Automated navigation control using Arduino

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***Abstract*— With increase in different types of indoor navigation systems available and a growing demand in automated systems, our project helps club the two together and make an automated navigation control unit. This unit helps in moving a prototype from one location to the next desired location automatically, without the need to drive the prototype unit manually. This is done by predefining the path between the two locations in the user's database and accessing it when required.**

Index Terms—navigation system, navigation control, automated navigation, RFID control

I. Introduction

The main reason for the need of such a system is to help eliminate the dependency on the use of joystick for manoeuvrability. For remote places, an automated control system could help move the system without the need of a skilled operator.

Though there are many forms of navigational system, they are mostly tasked with locating an object by certain means. Whereas in the prototype mentioned in this paper, we have a system that is capable of being navigated and controlled around from one area to another rather than just locating it.

In order to do this, the project is broken down into three parts:

i. Adding new Rooms

The very first step when wanting to go to a room is knowing the number of different rooms that are available. Since a controller cannot just know how many rooms are present at any place and where they are located, we must assist in doing so by creating certain parameter. For this we make use of RFID tags and sensors.

In this case the passive tags will be fastened to the floor by some means and will act as a reference point corresponding to a certain room. As in the algorithm provided in Figure2, when adding a new room, the prototype must be over the tag in order to store the tag ID number under the room name.

ii. Making links between rooms

Once all the different rooms are known, the controller must then figure out the path it needs to take in order to travel from one room to the other. For this, we have allowed for the path between rooms to be recorded and stored with the points being recorded from the start RFID tag to the end RFID tag. Despite being hectic to do, it is a fairly simple solution to go on with. In order to make sure the prototype heads in the right direction, we make use of a magnetometer to keep the orientation of the prototype in track at the beginning. This system is more clearly defined in the algorithm as given in Figure3.

iii. Going to a linked room

Figure 4 shows us the functioning of the navigation control process. Now since all the rooms and the paths between them are known, we ask the controller to take us to a certain room. Unfortunately despite all the above programming the controller is still not smart enough to take us to the required room from any given area, so we guide the controller by taking it over any known point (RFID of a room) and then from there the prototype will take over and controls the movement all the way till it reaches the intended destination/room.

II. Literature survey

Few of the existing navigation control technology that are available to us include:

- **Radio Frequency identification (RFID) reader and tags**,

[2][3][5] This is type of a system is commonly found in places where there is no possibility of point-point satellite signalling. This module reads RFID tags which is an electromagnetic strip containing a unique identification key. It can be attached onto a card, ring, etc.

- **Global Positioning System (GPS),**

[4][8] In this system, we make use of GPS satellites in order to help track the prototype module's location. This is done by connecting the module to more than three satellites and then triangulating its location with respect to the know position of the satellites in order to get accurate location readings.

- **Gesture control,**

[7][9] This method is less of a navigation and more of a control system. It uses flex resistors which are added onto gloves. Flexing of the sensor gives different resistance readings and can correspond to different actions by programming it to control the device in particular manner.

- **Voice recognition,**

[8][10] Unlike the previous control methods mentioned above where we measure the electronic signal produced, here we check for sound signal. There are already ready-made Voice control modules which just requires one to pre-program the module with their voice and make that voice command activate a certain task.

- **Wi-Fi or Bluetooth,**

[6] Instead of calculating the Received Signal Strength (RSS) from the satellites, we can use the same type of approach with help of local signals, like those provided by routers or Bluetooth. This can tend be expensive and a little complex as it requires three or more routers and they must all be in direct sight with the module and each other. This is required as when signal passes through walls, it has the tendency to attenuate.

III. Research methodology

In order to design the navigation system, we must first look in to the different types and option mentioned above and choose the one most suited for our requirement and use.

i. The first module we looked into was the **GPS module**, but on further research found it inadequate due to certain drawbacks encountered such as follows:-

- Inability to provide accurate coordinate values in places due to range or effect of attenuation by building walls, tress, etc.
- When used in a closed place such as an apartment, the location readings from one end of the room to the next may happen to be the same, hence reducing accuracy and efficiency of the module.

ii. We next looked at the usage of **Wi-Fi signals** in order to help us with locating, but noticed that the module must always be in plain sight of the router and sometimes even then the Received Signal Strength (RSS) acquired happens to be fluctuating which is undesired.

iii. A similar system that is looked into is the use of **Active RFID** but then in order to use triangulating signals we would require extra supplies and also raise the project's complexity.

iv. All this trial and error methods got us to our next idea of using **passive RFID**. Despite some drawbacks, it is the only system so far that we made more positive progress.

IV. Block diagrams

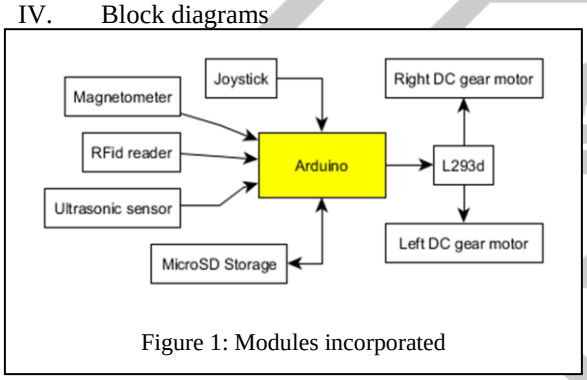

Figure 1: Modules incorporated

V. Hardware design

In this section we will discuss about the different modules involved in the system as shown in Figure1 along with their respective functions.

- **Arduino**

This module is the heart of the project as it does all the work required in controlling the working of the system. It is capable of interfacing with different modules through digital and analog signals.

- **Joystick**

It is the main controller that helps manually move the prototype around. It is also used in this case to record path from point A to B when required by the system.

- **Motor Driver**

We make use of the IC L293-d which consists of two H-bridge driver that help control and supply additional power required to drive the motors by use of a separate external battery.

- **DC Gear Motors and Chassis**

The Dc gear motor that is used came along with the chassis ordered. The dc motor has a rating of 3-6VDC and about 150RPM.

All the modules shown as in figure1 are fastened over the chassis except for the RFID reader module which is attached below in order to allow easy access to read the passive RFID tags that would be attached to the floor of the rooms.

- **Magnetometer**

HMC-5883L module is a three axis magnetic field module that uses I2C Address for communication. It is used in order to properly orient the prototype in the required direction before it can start to automatically go towards its destination.

- **RFID reader**

We use the sensor RC522 which helps in reading RFID tags up to a distance 2.5cm. Due to this, we fasten the sensor under the chassis, keeping it at a height low enough to detect a signal but not too low that it drag on the floor. Unlike the intended manner of use, here we keep the tags at a fixed place and move the sensor around instead.

- **MicroSD storage module**

It is a Micro SD card reader module and the SPI interface via the file system driver that allows user to read and write to the card with help of the Arduino IDE. Communication interface is achieved using standard SPI interface

- **Ultrasonic sensor**

This module acts as an obstacle detection system, where if it happens to detect an object at a distance closer than a given threshold, the system stops moving and makes a beep noise to notify of the obstacle in order to avoid any collision.

VI. Software implementation

- **Arduino IDE**

This is an open source software used in order to help program any type of Arduino board. The Integrated Development Environment is common to all boards and can be run on both online and offline modes. It contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. The system supports the languages C and C++ using help of special rules of code structuring and the program consist of only two functions being 'Setup' and 'Loop'.

VII. Algorithms

The project being divided into three different parts having their own functions as explained in the introduction,

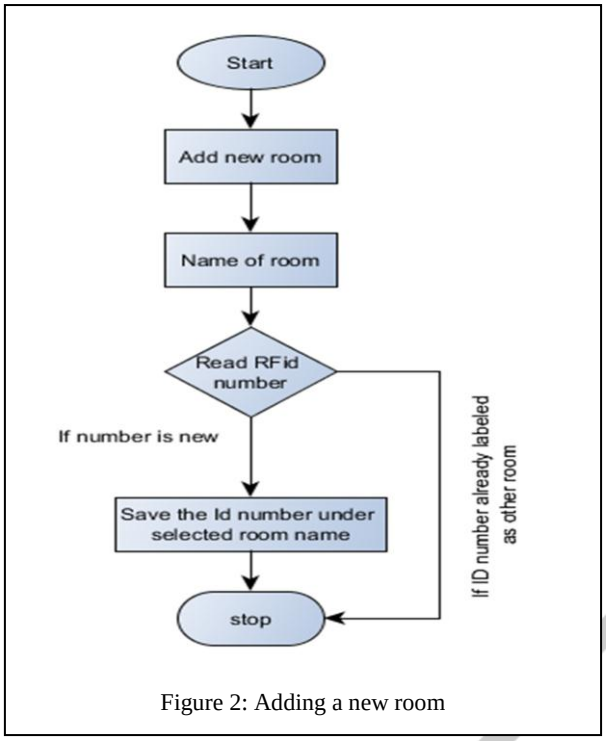

Figure 2: Adding a new room

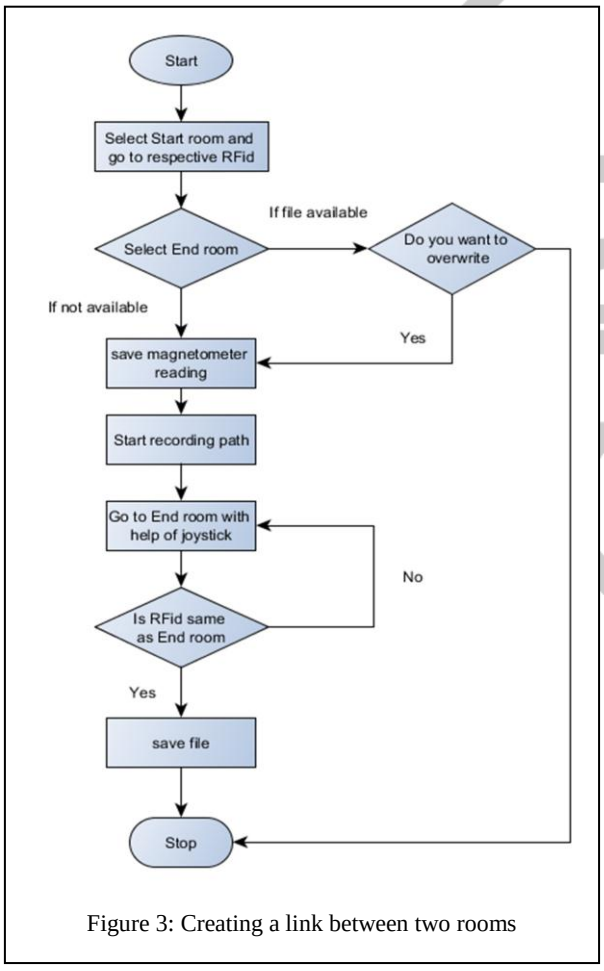

Figure 3: Creating a link between two rooms

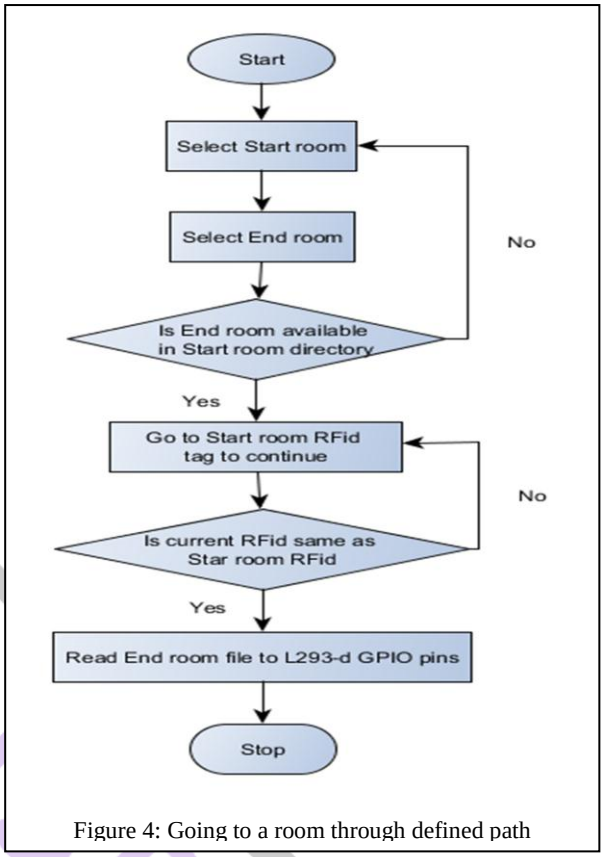

Figure 4: Going to a room through defined path

VIII. Result and discussions

After completion of all of the above, we now have a prototype which is capable of basic level automatic navigation control.

Figure 5: Prototype

Figure 6: Room location RFID tag

In Figure5, the system is displayed as a whole which shows all the main modules accessible to users in order to control the system as well as the navigation system.

Figure6 shows the RFID tags that act as the room location by fastening it to the floor.

IX. Applications

Such a type of system can be used for a numerous applications, some of which being in:

- **Hospitals**, in the wheelchairs and beds of patient which can help in automated transport of patients from one room to the next required room and so on.
- **Industries**, it can be used as an automatic goods transporter or an automated transport service vehicle to move goods or employees from one point to another point saved on the system.
- **Personal home use**, this is system is done in the case of wheelchair users. Where its simplicity allows for it to be user friendly to the elderly, people that are suffering from other physical disabilities or paralysis.

X. Limitations and advantages

- If the number of rooms available are more, the **more number of paths** or links will have to be created in order to make sure that all the rooms are linked to each other. Let's take an example, for four rooms, in order for all of them to be linked to one another, there must be a total of twelve paths defined and stored in the memory.
- Passive RFID tags used that act as the room locations have to be **manually attached** to the floor and must not be covered, tampered or move when accidentally bumped into.
- The **magnetometer isn't completely reliable** in all cases, therefore a better substitute has to be explored in order to fix the orientation before the automatic control of the motors by the system.
- If the **prototype happens to bump** into something and gets pushed off course due to it, the system would not be aware of such a change and would continue moving in the wrong path. This brings a need for a closed loop feedback system.

XI. Conclusion

Such a kind of system comes in handy in places where there is no UWF band of frequencies or direct range for satellite connectivity (like in case of gps) in order to assist in the navigation process. This helps making it possible to work inside buildings and other places where such signal happens to be weak, thus making it a good approach for an automated indoor navigation control system.

XII. Future work

This system has great scope in the future. With improvements to our current prototype implemented we can upgrade both, the performance as well as the user experience, some of which include:

- **Voice recognition** Addition of such a system could help as voice commands could be enabled to perform certain tasks and processes.
- **Obstacle avoidance** so that the prototype can navigate around an obstacle and then towards the intended end destination without the need for the user taking control.

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