1 Introduction & Related Work

Error situations occasionally happen during human-robot interaction (HRI), due to imperfect robot sensors and cognitive systems. In order to make HRI more robust and more fluent, interactive robots should be able to detect error situations accurately and react appropriately to resolve those error situations. Research on error situations during HRI is a relatively new focus area in the HRI research field. Some of the pioneers of this research are Giuliani et al. [1] and Mirnig et al. [2], which analysed 201 videos that show error situations in four different HRI experiments. Giuliani et al. [1] found that there are two types of error situations in HRI, social norms violations and technical failures. They also noticed that humans show distinguishable social signals especially in the form of head gestures and facial expressions during error situations.

Mirnig et al. [2] also concluded that people frequently combine a verbal utterance with a leaning forward body movement in response to error situations. Mirnig et al. [3] recently brought the research further by conducting an HRI experiment with deliberate faulty robot behaviour. They manually annotated and analysed the experiment videos and concluded that interpreting a human's social signals can help robots determine if error situation happens and react accordingly. They emphasised the importance of gaze shifts and smile/ laughter as the indicators of error detection. Trung et al. [4] utilise the dataset from [3] to develop the first automatic error recognition in HRI based on the classification of head and shoulder movements of humans using Naive Bayes and k-nearest neighbour machine learning algorithms.

2 Goals

We plan to complement our previous works in error recognition in HRI [5] by conducting an online user study to find out how the robot should react after detecting an error situation in HRI. Our aims in this experiment are:

- Identify the appropriate robot reaction to three different error types in HRI (social norm violations, planning errors, and execution errors) based on human raters.
- Investigate whether the appropriateness of a certain robot reaction differs by gender, age, and personality traits of the human raters.

3 Hypothesis

- There is a common consensus among human raters about the appropriate robot reaction to handle error situations in HRI.
- The appropriate robot reaction to handle error situations in HRI is dependant on the type of error situations.
- The appropriateness of robot reaction to handle error situations in HRI is affected by the human raters demographic and personality factors.

4 Study Details

- Location: Online user study
- Date: March 2021
- Duration: 30 minutes per participant

5 Methods

- Before the user study begins, the participant will be asked to fill a demographic survey and a personality assessment.
- After that, the participant will be asked to watch three short videos of people collaborating with a robot in which the robot created different types of error situations.
- After each collaboration video, the participant will be shown eight robot reactions to handle the error situation.
- After each robot reaction, the participant will be asked several questions about the possible effect of that particular robot reaction to the people interacting with it and to the following interaction.
- The whole study will take around 30 minutes to complete.

6 Results

All published data will be completely anonymised with no identifying information about individual participants. The findings from this research may be used in publications in academic journals and also presentations at academic conferences or teaching purposes.

References

[1] M. Giuliani, N. Mirnig, G. Stollnberger, S. Stadler, R. Buchner, and M. Tscheligi, "Systematic analysis of video data from different human–robot interaction studies: a categorization of social signals during error situations," *Frontiers in Psychology*, vol. 6, no. July, p. 931, 2015.

[2] N. Mirnig, M. Giuliani, G. Stollnberger, S. Stadler, R. Buchner, and M. Tscheligi, "Impact of Robot Actions on Social Signals and Reaction Times in HRI Error Situations," in *ICSR 2015, Proceedings*, vol. 1, pp. 461–471, 2015.

[3] N. Mirnig, G. Stollnberger, M. Miksch, S. Stadler, M. Giuliani, and M. Tscheligi, "To Err Is Robot: How Humans Assess and Act toward an Erroneous Social Robot," *Frontiers in Robotics and AI*, vol. 4, no. May, pp. 1–15, 2017.

[4] P. Trung, M. Giuliani, M. Miksch, G. Stollnberger, S. Stadler, N. Mirnig, and M. Tscheligi, "Head and shoulders: automatic error detection in human-robot interaction," *Proceedings of the 19th ACM International Conference on Multimodal Interaction - ICMI 2017*, pp. 181–188, 2017.

[5] D. E. Cahya, R. Ramakrishnan, and M. Giuliani, "Static and Temporal Differences in Social Signals Between Error-Free and Erroneous Situations in Human-Robot Collaboration," in *ICSR 2019, Proceedings of the International Conference on Social Robotics*, p. Accepted, 2019.