Design and Implementation of Virtual and Real Kawaii Companion Robots by Affective Evaluation using EEG and ECG*

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***Abstract*— Companion robots become more familiar year by year. This manuscript describes our collaborative project related to the design and implementation of virtual and real kawaii companion robots by affective evaluation using EEG and ECG by Japanese and American university students. Each group, which consisted of a combination of Japanese and American students designed and implemented several robots which cause different affective reactions estimated by EEG and ECG.**

I. Introduction

As robots become increasingly common in our daily life, it is critical that roboticists design devices that are accepted broadly, including across cultures and genders. Towards this end, global collaboration is pivotal today and in the future. This paper reports on the final year of a three-year cross-cultural collaboration between students and faculty at Shibaura Institute of Technology in Japan and DePauw University in the United States. We formed two cross-cultural teams to design and evaluate companion robots to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, these devices across cultures. Although this collaboration was planned from Aug. 2019 to July 2022, it was postponed one more year because no American students could visit Japan for collaboration during this period due to the COVID-19 pandemic. During the first and second years, the collaboration was conducted online. Each cross-cultural team designed and developed virtual companion robots [1][2][3][4]. As for the final year, as a result of the one- year postponement, American students could come to Japan from the end of May 2023, and continue to work together with Japanese students to create both virtual and real companion robots by the middle of July, 2023. This paper describes the on-going activities for the final year.

II. Previous Work

A. Kawaii

As we have previously reported in [1], the word, *kawaii*, is often translated into "cute," "lovely," "adorable" and some other words depending on the context. There does not seem to be an exact word that can be used as a counterpart in English [5]. That's probably because Japanese people's affection for "*kawaii*" has been cultivated throughout Japanese history [6]. Anyway, the adjective "kawaii" is one of the most important affective value at least in Japan and it seems the value is rapidly being shared around the world [7][8].

B. The First-year Activities

Because of the COVID-19 pandemic, we had to change our planned 7-week collaboration from in-person to virtual with a resultant change in the target product of our collaboration from real robots to virtual robots. Based on our new plan, students designed virtual spaces with robot pairs using Unity, proposed evaluation items for the robot pairs, evaluated their designs, and analyzed the results. The students designed each robot pair with the goal that one robot would be more kawaii and the other would be less kawaii due to a variation in a single attribute such as shape or color. Examples of those robot pairs are shown in Fig. 1. The evaluation instrument used adjective pairs that were suitable to evaluate the affective values of the robot pairs and the virtual spaces the robots occupied. For more information, see references [1][2].

C. The Second-year Activities

As for the second year activities, students focused more on robots than the first year. Each team developed a persona (composite user to design for) and a scenario to guide the work. Then, each team designed four versions of a virtual companion robot that demonstrated one part of their scenario. One example of those robots are shown in Fig. 2. Each robot was evaluated both by kawaii score (from 0 to 10) and biological signals (EEG and Heart Rate). For more information, see references [3][4].

III. On-going Activities

This year, 2023, American students were able to come to Japan physically for these activities. Persona was given as "Sam is a first-year college student who is studying mathematics. Sam is having trouble getting homework completed on time and Sam and the stress of homework makes Sam sad," and scenario was also given as "Sam's companion robot says "Sam, you look tired and sad. I know you have a lot of work to do so let me try to cheer you up." **The companion robot makes some movements and sounds for about 30 seconds.** Then the robot says "Sam, now that you are happier please start your homework. Sam begins his homework and is pleased to be done." The sentence written in Bold should be the target for design and development. Each team designed 8 versions of a virtual companion robot with the combination of appearance (kawaii, non-kawaii), movement (kawaii, non-kawaii), and sound (kawaii, non-kawaii) using Blender.

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Moreover, students use the Emotion Visualizer, which can estimate the user's emotion by EEG and ECG in real time [9], to differentiate the emotion evoked by each robot. Based on the evaluation both by kawaii score (from 0 to 10) and the Emotion Visualizer, the effects of appearance, movement, and sound can be clarified for implementation of real robots. The most kawaii robot and the least kawaii robot should be implemented as real robots using 3D printer. For the movement and sound of each robot, Zumo (Fig. 3) [10] was employed. That is, each team should design their virtual robots which can contain Zumo inside, and their movements and sounds should be realized by Zumo. Students will implement their real robots by middle of July, and those robots will be evaluated both by kawaii score and the Emotion Visualizer to compare those of their digital twins. Fig. 4 shows examples of appearances of the virtual and the corresponding real robots at present.

IV. Discussion and Conclusion

As for the on-going activities, students could come to Japan and collaborate with Japanese students on-site. We have recognized the big differences between online collaboration and collaboration in person. In addition, evaluation by using EEG and ECG also can work much better in the presentation in person. The real robots will be implemented and we will compare the emotions evoked by the real robots and their digital twins. Finally, these activities will clarify the effect of kawaii-ness of companion robots and evoked emotions estimated from EEG and ECG.

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Figure 1. Examples of robot pairs cretaed in the first year activities [1]

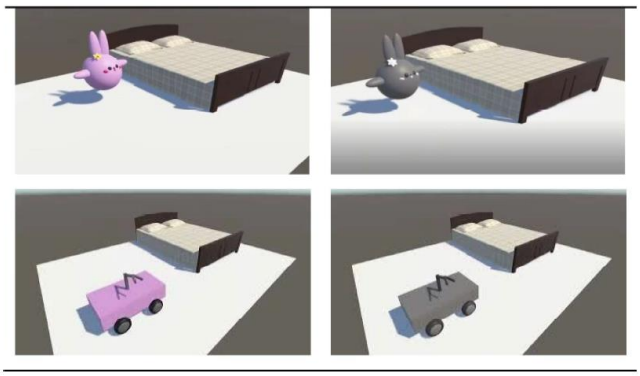

Figure 2. Examples of four versions of robot cretaed in the second year activities [4]

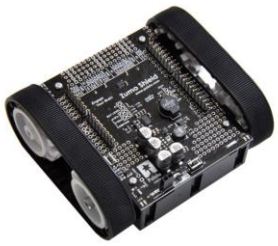

Figure 3. Zumo

(a) Virtual robot (b) Real robot

Figure 4. Examples of robots