Challenges in Developing Socially Assistive Robots in Pediatric Inpatient Care Context

Sooyeon Jeong
Media Lab
Massachusetts Institute of Technology
Cambridge, USA
sooyeon6@media.mit.edu

Cynthia Breazeal
Media Lab
Massachusetts Institute of Technology
Cambridge, USA
cynthiab@media.mit.edu

***Abstract*—Developing successful long-term child-robot interactions in pediatric inpatient care context requires overcoming various challenges. Young patients admitted to a hospital are physically and emotionally more vulnerable than healthy children. These children might not be able to interact with a social robot in a natural way due to their medical conditions, and an interruption or a medical emergency can happen during the interaction at any time. The hospital environment has unstable wireless network environment that might hinder cloud computing or remote data processing feature of the robot. Scheduling repeated interactions could also be challenging when evaluating long-term effects of interactions between a socially assistive robot and child patients, since patients' daily routine can change drastically based on their needs and health conditions. Post-interaction evaluations can also be difficult when the study participant gets easily fatigued after the interaction with the robot. These challenges are hard to tackle but much conversations and collaborations with clinical staffs who work in the field would further the progress in building a social robot for pediatric inpatient care in the future.**

Keywords—socially assistive robot; pediatric care; inpatient care; long-term interaction; child-robot interaction

I. Introduction

Being admitted into a hospital is not the most pleasant experience for many children. Most pediatric hospitals have a team of certified child life specialists [1, 2] that provide age-appropriate interventions for these children to mitigate their anxiety, pain and stress and to enhance their emotional well-being during the hospital visit. However, there is a big gap between the supply and demand for social and emotional support for these young patients. In order to close this gap, researchers have been developing robotic platforms and designing interactions for social robots to assist young children in the hospital setting [3-7]. However, building and developing long-term child-robot interactions for pediatric inpatient care creates many challenging tasks to overcome. Pediatric inpatients are a very vulnerable population that requires much considerations and accommodations. Children's health should always be the most important priority in any event, and the social robot would need to be able to mingle into the dynamic and busy hospital environment. In this paper, we discuss the challenges we experienced while preparing and running the Huggable study [3] in multiple inpatient units at Boston Children's Hospital. In the current study, the robot is remotely operated by a clinical staff but in the future we aim to create an autonomous robot that can help children cope with stress, anxiety and pain by interacting with them with a variety of playful activities, and assists communications among patients, caregivers and medical staffs for better experience during medical procedure and overall hospital stay. We envision our future robot to provide emotional support for patients as a friend and a confidant that they can bond and build relationships over repeated hospital visits. In this paper, we identify challenges to be tackled and considered in order to successfully building and developing such social robot in pediatric inpatient care setting.

II. The Huggable Project

We are currently running the Huggable project in collaboration with Boston Children's Hospitals and Northeastern University. The Huggable project is a clinical research trial that compares the efficacies of a plush teddy bear, a virtual character and a social robot in mitigating child patients' pain, anxiety and stress in inpatient care context [3]. We recruit children of age 3 to 10 admitted to Postsurgical Units, Oncology Units or Medical Surgical Intensive Care Units and bring the Huggable robot [4] into each participant's bed space for the child-robot interaction study. During the interaction, a certified child life specialist remotely operates the robot from the hallway. The remote operator can talk through the robot in a pitch-shifted voice, see and hear the child and her surroundings, trigger canned animations for the robot's audio playback and physical movements, and visually monitor the robot's movements on the remote operation interface [3, 4]. The child and the robot engage in casual conversations, I spy games and nursery rhyme singing as much as the participant desires or up to 45 minutes. Before starting the study session, we ask all the hospital staffs, e.g. residential nurses, cleaning staffs, etc., to freely enter the patient bed space as they normally would. Before and after the interaction with the Huggable robot, the child participant is asked to answer developmentally appropriate questionnaires on pain, positive/negative affect and anxiety.

In the next two sections, we describe challenges faced while preparing the Huggable project in Boston Children's Hospital and the lessons we learned from those challenges.

III. Challenges in Developing Social Robots for Pediatric Inpatient Care Context

A. Children with Medical Conditions

Children get admitted to a pediatric hospital for variety of medical conditions. Depending on their health status and the medical treatments they receive, the children have different symptoms that affect their everyday physical, social and emotional behavior. For instance, patients receiving chemothearpy might lose hair and have a mucositis as side effects. A child with mucositis might have difficulty with clear verbal expression. Majority of the patient units are kept dark for resting and sleeping. Depending on the health condition, some children might be sensitive to certain topics of activities or conversations. During one of the study preparation meetings, a child life specialist in the Huggable research team noted that food related game activities would need to be avoided when the robot interacts with a patient with strict restrictions on diet. On the other hand, she also noted some children who are not able to physically move due to their condition enjoy playing virtual sports on a digital device since they cannot physically play the sport themselves.

All of these medical conditions could affect a social robot's performance in creating and maintaining a socially and emotionally sounding interaction. The loss of hair in the face from chemotherapy could potentially cause a problem in recognizing facial expressions because the eyebrow features are one of the crucial components for inferring a person's emotional states [8, 9]. A mucositis that refrain children from speaking clearly could cause failure in speech recognition and prosody detection for the social robot. The dark lighting in the patient bed space could cause unreliable image processing features for the robot to understand its surroundings and the state of its interaction partner through the camera data. Furthermore, if not aware of preferred or sensitive topics for a child patient, the interaction with a social robot could be unpleasant and awkward. A social robot for pediatric inpatient care should be able to cope and deal with these challenges. Perhaps, a social robot in pediatric inpatient care should have a capability to infer and choose the appropriate interaction activities with each child patient based on her medical condition in order to avoid repeated failures and frustration in communication.

B. Medical Emergency and Interruptions during the Interaction

Social robots in pediatric care should be prepared for dealing with medical emergency during the interactions. All of the study sessions happened in each participant's bed space where various medical equipment are installed and clinical staffs frequently come in and out of the room. Therefore, it was important for the Huggable research team to set up the robot system to prevent any interference or complications with the medical procedures at any time. Except for the static cameras, most of our equipment is placed on a mobile over-bed tray table and a rolling computer table cart for quick setup procedures [13].

Also, a few of the participants had medical emergency that needed some privacy and the Huggable equipment could be removed from the patient bed space in a timely manner to provide space for medical staffs due to our mobile setup system. The Huggable robot could pause or exit the interaction in an appropriate manner since a remote operator was controlling the robot's behavior. However, if the robot were to be autonomous, it would require detecting medical emergency events and selecting a proper method to respond to the situation. It would need to be able to detect the social signals from not only the child patient but also the clinical staffs to classify whether the staff's visit is for a quick vital checkups that would not affect the interaction between a child and the robot, a painful procedure that the robot could potentially distract the patient from or a more serious procedure that needs privacy and full attention from clinicians. In each different scenario, the robot would need to know appropriate ways to respond, whether it would be dismissing itself from the patient unit or asking whether the child would like the robot to wait until she is ready to resume the interaction.

C. Unreliable Wireless Networks in the Hospital

Hospital buildings incorporate many features that interfere the wireless network. For example, some of the radiology or operating rooms have metal- or lead-lined walls that reflect or absorb wireless signals. Medical devices are becoming more and more wireless, and pagers are primary communication tools for most of the medical staffs. Due to significant amount interference in radio frequency signals, we have observed different performance on the Huggable robot system in the hospital depending on the location of the hospital. Initially, most of the system testing was done in the hospital's research laboratory environment where no patient units were located. In the testing area, we observed very short delay in the pitch-shifted voice streaming from the remote operating interface to the robot's speaker system. However, the robot system had significantly longer delay in receiving the processed audio data in one of the operation rooms on the Medical Surgical Intensive Care Units, and relatively shorter delay in oncology units.

With more usage of cloud computing to remotely process of raw sensory data stream, the unreliable and slow wireless network could cause significant issues for a social robot in creating believable and natural social interactions. We suggest that a social robot in pediatric hospitals should be able to adjusting sensory data sampling and processing rates and other parameters appropriately in order to adjust to the variable wireless network status, instead of expecting and relying on constant data processing rate for every interaction.

IV. Challenges in Evaluation Long-term Child-Robot Interactions in Pediatric Inpatient Care Context

A. Unpredictability in Patients' Schedule

Recruiting patients with serious medical conditions for the Huggable study has not simple. The patient's health and wellbeing are the top priorities at any time, and thus approaching the potential participant for a consenting process required many levels of approval steps from clinical staffs. Most of the time, the consenting process occurred a few days prior to the experiment session. Even after obtaining all of the formal consents and the tentative schedule for the study was planned, we had to check in with the participant's family and the nurse a few hours before to reconfirm the patient's availability for the child-robot interaction. Many of the study sessions were canceled due to unexpected medical conditions that required immediate attention, severe fatigue or changes in the medical treatment or exam schedules.

This unpredictability and lack of control in scheduling study sessions cause even bigger challenges when evaluating long-term effects of child-robot interactions. For scientific research, ideally researchers would control for the frequency of the repeated interactions between a child patient and a social robot. However, it is very unlikely to exactly know in advance when a child patient would be admitted into the hospital, how long she would be staying for the admission and once discharged when she would come back for another admission or an appointment. And even if a researcher tries to schedule multiple interactions during one admission phase, the tentative plan can always be overthrown an hour before the scheduled study session for unexpected events. Therefore, it is crucial to be allow flexible scheduling when running long-term child-robot interaction studies in pediatric inpatient care, and to prepare methodologies to still get meaningful study results from variable timing of the long-term interactions.

B. *Difficulties with Post-Interaction Questionnaires*

Evaluating any child-robot interaction through quantitative surveys is not simple. However, when the child participant is physically ill and is in their personal patient bed space, it becomes even more challenging. In the Huggable study, most of the participants were observed to have positive experience when interacting with the robot. Majority of them did not have much difficulty when we applied pre-interaction surveys to measure their pain [10], anxiety [11] and affect [12] before the child-robot interaction. However, post-interaction evaluations were much more challenging. In our study, the children are allowed to play with the robot as much as they would like or up to 45 minutes. And they are told that they could stop the interaction at any time, if desired. Most of the participants who recently received bone marrow transplant enjoyed their time with the robot but exited the interaction because they became fatigued and had to "take a nap." As soon as the robot departed their unit, many of these participants were eager to rest and refused to answer post-survey questions. Thus, we had to amend the study procedure to separate the pre- and post-questionnaires into two parts; we used simple and quick picture-based measures immediately before and after the child-robot interaction, and applied longer text-based questionnaires roughly 30-45 minutes before and after the interaction if the participant needed some break.

V. CONCLUSION

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