Affect Evaluation of Biological Information Approached by a Nursing/care Robot

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Abstract: With a growing shortage of labor for nursing and care in Japan due to its increasingly super-aged population, nursing/care robots are being turned to as one potential solution. In particular, there is high demand for autonomously mobile robots used to assist in the movement of those under care, but their size and movement speed causes feelings of fear and displeasure for some. This research proposed a method of applying a smooth, bell-shaped speed pattern to autonomous robots, attempting to improve the impression they produce when approaching a human subject. EEG and heartbeat data were used to evaluate the reaction subjects had, with affect measured according to indicators of arousal and displeasure on a Russell circumplex model. A comparative experiment using the proposed methodology above and different speed patterns found that the methodology in fact produced negative reactions.

Keywords: Nursing/care robots, affect evaluation, proximity, displeasure

1. Introduction

In recent years, Japanese society is undergoing a super aging phenomenon. A survey by the Cabinet Office estimates that by 2025, there will be a shortage of approximately 370,000 nursing and care personnel, putting the sector under serious conditions. For these reasons, Japan is researching and developing a range of nursing and care robots used to alleviate this shortage and compensate for a lack of personnel. Existing nursing/care robots include those designed to foster communication and provide psychological wellbeing, those designed to alleviate physical strain and aid in movement, and other varieties. In particular, there is expected to be growing demand for mobility assistance robots which engage with people one-on-one. At the same time, many elderly people are inexperienced with devices and robots, and they perceive them as impersonal, frightening, or other negative feelings.

There is considerable existing research on communication between people and robots. Yamamoto et al stated that when a robot and human subject simultaneously approach each other to interact, the human user may have a positive reception towards the robot.[2] However, robots used to assist with physical activity, such as movement to and from bed and dispensing of meals, may approach an immobile human user single-handedly. Furthermore, robots that can hold people up in their arms must be of a certain size, which can cause them to appear more imposing. This research focused on the feelings of fear that people have of human-sized mobile robots and explored ways of alleviating that fear. We consider these feelings of fear associated with an approaching robot could be reduced by calibrating the speed pattern, and this could be evaluated and tested using biological data. In this paper, we propose the appropriate calibrating pattern to reduce fear and evaluate it by biological information, which assumes to be correctly evaluate the feeling of the human without any subjective bias of the people [7,9].

The paper is organized as follows. In section 2, we describe about he preliminary evaluation and related work, and section 3, we show the evaluation methodology. Then, in the section 4, evaluative experiment is shown, and result is described in section 5. Finally, we conclude it in section 6.

2. Preliminary Evaluation

2.1 Survey of reaction to nursing/care robots

In order to ascertain what impression people have of robots in practical use today, a comparative survey was made of elderly and youth cohorts. The subjects were thirty elderly persons aged between their 60s to 80s, and twenty-five youth in their 20s. The survey focused largely on questions about desire to use nursing/care robots and evaluations of presumed usage conditions for said robots. Below, we discuss those questions for which significant results were obtained.

In a question on desire to use nursing/care robots, images of nursing/care robots actually in use were shown, with accompanying explanations of their uses. Subjects were asked whether they would want to use a particular robot if they were under nursing or care and given an evaluation rubric with four levels. The average scores given to the Paro seal-shaped communication robot [3] and the large mobile care robot, RIBA [4], were calculated and an age-related difference found. This is described in Figure 1. The graph indicates that the youth group had a significantly higher desire to use the communication robot, but no difference was seen in the elderly group in terms of preference for one robot over another. One possible reason is that the elderly, due to physical decline, may have experienced impediments to their everyday lives, so have a greater awareness of the need for mobile robots. The elderly group indicated a need for both communication and mobile care robots with no preference for one over the other.

Respondents were also asked to evaluate presumed usage conditions for robots based on the size of the robot in specific contexts like a robot approaching the user or being distant from the user. They were given five choices: “enjoyable,” “frightening,” “comforting,” “concerning,” or “no particular feelings one way or another,” and asked to select one. Figure 2 describes the

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proportion of respondents who selected “frightening” or “concerning” for a question about the robot approaching the user at a speed slower or faster than the human. The findings showed a higher proportion when the robot was faster, irrespective of size. Looked at by size, there was a higher proportion for larger robots. This seems to imply that simply imagining a large, fast robot approaching one elicits feelings of fear and concern, making this an issue specific to large mobile assistance robots.

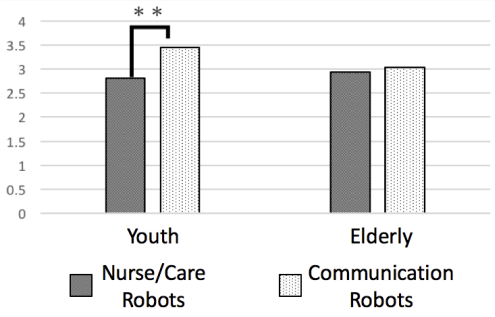

Fig. 1 Desire to use robots, by age group

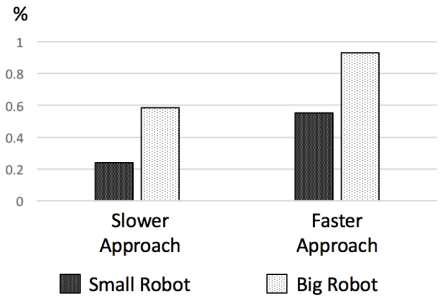

Fig. 2 Proportion of people reporting fear or caution

2.2 Related Research

There is some past work on human reactions to approaching robots. Shibata et al evaluated the speed of robots delivering an object in a single direction from the perspective of psychological desirability, and state that after the speed exceeded a certain value, the robot stopped eliciting a positive reaction in human subjects. They also hypothesized that robots the movement speed of which is based on that of humans is preferable, and performed a comparative experiment using robots accelerating in a primary phase and then decelerating in a secondary phase, using four differing types of acceleration and deceleration timings. The experiment found that both men and women reported the most positive reactions to robots when they moved in a bell-shaped speed pattern and reached their peak acceleration at the 30% point of the entirety of time needed to deliver an object to a human.

Nakashima et al performed a heartbeat analysis of the psychology of subjects faced with a 130cm tall mobile robot approaching them. [6] Subjects were asked to raise their hands at the moment they felt they would not like the robot to come any closer.

The heartbeat before and after these moments was measured at four intervals, and a change was seen after the robots reached a certain speed or higher. The authors state that psychological changes caused by the approach of the robot have an effect on the autonomic nervous system.

3. Evaluation Methodology

3.1 Hypothesis and methodology proposed

This research hypothesized that feelings of fear associated with an approaching robot could be reduced by calibrating the speed pattern, and this could be evaluated and tested using biological data. Given that, in recent years, biological data is being used to measure affective response in humans in real-time, we believed it would allow for accurately assessing what affective changes were occurring in subjects across various stages of the experiment. We referred to work by Shibata et al [5] when considering the movement speed of robots, and employed a bell-shaped speed pattern like that seen in Fig. 3. This speed pattern was then compared against a different speed pattern and the affect produced in a human when a robot approached.

According to research by Nakashima et al [6], biological data is a useful method of measuring in real-time unconscious psychological changes in humans, but measuring specific affective states using a standalone biological datum is difficult. Therefore, this research drew from past work by Ikeda et al [7] to employ a methodology whereby affect is measured using EEG and heartbeat through a Russell circumplex model. The Russell model employs pleasure/displeasure and arousal metrics mapped to two-dimensional coordinates and describes all affective states measured on this coordinate plane.

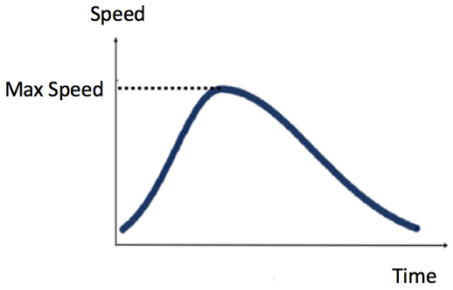

Fig. 3 Bell-shaped speed pattern

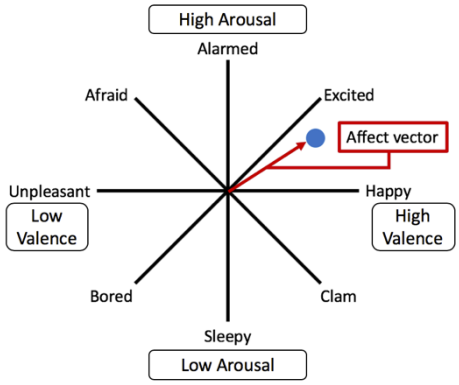

Fig. 4 Simplified Russell circumplex model

The research employed a Russell circumplex model as seen in Fig. 4, with a simplified depiction of eight affective states. The X axis represents pleasure, and the Y axis represents arousal, with heartbeat and EEG used as biological data to measure these states, and the resulting values used to attempt to determine the affect.

For heartbeat data, we measured pNN50, recognized as an indicator of the parasympathetic nervous system. Where this value was 0.3 or higher, it was treated as pleasure, and where the value was smaller than 0.3, it was treated as displeasure. For brainwaves, the Neurosky mindwave, a simplified EEG device, was used, and values obtained using a proprietary algorithm.

When the difference between attention and meditation was greater than 0, it was treated as high arousal; where lower, it was treated as low arousal. In this way, combining multiple biological data allows for, we believe, achieving a more accurate value expressing affect than when simply using a single datum.

4. Evaluative Experiment

4.1 Experiment overview

We conducted an experiment in order to evaluate differences in approach methodologies used in robots. The experiment employed an autonomous mobile robot "concierge" 120cm tall and had it approach subjects sitting directly in front of the robot and wearing EEG and heartbeat sensors, with biological data obtained from subjects. The experiment proceeded through the following stages.

1. The robot waits about 3m away from the subject.
2. The robot plays an audio cue saying "Hello" in Japanese.
3. The robot approaches the subject at a given speed and speed pattern.
4. The robot pauses about 45cm in front of subject.
5. After playing an audio cue saying "Goodbye" in Japanese, the robot returns to its previous position. This cue is used in order to prevent the subject from being startled by the sudden movement of the robot.

4.2 Approaching with a linear speed pattern

We conducted an experiment using the proposed methodology against a robot approaching at a linear speed with no change to acceleration. Subjects were twenty-one university students in their 20s (seventeen male and four female). The robot speeds were slow (0.2m/s) and high (0.4m/s), with the experiment conducted once with each speed. As a control, which speed to use first was decided at random.

Fig. 5 Concierge robot

The average affective values measured between the time the robot started moving and the time it approached the subject and stopped were obtained and compared by level of speed. While no significant difference was found in any value, displeasure was the highest affective state in both speeds. This was followed by pleasure, but the displeasure value increased at the high speed and the enjoyment value decreased. This implies that there may be a correlation between the robot's approach speed and affective value.

4.3 Approaching with a bell-shaped speed pattern

Given that no significant difference was seen by speed when looking at the linear pattern, we designed the experiment involving the bell-shaped speed pattern we proposed above such that the experiment was followed by a questionnaire in which respondents were asked to evaluate their reaction to the robot at different speeds, as well as questions pertaining to individual attributes. A Godspeed questionnaire format was used, with reaction to the robot measured using twenty-four adjectives such as "familiar/unfamiliar" and corresponding to the categories of "familiarity," "humanity," "animacy," "functionality," and "safety," and measured across six levels. [8] Two robot speeds were respectively used for the experiment: slow (0.2 m/s) and fast (0.4 m/s), and selected at random, as was done in section 4.2. Subjects were eighteen students in their 20s (sixteen male, two female).

After excluding subjects the biological data of which could not be obtained, there were fifteen subjects for the high speed pattern and seventeen for the low speed pattern.

5. Experimental Results

5.1 Comparison by speed pattern

No significant difference in affect was seen based on maximum speed in the bell-shaped speed pattern. However, a comparison of affect in the linear speed pattern and bell-shaped pattern found a significant difference in several affective states. The findings are described in Fig. 6. A significant difference was found in "enjoyment," "calm," "displeasure," and "fear." Per the Russell circumplex model used, enjoyment and calm correspond to pleasure and displeasure, and displeasure and fear correspond to discomfort. Given this, the data seem to suggest that the bell-shaped speed pattern is in fact undesirable to the human user, so our hypothesis was not supported.

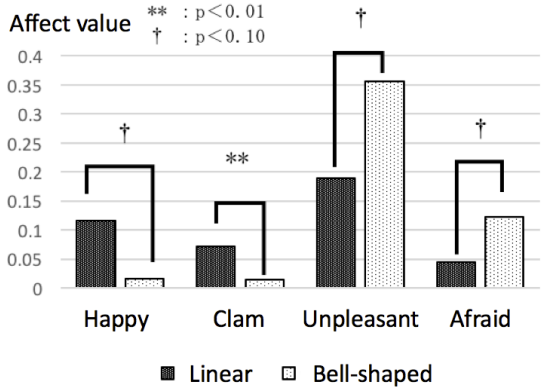

Fig. 6 Affect measured by speed pattern

5.2 Reaction evaluation survey administered post-experiment

After conducting the experiment using the bell-shaped speed pattern, the evaluations of reactions to different speeds were

compared, and a significant difference was found in terms of "familiar/unfamiliar," corresponding to "affinity," and "doubt/calm," corresponding to "safety." In both cases, the slower maximum speed produced higher values, suggesting a higher familiarity towards the robot and levels of calm in the subject. A positive correlation was found between these two values. This suggests that increasing familiarity with a robot may decrease feelings of doubt held towards that robot.

5.3 Evaluation by level of interest

Using the individual attribute questionnaire that subjects responded to in advance, subjects were grouped into a group with high level of interest in robots and low level of interest in robots, respectively, and their responses evaluated. The group with a high level of interest had higher doubt/calm levels with respect to speed than did the group with a low level of interest. Furthermore, a comparison of affect data by level of interest also found a significant difference in displeasure levels, with the group with a higher level of interest in fact having the higher levels of the two.

5.4 Discussion

In terms of differences based on robot speed patterns, judging in terms of affective value, our proposed methodology was less desirable, so our hypothesis was not supported. Some subjects expressed the opinion that the robot accelerating in speed while approaching elicited fear. Experiments of robot approach in prior work involved small desktop robots, producing results likely considerably different from those herein. In terms of personal space, given that the "social distance" maintained between people one is not especially familiar with is held to generally be between 120-350cm, when the robot's movement speed was high, it may have produced feelings of displeasure by invading subjects' personal space. Furthermore, since we did not indicate in advance to subjects with what speed pattern the robot would approach, the linear pattern made it comparatively easier to determine where the robot would come, possibly preventing feelings of displeasure.

A comparison of affective state and reaction to the robot based on degree of interest found that the group with a high level of interest had positive results in terms of feelings of affinity and calm in the subjective evaluation, but in terms of affect, feelings of displeasure were higher than in the group with low level of interest. While subjects with a high level of interest held positive feelings towards the concept of robots, the slow speed pattern elicited reactions that the speed was too slow and irritating, suggesting that the sluggish speed of movement diverged from subjects' ideal speed and produced feelings of displeasure.

The result was different from the hypothesis, which is fixed pattern obtained the better feeling reaction than the bell-shaped speed pattern. However, by using the emotion information obtained from the biometric information, it was possible to accurately evaluate the emotion which could not be judged as a reaction originally. As a result, it was found that a fixed speed pattern robot is preferable. Thus, it is important that there was a new discovery by this research.

6. Conclusion

We considered using a methodology whereby feelings of fear associated with the movement of nursing/care robots were reduced through changes to speed patterns and tested this hypothesis by evaluating biological data (heartbeat and EEG), but we did not obtain data supporting the hypothesis. Going forward, additional experiments should be conducted based on robots configured to reach a maximum speed deemed natural to human users, and their reactions obtained. Given that the research did imply some effect on affective state and reactions based on degree of interest in a particular robot, further experiments would need to not only control the robot's movement, but be based on individual attributes. Specifically, this could include having a robot approach while continuously decelerating, or changing the maximum speed based on a particular level of interest in the subject.

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