Assisted Living for People with Disabilities using a Service Robot

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Abstract—In this paper, we introduce a concept in personal robotics to support independent living for people with disabilities. Specifically, we introduce our current efforts on object retrieval and physical therapies for stroke rehabilitation. Our major contributions are as follows: general-purpose personal robots that can potentially deliver many kinds of services; methods of conveying goals to the robot that searches for and retrieves misplaced objects; and adaptive teletherapy.

I. INTRODUCTION

Our goal is to provide technological support for individuals with disabilities to be independent, safe, and productive for a longer period of time and to delay (or eliminate) institutionalization. We consider general-purpose (personal) robots that can potentially deliver many different kinds of service rather than special-purpose devices. This proposes that such a concept can lead to cost-effective solutions for residential eldercare. We demonstrate two important examples of such services: finding and fetching misplaced objects; and serving as a conduit for adaptive teletherapy in stroke rehabilitation. Due to motor and communication deficits, this community has difficulty in finding and retrieving daily items as well as effectively conveying tasks to personal robots. In Section II, we introduce a framework that can facilitate communication between human clients with communication deficits and personal robots in order to retrieve misplaced objects. In Section III, we discuss case studies to facilitate the interaction between the client and a remote therapist and to extend and reinforce teletherapy.

II. COMMUNICATING GOALS: OBJECT RETRIEVAL FOR PATIENTS WITH COMMUNICATION DEFICITS

Often, eldercare patients with cognitive deficits misplace objects and need assistance. Moreover, the same individuals often have associated word-finding issues that could make conveying goals to a robot assistant challenging as well. How can a robot efficiently and effectively infer an object that a patient is looking for? We propose methods that use multimodal cues including gestures and words to identify target objects in object retrieval tasks (Fig. 1a). Adopting Marengoni et al. [1], we use Bayesian networks and utility theory to determine the object in the course of a human-robot dialog by identifying the next best question to ask. The system computes the value of information in each potential query by subtracting the current utility from the expected utility after communication using a Bayesian network. It weights the value of information by the cost of the question. Then, it determines the best feature, \( f^* \), to ask about.

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f^* = \arg \max_f \frac{EU(o = \alpha'|E, f) - EU(o = \alpha|E)}{\text{cost(question}(f))},
\]

where \( EU \) is expected utility, \( E \) is partial information collected by asking questions, and \( o \) is the target object. The robot asks a question about \( f^* \) and updates the Bayesian network based on an answer from the user in a process reminiscent of “twenty questions” until the robot accumulates enough confidence to act.

III. THERAPY USING SERVICE ROBOTS

In addition to assisting daily activities like retrieving items [2], service robots can be a medium for delivering therapy in a residential setting (Fig. 1b). We have conducted a series of case studies and demonstrated that we can improve outcomes by replicating therapies prescribed by a therapist when the therapist is out of the loop [3]–[5]. These results suggest that the patient is able to achieve increasingly difficult targets more quickly using voluntary movements and no external motor assistance. In a teleoperated study, a therapist with no prior teleoperation experience was able to customize exercise targets for the individual patient [6]. This can be learned to extend the therapist’s service between teletherapies [7]. The robot emulated the choice of targets demonstrated by the human therapist when the therapist is out of the loop.

REFERENCES