**ABSTRACT**

Automatic Guided Vehicles (AGVs) is an intelligent cognitive system that processes signals from ultrasonic sensors, radars, lidars, and different modules to guide themselves without human intervention. With the help of sensors, it will detect any obstacle in front of the sensor, and the vehicle will avoid the obstacle. A centralized control station gets the requests from different compartments and runs the algorithm to assign the path to be followed to reach the destination. The centralized control station designates the work to the robot according to the availability of the robot. Based on the requests generated, the robot goes and delivers the specified goods by following the line and avoiding the obstacles in the most efficient path. When there is more than one request at the same time, a priority is assigned based on the urgency of the task, and a dynamic path is generated to incorporate multiple tasks at the same time in the order of the assigned priority. By establishing dynamic path planning, the system can run efficiently on fewer robots.

**INTRODUCTION**

With the rise of Industrial Revolution 4.0 (Industry 4.0), machines are becoming smarter to take decisions and carry out tasks with the help of Artificial Intelligence (AI). This helps shift the industry’s repetitive tasks to be carried out using robots more efficiently. Automating the industrial processes drastically increases the productivity of the total industry, which in turn helps increase the Return on Investment (RoI). One of the basic forms of automation in industries is automating the movement of materials inside the industry. Automated Guided Vehicles (AGVs) usually have a platform to carry the load or use a tow to move the load. This helps to transport the materials from one location to another more efficiently and avoid human accidents. By making use of AGVs, a company can deploy a group of robots that can carry out tasks that are assigned to them, and this only costs less than an employee’s annual salary, which is why many companies are in the process of incorporating automation to their industries [8]. The global automated guided vehicle market size was valued at USD 3.81 billion in 2021 and is expected to expand at a Compound Annual Growth Rate (CAGR) of 10.2% from 2022 to 2030 [7]. The tow vehicle type AGVs segment dominated the market in 2021 and accounted for a revenue share of over 40%. The unit load carrier segment is expected to rise at the fastest CAGR of 12.4% over the forecast period. Based on the Navigation system the laser guidance segment dominated the market in 2021 and accounted for a revenue share of over 35%, the natural navigation segment is expected to expand at the fastest CAGR of 17.4% over the forecast period. The warehousing segment also dominated the market in 2021 and accounted for a revenue share of over 40%. The assembly segment is expected to witness the fastest CAGR of 13.1% over the forecast period [7]. Hence global automated guided vehicle market has a golden period upcoming which companies are betting their money on. Considering the existing models and requirements of the industries to transport the materials, a bot is designed. The bot will localize itself inside a preloaded map, and based on the requests from the workstations through a web server, a path is generated and sent back to the bot, which it follows to deliver the materials. The paper starts with a literature review of the conceptually related publications and moves on with the design and implementation of path follower, followed by the design of the webpage, communication, and priority handling among the requests.

**LITERATURE REVIEW**

The literature review has been done on three domains: localization, path planning, and communication as these are the important concerns for the project.

**2.1 LOCALIZATION**

Localization is a process that occurs inside the robot to locate itself within an environment. For implementing localization, an Ultrasonic sensor is used to sense the environment, and these sensors are attached to the six sides of the hexagonal platform, this is combined with a servo motor to obtain a 360º coverage [3]. Another method is using the Hall effect encoders, where magnetic phased arrays that contain hall effect sensors are arranged in a pattern to match a magnetic wheel, as these sensors are embedded directly into the motor, they give direct feedback about their position [3]. Another method is using the Inertial measurement unit (IMU), which uses a 3-axis gyroscope and an accelerometer to trace the robot’s path and localize the bot in a given map [1]. Inertial Navigation System (INS), uses odometry readings and IMU readings to provide an implicit position relative to the initial position. It involves integration and suffers from a huge error due to the drift of sensor values. One other method is to obtain distance from power loss of beacon signal from references, it suffers from loss of communication or magnetic interference from the external environment [5]. Due to modern architecture in building structures in indoor environments, a technique must be developed to cope with issues like Line of Sight (LOS) and Non-Line of Sight (NLOS) or several multipath conditions [6]. The main issue to be addressed is the question Where am I? from the robot. There is a possibility of mislocating the robot from the above-listed methods, one possible way to tackle this problem is the use of laser-based localization which is on the higher side on the price front. To make the robot affordable to all people, a software-based check of location is incorporated. As the robot always follows the line and passes through the junctions, the location of the robot could be updated whenever the robot crosses a junction since the path is already defined. The algorithm works on the principle of the flow chart below. [10].



Figure 2.1 Tree-based algorithm for localization [10]

**2.2 PATH PLANNING**

The robot’s path is planned differently for different occasions and is done using several different algorithms. For dynamic environments, Rapidly-exploring Random Trees (RRT) is used which selects random trees and extends them toward the destination point, Dynamic-Window Approach method, the robot’s physical constraints are considered and a safe and efficient path is formed. The Artificial Potential Field (APF) algorithm uses a potential field which is an attractive or repulsive field, that helps in forming the path to the destination based on the effective attractive or repulsive force acting on the robot’s current location. On the other hand, when the environment is stable and can be made into a grid or a graph, the Dijkstra algorithm, A\* algorithm, and Bidirectional search are commonly used [5]. Dijkstra and A\* algorithm works as such, each of the sub-paths of the entire path should be made of the shortest distance. It is just like hopping the tiles which forms the shortest route at the end. Compared to the Dijkstra algorithm, the A\* algorithm uses a lot of memory and heuristics which needs a high computational efficiency, which is why the Dijkstra algorithm is preferred wherever there are no real-time calculations involved.[4]

**2.3 COMMUNICATION**

To send the path and requests to the robot, communication is needed between the host and the robot. The communication should use a lightweight protocol and must be able to support bidirectional communication with the communication open infinitely. The basic model of communication is a client-server model which has a communication protocol Socket communication. Socket communication is based on TCP/IP framework and the server and client work on a specific IP address and port number. It is unidirectional at a specific point in time, i.e., it can either send or receive messages but not both at the same time. There is a possibility of the socket communication getting closed as there is no acknowledgment of sending or receiving messages [8]. MQTT (Message Queuing Telemetry Transport) is a communication protocol that works on the publish-subscribe model of communication, which works with the use of a broker that helps in delivering the messages. It is a synchronous messaging, bidirectional, and topic-focused messaging protocol. It is built on the base of Socket communication but it can handle multiple requests and send messages at the same time due to the presence of a broker for synchronization. Moreover, a change in the topic values can be easily detected and multiple topics can be monitored at the same time. MQTT is a reliable protocol, which has got acknowledgment on sending and receiving messages. MQTT protocol is majorly used in various IoT devices, as it is easier for broadcasting messages and monitoring various unique channel data [9].

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