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AUTOMATED CART NAVIGATION USING ACTIVE RFID AND LabVIEW

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Abstract *- Radio Frequency Identification (RFID) is the fastest growing technology these days. In recent years Radio Frequency Identification technology has become the most promising technology, especially in the healthcare industry. It has significantly contributed to the reduction of health care costs, increased patient safety and better healthcare services. Patient management and tracking has been successfully done till now with the use of Radio Frequency Identification. Further to lessen the burden of hospital staff and to increase the convenience of patients, the concept of an automatic patient cart was introduced which could move all by itself within the hospital environment without any kind of assistance from hospital staff. In this paper, active RFID reader antennas and tags are used for automated navigation of patient cart. The hardware is tested practically for a selected path mapped for indoor localization of tags and patient cart.*

Keywords*-Radio Frequency Identification(RFID), Active Tags, Navigation, Tag Reader, LabVIEW Interface For Arduino (LIFA), (Virtual Instrument Software Architecture)VISA*

I. INTRODUCTION

ACTIVE Radio Frequency Identification (RFID) is the most widely used technology for the past decade. Although Passive RFID is the emerging technology these days, but still Active RFID has its own benefits. Active RFID consists of tags which are wireless transponders that can be automatically identified,tracked and monitored to locate a variety of processes. These have an on-board battery which directly powers RFID communication, hence these start communicating as soon as they are powered. These tags are usually larger in size and can store much more information because of their higher amount of memory and have greater range as compared to passive RFID tags. Therefore, though active and passive RFID capabilities are related yet distinctly different technologies which are used accordingly depending upon technical application and economic requirement of the user.

RFID in the past decade has emerged to be a better choice for indoor navigation as compared to GPS technology. In this communication and navigation is done by using RFID tags and readers. Passive RFID tags, can be used and embedded almost anywhere, without the presence of a power source and they have a range of 10-15 meters in case of Ultra High Frequency (UHF) RFID systems [1]. In indoor navigation techniques which are used to assist blind people, again RFID turned out to be a savior. This technique assists the blind people to reach their destination safely by following the shortest path within indoor environments [2].

Recently, RFID has been used in mobile robots. Information provided by tags is used for navigation, localization, mapping and people tracking. Now days a prior knowledge of position of RFID tags is not necessary, since only robot localization is considered. This is achieved by comparing current events of tag detection with the previously recorded RFID measurements and results at reference positions [3]. RFID is more rapidly branching its roots in medical field and healthcare. In the hospitals RFID navigation is used for asset management, patient care and movement, managing long queues of patients in hospitals. A method was lately launched in which one can accurately locate a person in the indoor environment by fusing Inertial Navigation System (INS) techniques with active RFID technology [4].

II. RECENT DEVELOPMENTS

RFID has been used for navigation and localization in different fields for many decades. So far it has been proved as a good substitute for other types of navigation and localization techniques. The work of various authors and researchers in this field has been really helpful in further improvement, development and innovation in this area. In the field of wheelchair rehabilitation RFID is proved useful for indoor and outdoor navigation.

The project called as **NavChair** [5], a semi-autonomous wheelchair for safe travel of patients in busy environments, having obstacle avoidance mechanisms, was developed by Michigan University. It used VFH method which relies on sonar information, for obstacle avoidance with minimum speed reduction. Then **Mazo et.al** [6] developed a prototype wheelchair for physically disabled patients. This wheelchair had an advantage over other wheelchairs that, it included a control system having voice commands along with multi-sensor system. **Sgouros et.al** [7] described a qualitative effective method for safe indoor navigation of the patient cart. Here authors studied sensor behavior at different adjacent regions in space and then finally used this observation in planning and controlling of the patient cart in indoor environments.

Another author, **Chowdhury et.al** [8] have discussed the design of an RFID based Hospital Patient Management System (HPMS) by using multi-layer health care system architecture. **Kim et.al** [9] discussed designing of a Patient Management and Tracking System (PMTS) based on RFID with Received Signal Strength Indication (RSSI) method. **Kantawong et.al** [10] discussed the design of a wheelchair ramp lift boarding supporter system required in case of boarding a public transportation. This system uses RFID as a solution along with the fuzzy PI control.

III. OVERVIEW

To navigate a patient cart within the hospital environment all by itself without the assistance of any medical staff, two parameters obstacle avoidance and instant path modification is important. An indoor environment was studied and selected and was thus mapped in order to be stored in a memory so that it could be recalled by the main program. The first phase of navigation was mapping of navigation area with minute details of relative distance and position between the check points. We developed the software model of moving reader and fixed tags, the software model of indoor environments, the simulation model and strategies of RFID systems in different conditions.

IV. MATERIALS AND METHODS

The RFID hardware used in this study was a product of Wavetrend working at 433 MHz. It consisted of RFID tags and reader. The RFID reader used was L-RX300 wih Version 3.0 working on 57600 baud rate and had protocol type B, and had RF active receiver with a RS232 interface. The reader consisted of MAX232 interface which converts signals from an RS 232 serial port to TTL compatible signals suitable for use in digital logic circuits. The RFID tags used had anti-collision feature which enabled the tag to respond to reader in accurate time slots thus preventing failed communication. To avoid collision of data sent by different tags, a tag doesn't respond to the reader in the time slot of any other tag. The number of tags must be kept limited as it may cause detection collision as the reader may detect more tags than it can actually handle at a time [11]. The system software was developed around LabVIEW, Arduino, LabVIEW Interface For Arduino (LIFA) and (Virtual Instrument Software Architecture)VISA.

V. PROPOSED SYSETM

We planned to navigate the mobile cart in our area of interest which was an office area consisting of corridor and four rooms. We used an RFID reader (L-RX300) & four Active RFID Tags (range: 10 meters), an Arduino and two IR sensors. Active RFID tags were used as they have onboard battery and have greater range than passive tags. The reader was placed on the cart while four tags were placed as one at the entrance of each room. Two 24 volts DC motors were used to drive the patient cart and two relays were used to perform the switching action. Various software platforms used in this system were, LabVIEW, LabVIEW Interface For Arduino (LIFA), Arduino Programming Toolkit and Virtual Instrument Software Architecture (VISA).

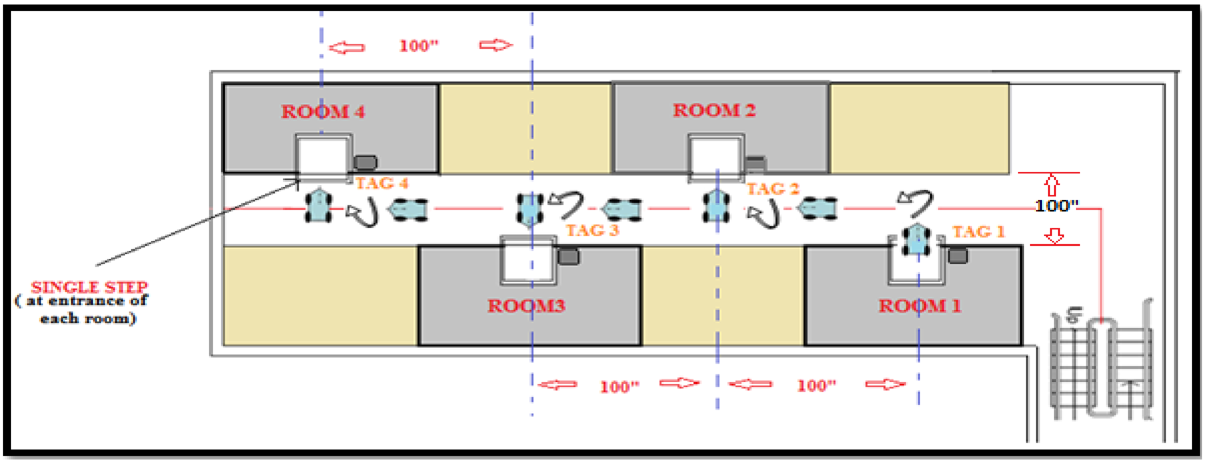


Figure 1. Schematic layout of corridor for wheelchair navigation

The figure 1 above shows the schematic of the corridor for mobile cart navigation. Each room is diagonal to its adjoining room with center to center distance of 100 inches and the width of the corridor is also 100 inches. We placed one Active RFID tag at the entrance door of each room and an RFID reader is placed on the moving patient cart. In order to move wheelchair freely in the corridor of the building all possible paths were specified from each room to every other room in programming so that the cart can reach any room from its current location just by specifying the target room. The programming is done by simulation in LabVIEW. The touch panel of wheelchair in actual is the front panel of LabVIEW program.

VI. SYSTEM IMPLEMENTATION

The RFID system only detects the tag which has the closest proximity to the reader and thus collects the information about its data and RSSI. Thus, by knowing this data we get the current location of the wheelchair.

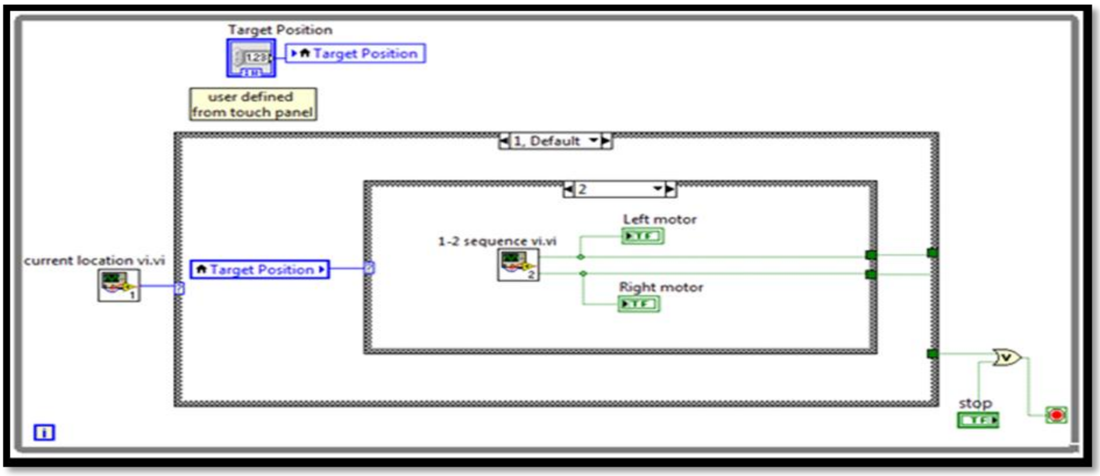


Figure 2. High level block diagram of RFID and Database control system

To navigate the wheelchair to target location which is input by the operator, programming is done in LabVIEW. A single board microcontroller called Arduino was used to interface hardware and software (LabVIEW). We used an interface called LabVIEW Interface For Arduino (LIFA). Figure 2 above shows the high level block diagram of RFID and Database control system having two case structures. The outer one is controlled by the current location of the wheelchair and the inner one shows the target location of the wheelchair, which is controlled by the operator through touch panel of wheelchair, as encircled red in figure 3 below. We had total twelve cases corresponding to twelve different paths that the wheelchair would be following for reaching different target locations from different current locations.

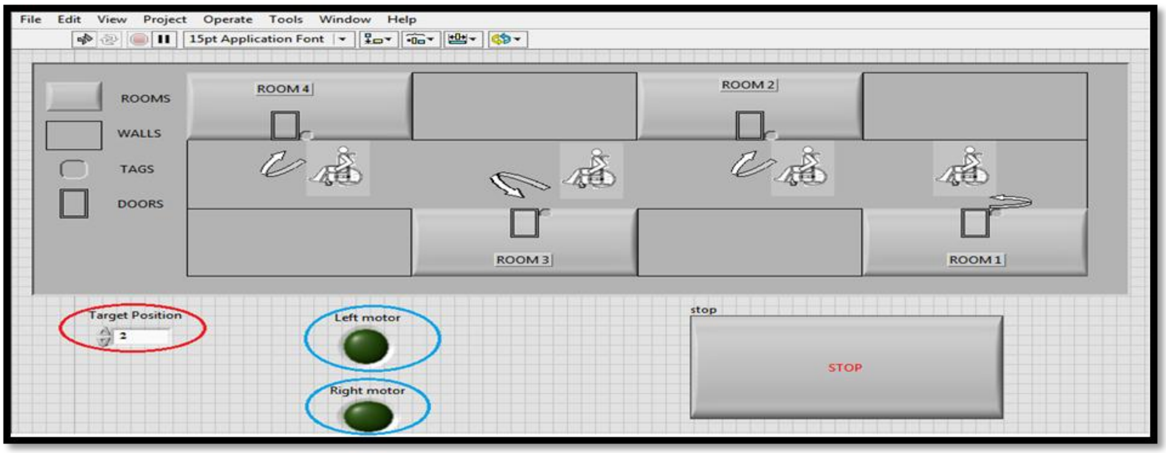


Figure 3. Front Panel to select target location

The current location of wheelchair is given by RFID using the following LabVIEW program given in figure 4.

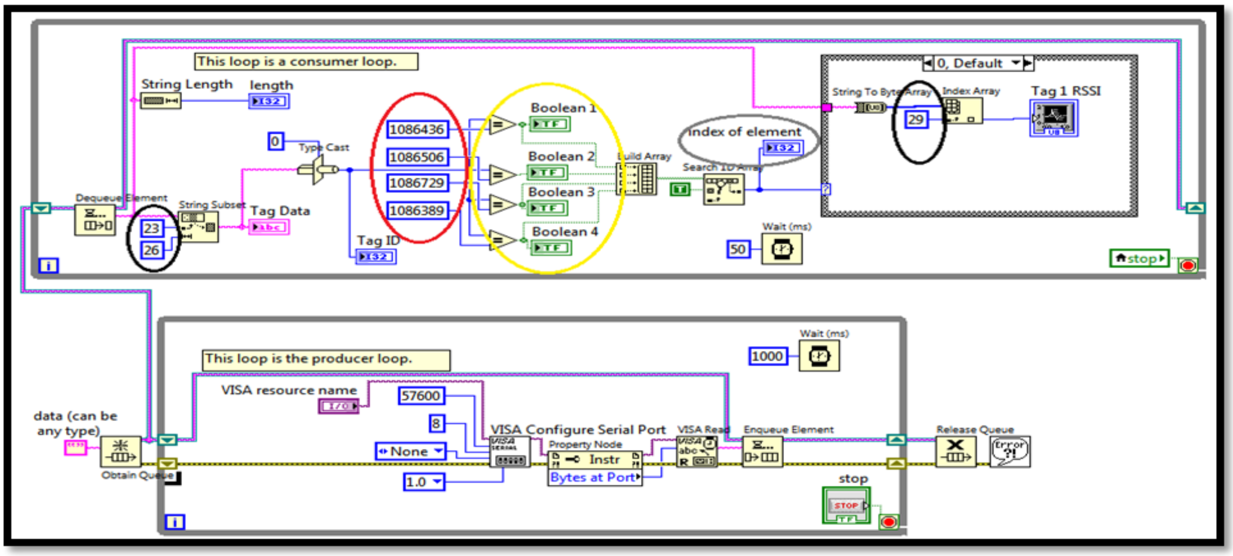
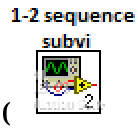
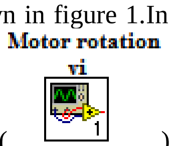


Figure 4. Block diagram for finding out the current position of the wheelchair

Here, to obtain the information given by this RFID system, VISA software was used in LabVIEW. We made a subvi of this tag detection VI and thus named it as current location vi (

) and used it in our main VI as shown in figure 2 and when RFID locates the current location of the wheelchair as room no: 1 and the operator selects the target location as room no: 2 then in that case our inner case structure will execute **"1-2 sequence subvi" (** 

). This subvi navigates our wheelchair from room 1 to room 2 based on the path specified in the program, i.e., the wheelchair will first move towards the center of the corridor, then turn left, then again go straight for 100 inches and then turn right and at last move to the entrance of the room. Various subvi's were designed and used in the main program, each defining a particular course of action to be taken by wheelchair as shown in figure 1.In order for a wheelchair to navigate through the specified paths we need to design a motor rotation subvi (

) which drives the motors of the wheelchair and thus the wheelchair moves by itself in the specified directions while comparing the distance covered by wheelchair at each instant by a fixed distance which vary for different cases. So, for driving the motors of the wheelchair we calculated for how long the motors should be driven to cover the specified distance and for that time period motors should continuously get the power. This is achieved by using Arduino and LIFA (LabVIEW Interface for Arduino) program. In this the power is provided to motors through driver card controlled by Arduino digital pins. For making Arduino compatible with LabVIEW, LIFA was used here. The distance covered by wheelchair is calculated with the help of an IR sensor mounted at each wheel as shown later .

On executing the tag detection VI, the following sequence of events take place.

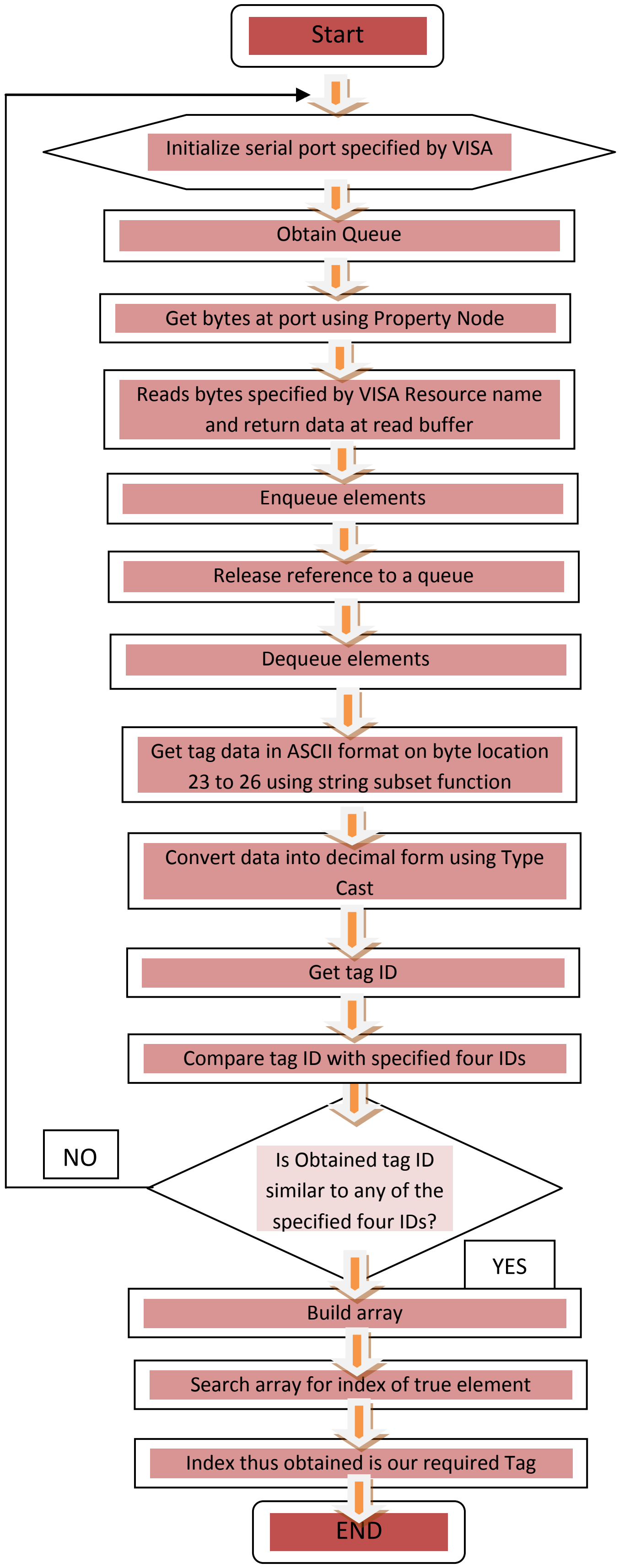

Start
Initialize serial port specified by VISA
Obtain Queue
Get bytes at port using Property Node
Reads bytes specified by VISA Resource name and return data at read buffer
Enqueue elements
Release reference to a queue
Dequeue elements
Get tag data in ASCII format on byte location 23 to 26 using string subset function
Convert data into decimal form using Type Cast
Get tag ID
Compare tag ID with specified four IDs
NO
Is Obtained tag ID similar to any of the specified four IDs?
YES
Build array
Search array for index of true element
Index thus obtained is our required Tag
END

Figure 5. A flowchart showing sequence of tag detection events

The following flowchart summarizes the working of this whole navigation system

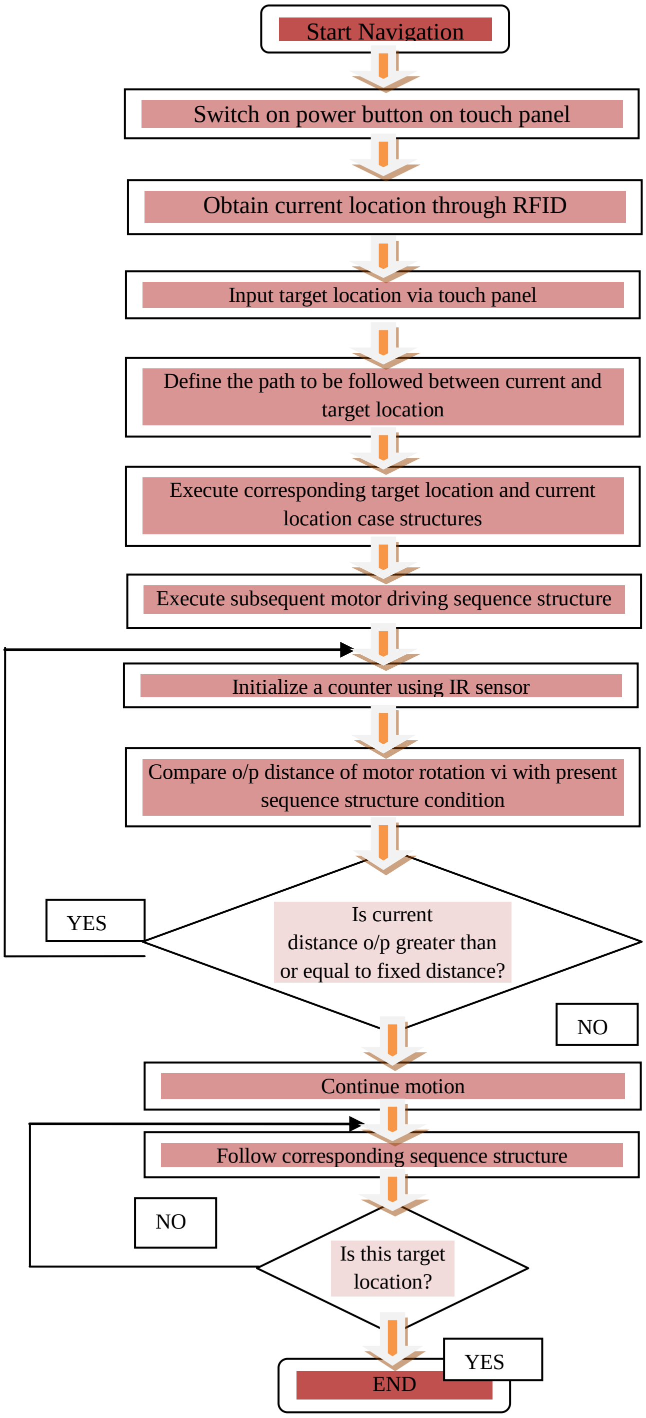


Figure 6. System flowchart

Thus, the distance covered by wheelchair is calculated using IR sensors which are mounted on center of the wheel of wheelchair. We have total fifteen (15) white strips on the circumference of the wheel of the wheelchair, each at a distance of 1” from each other. Now, the IR sensor will make the counter count fifteen times. This indicates one rotation and total distance covered by wheelchair is thus given by the circumference of the wheel.

$$\textit{Number of counts} = \frac{\textit{distance to be travelled}}{\textit{distance covered in one rotation}} * \textit{No: of high counts}$$

$$N = \frac{x}{2 * \pi * r} * n$$

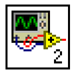
Where, N = number of counts, X = distance to travel, R = radius of the wheel and N = number of high counts

In order for a wheelchair to turn left or right certain calculations are needed. As our wheelchair is square of 20 x 20 inches , therefore to take a left turn, the contact patch of left wheel act as an instantaneous center of rotation and right wheel will make a a quarter circle whose radius is the width of wheelchair which is 20inches.

$$\textit{Circumference of circle} = 2 * \pi * r * \frac{\theta}{360}$$

Now, for quarter circle = 2πr * θ/360°

= 2π * 20 * 90/360 = 10π

Now, the output distance given by this motor rotation vi is compared with 10π i.e., the circumference of quarter circle continuously and thus based upon above calculations another subvi called **“turn subvi” (** Turn subvi.vi  **)** is designed. As soon as the distance covered by wheelchair while rotating becomes equal to or greater than 10π, the wheelchair will stop. Thus, in this way our wheelchair navigates from room 1 to room 2 on its own based upon RFID and LabVIEW programming. Similarly, all the other eleven cases are executed by defining a LabVIEW software based path for them.

VII. DISCUSSION & CONCLUSIONS

In this paper, we managed to present a design of an Automated Patient Cart Navigation using RFID and LabVIEW. By combining both, the shortcomings of one can be overcome by the other. While the current location positioning task is performed by RFID, the navigation and auto routing task is performed using LabVIEW.

This paper discussed a new technique in which the wheelchair navigates on its own to the destinations specified by the operator without the assistance of any other person. For this RFID technique is used to obtain the current location of the wheelchair in the area and for obtaining this data VISA software was used. In addition to RFID, LabVIEW software is used to specify different paths to be followed by the wheelchair under different conditions in response to different commands given by the operator. To achieve this target various obstacles were encountered and a many experiments were conducted at different locations under different conditions. The system was thus observed to be consistent in performance under majority of conditions.

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