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Stair Climbing GPS Enabled Autonomous Wheelchair with Health Monitoring System

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Abstract: - In recent years the health monitoring systems for wheelchair users have drawn considerable attention of the researchers. The key goal was to develop a wheelchair with a reliable patient monitoring system so that health care professionals can monitor their patients, who are either hospitalized or performing their normal daily activities. In this concern we present a mobile device based GPS enabled stair climbing wheelchair with wireless health monitoring system with collision avoidance than can provide real time physiological conditions of a patient through online sources. Our proposed system is designed to climb (up and down) the stairs, autonomous movement of wheelchair to reach destination according to GPS coordinates, to share live location using pedometer sensor, to measure and monitor important physiological data of a patient in order to accurately describe the status of his/her health and fitness. In addition, the proposed system is able to send patient critical health status via SMS and MAIL, so that the healthcare professional can provide necessary medical advising. This system mainly consists of sensors, microcontroller, wheelchair, mobile application. The patient's body temperature, heart beat rate, blood pressure, haemoglobin level in blood and ECG data are monitored and displayed using mobile application.

Key Words: — Wheelchair, microcontroller, heart beat sensor, temperature sensor, stair climbing, collision avoidance, mobile application.

I. INTRODUCTION

More than three-quarters of people who use wheelchairs are unable to walk a quarter mile, and over 60 percent are unable to climb stairs or stand for 20 minutes, and almost 60 percent are unable to walk by themselves without assistance. The aim of our project is to design an autonomous wheelchair that reaches the destination without personal assistance with stair climbing facility. The features of this wheelchair are mentioned below.

- Automatic identification of different blocks.
- Generation of path to reach destination safely.
- Stair climbing facility.
- Seating height adjustment.
- Collision avoidance system.
- Wheelchair cum stretcher.
- Health monitoring system.

With the help of these features people benefitted are

- Those who crawl on their limbs.
- Those who walk with the help of aid.
- Those who have acute and permanent problems of joints/muscles.
- Those who have lost sense of sensation in lower part of the body due to paralysis or other problems.
- Those who have twisted body parts and suffer from any kind of deformity in the body.

II. LITERATURE SURVEY

Along with Arduino Raspberry Pi a mini-computer is interfaced to monitor and control the operation of the robot. The Arduino placed on the robot and the robot will be able to move in any direction. Sensors are placed along with body which will show the depth of the path, and there is a mechanism for plantation and the information will be delivered to next robot using Wi-Fi. The system is not so strong to work in complex field, and range of communication range between the robots will be small [1].

This paper presents using Arduino, which will start moving from source to destination point by finding the path, avoiding the obstacle and video streaming. All the parameters will be achieved by Wi-Fi technology avoiding the Bluetooth module. Path is identified by the aggrandized genetic

algorithm which is best. Here, they failed to communication range for long distance [2].

This paper developed a two-wheeled robot which is compact and portable with an Arduino which is focused on collision detection, avoidance, and avoid to fall from height using Wi-Fi and Bluetooth module [3].

A mobile vehicle made using LabVIEW and embedded hardware. He developed a remote-controlled robot and an autonomous robot using arm processor, and monitoring is done at LabVIEW. The main idea behind this was to explore about the usage of hardware and LabVIEW. He presented Corn robot and luminary micro robot which are based on Arm cortex-M3 [4].

Fang and Duan in this paper they presented system which will identify and extract the features of moving vehicles in LabVIEW. The motor behind their work is to automatically generate and maintain a representation of the background, which can be later used to classify the background and foreground to identify the vehicle. They used the tools available from NI-like NI assistant modules, and in LabVIEW, they kept observation of vehicles. All the concepts are meant to explore the system automatically to for one or other application based on the LabVIEW instead of using other available programming languages [5].

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III. Existing System

Autonomous rovers are changing the world more automatic and becoming a great challenge to humans. The present systems are guided to follow the path line which was already programmed. And we have obstacle avoidance as an additional feature to the present technology.

IV. Propose Design And Development

A. Hardware Development

GPS Module:

The Global Positioning System (GPS) is a space-based navigation system that can provide us latitude, longitude, altitude, date, timing information, speed and many more data that works at any weather conditions. The Grove Ublox NEO 6M GPS module is a low cost serial communication configuration device which is used in our wheelchair. To calculate 2D position (latitude & longitude) and track movement GPS receiver must be locked with at least 3 satellites. Once our position has been determined, the GPS unit can calculate other information such as speed, distance to destination, track, bearing, trip distance.

Bluetooth module:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module designed for transparent wireless serial connection setup. The serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps modulation with complete 2.4GHz radio transceiver and baseband. The BT Bluetooth module is a stackable shield with serial ports based on HC-06 module. The shield can be connected directly to the Arduino UART port for wireless communication. Without obstacles or other interface, the shield can communicate in a range of 10mt (32ft).

Digital Compass:

We have used a 3-axis Grove digital compass which has a low field magnetic sensing multichip HMC5883L. A magnetometer sensor can sense where the strongest magnetic force is coming from, generally used to detect magnetic North. It provides heading accuracy up to 1◦ to 2◦. We have connected the digital compass with the SDA and SCL pin of the Arduino.

Ultrasonic Sensor:

Ultrasonic sonar sensor (HC-SR04) is used to detect any obstacle in front of the robot. It emits sound wave by its transmitter and receives eco-signal if there is any object in front of it. By calculating the time between transmitting and receiving signal, it can measure the distance of the obstacle away from it.

Heart bear sensor:

Heart beat sensor is designed to give digital output of heart beat when a finger is placed is on it. The heart beat sensor is based on the principle photo phlethysmography. It measures the change in volume of blood through any organ of body which causes a change in light intensity through that organ.

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Relay module:

We are using 4-relay module with 5V from onboard to enable the relay in parallel with 12V battery to run 4 dc-geared motors. It is used as a switch for controlling motor directions and easily compatible with arduino with few control lines.

LCD display:

Liquid Crystal Display (16×2 LCD) is used as a screen to show the direction of the wheelchair and detection of stairs.

B. Block diagram

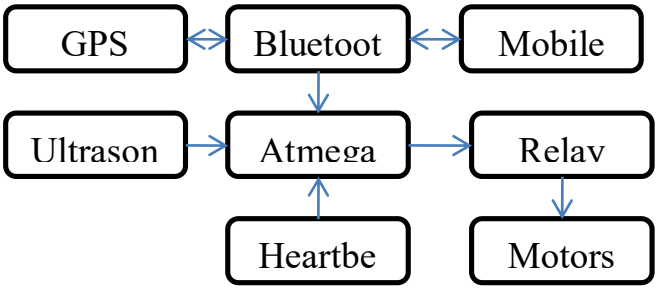


Fig.1. Hardware setup of the proposed model

C. Software Development

GPS Interfacing:

For receiving valid latitude and longitude data, GPS module must have to be locked with four satellites at least or more than four satellites. Usually GPS receiver locks with 8 to 9 satellites. The data set or information received by GPS receiver is called NEMA strings. Each NEMA string starts with a '$' symbol. From NEMA string, there is lots of information to be extracted. For our purpose, we only need the location's information like latitude and longitude. So we have extracted data form $GPGGA NEMA string. Each information in the string is separated by commas in a single line, for example

$GPGGA,120522,2372.486,

N,09039.149, E,1,09,0.9,530.4, M,46.9,M,,*47

This NEMA string means that the data is taken at 12:05:22 UTC, latitude is 23°72.4860 N, longitude is 90°39.1490 E, GPS fix (SPS), Number of satellites being tracked is 9, horizontal dilution of position is 0.9 and altitude is 530.4 meters above from the mean sea level and the check-sum is *47. For GPS data extracting, we have used TinyGPS++ header file in Arduino. Using a baud rate of 9600, we have extracted latitude and longitude information from the NEMA string, latitude and longitude values are then converted into decimal value to calculate the actual heading angle of the robot. After locking the GPS module with satellites, data is obtained in one second interval.

Digital Compass Interfacing:

The digital compass is used for heading angle calculation. We have measured angle with the North Pole and compared it with our target angle. Digital compass uses I2C communication protocol. For I2C communication, we have used 'wire.h' header file of Arduino. We have used continuous measurement mode of the compass and read the data all the time. The 16 bit x and y axis value is used in the calculation of measuring angle. The angle measurement formula is given below.

$$\text{Current angle} = [\![\tan]\!]^{(-1)}(y/x)\times 180/\pi + 180°.$$

Mobile application:

We have developed a mobile application which is connected to the wheelchair with Bluetooth connection. The application was developed using MIT app inventor2 an open source platform for arduino mobile applications. The app consists of two operation modes 1. Manual mode (in case of network problem to mobilize the vehicle using GPS) and 2. Automation mode (in which the wheelchair automatically mobilizes using GPS coordinates).

Manual mode:

In this mode the person has to know the way reach destination without GPS. The wheelchair was directed by user with manual (voice or button) commands. The other features body temperature, pulse rate can be monitored continuously and incase of any critical health conditions an SMS, picture of the person will be sent to the doctor, family members automatically so that they can take care of him.

Automation mode:

In this mode the wheelchair only needs the destination point and it takes the user safely without his assistance. The calculation of directions with GPS coordinates is shown.

The GPS module gives the present location of wheelchair; whenever the user gives destination it automatically shows the

predefined path in mobile application. To reach the destination it will have certain check points, at that point the wheelchair stops and checks whether it was moving in perfect direction and next direction to reach the next check point. If it reaches the last check point it will alert the user with voice command that it has reached the destination.

V. Structural Construction

A. Chasis and Chair

A 1cm thick acrylic sheet has been used for the structure chasis board and chair (dimension 40cm×20cm). The acrylic sheet is transparent and lighter than metal structure. Moreover, it is easy to drill and cut. The chair is fixed on the chasis board with handle to place mobile and magnetometer sensor. On the chassis board, we have mounted Arduino board, LCD display, ultrasonic sensor, motors and mobile phone on handle of chair.

B. Motors and wheel structure

The 12V, 220 rpm 4 DC geared motors are mounted on the acrylic sheet using clamp. The 3 wheels are screwed with the motor in triangle structure and used 7 gears to rotate all the 3 wheels with single motor as shown in fig2. So totally we used 12 wheels with 21 gears. The structure was designed in such a way that, whenever the first wheel on the flat surface hits the stair due to the external acted on it the whole set rotates and second wheel top starts stepping and moves. This structure of wheels even helps the wheelchair to move in uneven surfaces.

VI. Path Planning

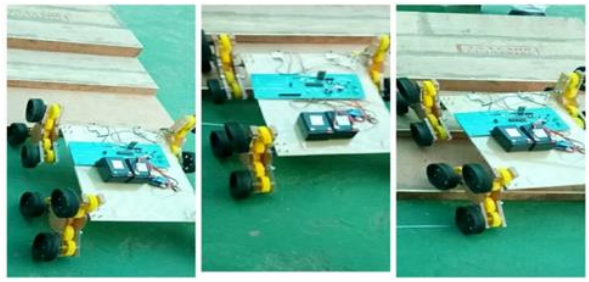
In order to travel from one location to another location, the GPS generates a series of direction oriented waypoints leading to reach the final destination. Each waypoint is destined by repeating the process of obstacle avoidance and selecting the path. The basic system to avoid obstacles and hazards to reach destination was discussed and it has the capability to stop if it finds the risky and unsafe. The map is displayed in mobile application and it constantly updates once the rover moves or changes its location. The path is selected by analyzing two considerations both safety and efficiency. By making these two considerations the rover selects the optimal path to reach the destination.

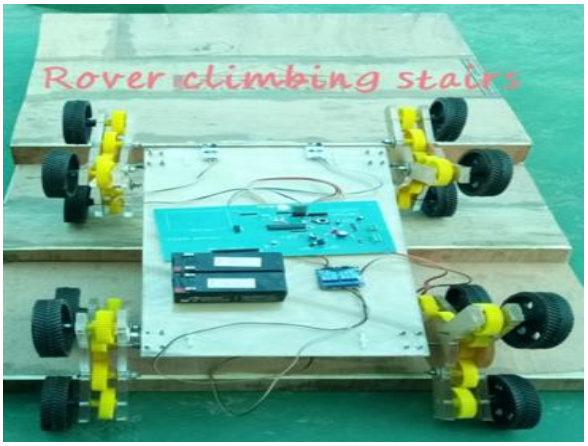
VII. Test And Results

By doing several tests, we studied the battery consumption was high due to the heavy usage of wheels for stair climbing. This can be solved by placing solar panels to provide power supply instead of batterys.

We observed these things while testing

- GPS is always on and transmits data continuously and location was updated successfully.
- Mobile application is able to receive data via Bluetooth without any loss.
- Ultrasonic sensor was able to detect obstacles and sends data to stop moving by that safety was given.
- Heartbeat sensor was properly detecting pulses for every 10 seconds and updates data.





VIII. Future Scope

In multiple missions, researchers have demonstrated autonomous rover capabilities. Automatic navigation not only enhances target approach it also improves vehicle safety and efficiency. It will be playing key role in crucial times. Further it can be linked to the traffic management system to avoid heavy traffic and also to the toll plaza gates for automatic allowance of these types of rovers.

IX. Conclusion

Autonomous rovers are still in infant stage and many challenges have to be rectified. The gradual progress in these

areas will definitely increase the efficiency and safety of autonomous rovers. These rovers will provide lead to the commercial use in various industries like transport industry, exploiting mineral resources, medical and military purposes.

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