Verifying Human Robot Interactions for RAISE

February 19, 2026

Research Question

How can we guarantee safe behaviour in a human-in-the-loop scenario?

Background

The CRADLE project (a partnership between the University of Manchester and Amentum), in collaboration with Scintam Engineering, have developed a robotic system for deploying Scintam's machining technology for removing bolts and screws. This system is referred to as RAISE (Robotic Automation of Innovative Spark Erosion) [CRADLE([n. d.])]. RAISE involves a human-in-the-loop who assesses the accuracy of the robot's alignment of the Scintam machining tool with the item to be removed. They also oversee the movements of the robot as it gets into position.

An obvious question for any organisation wishing to deploy this system is how reliable is it? What is the risk that something will be damaged as a result of misalignment of the tool, or movement by the robot? A technology called probabilistic model-checking has been used to assess the probability of errors arising from human-robot interactions [Webster et al.(2020)]. Models of the behaviour of the human and robot are created in the system together with probabilities of the error of individual tasks. The model-checking system can they compute the overall probability of some undesired event.

Approach

The object of this project would be to model the interactions of the human and the robot in the RAISE demonstration system in a probabilistic model-checking tool such as PRISM [Kwiatkowska et al.(2011)]. This would provide a framework in which the team could investigate the probability of

error in the process, based on assumptions of the probabilities of reliable action by human and robot.

The project would involve meeting with the team that created the RAISE demonstrator to understand the workflow and interactions between human and robot involved in typical tasks, translating that understanding into the input language of the PRISM tool and verifying some properties. Initial probabilities could be based on informed guesses, but implemented in a way that would allow data from human-robot interaction experiments to inform the numbers in future.

Milestones

1. A high level description of a typical workflow of human-robot interaction in the RAISE system.

2. A model of that workflow in the PRISM tool.

3. Identification of properties of interest that could be explored in the model and generation of the probabilities of those properties.

References

[CRADLE([n. d.])] CRADLE. [n. d.]. *Demo Day: Robotic Automation of Innovative Spark Erosion (RAISE) – with Scintam Engineering.* https://cradlerobotics.co.uk/raise-demo-day/

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[Webster et al.(2020)] Matt Webster, David G. Western, Dejanira Araiza-Illan, Clare Dixon, Kerstin Eder, Michael Fisher, and Anthony G. Pipe. 2020. A corroborative approach to verification and validation of human-robot teams. *Int. J. Robotics Res.* 39, 1 (2020). https://doi.org/10.1177/0278364919883338doi:10.1177/0278364919883338