TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
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M A S T E R ' S T H E S I S
for
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Safe robot manipulation strategies in potential human clamping situations

Problem description:

Humans and robots will share more and more a common workspace. In the field of household robotics, the shared workspace is the respective household, in an industrial setting the robot shares the same workspace with humans in collaborative tasks. The interaction between robots and humans, yet alone the presence of a robot near a human, leads to safety concerns. In recent years, the safety of physical human-robot interactions (pHRI) have been studied, however, many scenarios in pHRI still require more attention.
The biomechanical aspect of the collision between a robot and a human was investigated by [2, 1]. The results lead to dynamic velocity constraints - depending on the geometry of the end effector (POIs) and the trajectory dynamics. Together with a collision detection and reaction scheme, the robot trajectory is non-harmful to humans. However, in highly collaborative scenarios, quasi-static contacts between robots and humans are often intended. Here, standard collision reactions, such as stopping the robot or switching into zero-gravity mode, are rather disruptive. Nonetheless, the robots trajectory have to be safe in these situations, especially when there is the danger of clamping human body parts.
The main aim of this thesis is to identify situations where such clamping injuries can occur and to develop a method to prevent those injuries. By considering the robots trajectory, its end-effector (and entire structure), biomechanical injury data and the environment, a control strategy should be formulated to make the robots movement safe. This control strategy should finally be incorporated in a complete robot control architecture and validated.

Tasks:

- Literature review on soft-robotics, physical human robot interaction, and robotic control.
- Selection of relevant industrial use-cases to base and evaluate the control scheme on.
- Distance calculations between robot and environment for robots trajectory.
- Formulation, implementation and evaluation of a clamping-conscious control scheme.
- Implementation of trajectory optimization strategies for safe robot movements. (*optional*)

Bibliography:

[1] Sami Haddadin, Alin Albu-Schäffer, and Gerd Hirzinger. Safety evaluation of physical human-robot interaction via crash-testing. In *Robotics: Science and Systems*, volume 3, pages 217–224, 2007.
[2] Sami Haddadin, Simon Haddadin, Augusto Khoury, Tim Rokahr, Sven Parusel, Rainer Burgkart, Antonio Bicchi, and Alin Albu-Schäffer. On making robots understand safety: Embedding injury knowledge into control. *The International Journal of Robotics Research*, 31(13):1578–1602, 2012.

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