AHOBO: Frailty Care Robot for Elderly and Its Application for Blood Pressure Measurement

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Abstract. A robot support system for elderly people is proposed to care their own frailty, where a support robot "AHOBO" instructs elderly on the right blood pressure measurement, and gives them advice to improve their health with the visualized measurement data. Two types of evaluation are performed on 16 subjects (from their 20's to 60's). It is confirmed that there is no influence of robotic blood pressure measurement support on blood pressure readings.

Keywords: Healthcare and Medical Application, Human Robot Interaction, Presymptomatic Disease, Health practice, Blood Pressure

1. INTRODUCTION

In Japan, a society with the highest rate of aging in the world, unintentional home accidents in the elderly is increasing. Taking care of various functional changes and losses of capacity due to aging, i.e., frailties can help prevent accidents in the home.

In this study, we focus on blood pressure. More than 80% of the deaths at home are among the elderly, and an analysis of the causes of fatal accidents suggests that the majority of deaths have a possibility to related to blood pressure changes. It is important for elderly people to know their blood pressure status at all times and to take care of their health conditions. This directly leads to prevent accidents in the home.

A robot support system for elderly people is proposed to care their own frailty by themselves, where a robot instructs elderly people on the right blood pressure measurement habits and methods, and gives them advice on how to improve their health based on the visualized measurement data. And a support robot "AHOBO" is developed for this system. We examine and report the influence of robotic blood pressure measurement support on blood pressure readings. The appearance of AHOBO and its blood pressure measurement system is shown in Fig. 1.

2. HEALTHY HABITS TO PREVENT FRAILTY

2.1. Three Factors of Frailty and Its Countermeasures

Frailty is a condition in which the vulnerability to health maintenance increases due to various functional changes and loss of capacity with aging, and is similar to ME-BYO (presymptomatic disease) well known in Japan. Although aging is irreversible, from the viewpoint of health, frailty is reversible and can be restored to a healthy state with appropriate intervention. For this reason, it is important to establish a system for the early detection of frailty.

Frail is specifically defined as a condition in which one or more of the three functions - physical, mental, and social - are lost and affected [1]. Although these losses of functions may affect each other, we focus on physical factors among them. Physical factors are easier for elderly to manage on their own.

2.2. Frailty Prevention and Blood Pressure in Elderly

Health condition and blood pressure are prone to fluctuations, which can lead to accidents in the home. According to the demographic survey of the Ministry of Health, Labour and Welfare (MHLW) in Japan, the

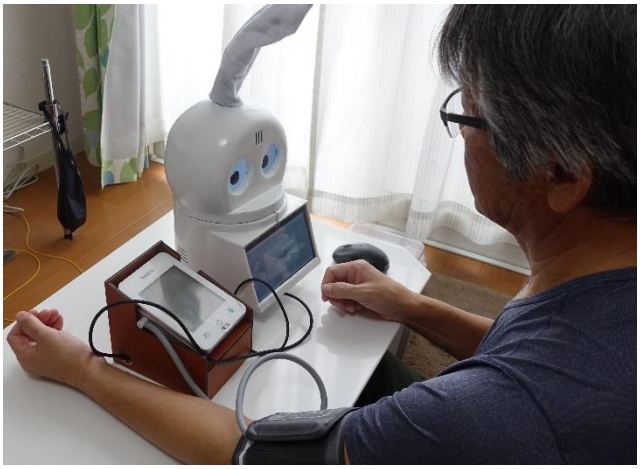

Fig. 1 Frailty care robot AHOBO and its experimental scene in blood pressure measurement support situation.

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unintentional fatal accidents of the elderly (aged 65 years and older) in the home has been increasing both in terms of the number of accidents and the percentage of all ages [2].

The top three fatalities were "Drowning (37.0%)", "Suffocation (27.5%)", and "Fall (18.9%)", and drowning and falls can be attributed in part to sudden changes in blood pressure. In order to prevent these fatal accidents, it is necessary for elderly people to monitor their daily blood pressure fluctuations and to act in accordance with their own condition. Although blood pressure measurement at home is effective for monitoring daily blood pressure fluctuations, it is not generally customary to measure blood pressure as part of daily health management and is not used to ascertain daily fluctuations. In light of this, it has been pointed out that there is a need for guidance in acquiring correct measurement habits and methods [3].

In addition, it has been pointed out that visualization of health data, including blood pressure, can change lifestyle habits, and it has been shown that behaviors can be changed to improve health in an environment that is designed for internal corporate use [4].

In this study, we construct a robot support system in that a robot instructs elderly people on the right blood pressure measurement habits and methods, and gives them advice on how to improve their health based on the visualized measurement data. This will enable elderly people to check their own frailty and to create the habit of taking care of themselves based on the improvement advice of the proposed system.

3. ELDERLY SUPPORT ROBOT AHOBO AND ITS APPLICATION FOR BLOOD PRESSURE MEASUREMENT

We develop AHOBO as a robot to support individuals in their daily life at home to prevent frailty of elderly people. Focusing on physical frailty, we build a robotic support system where AHOBO teaches right blood pressure measurement habits and methods, and gives advice for health improvement based on visualized measurement data.

3.1. Interview Survey for Robots to Support Elderly Individual

We have visited the elderly facility and elderly people's homes and have interviewed elderly people in their 60s to 90s about home robots. The interview scene is shown in Fig. 2. The summary of the hearing in the interviews are as follows.

- It is not desirable for elderly people to keep too large robots at home.
- The robots have hands, but elderly people feel uncomfortable when the hands are different from those of humans.
- Elderly people feel bipedal robots is restless because the robots are not stationary to maintain their posture.

Fig. 2 Interview scene about home robot. The left photo is with NAO at the elderly people's home. The right is with Pepper in the elderly facility.

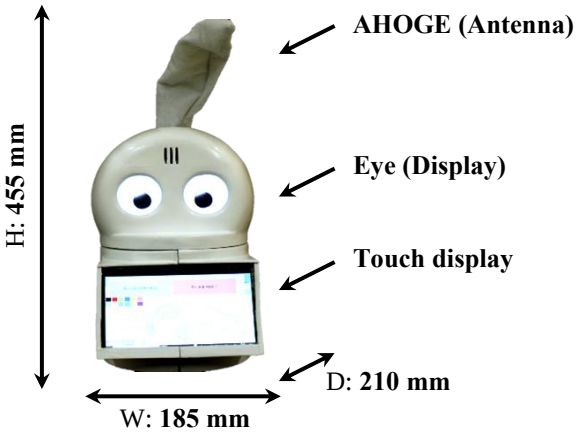

Fig. 3 Appearance of frailty care robot "AHOBO". Eye part and AHOGE (Antenna Hair-type Object for Generating Empathy) part give emotional expressions.

Based on the above, we have established the following requirements for robots to be placed in the homes of elderly people.

- Desktop size.
- It does not have a walking or moving mechanism. It can be placed in a fixed position.
- It has minimalistic emotional functions to be perceived as an intelligent character.

3.2. Frailty Support Robot AHOBO with Emotional Expression

We develop an AHOBO as a robot to support individuals in their daily life at home to prevent frailty of elderly people. An appearance of the proposed robot is shown in Fig. 3.

Based on the interview survey, the proposed robot is not a bipedal robot, but a stationary robot with minimal moving parts and no fine movement for stability.

In order to provide familiarity, it is necessary to use a motif of an object that the elderly people are familiar with. For the above reason, we decided to make a tabletop model with a bun motif. The size of the proposed robot is 185 [mm] in width, 285 [mm] in depth, and 455 [mm] in height for use in the home.

The robot is capable of speaking, interacting using a touch display, and expressing emotions using its eyes and AHOGE for friendly communication.

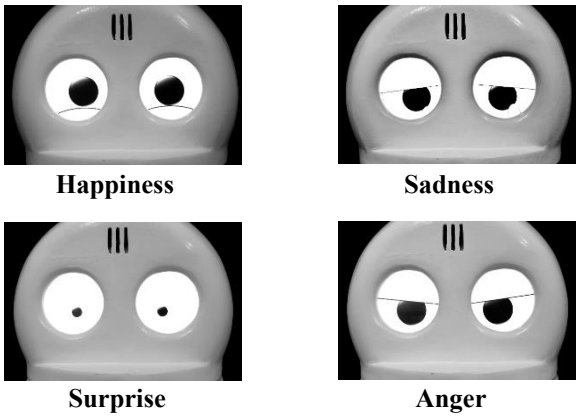

Fig. 4 Four emotional expression with eyes of AHOBO.

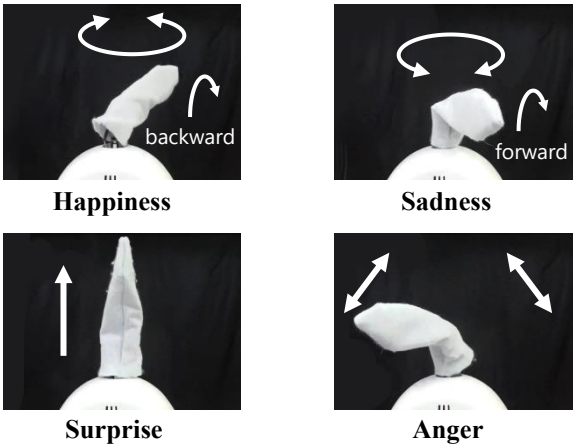

Fig. 5 Four emotional expression with AHOGE of AHOBO.

3.3. Emotional Expression of AHOBO using Its Eyes and AHOGE

In order to provide friendly communication, AHOBO has emotional expression function using its eyes and an AHOGE (Antenna Hair-type Object for Generating Empathy). AHOGE is an emotional expression element that does not imitate the human style, but makes use of the robot's own body [5]. The AHOGE part developed for AHOBO expresses four types of emotions: joy, anger, sadness, and surprise, with two degrees of freedom. Fig. 4 shows the emotions expressed by the display of the eyes, and Fig. 5 shows the emotions expressed by the AHOGE. These emotional expressions with the eyes and with the AHOGE are combined with each other in a coordinated/ confrontational manner, depending on the situation.

3.4. Robot Support System for Blood Pressure Measurement

Focusing on physical frailty, we propose and construct a robotic support system with a support robot where the support robot teaches right blood pressure measurement habits and methods, and gives advice for health improvement based on visualized measurement data.

In the proposed system, the support robot encourages users to measure their blood pressure periodically in their daily lives. AHOBO is prepared as a support robot and built in the system. An overview of the proposed system using AHOBO

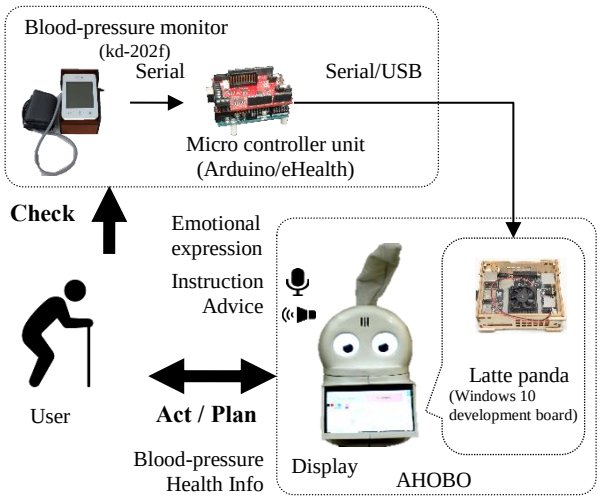

Fig. 6 Application for Blood-Pressure Measurement with AHOBO.

is shown in Fig. 6. We use kd-202f sphygmomanometer (Kodea co., LTD) with an accuracy of ±3 mmHg.

During blood pressure measurement, the robot gives voice instructions on the proper use of the blood pressure monitor. After the measurement, the blood pressure information, visualized as a graph, is presented on the display, and the robot gives voice advice on how to improve the lifestyle according to the estimated health condition based on the measured blood pressure value. The robot makes emotional expressions during voice instructions and advice.

The classification of blood pressure values used in the proposed system is based on the Guidelines for the Treatment of Hypertension 2014 [6]. If the blood pressure is above pre-hypertension (defined as a systolic and/or diastolic blood pressure ≥140/90), advices on eating and exercise habits are given. Regarding dietary habits, the system recommends a low-sodium diet and a diet consisting mainly of vegetables to reduce the rise in blood pressure. Regarding exercise, the system recommends a short, indoor exercise program.

4. VERIFICATION OF EFFECT OF BLOOD PRESSURE MEASUREMENT SUPPORT ROBOT ON BLOOD PRESSURE

In order to use the proposed blood pressure measurement support robot in daily life, it is a prerequisite that the robot does not affect the blood pressure measurements. In order to verify the influence of the proposed blood pressure support system on blood pressure readings, we compare blood pressure readings under two conditions: measurement by the proposed system and measurement by written instructions. In addition, we conduct a qualitative evaluation using a questionnaire. We prepare two types of support robots, AHOBO and NAO.

4.1. Experimental Procedure

The experimental scene is shown in Fig. 1. The experimental procedure is as follows.

Step1): Explain the experiment to the participant.

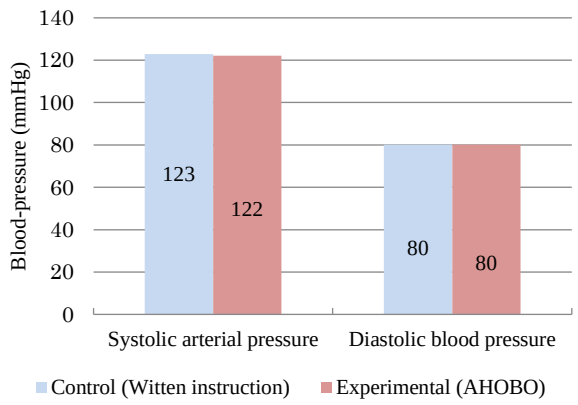

Fig. 7. Average of blood-pressure value in the experiment.

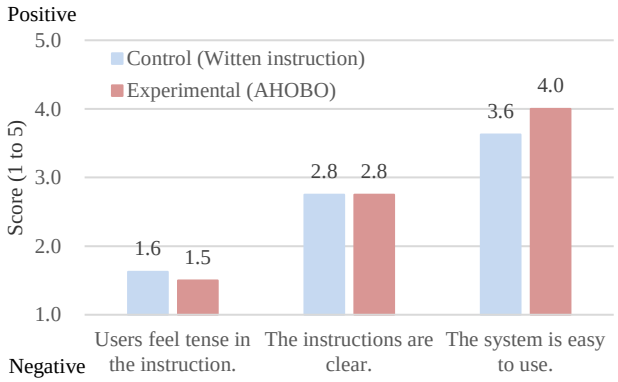

Fig. 8. Average of the evaluated value in the questionnaire.

Step2): Measure the blood pressure according to each condition.
In this verification, the following two conditions are set up. In the experimental condition “robot instruction (proposed)”, the participant measures the blood pressure according to the voice instruction by the robot, and the measurement results are presented on the display on the robot or on the display beside robot. In the control condition “written instructions”, the participant measures the blood pressure according to the written instructions and the results are presented on the display. The order of the experiments in each condition is randomly determined.

Step 3): Ask the participants to answer the questionnaire. The questionnaire contains three subjective evaluations: "Are you nervous in the instruction?", "Are the instructions easy to understand?" and "Is the system easy to use?". The participant rates it on a 5-point scale.

Step 4): Repeat steps 2 and 3 with the other conditions.

In the experiment, the AHOBO mainly expresses the happiness behavior with the eyes and the AHOGE when it gives each instruction, and expresses the happiness or sadness behavior in accordance with the blood pressure value.
The above is conducted on 16 subjects (from their 20’s to 60’s).

4.2. Results of Blood Pressure Measurement

The average of the blood pressure measurement results is shown in Fig. 7.
The systolic blood pressure in the experimental condition (AHOBO instructions) has been 1 mmHg lower than that in the control condition (Written instructions). The diastolic blood pressure has been equal in both cases. This value is within the measurement error of the sphygmomanometer (±3 mmHg), which confirms that the blood pressure value is not affected by the robot instruction.
Focusing on the differences in individual measurements, the mean absolute deviation is 6.8 mmHg for systolic arterial pressure and 4.7 mmHg for diastolic blood pressure. Although these are beyond the range of the measurement error of the sphygmomanometer (±3 mmHg), it may be within the variation of differences in individual blood pressure measurements and should be examined in the future work.

4.3. Results of Subjective Questionnaire

The average of the questionnaire results is shown in Fig. 8. Although the experimental condition (AHOBO instruction) has been more positive than the control condition (Written instruction) in the items "Users feel tense in the instruction." and "The system is easy to use.," there has been no significant difference.
In the experimental scene, the conversations were often repeated due to misrecognition of the speech recognition. Improving speech recognition may improve the results of the subjective questionnaire.

5. CONCLUSION

In this study, we have proposed a robotic support system that enables elderly people to get into the habit of blood pressure measurement for the purpose of daily frailty care in the home. To verify the short-term effectiveness of the proposed system, we have examined the effect of each instruction from the proposed system and written instructions on blood pressure readings, and been confirmed that the difference in blood pressure readings is within the measurement error of the sphygmomanometer and that the proposed system is practical for blood pressure measurement. The proposed system can be applied not only to encourage people to practice blood pressure monitoring at home, but also to support nursing homes that require daily blood pressure monitoring.

This study was approved by the Ethical Review Board for the use of human subjects of Kanagawa Institute of Technology (No.20170117-09).

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