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Communication breakdown: Gaze-based prediction of system error for an AI-assisted robotic arm simulated in VR

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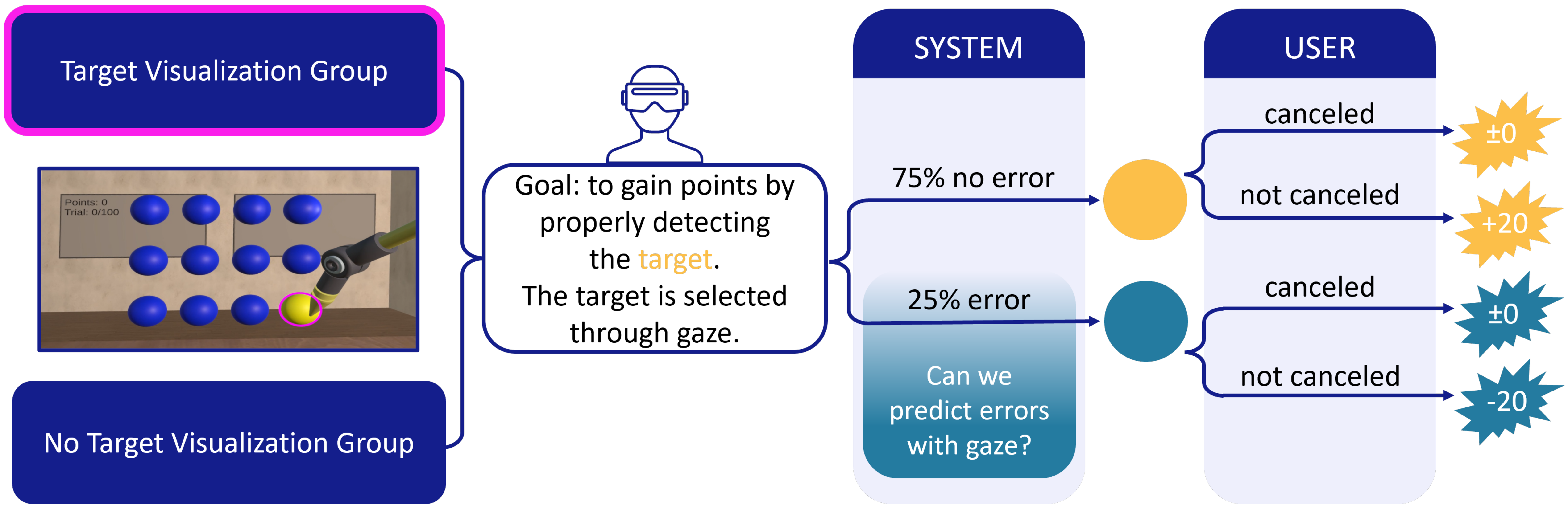


Motivation

Accessability with AI

- AI has shown promise accessability improvements, e.g., rehabilitation [1] and wheelchair navigation [2]
- AI has reached a stage where it can significantly enhance the functionality and effectiveness of these support systems

Procedure

- Design of a VR simulation that emulates an interactive scenario involving a robotic arm supported by AI
- Evaluation of gaze features as predictors to determine whether users can predict errors

Experiment

Select

- Look at the yellow ball
- Press button to select the target
- (Participant gets visual feedback from the system)

Move

- Robotic arm starts to move to the selected ball
- Participant is able to cancel the trial by pressing stop button

Return

- After ending the trial, the robotic arm moves back to start position

Experiment:

- Starting with calibration
- Explanation inside of the VR
- 2 training trials
- Starting the experiment

Distribution of Errors:

- 20 Trials without any Errors
- Trial 21 to 40 randomly 25% errors
- Trial 41 to 100 randomly 33% errors

References

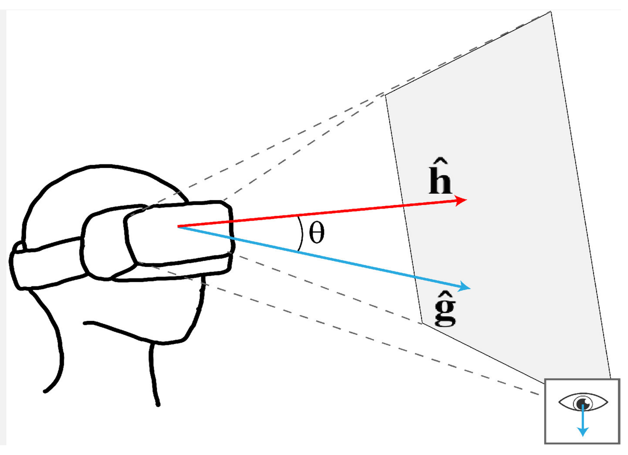
[1] Min Hun Lee et al. (2022) Enabling AI and robotic coaches for physical rehabilitation therapy: iterative design and evaluation with therapists and post-stroke survivors. *International Journal of Social Robotics (2022)*, 1-22.

[2] Walid Zgallai et al. (2019) Deep learning AI application to an EEG driven BCI smart wheelchair. In *2019 Advance in Science and Engineering Technology International Conferences (ASET)*. IEEE, 1-5

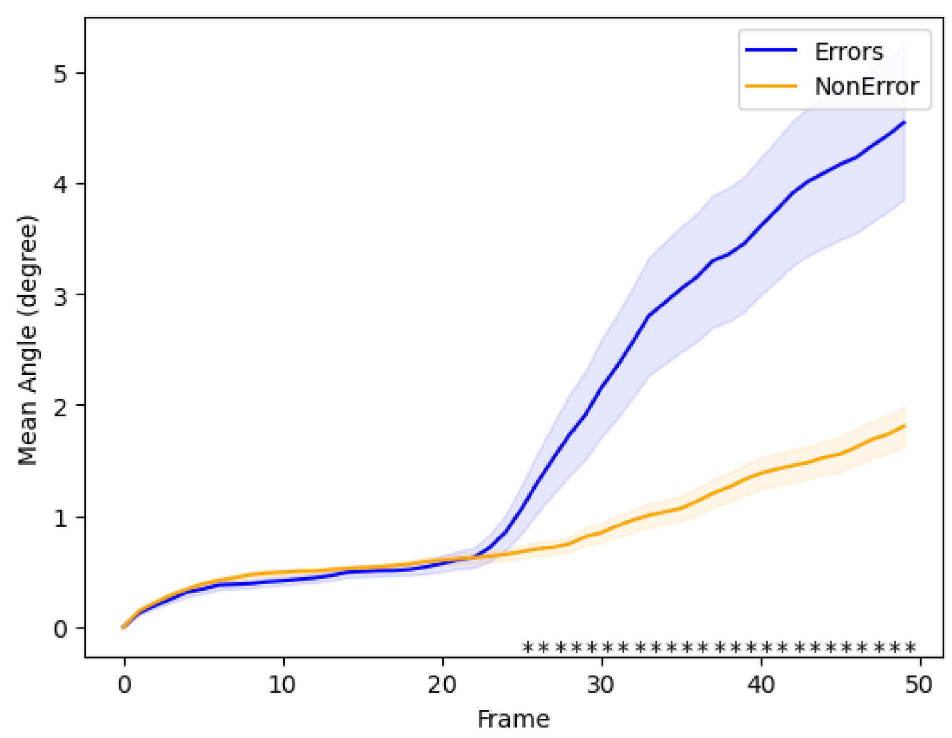
[3] Candace E. Peacock et al. (2022) Gaze as an Indicator of Input Recognition Errors. Proc. ACM Hum.-Comput. Interact. 6, ETRA, Article 142 (May 2022), 19 pages.

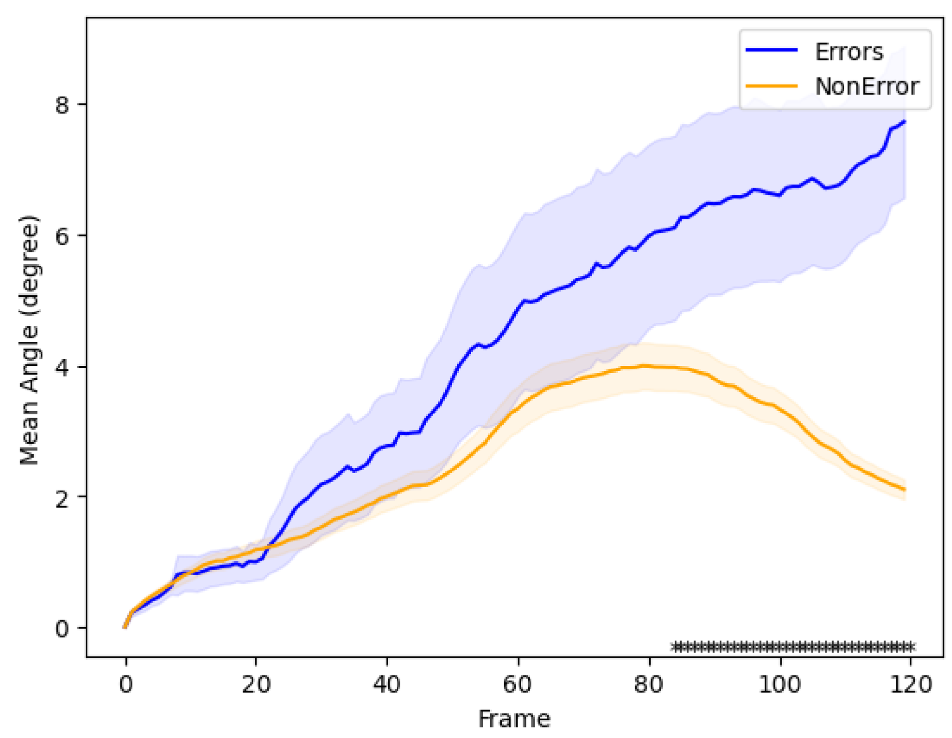
Feature

- Determination of the first gaze vector after selecting the target
- Calculate the angle between the first gaze vector and the following one
- This gives an impression of how far the gaze is from the first gaze vector after selection



Results





With visualization:

- Significant differences after 25 frames (≈300ms)

Without visualization:

- Significant differences after 85 frames (≈900ms)

Classification with visualization:

- Using a TCN [3]
- Input first order difference of the gaze vector of the last 40 frames
- Performance very subject dependent

	Accuracy	Chance	Precision	Recall
All	0.701	0.749	0.346	0.218
Subj12	0.933	0.667	1.000	0.800
Subj17	0.724	0.655	0.667	0.400
Subj08	0.500	0.667	0.353	0.600
Subj07	0.655	0.655	0.500	0.200

Summary

1. Design VR simulation that emulates an interactive scenario involving a robotic arm supported by AI
   - Choosing a target with gaze
   - Robotic arm will reach it
2. Evaluation of reaction to errors based on the interface visualization system
   - Possibility of false target selection by the simulated AI
   - Gaze based features found with significant differences
3. Using gaze features as predictors to determine system errors in an online setup
   - Gaze features are used for classification
   - Results are very subject dependent

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