Towards Stress Sensitive Voice Casting Robot for Cooperative Workspace

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Abstract: In future, it is expected that human and robots cooperate in workspace, for that, it is important for robots to learn how to consider human factors, such as stress. To robots cooperate in workspace with humans, we propose the use of voice casting to help the human to calm down whenever stress is detected during tasks. Stress is often associated with decrease or low heart rate variability (HRV), there are several methods for estimation, however, suitable method for voice casting robots is not clearly defined. To evaluate methods that suits better for voice casting robot, an experiment with subjects exposed to stressor test and different estimation methods was conducted. To help the subject to calm down during the test, the voice casting robot suggested short break for deep breathing.

1. Introduction

The Japanese Government has set out to achieve economic development and address social issues through Society (5.0), a human-centric society that employs advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data, particularly robotics [1].

Robots are now used to support humans not only in industrial settings, but also mentally. An expectation for robotics is to facilitate collaboration between robots and humans; however, it is essential to consider human mental states, including stress, cognitive workload, and emotions, especially during work, as stress can negatively affect work efficiency and quality of life for workers [2].

Previous studies [4] have found that voice casting has a positive effect on people's emotions when interacting with robots; however, issues of individual differences in emotion estimation methods remain, due to the use of fixed threshold values. Another study [5] developed a robotic control system that adapts to workers' stress levels and found that it could make difficult tasks less stressful. Nevertheless, further research is needed to determine how this method impacts people's stress levels during human-robot interaction.

Although studies suggest that voice-casting robots can positively influence the emotional state of humans during interaction [3-4], the effectiveness of voice-casting robots in reducing worker stress during task execution requires further evaluation.

Hence, this research proposes the implementation of stress management voice-casting robots that can estimate when the worker is feeling stressed and attempt to help them to relieve it. For this, two stress estimation methods based on [4] and [5] have been implemented on the voice-casting robot and compared through experimentation. It is expected that voice casting can be used to relieve stress, and the method used in [5] can solve the problem of individual differences in the estimation of stress.

2. Proposed Method

To conduct an experiment to test and compare both stress estimation methods, and the reaction of the subjects by the voice casting robot, we propose the implementation of the voice casting robot and stress estimations as follows.

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2.1 Stress sensitive voice casting robot

To test our hypothesis, the method showed in the Fig. 1 was developed. The workspace is shared between the robot and a worker wearing a pulse sensor. The heartbeat information is sent to the robot, so it calculates the pNN50, which a widely used HRV metric on research about human robot interaction [3-5].

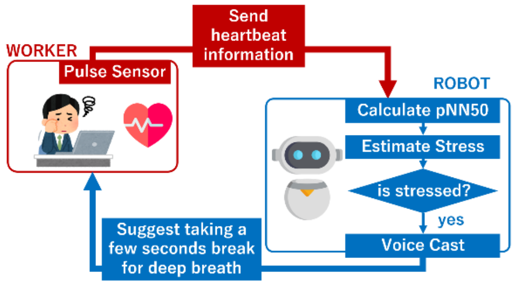

Fig. 1 Methodology for the voice casting robot

Based on the pNN50, the robot estimates stress of the worker, and if stress is detected, the robot voice cast to the worker suggesting him/her to take a few seconds break for deep breathing, since it is widely used as a reduction of stress method [6].

2.2 Stress estimation based on HRV

Although, what is the most appropriate method for estimation of stress based on HRV for voice casting robots still needs to be clarified. For that, two different time-domain methods were proposed based on previous research [3-5].

In the first one associates stress with the variation of mean pNN50 on a period, if the mean HRV decreases, the person is assumed to be feeling stressed [5]. The second method associates stress based on value of pNN50, if it is lower than a 0.23 [4], then the person is assumed to be feeling stressed. Both methods are illustrated by Fig. 2.

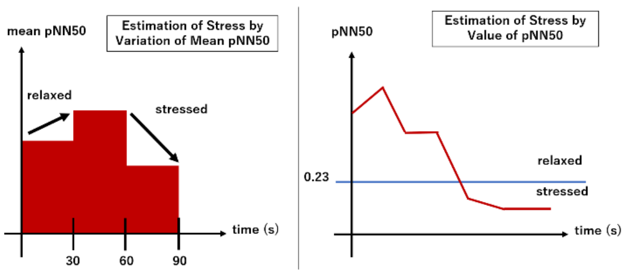

Fig. 2 Estimation of stress methods

3. Evaluation

The preliminary experiment was designed to simulate a situation in which the subject is executing a mentally stressful task so the intervention of the robot can be evaluated.

3.1 Pre-experiment procedure

The experiment consisted of answering the Paced Auditory Sequential Addition Test (PASAT), which is consistently used as cognitive stressor in psychology research [7]. During the test, the subject is expected to feel mentally stressed a few times.

1. Stay still (rest) for 60 seconds for baseline measurement.
2. Answer PASAT for 3 minutes, without robot interaction (used to induce stress [7]).
3. Answer questionnaire about own opinion on the test and robot interaction (if any).

The steps 1, 2 and 3 are executed 3 times. On the first time, the robot doesn't interact with the subject. The second time, estimation of stress by variation of mean HRV was used by the robot. Lastly, estimation of stress based on threshold value was used for the robot.

3.2 Comparison of stress estimation methods

The stress estimation methods were compared by analyzing the mean pNN50 of the subjects during the TEST in the 3 conditions presented previously, shown in Fig. 3. For subject 1, the estimation by variation of mean pNN50 had a higher mean value, while for subject 2, there was not a significant difference in the results. The method by value of pNN50 presented better results for subjects 3 and 4, who naturally had low pNN50 throughout the experiment. However, individual differences posed challenges in the results, highlighting the need for further investigation to address these issues.

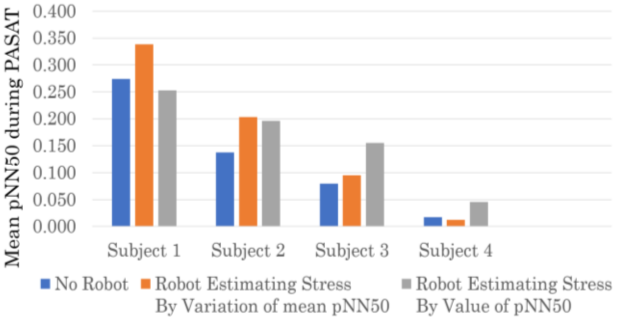

Fig. 3 Comparison of mean pNN50 of subjects during PASAT for different conditions

3.3 Deep breath voice casting as stress reduction

Lastly, the effectiveness of suggesting deep breath as voice casting was analyzed. For that, it was checked for every subject, the pNN50 that was increased by voice casting. The Fig. 4 shows an example of pNN50 of the subjects during one of the experiments. The percentage of voice cast that increased the pNN50 was 80%.

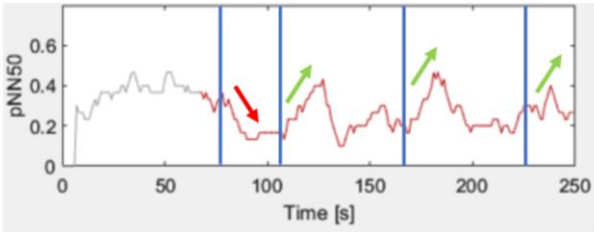

Fig. 4 Example of pNN50 of a subject

4. Conclusion

In this paper, it is reported about the works done on the development and evaluation of robot that manages the stress of workers while they are executing tasks. The goal is to reduce the stress of workers during execution of tasks by applying stress reduction methods on voice casting robots.

Two different stress estimation methods based on HRV were compared and the evaluation of deep breathing as stress reduction were performed on a pre-experiment designed to induce stress on subjects.

Although only 4 subjects participated on the pre-experiment, which is not enough to come into conclusion, we were able to identify problems that needs to be solved, such as individual differences on the HRV of participants and the repetitiveness suggesting the same stress reduction method.

Finally, for future works we plan to investigate and implement a stress estimation method based on HRV that can consider individual differences better by exploring other HRV metrics, such as mean RR intervals, SDNN and other time-domain metrics. We also plan to include a bigger variety of stress reduction methods for voice casting to solve the repetitiveness problem. And finally, making experiments with a bigger number of subjects, to be able to statistically evaluate the stress sensitive robot.

References

[1] Cabinet Office Home Page, "Society 5.0", https://www8.cao.go.jp/cstp/english/society5_0/index.html

[2] World Health Organization, "Stress". Available at: https://www.who.int/news-room/questions-and-answers/item/stress.

[3] Ikeda, Y., Horie, R. and Sugaya, M.: Estimating emotion with biological information for Robot Interaction, Procedia Computer Science, Vol. 112, pp. 1589‐1600, (2017)

[4] Suzuki, K. et al.: A prototype of multi-modal interaction robot based on emotion estimation method using physiological signals, Proceedings of Asia Pacific Conference on Robot IoT System Development and Platform, 2022, pp. 7‐12, (2022)

[5] Landi, C.T. et al.: Relieving operators' workload: Towards affective robotics in industrial scenarios, Mechatronics, Vol. 54, pp. 144‐154, (2018)

[6] Harvard Business Review, "Research: Why breathing is so effective at reducing stress" https://hbr.org/2020/09/research-why-breathing-is-so-effective-at-reducing-stress.

[7] Bali, A. Jaggi, A.S.: Clinical experimental stress studies: Methods and assessment, Reviews in the Neurosciences, Vol. 26, No. 5, pp. 555‐579, (2015)