Self Navigating Library Assistance Bot

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Abstract: *This project is based upon a smart robotic vehicle that has built intelligence in order to navigate itself and avoid obstacles in its path. The robotic vehicle is build using a microcontroller from the pi family called raspberry pi. A sensor is placed in front of the robotic vehicle in order to detect the obstacles and this information is passed to the microcontroller. Based upon the input data from the obstacle sensor the microcontroller redirects the robot to the location by actuating the motor driver. With this operation the robot navigates itself to the books shelf and fetches a text book of preference by the reader and brings it back to the user table without any human interference.*

1. Introduction

A robot is an automated machine that replaces human effort. It may not look similar to human or behave as like a human. With an increase in the use of mobile devices, QR code (Quick Response Code) has become a widely used technology for obtaining information about specific objects in our daily life [6]. In today's world robots are the essential machines in every part of task being automated.

In this category our Library robot comes in the library automation which serves to as an assistant to librarians and readers.

Library is the place of pure knowledge not only from books also from Magazines, Publications, audio and video gadgets, online resources etc. [21]. A library have thousands of books where it has to be arranged according to Author name, Categories, Publishers. The maintenance of these operations are done manually and computer operated manually. This becomes a tedious process when the number of books increases. Availability of the books should be monitored. The Library Robot and its applications [16] are designed in collaboration with librarian and library customers, specially designed to prevent obsolete or malicious applications. This democratization of robotics design is something to look forward to and anticipate in the future. The future of this library bot extends to braille learning system where the robot generates the braille code based on the book text. Thus even visually impaired can access any text books in the library without any support. Abundance of knowledge is the positive way of acquiring knowledge. If that happens easily with robots then there would be increase in IQ of people reading text books from 75 to 100 points undoubtedly.

1.1. Objective

The objective of the project is to automate the library book management [4][7][10] and provide an ease in finding a text book with an apt author. Also to check the availability of book and online resources of the book or topic in need. As libraries offer an increasing range of facilities and resources, vast amounts of books and printed material continue to be acquired. The combined demand to provide the readers with digital and print-based services has resulted in severe space restrictions for many libraries, especially in academic research libraries.

1.2. Problem definition

Normally in a library, there will be hundreds and thousands of books that are issued to readers as well as returned by readers. For this, we need a librarian to guide the book locations, issue the book and return. This will be easy if the library floor space is little. But in the case of a multistorey library with a huge collection of books. This will be a hectic job. And it will demand a lot of time and manpower.

1.3. Problem in existing system

- Existing robotic library assistant has the feature of taking the text books in order and leaving it near the specific shelf where it has to be placed. Sorting of text books are done manually. Also till date the library bots operating are limited.
- Existing library system has RFID tags for each book borrowing and return. And an automated kiosk for this task.

1.4. Solution to existing problem

The project of us, Lilly The Library bot, has overcame the disadvantage of text book locating as it takes the person to the particular location and in case of borrowing the books, it scans the RFID of the text book. Also it logs the user data such as borrow, return and book rent time to the database.

1.5. Block diagram or design

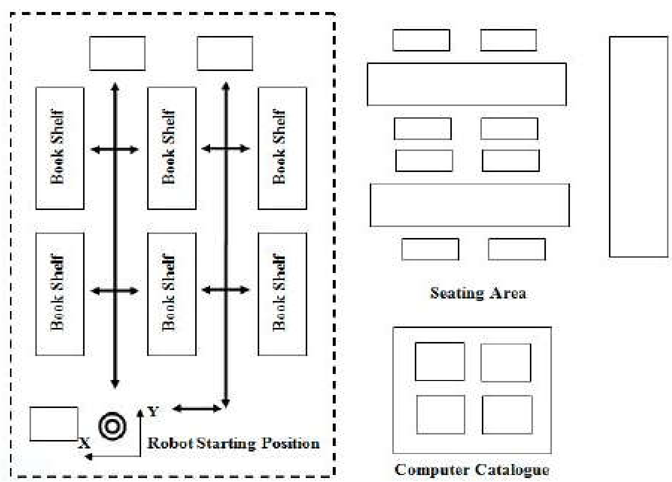

Figure-1.1 Library layout

Figure 1.1 describes the layout of proposed library and the map for the robot to move around. The robot path is predefined and fed. Also the book data scanned is fed to the bot thus it navigates itself and the text book autonomously. The seating area is saved in the map thus when the books arranging task is assigned the robot goes to the respective tables and picks the text books. This process is monitored by Librarian and the robot's emergency control is provided to the Librarian thus any manual control to the robot can be done by Librarian.

1.6. Software and hardware

- IR sensor
- PIC16F877A
- 100 RPM geared motor
- 350 rpm chassis motors
- Gripper motor 60 RPM
- Threaded rod M6
- RFID scanner
- RFID cards and text book tags
- LIDAR sensor
- 3D camera XBOX 360

1.7. Applications

- Interactive, User friendly bot.
- Single Robotic ARM [12] technology to for automatic book arrangement
- RFID book scanning for books borrowing and return [14][5][11]
- QR code scanner to search the text book [6]
- Autonomous navigation using ROS.

1.8. Advantages

- Ease in finding the specific author text book
- In-screen input with LCD display
- Self-navigating

1.9. Methodology

- The robot is started from the user position after reading the RF data.
- Autonomous navigation is done using ROS to the book shelf
- Grasping operation is done and the book is fetched
- The robot returns back to the reader table with the fetched text book
- The text book is kept at user table and the acknowledgement is sent to the controller.

1.10. Motivation to the project

The goal of this project is to develop an autonomous robotic aid to assist and benefit the increasing pool of potential users within a library environment. The users may include elderly individuals who find the library cataloguing system confusing, individuals with

Various impairments such as impaired vision, degenerative gait impairments (the robot leads the user directly to the location of the specific textbook and avoids the user traversing the aisles of the library to locate the textbook), cognitively impaired individuals or users who are simply unfamiliar with the existing library structure.

2. Literature survey

2.1. A mass-produced sociable humanoid robot: pepper [1]

Author: Amit Kumar Pandey and Rodolphe Gelin

Pepper is an industrially built humanoid robot that was launched in June 2014, originally built for B2B purposes and later adapted for B2C purposes. This machine can display body language, think and interact with its surroundings and move around. It can analyze public expressions and voice tones, use the latest advances in voice and proprietary algorithms, and use emotion recognition for spark interactions. The robot has features and high-level interfaces for multimodal communication with the humans around it. Pepper 1.2 meter long wheelbase robot, 17 additions to the beautiful and expressive body language, three omnidirectional wheels for gentle walking, approximately 12 hours of battery life and recharging at the station for nonstop operations. Ability to return if needed. It is a sharp-edged, neatly shaped robot for a more attractive and safe existence in the human environment. In some joints, soft parts (e.g., elbows, shoulders and hips) prevent the risk of pinching. Its purpose is to make the shape and form of the machine suitable and acceptable in everyday life for interaction with humans. It is designed for a wide range of multimodal expression gestures and behaviors and is equipped with a tablet (which also facilitates development and debugging).

2.2. An autonomous assistant robot for book manipulation in a library [2]

Author: Ramos-Garijo R, Prats M, Sanz P J, DelPobil

This paper refers to the work towards the whole system that serves to assist users in the library. With this goal, the system should be able to search a specific book on the shelf that any user asked for, and find it, to distribute it to the user as quickly as possible. To achieve its goals, the system integrates automatic object recognition, visually guided and compelling feedback, along with other advanced capabilities. (ICRA, IROS, etc.) Generally, for such systems built-in, it is a working system that helps users in the library. With this goal, the system should be able to search for a specific book on the shelf that any user asked for, and find it, and deliver it to the user as soon as possible. To achieve its goals, the system integrates automatic object recognition, visually guided and compelling feedback, along with other advanced capabilities.

2.3. The UJI librarian robot [3]

Author: Mario Prats

The UJI Librarian Robot is a mobile manipulator that can automatically search a book and interpret it from the bookshelf of a regular library using eye-in-stereo stereo vision and force sensing. The robot provides only some knowledge of the book code, the library map, and its logical structure, and by using a variety of techniques such as stereo vision, visual tracking, probability matching, motion, ratio-temporal constraints, and environmental regularity. Will benefit. Assessment, Multisensory Based Positioning, Visual Servicing and Hybrid Control It demonstrates robust and reliable performance. The system has been tested and the experimental results show how a book can be detected and understood in a reasonable time without human intervention.

3. Different types of methods

3.1. Line follower

Inline follower robots it follows either white or black color. There for there are two types of line follower robots one is white line follower robot another is black line follower robot. The concept is related to reflection of light in white and black color. The white surface will reflect the light whereas the black surface will absorb light. This is detected using a sensor and used by the microcontroller to define the.

3.2. Manually operated

Manually operated bots have to be controlled manually from remote and each keypad number is configured to do specific tasks regarding books fetching, barcode scanning etc. IR enabled remotes are used for this configuration and remains unaltered on doing once.

3.3. Vector filed Histogram Manually

Vector Field Histogram (VFH) is another local navigation method used to solve the route planning problem for mobile robots [18]. The idea of VFH is based on the VFF (Virtual Force Field) method. It is a sphere, as the name suggests so that the obstacles seen at some distance from the vehicle use attractive force to move the repulsive force on the vehicle away from the obstacles and pull the vehicle towards the target point. VFH uses a fixed grid-like radar screen where the sensor detected barriers calculate the fixed value at the corresponding coordinates of the fixed grid. That is, the high fixed value shows that the real object is detected by the sensor range. This method is suitable for low-moving objects because, in real-time, the grid is constantly updated every moment.

3.4. Laser Type

Laser navigation is considered to be the most effective and effective technique to avoid the obstacle and follow the path [19]. It does not need wires, rails, and tracks for speed. When a beam is transmitted and the form sensor is received, the time it takes the beam to travel and return determines the distance and angle that will assist the vehicle in its movement. The current state of the AGV is then compared to a map already installed within the AGV memory.

3.5. ROS Navigation

The ROS Navigation Stack is a widespread and popular framework for developing autonomous navigation applications [23]. The navigation stack provides a large number of useful tools but has some limitations designed to work only with differential drives and holonomic robots. Or works best with a circular robot. There are some solutions, such as plug-ins and data exchange, to be used with car-like robots that help connect other sensors, such as the popular Connect depth camera.

4. Controller

Raspberry Pi is a well-known fastest microcontroller with GPIO pins of 13-15 for the fastest processing and control. Each dedicated pin of raspberry pi goes to each sensor for the operations to be done.

- Pin1 goes to RFID scanner and acknowledgement signal
- Pin 2 goes to the digital compass for the navigation.
- Pin 3 goes to the GPS for autonomous navigation
- Other pins are connected to the motor drivers and relay modules for the motor driving
- Power supply of 12v is applied for the motors

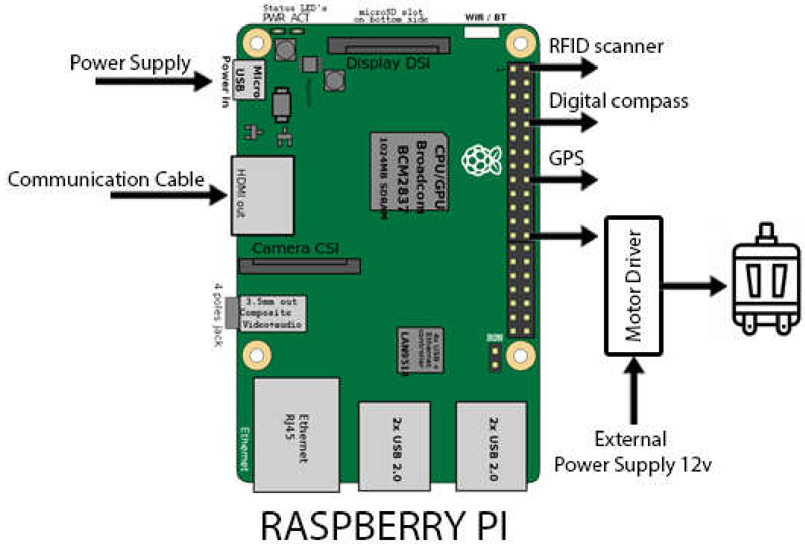

Figure 4.1 Raspberry pie configuration

Merits

- Raspberry pi microcontrollers are consistent.
- The performance of the Raspberry pi is very fast because of using RISC architecture.
- When comparing to other microcontrollers, power consumption is very less
- Programming is also very easy

5. Hardware and software

5.1. Hardware

5.1.1. IR Sensor: Proximity sensors are used to detect objects and obstacles in front of the sensor. The sensor transmits infrared light and when an object is approached, it is detected by a sensor that monitors the reflected light from the object. It can be used to prevent robots, for automatic doors, for parking aids or safety alarm systems, or by measuring the RPM of rotating objects such as fan blades and by contacting low tachometers. Proximity sensors are used for navigation through the library.

5.1.2. Relay: The relay is a power-operated switch. It consists of a set of input terminals and operating contact terminals for single or multiple control signals. Switches can have multiple contacts in multiple contact forms, such as contacts, breaking contacts, or a combination thereof. Here is a textbook called Lower, Arm, Movement of Wheels, and Navigation Triggering, which is mounted on the relay with motorists [20].

5.1.3RFID based scan [15]: The EM-18 RFID Reader Module running at 125 kHz is an inexpensive solution for RFID based applications. The reader module comes with an on-chip antenna and can operate with a 5V power supply. Power-up the module and connect the transmit pin of the module to get the pin of your microcontroller. RFID cards are shown at the reading distance and the card number is thrown over the output. Alternatively, the module can also be configured to have a Weigand output.

5.1.4 Gear Mechanism in robots: The gears are mechanical parts in which the cut teeth are duplicated with the teeth of the other parts, transmitting the force and vibration obtained. Cropped teeth are sometimes called cogs. Others can also ride like chainsaws and motors. In robotics, the gears are used to transfer the rotational motion between the axles. Spur gears are well-known gears. These are the simplest form of gear and are commonly used in light machines such as bikes, mixers, etc. They are not used in cars because they make too much noise and their design puts too much pressure on the teeth.

5.1.5 Motors: DC motors are one of the rotary electrical machines that convert direct electrical energy into mechanical energy. The most common types depend on the forces produced by the magnetic fields. Almost all types of DC motors have some internal mechanism, either electrically or electronically, that changes the direction of the current in the part of the motor. The simplest DC motor consists of one or more armatures of insulated wire wrapped around a smooth iron core centered on the stator magnets and magnetic field in the stator. Windings usually have multiple turns around the core, and larger motors may have multiple parallel currents.

5.2. Software

5.2.1. RFID scans and database updating: RFID scanning facility [5][11][13] is done for each rows of the books arranged in a manner that on arranging the books after reading there may be a misplacement of books inside the library. Thus the book location updated in the robot [8][9].The RFID scanning and updating procedure is explained in the block diagram which states that the scanned text book is done at a particular shelf it is saved in the database as below.

1. Text book name
2. Shelf number
3. Column and row number

Thus this gives the recent information about the updates

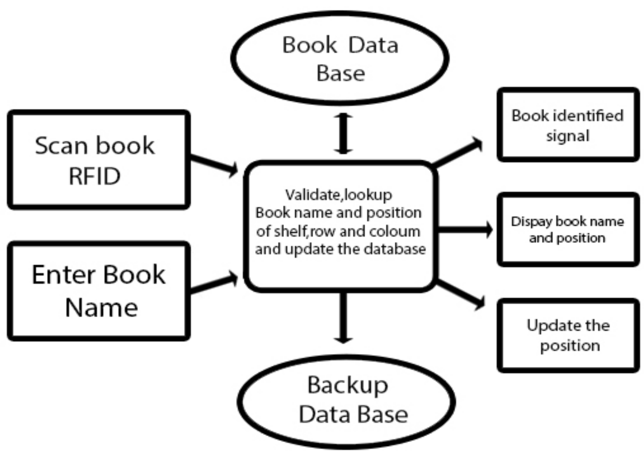

Figure 5.6 Data logging

5.2.2. ROS:

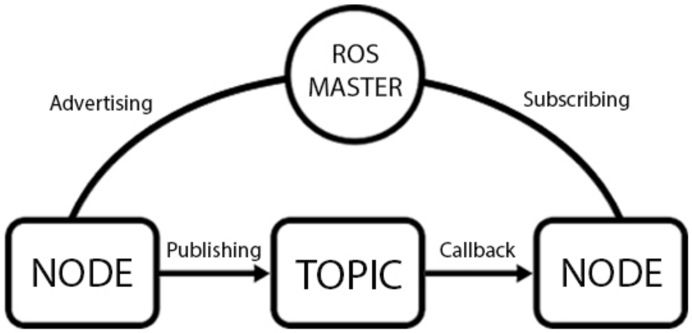

Figure 5.2.2 ROS basics

ROS [15] software consists of nodes where every node is determined by a specific process. This process starts with the triggering of Kinect 3d camera which is responsible for the image and obstacle avoidance. The primary node called ROS master is updated with the real time image while the robot moves an updates the information in node called ROS Master Node. This node branches into Advertising and Subscribing.

Advertising: Advertising is the way of sourcing the data to the nodes whereas the particular nodes are accepted with this data. The node responsible for other data does not accept this image or sensor data.

Subscribing: There are cases when the data is sent only when requested. In that case the nodes are subscribed by the ROS master for particular intervals and time where the data is sent only at that period of time. Predefining of that period of time is called subscribing.

After these two operations ROS topic is assigned to the nodes and the act of publishing the data to the user and acknowledgement starts. After publishing to ROS a call back signal is sent to the node to receive the data back again for future reference or comparison with previous data. This helps in accuracy of the localization and position determining.

6. Construction and working

6.1. Program is written according to the flowchart

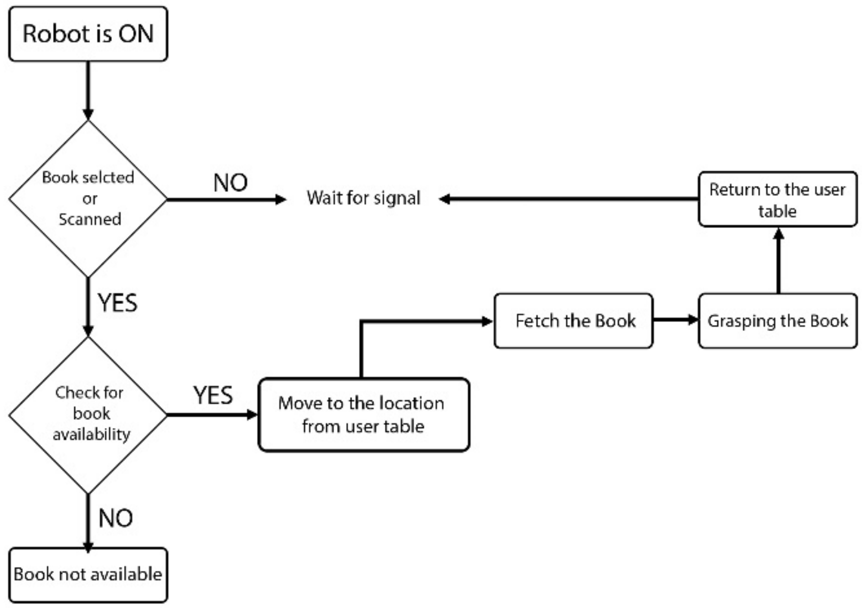

Figure 6.1 Program flow

6.2. Components configuration

- 100 RPM geared motor (up and down)
- Motor specification: 12v 360 degree rotation
- Thread size: M6
- Metal chassis ,gears and wheels
- 12v battery: 660/piece
- Gripper motor 300 rpm
- PCB designing and fabrication
- RFID module
- Raspberry Pie

6.3. Working procedure

- The robot is placed near the reading area for the user to operate.
- Required text book's RFID is scanned or selected.
- The robot checks the location of text book from the shelves and moves autonomsly to that place.
- The robotic arm moves towards the book and verify the RFID in the text book with the scanned one.
- It fetches the text book and returns to the reader table and places the text book on the table.
- The threaded rod placed on the robot is responsible for the up and down movement.
- The base disc moves to left and right of the robot.
- Navigation through the library is done through ROS.
- The RFID card is shown to the robot which shows the updated location of the text book.

6.4. RFID based book scanning and gripper action

RFID card or the text book tag is waived the button is pressed for the robot to start and move to the book location [5][11][12][15]. The robot follows a white space to moves and stops at black spaces which depict the shelf end.

6.5. Gear mechanism for the wheels and chassis

Spur gear mechanism is in involved in chassis and wheels for the robot move around. 12v Dc motors are installed and the height from the ground to the base disc is 42cms in measurement. From the disc to the top rail is 100 cm. At the top a 12v1000rpm Geared dc motor is installed for up and down motion.

7. Results and discussions

7.1. ROS stimulation

The library robot is applied with the navigation methodology Robot operating system (ROS) [15] and is being stimulated using gazebo and Rviz. It is found that the robot avoids the obstacles and navigates itself to the user chair shown in the figure 7.1.

Figure 7.1 ROS stimulation

7.2 Microcontroller display

The robot is ON and messages displays.

Figure 7.2 LCD message on robot starting

7.3 Gripper action

When the dedicated relay is triggered after the text book is selected in the robot and tit confirms the availability of the text book the gripper action starts. Grasping of the text book and placing is back in the shelf or the user table is done by the robot.

Figure 7.3 Gripper Mechanism

8. Conclusion and future scope

8.1 Conclusion

Some of these early experiments were a convenient position (such as the arrangement of books on the shelf in the vertical position). Therefore, our short-term goal is to improve the performance and efficiency of our algorithm, while simultaneously easing this ump halo into a more realistic scenario. Finally, as long-term goals, we plan the full integration of modules needed to scan all the bookshelves, embed navigation capabilities, and test the entire system in a real library scenario.

From the results and discussion we came into a conclusion that the gripper based robotic arm is not the most suited mechanism or method for the collecting the book from the book. As in real life scenarios the books in the library will be closely arranged therefore the gripper mechanism cannot find a gap in order to insert the claws for the gripper action.

Another problem for using the robots in the library is the noise from the actuators (motors) and the vibrations. As library is considered as a quiet place and the noise created from the robots makes it less likely to use in a library environment. This is one of the main challenge which we came across. We were able to reduce the noise to a percent by reassembling the parts and a better noise reduction can be achieved by using less vibrating motors

The speed of the robots is less due to the use of Raspberry Pie and this should be upgraded with a microcontroller of better processing speed.

8.2 Future scope

Future ranges include switching from feature detection and ultrasonic sensors to the LIDAR module or the Intel Real Sense R200 camera module. This allows you to understand the features inside the home and create a 3D map. Improving the efficiency of robots in mapping and path planning without compromising our speed of operation. A similar approach uses the application of robotic operating systems (ROS).For this we will be upgrading the microcontroller with a one with higher efficiency

Using existing scanners, optical character recognition (OCR) software, and indexing software developed by the Digital Knowledge Center, the CAPM system not only browses images of text but also the full-text generation and search and analysis images.

In the future we also like to add voice assistance and a better HMI system with a better user interface. Which helps the communication between the user and the robots. Which will be evenly helpful for visually impaired, Hearing Impaired and mute.

We are also planning a remote communication to the robot by means of a mobile application which helps the user to find the availability of book in the library and collection of the books without actually going to the library. So that by the time the user reaches the library he can collect the books from the reception as well know about the book before reaching the library. The will reduce the struggle for finding the books in the library and saves the time of the user.

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