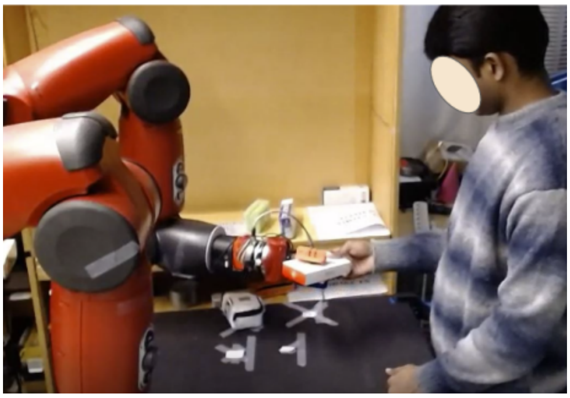
Master's Thesis Proposal

How should a robot release object as a human takes it: Investigating robot-to-human handovers

Description



The goal of this thesis is to investigate different human behaviours as they take objects from a robot in robot-to-human handovers and adapt the robot to these different behaviours. Humans use different strategies to take objects from a robot, leading to varied behaviours. The goal is to analyse various human behaviours in an experimental study and identify the parameters that can be used to classify these behaviours using suitable ML techniques.

A handover is a collaborative action in which an object is passed from one person to another. It is common in our daily lives, and we are very skilled at it. As a result, it is ideal for a robot to be skilled at handovers in order to collaborate effectively with a human, particularly in a social setting. Humans, on the other hand, tend to act differently in the presence of robots. In a recent study [1-2] of human-robot interaction, we observed that participants behaved differently when taking objects from an *interactive* robot. Moreover, we noticed that this behaviour could change as participants interacted more with the robot, i.e., took many objects from it. For the handover, the robot moved to the handover pose (as in the figure above) and said: "Please take the object back". It was programmed to release the object, i.e., open its gripper, when the participant has held the object and applied a sufficient pull to the object. (3N, Pull force-based grip release [3]). This particular strategy is most commonly used in literature. If no pull force is detected, the gripper will automatically open after 10 seconds. The participants were unaware of the strategy's implementation. The following behaviours were observed:

1. Pull fine (PF): Within 3 seconds of interaction, the participant would pull fine and take the object out of the gripper.
2. Pull slowly (PS): Participants pulled slowly and took longer to get the object. This demonstrates that they were more cautious when taking the object.
3. Hold-No-Pull (HNP), Verbal Commands: Participants would not pull the object and would instead give the robot verbal commands to open the gripper. They may hold the object with insufficient or no pull force at all. This demonstrates the human understanding of robots as completely verbally commanded and expecting the robot to obey.

Intriguingly, we also noticed that the same participant's behaviour changed as they removed several items from the robot one after the other. About 40% of participants exhibit a significant behavioural change (PF/PS to HNP), while 25% exhibit a moderate behavioural change (PF to PS).

Goals

The first task is to design and perform a focused experimental study of robot-to-human handovers. In this study, a robot would hand over multiple objects to the human participants while interacting with them. This would involve data collection, including audio-visual recordings, force/torque readings, and subjective questionnaires from the participants. You would observe and analyse various human behaviours. Further, you would need to apply suitable methods for the data-driven classification of these behaviours by identifying suitable parameters in the recorded data. This requires the use of suitable machine learning techniques, like clustering. Since the data will be in the form of a time series, you might employ corresponding techniques, for instance, Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTMs) and Gated recurrent units (GRUs). Once you have created a suitable classification method, it will be integrated with the existing human-robot experimental setup so that the robot giver can adjust to different behaviours. Thus, finally, you can test your method online via real-time human-robot experiments using the existing setup at RPL. It is also possible to use reinforcement learning algorithms to adapt robotic strategy by observing changes in human behaviour during repeated handovers with the same participant.

Requirements

This project is suitable for candidates with interests in human-robot interaction and social robotics.
Proficiency in Python and familiarity with ML algorithms is required.
Some experience with robots and ROS is a plus.

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References

[1] P Khanna, E Yadollahi, M Björkman, I Leite, C Smith, "User Study Exploring the Role of Explanation of Failures by Robots in Human Robot Collaboration Tasks". in HRI 2023: An interdisciplinary Workshop on the role of failure in HRI, arXiv preprint arXiv:2303.16010
[2] P Khanna, E Yadollahi, M Björkman, I Leite, C Smith, "Effects of Explanation Strategies to Resolve Failures in Human-Robot Collaboration". IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) 2023. arXiv preprint arXiv:2309.10127
[3] P. Khanna, M. Björkman, C. Smith. "Human Inspired Grip-Release Technique for Robot-Human Handovers". IEEE International Conference on Humanoid Robots (Humanoids) 2022.
[4] P. Khanna, M. Björkman, C. Smith. "A Multimodal Data Set of Human Handovers with Design Implications for Human-Robot Handovers", IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) 2023, arXiv preprint arXiv:2304.02154.