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Assistive Cyber-Physical-Social Systems in the healthcare industry

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***Abstract*—Due to the shortage of nursing staff as well as the challenges faced with doing mundane tasks, there is a need to look to automating some of the day-to-day repetitive tasks that are faced by healthcare staff. As such, this work proposes a way to automate these tasks using an assistive robot. The primary focus is on automating medication dispensation, which is a repetitive task that has proven to be one of the risky tasks during the pandemic as it needs a prolonged stay with the service user or patient to ensure the medication has been taken. As such, this work proposes the use of a mobile robot for medication dispensation. We have utilised the Tiago robot for its suitability and flexibility in navigating complex surroundings. We used face mapping for patient identification and QR codes for patient room identification. We conducted a simulation and found that the robot was able to execute these tasks in a safe and accurate manner.**

***Keywords*—ROS, Gazebo simulator, AMCL, Gmapping, Machine vision**

I. INTRODUCTION

Robots are increasingly being used in the healthcare setting, especially in the area of surgeries and rehabilitation [1] [2], resulting in the reduction of the recovery time for patients. The use of robotics in healthcare helped save £6 billion in 2018 by means of helping transport logistics and robotic surgeries [3].There have been different approaches available to transport medication in hospitals, these measure though may be effective, would not solve the problem of patient care from a distance, these measures include monitored dosage trolleys, pneumatic tubes, automated medication dispensing machines and mobile robots. Mobile robots were chosen for this project as they were the only option that could facilitate the primary purpose of the project, which is to help reduce the contact time between healthcare workers and the service users by helping with the task of medication dispensation. By doing this effectively and safely would help automate this task and give the healthcare workers more time in the day to tend to other tasks.

II. ROBOT/SIMULATION

In deciding the most suitable robots for this work, different robots were considered, but the lack of social robots with non-cosmetic end effectors proved to be a limiting factor. As such, the choice had to be made between the Tiago by PAL robotics and the Fetch robot. The Tiago robot by PAL robotics, was chosen because of the following features: a non-cosmetic modular gripper used to grab and dispense the medication, a telescoping torso to help adjust to the required height when dispensing medication, a laser range finder and sonar sensor to help with navigation and an RGB-D camera for image recognition. For any project to be carried out effectively and with as minimal errors as possible, a simulation must be done with a semblance of real-world events before the project is carried out in the real-world. The simulation was implemented using the Gazebo simulator using a pre-built hospital model shown in Fig. 1, which was published as open source by Amazon Web Services (AWS) [5]. The work was all done in simulation because of access to the lab being restricted due to the COVID-19 pandemic.

Fig. 1: Top view of the hospital World

III. IMPLEMENTATION

The robot first maps and stores the environment dynamically, the created map is used to place a starting position and waypoints for the rooms. It starts from its start position/charging station where the medication is loaded into its medication holder. The robot navigates avoiding all obstacles by implementing a probabilistic localization algorithm called AMCL (Adaptive Monte Carlo Localization Approach), to different waypoints located in front of a QR code with the patient' name encoded, these QR codes are placed at the entrance of a patient's room. It scans the QR code as shown in Fig. 2, then retrieves the folder matching the patient's name and containing the patient's pre-stored images, then proceeds into the room to the next waypoint, which is next to the patient's bed as shown in Fig. 3. Once there, it starts scanning for the face of the individual which matches the images stored in the retrieved folder using facial recognition. If the face is found and matched, the medication is handed over, if no face is found and/or matched the doctor is alerted. After the medication is handed over, the robot asks verbally, if further assistance is required, the patient can give a reply by verbally responding with a YES/NO or using a thumbs up meaning YES or a thumbs down meaning NO. The robot understands the hand gesture due to the gesture recognition algorithm. If the reply is YES, then the robot alerts a doctor, if it is a NO, then the robot continues its rounds. If the patient is unable to use his fingers, the robot is also recognised. The QR code, facial and gesture recognition is hard coded in Python to enable any other mobile robots that do not have the ability to perform these machine vision tasks to use the packages with ease. Provided they have a mounted camera.

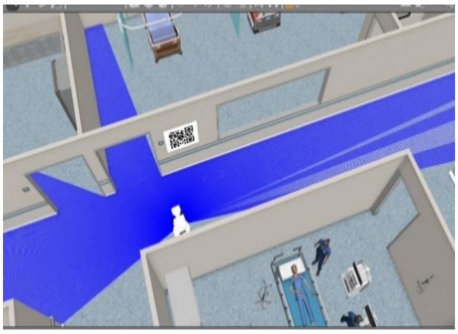

Fig. 2: The Tiago reading the QR code when after getting to the first waypoint

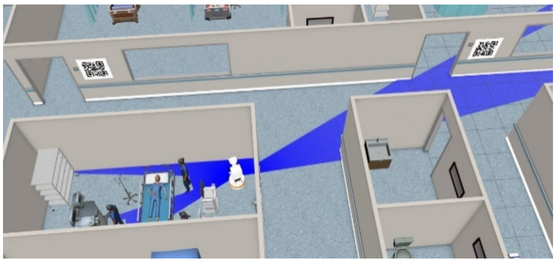

Fig. 3: The Tiago approaching patient after scanning QR code

IV. RESULT AND DISCUSSION

The robot performed its tasks accurately in the simulations, compared to other methods of automated transportation available like the [1]TUG mobile robot and [2]the Panasonic Medication Picking System, HOSPI, the robot is compact, and it fosters the needed distance between the healthcare workers and the patient, whereas other methods available still need a healthcare professional to hand the medication over the patient, this method cuts this out, the professional is only needed to put the medication in the designed medication holder and the robot does the rest. This has risks, because the medication in the holder could be tampered with or changed because it is not secure also the humans in the simulation used this risk can be easily mitigated by designing a case that it only opens after facial recognition has been verified. The human models in the world were designed to be static, which did not show real-world accuracy, this can be solved by real-world testing. Lastly, where the patient had on a face mask, this was found to obstruct the facial recognition feature. This could be resolved by the addition of an extra instruction for the patient to remove any facial covering obstructing the view of their faces.

V. CONCLUSION

In this work, we have presented the automated dispensation of medication in a healthcare setting using a mobile robot. This allows for the remote and safe dispensation of medication in situations where contact with the patient is to be minimised, or to assist with staff shortage. The robot uses object recognition for facial, gesture and QR code recognition We have shown that the robot can safely navigate a crowded healthcare setting, identify patients, identify hand gestures and the QR codes on patients' rooms accurately.

We have also found that the main limitation of this approach is the safety of the medication during transit, as it could fall off or be easily tampered with, leading to deadly results. As such, we have proposed designing a holder that only opens after facial recognition has been verified.

As part of future work, we intend to carry out a comprehensive real-world testing, where we can fully test the viability of this approach. Further work can also be done to increase the ease of operation and monitoring. A web-based GUI could be created to allow healthcare professionals monitor the robot in real-time.

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