A Pervasive Assistive Robot System Including Projection-Camera Technology for Older Adults

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ABSTRACT

Here we present a projection augmented reality (AR) based assistive robot, which we call the Pervasive Assistive Robot System (PARS). The PARS aims to improve the quality of life by of the elderly and less able-bodied. In particular, the proposed system will support dynamic display and monitoring systems, which will be helpful for older adults who have difficulty moving their limbs and who have a weak memory. We attempted to verify the usefulness of the PARS using various scenarios. We expected that PARSs will be used as assistive robots for people who experience physical discomfort in their daily lives.

ACM Reference Format:
Seungho Chae, Hyocheol Ro, Yoonsik Yang, Tack-Don Han. 2018. A Pervasive Assistive Robot System Including Projection-Camera Technology for Older Adults. In *HRI '18 Companion: 2018 ACM/IEEE International Conference on Human-Robot Interaction Companion, March 5–8, 2018, Chicago, IL, USA,* Jennifer B. Sartor, Theo D'Hondt, and Wolfgang De Meuter (Eds.). ACM, New York, NY, USA, Article 4, 2 pages. https://doi.org/10.1145/3173386.3177007

1 INTRODUCTION

Recently, social costs have been increasing rapidly due to an increased elderly population [8]. This is because life expectancy is increasing, birth rates are decreasing, and medical technology is advancing. Also, an increase in the number of single-person households has resulted in increased rates of mental health problems (e.g., depression) [7].

Although various policies aim to support the socially disadvantaged classes, these policies are limited by their costs [6, 9]. To support the vulnerable, it is necessary to have a suitable workforce, as well as sufficient financial resources. However, the workforce supply is insufficient. Indeed, about 20% of the world's population is vulnerable and needing observation, with about 190 million people experiencing suffering in their daily lives [9]. Workforce and cost limitations often arise during the treatment and rehabilitation of users who have physical and mental disabilities. In the United States, the personnel expenses of experienced observers range from $ 30,000 to $ 85,000 per year [9].

IT research has been applied to the development of systems that can help the socially vulnerable to live on their own or to help themselves [5, 7]. Most of these efforts have aided at assisting with the treatment, rehabilitation [4] or movement of persons with disabilities by using mechanical aids, such as wheelchairs and robots. However, there are relatively few studies aimed at providing support with daily living tasks, such as leisure time. Recently, with the advent of social robots, researchers are beginning to investigate the potential of companion robots, which offer friendship to lonely people, as well as robots that support weak memory [2, 10].

Here, we aim to provide an assistive robot for users with difficulty moving limbs. Assistive robot-based projection AR technology was used to provide a dynamic display. In addition, using a camera, we have developed a monitoring system that assists with the user's scheduling and detects abnormal behavior (motionless). The goal of this study is to improve the quality of life by providing appropriate services to users.

2 PROPOSED SYSTEM AND PROTOTYPE

2.1 Pervasive Assistive Robot System

The PARS proposed in this paper is based on a previously described PARS [3] and includes a social robot.

The PARS robot-based projection AR technology consists of hardware and software. The hardware configuration used in the prototype of the PARS is shown in Figure 1, which consists of a 360-degree controllable projector and camera-based system that includes two mounted servo motors, a projector, and a depth-sensing camera. An Arduino device was mounted on the pan-tilt system to control the servo motors.

The software for system control is designed based on three basic concepts: pervasive AR display, pervasive AR interface, and pervasive AR interaction. First, the pervasive AR display creates a display in the real world and can correct for perspective distortion of the display. The pervasive AR interface provides an intuitive interface for controlling the display and augmented information. Finally, the pervasive AR interaction derives optimal functions and scenarios for each space and adaptively provides them.

This study proposes a PARS by applying pervasive AR technology to an assistive robot and aims to assist with the daily life of user (especially the elderly, whose limbs might be in discomfort). The prototype is based on the structure shown in Figure 1.(a), and the completed PARS is as follows (Fig. 1(b)).

The PARS uses image processing and projection AR technologies to perform assistant functions for users that are in discomfort.

2.2 Case Study

2.2.1 Leisure time. Elderly users spend most of their leisure time in the family environment. However, leisure time is typically restricted to a particular environment. For example, when using

HRI '18 Companion, March 5–8, 2018, Chicago, IL, USA

ACM ISBN 978-1-4503-5615-2/18/03…$15.00
https://doi.org/10.1145/3173386.3177007

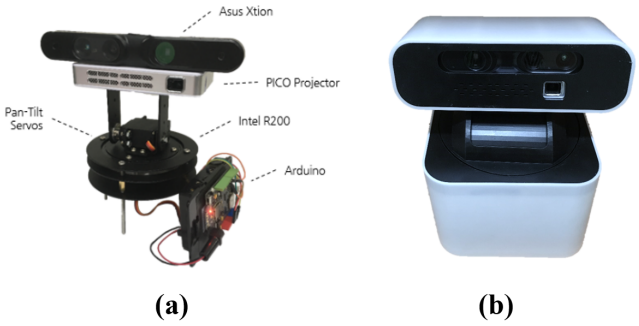

Figure 1: Pervasive Assistive Robot System Architecture. (a) Hardware configuration, (b) Pervasive Assistive Robot System Prototype

fixed furniture, such as a television, a user must go to that place. The PARS provides a dynamic display and mirroring technology that allows the user to spend their leisure time in their desired location. In addition, it is possible to provide a small screen of a mobile device as a large screen of a projection by using a mirroring technique.

2.2.2 Personal Assistant. The proposed system can support the memory of elderly users, who might have a weak memory and poor decision power. For example, the appropriate time for taking medicine and appointments are often missed unintentionally. To address this, the PARS could notify the user via the projector. In addition, using the object recognition technology, the PARS could provide information about the surrounding objects in real-time. For example, it would be possible to enlarge a manual that consists of small texts. This could be used as a substitute for an experienced assistant.

2.2.3 Monitoring. Using a pan/tilt based camera-projection system and user recognition technology, it is possible to track specific users and provide monitoring functions. Because the user is tracked through face recognition, the PARS can react to abnormal behavior, such as sudden collapse or motionless. Also, the PARS could raise the alarm if a suspicious person intrudes.

2.2.4 Companion. In recent decades, the share of single-person households has been steadily increasing. Currently, single-person households account for more than 40% of households in Denmark, Germany, and Norway, while this proportion is 28% in the United States, 27% in Korea, and 32% in Japan. As the number of single-person household increases, we expect increasing numbers of users suffering from a general discomfort, such as depression [1]. For such single-person households, the PARS could provide messages or images through the projector, thus replacing the role of the family and friends. Thus, psychological robots are likely to play a role in relieving the loneliness of users.

Figure 2: Applications. (a) Leisure time, (b) Personal Assistant, (c) Companion

3 CONCLUSIONS

Here, we use a PARS to directly support the daily life of elderly users who have difficulty moving limbs and who have a weak memory. Through a pan-tilt controllable projection AR system, the PARS was able to provide various functions, providing assistance during leisure time, monitoring the user, acting as a personal assistant, and offering companionship. As the elderly proportion of the population gradually grows, PARSs will be able to operate in more places and provide more functions, as well as potentially being extended to the disabled population. In the future, we expect that PARSs will be applied in home automation and education, in conjunction with the Internet of Things (IoT).

ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No.NRF-2015R1A2A1A10055673).

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