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Real Time Semi Autonomous Robotic Navigation and Path Correction in Constrained Environment

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Abstract: *In this paper, we have presented a cost effective navigation and obstacle avoidance of patient cart. Passive RFID (125 kHz) were used for navigation and ultrasonic sensors were used for obstacle detection and avoidance. Multiple 8 bit low cost microcontrollers were used in parallel processing mode, they complement one another working in a master slave configuration. One controller is completely dedicated to obstacle avoidance while other is looking for navigation, communicating with each other through serial interface. The system has an interactive graphical user interface, making the system user friendly.*

Keywords- *URM(ultrasonic ranging module) ,Passive RFID(radio frequency Identification) , Master Slave operation, Parallel processing.*

I. INTRODUCTION

Autonomous patient cart is basically used by persons who are physically disabled or a partly paralyzed. The autonomous patient cart based on RFID has been a common practice over the years. The heart of such systems ,the microcontroller is essential in deciding the overall performance. Navigation using RFID, both active as well as passive ones in hospital environments has attracted the attention of the researchers for a long time [1, 3, 5]. A lot of attention has to be given to the obstacle detection along with the navigation algorithm. Various techniques has been used such as camera based [10], laser [9] based & others [6-8] to achieve obstacle detection which are a costlier solution. Here, we have used ultrasonic sensors for achieving cost effectiveness. The Navigation system has been made using passive RFID tags. Prior to this, researchers have used passive tags along the entire floor plan [7]. Here, we have made set of cards and just placed it in front of the rooms at the entrance thus reducing the no of RFID tags.

II. RELATED WORK

Navigation using RFID has been a keen area of interest for researchers. Prior to our implementation, RFID location and mapping using probabilistic approach [1] has been used. The drawback with such method is that it fails under real time scenarios. Another approach has been implemented in modifying the antenna of RFID reader in [2] .This approach has positional accuracy errors due to the nature of antenna. The author in [3] has tried to combine RFID tags with speech commands, which is prone to errors due to nature of machine recognition systems. Other authors from [4-7] have tried different approaches for navigation but they lack reliability in real time scenarios. Seeing the other aspect that is obstacle detection system, camera based system [10] have been used recently. The main problem associated with such systems is complex computational algorithms. High end systems are required due to implementation of neural network and complex machine learning algorithms. In [9] author has implement laser technique for obstacle avoidance. Most of the healthcare environments have major concerns implementing these systems as laser has various associated health hazards. Other researchers have implemented fuzzy logic systems which again demands heavy computational requirements.

III. SYSTEM ARCHITECTURE

Our system consists of three different low cost microcontrollers working simultaneously. The overall system architecture is shown in Figure 1.Here the first part highlights the basic interfacing of RFID with microcontroller. We have used Passive RFID tags (125 kHz) and Serial TTL based RFID reader. The TTL serves an easy interface with the controller and also aids in developing power efficient system. The second part deals with interfacing of motor controllers and ultrasonic modules to the controller. The path corrections algorithm and motor controls are handled by this controller. The third part consists of interactive user interface where the user enters the desired location. The last part sees the overall health of the system. It monitors any sensor failures as well as current and voltage limitations of associated circuitry.

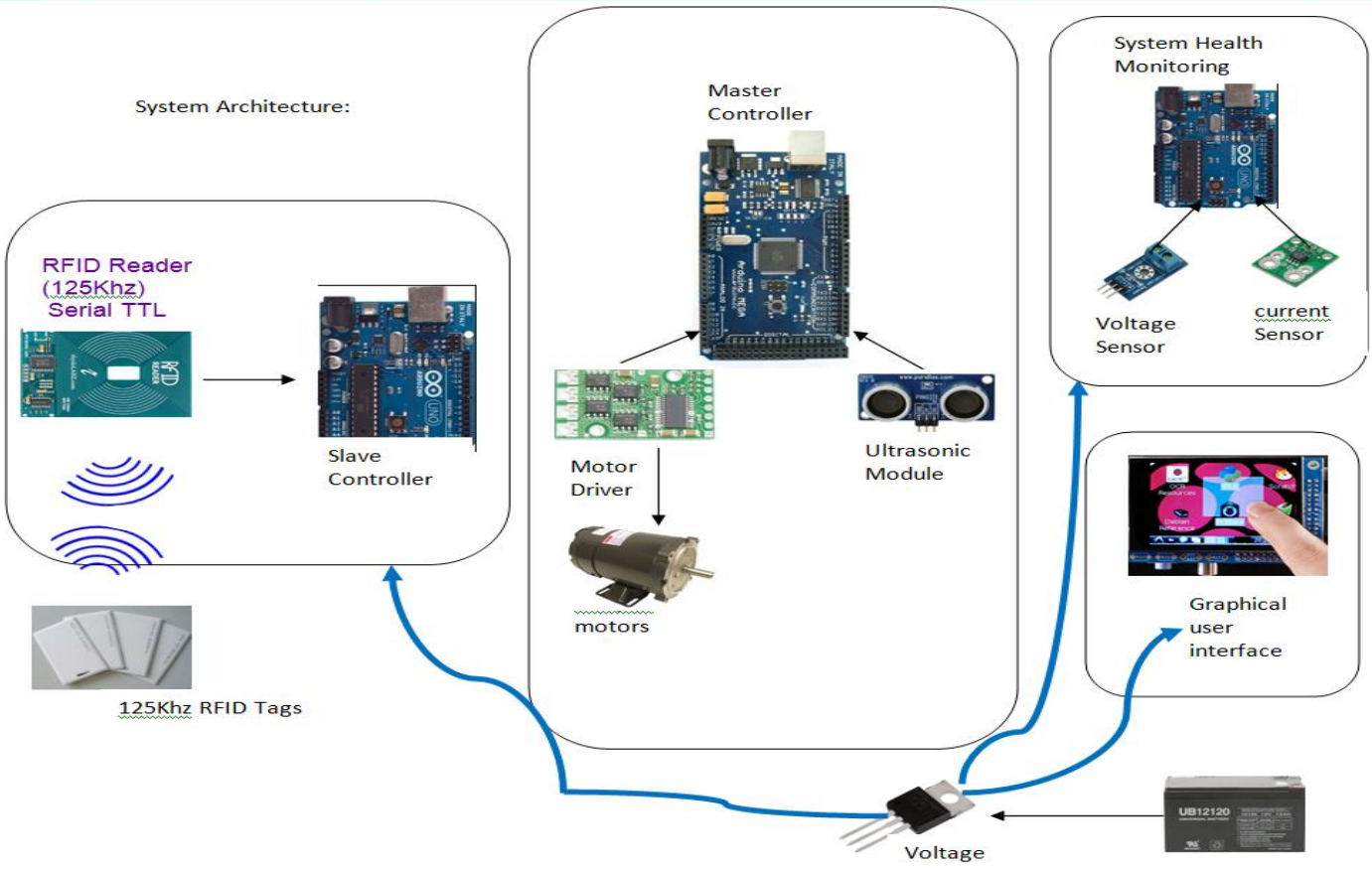

Figure 1. System Architecture

3.1. Obstacle detection and path correction

Here, ultrasonic Sensor modules are used for obstacle detection and avoidance as well as path correction has been used in the patient cart depicted in Figure 1. A total of six sensors had been used at locations Left, Front Left, Right, Front Right, Side Right and Side Left. In general, most of the hospital environments have a lot of movable equipment's such as stretcher, hospital staff as well as cans for dispatching various materials. These all can act as potential obstacles for the patient cart. Furthermore, while moving from a certain location to some other location, the patient has to move through the corridors where they face these obstacles .Here we have developed a path correction algorithm that focuses on moving the cart or the vehicle along a straight path when moving through the corridors.

Various commands have been used for the right and left motors in order to move the vehicle in various obstacle situation. A typical environment will consist of dead ends (wall or a rigid structure) at the corners, T points (where more than two path meets) and other structures. Eight commands namely forward, reverse, right , left, slight right, slight left ,Reverse and hard stop had been used to achieve desired movement of the cart in such a constrained environment.

3.2. Navigation

3.2.1. RFID Reader and RFID Tags

RFID stands for Radio Frequency Identification and Detection. We have used the 125 KHz RFID reader provided by Rhydolabz and the corresponding passive RFID tags. This RFID reader comes with an onboard LED that tells whether a tag has been detected by the reader or not. The reader provides a 12bit output, of which the first and last bit is the start and stop bit, respectively, and the remaining 10 bits are the actual unique ID of the tag. The reader has a range of 10-15 cms and works on the EM402 protocol, making it compatible with any tag that uses this protocol. It has a built in antenna and is operable at low power.

3.2.2. Mounting of RFID Reader

The reader has been mounted on a rotating servo motor at the base of our wheelchair. The servo motor is made to rotate at a certain fixed angle and speed, such that the tags placed in front of the wheelchair are detected with 100% efficiency, thereby providing fully accurate data. The servo motor is attached 15-20 cm above the surface so that the reader can be mounted easily, without it touching the floor. The speed and angle of turn of the motor has been synchronized with the speed of the wheelchair, so that RFID reader does not miss the tags. A separate microcontroller unit has been used solely for the purpose of driving the servo. The angle at which the servo motor rotates is taken to be approximately 130 degrees.

Figure 2. Various Tag Patterns (Square, Crescent etc.)

3.2.3. RFID Tag pattern

The RFID tags were placed in different patterns shown in Figure 2 and then tested tags on the floor as in Figure 2 and checking how the. The patterns tried were square, circular, crescent, etc. Keeping in mind the moving servo and the wheelchair, a particular crescent type pattern has been used that provides greater accuracy in the detection. Using a particular shape like pattern has enabled us to reduce the number of tags required in the detection process. Presently, we have associated 6-8 cards per room.

IV. METHODOLOGY

4.1. Algorithm 1:

STEP 1: Set up Initialization (URM modules, buzzer, and motor drivers)
STEP 2: start of loop: Runs Continuously
STEP 3:Get data from URM
STEP 4: create various motor functions
STEP 5: if: check Side Right & Left threshold {Slight left & right comm.}
STEP 6:else if: check front left & Right threshold
{Slight left & right comm.}
STEP 7: else if: Critical case
{Issuing hard stop comm.)
STEP 8: End of Loop

4.2. Algorithm 2

The RFID reader communicates serially, we have used software serial on the microcontroller board to get data from the reader and process it and communicate it to the master microcontroller.
Step 1: Initialization: RFID, start, finish. Include libraries: Wire, Software Serial.
Step 2: Setup: Set modes.
Step 3: Loop begins
Step 4: Check Serial for data.
Step 5: Receive Data from RFID reader.
Step 6: Process data and communicate to master controller.
Step 7: End

4.3. Parallel Processing(Master Slave mode):

Efficient communication and low cost solution are a major focus in developing a system. Here, we have used multiple low cost microcontrollers to achieve the power of parallel processing whereby obstacle detection and avoidance algorithm as well as navigation algorithm run simultaneously as shown in Figure 3. An interactive graphical user interface had been developed where the user inputs the desired location through software which is communicated serially to the micro controller. We used a master slave architecture where obstacle avoidance algorithm runs on the master controller. In normal mode, when the user doesn't enter any input but still, the cart which is having obstacle avoidance algorithm runs in the background. In this mode,

Figure 3. Master Slave Operation

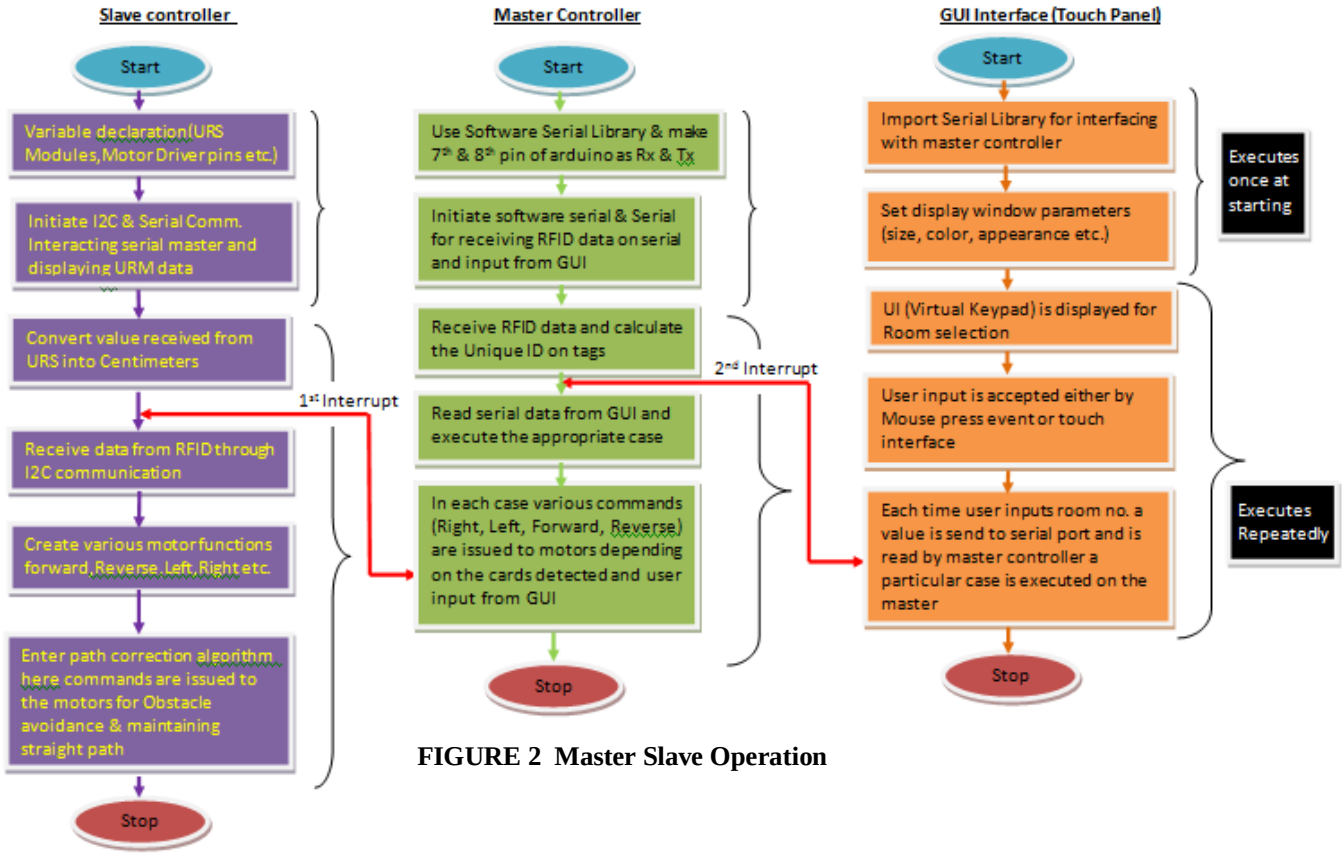

FIGURE 2 Master Slave Operation

the cart continuously store the value from ultrasonic sensors and gives command to the motors to move in various directions depending on the clutter while being most of the time remains in path correction algorithm. The slave controller has the code written for detection of the RFID tags and receiving input from the user for room selection. Various sets of cards has been th each room no. When the user selects a certain input, the RFID reader mounted on the server gets activated and starts searching for the RFID tag placed on the floor below. Based on the card detection and its association with a room the slave algorithm gets executed. Here, with each case structure various directions are associated and the cart is guided accordingly based on the inbuilt map where various card positions are defined. The master to slave communication is done through I2C communication. A unique text is send from slave to master when a particular tag is detected now the master is forced to enter into a interrupt condition where the obstacle detection algorithm is halted for a certain period of time (few seconds). Meanwhile, the cart moves in the specified direction specified in the built in path associated with the master arduino, so as the vehicle navigates through the path given specified whenever certain tag ID is detected .Each time the cart is forced to switch in navigation and obstacle avoidance algorithm simultaneously.

V. RESULTS

The effectiveness of the wheelchair system has been experimentally evaluated for path correction and navigation using RFID technique in an indoor hospital environment. It is a good environment for the testing of our system as the environment is already occupied with obstacles, rooms and partitions, providing a right place for our testing purposes. The experiment was carried and was successful with near accurate results. The sensors mounted on the wheelchair provided

for absolute path correction avoiding and bypassing any obstacles in the way. Figure 4 shows the results of path correction algorithm results.

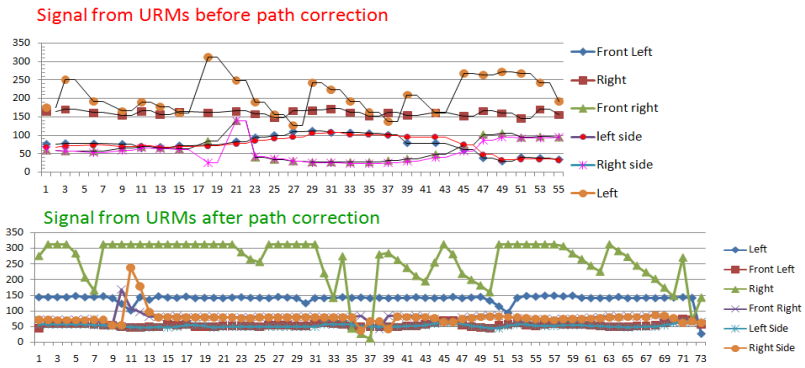

Figure 4: Path correction data

VI. CONCLUSION

An indoor navigation and path correction system using Passive RFID and ultrasonic sensors has been implemented. The use of a graphical interface for room selection, allows the user to move autonomously. It has the advantage of using inexpensive RFID passive tags for navigation and lesser number of ultrasonic sensors for path correction. An intuitive user interface is provided with an option to select the desired end location. This research has been done keeping in mind a fully paralyzed person, with just the hands working. The keypad on the interface has been designed in such a way that the person with a single tap can select his destination. We have used such a path correction algorithm that provides a high level of patient security. The wheelchair is operated at a controlled speed, keeping in mind the comfort of the paralyzed. Critical stopping algorithms has been used that prevents the wheelchair from any hard collisions, or any dead ends, as may be the conditions.

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