Autonomous Tour Guide Robot using RF Module

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Abstract: ***Tourists and tourist locations are a major source of income to any country's economy. A good tourist location can help improve the economic standard of a place. So it is very important that there are adequate measures to improve the tourism sector. The best way to see and enjoy a place is on our own, because when we find out a thing on our own, the experience remains with us ever. This is the main idea that brought us to make this project. We are presenting in this paper a tour guide robot that will take tourists through a location of interest, using a robot navigator. The device is equipped with an Arduino module that controls the device. The user needs to use a mobile application to pair with the device and start the robot, once started it will take the user to different locations and will inform him of the details or importance of each location. The device is also equipped with a panic button and a heart-rate sensor that helps to inform the authorities if any emergency situation arises.***

Keywords: Arduino; Heart-rate sensor; Mobile Application; Rotary encoder.

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1. Introduction

Tourism sector of a country is a good indicator of its foreign reserve revenue. It is a very valuable resource to have and all countries try to focus a lot on this sector. There are trained and untrained people who work as tour guides in a location. A person will return to or suggest the location to another person if and only if he finds the place worth watching and if he had a good experience there. We have heard of a lot of news that people try to exploit the tourists that come to a country, mainly this is done by the locals of that area who work as false tour guides. They will be unauthorized personnel who act as trained ones and try to extract as much money from the tourists as possible. This is where tour guide robots come into existence, a robot will do only what it is programmed to do and it will not try to cheat or bribe the tourist. Moreover, the best way to explore a location is by our self. The goal of this work is to provide the tourists with a never before freshness and feel during a touring experience which will be safe for the touring party, which can be authorized by the government and authorities of an area. The proposed device makes use of an RF module to identify a point of interest, a rotary encoder to help in the routing of the device, an ATMEGA 328 for controlling, 2 ultrasonic range sensors in the front for obstacle detection and avoidance. We have listed the design and implementation of our project in this paper with the added details of the problems we faced. Section 2 deals with the literature; Section 3 deals with system implementation. Section 4 presents the experimental results, followed by the conclusion in section 5.

2. Related Works

Tour guide robots that have been implemented so far have taken inputs from various sensors for their operation; some such papers and previous works are discussed here in the literature. Jinny [1] is a tour guide robot with two laser finders and two infrared sensors for navigation. CATE [2] is an interactive tour guide robot, equipped with a four-wheel drive chassis and it had obstacle detection features with the use of infrared sensor and sonar sensors, it had two onboard PCs and one touch screen. Authors D. Rodriguez-Losada *et al.* [3] talk about a tour guide robot which uses RFID technology to assist visually impaired. RFID tags and modules can be used for location identification and navigation; there are devices that use this technique which has been seen in the literature [4]-[7]. Authors R. V. Aroca *et al.* [8] present a device that uses QR codes instead of RFID to implement the tour guide robot. The robot is using this QR code for the location identification and to help in the routing. Our navigation method uses a combination of RF module and QR code scanner, so it is more effective as it is a ranged signal rather than a localized signal, plus it is much cheaper and more efficient. The use of RF module is that: it's simple installation, it can be easily modified to change the guide route when necessary and it's relatively cheap. However, one of the main challenges with this technology is that of interference with the signals from a nearby location. The problem could be reduced by placing transmitters far from one another.

3. Working of the System

This section presents the working of the device. Fig. 1 shows the device with all the components placed on it.

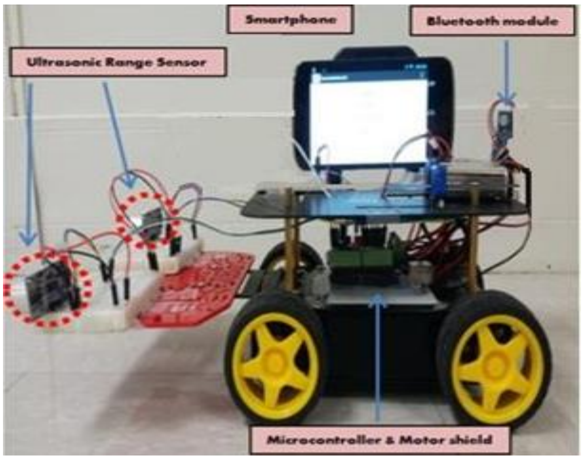

Figure 1: The four wheeled device

The pre-requisites of the work are mentioned as a flow chart in figure 2. We need to initially fix the rotary encoder on the robot and then route it through the entire path. For example, in our case while doing the experiment there were 5 locations of interests named A, B, C, D, E. What was done initially was that we fixed a remote control for the device and the rotary encoder was fixed on the front two wheels, we started from A and then we went to B, then to C and other locations. Then the rotary encoder [9] fixed on the front wheels stores the routing information on the SD card module. The entire routing is done like this from each point to every other point. Once that was done then we placed RF modules in the target locations and pasted QR codes on the ground to mark the starting locations. Then the robot was fitted with the other components like the ultrasonic sensor, QR code scanner, heartbeat sensor panic button, GSM module and blue tooth device.

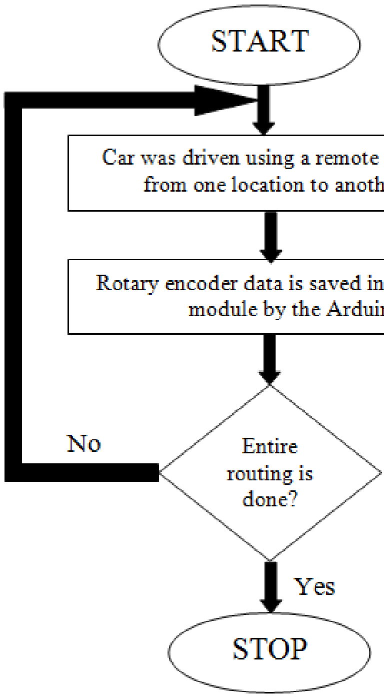

Figure 2: The Flow chart representing the initial setup required for storing the routing information in the SD card.

After this, we placed the robot on the starting point near A, then the mobile device was connected and the start button was pressed. Then the device moved from A to B, and then to C and finally it came back to A after the entire tour. This was the initial stage of the work where we identified that the device followed the entire path without errors and that it reached and stopped at each location exactly at the QR code site. Thus, the use of rotary encoder was justified. Then what we did was to update our code to make it more user-friendly. Now what it does is if we place the device on top of any QR code near a target location then the mobile application, made using the MIT app inventor option [10], will show the exact location that the person is in and then the user can decide where he wants to go to next, like in a normal mode the device will take the users to different locations in a pre-set order for example from A-B-C-D-E-A, in a custom mode the user can decide to which location he needs to go from his current location This information is sent to the Arduino using the Bluetooth module [11]. This allows the users with a unique experience where in the application there is a dropdown button from which they can select any location they need to go to next. The device will stop at each location and will give a voice output stating details of that location. The panic button is activated if the user's heartbeat is above or below a certain limit. It will monitor the heart rate using the heart beat sensor [12] and notify him if it crosses the limit. Once the user is warned, the device will wait for 15 seconds for the person to respond. If he presses the panic button then the emergency response is halted, else the emergency alarm is sounded and the GSM module is activated. It will call the emergency response team in that location to come and check on the user. The devices monitor the obstacles, if any, present in-front of the user using the ultrasonic sensor [13] and then re-routes the user accordingly.

4. System Design

The device has two main parts mainly the mobile application for interfacing with the user and then the Arduino for controlling the motion of the rover and other devices on the rover.

4.1 Components and their functions

The main components that are used in this module are explained here.

4.1.1 Arduino

The initial function of the Arduino module is to take the location data from the RF module. Then once that data is taken it will also read the data from the QR code scanner. If the device is not placed on top of the QR code then the Arduino will keep the buzzer connected to it on, so that the starting location will be exactly as programmed. Once the QR code is correctly scanned the Arduino will send a data to the mobile application to inform the user if he needs to use the normal mode or custom mode. Then according to the users input it will do the rest. If the user selects the normal mode, then the Arduino will check if the user is at location 'A' (programmed starting location), else device takes the user to the starting location. Then from there the user is guided to the next location. Then when the next location is reached the QR code is again scanned and the data from RF module is taken and then the data is sent to the application. Then the mobile will inform the user of that location. Then once the user is done seeing a location it presses the GO button on the application and then the device will move to the next location. The L293d motor driver IC is used to make the Arduino control the rover. The Arduino gets the information from the SD card module to read the routing data. The SD card module will have stored how to move from one location to another in different text files, the Arduino will open each text file corresponding to the present and next location then the data is used for controlling the wheels of the rover. The Arduino is also responsible for obstacle detection using the ultrasonic modules [9].

4.1.2 Routing based on Rotary Encoder and SD card module

The main task of the SD card module is to store the data of the rotary encoder on different files named by the user. For example, while the initial setup was done, we named the text file according to the name of the 2 locations it is travelling from and to. The rotary encoder is a device which when rotated in clock wise direction will produce an increment in a count and it will decrement the count if it takes a counter-clock-wise turn. So, we attached the device one on each of the front wheels of the car during the setup phase, then as mentioned earlier the car was moved through each of the set path from one QR code to another code placed on the ground. When the wheels are rotating the count of the encoder is increasing and the data is stored in the SD card. For example, while moving from A to B; the data from the rotary encoder was saved in the SD card in a text file named AtoB.txt. Then when the same is done between each location to every other location. Once the setup was done, while in execution the Arduino will open up the required text file and then reads the data from left and right module and then this data is used by the Arduino to control the left and right when of the motor driver module. For example, if the right wheels present value is greater than the previous value then a forward step is taken by the right wheel and the same is done for the left wheel. If the value is less than the previous value then the device takes a backward turn. This is how the device will route from point A to B. The code from which the rotary encoder was used to route a robot is available online. The device takes a right or left turn whenever required as it was programmed to do. At each check point the QR code is correctly scanned in all our experiments as the device stopped on the QR code. Then the RF modules data was also used to ensure the location identification. The figure 3 shows us how the device will route itself in different locations, like for instance if the device needs to take a right or left turn or if the location of interest is reached means the device will adjust according to the location's specification, this is done by the help of the data received from the rotary encoder.

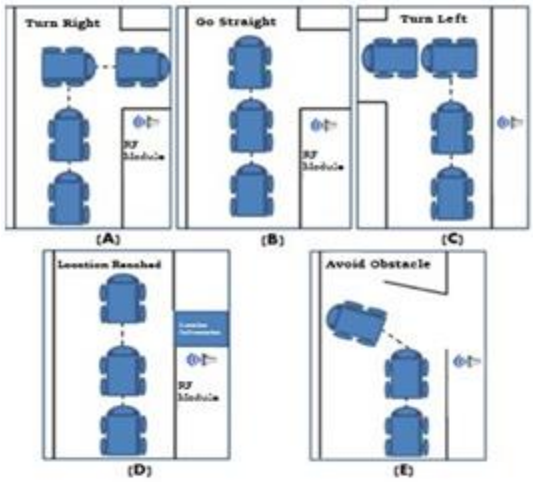

Figure 3: Routing of the device at different location check points.

4.1.3 Obstacle Detection and Routing

The Obstacle detection, as shown in figure 4, is done currently using the ultra-sonic sensors, which is programmed to sense obstacles of any. If the ultrasonic sensor senses an obstacle in front of the user on the ground the Arduino will initiate the obstacle detection and routing protocol, what happens here is the device stores the next location address and then it instructs the Arduino to calculate the angle of the obstacle with respect to the device. Then Arduino instructs the device to move in that angle till the obstacle is crossed, then the (180-that angle) degree is turned so that the obstacle can be avoided. Now the Arduino opens the text file from where it left off and then the normal procedure is continued.

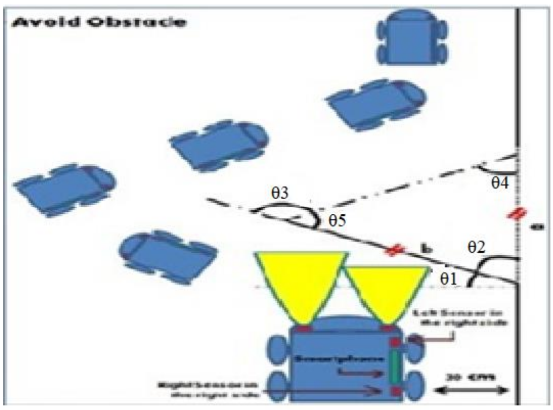

Figure 4: Obstacle Avoidance

$$\Theta 1=\arctan(D/Dist\_sensor) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\Theta 2 = 90° - \Theta 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\Theta 3=180- \Theta 5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\Theta 4= \Theta 5=(180 - \Theta 2)/2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The working of the obstacle avoidance is as described as in figure 5.

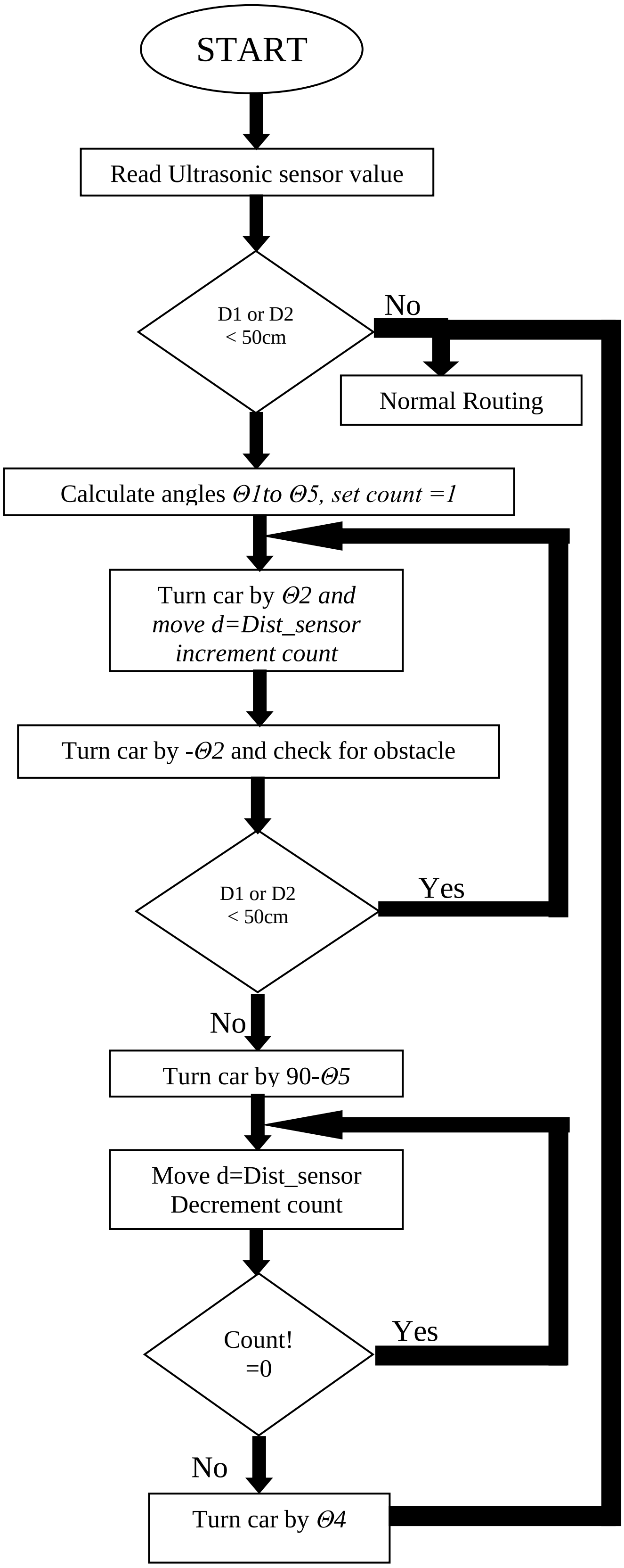

Figure 5: Flow chart of the Obstacle avoidance

The reading from both the ultrasonic sensors will be taken, if the reading of any one sensor is below a threshold of 50 cm, then an obstacle is said to have observed, then in that case, the readings of left and right sensor (D1 and D2) are taken. D is the difference of D1 and D2, Dist_sensor is the distance between the sensors placed on the device. Then the above-mentioned angles will be calculated, the device will then turn *Θ2* angle and move a distance d which equals to Dist_sensor, then it turns at an angle *Θ2* in opposite direction and checks if obstacle is present or not, if the obstacle in not found it turns by 90-*Θ*5 and then it moves the distance it had moved at *Θ2* angle and then reaches a location parallel to location it was in earlier by avoiding the obstacle. If the obstacle is still present after it moves at an angle *Θ2* then the device will again turn back to the *Θ2* angle and move further forward and then again repeats the same till obstacle is covered, then it will move in 90-*Θ5* angle all the distance it has covered, then it will reach the end, there it turns by an angle *Θ4* so as to align with the original trajectory.

4.1.4 Mobile application

The mobile application is the thing that we use to interface the device to the user, the app was made using MIT App inventor 2 [10]. The application contains the information about the locations and the details of each location. The application is having a map of the location that the user is in and the map will have different check points (points A to E in our example), these check points is what the user uses to determine where he needs to go to. The application will turn on once the Arduino commands it to, then the app is having separate button asking the user if they want normal mode or custom mode. In the normal mode a map will be shown on the screen of that area and as the user moves the map will also move accordingly and then when the user reaches each check points the application will explain about the importance of that area. Then when user is done with that location the NEXT button can be pressed so that the device moves to the next location. Then in the custom mode a drop-down button appears on the screen which contains the locations of that area, the user can select which location he needs to go to and then that data will be sent to the Arduino and when he reaches that location then the device notifies him of that location's details.

4.1.5 Heart-rate sensor and GSM module

The heart rate sensor will be attached on the arm of the user and will be sending the data the mobile device using the USB connector. The heart rate will be continuously monitored and will be displayed on the screen of the application. Then if the heart rate is above or below a limit then the application will warn the user of the heart-rate and the count-down of 15 seconds will be shown. If the user does not press the panic button within this time, then the GSM module is activated and the call is made to the emergency team and a message is sent stating the location of the user. During this case if the panic button is pressed this function is not activated. The panic button serves a different function at all times, i.e., if the user needs any help from the authorities, then the user just needs to press the panic button, then the application will ask the user if he needs assistances, then if he presses the button then the GSM module will be activated again and the same process is done.

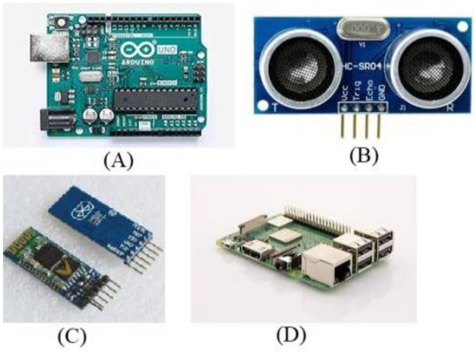

Figure 6: (A) L293D motor drive (B) HC-05 Bluetooth Module (C) Ultrasonic Sensor (D) Raspberry pi 3

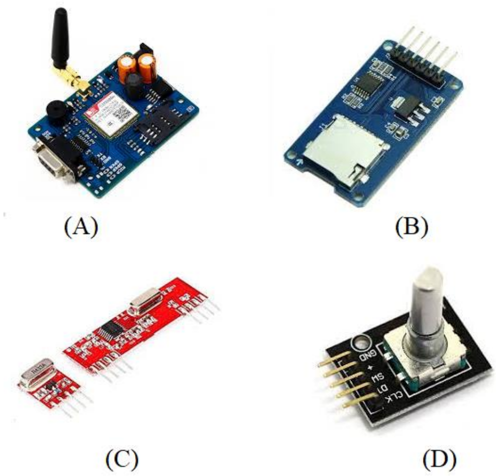

Figure 7: (A) GSM module (B) SD Card Module (C) RF Transmitter and Receiver Module (D) Rotary Encoder

The components used in this work are shown in the figures 6 and 7. The testing of the device was done in our department facility. The map of the department is show in figure 8 with the open doors considered as obstacles on the path.

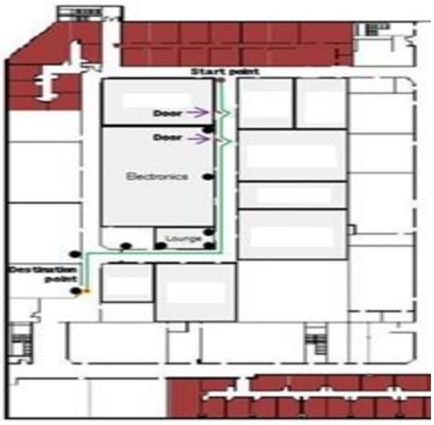

Figure 8: The test environment where we tested the device

5. Results and Discussions

A device that will guide a person in a tourist spot on a predefined path was made and was successfully tested in our university campus. We did the testing inside the department and we found the device working perfectly both in the setup phase and in the testing phase. It worked perfectly in the tests that we conducted, with ourselves being the tourists and then we did some tests with the other students in our class both using the custom and normal mode. Some of the limitations that we have identified in the device were that the routing to be done should be perfect and the device must be routed from one QR code to the next. Then the custom path must be correctly stored in the SD card, if there is any error in the SD card then the car will not be able to route itself from one place to the next.

This device is designed for the outdoor locations it can be used even in the indoor locations like in museums or malls etc. In these environments the number of locations of interests will be higher so the RF modules placed must have their range limited to a small distance otherwise if placed together it was found to cause interference to the other sensors in its close vicinity. Thus, we reduced the size of the antenna to decrease the transmitting range. We tested the device in this manner as well and the results were satisfactory.

6. Conclusion

The main objective of any Tour guide system should be to maximize the user experience in the location. It should adapt to all environments and should be easy to use. This work is mainly focused on helping tourist from being cheated in any way by unauthorized people. The device will help the person to get maximum information about a location and have the best experience. It is designed to face any contingencies like a user needing immediate help from an emergency team.

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