Self-Conscious Support on Walking Posture Through Mobile Avatar: Focusing on Women's Frailty Prevention Toward Old Age

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Abstract. An aging population in a society leads to higher expenditure on social security and medical care. To reduce the cost of treatment, it is essential that preventing frailty of nearly aged women by undertaking habitual physical exercise such as walking, since 70 % of national nursing expense is for this cohort. However, if walking activity has performed with bad posture, it will result in musculoskeletal disease. Therefore, a system that supports to correct walking activity is required. In this research, we propose a system that promotes each users walking habits, including daily steps and walking posture. The result of the experiment suggested that Avatar-based gait representation improves the self-consciousness of users' walking posture significantly rather than number-based representation.

Keywords: Avatar · Elderly people · Gait · Walk habit · Smart phone

1 Introduction

The purpose of this research is to prevent frailty of women toward an advanced age. Japan is experiencing a yearly increase in the proportion of the elderly population. The proportion of the elderly over the age of 65 has exceeded 25 % in 2013 [1], and is expected to increase to 40.5 % by 2055 [2]. Health problems of the elderly in this hyper-aged society are directly linked to the country's financial problems. Social security costs are expected to rise as the number of unhealthy elderly increases. As a result, there is a risk of the essential social support not reaching to the entire populace of nation. Therefore, supporting the promotion of health-related activities for the super-aged society is important.

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Japanese government's nursing expense reaches 12 trillion yen, and 70 % of this is for women. The need of nursing care is mostly caused by musculoskeletal disease. Though daily exercise is needed for maintaining the function of musculoskeletal system, only 29 % of Japanese women have exercise habit. Friedman et al. suggested that having an exercise habit until an advanced age extends the healthy life expectancy [3].

Walking is the most familiar exercise, and is closely related to the daily life and social activities. It is considered to be suitable for preventing frailty. However, walking in an inappropriate posture may increase the risk of falling in reverse. Hence, it is important to obtain proper walking posture before getting old. In this work, we have focused on building a system to support the long-term posture improvement and increase the number of steps. We have built and validated the system to solve the health problems of women by implementing an application that gives feedback of user's gait and number of steps by using a smartphone.

2 Design and Implementation

2.1 Study on the Measurement and Learning of Walking Motion

Kojima et al. [4] proposed a system to measure the walking posture without contacting the participants of the experiment. This system has been reported to be effective in the objective attitude presentation. The following are the four parameters to be acquired: the tilt of the back part (slouch); the longitudinal direction of the range of movement of the hands (arm swing); the range of movement of the left and right direction of the foot (horizontal width of the foot); the range of movement in the longitudinal direction of the foot part (stride). This system is able to gather sufficient data to promote a healthy walking habit. Moreover, it has high applicability, given that it does not requires physically contacting the user.

Once the walking posture is acquired, it is imperative to present the data in a recognizable manner for the user to learn the correct walking posture using the measured data. The technique to reflect the attitude data into human-type avatars as a presentation method on the virtual reality space (VRS) is considered valid. Nawahdah and Inoue [5] have reported that presenting the attitude-teaching avatar in VRS has improved the learning efficiency of attitude. Therefore, it is a system that can observe the avatar freely in VRS that is considered to be valid presentation of the measured gait.

2.2 Study on Techniques to Support the Habit for Health

Kobayashi et al. [6] have classified the 16 elements involved in motivation by extrinsic or intrinsic, and personal or social. For example, Skill Fitness as intrinsic and personal, Social Contribution as intrinsic and social, Payment as extrinsic and personal, and Social Contract as extrinsic and social motivation have been cited.

Gamification. The proposed technique described in the previous section can be effectively applied to the motivation, by gamification. Gamification results in extrinsic and intrinsic motivation by using the mechanics often appearing in games. The following items can be cited as the mechanics that are treated at Gamification.

- Experience: The value experience is stored by the visual display of the various actions. Reward is offered to level up and multiple levels are offered.
- Badge: A badge is given to honor a particular action. Usually, a badge has a variety of types, and it motivates the user to collect more badges.

In addition, when considering Gamification, an avatar is essential. The avatar often mediates the experience value and badge. Avatars are presented to the user to specifically motivate the user. Avatar is the only place in the game world, where the user can associate a strong sense of unity, intimacy, and a feeling of individuality. The clothes and items used for the avatar change in various ways and are factors that motivate the user behavior.

2.3 Design

In this study, the function of performing the present posture of the user through an avatar, the function of measuring and presenting the number of steps and the function to support the habit of walking exercise so that above 2 functions provide a long-term effect on the user is proposed as a method in order to wear a healthy walking habit.

2.4 Implementation

Precedents in above, which devised to encourage the active participation of the user along with the mention introduce research and products for gait analysis and improvement of the past with the advantage of gait analysis system of the past for its limits It was analyzed. Therefore, in the third section to propose and build an avatar system to help so that the user actually light of these related research is wearing a healthy walking habits.

2.5 The Proposed System

System Overview. The configuration of the system requires two applications that provide feedback to the user through the avatar based on the pedometer data held in the posture data. Internal data is obtained through an inquiry of attitude data in response to the ID of the server user that stores and delivers the attitude data. The non-contact type mentioned in Sect. 2 is desirable for a conveniently utilizable measurement method of attitude. In this case, it was decided to use a walking measurement system by implemented the Kinect system.

The system comprises mainly of the following three functions. The number of steps presentation function, which counts the number of steps by accessing the motion measurement chip in the smartphone. It is possible to change the degree of obesity of the avatar according to the step count of past days. The posture presentation function, which converts the gait data acquired from an external system, downloaded at any time, to the motion of the avatar. The habit support function, which prompts the user to inculcate healthy walking habits

Avatar Design. For providing attitude feedback as a condition, the avatar is required to have human-like features. In addition, the learning of attitude, as seen above, is considered to be freely observed in avatar wear enabled on the VR space. Moreover, there is a need to be careful as to some extent the approach and favorability in reality does not fall into the so-called uncanny valley [7,8], which decreases avatar's familiarity. According to Heike et al. [9] avatars that have minor deformation are easy to use and most preferable.

According to the survey of Banks and Bowman [10] about the relationship between the avatar and the player (user), user's sense of reality, operational feeling and a sense of responsibility in the system depends on whether the user considers the avatar as "object", "myself", "symbiote" or "others." Like the Johnsen et al.'s method [11], it is considered important to increase the sense of responsibility of the user so as to provide a motivation to walk when the avatar gets fat. Therefore avatar should be designed as others.

By the way, the purpose of the this study is not to pursue the detailed modeling of the avatar, but is the development of the avatar system to support the walking habits. Again, it is difficult to produce a character with a sense of intimacy from scratch, and character design is considered to be a field difficult to establish a unified opinion. So based on the above conditions, we chose the Avatar used in this study from existing characters. This time, it is the mascot character "Kokoron" of Shimonoseki, Insurance Department of Yamaguchi Prefecture.

Pedometer Function. Step umber presentation function shows user's daily steps in 3 ways: by steps number, by progress bar, by percentage of ratio of today's steps to goal steps.

Real time goal achievement status display: The achievement status is displayed as an image display by the percentage progress bar of the goal. The degree of obesity changes in the avatar. The degree of obesity of the avatar, which is displayed in the system center, depends on the number of steps walked.

Change of avatar's degree of obesity: The degree of obesity of the avatar, which is displayed in the center of display, changes depending on the number of past achievement of goal steps (shown in Fig. 1).

Posture Presentation Function. First we need to determine the gait parameters used in this research. Referring to previous studies [4,12–14], gait parameter to be used in the proposed system is composed of following four parameters: slouch – the forward displacement of center of shoulders from center of waist, expressed in millimeters; swing – the ratio of the arm swing width to the ideal

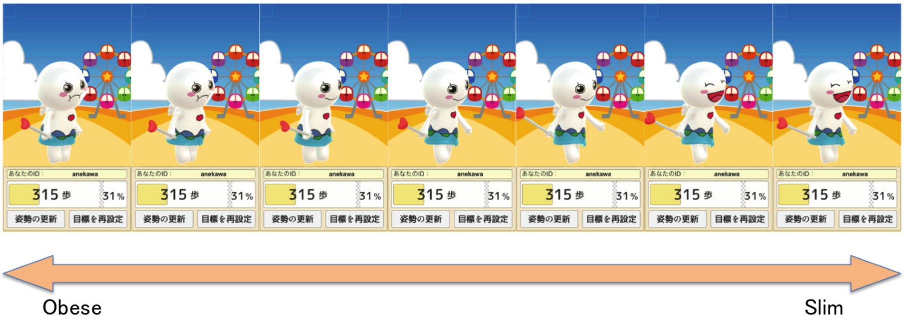

Fig. 1. The degree of obesity of the avatar is changed in accordance with the progress in target number of steps

arm swing width, expressed in percentage; swing position – the forward displacement of center of arm swing from the shoulder, expressed in millimeters; stride – the ratio of stride over stride to ideal stride, expressed in millimeters. For the ideal gait referenced in the swing and the stride, instructor's walking motion was captured.

Stepless reflection of the gait data to avatar animation: It is the regeneration of the walking motion of a 3D model of the avatar, in the 3D space created within unity, and reflecting the user's posture data. Attitude data in this system is used as a weight, when it has been digitized by four parameters blending the motion data that does not deviate from the ideal motion data. The motions are blended by Unity [15] mecanim [16].

Habits Support Function. Get and loss of avatar parts: Acquiring and/or losing the parts by the upper and lower relationship of each of the attitude parameters and threshold values on receiving an update of attitude.

Regular stimulus presentation using the notification function: The smartphone can be set to notify in advance by specifying the date even when the application is not running. This feature is called push notification. Healthy walking habits can be encouraged by displaying a notification statement to the user by using this feature in this system.

Variability of the target number of steps: There is a possibility that if user set goal step too high, the goal step will be never achieved and the user will stop using the system, because positive feedback isn't given. So we implemented a function to alter the goal number of steps if necessary.

3 Experimental Method

In this section, we propose an experiment to verify whether the user can recognize and improve of their walking gait by using proposed system. The purpose of this experiment is to verify if avatar gait representation is more effective than number gait representation, to investigate to which element in application users pay attention, to survey the feasibility of avatar system that promotes walk habit comprehensively.

Fig. 2. The interface of each representation condition

3.1 Experimental Environment

A comparison of the attitude presented by the numerical Avatar was investigated. In both the experiments, participants were presented the attitude and in each of the technique during the orientation, we verified whether the measurement can improve the level of attitude.

The experiments were performed among the participants plan consisting of the following two conditions.

– Avatar condition (Fig. 2 left): The participants of the experiment are presented the attitude that has been reflected in the avatar after the first measurement. The application to be used in the presentation will also be carried out to display the balloon acquisition and loss of exactly the same parts as those described in Sect. 3.
– Number condition (Fig. 2 right): The participants of the experiment are presented with the measurement data after initially extracting the attitude data as a real value. The application to be used in the presentation was modified in the following manner.

- Avatar maintains the T-pose (upright posture with open arms horizontally), and doesn't animate the walking motion.
- Four parameters are arranged numerical display for the window next to the avatar is displayed.
- Even when sliding finger on the screen avatars doesn't rotate.

It should be noted that display of the balloon acquisition and loss of avatar parts also in the numerical conditions is carried out. However balloon position is not adjusted. There were 25 women participants for the experiment with their ages in the range 24–57 years (average age 33.1 years, standard deviation 7.1 years). These participants were the members of the experiment on the same day. There are 12 people as number condition, and 13 people as avatar condition. In addition, we questioned the users by using an alternative formula to judge which of the participants had the most attention towards the function at the time of the attitude presented orally during the hearing after the experiment. The hearing feedback received a reply from 28 people immediately, after the posture presentation of the second measurement. The results are discussed in the next section.

4 Results and Discussion

The degree of improvement under each application conditions for each posture is shown in Fig. 3.

The equality of mean slouch improvements between avatar condition and number condition was rejected at a significance level of 0.05 (*) using the Welch t-test. The results of the avatar conditions were excellent, improving the swing position by 19 mm and the stride by 1.8 % more than that the number condition. Focusing on why the significant difference was observed in the slouch, the difference from other parameters is the necessity to be aware of the trunk. Number

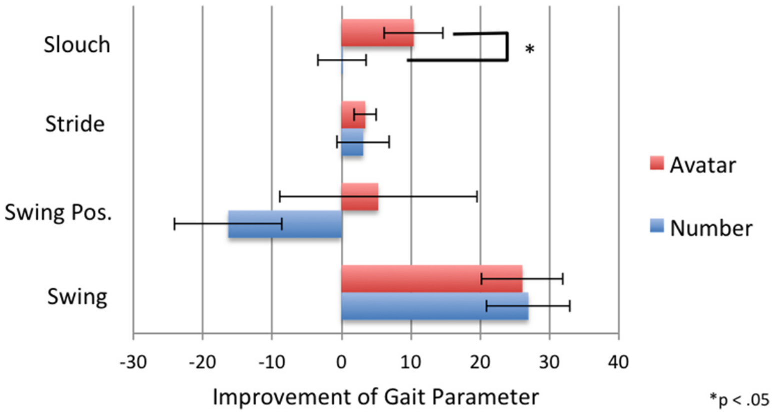

Fig. 3. Comparison of Gait parameters improvement between representation conditions

presentation of gait information may be useful in the control of the ends of the body, such as arm swing; But for trunk gait recognition, intuitive representation by the avatar is considered to be more effective.

Among 12 number condition participants, 7 felt that they were paying attention to the numerical value, 3 on the avatar parts, and 2 on the balloon. On the other hand, among 13 avatar condition participants, 4 felt that they were paying attention to the walking motion of the avatar, 7 on the avatar parts, and 2 on the balloon. Figure 4 shows attention distribution of each condition.

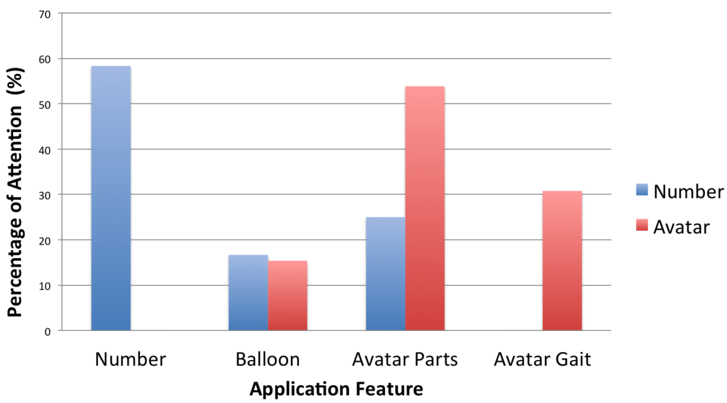

Fig. 4. Comparison of attention between representation conditions

It is suggested from the experimental results that the first avatar presentation is much more valid than the numerical presentation in terms of attitude improvement. However, the reason for the consideration of the avatar group is that the attention was focused on the numerical value of a numeric army, while an avatar attitude and parts focused on the same degree. The numerical consideration is the idea that attitude improvement from a schematically macro point of view, which is in effect the acquisition and loss of Avatar attitude is more effective than improving the attitude from an accuracy and microscopic point of view.

5 Conclusion and Future Work

It is necessary to improve and maintain the walking habits of women toward an advance age for promoting and maintaining their health. In this study, we developed a smartphone application, My Kokoron, which encourages good walking posture by visualizing an avatar for the users walking habit rather than increasing the number of steps. This application improved the users motivation to exercise by visually presenting the walking motion of the user in the form of an avatar. Moreover, the establishment of continuous walking habits of the user was promoted and incorporated using Gamification. In the study, an experiment was performed to the validity of the proposed application; The avatar attitude representation was found to be effective in improving the posture as opposed to the attitude presented by the numerical value. A system, such as adopting a walking habit by the women that do not actively exercise, is required to greet the bright aging society so as to increase the proportion of the healthy and active elderly.

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