"DESIGN, FABRICATION AND SIMULATION OF OMNI DIRECTIONAL WHEEL OPERATED AUTOMATED GUIDED VEHICLE"

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ABSTRACT:

An automated guided vehicle (AGV) is a mobile robot that follows markers or wires in the floor, or uses vision, magnets or lasers for navigation. They are most often used in industrial applications to move materials around a manufacturing facility or warehouse. In this paper a review concerning practical applications for mobile robotic platforms based on special wheels (in this case, omnidirectional wheel) is presented. The paper also consists of detailed review on design, construction, manufacturing and simulation of AGV. It includes programming for Arduino mega 2560 with Adafruit motor shield to run each omni wheel individually with help of DC geared motor. Mobile robots equipped with four omni wheels have the omnidirectional property, which means, they have the ability to move instantaneously in any direction from any configuration. Therefore, compared to conventional platforms, these vehicles possess multiple advantages in terms of their mobility in narrow spaces or crowded environments.

Keywords:
Omni wheel, Arduino mega 2560, Adafruit motor shield, ultrasonic sensor, AGV.

INTRODUCTION:

An automated guided vehicle (AGV) is a vehicle that is driven by an automatic control system that serves the role of the driver. Sensors on the road or infrastructure and onboard the vehicle provide measurements about the location and speed of the vehicle in order to follow certain position and speed trajectories. AGVs are considered to be the most flexible type of material handling system.

We have manufactured the Unit load carrying AGV with a self guided control system. Our AGV consists of an inertial guidance system in which arduino is used for programming and an ultrasonic sensor for obstacle detection.

Omnidirectional wheels have been used in robotics, in industry, and in logistics for many years. By reviewing and analyzing .

systematically the existing literature concerning this type of wheels, it was revealed that systems based on omni wheels detain omnidirectional capabilities, whereas systems based on conventional wheels do not.

The main moto of choosing this particular area of material handling is to minimize the man power in such systems and to empower automation in this sector to increase productivity. The global requirement for today majorly supports towards automization with less investments and better technologies. Many types of AGVs worked up-till now do not consist of omnidirectional or mecanum wheels. Omnidirectional wheel or mecanum wheel not only have zero turning radius but also has special feature to travel diagonally. Thus, we have implemented these features of omnidirectional wheels to automate the transportation on the shop floor using AGV.

DESCRIPTION OF COMPONENT:

1. Automated Guided Vehicle

Automated guided vehicle is a material handling system. The main objective of the research of AGV is automation in general for improving terminal capacity and efficiency in the context of the agile port concept. In particular, several automated container terminal concepts that employ AGVs are developed and evaluated using a computer performance and cost model.

AGV has been applied for the flexible manufacturing system. Many factories have adopted it into assembly line or production line such as automobile, food processing, wood working, and other factories. Many researchers developed and designed in order to suite with their applications which are related to the main problem of factory. Automatic Guided Vehicle (AGV) has firstly developed and conducted the research by in the attempt to using at Jumbo Truck Manufacturing in Thailand. PLC was used earlier for the programming of AGV. Modern AGVs are computer controlled vehicles with onboard microprocessors, arduino and Position feedback system to correct path. Communication between vehicles via system controller

- RF communication
- Electric signals

System management is done by computers for optimizing the use of AGV. It also includes tracking of material in transfer and directing the AGV traffic. In short AGV is a driverless vehicle operated

with electric motors and battery which has programming capacities for Destination, Path selection, Positioning, Collision avoidance.

Types of AGV

- AGVs towing vehicle:
- AGVS unit load carriers:
- AGVs pallet trucks:
- AGVs Forklift Trucks:
- AGVs light load transporters:
- AGVs Assembly-line Vehicles:

Important issues for AGVs

Guidance system

1. The goal of an AGVS guidance system is to keep the AGV on predefined path.
2. One of the major advantages of AGV is ease in modification given by the guidance system for changing the guide path at low cost compare to conveyors, chains, etc.
3. Another benefit is to guide path is flexible which means intersection of path is possible.
4. Generally, guide path does not obstruct other systems.
5. The guidance systems can be selected based on the type of AGV selected, its application, requirement and environmental limitation.

Types of guidance system

Wire-guided- An energized wire is rooted along the guide path. The antenna of the AGV follows the rooted wire.

1. Optical- Colorless florescent particles are painted on the floor. Photo sensors are used to track these particles.
2. Inertial- The guide path is programmed on a microprocessor which is fixed on the AGV. Sonar system is incorporated for finding obstacles.
3. Infrared- Infrared light transmitters are used to detect the position of the vehicle. Reflectors are affixed on the top of vehicle to reflect the light.
4. Laser- Laser beam is used to scan wall-mounted bar-coded reflectors. Accurate positioning can be obtained
5. Teaching type- AGV learns the guide path by moving the required route. Sends the information to the host computer.

AGVS control system

1. Computer controlled system
   - The path controller controls the guide path of AGVS. Sends information to AGVS process controller.
   - Process controller directs movement of vehicles
   - Interchanges information with the host computer
   - Most Expensive and complex type of control.
2. Remote dispatch control system
   - Instructions are issued to vehicle from a remote control station via a human operator.
   - Control system sends instruction directly to vehicle.
   - The human operator does have the direct control over the vehicles.
   - This type of system generally has automatic loading and unloading capability.

3. Manual control system
   - The destination is fed on the onboard control on the vehicle via a human operator after loading.
   - The vehicle moves through the guide path for the destination by itself.
   - Reaching destination, it stops for the human operator to direct unloading.
   - Least expensive control system.

We have used Manual control system in which the destination or the path is programmed on the vehicle by a human operator.

Advantages of AGV

1. Unobstructed movement
2. Flexibility
   - Locations, path, P/D points can be reprogrammed
   - Easy to change guide path system
   - Number of vehicles can be altered depending on requirement
3. Greater reliability
   - Less environmental problems
   - AGV can be replaced by another, in case of failure.
4. Lower investment
5. Higher operating savings on long run
   - Minimal labor cost
   - Easy maintenance
6. Easy to interface with other systems
   - Best choice for AS/RS, FMS

2. Omni-Directional Wheels

Omni wheels or poly wheels, similar to Mecanum wheels, are wheels with small discs around the circumference which are perpendicular to the turning direction. The effect is that the wheel can be driven with full force, but will also slide laterally with great ease. There is a line contact between surface and roller of omni wheels. There is chance of slippage. By this kind of wheels all possible direction can be achieve.

(a)Side view

(b)Front view

Figure 1: Omni directional wheel

Specifications:

- Outer diameter is 58mm
- Double strand wheel
- Weight bearing capacity upto 3kgs

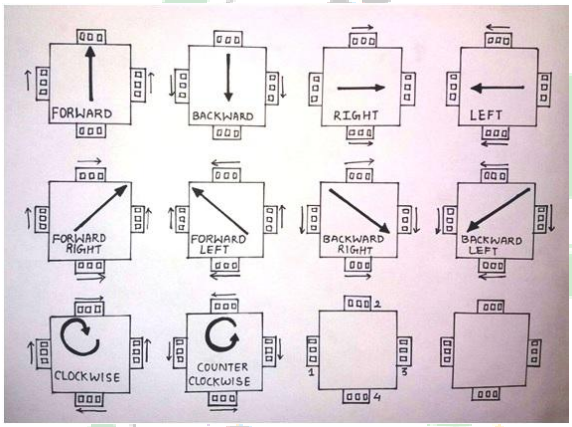


Figure 2: Omni Wheels mounting position and Direction of AGV

Forward Side Direction	:	Wheels 1 and 3 are moving in forward direction.
Rear side Direction	:	Wheels 1 and 3 are moving in backward direction.
Right side Direction	:	Wheels 2 and 4 are moving in forward direction.
Left side Direction	:	Wheels 2 and 4 are moving in backward direction.
Clockwise Direction	:	Wheels 1 and 3 are moving in forward direction and wheels 2 and 4 are moving in backward direction.
Counter clockwise Direction	:	Wheels 1 and 3 are moving in backward direction and wheels 2 and 4 are moving in forward direction.

Table: Comparison with other wheels

Type of wheel	Advantages	Disadvantages
Omni wheels	1.Low weight, compact Design. 2. Simple mechanical design. 3. Commercially available.	1. Discontinuous wheel contact or variable drive-radius. 2. Sensitive to floor irregularities.
Mecanum wheel	1. Compact design. 2. High load capacity.	1. Discontinuous wheel contact. 2.High sensitivity to floor Irregularities. 3. Complex wheel design.

3. Arduino Mega

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Simply, you load on some code and it can read sensors, perform actions based on inputs from buttons, control motors, and accept shields to further expand its capabilities. All Arduino boards have one thing in common; they are programmed through the Arduino IDE. This is the software that allows you to write and upload code. The number of inputs and outputs (how many sensors, LEDs, and buttons you can use on a single board), speed, operating voltage, and form factor are just a few of the variables. Some boards are designed to be embedded and have no programming interface (hardware).

The Mega 2560 consists of 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Figure 3: Arduino Mega 2560

Features:

- ATmega2560 microcontroller
- Input voltage - 7-12V
- 54 Digital I/O Pins (14 PWM outputs)
- 16 Analog Inputs
- 256k Flash Memory
- 16Mhz Clock Speed

4. Adafruit Shield

The Adafruit motor shield is a driver module for motors that allows you to use Arduino to control the working speed and direction of the motor. An Arduino shield is used for easily controlling motors like DC motors, steppers, servo motors and more. The current carrying capacity of the shield is suitable for the motor and the maximum voltage sustained by the shield is 9volts.

Figure 4: Adafruit Shield

- Up to 4 bi-directional DC motors with individual 8-bit speed selection (so, about 0.5% resolution).
- 4 H-Bridges: L293D chipset provides 0.6A per bridge (1.2A peak) with thermal shutdown protection, 4.5V to 25V.
- Pull down resistors keep motors disabled during power-up.
- Big terminal block connectors to easily hook up wires (10-22AWG) and power.
- Arduino reset button brought up top.
- 2-pin terminal block to connect external power, for separate logic/motor supplies.

5. DC Geared Motor

A motor is an electrical machine which converts electrical energy into mechanical energy. The DC Motor runs on direct current and gears are used for speed reduction. The speed reduction is necessary to get the essential torque to carry the specific weight for which the AGV has been designed. As the load on a motor increases, speed will decrease. The basic working principle of motors is “whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force”.

Figure 5: DC Geared motor

Specifications of the motors:

- 100RPM 12V DC motors with gearbox
- 6mm shaft diameter with internal hole
- 125gm weight
- 1.2kgcm torque
- No-load current = 60mA(Max)
- Load current = 300mA (Max)

6. Battery

Lead-acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Here two 4V batteries are connected in series to provide 8V DC supply to adafruit motor shield.

Figure 6: Battery

7. Ultrasonic Sensor

We are using the ultrasonic sensor for obstacle detection so that our automated guided vehicle can fully be automated. This sensor consists of the transmitter and receiver, transmitter transmits the signal and this signal is revered back by the obstacle and received by the receiver.

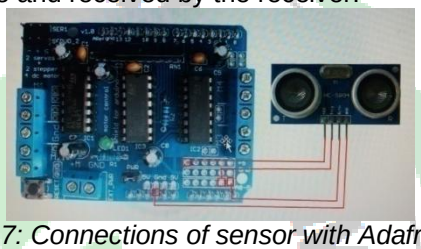


Figure 7: Connections of sensor with Adafruit shield

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats do. It offers excellent non-contact range detection with high accuracy. The range of the sensor is from 2cm to 400 cm. Its operation is not affected by sunlight or black material.

Features:

- Power Supply :+5V DC
- Quiescent Current :<2mA
- Working Current: 15mA
- Effectual Angle: <15°
- Ranging Distance : 2cm – 400 cm
- Resolution : 0.3 cm
- Measuring Angle: 30 degree
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm

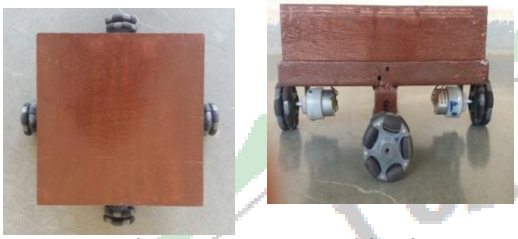
Pins:

- VCC: +5VDC
- Trig : Trigger (INPUT)
- Echo: Echo (OUTPUT)
- GND: GND

FABRICATION:

Automated Guided vehicle is a robot that can deliver the materials from the supply area to the technician automatically. This is faster and more efficient. The robot can be accessed wirelessly i.e. a technician can directly order the robot to deliver the components rather than order it via a human operator. To avoid collision, a proximity detector has been added which causes the robot to stop as long as there is an obstacle in its way, thus avoiding accidents.

The fabrication is all done on the basis of load carrying capacity of each omnidirectional wheel used which is 3kg. As such four wheels are used one at centre position of each frame side, so the total capacity of AGV becomes to be 12kg. But considering the mass of different components as shown in table below and making some assumptions, the actual load carrying capacity of AGV is 8kg.



Top view *Side view*

Figure 8: Automated Guided Vehicle

Let us study all the components in details:

1. Frame

The frame is the base of automated guided vehicle as it works as supporting structure for other components such as Arduino mega board, Adafruit motor shield, motors, wheels, etc. Thus base must be strong enough. Considering all the factors (such as load carrying capacity, uniform load distribution, strength, etc), the frame of 10 × 10 inches made-up of iron material was decided.

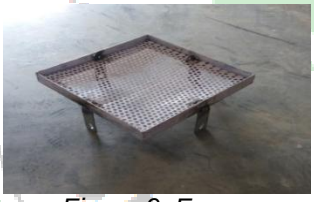


Figure 9: Frame

The perforated sheet of very small thickness made-up of iron was cut and inserted fit into the structure made.

After ensuring proper alignment of frame, the dc geared motor is fitted into the hole of small vertically welded L-angles and fixed permanently to damp vibrations while motion and for proper alignment of wheels. Also the nut with the gear motor is locked tightly after L-angle in between.

The shafts of the motors are grinded to 4 × 5 mm rectangular upto length of 11mm. The bush of omnidirectional wheel fits on this shaft. Hence wheels get tightly fitted on the motor shaft and providing proper motion to the AGV.

Wire connections of motors are done to adafruit motor shield by passing via holes of perforated sheet. The 8volt power supply is given to adafruit motor shield through the battery.

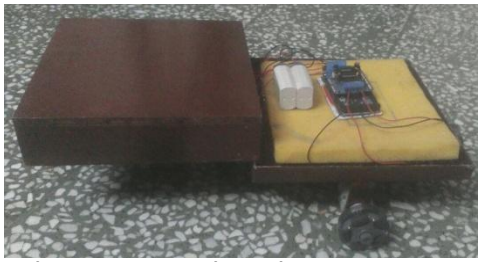


Figure 9: Mounting other components

2. Wooden cover box

The wooden cover box of 24.5 * 24.5 cm and 6.5cm in height was made. The purpose of this wooden box is to cover all the electronic components (Arduino mega board, Adafruit motor shield, battery and the connections) to keep them safe. Along with that it also provides base platform for any type of material to be placed on it to transport them to final destination. This box consists of on/off switch of AGV and charging point for battery. The box also provides look to the AGV. The wooden cover is as shown in the figure below.

Figure 10: Wooden cover box

CALCULATIONS FOR AGV:

According to the current supplied by the battery and shield, the motor has been selected. The torque given by the motor is suitable for carrying the considered weight of AGV which is shown by the calculations given below:

- Maximum weight =2.5kg
- Total weight(assume) = weight of vehicle + external weight

Specifications:

- Motor torque =0.117Nm
- Omni wheel radius = 0.029m
- Motor speed=100rpm
- Coefficient of friction=0.058

Where,
N=speed of motor in rpm
T=torque of motor in Nm
M=mass in kg
F=force in N

- Weight, W =2.5 kg =24.52 N
  Weight on each wheel=W/4=6.13N (downward)
- Reactions on each wheel=6.13N (upward)
- Frictional force = μ×R =0.58× 6.13 =3.555 N
- Required torque T =F×r =3.555×0.029 =0.103Nm

- Circumference of wheel=π×d
  =π×0.058
  = 0.182m
- Distance travel by wheel = 0.182m
- Power (P) = 2×π×N×T/60
  = 2×π×100×0.1172/60
  P=1.227 Watts

PROGRAM FOR AGV:

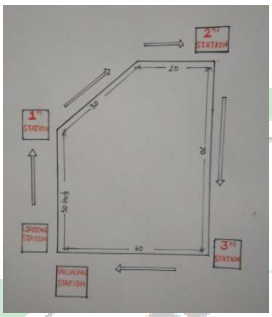


Figure 11: Path layout

CODING

```
// SIM CARD SHAPE
#include <AFMotor.h>
AF_DCMotorMotor1(1);
AF_DCMotorMotor2(2);
AF_DCMotorMotor3(3);
AF_DCMotorMotor4(4);
void setup() {
Serial.begin(9600);   // put your setup code here, to run once:
Serial.println("Motor run!");
}
void loop()
{
Motor1.setSpeed(250);
Motor2.setSpeed(250);
Motor3.setSpeed(250);
Motor4.setSpeed(250);
//turn forward
Motor1.run(FORWARD);
Motor3.run(FORWARD);
delay(5000);
Motor1.run(RELEASE);
Motor3.run(RELEASE);
delay(1000);
//turn diagonal
Motor1.run(FORWARD);
Motor2.run(FORWARD);
Motor3.run(FORWARD);
Motor4.run(FORWARD);
delay(3000);
Motor1.run(RELEASE);
Motor2.run(RELEASE);
Motor3.run(RELEASE);
Motor4.run(RELEASE);
delay(2000);
//turn rightside
Motor2.run(FORWARD);
Motor4.run(FORWARD);
delay(3000);
Motor2.run(RELEASE);
Motor4.run(RELEASE);
delay(1000);
//turn backward
Motor1.run(BACKWARD);
Motor3.run(BACKWARD);
delay(7000);
Motor1.run(RELEASE);
Motor3.run(RELEASE);
delay(2000);
//turn leftside
Motor2.run(BACKWARD);
Motor4.run(BACKWARD);
delay(7000);
Motor2.run(RELEASE);
Motor4.run(RELEASE);
delay(3000);
Motor1.setSpeed(0);
Motor2.setSpeed(0);
Motor3.setSpeed(0);
Motor4.setSpeed(0);
Motor1.run(RELEASE);
Motor2.run(RELEASE);
Motor3.run(RELEASE);
Motor4.run(RELEASE);
delay(1000);
}
```

FUTURE SCOPE:

The project that we have developed can be considered as a base for further development. The lot of development can be done such as –

- Replacing omni wheel with Mecanum wheel results in increase surface contact as omni wheel has point contact while Mecanum wheel has line contact with surface. This also helps to reduce the chances of slippage.
- We can use raspberry pi3 or any other advance central unit in place of arduino mega 2560 which provides large memory and more features. Raspberry pi3 simplify the problem of complex programming. It automatically stores the path when it is followed once.
- Various mechanical mechanisms can be added to AGV for loading and unloading purpose as per our requirement. Ex: lifting mechanism.
- The high torque motors and higher version motor shields can be applied to increase load carrying capacity of AGV.

CONCLUSION:

The results of the individual and overall testing of the proposed AGV are very encouraging. One of the remark-able features of the result is its reproducibility. It gives a great tool in the hands of developer to modify the data with suitable calibration. Without this feature no AGV systems can be brought into the existence. The other achievement of this design is discrete control of the DC motor based steering system. The coordination of dc motor along with the detection system helps to locate the obstacle and is helpful for the avoidance of collision. The integrated working of this whole system opens the doors of closed loop working system.

The Digital operation of system makes the system suitable to be adapted as Commercial vehicle. This feature alone opens immense research possibility in this field of Automated Guided Vehicle Using Artificial Intelligence.

It is concluded that the use of AGV is effective in material handling and promises to meet the driverless movement of vehicle in future.

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