International Journal on Emerging Technologies 11(2): 1105-1109(2020)
ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Design and Development of IOT Based Smart Library using Line Follower Robot

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(Received 09 March 2020, Revised 11 April 2020, Accepted 14 April 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The main objective of this paper is to automate the existing system in the library which includes the operations like search, detect, pick and place the book from shelves, which will help the readers in seeking the book in less time and quite efficiently. The paper emphasis on how a robot can issue and return a book in the library. The robotic system includes a robot that uses a LAN network with static IP for accessing the robot from anywhere in the campus. The robot is capable of picking the book and placing it with the help of a Robotic arm to the library counter. This robot introduces the Multiple Source Multiple Destination Robot, which is capable of detecting the target line through several color lines via a color sensor for its movement in the library which solves the problem in tracking the path to the shelves. Each line is colored differently, as its identity. The robot will distinguish between various colors (red, blue, green) and choose the desired destination. Librarian staff can access the robot using recognized voice commands. This robot can be called a fully autonomous line follower robot that has the ability to train voice commands through an easy procedure, unlike any other specific line follower robot. The robot senses a line through a color sensor and therefore strives towards the desired target by using a simple feedback mechanism to correct the wrong moves, but still a very efficient closed-loop system. Further, all the actions are recorded /monitored through a camera which is attached to the robot. A bar code scanner and camera is used to detect a particular book from different shelves. After detecting the book it will grab using a robotic arm and move back to the counter. People can also check the availability of the particular book as well as the number of existing copies available from the library database.

Keywords: Colour sensor, Library, Line follower, Recognized voice commands, Robotic arm

Abbreviations: LAN, local area network; IOT, internet of thing; IP, internet protocol; RFID, radio frequency identification; IR, infrared ray; SoC, system on chip; ISBN, international standard book number; ICSP, in-circuit serial programming.

I. INTRODUCTION

In this 21st Century, where the world is moving forward in the field of robotics and automation, Industry 4.0, digitization of things, etc but we are lagging when it comes to the library. Despite the increasing availability of digital platforms like Kindle, eBooks etc, people still favour reading physical books. In large libraries, people need to invest a lot of time in searching for a book, get it issued or return while standing in a long queue. This is because people nowadays are not interested in going to the library to search for the book, wait for issuing and returning the books in the queue.

In the last 50 – 60 decades the evolution of libraries are achieving great heights in terms of quantity and quality of different books. The number of books is increasing day by day. In past, using a manual administration process for maintaining and managing the books requires a lot of staff and manpower. As the new technologies and researches are evaluating that changes the whole process dramatically [1]. Now the libraries are equipped with different sensors and modules for library management to manage a large number of books with their different editions are much easier [2]. A line following robot is designed to keep track of the line direction defined for library bookshelf arrangements using sensor-driven motors [3]. Line follower robot is a mobile robot capable of detecting and following the line drawn at the ground. The route is usually predefined and can either be visible on a white surface with a high contrasting colour like a black line, or it can be invisible as a magnetic field. This type of robot will certainly feel the line with its IR sensors mounted under the device [4]. After that, particular transfer buses transmit the data to the processor. The processor will then decide on the proper commands and then send them to the driver, and the robot will obey the path [5]. RFID tags and the bar code readers are used for identifying the different rows and columns in the library which will safe time in searching the book [6]. Nowadays, libraries are getting digitalize to seek the location of the books, users authentication, getting details of the books (edition, number of copies present, place where they were kept) easily but for issuing and returning the book the process is still manual and time-consuming for both readers and librarian staffs. Another problem is that if we have tracked the location of the book through database and send it to the robot though ZigBee transceiver or wi-Fi, the movement of the robot in the library to find that tracked location is very difficult [7]. There is no guided path for the robot to move to

overcome this problem so a system has been developed which can do it automatically using a simple algorithm. This system consists of a multidirectional line follower robot. Here, Red, Blue and Green colour lines has been identified and developed for the movement of the robot in the library that will guide the path to the robot. The robot is also equipped with WIFI camera, barcode scanner and robotic arm with availability of internet. Book identification is done using a bar code scanner and the camera which will command the robot to pick the book from the particular shelf and place it to the library counter. Similarly, the reverse process follows for returning the book. The robot can also accessible through voice commands of the librarian staff only for managing and maintaining the books properly. We have also work on the efficiency of the robot and the time required by the robot to complete the operations.

II. PROPOSED SYSTEM

Any library consists of all the records of the books, user's information in the database handled by librarians. A reader has to login the online database platform using the credentials and after getting the successful login, user can access the platform for searching the availability of the particular book or article in the library. After getting the information from the online database the reader can do following operations such as calling the book or article from its place for reading in the library, issuing and returning the book. A robot will detect the line and follow the particular line [8]. It is also accessed from the registered voice commands of the librarian staff for various operations like keeping the book back to its places or managing the book in particular order [9]. In Fig.1, the block diagram of the proposed system is shown.

Voice commands are predefined and trained in the voice recognition module easily by the user. It can support up to 80 voice commands, maximum 7 voice commands at the same time with each voice 1500ms (one or two words speaking). Voice command data of librarian staff is stored in the voice recognition module and accessible to them only for managing and maintaining the library properly. Voice recognition module is connected to a microcontroller (Arduino). Arduino will give commands to the robot and instruct the robot to control the processes [10]. Esp8266 is used for creating a web interface for database and connected to Arduino.

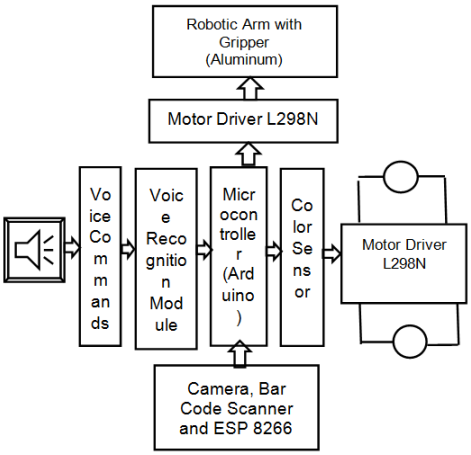

Fig.1. Block diagram of the proposed system.

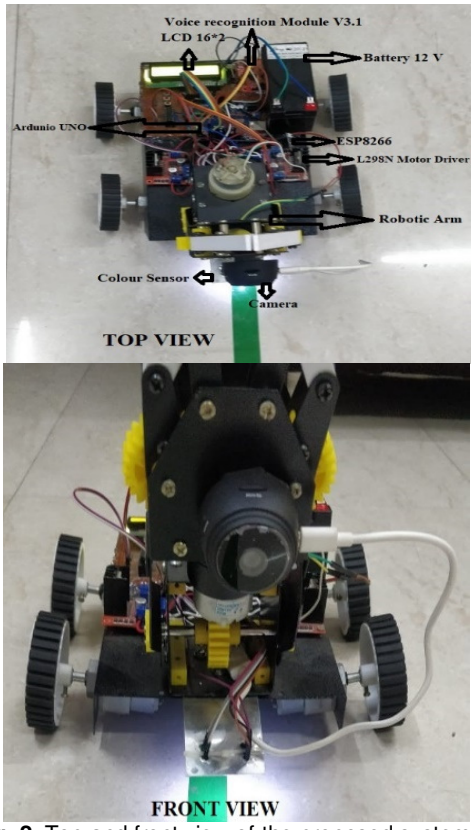

Fig. 2. Top and front view of the proposed system.

This database will guide the reader about the information [11] of the book if it's available in the library or not. If the book or article is present in the library then the reader can issue it otherwise it will pop up with the message like the book or the article is not available.

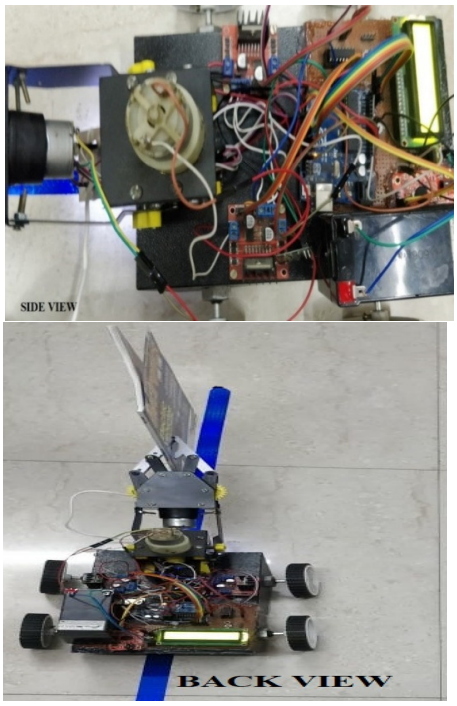

Fig. 3. Side and back view of proposed System.

Based on the inputs of the reader through the database and web interface, the robot will get the task like issuing the book or returning the book. A robot can follow 3 different lines (Red, Blue, green) as for now using the color sensor (TCS3200 color sensor) which is attached to the robot for determining the line or the path of the robot [12-13]. Color sensor will instruct the motor driver L298N to follow the particular line among the 3 different colors. A WIFI camera is also mounted over a robot to guide the path and observing its actions and useful in searching the particular book along with bar code scanner. After getting the location of the book with the help of database through bar Code scanner and the camera the robot will pick the particular book with the help of robotic arm which has a 2 degree of freedom [14]. Robotic arm with gripper will grab and hold the book and place it to the required place.

A. Overview of technology used

Esp8266. ESP8266 is developed by Espressif system which is Wi-Fi enabled system on chip (SoC) module. The ESP8266 is a low-cost user-friendly device which is used to provide internet connectivity. It can be work both as a station (can connect to Wi-Fi) and an access point (can create hotspot), hence it can easily fetch information and upload it to the internet making the Internet of Things. It can fetch any information from the internet using API's which is available on the internet. It is compactable with Arduino also, that means it can be programmed through Arduino itself. It can also programme using the FTDI board. It requires a 3.3 V power supply [15].

Bar Code Scanner. Barcode Scanner/Reader is used to read the code which is a sequence of vertical bars and spaces. This bar code represents the number and other symbols. Each barcode is a unique number. The barcode scanner/ reader uses a compact, long-range CCD barcode scanning module with a highly sensitive liner image sensor and build in auto-sense function, which can be used to decode nearly any kind of 1D(striped) barcode[16].

Voice recognition Module: V3.1. Voice Recognition Module V3.1 is compatible with Arduino microcontroller which makes it a compact and easy-control speaking recognition board. It has built-in microphone. Speak (Voice) Recognition Module V3 is a speaker-dependent voice recognition module. It can store up to 80 voice commands, while simultaneously detecting a maximum of 7 voice commands. Commands can be of any type and can be trained through an easy algorithm. This board can be managed in two ways: Serial Port (full function), General Input Pins (part of function). General Output Pins on the board were able to produce many forms of waves while the corresponding voice command was recognized [17].

Colour Sensor (TCS3200). TCS3200 colour sensor is compatible with Arduino. It consists of a TAOS TCS3200 RGB sensor chip and 4 white LEDs. TCS3200 chip will convert the Colour Light-to-Frequency. This chip is capable of sensing a variety of colours and gives the result in the form of corresponding frequency. The sensor uses 4 white LED's so that it can detect the object colour correctly. TCS3200 chip consists of 8*8 array of photodiodes. These photodiodes consist of RBG filter (red, green, or blue filter) or no filter. Each photodiode has either a filter, red, green or blue, or no filter. Each colour's filters are uniformly distributed throughout the array to reduce location bias among the colours. Internal circuits include an oscillator producing a square-wave output which is proportional to the intensity of the colour chosen [18].

Arduino UNO. Arduino Uno is an 8-bit, ATmega328P based microcontroller. For support the microcontroller, it consists of serial communication, voltage regulator, crystal oscillator, etc. Arduino UNO has 6 analog pins, 14 digital input/output pins, ICSP header, power barrel jack, reset button, and USB connector. Each analog and digital pin operates at 5V and provide a maximum current of 40mA [19].

III. METHODOLOGY

We defined different colors to the different columns of the library so that the robot can identify the different columns. Let's consider 3 columns, for now, we are distinguishing the columns based on Technology, Friction, Encyclopedia with Red, Blue, Green color respectively. All the details of the books are feed inside the database by the librarian.As in this system, the first step is to log in the database and enter the student information for authentication. After getting into the system reader can search the book. The reader will get all the information related to the book (ISBN, edition, Author, Publication).

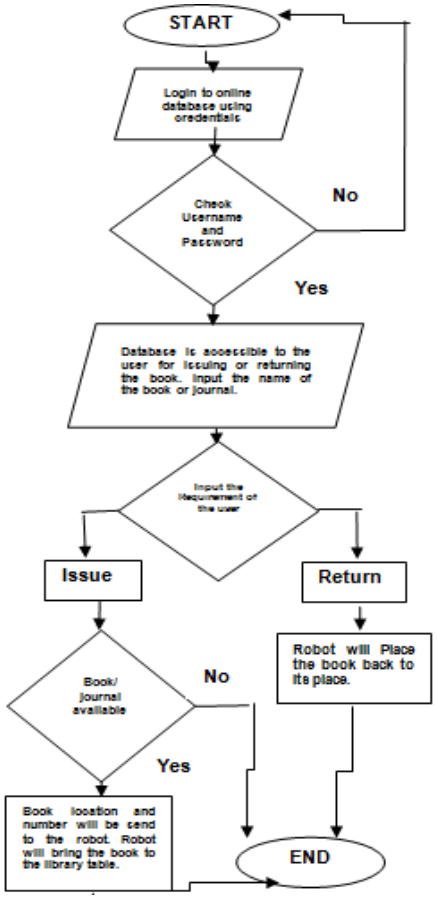

Fig. 4. Flow chart for illustrating operations at user side.

Further all this information will send to robotic arm side using WIFI module (Esp8266) and then the robot will decide which line to follow as per the information and move according to the path drawn for that particular column. Books need to arrange with the separation of

2 inches with each other. Voice commands are only assessable for librarian staff to command the robot. Voice commands need to train by the librarian staff, total of 80 commands can be stored (0-79). Here in this system voice commands used are as follows:
– Stop: To stop all the operations of the robot.
– Start: To resume the system back.
– Right: To turn the robot right.
– Left: To turn the robot left.
– Pick Up: To pick up the book from library counter or any shelf.
– Drop Down: To drop down the book.
Each command needs to train until it shows success message. After successfully training the commands, load the commands in the module and the system is ready to perform tasks. All the actions of the robot are being recorded and monitored on the control room of the library with the help of the camera which is mounted over a robot. After reaching that particular column, it starts searching for the books ISBN using bar code scanner and with a camera. If the book ISBN matches with the required book then it will grab the book with the help of the robotic arm and return back using the same path to handover the book to library counter. The database can be accessed from anywhere in the campus as it uses a LAN network with static IP for checking the availability and other details.

IV. RESULTS

The developed automated smart library system that will help the readers to get the library resources efficiently with the help of a library database for searching the book and users details. Library database will get auto-updated with all the records of all the readers. The developed system is very useful in large and bulky libraries where operations like searching, maintaining and managing of the books are difficult.

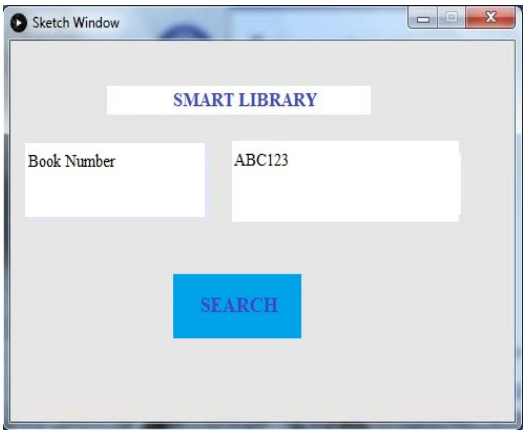

Fig. 5. Book details fetch from database.

Here in this experiment, we have bifurcated only 3 columns Technology, Friction, Encyclopaedia with Red, Blue, Green colour respectively which can be increased to many columns with different RBG color combinations. Books should be kept with a distance of 2 inches from each other for better performance of the robot. Moreover, it has been observed that the time required by the robot to complete the operations are 6-7minutes if the distance is approximately 23 meters. The robot will provide efficiency of 80-90% for picking the book.

Table 1: Summarized Result.

Colour Code	Shelf	Time Taken (Minutes)	Distance (Meter)
Red	Technology	6	22
Blue	Friction	5	27
Green	Encyclopaedia	7	30

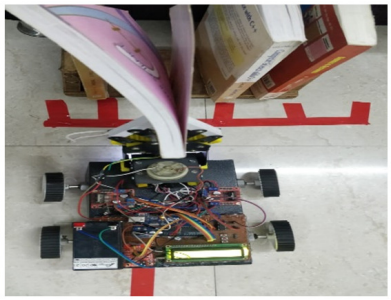

Fig. 6. IoT based smart library using line follower robot.

If multiple arms are added in the large libraries then it will also slow down the time required to search the books for various readers. The bar code scanner and the camera make it easy to identify the book even if the same book has a different edition with the same author. We used color sensor for lane detection that will help in tracking and moving the robot continuously. The robotic arm design is different for different library structures.

V. CONCLUSIONS

The purpose of the Smart Library system is to provide the details of a large number of books, magazines, journals, thesis and allow the administrator/Librarian, staff or students to search, borrow and return facilities. This system will reduce the time required for a task like issuing and returning the book as it reduces the human interception and uses electronic and mechanical automation in place of that. Executing this system in central libraries will help many readers. Various privileges are accorded to different user types. For librarian staff, the robot is accessible through voice commands as well so that it can help the staff in managing and maintaining the library properly. While the readers can access it through the web database for getting the details of their account and can opt for issuing or return a book though it without going anywhere. Advantages of this system are:
– Fastest, easiest, most efficient way to track, locate & manage library materials.
– Efficient and safe book management.
– Fast and easy for the people to issue the book.
– Management of the book through a robot.
– Library inventory tracking in minutes.
– Unique code is assigned to every book so that it prevents counterfeiting.
– Automated pick and place operations for the book using a robotic arm.

VI. FUTURE SCOPE

– Machine learning algorithm can be used to detect the book from the shelves so that the time required to search the book can be reduced.
– If any disturbance or distortion occurs in the path of the robot then the robot can able to rectify its path their own using camera and machine learning algorithms.

– Robotic arm can be modified with 6 or more degree of freedom. More color lines or path can be drawn for more columns of the library.

ACKNOWLEDGEMENTS

Authors acknowledge to all faculty members, dean, school of electrical, electronics & communication engineering, Vice Chancellor and Pro-Vice Chancellor of Galgotias University for continuous motivation and support who provided insight and expertise that greatly assisted the research.

Conflict of Interest. No conflict of interest exits in this study as the present study is based on the experimental hardware and tested in the field.

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How to cite this article: Gupta, T., Tripathi, R., Shukla, M. K. and Mishra, S. (2020). Design and Development of IOT Based Smart Library using Line Follower Robot. *International Journal on Emerging Technologies*, *11*(2): 1105–1109.