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Intelligent Autonomous Automated Guided Vehicle

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Abstract: Design and modeling of an autonomous AGV with intelligent navigation and control system is an implementation of automated guided vehicles which are used to navigate goods from one place to another. This paper shows the methodology which can maximize the performance of an AGV. We have also mentioned the algorithm to avoid obstacles in the way of an AGV and also to find the shortest path to the destination. This methodology not only reduces the cost but increase the efficiency from compared to previously proposed AGV. The proposed AGV will decrease the chances of accidents and mistakes. We are going to increase the working speed of AGV as it will not need to stop its work due to some external obstacles. We have used Kalman filter and PID to increase the accuracy of AGV. The A* algorithm is used to find the shortest path by avoiding obstacles to reach destination in minimum time. We have used directional sensors to get information about current position and destination of AGV. The highly accurate directional sensor will help AGV to easily calculate the position of it at any point.

Index Terms: AGV (automated guided vehicle), LASER (light amplification by stimulated emission of radiation), P (proportional), PD (proportional derivative), PI (proportional integral).

I. INTRODUCTION

Automated guided vehicles (AGVs) is a kind of autonomous robot which increase efficiency and reduce costs for helping in manufacturing facility or warehouse. The first AGV was invented by Barrett Electronics in 1953. The AGV can tow objects with them in trailers . The trailers can be used to move raw materials or finished product. The AGV can also store objects on a bed. The objects can be placed on a set of motorized rollers (conveyor) and then pushed off by reversing them. AGVs are employed in nearly every industry, including, pulp, paper, metals, newspaper, and general manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done[1]. AGVs are actual vehicles that can take materials/tools from one location to another using a variety of different paths based on traffic in the area and programming that is done that will direct the AGV down the path that will get it to its location the quickest. Since AGVs are unmanned, they can run 24 hours and 365 days a year. Throughout requirements for the AGVS must also be examined closely when determining the route the vehicles must travel. If a company can minimize the time spent moving between two locations and the time it takes to load vehicles, the number of vehicles will decrease, and the number of paths for the vehicles will decrease in quantity. A carefully planned route can lead to an efficient, cost effective implementation of an AGVS.

Types of AGV

1. Based on load carrier
a.) Tow
b.)Unit load
c.)Fork

2. Based on navigation
a.)Fixed path
I) wired
II) Guide Tape
III) Magnetic spots

b.)Free path
I) Gyroscopic Navigation
II) Vision Guidance
III) Laser Guided

 WIRED

A slot is cut in to the floor and a wire is placed approximately 1 inch below the surface. This slot is cut along the path the AGV is to follow. This wire is used to transmit a radio signal. A sensor is installed on the bottom of the AGV close to the ground. The sensor detects the relative position of the radio signal being transmitted from the wire. This information is used to regulate the steering circuit, making the AGV follow the wire.

 GUIDED TAPE

AGVs (some known as automated guided carts or AGCs) use tape for the guide path. The tapes can be one of two styles: magnetic or colored. The AGC is fitted with the appropriate guide sensor to follow the path of the tape. One major advantage of tape over wired guidance is that it can be easily removed and relocated if the course needs to change.

Colored tape is initially less expensive, but lacks the advantage of being embedded in high traffic areas where the tape may become damaged or dirty.

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A flexible magnetic bar can also be embedded in the floor like wire but works under the same provision as magnetic tape and so remains unpowered or passive. Another advantage of magnetic guide tape is the dual polarity. Small pieces of magnetic tape may be placed to change states of the AGC based on polarity and sequence of the tags.

 LASER GUIDED

The navigation is done by mounting reflective tape on walls, poles or fixed machines. The AGV carries a laser transmitter and receiver on a rotating turret. The laser is transmitted and received by the same sensor. The angle and (sometimes) distance to any reflectors that in line of sight and in range are automatically calculated. This information is compared to the map of the reflector layout stored in the AGV's memory. This allows the navigation system to triangulate the current position of the AGV. The current position is compared to the path programmed in to the reflector layout map. The steering is adjusted accordingly to keep the AGV on track. It can then navigate to a desired target using the constantly updating position.

GYROSCOPIC NAVIGATION

Another form of AGV guidance is inertial navigation. With inertial guidance, a computer control system directs and assigns tasks to the vehicles. Transponders are embedded in the floor of the work place. The AGV uses these transponders to verify that the vehicle is on course. A gyroscope is able to detect the slightest change in the direction of the vehicle and corrects it in order to keep the AGV on its path. The margin of error for the inertial method is ±1 inch.

Inertial can operate in nearly any environment including tight aisles or extreme temperatures. Inertial navigation can include use of magnets embedded in the floor of the facility that the vehicle can read and follow.

VISION GUIDANCE

Vision-Guided AGVs can be installed with no modifications to the environment or infrastructure. They operate by using cameras to record features along the route, allowing the AGV to replay the route by using the recorded features to navigate. Vision-Guided AGVs use Evidence Grid technology, an application of probabilistic volumetric sensing, and was invented and initially developed by Dr. Moravec at Carnegie Mellon University. The Evidence Grid technology uses probabilities of occupancy for each point in space to compensate for the uncertainty in the performance of sensors and in the environment. The primary navigation sensors are specially designed stereo cameras. The vision-guided AGV uses 360-degree images and build a 3D map, which allows the vision-guided AGVs to follow a trained route without human assistance or the addition of special features, landmarks or positioning systems [2].

DEMERITS OF PRESENT AGVS

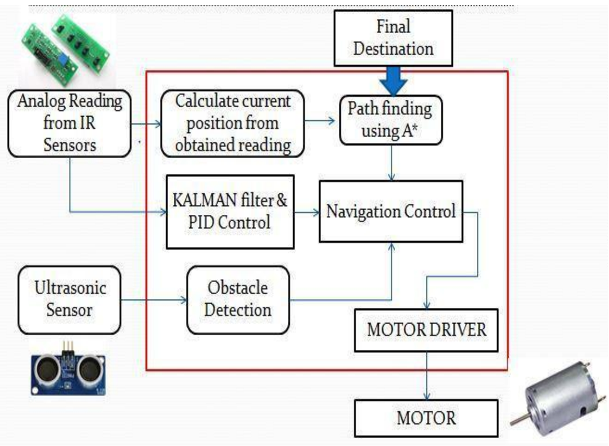
- In wired the breakage in wire makes impossible to follow route, if the path has to be changed lot of labor work is needed [3].
- In laser guided AGV considerable amount of time is required for adjusting the position of the reflectors to prevent the reflected light from being blocked [4].
- The installation cost and expansion cost is high of laser guided AGV [5].
- Gyroscopic Navigation needs evenly plane surfaces, & the gyro changes its value abruptly & hence it has to be used with magnetic markers [6].
- In the Vision Guidance for the image processing the 360 degree image of the surroundings has to be fed to the system which needs lots of memory [7].

II. PROPOSED METHODOLOGY

- To overcome all of the demerits we have a new concept of autonomous automatic guided vehicle.
- This autonomous AGV can have a lot of manoeuvrability & application.
- This autonomous will also have ability to avoid obstacles & will be equipped with better handling ability.

III. BLOCK DIAGRAM

 The Autonomous AGV will be working on a maze like surface which will be used for the navigation purpose. This maze structure can be a pattern of two colours or more made up of vinyl which can be easily pasted over floor. This pattern would be used for navigating freely. Autonomous AGV will be provided with A* algorithm to find a path from one place to another. If in case on the desired route is again obstructed by some other material it will re calculate the path to the destination. Ultrasonic sensors will be placed to three sides of the autonomous AGV to avoid accidents. The AGV will decelerate first & would finally stop if the object is too much close to the AGV & will avoid collision.



IV. PID CONTROLLER

PID is used for controlling any automated mobile machines. For the navigation purpose the analog values will be used in place of digital. Before feeding it to the motor the PID will calculate the proportionate input for the proportionate output to get balanced result.

1 - Proportional Control:
This controller multiplies the current "error" by a constant called Kp. This "error" is the difference between actual output and the desired output which is fed back into the system, so the error is calculated. This error is inserted into the PID controller as input, and the PID controller will calculate P, I and its D terms and commands the system to remove the error.
Thus the desired output will be achieved as soon as possible with best stability.

2 - Integral Control:
The Integral term is used to multiply the current error and by a constant Ki, making a summation of all that information. When Integral term is added to the proportional term, it accelerates the process of reaching the steady state of the system. In other words, it also eliminates (or at least try to eliminate) the residual error, arriving faster to the desired result.

Derivative Control:
The Derivative term, causes the rate of change of the error signal which is multiplied by a constant Kd. This will predict the error and hence decrease the rate at which errors produces changes in the system.

P controller (sometimes used):
In this controller we use small values of the constant Kp to get to the desired value, but its control is slow (that it takes some time to get to the desired value). If the value of Kp is increased an overshoot will occur.

PI controller (most commonly used):
It removes the residual portion of error in the steady-state case (improving transient response), but in this case it will have more overshoot, occurring system oscillation and which will lead to instability, the system will over-damp, under-damp or oscillatory. This type of control will make the system slower. By using large values of Ki, it will leave the system faster, however, increases the overshoot and decrease the margin of stability of the system.

PD controller (rarely used):
It is used to decrease the overshoot magnitude of the systems that uses integral controller and improve the stability of system. But a Derivative controller increase the noise error term and make the system process more unstable. The PD controller decreases the time to reach the desired value considerably so that the derivative gain Kd should be high. This decreases the control time, but increases the bandwidth of the system, leaving the system susceptible to disturbance or noise.

PID controller (sometimes used):
PID is combination of PI and PD. It is used to remove the system errors ratio and decrease the response time without oscillations or instabilities. In our AGV the error is calculated using the pair of two sensors. The error is them multiplied with the constant which are derived using the PID algorithm. The values of the constants were evaluated at certain speeds & these values are always proportional to the speed & the voltage levels [8].

```
previous_error = 0
 integral = 0 start:
 error = setpoint - measured_value
integral = integral + error*dt
derivative = (error - previous_error)/dt
output = Kp*error + Ki*integral+Kd*derivative
previous_error = error
wait(dt)
goto
start
```

A* algorithm
A* algorithm is used to find the shortest path to destination by avoiding the obstacles. It has two functions i.e., (g(x) and h(x)). The function of g(x) is used to find the real cost to reach to node x. The h(x) is also called as heuristic function is used find approximate cost from node x to goal node. The total cost of each node is calculated by

$$F(x) = g(x) + h(x).$$

A* algorithm checks it neighbor nodes every time to reach goal. It is more advantageous than dikstra's algorithm as A* checks much less nodes than dijkstra. Thus we use A* algorithm in our proposed AGV to decrease the consumption of time. The process of plotting and efficiently traversable path between points, called nodes.

V. DIRECTIONAL SENSOR

In our proposed AGV we had used directional sensor to calculate the position of AGV, the position will be determined in the form of coordinates with value of X and Y. The AGV can find its position at any time with the help of this sensor. Mouse is used in our AGV which will give an accuracy of 360um, which means that the distance between each will node will be much less so that the accuracy will be increased. The shortest path algorithm that is A* algorithm will be applied it to reach its final destination. Ultrasonic sensor will be used to check the obstacle at any node.

VI. PRODUCT OVERCOME

- This new Autonomous AGV can move freely from any random point to any random destination. Only we have to feed the destination every time.

- The autonomous AGV can be made so flexible such that it can also be employed in restaurant where we need a waiter to serve things from one table to other. It can be also used in large ware house and manufacturing firms for transportation of heavy machineries.
- There is no need of any line or tapes to find path which will reduce its cost and increase efficiency.

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