Enhancing Robot Performance Through Human-Robot Collaboration

Student: Guglielmo Borzone
Supervisor: Aljaz Kramberger
Co-supervisor: Leon Bodenhagen

Context

Robots are becoming part of the workspace in more and more working places. Opposed to when robots, and more specifically robot manipulators, were initially introduced in the industries, where the robots were placed in separate areas from the human operators, nowadays, with the increasing popularity of cobots we have workspaces where a human and a robot will work closely together. This comes with many advantages, such as the possibility for the human to directly inspect the work of a robot, or even the possibility for a robot to perform a task that without human supervision would be likely to fail. But it also comes with challenges and risks, for the task quality and success rate, and more importantly for the safety of the human operator.
This is why the interest for the field of human-robot interaction and of human-robot collaboration is growing in the last years. Most of the studies in this field focus on human-robot social interaction, such as teaching, providing entertainment, assistance to elderly and children and so on. This focus leaves space for further research in the field of human robot collaboration for the industry where the two agents work side by side towards a task. To turn robots, that now are complex machines, that need to be fine tuned and programmed by experts in tools that even an inexperienced operator can exploit, more studies in the fluent communication between robot and human has to be conducted.

Problem

We want to find the best way for a human to interact with a robot during a task and to do so in the most intuitive and safe manner possible, while at the same time ensure the robot precision and success rate for the task. This comes with a series of challenges.
Where and how the human and robot can collaborate in a task, how can the human communicate and what is the most suitable way to do so.
All this is to be done keeping the collaboration simple so that it may serve inexperienced users that would benefit from a robot cooperator.

What theories and technology are in play?

Behavior trees are a tool that are starting to gain popularity in the last years for robot control, because of the chance to design the low level actions of a robot, and the high level structure that describes how these actions are performed and in what order in a separate and modular way. This, paired with the scalability, reusability, modularity, and the visual design behavior trees have, make this tool a suitable choice for the design of stable robot behavior.

The aid of simulation tools allows us to perform various experiments without the need of a real world environment that would take time and resources to set up. This is why the first experiments of the thesis will be performed in the NVIDIA Isaac Sim™ : a robot based simulation software that will

test the theories of this thesis in a virtual environment improving debuggability, time spent and repeatability.

Solution proposal

Low level functions of the robot, such as moving in the workspace, grasp objects, and so on to perform the tasks will have to be defined, as well as the high level behavior of the robot that has to both know when and where to use the low level function.
A mid-level interface that works as a connection between the two, would be an addition that would allow the human input to be processed and to adjust the robot behavior both in the high and low level according to the operator's desire and expertise, allowing even an inexperienced person to modify the robot behavior and collaborate with it towards the completion of the task.

Overall timeline:

September: Literature review
October: Literature review and simulated setup of pick and place task
November: Define collaboration area for pick and place task and 3d scanning task and prototype it in simulation
December: Setup real world scenario for pick and place task
January: Run experiment and collect data
February: Run experiment and collect data
March: Data analysis
April: Data analysis and writing
May: Writing