Wearable robot that measures user vital signs for elderly care and support

Hirotake Yamazoe
Ritsumeikan University
1-1-1, Nojihigashi, Kusatsu
Shiga, Japan
yamazoe@fc.ritsumei.ac.jp

Tomoko Yonezawa
Kansai University
2-1-1, Ryozenji, Takatsuki
Osaka, Japan
yone@kansai-u.ac.jp

ABSTRACT

In this paper, we introduce a wearable robot with vital sensors. So far, we have been developing a wearable partner agent that makes physical contact, which is generated by combining haptic stimuli and the agent's anthropomorphic motions. The haptic stimuli are adjusted and controlled corresponding to the user's posture and surrounding context. However, neither is sufficient to recognize the user's physical and emotional conditions. Thus, we extend our system by adding vital sensors, especially a blood pressure sensor, to estimate the user's physical and emotional conditions and achieve elderly care and support based on the obtained user's information.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces

General Terms

Design

1. INTRODUCTION

Worldwide, aging societies are facing a variety of serious problems related to changes in lifestyles, such as an increase in nuclear families. In these societies, the elderly and the disabled who are living alone sometimes feel anxious even when they just want to go out and need the support of caregivers to overcome such anxiety. A shortage of caregivers and volunteers and the burden of asking for help often cause these people to withdraw from society. However, withdrawal from society creates many problems, such as advanced dementia.

During outings, elderly individuals often face two problems: physical problems, which stem from impaired body functions, and cognitive problems, which can cause memory loss and attention deficit issues. For example, persons with dementia are at risk of becoming lost [13]. We focus on cognitive problems and solve them by employing robots. To realize robots that can care for and support such people during outings, we proposed a wearable message robot [19] (Fig.1). Since our robot is wearable, it can support the wearer anytime and anywhere.

Figure 1: System view

To appropriately support an elderly person, the robot needs to know her physical and mental conditions. However, our previously proposed robot [19] had only motion sensors (a 3D accelerometer and a 3D compass) for obtaining the user's activities and the robot's poses. In this paper, we describe an extension of our robot that has vital sensors and describe the interaction between the proposed robot and users.

By using sensors including vital sensors, our robot can recognize not only physical activities but also physical and mental conditions [8, 7] and can make such appropriate responses as "You seem tired. Let's take a break." Furthermore, continuously measuring vital signs is important for recognizing an elderly person's physical condition and relaying them to doctors and caregivers. Our system naturally measures vital signs.

BICT 2015, December 03-05, New York City, United States

DOI 10.4108/eai.3-12-2015.2262512

2. RELATED RESEARCH

Many researches are related to both haptic stimuli and anthropomorphic agents.

On haptic stimuli as feedback of information, various researches exist on haptic stimuli as displays for mobile situations, such as vibration stimuli as feedback [6], directional indicators [5], skin stretch feedback [3, 10], and traction force feedback [2]. These researches physically notify the users of the information. Such stimuli are important triggers of the information notification; however, they are sometimes considered artificial signals by the user.

On the other hand, natural interaction is preferred for daily involvement. Many human-like interaction studies have focused on such anthropomorphic presences as robots or virtual agents.

Considerable researches have also been conducted on anthropomorphic behaviors, such as affection, the attention of robots and agents [11], and wearable haptic interfaces [4, 17]. Physical interaction with users, as represented by pet robots, has also been investigated. As a first step toward reaching our goal, we combined haptic stimuli and anthropomorphic behaviors to enable physical contact with robots.

The idea of a robot's physical contact is expected to extend artificial haptic signals into natural, warm, and affective interactions. Communication robots or agents as media have also been developed based on the premise of ongoing communication among people [15, 14]. Other schemes feature a wearable avatar robot on the shoulder [9]. A mobile phone type robot was also proposed [12]. Such communication robots that support user outings do not refer to health conditions in current systems.

In other situations, robots support health and medical care in hospitals [1]. Unlike absolutely locational and public uses, we focus on the personal uses of anthropomorphic robots that provide care for health conditions, support human-human communication, and respond to health problems. Especially for 24-hour, personal and daily support, we adopted both vital sensing and a robot that supports the elderly during outings, especially for toilet problems/situations. We proposed a toilet map acquisition system [18] and a toilet timing suggestion system [16]. To realize such an elderly support system based on such researches, appropriate mechanisms for transmitting the support information are crucial.

3. WEARABLE ROBOT WITH VITAL SENSORS

3.1 Wearable message robot

First, we introduce the prototype of our wearable message robot [19]. As described above, both notification and affection are critical for human-robot communication. Our prototype system is designed to achieve both behaviors.

Figure 1 shows our wearable message robot, which consists of a stuffed-toy robot including sensors, actuators, and a fixing textile. The robot has two DoFs in its head and one in its left hand. A 3D accelerometer with a 3D compass

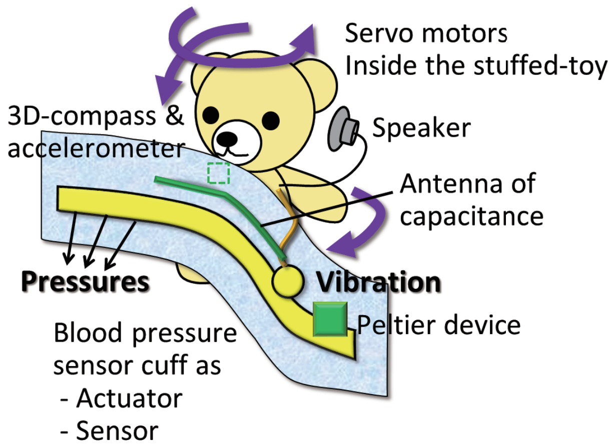

Figure 2: System configuration of wearable message robot

for detecting the activity of both the user and robot and a speaker are placed inside the robot. A vibration motor for the haptic stimuli is attached to the fixing textile. An antenna of capacitance (as used in theremins) is placed on the lower part of the fixing strap to measure the thickness of the user's clothes to accordingly adjust the strength of the haptic actuations.

The system's fixed part weighs about 350 g, including the stuffed-toy robot, the actuators, and the battery. But since this prototype requires a small PC (400 g), its total weight is about 800 g.

As described above, we implemented two types of expression behaviors: notification and affection. Both are implemented by combining the robot motions and the haptic stimuli by the actuators. Our proposed robot provides users with a feeling of physical contact. To express a notification, the robot repeatedly strokes the user's arm, while a short-term vibration simultaneously creates haptic stimuli to express the physical contact of the robot's touch. When the robot wants to say something, first, it performs the notification behavior that will be noticed by the user. After that, the robot says its message. Such behavior simulates responses when humans communicate with each other and increases the naturalness of the robot's communication. To expression affection, the robot turns its face toward the user, and a simultaneous pressure stimulus relays the physical contact of the robot's hugging behavior. In addition, the temperature of the Peltier device changes depending on the robot's feelings. Both expressions increase the comprehension of the message transmitted by the robot and its intimacy.

3.2 Proposed system

Next, we describe the details of our proposed wearable robot and its vital sensors. Fig. 2 shows the system configuration, and Fig. 3 shows the process flow. The configuration of this proposed system is basically the same as our previous work [19]. One difference is the purpose of the fixing textile. In our previous work [19], the textile and pressing actuator were based on a blood pressure sensor cuff. But in this work, we use the fixing textile as both an actuator and a

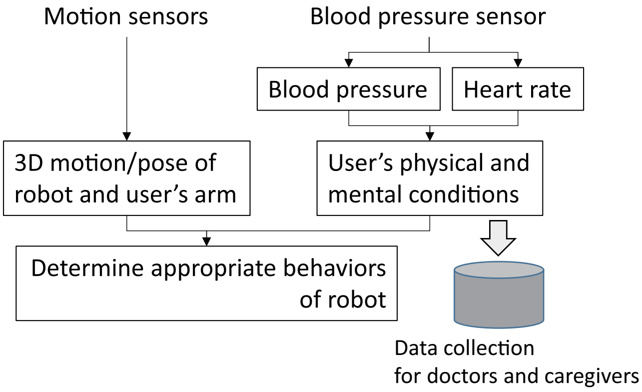

Figure 3: Process flow

blood pressure monitor.

With a blood pressure sensor, we can obtain both the blood pressure and the heart rate. As described in the previous subsection, the robot can understand the user's activity through a 3D accelerometer and a 3D compass By adding blood pressure and heart rate measurements, the robot can recognize not only physical activity but also mental situations. One straightforward usage of blood pressure and heart rate information is to suggest breaks; when the user's heart rate has increased, the robot says, "Let's take a break." By estimating mental situations, the robot can also perform more appropriate behaviors. For example, when the user seems nervous, the robot can notify the user's family or the caregivers.

Furthermore, periodic measurements of vital signs are useful for doctors and caregivers to diagnose or understand the user's physical conditions. Therefore, the robot periodically measures the vital signs and sends the measured data to the database. Since our system is wearable, natural measurements of vital signs can be realized.

4. CONCLUSION

This paper proposed a wearable robot with vital sensors. Our robot has a blood pressure sensor and can recognize a user's physical and mental conditions based on sensor data. In addition, our proposed robot can be used as a periodic measurement device of vital signs. Such data are useful to help doctors and caregivers monitor the user's physical conditions.

Future works will downsize the robot and evaluate its effectiveness.

5. ACKNOWLEDGMENTS

This research was supported in part by JSPS KAKENHI 15H01698, 25730114, and 25700021.

6. REFERENCES

[1] E. Ackerman. Panasonic revives hospital delivery robot. http://spectrum.ieee.org/automaton/robotics/medical-robots/panasonic-hospital-delivery-robot, 2014. [Accessed 25/Oct/2015].

[2] T. Amemiya and H. Sugiyama. Haptic handheld wayfinder with pseudo-attraction force for pedestrians with visual impairments. In ASSETS 2009, pages 107–114, 2009.

[3] K. Bark, J. Wheeler, S. Premakumar, and M. Cutkosky. Comparison of skin stretch and vibrotactile stimulation for feedback of proprioceptive information. In Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, pages 71–78, 2008.

[4] L. Bonanni, C. Vaucelle, J. Lieberman, and O. Zuckerman. Taptap: a haptic wearable for asynchronous distributed touch therapy. In CHI'06 extended abstracts, pages 580–585, 2006.

[5] A. Cassinelli, C. Reynolds, and M. Ishikawa. Augmenting spatial awareness with haptic radar. In International Symposium on Wearable Computers (ISWC2006), pages 61–64, 2006.

[6] M. Fukumoto and T. Sugimura. Active click: tactile feedback for touch panels. In CHI'01 extended abstracts, pages 121–122, 2001.

[7] F. C. Geisler, N. Vennewald, T. Kubiak, and H. Weber. The impact of heart rate variability on subjective well-being is mediated by emotion regulation. Personality and Individual Differences, 49(7):723–728, 2010.

[8] G. Innes, W. M. Millar, and M. Valentine. Emotion and blood-pressure. The British Journal of Psychiatry, 105(440):840–851, 1959.

[9] T. Kashiwabara, H. Osawa, K. Shinozawa, and M. Imai. Teroos: a wearable avatar to enhance joint activities. In CHI'12, pages 2001–2004, 2012.

[10] Y. Kojima, Y. Hashimoto, S. Fukushima, and H. Kajimoto. Pull-navi: a novel tactile navigation interface by pulling the ears. In ACM SIGGRAPH 2009 Emerging Technologies, 2009.

[11] H. Kozima. Infanoid: A babybot that explores the social environment. In Socially Intelligent Agents: Creating Relationships with Computers and Robots, pages 157–164, 2002.

[12] T. Minato, H. Sumioka, S. Nishio, and H. Ishiguro. Studying the influence of handheld robotic media on social communications. In Social Robotic Telepresence in ROMAN'12 Workshop, pages 15–16, 2012.

[13] M. A. Rowe, N. G. Feinglass, and M. E. Wiss. Persons with dementia who become lost in the community: a case study, current research, and recommendations. Mayo Clinic Proceedings, 79(11):1417–1422, 2004.

[14] E. Saadatian, H. Samani, A. Toudeshki, and R. Nakatsu. Technologically mediated intimate communication: An overview and future directions. In 12th International Conference on Entertainment Computing, pages 93–104, 2013.

[15] D. Sekiguchi, M. Inami, and S. Tachi. Robotphone: Rui for interpersonal communication. In CHI'01 extended abstracts, pages 277–278, 2001.

[16] A. Tsuji, T. Yonezawa, H. Yamazoe, S. Abe, N. Kuwahara, and K. Morimoto. Proposal and evaluation of the toilet timing suggestion method for the elderly. International Journal of Advanced Computer Science and Applications, 5(10):140–145, 2014.

[17] R. Wang, F. Quek, D. Tatar, J. Teh, and A. Cheok. Keep in touch: Channel, expectation and experience. In CHI'12, pages 139–148, 2012.

[18] H. Yamazoe, T. Yonezawa, and S. Abe. Automatic acquisition of a toilet map using a wearable camera. In Joint 7th International Conference on Soft Computing and Intelligent Systems and 15th International Symposium on Advanced Intelligent Systems, 2014.

[19] T. Yonezawa and H. Yamazoe. Wearable partner agent with anthropomorphic physical contact with awareness of clothing and posture. In The 18th International Symposium on Wearable Computers (ISWC2013), pages 77–80, 2013.