CS6755 Final Project Proposal: Robotic Medical Crash Cart

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1 Introduction

Our final project proposal aims to transform a medical crash cart into a robotic system that can be interacted with healthcare workers. The system is designed to assist healthcare workers by taking on repetitive tasks that would otherwise take them away from patients. This has the potential to alleviate the staff shortage problem that is prevalent in healthcare facilities across the nation.

Deploying robots in hospital environments is challenging due to various obstacles. Firstly, high accuracy and reliability are crucial for inventory management as a malfunction can be life-threatening. For example, administering incorrect medication to a patient can lead to serious medical problems. Secondly, robots need agile mobility to be responsive to emergency situations, such as understanding the situation and navigating around rapidly moving people without blocking hallways. Lastly, a multi-modal interaction channel is required for robots to be more responsive in emergency situations. Instead of relying solely on limited camera feeds, they must understand human commands and language in context-specific scenarios.

Specifically, we will be focusing on inventory management, social navigation, and language interaction.

2 Potential Interactions

2.1 Inventory Management

Medical crash carts are crucial for providing emergency medical supplies quickly and efficiently. An inventory management robot can assist in tracking inventory levels and alerting nurses when restocking is needed. This system saves time and reduces the risk of errors, such as dispensing expired or incorrect medications. Additionally, a well-organized crash cart with equipment readily available can be critical in saving a patient's life during an emergency. Some prior work has used radio-frequency identification (RFID) technology to track and restock emergency crash carts and drug inventory [3]. Instead of manually labeling RFID tags, we will explore how accurate computer vision and supervised learning can detect the supplies and track the inventory of crash cart supplies.

Figure 1: A sketch of the inventory management scenario

Below is a sample interaction flow between a nurse and a medical cart for inventory management:

1. The nurse approaches the robot and requests equipment, saying *"Hey robot, can you tell me where the bag-valve-mask is located?"*
2. The robot responds by lighting an LED on the drawer where the equipment is located, saying *"Sure, the bag-valve-mask is located in drawer number 2 on the left side."*
3. The nurse retrieves the equipment and thanks the robot.
4. The robot closes the drawer and alerts the nurse, saying *"By the way, that was the last mask. Would you like me to restock?"*
5. The nurse consents to the robot automatically retrieving more supplies from the storage room, saying *"Yes, thank you for your help."*

2.2 Follow-Me

Hospitals require a variety of tools and equipment for medical treatment, and doctors and nurses need to move around frequently to attend to patients. A tool-cart robot equipped with a follow-me function can automatically carry tools and follow healthcare workers while avoiding crowded areas. This can help healthcare workers save effort and treat patients more efficiently. The nurse-following robot is not a new concept; an example is fusing the Kinect sensor and Xbox 360 video games into a high-speed vision system [1]. Building on this feasibility, our robot will focus on simplifying interactions and creating a user-friendly design.

To achieve efficient nurse-following capabilities, the robot will use a step-by-step interaction approach as follows:

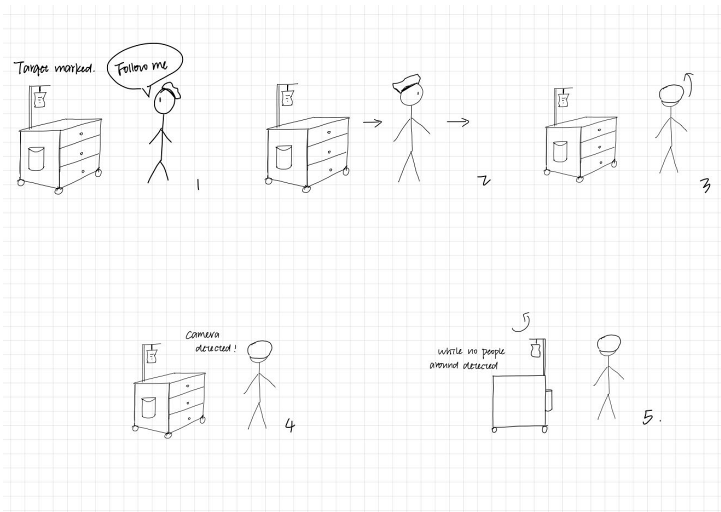

Figure 2: A sketch of the Follow-Me interaction scenario

1. Firstly, the target person will be set by saying *"Follow me"*.

2. While moving around with the target person, the robot will automatically avoid obstacles and people, saying *"Excuse me"* or *" On you're right"* if necessary.
3. If the robot loses sight of the target person, it will search for them and re-follow once the person is re-identified.
4. The robot will adjust its speed to match the target's speed and the environment.
5. Lastly, the robot will unfollow the target person if requested by saying *"You can stop following me."*.

2.3 Language Interface

With OpenAI recently launching APIs for ChatGPT, we now can incorporate well-trained language models such as Whisper [2] into robots. The hospital environment can particularly benefit from ChatGPT models, as doctors and nurses can give verbal instructions to robots for retrieving or disposing of specific medical materials. With ChatGPT's language feature, robots can also answer simple questions and verbally interact with users like this sample interaction flow:

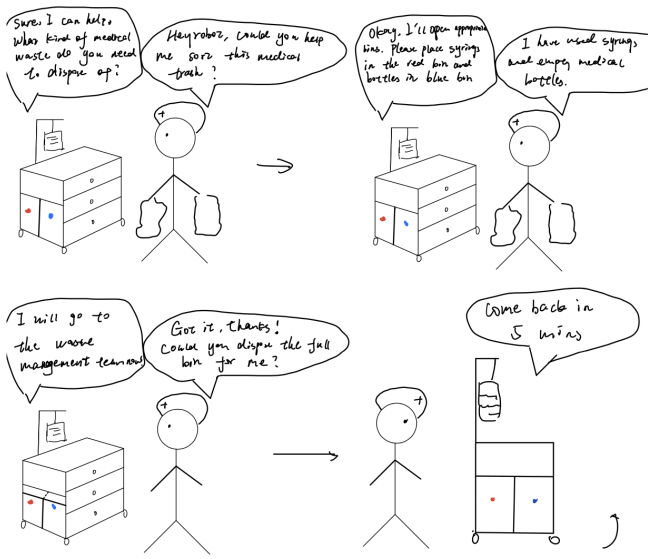

Figure 3: A sketch for Language Interface scenario

1. Nurse: "Hey robot, can you help me sort this medical trash?"
2. Robot: "Sure, I can help. What kind of medical waste do you need to dispose of?"
3. Nurse: "I have some used syringes and some empty medication bottles that need to be properly disposed of."
4. Robot: "Okay, I'll open the appropriate bins. Please place the syringes in the red bin and the medication bottles in the blue bin."
5. Nurse: "Got it, thank you. Could you dispose of the full bins for me?"
6. Robot: "I will go to the waste management team now and come back in 5 mins."

References

[1] B Ilias et al. “A nurse following robot with high speed kinect sensor”. In: *ARPN Journal of Engineering and Applied Sciences* 9.12 (2014), pp. 2454–2459.

[2] OpenAI. *Introducing whisper.* URL: `https://openai.com/research/whisper`.

[3] Jonathan H Sin et al. “Utilising an automated medication inventory management system for emergency crash carts during the COVID-19 pandemic”. In: *Future Healthcare Journal* 9.1 (2022), p. 87.