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Autonomous Concierge Robot

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***Abstract*— In today's modern world, families face a great challenge to take care of their ailing grandparents. Providing the right medicines at the right time to the elders is quite impossible due to their busy schedule. To overcome this situation, proposing household "AUTONOMOUS CONCIERGE ROBOT" which can take care of sick & old people. Since it is autonomous robot, it needs to navigate the house to reach the patient position from its position; also it needs to avoid the obstacle while moving. Major task of Concierge Robot is to nurses the patient with the medicines at the right moment, intimates the same to the family member and it also remind if there is any shortage of medicine. Suppose if the patient does not respond or in absence of patient it will remind to the family members. The patient medication details can be reviewed by family member when it required.**

Keywords*— *Robot, obstacle detection, Path planning, Service robot, Real time clock, Digital Compass.

I. INTRODUCTION

In current generation the people do not have sufficient time to take care of their ailing grandparents. In the case of carelessness leading to incorrect dosage or forgetting to dose, it might land in tragedy. To prevent incorrect dosing their caretakers should keep monitoring the dosing adequacy, each and every time the patients are dosed .Moreover, the system which can assist the recipients in correct dosing is needed. Therefore, some medication support systems have been developed.

For example Intelligent Medicine Case system[1] has a interface for setting the dosing timing into every divided storage spaces, a sensor for recognizing medicines in each space, and a computer for estimating the living state of the recipient. Also, iMec has a display and a speaker for assisting the recipient. But this system is tedious to implement because the sensor is placed in different places in a living room and it needs a server to control. This system is done via internet of things (IOT). Suppose if the network is fail the entire system leads to fail.

Medication box plays a major role for this robot. For example the sensor enabled box was implemented in Elderly Medication Adherence Monitoring [2].But this box is not automated box, opening and closing of box is done manually.

Navigation plays a major role for an autonomous robot. Navigation is the combination of three fundamentals such as Self Localization, Path planning and Map building. With the help of path planning algorithm shortest path can be determined and robot will move to its goal position. Several modifications and improvements of A star algorithm has compared [3]. To determine the shortest path A* algorithm is used. A common task for a mobile robot is to navigate in an indoor environment [4]. A robot might be asked to perform tasks as building a map of the environment [5], determining its precise location within a map [6], or arriving at a particular place without collision [7] etc. First two tasks are usually connected into one problem called SLAM (Simultaneous Localization And Mapping).

A. Proposed system

In order to eliminate the previous system difficulties, we proposed a system which is fully autonomous. The patient medication details are programmed based on chart given in Table 1.

Table 1. General Medication Chart

Dosing Timings		Explanation
After Sleeping	AS	30 minutes after sleeping
Before Eating Breakfast	BE	30 minutes before eating breakfast
After Eating Breakfast	AE	During eating breakfast
During Eating Breakfast	DE	30 minutes after eating breakfast
Before Eating Lunch	BL	30 minutes before eating lunch
After Eating Lunch	AL	During eating lunch
During Eating Lunch	DL	30 minutes after eating lunch
Before Eating Dinner	BD	30 minutes before eating dinner
During Eating Dinner	DD	During eating dinner
After Eating Dinner	AD	30 minutes after eating dinner
Before Sleeping	BS	30 minutes before sleeping

Based on the dosing timings the robot will provide the tablets to the patient. Instead of manual Sensor Enabled Medication Box, automatic box are provided and it is placed in the robot itself. The box will open when the robot finds the patient in the home. If the patient has taken the pills, box will be closed automatically. Suppose if the patient does not respond or if there any shortage of medicines our robot will be intimating the medication details to the family members through SMS.

Digital compass is used for self-localization, because of low cost. Based on the output of digital compass the robot identifies its current location and where it is and moves on further. A* algorithm is used for path planning. It determines the shortest path and the robot will be moving to its goal.

$$f(n) = h(n) + g(n)$$

where n is the last node on the path, $g(n)$ is the cost of the path from the start node to n, and $h(n)$ is a heuristic that estimates the cost of the cheapest path from n to the goal. The ultimate goal for an autonomous robot is to build a map or a floor plan for navigation.

2. SYSTEM OVERVIEW

A. Block diagram:

Overview of proposed system is shown in Figure 1.

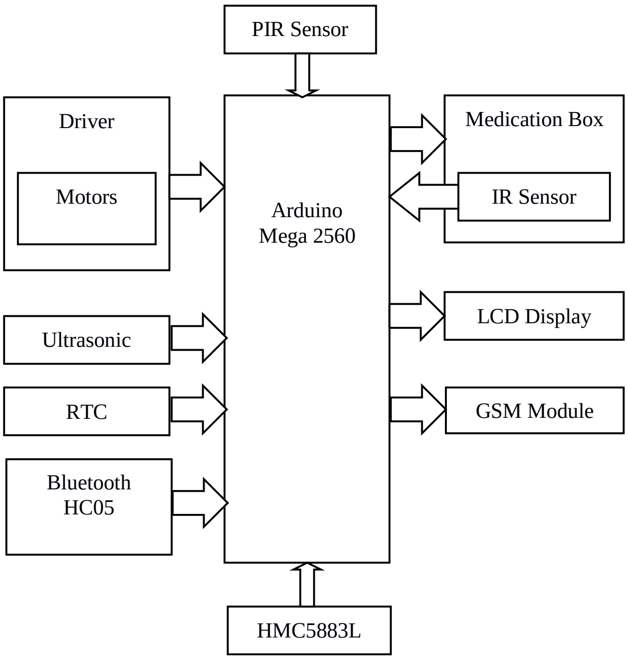

Figure 1: Overview of concierge robot

B. Description:

2.1 Motor Driver:

L239D Driver IC is used to drive the DC Motor. It allows DC motor to drive on either direction.L239D controls two DC motor to run simultaneously in any direction. It will works on the concept of H- Bridge. In a single chip it has two H-Bridge circuit which is used to run two motors independently. The motors are rotated on the basis of the input provided across the input pins as Logic 0 and Logic 1.Logic Table is shown in Table 2.

TABLE 2. Logic Table

Input Pin 1	Input Pin 2	Description
Logic 0	Logic 0	Idel (No rotation)
Logic 0	Logic 1	Anticlockwise direction
Logic 1	Logic 0	Clockwise direction
Logic 1	Logic 1	Moves Forward

2.2 Ultrasonic Sensor:

Ultrasonic Sensor is used to measure the distance to the object by using the sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

$$\text{Distance} = \frac{\text{speed of sound} * \text{time taken}}{2}$$

2.3 Real time clock:

Real time clocks (RTC) as the name recommends are clock modules. The DS1307 is used for our bot. DS1307 using an I^2C interfacing. It is a low-power clock/calendar with 56 bytes of battery backup SRAM. The clock/calendar provides seconds, minutes, hours, day, date, month and year qualified data. The end of each month is adjusted automatically, especially for month which is less than 31 days.

2.4 Liquid Crystal Display:

Liquid Crystal Display is used for displaying the output of real time clock. Like light emitting diode and gas plasma, LCDs allow to display much thinner than the cathode ray tube (CRT). LCD consumes less power than the light emitting diode and gas plasma because they work on the principle of blocking light rather than emitting it.

2.5 Digital Compass:

HMC5883L digital compass is used for localization. It is designed for low field magnetic sensing and it is also said to be a 3 axis magnetometer. It can be operated in either 5volt or 3.3volt; communication is done via I^2C interfacing. It has 5 pin configurations such as VCC, GND, SDA (serial data), SCL (serial clock), DRDY. Among them SDA and SCL are connected to the analog pins of controller where DRDY is not connected to the controller because it is optional connection.

2.6 Passive Infrared Sensor:

Passive Infrared Sensor is often called as PIR. PIR sensor allows to sense motion. It is used to detect whether the human moves in or out of the sensors range. It can be operated in either 5volt or 3.3volt. PIR sensor can detect up to 10 meters at an angle of (+ or -) 15 degrees and the switching threshold can be set from between 0% and 100%.

2.7 Sensor Enabled Box:

Automatic opening and closing of sensor enabled box is done using gear motor. Suppose if the output of the motor is high, the box will be opened or if the output is low the will be closed. Inside the box the Infrared Sensor(IR) is placed because the output of the motor is low only when the output of the IR sensor is high.

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2.8 GSM:

For sending SMS sim900 GSM (Global System for Mobile Communication) module is used. SIM900 GSM Modem is operated at a frequency range of 850MHz, 900MHz, 1800MHz and 1900MHz. The modem is designed with RS232 circuit which allows direct interface. The SIM card is attached to the slot provided in the module. It is operated in 12volt.

2.9 Arduino Mega 2560:

Arudino is the main controller which is used in our proposed system. It is operated in 5v. It has 54 digital inputs/outputs pins, 16 analog pins and 4 UARTs. It is powered up by using AC-DC adapter or battery.

2.10 Bluetooth Module:

HC05 Bluetooth module is used in our proposed system. The communication between PC and Mobile robot is done via Bluetooth module. The HC-05 Bluetooth Module is used as a Master or Slave configuration, making it a great solution for wireless communication. RF transmit power is up to +4dBm. It is operated in 3.3v to 5v.

3. ALGORITHM

3.1 Obstacle Map Creation:

Robot workspace, where the robot performs its task is created into a map [13]which includes fixed obstacles; the obstacle map is shown in Figure 2. Obstacles are represented as dots in red color.

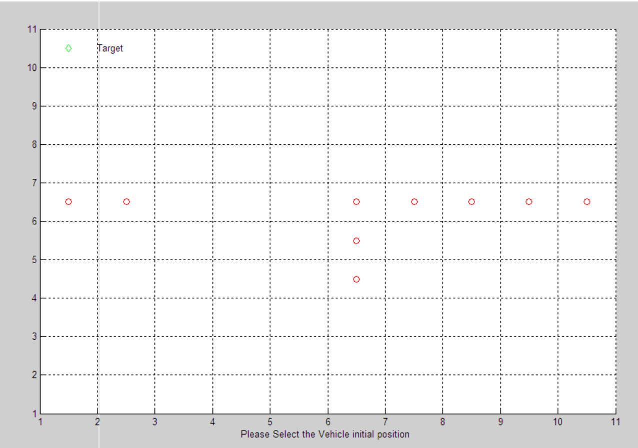

Figure 2. Obstacle map

3.2 Self- Localization and Path Planning:

A*, a global space search algorithm is used to determine the shortest path from starting point to destination. The A* search algorithm is implemented for given obstacle map after getting the start point of the robot and selecting the destination on the search area.

Self-Localization is done using digital compass. The reference point is fixed at lower left end as shown in figure 3. The directions x and y are also fixed, and all other points are measured with respect to reference point. Starting point is taught at the time of calibration of the robot. The robot will keep track of its location by using its x co-ordinate, or position itself with respect to some fixed reference point in the *x* direction, and its *y* co-ordinate, its point with respect to some fixed reference point in the *y* direction to the goal point. Compass is used to keep track of these directions. The position of the goal, also given in *x* and *y* coordinates with respect to the fixed reference point. If you know the starting location and the starting angle of the robot, we can calculate the optimum path (shortest distance) to the goal. To do this, we used the goal location and the robot location, and some fairly simple math to calculate the distance and angle from the robot to the goal point [6].

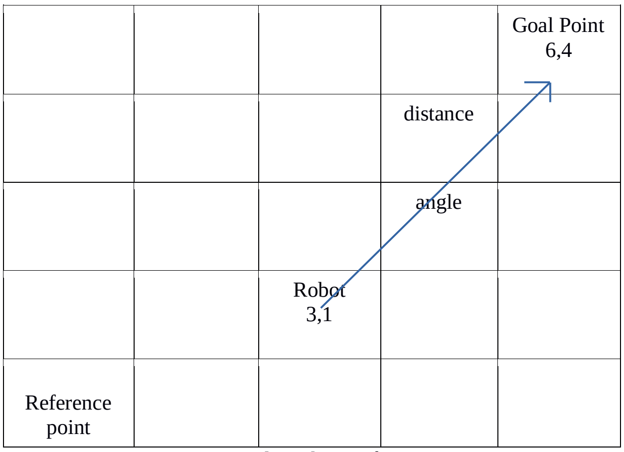

Figure 3.Algorithm performance

Distance is calculated as

$$d = \sqrt{(X_{goal} - X_{robot})^2 + (Y_{goal} - Y_{robot})^2}$$

Angle is calculated using

$$\theta = arctan\left(\frac{Y_{goal} - Y_{robot}}{X_{goal} - X_{robot}}\right)$$

Based on the distance calculation, robot position is predicted. So that it can localize and it can understand how far it is from goal.

Algorithm for autonomous navigation:

1. Calculate the current robot position
2. Read the compass value
3. Find the shortest path to reach the destination and extract the grid to move
4. Read the ultrasonic sensor value to avoid the obstacle. Suppose if the obstacle detected it avoids and modify the map to move further.
5. Update the compass value
6. Read the current position and goal. If it is equal robot reaches the destination.
7. If it is not equal go to step 3

3.3 Concierge Robot Performance:

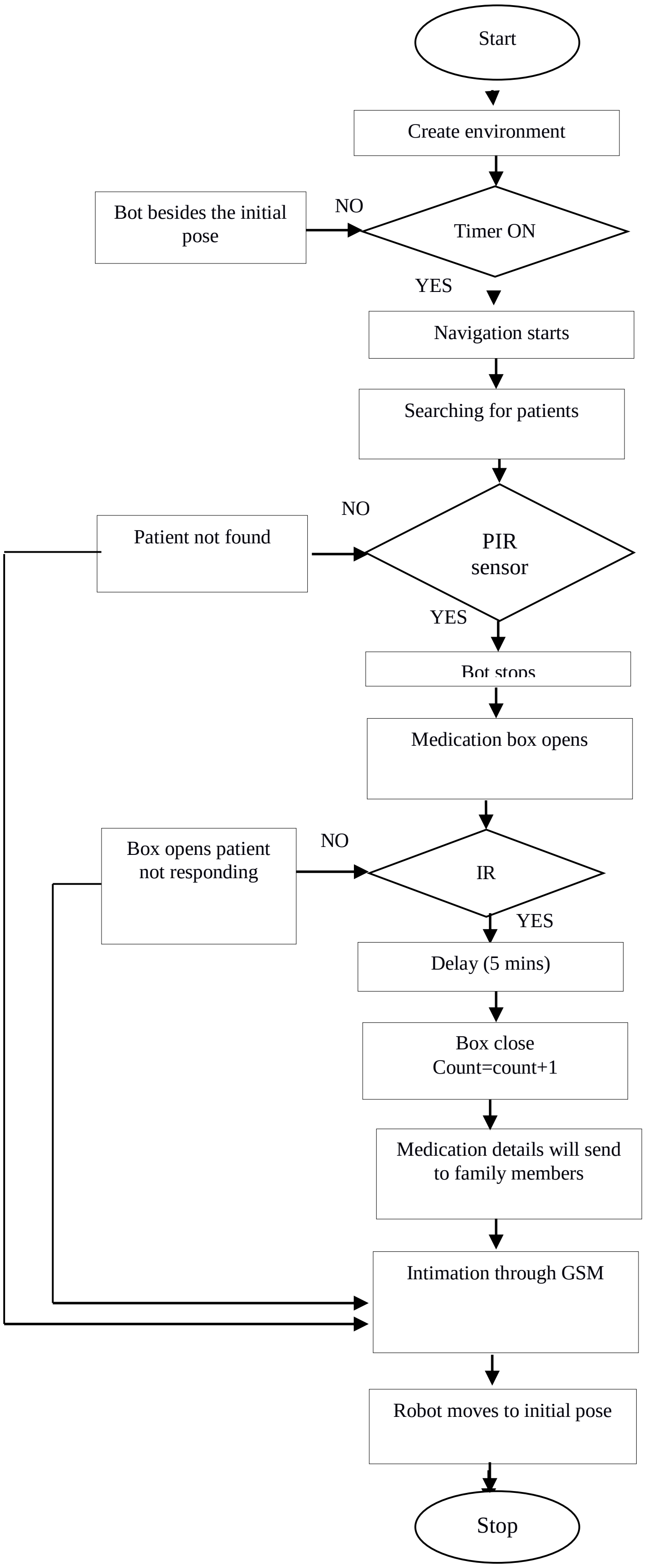

Figure 4: Concierge flow diagram

Robot navigation and mapping is performed as shown in figure 4. When the timer is ON, robot starts to search the patient in its environment. Then patient detection is done using PIR sensor, when the PIR sensor input is high bot finds the patients and stop moving. After identifying patient, the medication box is opened automatically as per the medication chart. IR sensor is used to find whether the patient taken a pill or not. If the IR sensor input is high it denotes the patient taken a pill otherwise it denotes the patient is not responding. Based on the conditions, the robot intimates to the family members through GSM. Medicine Inventory feature also maintained in the robot.

4. IMPLEMENTATION

When we initialize the target position, obstacles and robot pose, the robot find the shortest path and reaches its destination as shown in the Figure 5

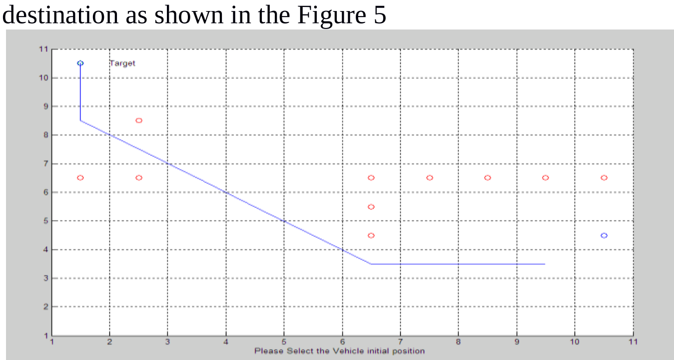

Figure 5 Path planning simulation result

Experimental working model of proposed Concierge Robot is shown in figure 6.

Figure 6: Top view of the robot

Figure 7a and 7b shows the snapshots of the various robot test condition performed.

Figure 7 a

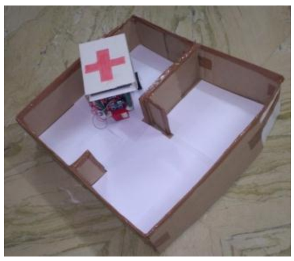

Figure 7 b

5. CONCLUTION AND FUTURE WORK

Our proposed algorithm is verified using MATLAB simulation and done it on real time using Arduino. Future work includes complex environment and obstacles in mobile robot navigation.

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