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An Automated Guided Vehicle for an Small Scale Industry

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Abstract - *Automated guided vehicles (AGV) are one of the greatest achievements in the field of mobile robotics. Without continuous guidance from a human they navigate on desired path thus completing various tasks, e.g. fork lifting objects, towing, and product transportation inside manufacturing firm. Their development can revolutionize the world in the sense of fool proof navigation and accurate maneuvering. Though most of the presently the AGV work in a retrofitted environment, work space as they require some identification for tracing their guide path, works are going on developing such AGVs which are dynamic in sense of navigation and whose locomotion is not limited to just a retrofitted workspace. Typically their job is to move raw materials or parts around a manufacturing facility, and they can be very accurate by following the guides from wires in the floors, magnets, laser, or vision. Therefore, the purpose of this thesis is to discuss the implementation in Cake Industry for material handling. The environment indoors can be easily controlled hence AGVs are useful for material handling. In Cake industry it is essential that, the material should be transported safely and without any damage Also, the chances of mishandling by persons may occur which can be reduced by using AGVs and reduce loss of industry. The AGV set up developed, used a commercial electric motor. These controls were communicated, or better imparted to vehicle using programming to servo motors, which in turn controlled the motion of vehicle. And it is found useful in Cake industry. An AGV solution has been proposed as an alternative system capable of providing a good service level while reducing the accidental losses.*

***Key Words*: Automated Guided Vehicle, Material Handling System, Components, Design**

1. INTRODUCTION

Automated guided vehicles (AGV) have been increasingly employed by the industry in the past decades. Especially in modern factories, a few workers in a well-designed mechanical production line are capable to accomplish the job that used to require hundreds of skilled workers to do. Specially, machines brought to us not just efficiency, but also accuracy and reliability. Therefore, automatizing production or, rather, replacing human workers with robots is imperative for every production plant. The technology is based on vehicles utilized as material handling equipment that operate autonomously in a manufacturing plant, without the need for a human operator. The AGVs are widely used in large-scale production facilities, especially in the automotive market, to increase efficiency and reduce internal transportation costs. The technology meets the current trend within the international industry towards an increasing level of automation of the manufacturing plants. The concept of Industry

has been also consolidating the idea of a fourth industrial revolution based on perpetual communication via Internet that allows for a continuous interaction and exchange of information not only between humans (C2C) and human and machine (C2M) but also between the machines themselves (M2M)".

AGV can have a variety of functions but are presently being utilized for the following functions commercially

- To tow objects behind them
- To move raw materials, to get them ready for manufacturing
- In lifting the objects
- For transporting materials e.g. medicines in hospitals

2. Applications of AGV

Autonomy is the key factor for using AGV in different fields. It will achieve a high degree of accuracy and accuracy which will result in a complete reduction of system errors and improvement time. Flexibility is the key factor that will help AGV become popular in other material handling systems. The AGVs are used inside the factories, but they also expand their spaces in other service sectors

- **Material handling:** used in extremely large car and electronic factories, at the unloading station.
- **Warehouse:** used in the electronic commerce warehouse for the transport of the material.
- **Commercial:** luggage transport to the airport, supermarket, mall, floor treatment, such as washing, exchange.
- **Energy and defense:** transportation of high-risk substances, mapping of bombs and mines, recovery and elimination of nuclear and steam generator inspection, pipeline inspection.
- **The medical service:** delivers water and food medicine, administrative reports, handling of hazardous materials, and disposal of biological waste.

- **Personal care:** Assistance for persons with disabilities and early assistance with personal hygiene.

3. Problem Identification

Generally, the Automated Guided Vehicles are used for bulk production, material handling in large quantities of products. The small scale industries generally hesitate to implement such automated system due to its heavy cost even though AGVs are beneficial for long term goal of Industries. So, we have decided to build an AGV which will be economical and with less maintenance and applicable for doing work for small scale Industries. This project also tries to minimise the losses of Industries as compared with human labour exists and will provide good material handling.

The robot must be capable of following a line.

- It should be capable of taking various degrees of turns
- It must be prepared of a situation that it runs into a territory which has no line to follow.
- The robot must also be capable of following a line even if it has breaks.
- The robot must be insensitive to environmental factors such as lighting and noise.
- It must allow calibration of the line's darkness threshold.
- The robot must be reliable
- Scalability must be a primary concern in the design.
- The color of the line must not be a factor as long as it is darker than the Surroundings

4. Components of AGV

1) Chassis

- **Base and Supports:** The proposed AGV's chassis is made of a 5 millimeter thick rectangular sheet metal (350×50) millimeter at the bottom, supported by parallel and perfectly welded (50×50) millimeter profiles at the top in order to be able to stand the heavy weight of the other components and the maximum expected load. The grate size is 18' x 15' x 15'.In addition the base is surrounded by the same perpendicular profile to hold the covers and withstand unexpected load, collisions, anything unpredicted or further from the project subject and other applications.

- **Two Motor Plates:** On each side there is special thick plate (4×70×240) millimeter to hold the motors. Each plate has 4 slots one for the motor shaft in the middle and the remaining 3 slots, 120 degree from each other, to tight and adjust the motor in the right place in order to make the belt sufficiently tight. This part is highly accurate therefore it is produced by the CNC milling.

- **A Platform for Lifter Motor:** There is one platform (600 × 450 × 150) millimeter, held by 4 legs wielded to the base for suspending the motor to an adequate position.

- **Electric Devices Stand:** Three stands are considered at the head of the AGV for kits and other electric devices to be hold.

Figure 1: Chassis with components

2) DC Motor Drivers

There are two 12V-3A DC electro motors adjusted and tighten to the *motor plates* on each side. These motors are considered to drive the AGV. Figure 5.2 shows the Motor Driver.

Figure 2: DC Motor Driver

3) Power Transfer System: (two sets, one for each side)

- **Driver Gear:** A spur gear is fixed to the motor output axis (D: 60 W: 35 millimeter). This gear is not only meant to transfer the power from the motor shaft to the driven gears, but also to keep the belt over the gear set in order to have continuous revolution under the load. This is done by special two fixture rings wielded to each side of this gear called gear guards.

- **Fixed Shafts:** At the bottom of the AGV there are two shafts (D: 15, L: 430 millimeter) parallel to the chassis with each 175 millimeter away from the center welded to the base. In order to be able to assemble the pinion gears on these shafts, the diameter is reduced using turning machining by 10 millimeter from each head for 25millimeter. In this way the pinion gears are free to spin around the shaft with little friction.
- **Pinion Gears:** There are a pair of spur gears on each side (D: 120, W: 25 millimeter) seated on the fixed shaft with ball bearings. Consequently, these gears have only one rotational degree of freedom around the shaft.

4) Electrical components

- **Batteries:** Two 12V-7A batteries are assigned to supply the required energy for the drivers and the main unit. These batteries are placed at the back side of the vehicle to balance the weight and keep it close to the center.
- **Main Unit Kit:** This unit is the brain of the AGV. It has three 8Mb micro controllers (Adriano Nano)which are meant to control all of the components for each of two applications. It consists of three subsets, one processor for each, programmed with respect to the application requirements and expected respond. Figure 5.3 shows the picture of the main unit in which three micro controllers are seen.

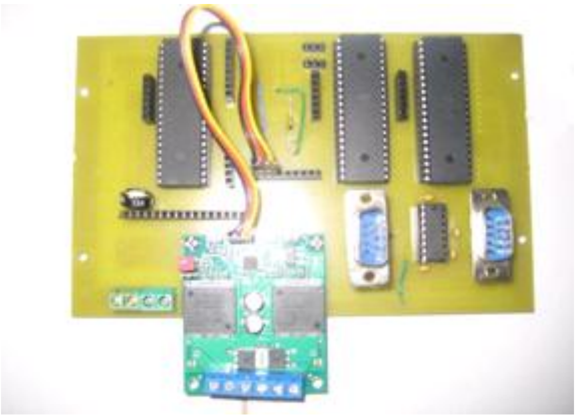

Figure 3: Main Unit Kit

- **Application Controller Set:** This unit realizes the application mode (line follower or 3-D scanner), reads specific code sets and sends the commands to the pertinent subset to be processed. In addition this unit is connected to the communication unit which can receive and transmit commands and data with respect to its program.
- **Line Follower Set:** This unit is connected to the sensor (Infra-red) set and reads them frequently and makes decisions in processing the received data. As mentioned earlier, this process is done in the assigned processor which is programmed appropriately to the line following AGV application. This program consists of three main parts: data source, decision making part and movement functions.
- **Communication Unit:** Since this unit is meant to communicate with the host controller all the time for the both applications, it is considered as a part of the main unit, although this unit has no part in the making decisions.

- **Switch:** A switch is considered and placed at the back cover, connected to the electrical circuit of AGV after power supply. Therefore it turns the vehicle on and off.

5. Path and Guide-Path Design

The essential capability of an AGV is the ability to transfer loads to distant locations through complex paths. Moreover, the FMS has multiple station some in process which are not yet known as AGV targets, and some which awaiting loading/unloading known as AGV targets.

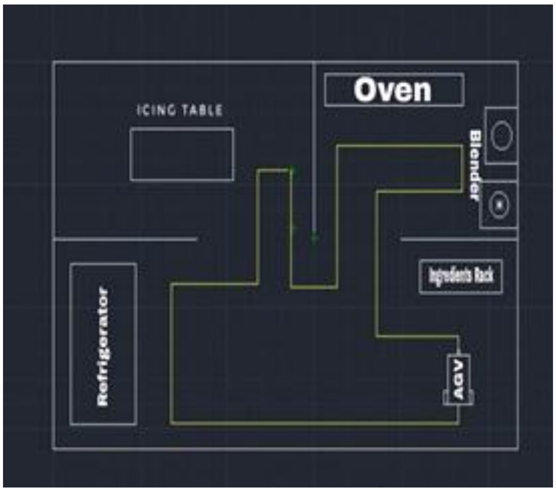

Figure.4: Main Guide Path of AGV

5.1 Interaction of Paths and Sensors

Each station has its own path; however this path might be partially in common with the other station's path. It is assumed that as soon as the AGV is dispatched to a station, the pertinent guide-path is selected and followed by the AGV. Meanwhile the sensor is collecting path data and sending them to the *line follower unit* to be processed and driving the motors according to the path at all times.

5.1.1 Path's Specifications

As mentioned earlier (the interaction of the sensors and different colors) there are two colors chosen for the guide-path.

- **Basis Color:** This color is a matt color with very low reflection drawn on the ground between stations and links them together. The basic width of this line is 300mm but it becomes greater when it gets closer to the junctions. This is to avoid failures happening while turnings. In this case the sensor board may go out of the basis path and read the data from the marble carpet of the shop floor which makes the plan unlikely and unpredictable.
- **Guiding Color:** This color is a shiny color with high reflection drawn precisely at the middle of the basis path with 20 millimeter width to keep the deviation detector sensors exactly on its side edges. It goes between stations and ends up in a specific form. All the paths end up with a special T-shape without the head to provide a special opportunity for the guiding unit to realize the deadlocks which are meant to be the stations

5.1.2 Work Stations Information

Station information basically includes the height of the station and the path addressed for each station to the others. The information about each station is stored in the data base of the host controller unit. Before the AGV is dispatched to a station, this information is loaded to the guiding unit so that the AGV adjusts the turning priorities as well as the lifter height adequate to the height of the station. Moreover, for the next command the guiding unit uses this updated data as a reference position

5.1.3 AGV Scheduling

The aim of AGV scheduling is to dispatch the AGV to achieve the goals for a batch of traveling tasks under certain conditions such as minimum lead-time and maximum reasonable speed within minimum deviation. The goals are normally related to the processing times, utilizing data resources and minimizing the AGVs traveling distance which leads to minimum total travel time. A heuristic scheduling algorithm finds the end point of the late task assigns a path and starts a point of the next task; a list of probable tasks is predefined. Each task (either loading or unloading) contains three operations.

Idling : When the AGV turns on, it goes on idle mode waiting for the host computer command. This command might be one or more numbers implying different priorities of the possible path.

Moving : As soon as the AGV gets the command, it starts to move on the line with the updated priorities to reach the destination station

Stopping : When the AGV reaches the destination, it does a U-turn and turns backs on the line ready, on the idle mode, waiting for the next command.

5.2 Software Design

5.2.1 Algorithm

The success of the AGV system is highly dependent on the quality of the logic control design. In other word, in order to operate an AGV system efficiently, AGVs require an extensive controller system.

The responsibilities of the AGV controller include the following decisions:

- How to assign idle position till the picking up of a request? This is referred to as the dispatching problem.
- Which route is to be taken to the station and from the station to the next destination? This is referred to the routing problem.
- How to employ resources, guide paths and functions to avoid system deadlock while traveling? This is referred to as the movement control problem.

5.2.2 Programming

The next step after algorithm is to write the program according to the algorithm. Due to employed processors, the programming language has to be Basic. The program is written in three phases:

- Inputs
- Guiding section
- Functions

5.2.3 Interface Commander

To simulate an integrated manufacturing shop floor, an Interface Commander is designed to play the role of the host computer. In real integrated FMS, it is the host computer which sends the commands to the AGV controlling unit with respect to the requirements. Since the integration is out of the subject of this thesis, this commander is designed to send the commands in the absence of the host computer.

6. Battery Management

Battery management of the AGV is an issue that is not being strongly focus on but as an electrical vehicle is considered, battery State Of Charge (SOC) estimation becomes an increasingly important issue in terms of both extending the lifetime of the battery and displaying the usable charge to the user before recharging. However, the SOC cannot be measured directly, but rather must be estimated based on measurable battery parameters such as voltage and current

7. Operation Result

Due to this fact that all of the AGV components are made by hand as well as the justifications and settings, the straight movement of AGV might have a functional error deviation from the straight line. However, the combination of the error deviation and the guide line deviation are always controlled and covered by the supervisory unit. In order to see how the supervisory treats, controls and over comes the error deviation angle and path deviation, the AGV is examined in two situations and four correlating variables (Real Deviation, Classified Deviation, V_l, V_r) in each loop of the program are transmitted to the host controller of the AGV and issued on a list.

- **Straight Line Examination**

This examination shows how the AGV finds the path and its own precise position on the straight line.

- **Curve Line Examination**

This examination shows how the AGV finds the path and its precise position on the straight line.

8. Conclusion

An Automated guided vehicle (AGV) is defined as a set of cooperative driverless vehicle, which is used on manufacturing floor and coordinated by manually. The main usage of them as mentioned is to facilitate automation process of doing manufacturing subjects. In this, according to the instructions of earlier study, an AGV have been made. Moreover a guide line has been provided with the mentioned specifications. The primary goal of the AGV was to travel between stations. Therefore, the designed AGV has been examined numerously between all of the stations. Observations proved in every part of the testing procedure the AGV was able to get the commands, follow the line, find the appropriate rout, recognize the station, stop, and report its position.

Secondary goal of this thesis was to increase flexibility of the AGV. This is also successfully provided using the simple instructions of path designing.

9. Future Work

The battery management is not an issue being strongly focus on in this thesis. In this respect Battery State of Charge (SOC) estimation has become an increasingly important issue in terms of both extending the lifetime of the battery and displaying the usable charge to the user before recharging of the AGV. It can be taken to improve the performance and efficiency of AGV. If there is not enough energy to finish the task then recharging will be proceed before the ordered task. The SOC cannot be measured directly, but rather must be estimated based on measurable battery parameters such as voltage and current which is offered as future work.

The main focus of this study was to use a single AGV for all of the required material handling. Considering the recharging issues and hiring multiple AGVs in a same time in a manufacturing fool with several pallets makes the plan much more complex. In such plan the proposed logic is no longer applicable due to the nature of the employed software and hardware. In this case replacing the micro controllers by a Programmable Logic Controller (PLC) with higher accuracy, reliability and adaptively to other machines seems to be necessary as well as using a fuzzy logic appropriate to the new plan.

This time could be eliminated by adopting an automatic loading system

Additionally, RFID tags could replace the current labels attached to the boxes. If an RFID receiver would be installed on the gravity tow rack that receives the incoming boxes from the production area, the FGs tags could be automatically scanned. This solution would increase the initial investment and it would have a large impact on the plant layout

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