Master's Thesis:

Development of a Standard Test Device for Injury Assessment in Robotics

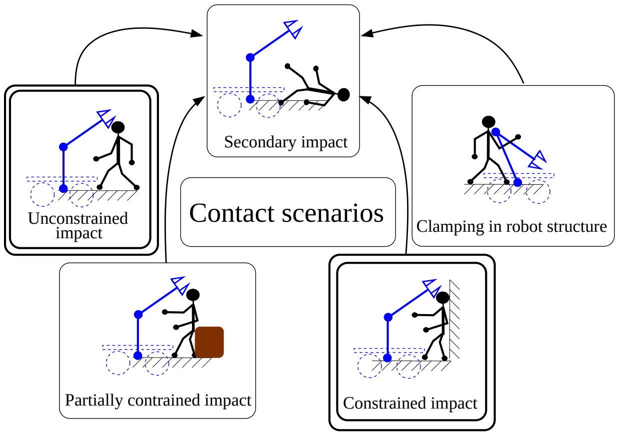

Figure 1: The new KUKA Lightweight Robot (right) is designed for direct physical interaction with humans. Contact scenarios in physical Human-Robot Interaction (right).

Recently, first robots have gained capabilities in both sensing and actuation, which enable operation in the proximity of humans, and even direct physical interaction is possible without suffering from loss in speed and payload. The DLR Lightweight Robot III (DLR-LWRIII), which technology is currently transferred to the robot manufacturer KUKA Roboter GmbH is such a device. The result of this collaboration is the KUKA Lightweight Robot (KUKA LWR), see Fig. 1 (right). The robots have a load-to-weight-ratio of 1 and are equipped with a joint torque sensor in each of their seven joints. This key technology makes it possible to realize various features that are crucial for direct interaction with humans. Impedance control and collision detection with adequate reaction are powerful key components for realizing "soft and safe" robotics.

In this thesis the essential question of what requirements are necessary for a presumably safe robot will be treated. The approach taken here especially focuses on the biomechanical level of injury assessment, meaning the physical evaluation of robot-human impacts and finding the major factors that define injuries during various worst-case scenarios, see Fig. 1 (right). This assessment is the basis for the design and exploration of various countermeasures in order to improve the safety in human-robot interaction.

To make the human the central entity of the evaluation of safety in robotics, i.e. to analyze injuries a human can actually suffer if direct contact with a robot is possible, is the essential step rigorously taken in previous work at DLR. If the physical properties, i.e. the biomechanics of the human are not taken into consideration, a realistic prediction of the resulting human injury or benefit of a particular countermeasure is not possible.

Therefore, it will be one of the first steps taken in the thesis to identify the body parts and injury mechanisms which were not treated in the robotics literature up to now and get an overview of the biomechanics, injury mechanisms, and tolerance thresholds of these body parts. An important example which has large industrial relevance is clamping of the human hand between robot and table/workpiece with different contact geometries. Based on this literature review and eventually some first simulations a testbed will be planned and built up which will consist of a mechanical dummy of the human body part, the appropriate sensors, and electrical periphery to measure the relevant quantities defining human injury. The development of the setup aims at a standardized collision test procedure to compare different robots with each other concerning their worst-case characteristics and their ability to reduce or even prevent human injury. The verification of the setup is of large interest since this provides the opportunity to compare different robots on an objective basis. Finally, the characteristics of the DLR-LWRIII/KUKA LWR should be evaluated to show the applicability of the concept.

Expected work steps

- Literature review
- Selection of injury mechanisms and body parts which were not analyzed in the literature and deserve further treatment
- Choose and built up the appropriate sensing and data acquisition setup for the test bed
- Plan and built up a mechanical test setup for mimicking the particular human body part
- Test and verify the setup
- Evaluate the existing safety strategies of the DLR-LWRIII/KUKA LWR with the setup

Prerequesites

- Knowledge in MATLAB/Simulink
- Knowledge in mechanical and electrical design
- Ability to work well structured and organized
- Creativity

Contact

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