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Dashboard For Automated Guided Vehicle System

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Abstract: Automated guided vehicles are working in nearly every industry which includes pulp, paper, metals, newspaper, and general manufacturing. This paper is about the design and development of electric automatic guided vehicle which is an initiative towards the automation. In Rajarambapu Institute of Technology there are different facilities. As a result of large campus, facilities are situated far from each other. If anyone who is visiting the institute campus will require a lot time to roam around all the facilities by walking. Considering this problem, we are developing an electric automated guided vehicle which will trace a pre-defined path and carry the passenger from one place to another as per their own choice within the campus. This paper describes different modules such as drive control, steering control, obstacle detection, power supply control, human machine interface, camera and single board computer which will be implemented in AGV. Implementation details of different functionality like video capture, color detection, masking, edge detection and shape detection are described in paper.

Index Terms **-Automated Guided Vehicle, Image processing, Path follower, Ultrasonic Sensor, Raspberry Pi**

I. Introduction

In the modern world autonomous vehicles are becoming more and more important. Electric automated guided vehicles contribute to the automation of a plant or warehouse, increasing efficiency and lowering expenses. Automated guided vehicles are used by virtually every sector of the economy, including pulp, paper, metals, newspapers, and general industries. With the use of an automated guided vehicle, greater product handling and speed can be attained. AGVs are introduced in 1954. They were used to transport material from one point to another, without any operator. The use of AGV increases flexibility, as it chooses the most efficient path from several options. This paper is about the design and development of electric automatic guided vehicle which will initiate towards the automation and advancement in the field of automobiles with the help of multidisciplinary engineering including Automobile, Computer Science & Information Technology, Computer Science, Electronics & telecommunication, and Mechanical Engineering streams.

We intended to design and develop an electric automatedvehicle. This vehicle will trace a defined path and carry thepassenger from one place to another as per their own choice within the facility.

1.1 NEED

As AGV works in collaboration with software technology, it has been created to minimize human intervention in industrial operations. AGV relies on sensorsto identify impediments and discover a different route toitsobjective. The creation of an AGV that can carry goods autonomously in a warehouse or other environment is required.

1.2 OBJECTIVES

- To develop a line following algorithm using Image
- processing for vehicle.
- To design a user interface for the human-machineinterface display.
- To program the human-machine interface tocommunicate with SBC.
- To test & debug all the modules for our application.
- To involve in the project activities & build the projectas a team.

2. BACKGROUND

The technologies that were used to develop the AGV system will be introduced and discussed in this part.

2.1 SENSORS

The system's primary data source is its sensors. Electronic sensors may transform environmental information into signals by taking it and processing it. Following sensors will be employed in the proposed AGV system for obstacle identification and collision avoidance.

Ultrasonic sensor: This sensor measures distances. It operates on the idea of sound waves being emitted and reflected.

2.2 RASPBERRY PI (MICROPROCESSOR)

A single core computer system known as a microprocessoris capable of managing sensors and other similar devices.It is in charge of analyzing the information acquired by the

sensors and determining the proper orders to be given tothe actuator (Motor).

In the proposed system, Raspberry Pi microprocessor is used. It is a portable small board computer, widely used inrobotics and research papers. Out of various available models, Pi 4 is chosen for the proposed system. It has aprocessing speed of 1.4 GHz, and 8 GB of RAM. SD cardis used to store the operating system and program memory.It has Wi-Fi, Bluetooth and USB boot capabilities.

2.3 RASPBIAN OS

The operating system for the Raspberry Pi is called Raspbian. The Raspberry Pi Foundation recommends it foreveryday usage and it is a free operating system. An SD card that has been formatted contains the OS. It is an OSthat is simple to use and contains a lot of built-in programming applications and packages.

2.1 LITERATURE REVIEW

There are several methods employed for the automated guided vehicle. Numerous methods, such as frequency chosen mode, path selected mode, vision-based mode, etc.,are used to achieve this. Following are some of the references which have discussed literature related to different methodologies to optimize AGV:

https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9247159

IEEE ACCESS | Multidisciplinary | Rapid Review| Open Access Journal | An review of current autonomous guidedvehicle advancements **[1]**, including integrationchallengesand prospective research areas for 5G-based smart industrial applications. The current edition is from November 18, 2020; the publishing date is November 3,
2020.

In this work, we examined the conception and operation ofautomated guided vehicles (AGVs), as well as a review of the most recent AGV and AMR research findings duringthe previous ten years.

Different methods and challenges with existing AGV technologies are discussed as follows:

1. Laser Navigation System: -

Artificial landmarks are used by laser-based AGV navigation systems for localization and navigation. Despite the fact that using a laser is preferable, the usage of artificial landmarks may occasionally compromise the operational safety of a production. To remedy this problem, laser range finders might need to be used on themanufacturing floor, which isn't always a good idea and could have a bad effect on the environment. Additionally,clustering or LOS situations are difficult for laser AGV navigation to operate effectively.

2. Inductive guidance system: -

Inductive guidance Electromagnetic wires hidden in the floor are found by the AGV system. AGV navigation is accomplished by inserting several wires and turning on thewire that will direct it to the target location. Installing inductive guidance systems often results in substantial logistical problems since digging up factory floors typically necessitates shifting machines and altering the industrial architecture.

3. Free-ranging vs fixed-path navigation: -

AGVs can use a variety of fixed-path navigation techniques. AGVs can only go along a few predetermined pathways in the factory when using fixed-path navigation.With free-ranging navigation, such as a laser-based navigation system, which can be provided by methods likelaser navigation systems, AGVs can travel in any directionto avoid obstacles on the production floor. In the permittedAGV navigation paths, an AGV can also travel between points in the free-ranging mode by using shorter routes.

- https://www.researchgate.net/publication/301261727_Design_and_Methodology_of_Automated_Guided_Vehicle

Design and methodology of an AGV—A review—IOSRJournal of Mechanical and Civil Engineering (IOSR- JMCE) |e-ISSN: 2278-1684, p-ISSN: 2320-334X |
Published April 2016 **[2]**

In this paper, we studied methodologies of automatedguided vehicles, most commonly used guidance technologies in AGV are

- Behaviour Navigation System:

A behaviour navigation system was created because it canaccommodate several sensors and is ideal for the unstructured environment. The best navigation method's behaviour requires a powerful computer, a neural network,a genetic algorithm, and several technical components. Formobility, the Behaviour Navigation system makes use oflaser range navigation technology. In order to locate the car and traverse the system, laser range navigation is employed.

- Inertial (Gyroscopic) Navigation:

The vehicles are guided and given duties by an automated computer control system known as inertial guidance. There are transponders buried in the office's floor. These transponders are used by the AGV to confirm that the vehicle is on track. A gyroscope can detect even the smallest shift in the vehicle's orientation and adjust it, keeping the AGV on course. Inertial can function in almost any situation, including narrow aisles and high temperatures. Magnets installed in the facility'sfloor that the vehicle can read and follow can be used forinertial navigation.

Quan V. Nguyen [4] offered an indoor autonomousguided vehicle route tracking task using two mono cameras and a visual sensor-based driving algorithm (AGVs). To monitor the surroundings and spot markers infront of the vehicle, one camera was put on the vehicle. The image from the other camera was set up such that it was perpendicular to the ground in order to make up for the space between the wheels and the markers. The distance and angle between the centers of the two wheelsand the marker's center were also measured using these two cameras.

It included a mobile robot system made up of a three-layered plate frame, two built-in nonholonomic wheels, two DC motors coupled to encoders, a motor driver, one caster wheel, a power module, and a battery. The controller device was a Lenovo ThinkPad computer.Instead of employing the line tracking technique, the marker recognition algorithm provides the AGV with directional information.

Steps of algorithm are as follows:

1. Train itself on the marker pictures, then use a supportvector machine to categorise them (SVM).
2. Gather images using two cameras: one for aperpendicular angle and one for a bird's-eye perspective.
3. Color-based picture calibration based on HSV (hue, saturation, and value).
4. Using median filters to reduce noise.
5. Binary image conversion.
6. Marker extraction using the HOG method (histogram ofdirected gradients).
7. The AGVs travelled from the starting point to the end goal by identifying the sign marker with the driving algorithm.

The AGV evaluates the angle between its centre and the centre of the navigation marker on the floor in order to follow the guiding path reliably and smoothly. The algorithm was employed by the upper and lower cameras to guarantee more accurate route following. It used one for straight-ahead movement, four for left turns,four for right turns, and nine angle intervals for AGVs, which translate to nine velocity levels. The results demonstrate the effective implementation of the vision sensor-based driving algorithm for AGVs on a genuine route guidance system platform in a laboratory environment.

M. De Rycka [3] - gave a thorough review of all AGV- related control methods and algorithms. The author researched the algorithms and methods utilised in the mostrecent AGV in addition to those that were employed in theearly phases of AGVs. The AGV control was broken downby the authors into five main basic tasks. In a decentralised setting, every fundamental task received criticism. The primary benefits and downsides of dispersed control were explored, and several decentralisation models were defined. The centralised technique works well for small systems and is consequently hardly utilised in industry. AGV has access to global information and global optimal.Contrarily, decentralised systems can be built because they have imperfect access to local information.

The authors covered five fundamental processes, including work distribution, localisation, path planning, motion planning, and vehicle management. Task allocationwas nothing but optimally allocated set of tasks to set of AGV's, localization was obtaining exact location map, path planning included generation of obstacle free path from point A to point B, real time modification of path according to dynamic obstacles fall under motion

planning. Vehicle management handled battery, error andmaintenance. This article discusses the most recent approaches and algorithms for AGV system control for both centralised and decentralised architectures, as well as their potential applications in the future. To meet requirements such as flexibility, openness, scalability, androbustness decentral architecture was helpful.

3. EXISTING SYSTEMS

Automated guided vehicle has variety of applications in many different industries. They are widely used to transport raw materials, products, from one sector to another. These systems are also used in local transportation for visitor like Park Shuttle. They come handy in large hospitals for efficient handling medicinal stocks.

There are three types of AGVs based on navigation:

1. *Line following AGV*

As the name suggests, line follower robots are autonomousvehicles that follow clearly marked lines on the ground. Vehicles following the line will follow this clearly visibleline. Most often a black line on a white background is used, but you can also set a white line on a black background. This line follower robot uses an IR transmitter and receiver. Using them, light is sent and received. A white surface reflects IR photons back to theIR receiver, causing a certain voltage fluctuation. IR photons are not reflected when they hit a black surface, sothe IR receiver takes images as they pass the camera andprocesses them to find lines.

Fig 3.1 Line Following AGV

2. *AGV using Environmental Image*

The term "Natural Navigation" refers to a number of technologies! New Natural Navigation Technologies are being developed and marketed by excellent providers. AGV manufacturers have the option of purchasing from asource of navigation technology or creating their own. Simultaneous Localization and Mapping is the most significant technological advancement (SLAM). It meansthat an Automated Guided Vehicle with SLAM Navigationcapability may map its surroundings and its location usinginformation gathered from them. This particular AGV uses visual guiding as its primary means of navigation. The AGVs in this system rely on the features that were recorded by the cameras in order to navigate.

Fig 2.2 AGV Using Environmental Image

3. *Lidar sensor based AGV*

Using sensors that send out laser pulses to estimate the distance between the robot and the objects in its surroundings, light detection and ranging is a navigation technique. This style of navigation is used by the majorityof autonomous vehicles.

By creating a 360-degree picture of the surroundings, thisnavigation technique enables robots to move about the building and avoid obstacles without the use of any external infrastructure. Instead of using radio waves, lidarsends out bursts of light that are reflected off of surfaces and objects and returned to the sensor, where they are picked up by detectors. The system determines how long ittakes the light to travel from its source back to the sensorand then transforms that information into distances. Fromall the distances, a precise point cloud of the surrounds isproduced.

Fig 2.3 Lidar Sensor Based AGV

4. PROPOSED SOLUTION

In RIT all facilities are situated far from each other, currently, there is only one way to move around those places is to walk. Providing efficient and effortless tour byusing traditional vehicle is possible but an ecofriendly option such as electric vehicles will be a better choice. That's why Automated Guided Vehicle comes in the picture. AGV is an electric driverless car will follow preinstalled path using localization with help of markers and direction through path shape detection software and hardware communication protocols such as I2C and SPI.The block diagram for proposed solution i.e., AGV path follower to achieve the abovementioned objectives is

given below in Fig 4.1. The basic structure of AGV is based on modules such as drive control module, steeringcontrol module, obstacle avoidance module, power supplymodule. The details of modules are as mentioned below.

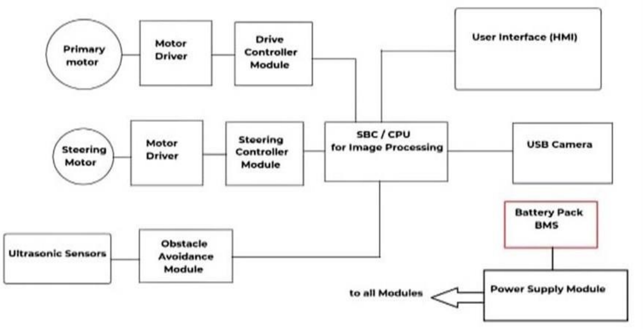


Fig 4.1 Block Diagram for AGV

• *Drive control module:*

The primary motor is of 72v. This motor has an inbuilt driver to control its functionality. SBC is not directly connected to motor as it doesn’t have that much of powerto control it. So, with the help of motor driver SBC controls the motor by controlling its power supply. This motor provides movement of AGV.

• *Steering control module:*

This module control steering motor which is a servo motor. This motor is controlled by inbuild motor driver which is the part of steering control module. This motor driver helps in directing the AGV. The slope of pre- defined path is used as input by this module to decide angle at which steering going to turn.

• *Obstacle avoidance module:*

This module is used to control trigger pin and echo pin. These pins are used for obstacle detection and calculatingdistance from obstacle. Trigger pin sends ultra-sonic soundwaves in environment. Echo pin capture reflection ofultrasonic soundwaves. Reflection represents obstacle presence in front of vehicle. This is vital part of AGV considering safety of vehicle and passengers. Signals fromthis module used to control the speed of vehicle and breaks. Breaks are controlled by a linear DC motor.

• *Power supply module:*

This module is used to control main power supply to different module. Battery Management System (BMS) helps to provide power to all the electric and electronic components of AGV. The main goal is to optimize use ofenergy stored in battery.

• *Human Machine Interface (HMI):*

HMI to give manual instructions to AGV. HMI is the interface between user and AGV. While system seems to be fully automated but considering need of manual override, HMI provides this additional functionality of manual override along with localization and options to choose destination

• *USB camera:*

It is most important input device that continuously captures images of pre-defined path. USB camera situatedunder the vehicle as it’s used for capturing images of preinstalled path. The images captured by camera sends toSBC for image processing. Image processing includes detect the line, calculate the slope of line used to direct andcontrol the speed of vehicle accordingly.

• *Single board computer (SBC):*

Single board computer is central computational part ofautomated guided vehicle. Raspberry pi 4 is used as singleboard computer. Decision making of all modules whichcontrols activities of respective modules in AGV. Activities such as directing, speed control, lights control,image processing, line detection, calculating slope of lineare managed by SBC. Image processing is the activity toprocess the images captured by camera and send thisprocessed image to activities like line detection, shape,slope detection. Image processing helps in following pre-installed path and keep vehicle on track. This is achievedwith help of shape, slope detection activities.

Communication between different modules and SBC is achieved by I2C/SPI protocol. Inputs received from inputdevices like ultrasonic sensor, camera are used to controlthe activities such as speed of motor, lights control and rotation of steering.

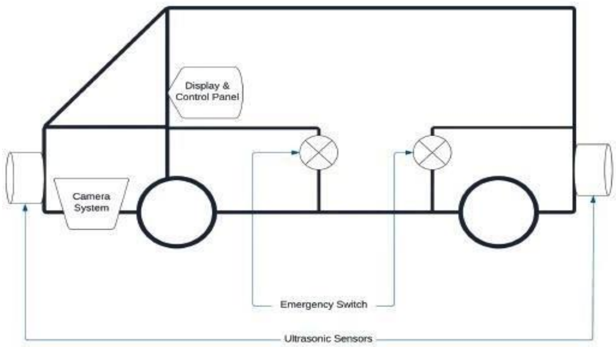


Fig 4.2 Approximate Component Placement Diagram

4.2 IMPLEMENTATION

In our project for lane detection and accordingly movingvehicle we have created 4 separate modules:

1. Main Module
2. Webcam Module
3. Lane Detection Module
    a. Utilities
4. Motor Module

1. Main Module: In this module all other modules are connected so that it will be called automatically wheneverit needs. It will first connect to our webcam module.

2. Webcam Module: Why we have a separate module forwebcam why don't we just add it in our lane detection. The reason is that later on we might actually add a different modules that we need images as well for example

we might need a traffic sign module as well to detect different traffic sites so in that case that we need the imageas well so if we put image code in each of the modules thatwill be a bad way to do it so we will have one module to capture the image and then it will send it to the main module and from their own words it will send the imagesto whichever module requires it so in this case it is required by our lane module.

3. Lane Detection Module: In this we are going to sendour image captured by webcam and it will send back us thecurve value so we are simply sending an image it is doingall the processing by itself and it is sending us the curve value of how much we need to turn in which direction.

a. Utils: Now we also have a utilities file that is linked to our lane module and the reason for thisis that we don't want to write all the code in one module if it is too long so we will write all the supporting functions in the utilities file and then we can relate to that.

4. Motor Module: So once the curve is reached the mainmodule, we can send this curve to our motor module which will turn the motors based on the speed we have provided and based on the turn that we have provided or we have received from the lane module.

So, this is the main structure of our code.

4.3 ALGORITHM

1) Getting the Curve

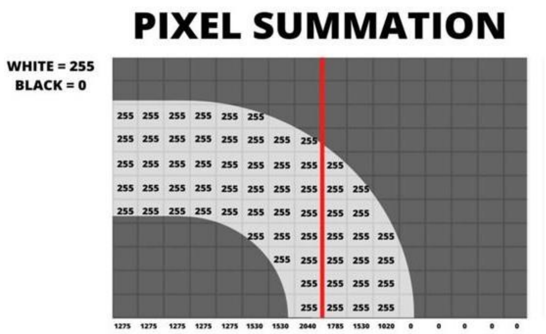
    Now the idea here is to get the path using Color.

2) Warping Lane

    We don't want to process the whole image because we just want to know the curve on the path right now and not a few seconds ahead. So, we can simply crop our image, but this is not enough since we want to look at the road as if wewere watching from the top. This is known as a bird eye view, and it is important because it will allow us to easily find the curve. To warp the image, we need to define the initial points. Thesepoints we can determine manually. So, to make this process easier we could use track bars to experiment with different values. The idea is to get a rectangle shape when the road is straight.

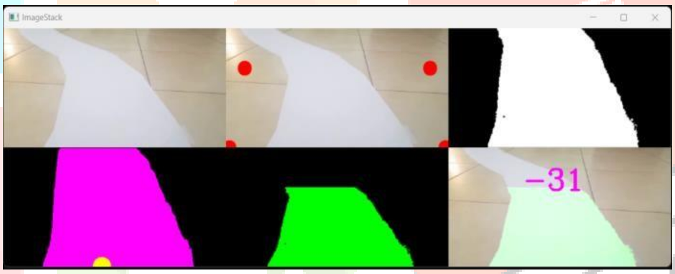
3) Finding Curve

Now comes the most important part, finding the curve in our path. To do this we will use the summation of pixels. But what is that? Given thatour Warped image is now binary i.e., it has either black or white pixels, we can sum the pixel valuesin the y direction. Let's look at this in more detail.



The picture above shows all the white pixels with 255 value and all the black with 0. Now if we sum the pixels infirst column it yields 255+255+255+255+255 = 1275. Weapply this method to each of the columns. In our originalImage we have 480 pixels in the width. Therefore, we willhave 480 values. After summation we can look at how many values are above a certain threshold hold let's say 1000 on each side of the center red line. In the above example we have 8 columns on the left and 3 columns onthe right. This tells us that the curve is towards left. This isthe basic concept, though we will add a few more things toimprove this and get consistent results. But if we look deeper into this, we will face a problem. Let's have a look.

4.4 Output



5. FUTURE SCOPE

In next phase of Automated Guided Vehicle development,we are intended to prepare fully functional AGV. Next phase involves various tasks like speed control, lights control, steering control module. Major objective of next phase is integrating software modules and hardware components which includes implementation and deployment of remaining modules of AGV.

6. CONCLUSIONS

Automated Guided Vehicle is intended to build a vehiclewhich will follow the pre-defined path to reach the selected destination within a facility of RajarambapuInstitute of Technology. The implementation of differentmodules like image capture, video capture, colordetection,shape detection, edge detection & masking are performedon trial basis for AGV. The functionality of different sensor like ultrasonic sensor has been performed. Raspberry pi 4 is ready to work as SBC in AGV project.

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