Timely And Precise Medicine Delivery To Hospital Patients Through Robotic Assistance

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Abstract- *In view of the safety and medical concerns of patients and the persons delivering medicines on a timely fashion, robotic delivery of medicines in wards of hospitals using artificial intelligence techniques is investigated in this work. The robot traverses the wards where the medicine needs to be delivered using intelligence-based algorithm based on sensors and indicator marked in the wards, in the best possible shortest path and exits the ward. The program would ensure that the robot does not collide with other robots and humans in the path and also would search for the indicator where the medicine would have to be delivered on a timely fashion. This way, we would ensure that contagious diseases are not transferred when medicine delivery is done and also compared to the same with laborious process being done manually. The proposed method saves time and also human resources and is easy to operate with external monitoring from the hospital reception.*

Keywords- Medicine Delivery, Artificial Intelligence, Sensors, Timely Medicine Delivery, Hospital Automation, Medical Robotics

I. INTRODUCTION

Autonomous driving systems will become the state of the art technology in the future in house hospital medicine delivery. The Robotic Medicine Delivery systems (RMDS) are similar to autonomous driving systems that would be normally seen to be implemented at the basement of shopping malls, tech parks, apartments and other commercial buildings. The major parameters are operational speed, accuracy, safety, reliability, cost-effectiveness, convenience, space; efficiency and eco-friendliness play a key role in these kinds of systems. Hindrance in the delivery of medicine to some patients is an operation which is challenging. In these operations, the research has been considerably low due to the lack of trained experts for the RMDS to do its job efficiently. The most important parameter that would decide the logistics would be the gross time taken by a vehicle to enter and deliver medicine. If this time is kept as low as possible, then entire logic involved in the delivery of the medicine and health issues in diseases like COVID-19 (Corona Virus Disease) would be minimized.

II. RELATED WORK

Nayak et al. [1] have discussed the robotic valet parking system with four parking slots and have shown how a robotic valet would park the vehicle efficiently. Though the technology developed is interesting, it might not be a very cost-effective method that can be used. But, the theme developed can be used for hospital systems. Conner et al. [2] explained simulating the valet parking without actual the valet based on a synthesis algorithm that generates automaton that governs the execution of the local policies; however, the continuous evolution of the system induced by the local policies governs the state transitions within the automaton, the approach mainly being verified using a simulation environment. Min et al. [3] had carried out the autonomous driving and parking experiments in the real test area on autonomous vehicle valet parking service where they have re-modelled steer, brake, accelerator and shift of the electric vehicle using three motors for steer, brake and accelerator and a lower controller which is an interesting theme for the control of autonomous vehicles. Stanek et al. [4] discussed the advanced driver assistance systems which become more sophisticated with increased functionalities as it becomes more important to acquire accurate geometric knowledge of the environment that the vehicle is driving in. Thus perception will increasingly move to a 3D world. Current state-of-the-art imaging lies to deliver high resolution point cloud data which provide dense 3D images of the environment. Object detection and tracking algorithms can process the 3D point cloud to accurately describe the location and movement of objects in the environment.

Though in the literature there has been a considerable amount of work, there is not much work found where the theme of autonomous vehicles is taken to hospitals for medicine delivery through the RMDS to minimize the time delivery of medicine. The prototype of robot was a firebird [5] used for testing the execution of the plan. Keeping this in view, the functionality of RMDS is a challenging task for an autonomous system if an arena of a hospital ward is considered. Although similar work has been developed for tuberculosis patients [6]. The manuals of e-Yantra have been used for setup of the test bed as indicated in [7]. [8,9] have discussed how to use IOT and Artificial Intelligence techniques in the scenario of COVID-19. Marat et al [10] investigates the control algorithms under the influence of varying dynamic parameters. Emily [11] illustrated about tele-robotics in stroke care, although a direct integration of these concepts is not seen to the work, this paper is being cited that a leaflet from tele-robotics can be taken and used for improving the aspects of mobility.

Margaret et al[12] reviews applications of robotics in nursing and implications in nurse education. Wireless sensor networks usage and performance improvements with integration in robotic environments are said by Hailong[13]. Piver[14] described how robot technology is used in Gynecology and an important take away point from this is the usage of robot assisted devices in surgeries as well. Russell[15] discussed about the common safety and regulatory compliance issues associated with robot architectures. The application of the studies on autonomous mobile robots to minimize delivery time is an important issue in view of persistent delays that exist with the system and speed of operation.

The method proposed can be extended to tuberculosis patient wards and other dangerous diseases which require isolation and proper care of patients without physical contact. The contactless delivery system through RMDS is a strategic method for better delivery of medicines in a timely fashion which is in the development stage. The development of this kind of system will not help hospitals, but the technology can be leveraged to other areas of research like parking, missions in outer space where physical contact needs to be avoided.

III. METHODOLOGY

Automatic delivery of medicines through RMDS is a difficult task as the time involved in identification for the correct patient with markers and sensors is the difficult task. The procedure for RMDS involves an autonomous mobile robot. The programming was done in C language.

The used in this work is an ARDUINO UNO based robot with provisions for additional microcontroller boards to be mounted, designed in a versatile style and which is managed by Li-Ion batteries and with the following provisions.

1. It has IR sensors.
2. It additionally has proximity sensors.
3. A 16 X 2 line LCD display is used for display.
4. This Robot has two 100 DC geared motors in differential drive configuration along with the third caster wheel for the support.

The robot has a top speed of about 24cm per second. Using this configuration, the robot can turn with zero turning radii by rotating one wheel in the clockwise direction and other in the counterclockwise direction. Position encoder discs are mounted on both the motor's axle to give position feedback to the microcontroller. The robot uses auxiliary battery power once it is charged while in locomotion.

ALGORITHM:

1. The robot enters the ward arena in the hospital which was based on [7] of valet parking and uses the basic sensors already mounted on the same for sensing and mainly uses white line sensor for initial locomotion to reach the patient.
2. Traverses the entire ward for the correct indicator of the patient suffering from disease without using any camera and using only IR sensors.
3. Distinguishes the delivery of the medicine with a person to whom the medicine is already delivered.
4. RMDS completes the delivery of the medicine after a 2-minute wait at the patient and exits the ward based on the program flagging delivery/non-delivery of medicine.
   a. The program moves the robot by turning the robot to the required level of rotation in order to stop itself and deliver the medicine in the shortest span of time.
   b. Once it has reached the patient in the correct location, it uses the LCD to display the medical status of RMDS.
5. Exit the nearest gate on command when given the command to leave the ward.

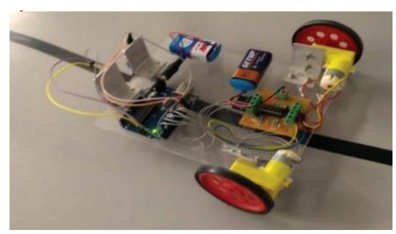

Figure 1: Robot on the track for delivery of medicine based on identifiers

IV. RESULTS

The programs were developed in AVR Studio and where loaded to the mobile firebird robot using NEX AVR USB ISP STK500V2 which is a high speed USB powered STK500V2 compatible In-System USB programmer for AVR family of microcontrollers. The programmer takes power directly from PC’s USB port which eliminates need of external power supply. The programmer can also power the target board from PCs USB port with limited supply current of up to 100mA. It was implemented by designing the arena such that the pink spots indicate the COVID patient spots and the green represents the non-COVID patient's spots which now are used for the pink spots to be the patients with COVID-19(Corona Virus Disease) or other contiguous diseases and green spot indicates that they are patients without any requirement of delivery of medicine by the RMDS. If the total number of patients to be delivered are pre-programmed and designated as in the arena, the markers would help the robot to deliver the medicine efficiently. Each of the thermo-coal pieces, as shown in the figure, are some examples of markers used for adding artificial intelligence to the robot, which would indicate the delivery of a medicine to a particular person. The robot used an imprint of a black line and followed the line to look for the vacant positions. The camera used an infrared sensor to identify the presence of a patient in a particular ward and then moved along the line to find the patients who were not delivered the medicine. The RMDS was programmed in such a way that it identifies the spot closest to the exit gate and stops for 2 minutes itself automatically for the patient to pick his medicine. The interesting part of this work is that it has not used any camera for finding the patient which helps in not interfering with the privacy of the patient and strictly the RMDS is working on coding and not working without hindering the privacy of the patients concerned and only completely relied on the sensor information for delivery of the medicine. The difficult part of the task was to complete the activity in the least possible time. Based on the position of the delivery, the time for delivery changes dynamically; however, it could be identified that the system designed was fail-proof and would be a good asset to hospital and nursing staff.

The RMDS designed with the firebird V was done successfully in identifying the position, and the procedure was tested for various scenarios based on table 1. The following observations were drawn from the analysis. The RMDS designed with firebird V robot in the vacant spot in the least possible time is dependent on the following parameters

i) Patient with contagious diseases.
ii) Closeness to the exit space from the ward.

S.no	Condition STATES OF PATIENTS		
	PatientType	Colour	Block
1	COVID-19	PINK	Filled
2	NON-COVID-19 PATIENT	GREEN	Filled
3	ANY	-	EMPTY

Table 1. Condition states

The condition states of patients in table 1 were evaluated in an arena, which is the prototype. The time taken to traverse in this test arena was about only less than a minute.

S.no	Extrapolation of Robot path planning			
	Traversed Length	Approx. Time	No. of turns	No. of Stops
1	Less than 5 mts	60 seconds	2	None
2	Extrapolation or 200 Mts	100 Minutes	2	None
3	Extrapolation for 200 Mts	200 Minutes	2	2
4	Extrapolation for 200 Mts	320 Minutes	6	2

Table 2. Performance Analysis Extrapolation

Table 2 is an extrapolation of the work that is done which is to project the values that were obtained to an arena which is like the hospital room which typically has one entrance and one exit and or if it has one entrance and multiple exits.

Additionally, the numbers of turns that the robot has to take also is considered as a distinguishing parameter and for each turn additional 20 seconds is to be added for the actual time in extrapolation. So, these values will typically change with the payload values of the load that the robot is carrying and also with the value of the speed of the motors. If the motors have a higher capacity, then it might yield better speed and accuracy. It is all through assumed that the number of obstacles that are there in the path of the robot is minimal or zero.

This requirement would definitely need more time, and in this scenario, the additional time could be extrapolated as follows.

S.no	Extrapolation of Robot path planning			
	Traversed Length	Approx. Time	No. of Obstacles	Approx. Extra Time
1	Less than 5 mts	60 seconds	4	100 Seconds
2	Extrapolation or 200 Mts	100 Minutes	4	20 minutes
3	Extrapolation for 200 Mts	200 Minutes	6	40 minutes
4	Extrapolation for 200 Mts	320 Minutes	8	60 minutes

Table 3. Extrapolation With Obstacles

$$X= A/Y+B +C/Z +K \quad (1)$$

where A is the traversed length, Y is the time taken, B is the actual velocity, C being the number of obstacles and Z being the time taken to move from the obstacle and K being the constant of approximation.

Thus this being an approximate analysis can be used for understanding the typical problem and coming up with rapid solutions for the system for the motion of the robot. If the obstacles are placed in the robot, the robot has to rearrange it's path so that it does not collide with the obstacle and completes it's the mission of getting the medicine delivered to the patient as required.

V. DISCUSSION

The drawback and flaw with this kind of setup were that it is assumed that the ward arrangement is static in nature and while searching for the patient, the robot is accurately fed with the information location of the patients with the markers as there is no change in the existing dynamic map of the ward. In other words, it is assumed that wards are not updated until our robot delivery of the medicine. Thus, the dynamic updating of medicine delivery status would make the problem more challenging if the time of exit is to be minimized. It is also assumed that other robots are not moving in the arena in this scenario. If some robot enters the arena in motion in the opposite direction or starts exactly to leave at the same instant as that of the instant at which our robot is trying to enter a location is not considered during this method. Thus, though there were flaws with the arena design and the conditions imposed in the problem, this being an open-ended problem would give rise to interesting studies which are important in the contest of the ever-changing area of RMDS is one difficult challenge.

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