RFID-Based Intelligent Books Shelving System

Thein Moe Win @ Shamsudin[1] M.J.E Salami[2] Wahyudi Martono[3]

Department of Mechatronics Engineering, Faculty of Engineering
International Islamic University Malaysia, Jalan Gombak,53100 Kuala Lumpur, Malaysia
Tel:+6019 3419 304, E-mail: theinmoewin@yahoo.com,
Tel:+603 6196 4494, E-mail: momoh@iiu.edu.my,
Tel:+603 6196 4435, E-mail:wahyudi@iiu.edu.my

Abstract

Searching and sorting misplaced books is a difficult task often carried out by the library personnel. Quite often, librarians are busy with searching misplaced books which are left in wrong locations by library users. It is quite difficult and almost impractical to place back all books to their assigned locations daily. To overcome this, Radio Frequency Identification (RFID) based Intelligent shelving system has been proposed to provide an efficient mechanism of books management monitoring through wireless communication between the RFID reader and the books. It is quite essential for the proposed system to have a smooth motion for the RFID reader during the shelving operation; otherwise acquired data will have no value due to inconsistency in reading the tags. Consequently, in this paper, the performance of RFID reader motion and tags data management such as retrieving information, matching with database, sorting out the order and displaying the status of books locations are discussed. A prototype consisting of monitoring PC with embedded controller, two dc motors with drivers, RFID reader and aluminum frame stick on rack have been developed. The performance of the proposed system has been investigated and found to be satisfactory. And it has a lot of potential applications, especially in its ability to alleviate the intensive labors and efforts in shelving library books.

Keywords: ***RFID, Motion Control, Tags data management, LabView User Interface***

1. Introduction

It is well known that RFID Technology has emerged as a very efficient technology to contribute to the supply chain management as it is flexible enough in terms of detectable range and accessible mechanisms. It also provides significant improvement on items identification, tracking the objects and stock control. As RFID allows the wireless storage and automatic retrieval of data, as in [1], many companies are realizing its importance of increasing performance within the supply chain. Consider a typical library, in which each book has its own assigned location in order to get easy assessment. However, library users would often remove books from perhaps multiple shelves and browse them through to search for intended ones. Then, it would not be easy to place them back to their original locations which make them inaccessible. A similar situation occurs in many retail stores where customers would try out things before deciding to buy them, as in [2]. Eventually, these items would be mixed up without putting them back to their proper places. Many approaches have been suggested on how to restore books or stocks to their actual locations. These procedures differ with respect to the technology, accuracy, frequency of updates, and the costs of installation and maintenance, as in [3]. For instance, manual re-shelving using hand-held scanner in searching misplaced books is shown in Fig.1. The design and development of RFID-Based books shelving system for automatic sorting of misplaced books in library is presented in this paper. The operation of this system relies on appropriate control strategy for smooth motion of RFID to capture (acquire) books data at appropriate speed. Software which displays the status of the books locations has also been developed.

2. Design and Modeling

RFID reader has to capture data from books of each row and then proceed to the next row until it accomplishes the task. Here, the RFID reader has to move very smoothly while sending tags data to the main server through wireless communication channel. An appropriate control strategy plays essential role in allowing the RFID to attain smooth and steady motion during the reading process, as in [4]. The proposed system consists of both hardware implementation and software configuration. The hardware components are: book-racks, aluminum rail path, two dc motors for horizontal and vertical motions, RFID reader with wireless Bluetooth and DAQ card, whereas the software tools are MatLab 6.5 and LabView7.1.

Fig.1. LIBRARIAN SEARCHING MISPLACD BOOKS USING HANDHELD SCANNER

2.1 *Hardware Mechanisms*

Book racks are built as a prototype and the rail path is also designed and placed on top of each rack to enable the reader frame to move without any obstruction, see Fig.2. RFID reader is attached to the conveyor which has vertical motion in order to read tags from each row. It is essential for RFID reader to provide wireless communication to avoid cable interruption and fast response since it runs through rows and racks. The actuators in this system are two DC motors of which one motor carries the RFID attached frame and another one drives vertical conveyor to move reader up and down. Both actuators have added gear head to produce much higher torque during driving mechanisms, as in [5]. The applied parameters like friction between pulley and rail path, carried load (attached frame), gravity, force of inertia, and load torque are all considered in developing control transfer function of the plant, which can be expressed as in (1).

$$G(s) = \frac{116.4975}{s^2 + 12.442s + 12.69} \quad (1)$$

2.2 *Simulation Studies*

This section investigates good positioning and speed control systems which are needed to produce fast response and robustness for the proposed system, as in [6]. To satisfy these requirements, the performance of PID, Fuzzy and NCTF-Fuzzy controllers have been evaluated for both horizontal and vertical motions control, see Fig.3. It is observed that the PID controller reaches its steady state in 4.5 s whereas both Fuzzy and NCTF-Fuzzy controllers reach their steady states in 4.5 s and 4.0 s respectively. Even though all controllers provide high accuracy and smooth system performance, NCTF-Fuzzy compensator is considered the most effective to compensate for the effects of any form of disturbance which can lead to poor performance (inaccurate position, unsteady motion and poor unreliable data acquisition).

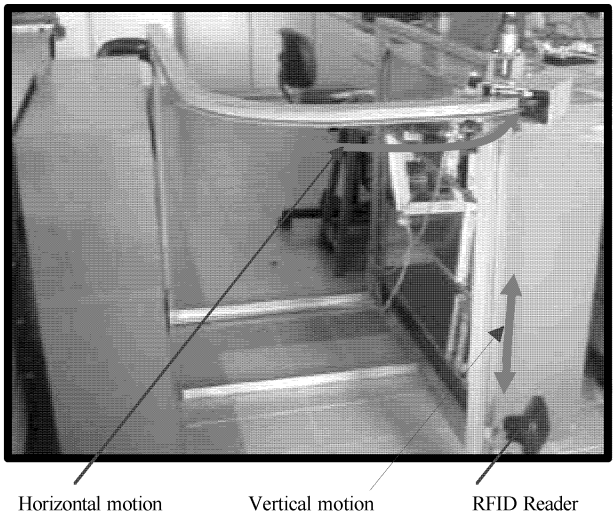


Fig.2. LAB-SCALE PROTOTYPE

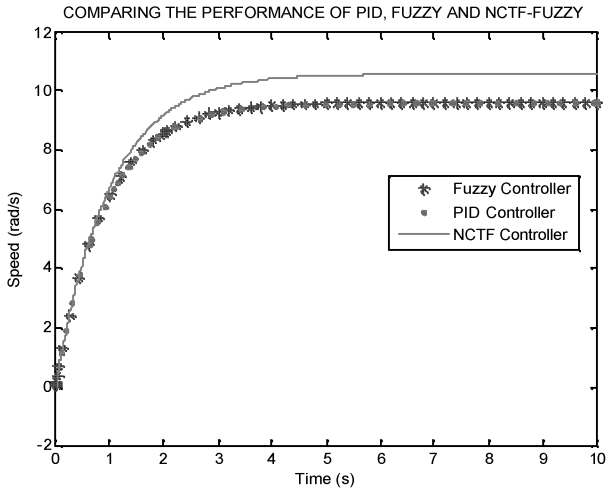


Fig.3. PID, FUZZY, NCTF CONTROLLER PERFFORMANCE COMPARISON

3. RFID System Operation

The main purpose of this section is to analyze the reader motion while acquiring data from books. RFID reader plays the important role in collecting data from books' tags, the details of books information would then be displayed either as the status OK in its original location or misplaced. The main advantage of using RFID reader is that it can read tags from a distance of 1.5 meters using a single antenna at a rate of up to 6 tags per second and it can retain up to 100 tag IDs in its volatile memory, as in [7]. A circular polarized antenna is integrated into the handle to read tags in any orientation, as in [8]. Furthermore, the proposed system has made wireless reader easier to move form one rack to another in order to retrieve tags information to update database using network data transmission through Bluetooth, see Fig.4.

4. Wireless Communication via Bluetooth

The proposed system implements Bluetooth connection to enable the reader move freely without any attaching cables. Normally, using the cables has become the bane of many systems and therefore it would be difficult to figure out what cable goes where, and getting tangled up in the details, as in [9]. Bluetooth (cheap radio chip to be plugged into computer) essentially aims to fix these difficulties, and it is called cable-replacement technology, see Fig.5.

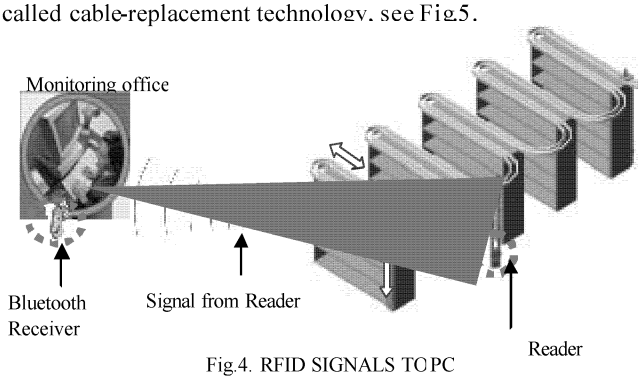


Fig.4. RFID SIGNALS TO PC

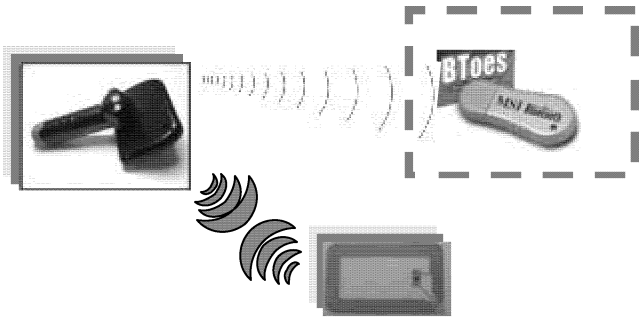


Fig.5. WIRELESS COMMUNICATION BEWTEEN RFID AND PC

It is also aimed to produce a kind of flexibility where the reader will be moving from one book rack to another. In this lab-scale RFID system, the transmission range of reader is 150 mm and therefore, using the Bluetooth wireless connection provides best solution to communicate between RFID reader and tags.

5. Data Server management

A database is needed in this project as the scanned data that refer to the tag ID from the reader of a book must be compared to a database in order to know the details and the position of the book. The database stores a set of original data which consist of the ID tag, the author, the title of book, its call number and position. By comparing the scanned data with the original data, the books can be identified either to be in the correct shelf, misplaced or missing. In order to perform that function, LabSQL is used as a medium to store data to the database. The step by step stages operated by MySQL from retrieving tags to filtering, matching, sorting and final displaying are shown in the flow chart depicted in Fig.6.

MySQL is a fast, easy-to-use Relational Database Management System (RDBMS) used for databases on many Web sites. Speed is the developers' main focus from the beginning. It is a reliable database management system as it can operate at many operating systems, fast, inexpensive, easy to use as well as secured. This database is also capable of storing a large number of data like book collections in a library or a resource centre. In MySQL, database has been separated into 5 categories such as temp3, temp4, temp5, original and results as mentioned in the flowchart where each one means:

- temp3: To store data read from the RFID reader. This data is unfiltered and may include several ID tags in one particular row.
- Temp4: To store the partitioned ID tags from *temp3* that contains more than 18 characters in a row.
- Temp5: To store the ID tags after eliminating any repeating ID tags in *temp3* and *temp4*.
- Original: Stores the original set of data of the books which include the ID tag, author, title, call number and location of every book. Flag is added as an indicator whether the book is being scanned by the reader or not. This table is used to be compared with the *results* table to determine the status of the book.
- Results: The information from *temp5* is copied here and being compared to the *original* table to determine the status of the books whether they are in their correct positions or not. This table consists of five attributes similar to the *original* table, except that the *status* attribute is added. It stores the book condition strings which can be *available, missing* or *misplaced* depending on the book status.

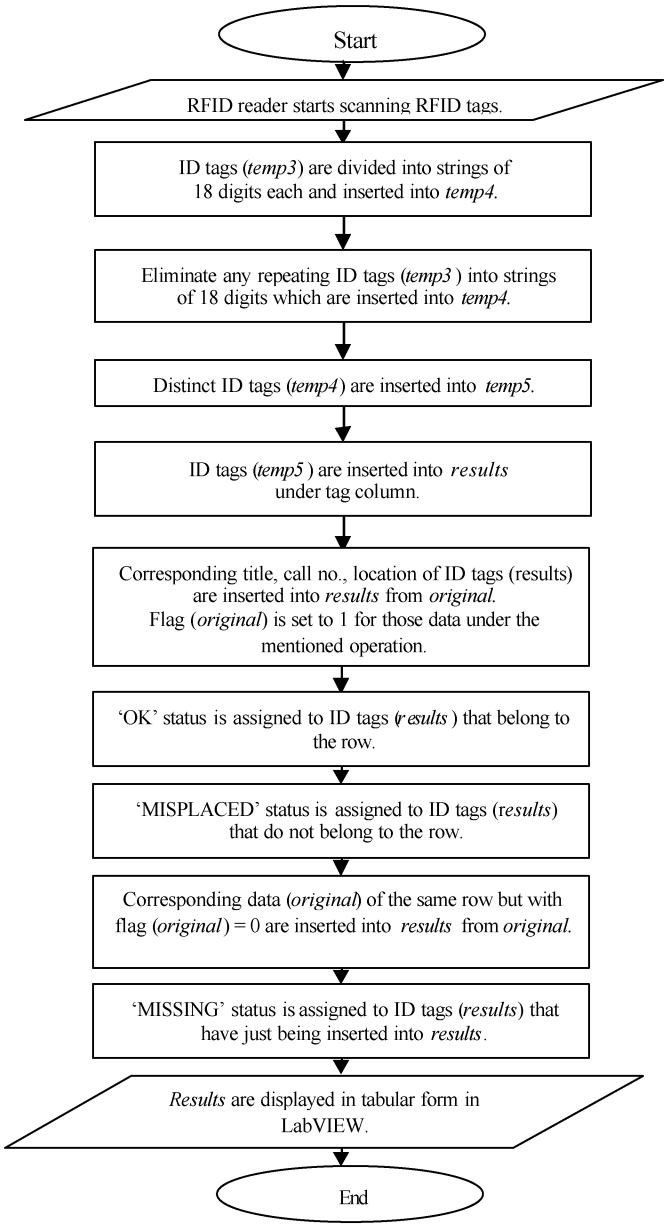


Fig.6. FLOW CHART OF MYSQL OPERATION

6. Interaction between LabVIEW and MySQL

The necessary settings have to be done on LabVIEW while connecting with MySQL such as COM port, baud rate, data bits, parity bits, stop bits, flow control, delay before read and scanning method. COM port should be adjusted according to the communication port that the reader is connected to. LabSQL is a collection of virtual instruments (VI) that use the ActiveX Data Object (ADO) collection in LabVIEW so that LabVIEW can be connected to almost any databases (including MySQL), performing SQL queries, manipulate records and others. Essentially it is a collection of VIs that acts as wrappers for ADO properties and methods. Microsoft® ADO enables the client applications to access and manipulate data from a

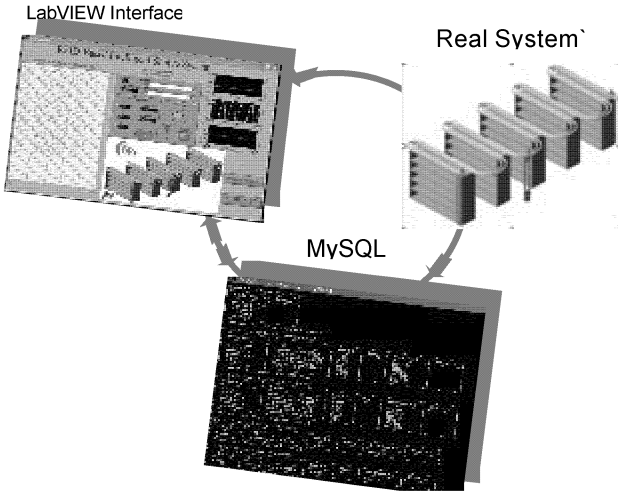


Fig. 7. LABVIEW-MYSQL LINKAGE

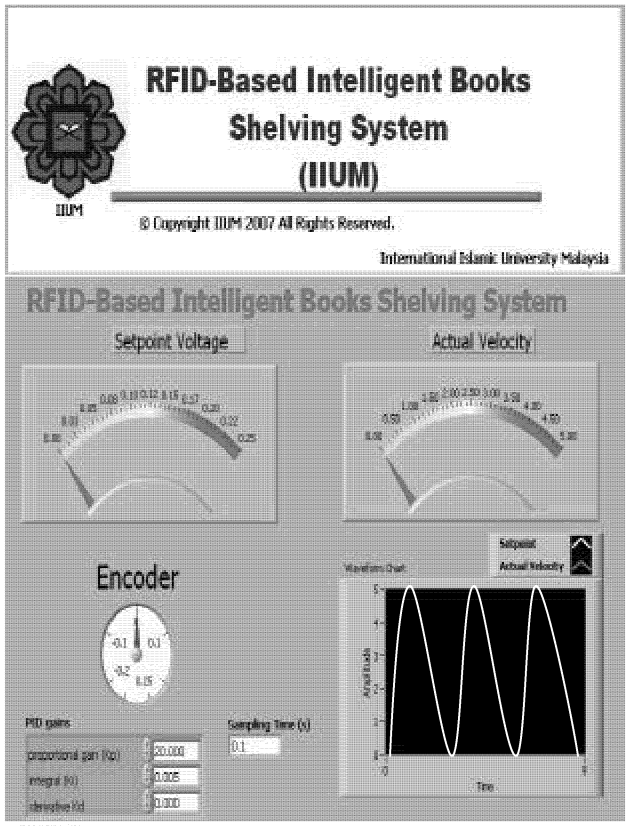
database server through an Object Linking and Embedding Database (OLE DB) provider. In this project, the most suitable method is to read multiple tags with spaces as it would enable the reader to scan the tags continuously. The RFID tags that are detected will be shown inside the ID detected box whereas the MySQL input command would appear inside the MySQL Query box as soon as the RFID tags appear, see Fig.7. The Results Interface will appear automatically soon after the reader finishes scanning all the books.

7. User Interface

For practical purposes, it is much essential to have System Monitoring Screen (SMS) in order to communicate between end user and book racks, see Fig.8. This is to make it easier for the system to monitor the lists of books being read, and to check their status whether OK or misplaced, as in [10]. As soon as the start button is clicked, the reader will move on rail path which is placed on top of each rack and reads the data for all the books. The acquired data would appear on the screen using Bluetooth wireless communication. The end user can print out those misplaced books lists for collections. The main advantage is in modern library, where saving time in searching books, overall operational costs and efficiency are crucial factors.

8. Conclusion

In conclusion, this paper presented a prototype of a noble automate procedure to track tagged items or books where experiments show that position/speed control algorithms can bring reasonable accuracy. The RFID reader also enables it to capture tags data from all books and update to the interface. The end user can monitor the system performance and easily get the misplaced books lists without exerting desperate efforts in searching those books. This system can also be employed in other applications like retail shops or industries, where the stocks are required to be monitored. Further improvement to the system would also be made in future to have more robustness in reader motion which is the most crucial part of the system; otherwise the desired tags will be out from the reachable range. Moreover, the reading algorithms in displaying captured data would further be analyzed to make adjustment to include any needed functions.



SQL Results 2

ID TAG	LOCATION	STATUS	TITLE	AUTHOR	CALL NO.
14E004010006956704C	1.2	MISPLACED	Energy-efficient electric motors :	Jordan, Howard E.	TK2781J82E
14E004010006956826	1.2	MISPLACED	Electric machines : dynamics and	Nasar, S. A.	TK2781N243E
14E004010006957052	1.2	MISPLACED	Linear induction drives	Gieras, Jacek F.	TK2785G454L
14E004010006956C97	1.2	MISPLACED	Stepping motors and their microp	Kenjo, Takashi	TK2785K335
14E004010006956EDD	1.2	MISPLACED	Switched reluctance motor drive:	Krishnan, R. (Ramu)	TK2787K925
14E004010006956D17	1.2	MISPLACED	Handbook of transformer design	Flanagan, William M.	TK2791F583H
14E004010006956FCA	1.1	OK	Electric motors	Cox, V.J.	TK2511C877E
14E004010006956EC6	1.1	OK	Electric motors and their controls	Kenjo, Takashi	TK2511K33E
14E004010006956B9F	1.1	OK	Energy conversion : electric mot	Ramshaw, Raymond	TK2514R183E
14E004010006956A3A	1.1	OK	Permanent magnet motor technc	Gieras, Jacek F.	TK2537G454P
14E004010006956B19	1.1	OK	Electric motors and drives : fund	Hughes, Austin	TK2514H893E
14E004010006956ECE	1.1	OK	Linear synchronous motors : trar	Gieras, Jacek F.	TK2537G454L
14E004010006956D0A	1.1	OK	Electric motors & control techniq	Gottlieb, Irving M.	TK2511G686E
14E004010006957038	1.1	OK	Electric motor handbook	Beaty, H. Wayne	TK2514B369E
14E004010006956C0E	1.1	OK	Handbook of small electric motor	Yeadon, William H.	TK2537H236Y
14E004010006956D0E	1.1	OK	Electric motor maintenance and t	Hand, August	TK2514H236E
14E004010006956F3	1.1	OK	Permanent-magnet DC linear mo	Basak, Amitava	TK2537B297P
14E004010006956ECA	1.1	OK	Stepping motors : a guide to mo	Acarnley, P. P.	TK2537A168S
14E004010006956FCA	1.1	OK	Electric motors	Cox, V.J.	TK2511C877E
14E004010006956EC6	1.1	OK	Electric motors and their controls	Kenjo, Takashi	TK2511K33E
14E004010006956B9F	1.1	OK	Energy conversion : electric mot	Ramshaw, Raymond	TK2514R183E
14E004010006956A3A	1.1	OK	Permanent magnet motor technc	Gieras, Jacek F.	TK2537G454P
14E004010006956B19	1.1	OK	Electric motors and drives : fund	Hughes, Austin	TK2514H893E
14E004010006956ECE	1.1	OK	Linear synchronous motors : trar	Gieras, Jacek F.	TK2537G454L
14E004010006956D0A	1.1	OK	Electric motors & control techniq	Gottlieb, Irving M.	TK2511G686E
14E004010006957038	1.1	OK	Electric motor handbook	Beaty, H. Wayne	TK2514B369E
14E004010006956C0E	1.1	OK	Handbook of small electric motor	Yeadon, William H.	TK2537H236Y
14E004010006956D0E	1.1	OK	Electric motor maintenance and t	Hand, August	TK2514H236E
14E004010006956F3	1.1	OK	Permanent-magnet DC linear mo	Basak, Amitava	TK2537B297P
14E004010006956ECA	1.1	OK	Stepping motors : a guide to mo	Acarnley, P. P.	TK2537A168S

Fig. 8. LABVIEW USER INTERFACE

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