, instead of alternating current. As the battery capacity is limited, it's recommended to consider the amount of power consumption during design phase.

As the battery is being used, its voltage will also change. When the voltage reaches to a certain level, some of the elements within AGV will be unable to function normally [5], which will produce error messages. It's recommended to implement a voltage surveillance system so that different actions can be taken in response to voltage changes. Asides from understanding battery voltage and capacity by-the-minute, developer can also design a mechanism to cut off specific power input/output when the voltage reaches a previously defined level [6].

The actuating system is also designed with a surveillance mechanism. This is because that sometimes when the motor is operating, the guidance system is also making commands. To ensure the information is synced between the systems, the surveillance system is designed to check motor status [7].

The central body of the AGV is 8051 chip. It requires only simple wiring, has small footprint, and boasts a faster processing speed, which makes it ideal for guidance purposes [8]. What needs to be discussed is how to burn Basic programming onto 8051 chip, and making it

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the main factor in controlling movements, making optical analysis, and accommodate with stepping motor [9-13]. Stepping motor is a device that transforms input pulse frequency into mechanical energy. Coupled with 8501 chip, the two becomes the central drive of AGV [14].

2. Research Background

AGV is "a vehicle that is fully motivated and controlled using light, electro magnet, and lead wire, without the intervention of human factor". Based on the characteristics of the guidance mechanism, it can be further divided into several types. But regardless of which, each AGV must equip a fully integrated system that consists of the following five major areas.

2.1. Power System

AGV must automatically sense navigation path, and deliver forwarding or back up commands. The body of the AGV should include the main body part, motor, wheels, light sensors, and control panel. It must also contain the power source. This research is based on eight 1.2V Ni-MH battery as the power source, making the total voltage 1.2Vx8=9.6V. This gives sufficient power source with the voltage stabilization effect, making it the ideal choice for experimenting on small-scale AGV.

2.2. Driver

Stepping motor has good responsibility. Just one pulse signal is enough to move it one step forward. Therefore, it is widely used in AGV researches. There are four related coils on a stepping motor's stator, each provides 90 degrees of phase difference. When the stepping motor is set as single pole initiation, a pulse current can stop each rotor in the relevant position. An angle that can be set at a single move is called a Step Angle. The relation between step angle and single pole initiation can be illustrated with the following formula:

Step angle = 360°/Phase number x rotor teeth number

Example: the step angle of 4 phase and 50 rotor teeth can be shown as:

Step angle = 360°/(4x50) = 1.8

2.3. Chipset

The main purpose of the chip is control. It demands processing speed. Therefore, its programming is based on assembly language, like EM78XX series. In practice, assembly language is closely linked to CPU. Since the programming format is very similar, it can be easily applied to any CPU instruction set (ISA). Assembly language is the collection of commands. Each instruction set includes the following four types: data handling and memory operation, control flow, arithmetic and logic, note and comment.

2.4. Control System

Control system indicates the AGV's motherboard and guidance mechanism. The motherboard uses EM78447 as AGV's core. The guidance mechanism uses taped guidance, which is done by applying electrical tape on a whiteboard, then uses Infrared sensor to detect whether there is guidance line on the white board. When the guidance line doesn't exist, the optical sensor will receive the infrared ray that is reflected from the whiteboard, which will make electro-optical crystal become saturated. On the other hand, if guidance line is detected, the black electrical tape will cause no reflection, preventing the optical sensor from receiving the reflected infrared ray. The different behavior between whiteboard and electrical tape can be used to control AGV.

2.5. Guidance System

The placement and the position between optical sensor and the guidance line are very important. Refer to Figure 1 where three optical sensors (L, C, R) are shown. If they are placed too far apart, as shown in scenario A, the AGV won't modify its heading direction until it's departed too far away from the guidance path, making the vehicle move in a side winding pattern. Scenario B shows the two elements placing too close against each other, which makes the vehicle modify its position too often and cause it to shake. Scenario C is the most adequate distance and thus facilitates the AGV to move forward smoothly.

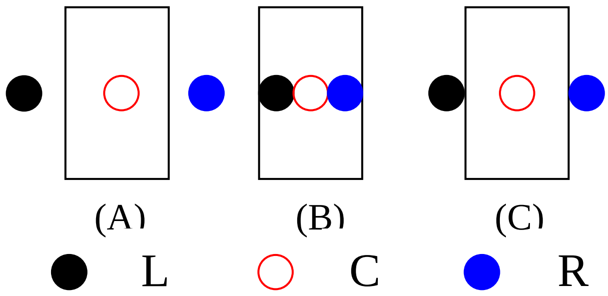

Figure 1. (A) Too wide, (B) Too close, (C) Perfect

3. Research Methods

3.1. Design

AGV must automatically sense navigation path, and deliver forwarding or back up commands. The body of the AGV should include the main body part, motor, wheels, light sensors, and control panel. The driver circuit uses initiation signal to control the initiation current switch in the stepping motor. The high-frequency Darlington transistor is often used to switch circuit. A four-phase stepping motor uses four Darlington transistor, each contains 3A drive force.

In chip design, EM78 series is used as the main part. EM78 chip has a total of 58 rows of command and with a 13-digit width. Each command can be seen as two parts. The first highlight the operation code for commands. The other part points out the variables those are required for the operation code. Command type can be roughly divided into four types: (1) Control type, such as INT and others. (2) Register command, such as MOV A.Reg B:move Reg B to A and others. (3) Bitwise operation command, such as BC.JBS and others. (4) Constant command, such as MOV A. @0X55:move 0X55 to A and others.

3.2. Control

As shown in Figure 2, the connecting circuit on EM78447 is used to connect to the main part of the vehicle and to deliver task command. Figure 3 illustrates how it works with infrared ray sensors to detect navigation path and turn at corner.

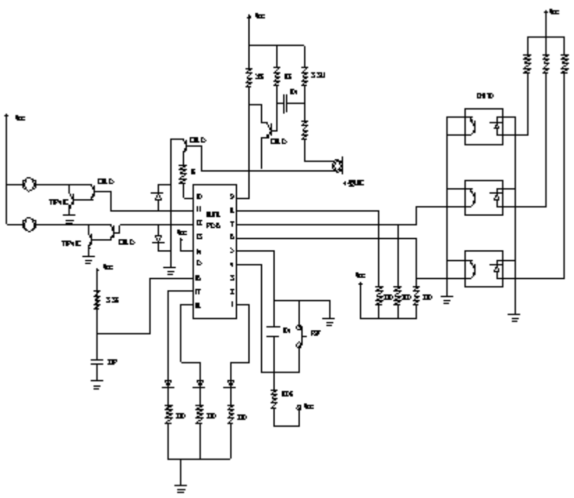

Figure 2. EM78447 Circuit Connection

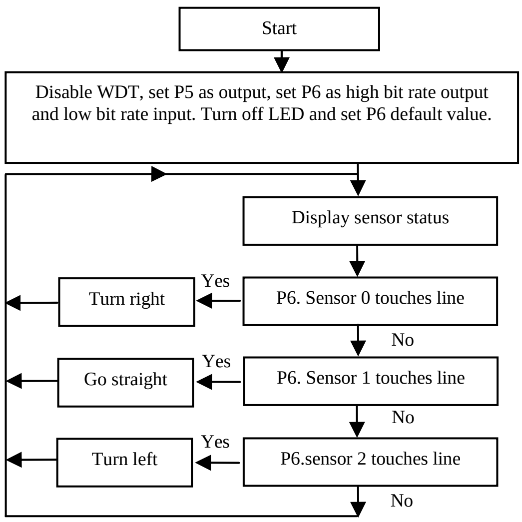

Figure 3. Optical Sensor Flow Chart

4. Result and Discussion

A circular path (ex: Figure 4) can test an AGV's minimum turn-around radius and the quality of sensors. The vehicle showed great stability during movement. However, due to the stepping motor and the length of AGV, the minimum turn-around radius is 90mm. The overall performance is satisfying.

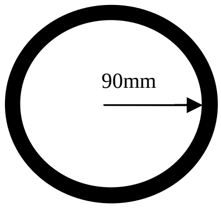

Figure 4. Circular Path

Figure 5 shows the AGV running on a path with right angles to test the behavior when encountering 90-degree corner turn. The key to the experiment lies in the processing quality of chipsets. Actual testing shows that the vehicle can make a turn in 3 seconds while holding good balance. Although scenario like this doesn't happen often in real life and there isn't many research on its actual operation.

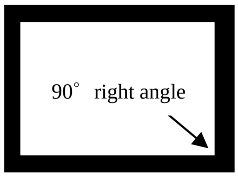

Figure 5. 90 degree Right Angle Squared Path

Curve path (ex: Figure 6) is one of the most common path that AGV runs on. It can be used to test the quality of a vehicle's stability, light sensor, stepping motor, and chip processing speed. In this experiment, the turning radius uses the minimum turn-around radius. Vehicles move in slow and stable pace during the experiment. When the vehicle starts to go off-track, the direction is immediately revised. The overall result is satisfying.

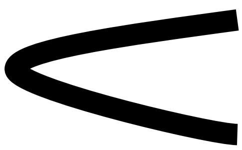

Figure 6. Curve Path

Uphill path (ex: Figure 7) poses as a challenge to AGV's stepping motor and power system. While this research mainly focuses on the behavior on a flat surface, the uphill testing is only used as reference. In the experiment, the vehicle moves very slowly on a surface which maximum slope is 20 degrees. It's believed that by improving the wheel's ground grasping force and power system, the result should be impressive.

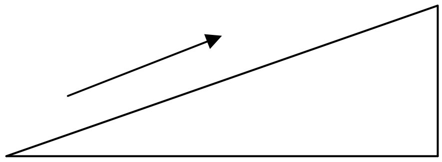

Figure 7. Uphill Slope

Complicated turning path (ex: Figure 8) focuses on the AGV's sensitivity and real-life performance. AGV requires very sensitive path sensor and the capability of revising navigation path within a very short range of time. Eight 3A batteries work as power source. Although the vehicles shake occasionally during the first test, the issue is resolved after revision. The power supply is enough for the vehicle to run continuously for 3 hours. The overall performance is very impressive.

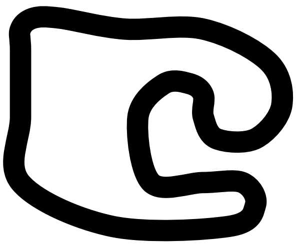

Figure 8. Complicated Turning Path

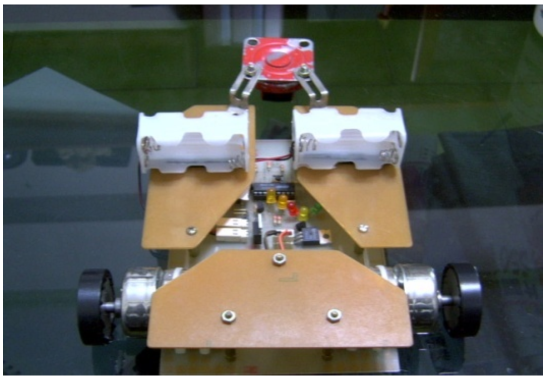

Figure 9. AGV Image

5. Conclusion

AGV bears great potential and also enjoys a certain degree of influence on the market. Chipsets are being widely used in travelling, manufacturing, transportation, etc. Its advantages include low cost, high safety, and high efficiency. The easy design and assembly are also the reason why it's being widely used in industries.

The optical sensing AGV (see Figure 9) designed by our lab is unable to move in high speed. This is because the stepping motor can only precede using excited current and step angle. The torque strength is also another area for improvement. The current design is limited to run on flat surfaces and cannot be applied to uphill operation.

Future researches on AGV and stepping motor should consider using motors with higher torsion to accommodate to leveling surfaces. This way, AGV usage can be applied to more situations. Different chipsets and feature can also be included to strengthen the integration and application of AGV.

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