

Gaze Tracking Enabled Automatic Robot Error Detection

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Introduction

- As scenarios of human-robot interactions and collaborations become more prevalent in society, it is important to recognize instances when robots make mistakes. Previous work has shown that humans have social responses to physical robot errors, and facial action units have been utilized to automatically detect robot errors.
- We hope to investigate human gaze in response to robot errors, and how analyzing human gaze can provide a better understanding of robot errors.

The Problem

- Robots are fallible and can make mistakes when executing their actions.
- If a robotic system does not have a built-in error detection system in place, recognizing that an error has occurred from a human's reaction is critical information.
- The feedback from such a detection system can allow a robot to minimize the severity of an error, allow a robot to correct its error, or even implement early stopping if the error is detected with enough notice.

The Solution

- We conducted a pilot study to study human gaze reactions to robot errors during a collaborative packing task. The goal of this project is to analyze human eye gaze as a potential metric of robot error detection, to eventually include gaze in an automatic robot error detection system created by Maia Stiber.
- We created an exploratory study design, shown in Figure 1, to analyze conceptual and physical robot errors during a human-robot collaborative packing task. We hoped to gather data on where people look during the task and where they look when the robot makes a mistake.
- A total of 6 participants were convenience sampled for the pilot study.
- The data was recorded via the Pupil Labs invisible gaze tracker eyeglasses and a microphone. The recorded data was downloaded from the Pupil Labs cloud software and gaze fixations were manually annotated using the datavyu software. The study setup is shown in Figure 2.

Conceptual Task Error	Crush fragile object	Box won't close due to wrong object
Physical Task Error	Drop object	Doesn't pick up object
	Low Severity Error	High Severity Error

Figure 1: Exploratory Study Design; the task-specific errors used categorized by error type and severity.



Figure 2: Setup of the space where the user will complete the packing task in collaboration with the robot. The items for packing can be seen to the left of the robot, and the boxes used can be seen to the right of the robot. The list of items was given via the tablet on the table.

Outcomes and Results

- A few participants did not always perceive some of the robot errors as an error, but rather as an experimenter error.
- Goal appears to be goal-oriented, as the literature suggests.
- Gaze appeared to linger in an area where an error occurred, and there appeared to be occasional gaze shifts during errors.

Limitations

- Video coding the pilot study data was time consuming (3 hours / participant).
- This metric only leads to qualitative rather than quantitative data.
- We experienced several technical difficulties while learning how to measure gaze velocity from the Pupil Labs gaze tracker.
- AprilTags were not always detected in post-processing, but there were still some detection issues after switching to ArUco Tags

Future Work

- Finishing the physical setup for an ArUco grid board approach to calculate gaze velocity, a quantitative metric.
- Finalizing our user study with errors that can be perceived more clearly and explicitly as errors by the participants.
- Run a full-scale user study.

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