System and Design of a AGV for Flexible Production Line

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Abstract. Automated guided vehicles (AGV) are future products that can provide driverless transportation and can transport a variety of products without manual intervention in production, logistics, warehouse and distribution environments. The main advantage of AGV is that they can operate as independent systems with higher efficiency. The proposed work has the main function of AGV, of which EPROM is used to save data. Taking advantage of EPROM, the robot can maintain and continue to execute the current program even if the system returns to the power-on state after a period of power failure in a crisis situation. Compared with manual functions, AGV provides higher efficiency for many industries. The ultrasonic sensor assists the controller, which can realize the obstacle detection function in the robot. Through the artificial intelligence controlled by Bluetooth/Wi-Fi, AGV can be further improved to the level of automation.

1.Introduction
Automatic guided vehicles (AGV) are used to load and unload materials in most manufacturing systems. The main purpose of AGV is to more easily send goods from one location to another. AGV can automatically drag objects behind the trailer. This trailer is used to move raw materials or finished products. Before, this was completely done manually, and the efficiency was not high. Artificial work has been replaced by Line Followers [1]. Line trackers have been divided into main types based on their utility. Wired follower, in which a slot is opened on the floor and a wire is placed, and the AGV follows along with a sensor that detects the relative position of the radio signal. The main disadvantage of wired line followers is that installation in the dynamic industry becomes very tedious.

There are many types of AGVs on the market. According to the applied navigation method, AGV can be divided into wired, tape guidance, laser guidance, inertial guidance and visual guidance types. Although tape guidance is an old type, it is still widely used in modern factories because of its simplicity and reliability.

The structure of this paper is as follows: We start with an introduction to AGV followed by a description of AGV system, in Section 2. Section 3 illustrates the navigation system design, including RFID site identification unit. And in Section 4, the path planning system is presented in detail. The paper is summarized with a conclusion in Section 5.

2.System description
The AGV constructed in this paper is by STM32F103 board which is represented in Figure 1
We use STM32F103ZET6 in our AGV which is a low power CMOS 32-bit microcontroller based on the Cortex—M3 architecture. They are capable of executing powerful instructions in a single clock cycle; STM32F103ZET6 This is the core chip of the development board. The chip has 64KB SRAM, 512KB FLASH, 2 basic timers, 4 general-purpose timers, 2 advanced timers, 2 DMA controllers (a total of 12 channels), 3 SPI, 2 IIC, 5 serial ports, 1 USB, 1 CAN, 3 12-bit ADCs, 1 12-bit DAC, 1 SDIO interface, 1 FSMC interface and 112 general-purpose IO ports. They provide everything that is required to connect with a PC for inter-communication[9]. The board can be powered either using a AC-to-DC adapter or with the USB port or using a battery. The Arduino board is more user friendly in which programming part becomes very effortless even for an intricate applications. The navigation of AGV is obtained using servo motors which are connected to the controller using an interface of motor driver. In our work we use L293D motor driver which facilitates AGV navigation with ease. The STM32 pin diagram is represented in Figure 2

![Pin diagram of STM32F103](image)

The data are stored into the EEPROM module. The data is fetched in such a way that they are executed in either ways-top to bottom or bottom to top fashion. But as it's required to execute in both ways the programming is made for dual execution. The usage of EEPROM takes a vital part in AGV. Taking up the advantage of EPROM (non volatile), the robot can retain and progress with their current execution even when the system comes back to the powered state after a period of power loss at crisis conditions. [2]

3. Navigation module
In modern automated logistics systems, AGV's guidance technology has always been a research hotspot, mainly responsible for AGV's path recognition, site information recognition and real-time positioning [3]. The choice of navigation positioning method directly affects the accuracy and stability of AGV operation And the reliability of the entire control system. At present, there are two general AGV navigation methods. One is the predetermined path navigation, that is, the AGV conversion path is fixed, and auxiliary signs need to be set in the displacement path and the station station. The AGV obtains the
current position and direction information by detecting the marker, such as magnetic nails Guidance, optical guidance, tape guidance, etc.

The other is an unscheduled path navigation method. There is no auxiliary positioning device on the displacement path of the AGV. According to the task requirements and the path instruction information issued by the decision layer, the AGV detects and determines the vertical path by detecting local environmental information in real time during the operation process. Such as laser navigation (without reflection board), coordinate recognition navigation, visual navigation, etc.

The tape guidance system applied to AGV includes two parts: tracking unit and station identification unit. The tracking unit is used to identify the guidance path and ensure the vehicle's accurate driving through real-time correction. This article uses Xingsong Technology's CNS-MGS-16 type magnetic navigation sensor. The sensor has a 16-bit magnetic resistance sensing point, no temperature drift, and supports N/S magnetic strip induction, 0-9 level sensitivity adjustment, response time 5ms, detection accuracy can reach 5mm. 16 NPN signals are output, and the installation height and sensitivity of the magnetic sensor need to be adjusted during installation, so that 16 magnetic points are arranged perpendicular to the magnetic stripe.

3.1. Site identification unit
In the magnetic navigation system, the tracking unit is used to identify the path, and the motion control instructions such as acceleration and deceleration, parking, and fork movement at the path and station are borne by the station identification unit. This technology is mainly used to detect, read and process the label information at the line and station, so that when the vehicle detects the corresponding landmark information, it can quickly make corresponding operations according to the instructions issued by the decision-making layer, and real-time Precise positioning and motion control play an important role. There are currently two commonly used site identification methods, one is to use landmark magnetic stripe to identify sites, and the other is to use radio frequency identification technology to identify sites.

Landmark magnetic strip station identification is the station identification method adopted by the magnetic navigation AGV earlier. It represents the specific action information through the combination of the magnetic labels set on the line and the station. It is mainly composed of the combined magnetic label and the magnetic label detection sensor.

Under normal circumstances, two sets of magnetic labels need to be set perpendicular to the direction of the navigation magnetic strip, and maintain a certain distance from the navigation magnetic strip to prevent magnetic interference (the minimum distance is greater than 15cm), one group is used to accumulate the magnetic label information. The command information is used to realize the acceleration and deceleration, turning, parking and fork movement control of the vehicle at the line and station. This site identification method that uses a combination of several pieces of magnetic labels to represent tag information can meet general automation needs. However, there are the following defects:

① Each mark needs to be equipped with multiple magnetic labels, and the length and location of the magnetic label are strict. When the production line is complex and there are many stations, it is more troublesome to paste each group of magnetic strip landmarks;

② The magnetic marks are easily susceptible to magnetic interference between the magnetic marks and the navigation track, especially at intersections and other places where there are many magnetic marks may cause the landmark sensor to fail to accurately obtain the magnetic stripe information and reduce the tracking accuracy;

③ The combination of the landmark magnetic stripe is limited, and the limited number of magnetic stripe combinations can only issue several commands. When there are many stations, it is more troublesome to arrange. When there are more than 100 stations on the production line, at least 7 magnetic strips are required to constitute a combination of instructions;

④ All the magnetic labels set on the production line need to be defined and processed in the program, and the task volume is huge.
3.2. RFID tag site identification
RFID technology is a non-contact automatic identification technology that uses radio signals for target positioning and reads information data in tags. It can be widely used in warehousing, logistics and other fields. It is one of the core technologies of the current Internet of Things concept. The RFID module is usually composed of a reader, antenna, transponder and application software system. The vehicle-mounted reader transmits a fixed-frequency radio frequency signal to the external space through the antenna in real time. When the RFID tag enters this area, the coil in the tag is When receiving this RF signal, it generates an induced current and obtains energy, and then drives the internal circuit of the RF card to send out the data stored in the RF card memory through the built-in antenna or store the content to be written by the card reader into the RFID tag. [5] After receiving the tag information, the reader decodes it and sends it to the onboard controller. The principle diagram of radio frequency identification is shown in Figure 3.

The most important feature of RFID technology is non-contact identification, which can adapt to information recognition in severe weather such as ice, snow, dust, etc. It has a small size, fast reading speed, easy storage content modification, high encryption security and large data memory. And other advantages, the tag information can still be accurately read to achieve multi-objective discrimination. While optimizing the efficiency of the logistics and warehousing industry, Radio frequency identification technology has increasingly become the core technology of industrial automation, so this article chooses RFID technology as the site identification technology of AGV forklift control system.

4. Pathplanning System
The task of our navigation system is to find a path connecting the current position of the AGV and the target station. Because there are branches in our map, navigation must deal with tape branches. In order to reduce the number of communications, our goal is to make the AGV navigate as automatically as possible, while the central server localizes the AGV only for monitoring.

RFID tags are used in our navigation system because AGV can read them steadily while running and stopped. To handle branching, RFID is placed on each node with two links. Then, by performing a depth-first search in the map, you can determine the path consisting of a series of nodes connecting any target site and AGV location, and you can also determine that the branch direction of each branch node is determined by the link that meets two conditions: a) Belongs to this node; b) is included in this path. Each time AGV reads a new RFID tag, it will make different decisions according to the tag path: a) If the tag belongs to the target stop, the AGV is ready to stop; b) If the tag has a branch direction, the AGV will follow this direction Select the branch; c) AGV to continue driving.

4.1. Dijkstra steps to achieve the shortest path
Dijkstra algorithm is one of the commonly used algorithms to achieve the shortest path, and its path planning is based on the greedy algorithm. [6] First, a vertex set S is established, and then the vertex set is filled by the screening of judgment conditions. At the beginning, the set D contains only the initial point of the AGV robot, namely the source point. The robot's working space can be divided into a planar two-dimensional network. Set a new array of marked path vertices, Dijkstra algorithm calculates the
shortest path from all vertices to the target position, until the array contains the coordinates of the target point, which means that the path planning is completed, the shortest path from the target point to the source point is the shortest planned path. The schematic diagram of the shortest path is shown in figure 4.

5. Conclusion
In this paper, a new AGV system for flexible production line is proposed. This paper proposes a complete set of AGV robot technical solutions from the aspects of demonstration of feasible solutions, mechanical systems, control systems, and trajectory planning. The AGV can efficiently transfer raw materials or finished products in the workshop which is proved by the payload test and stopping error test. Besides, modularized software system provides an convenient interface for both the supervisor and workers to monitor, control and work with our AGV system.

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