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Wireless Position Tracking of a DTMF based Mobile Robot using GSM and GPS

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Abstract

The advent of new technologies has revolutionized the era of embedded system design in a way that every user is surrounded by smart devices (robots) which makes their life easier and comfortable. It has also been predicted by the researchers that by 2020, there will be billions of embedded devices talking to each other as compared to human beings termed as Internet of things (IOT). This paper is generally appropriated with the development of autonomous mobile robot used for wireless position tracking using GPS and sending that precise information on to a device such as mobile or tablet using GSM. This robot is equipped with GPS (for detection of location), GSM (for wireless data transfer), DTMF (for controlling robot with mobile or tab), sonar sensor (for obstacle detection) and flash light (for night vision). This mobile robot has wide variety of applications in industries like defense, aerospace, agriculture, and security etc. The basic functionality of the proposed design is simulated on proteus 7.1 and the complete design is implemented around ARM7 controller with required necessary interfaces.

Keywords: DTMF, GPS, GSM, NMEA Standards

1. Introduction

In Modern era of science and technology, Robotics has played a vital role in enhancement of not only technological aspects but also contributed a lot in human being day to day schedule. Approaching towards the next level of technology, robotics has become a blooming topic of concern for researchers such that maximum part of robotics applications can be explored and may become useful for human being. Previously robotics is limited to certain technologies such as RF based robots or Bluetooth or Wi-Fi controlled robots but as the technology has advanced in field of internet of things robots can be controlled globally through pre-fetching data from anywhere and then controlling our device. In aspect of increasing lifespan of robot energy conservation is more important generally in case of battery based robots. The GPS module is attached on the mobile robot. We designed it in a way such that it will send location's information in terms of Longitudes and Latitudes to the user with the help of attached GSM Module. The possible application of our project can be extensive.

2. Planned Architecture

The goal of the anticipated system is to develop an autonomous robot system that will generate information in terms of Longitudes and Latitudes of a location wherever it is directed by the User and also being capable of sending that information through GSM. The system

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consists of ARM7 microcontroller (LPC2148) with Two UART's interface. ARM chip is given the preference over all other processors as it acquire soaring process speed and numbers dealing out capability and effortless to bear out a fitted structure growth. The microcontroller which we have used in our project is LPC2148 of NXP founded by Philips organization which is an ARM7 TDMI-S based high performance 32-bit RISC controller having tremendous configuration in comparison to other controllers such as thumb extensions and on-chip 512N kb Flash ROM with two 10 bit ADCs containing 14 channels. Other than that it contains 2 UARTs, 2.0 USB full speed device controller, one full modem interface, two 32 bit timers and on chip crystal oscillator providing CPU clock up to 60 MHz. In communication interfaces controller provides two I2C serial interfaces and SPI interfaces. We have used GSM for communicating with the device and it's interfacing with the controller is an important prospect. The data communication is done by using the GSM module through MAX232 into the SBUF register of LPC2148 microcontroller. The signals from an RS-232 serial port are converted by MAX232 IC to signal appropriate for use in TTL companionable digital logic circuit

For the direction control of our robot, we have used DTMF decoder IC named MT8870 which decodes the DTMF (Dual Tone Multi Frequency) tone into its equivalent binary digit and then correspondingly that number is sent to the microcontroller. This dual tone is generated by a remote area mobile phone controlled by user and preceding to it one mobile phone is attached to the robot to receive remote frequency tones. Microcontroller understands this frequency the way it is preprogrammed and according to that it takes decision for the motors to rotate in clockwise or anticlockwise direction summing for the movement of robot either in forward or backward motion or take any other movement.

The GPS is a main factor of our project. It is the component that provides the robot with its position. In general, Global Positioning System (GPS) has been used to determine the actual position of location. Mobile robots utilize it as a means to recognize their own position in global coordinates. However, especially in urban and sub-urban environments, there exist significant problems to achieve highly accurate and versatile positional estimations using GPS because of different kinds of surroundings (e.g. Buildings and trees nearby) that usually give rise to the fatal position error known as multi-path error. Since our robot is for small distance, we have neglected this phenomenon.

Sonar sensors are used for the obstacle avoidance. Being further receptive than IR sensors, Sonar sensors are the favored option for barrier dodging. In general, a solitary sonar sensor is preferred at the front of the rambler. In fact we have used two sonar sensors, one point a speck to the right and another one a speck to the left, to barely perceive obstacles except shove absent from them.

3. System Implementation

The host will give the commands to the controller using DTMF module to operate the robot in specified direction. Robot will receive the specified coordinates with the help of GPS which will be enriched by the controller using GSM. So basically we are getting the exact position of robot in terms of Latitudes and Longitudes i.e. co-ordinates.

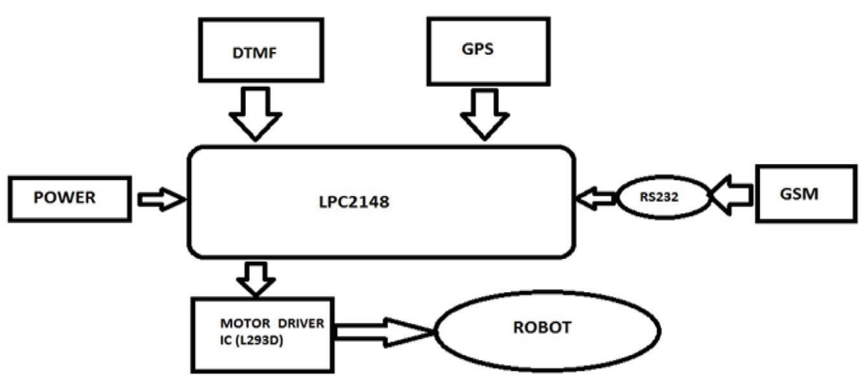

Figure 1. Block diagram of complete system.

3.1 Automation of Robot using DTMF Module

As it is discussed earlier that for the direction control of our robot, we have used DTMF decoder IC named MT8870 which decodes the DTMF (Dual Tone Multi Frequency) tone into its equivalent binary digit and then correspondingly that number is sent to the microcontroller. This dual tone is generated by a remote area mobile phone controlled by user and preceding to it one mobile phone is attached to the robot to receive remote frequency tones. Microcontroller understands this frequency the way it is preprogrammed and according to that it takes decision for the motors to rotate in clockwise or anticlockwise direction summing for the movement of robot either in forward or backward motion or take any other movement.

Traditionally, in wireless based robots RF circuitry is used which comprises of certain limitations such as range of frequency and working is restricted and less control. When we use mobile phone for automation of robot these certain factors can be overcome relishing additional advantages such as higher rate of accuracy in control and frequency ranges. Another advantage is that interference is boundless with other controllers. During such automation there are three rigorous steps: Processing, Perception and action. Adequately, task is completed by Motors interfaced on to the device or by actuators and processing is completed by involved microcontroller. Preceptors are some sort of sensors attached on top of the robot.

3.2 Obstacle Avoidance using Sonar

Sonar sensors are used for the obstacle avoidance of mobile robot. The methods to implement this are innumerable. Obstacle avoidance plays an important role in day to day environment. This accounts for two reasons, firstly it is very unlikely to happen that a robot which has planned a path is not required to deviate from the nominal path due to the presence of unforeseen hurdles and obstacles. Secondly, even if the environment is completely known and no additional obstacles are encountered, the robot has only an approximate estimate of its own position, since self-localization is necessarily affected by Errors. Thus, as a consequence of localization errors, the robot needs to be able to deal with an environment which - in a subjective view - is not exactly as expected, thus requiring strategies to properly modify the nominal path. We have tried to design an algorithm for obstacle avoidance. It is based on the difference between the coordinates provided by mobile robot and actual destined coordinate. Whenever an obstacle comes microcontroller will rotate robot 10 degree clockwise or anti-clockwise and will check simultaneously that the difference between the desired and actual coordinates is increasing or decreasing. The decreased data is been preferred and direction is utilized by the robot. This loop will keep on working infinitely till the robot reached the final destination.

3.3 Surveillance of Co-ordinates in GSM Module using AT Commands

In order to transmit a required co-ordinates, prescribed AT commands are used in our coding. AT commands stand for attention which are used in MODEM. Origins of these commands are exploited from HAYES commands which are preferred for Hayes smart Modems. Generally AT means seeking attention from MODEM. Explanation of some commonly used AT commands is:

• AT: It is used to verify communication between the computer and module.

For example, AT OK

Result would be printed OK if our module is connected otherwise it would prompt an error.

• CMGF: It is used to fix the mode of SMS. There are two modes, one is text and other one is PDU mode.

For example, AT+CMGF=<mode>.

0: PDU mode

1: text mode

The mode which we prefer the most is SMS mode because it is easier to access but has restricted features. If we opt for the PDU mode which stands for Protocol data unit allows maximum utilization of the services but requires knowledge of bit type TPDUs.

• CMGW: It is used for storages of messages in the SIM.

For example, AT+CMGW=”Phone number”>. And then message is typed with Ctrl+z.

After the above command is typed with phone number from which message has to be perceived, ‘> ‘sign comes into the picture on next line here the message has to be typed. In case of multiple line messages, particular message has to be terminated with Ctrl+z combination.

• CMGS: It is used for sending a SMS message to a preferred phone number.

For example, AT+CMGS=message serial number.

When the command and serial number is entered message is transferred to the prescribe phone number.

- ATD: It is used for dialing or calling a number.

For example, ATD<Phone number> ;(Enter).

- ATA: It is used for answering a call. An arriving call is indicated by a message 'RING' which is constant for every loop of the call. When the call split ends 'NO CARRIER' is displayed on the monitor.

For example, ATA (Enter)

When ATA followed by enter key is typed, inward call is answered.

- ATH: It is used for disconnecting distant customer linkage with the GSM component. For example, ATH (Enter).

3.4 NMEA Standards used in GPS

NMEA stands for National Marine Electronics Association which categorizes a specification to develop interface for various bodies of marine electronics association. Under these standards there is a handshaking of information or collective database within computers and other marine electronic equipment. One of the tools used to define communication under these standards is GPS receiver communication which provides information about real time and position in NMEA standard format. Data collected may contain some other fetched information such as velocity, tracking angle, zones or regions of hemisphere. This whole bunch of information is collectively represented as sentence and is unique for each region i.e. totally self-contained information. In all of the data sentences there are two rich sources of data standards that are useful to us for accomplishing our object. These standard sentences have two letter prefix such as GP is used for GPS receivers.

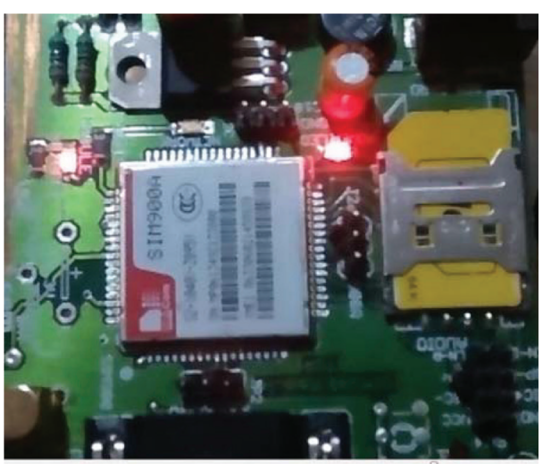

Figure 2. GSM SIM module for communication.

3.5 Calculation and Understanding of NMEA Standards in GPS

There would be a repeated set of co-ordinates reported through GPS receiver but co-ordinates which would give us precise information would be the following,

$GPRMC,182303.000,A,2839.689606,N,0722.115435, E,0.00,138.01,231114,,,D*6F

$GPGGA,182304.000,2839.689606,N,07722.115435, E,2,11,0.78,187.252,M,-35.754,M,0000,0000*4A

The usual meaning of Code is explained below, keeping in mind that only which part of the code is to be understood so as to finally calculate co-ordinates.

Here GPRMC stands for global positioning recommended minimum standards. 182303.000 conveying is universal co-ordinated time and can be converted to our standard time zone. Basically above number gives us information as 18 hours, 23 minutes and 303.000 seconds.

A stands for active i.e. our GPS receiver is in active mode and receiving data. If it is V which stands for void then our GPS receiver is in off mode i.e. not getting any information.

2839.689606 give us information about latitude as 28 mean twenty eight degrees and 39.689606 are in minutes. One important aspect to note about this code is that a degree can be of two or three digit depending upon the region you are locating your GPS device (region indicating about different part of globe i.e. N, S, E, and W) but two digits to left of the point after degree would always give you information in minutes and is fixed i.e. does not depend on regions.

N stands for Northern Hemisphere. 07722.115435 give us information about longitude as 077 mean zero seventy seven degrees and 22.115435 are in minutes. Again there is same understanding of this code as we have observed in latitude code in terms of how much part of the digit should be in degrees and rest in minutes.

E stands for Eastern Hemisphere. Here 0.00 give us information about speed or velocity of our satellite in knots. 138.01 give us information about tracking angle of our satellite. 231114 give us information about date (23), month (11) and year (14). And rest of the code is responding to some other parameters of our satellite position which is of no use to us.

Now moving on to next NMEA standard code i.e. GPGGA standard give us same information as in GPRMC till code E but code to right of that reveals some useful information. 2 give us information about i.e. we are insink with our satellite or establishing connection with our satellite. It might be 1 or 2 but usual meaning is same. 11 give us information about number of satellites locked on to our device. 0.78 give us information about horizontal position of our satellite and 187.252 give us information about altitude position i.e. 187.252 meters above sea level.

Rest of the code is of no use to us in calculating or locating device co-ordinates. Now we are aware of the code and understand the meaning of each term. If we look at real scenario this part of our project is done by Hardware or we can say that we have received co-ordinates by our GPS hardware module but it is duly important to assemble or extract the position our robot with these co-ordinates which is a part of our simulation software.

There are several software's to achieve this goal but we have used standard Google Earth software. Proceeding towards software, Google Earth has its own standards which have to be matched with NMEA standards. Basically Google Earth supports KML standards or file according to which there should be no spacing in Latitude and Longitude coding i.e. code should not be like 28 39.689606 and minutes are converted in degrees. Other

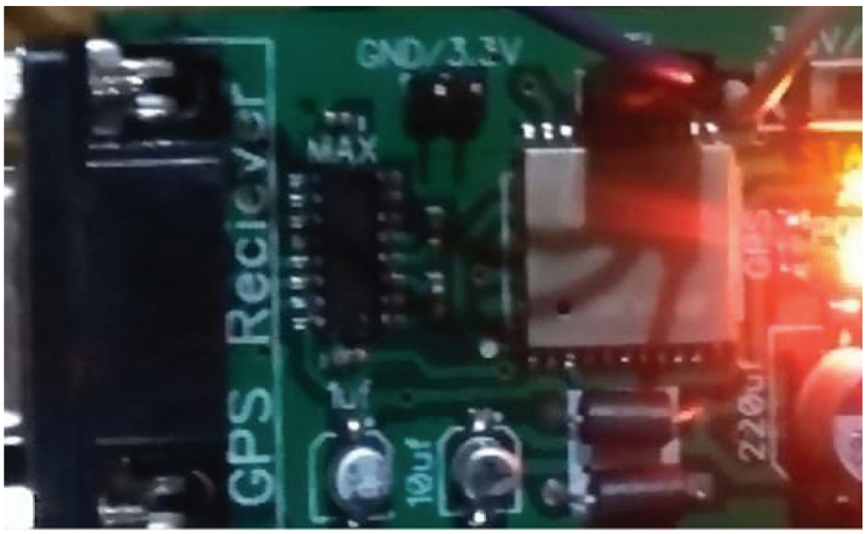

Figure 3. GPS module for tracking.

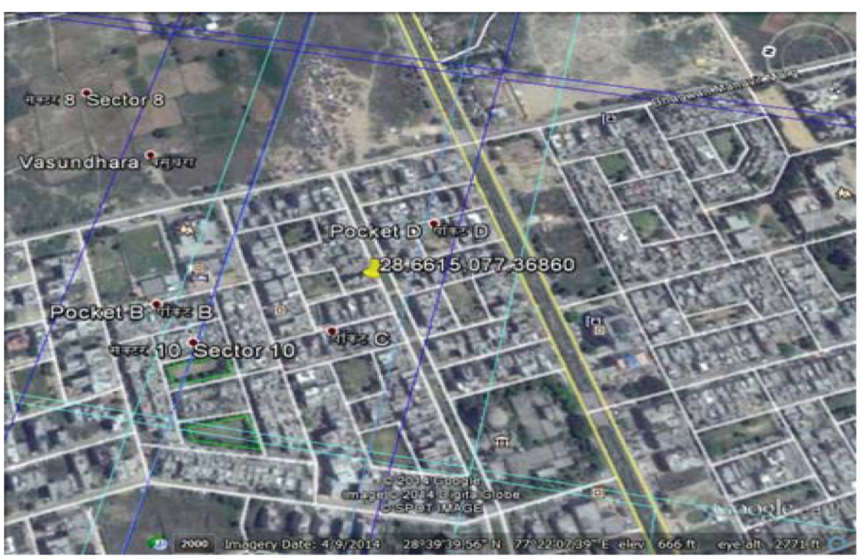

Figure 4. Extracted image from mobile robot on received specified co-ordinates.

than that alphabets like N or E gives an error while feeding in software so it has to be converted. First of all, we convert minutes in degrees and there are sixty minutes in one degree so,

39.689606/60 = 0.66149.

Similarly,

22.115435/60 = 0.36859.

Secondly, moving on to conversion of regions positive sign is indicated for N or E and negative sign is indicated for S or W. Finally, information which we have to feed in software is below:

Latitude: 28.66149

Longitude: 077.36859

After feeding above information software starts the simulation and exact position of our robot is located which is shown in figure below at right side.

4. Acknowledgement

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