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Design and Implementation of Automatic Guided Vehicle for Hospital Application

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ABSTRACT—With the advancements of robotic technologies, the medical environments are adopting more and more aspects of automation to enhance the services in hospitals. In pandemic conditions such as COVID 19, direct contact with patients may result in the spreading of disease. Hence the health community finds difficulty in distributing medicines and disposal of waste. The design and development of an automatic guided vehicle for hospital applications, which can be controlled remotely is specified here. AGV is a line follower robot, powered by a battery that can be charged from solar energy. It has infrared sensors at the bottom for path identification and an ultrasonic sensor held in front of the vehicle for obstacle detection. It collects medicines from the nurse's station and follows the path provided to reach the supply point, which is the patient's bed. The sensors provided will detect the bed and opens the corresponding box of medicine. In addition to this, it helps in real-time monitoring of patient's parameters such as temperature, pulse rate, etc. and sends information to the doctor through the internet. AGV also collects waste from the bin and dump it to a proper place.

Keywords—Automatic Guided Vehicle (AGV), Hospital, Drugs, Monitoring, Waste, COVID 19.

I. INTRODUCTION

Technology is evolving day by day. As the population increases, the need for automation in the health care sector is essential. Hence hospitals adopt novel ways to increase productivity and efficiency without investing more in human resources.

On handling pandemic conditions such as COVID 19, the lives of health workers are in grave danger. Nurses and associated workers in the hospital are in fear of getting diseases while working in isolation wards. Therefore the development of

an automatic guided vehicle (AGV) is important for doing hospital functions like the supply of medicines, patient monitoring, and waste management [4]. The noticeable development in the field of power electronic converters and electric drives enhances the growth of AGV. [3].

Many hospitals already adopted some methods for automation, such as conveyors for moving medicines from one place to another. But the automatic guided vehicle is a more reliable system that can be adopted over other automation systems. By using advanced technologies in locomotion and interfaces which ease the handling of the vehicle leads to transplant AGV, which is familiar in the manufacturing sector to hospital environments. [5]

This prototype includes an automatic guided vehicle for carrying medicines, real-time monitoring of patients, and dumping of waste. It helps in cost reduction, better efficiency, proper waste disposal, and reduction of time. Now the hospital is becoming a 4.0 facility, hence the automatic guided vehicle will performing a frequently important part to guarantee excellent performance [1].

II. DESIGNING OF INTERNAL AND EXTERNAL SECTIONS OF VEHICLE

A .Design of mechanical system

Implementation of the aforementioned work required mechanical, electrical, and programming elements. Execution of every element involved planning, development, and evaluation. The mechanical base was built using plywood and iron. The plastic box was placed as the medical box and the carry basket is placed as the waste carrier basket.

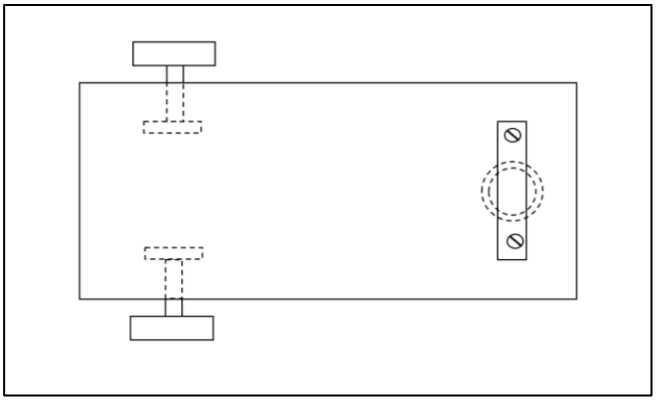

Fig 1: Top view of AGV

B. Design of Navigation and control system

Execution of the electronics section of our work includes, the planning, development, and evaluation of the electronic circuitry. The programming section of our work was done with the help of arduino.

An ultrasonic sensor is placed in front of the vehicle to avoid collision with other objects. L293d is used as the motor driver it can drive the dc motor used for navigation in either direction. Left data in pins will control the motor attached at the left-hand side and, pins on the right-hand side are employed for the motor on the right. The motors are operated based on the information rendered through the input pins such as LOGIC LOW or LOGIC HIGH. The line follower mechanism is employed using Infrared sensors. It has an Emitter, which is an Infrared light-emitting diode and, the detector is an Infrared photodiode placed in the vehicle. Based on the received infrared light, resistance of photodiode and output voltage changes. The light from the infrared LED hits the non-transparent facade, gets collected by the sensors, which recognize the tint of the facade beneath it. It transmits a signal to the microcontroller or the central circuit, which then makes a judgment according to the algorithm established in programming. The infrared beam gets reflected and received from the dark path surrounded by the light tint surface. Black color will absorb the beam falling on it completely. [11]

The crucial element of our work was programming. The initial part of the code is to control the movement of the vehicle to the front, back, left, and right. The microcontroller drives high or low to motor driver according to data inputs from sensors. The motor driver IC controls the motors according to the information from the controller. There are three cases of movement:

- Case 1: AGV will start its movement in forward direction when both motors are turned on at the same time.
- Case 2: The AGV will move to the left when the right motor is turned on, and the left motor is turned off.
- Case 3: The AGV will move to the right when the left motor is turned on, and the right motor is turned off.

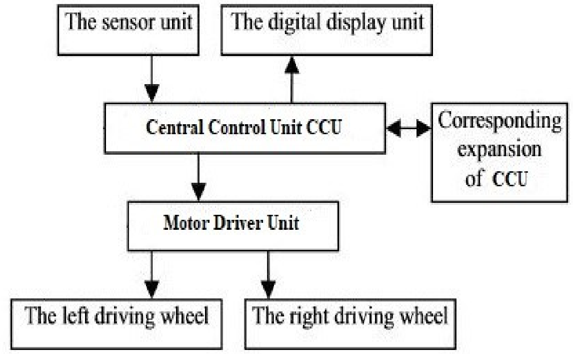

Fig 2: Block diagram representation of vehicle driving system

The main units of the navigation and control system may be classified as follows:

1. Central control unit CCU

The Arduino microcontroller (ATmega328) is used as the processing unit of the automatic guided vehicle. It can convert analog data from sensors to digital data, control motor driver IC to operate motors and storage of digital information.

2. Motor driver unit

The motor driver IC controls the motor and allows the AGV to move forward, backward, and turn.

An L293d is used as the motor drive unit. The main parameters of the driver are as follows:

TABLE I MAIN PARAMETERS

Parameter	Value
Supply voltage	36 V
High-level input voltage	2.3 - 7 V
Low-level output voltage	-0.3 - 1.5 V
Peak output current	-1.3 - 2 V

3. Sensor assembly

Sensor assembly comprises of infrared sensors for path finding and an ultrasonic sensor for avoiding collision. [9] The sensors obtain necessary data concerning the working conditions, position, and posture. They give certain data for the direction, positioning, and obstacle avoidance of the vehicle to achieve the purpose of regulating its movements.

Infrared sensors are placed beneath the vehicle, utilizes the dark and light color lines to accomplish the tracking purpose. Ultrasonic sensors are placed in front of the vehicle to avoid obstacles. Whenever the separation between obstacle and vehicle is less than a secure distance, an interrupt signal to the ATmega328 is generated with the help of ultrasonic sensors to stop the vehicle. [4]

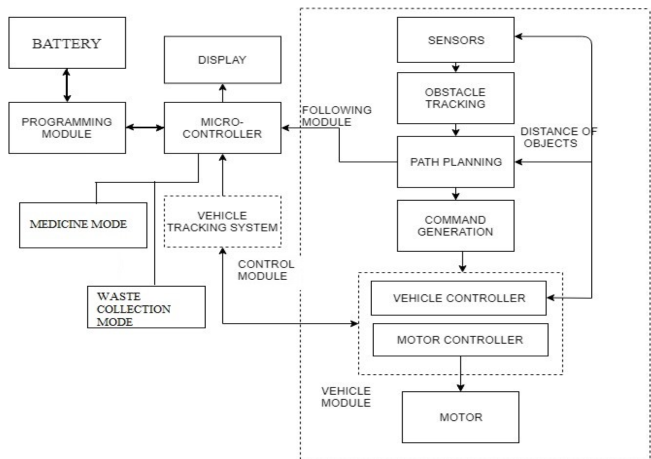

Fig 3: Block diagram of Prototype of AGV for Hospitals

C. Communication Module

An Android app was developed for monitoring patient data and controlling the movement of the vehicle. The communication between AGV and android app is via Bluetooth. The Bluetooth module used in AGV is HC05.

Fig 3. Shows the detailed block diagram of prototype of AGV for hospitals. It consist of various sensors such as ultrasonic sensors and infrared sensors for obstacle detection and path finding. According to the response from the sensors provided, command is generated and is given to the motor driver, here represented by vehicle controller and motor controller block. According to the input received by motor driver, the motor is powered. It also consist of battery, a display which gives various instructions like those given to patients while temperature sensing and also displays the measured temperature. It has two modes of operation, medicine supply mode and waste collection mode. All are connected to the microcontroller.

III. FUNCTIONAL FEATURES OF AGV SYSTEM

A.Medicine supply and patient monitoring

The primary aim of the vehicle is to supply medicines to the patients and monitor their body parameters such as temperature. [12] A control app, Hospital 4.0 was developed using MIT app developer to communicate between vehicle and nurse. The nurse has to select the mode of travel after placing medicines on the box. Once the control signal is given, robot checks for an obstacle in front of the vehicle. [10] If no obstacle is found robot starts its navigation through the black path which is directed by the IR transmitter and receiver signals. When the vehicle reaches near the patient's bed a proximity sensor gets activated sending signals to stop the vehicle. The patient can take the medicine from the box with the help of bystanders.

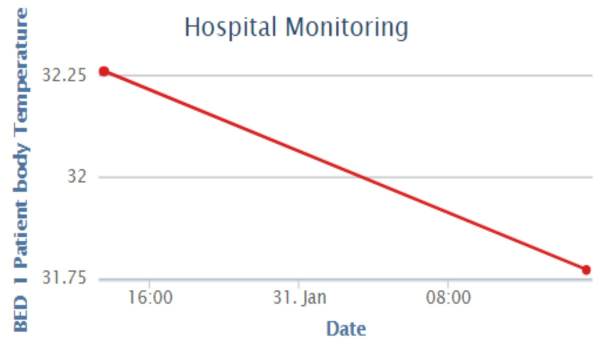

Fig 4: Measured values uploaded and displayed in internet

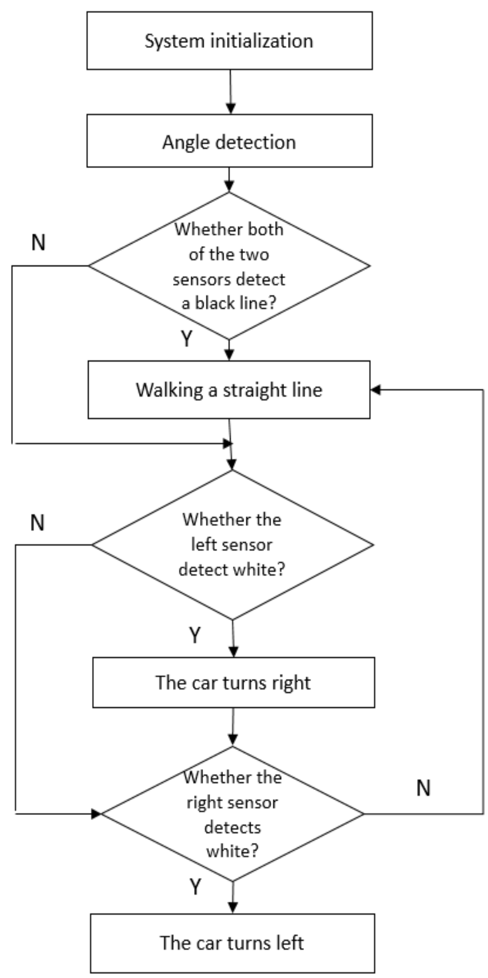

Fig 5: Flowchart for navigation

LED display indicates the directions to tie the temperature sensor band. It has an LM35 sensor. The measured temperature will be displayed on the led screen and it also gets sent to the concerned doctor through the internet.

Fig 6: Medicine supply with comments displayed

B. Waste Collection

Wastebaskets are placed at different parts of the hospital. When the Bot is on the waste-collecting mode it travels through the black path to reach near the bin. Dc motor is used to rotate the bin to transfer waste into the carrying bin in the Vehicle.

Fig 7: Waste collection mechanism of AGV system

Waste from the collection basket is transferred into the front basket. After a predetermined delay, once the whole waste is transferred vehicle moves into the dumping yard or recycling center to eliminate the waste. This mode also uses the line following technique.

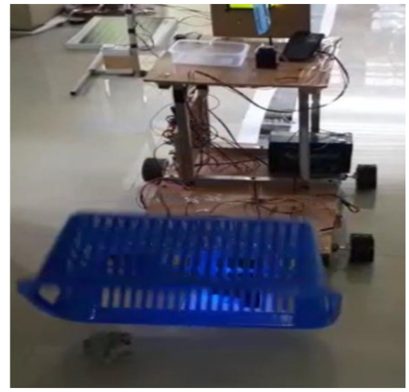

Fig 8: Waste dumping mechanism of AGV system

IV. SOLAR CHARGING OF AGV BATTERY

Automatic guided vehicle for hospital application uses a 12V battery is in plug and play mode which can be charged from solar energy. Due to the average thermal conductivity of substrate material, commercial PV panels cannot provide equal performance [3]. Here the final model of the PV panel is built by utilizing 18 solar cells [7]. The Simulink model of the PV panel employed in the hybrid electric vehicle power systemto support the battery is shown [2].

The output response of the PV panel is obtained in MATLAB using the Simulink model displayed in fig 9. A battery of rating 12v, which is used as the supplementary battery in the hybrid electric vehicle, will get charged from a PV panel. Simulation data shows that the PV panel produces 11.929V initially, whereas the production is diminished until 15.95s. A regular supply of 11.928 V is obtained from the 16th second, and it is equivalent to charge 12V battery. It indicates that the PV panel successfully meets the system constraints.

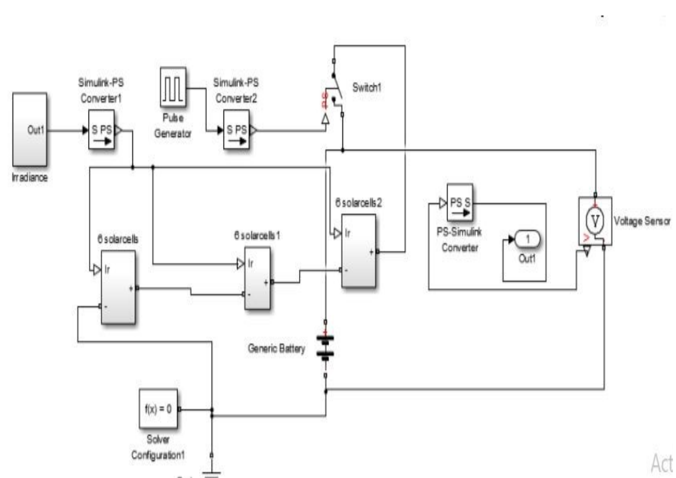

Fig 9: model of PV Panel using simulink

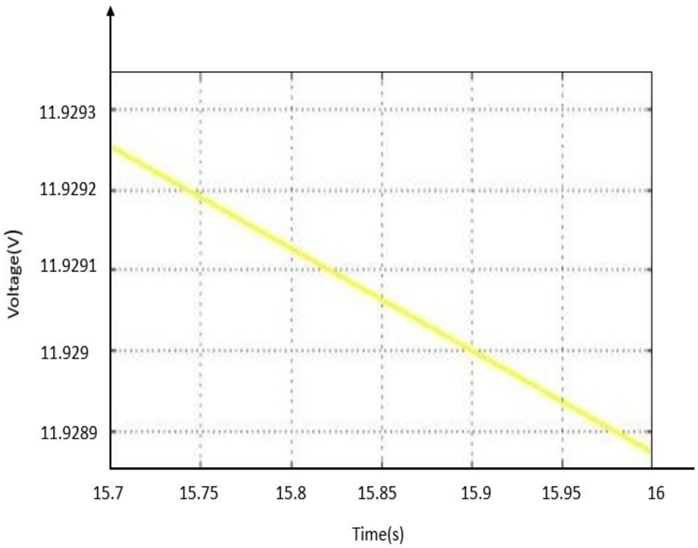

Fig 10: Solar panel response curve

V. EXPERIMENTAL TEST

The working of an automatic guided vehicle prototype is tested for both medicine supply mode and waste mode. The robot is moved in every direction using the android app. The robot successfully navigated through the black path with the help of signals from IR sensors. The presence of human beings and other obstacles are detected with the Ultrasonic sensor. Body temperature is successfully measured with less error using LM35. Results for every bed is transferred to the cloud which can be visible from any parts of the world. The test results prove the efficiency of the above-stated design in delivering medicines and eliminating waste and thereby saving more time and the number of workforces

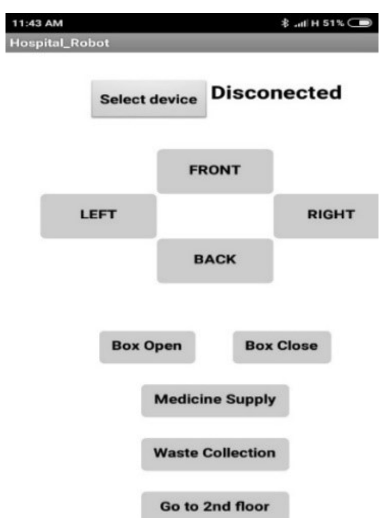

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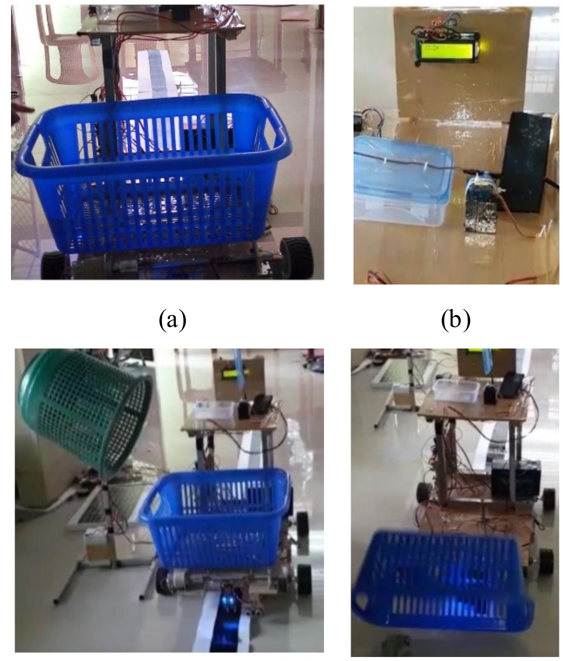
Fig 11: Screen shot of mobile app for test



(a) (b) (c) (d)

Fig 12: Testing of robot (a) Movement of Robot (b) Display of comments (c) Waste Collection by Robot (d) Waste disposal at predetermined place

VI. RESULTS AND DISCUSSION

The prescribed model is intended to work either in automatic or in manual mode. The volume of the wastebasket is 5L, and the waste carrier in AGV is 8L. The prototype is made to serve a single bed that has a single medical box for one bed.

The ultrasonic sensor detects the presence of obstacles when the vehicle starts. If there is no obstacles vehicle will start moving through the black path provided. The path can be sensed with the help of IR sensors. DC motors are used for the navigation of the vehicle through the path. When the vehicle reaches the bed a proximity sensor gets activated which is placed in the sideways. The signal from the proximity sensor triggers the controller to stop the vehicle. As soon as the vehicle stops medicine box will open from which bystanders can take the medicine, Proper directions will be given through the LED display. Sensed data of temperature through the LM35 band will be displayed on LED for patients' information and bed details will be sent to the doctor through the internet. Medical boxes are operated by using servo motors and DC motors are controlled using L293d Motor drivers.

Navigation of the vehicle will be the same for waste collection mode. When the vehicle reaches the bin it transfers the waste into the collection bin with the help of a dc motor.

VII CONCLUSION

This thesis has outlined the construction of an AGV designed for the distribution of medicines and disposal of waste in hospital environments.

The AGV mainly does three main functions, medicine distribution, sensing of body temperature and waste collection and disposal. It collects the medicines for different patients and follows the path provided. On reaching the supply point it supplies the medicine for that particular patient. By the use of a band provided, the body temperature of the patient is measured. It also collects waste from specially designed baskets kept at the passages and properly dumps the waste at a predefined place. This prototype can be used in pandemic conditions for the treatment of affected people. Therefore AGV reduces spread of COVID 19 by avoid direct contact with the people.

The prototype built is lightweight and designed for a single bed. In the future, a step climbing facility can be employed to the bots to improve the application range of the product. More functionalities including monitoring of pulse rate, blood pressure, etc. can be added.

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