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F O R S C H U N G S P R A X I S

Simulation of physical Human-Exoskeleton-Interaction with soft contacts

Problem description:

In order to provide a safe and seamless Human-Exoskeleton-Interaction (HEI), a precise understanding of the dynamics governing the interactions between the robotic system and the human is essential. These interactions are primarily performed through physical contacts, which are generally challenging to model, due to visco-elastic properties of human soft-tissue, passive degrees of freedom in the joints, and unobservable residual forces. Nevertheless, if these components remain unknown, they may result in undesired interaction forces during the control of the exoskeleton resulting in discomfort and safety risks for the user.
Previously, it has been attempted to analytically describe these parameters and identify them subsequently using experimental data [1]. However, the resulting values are difficult to validate as ground-truth data is missing and the underlying physical model may not describe all of the existing dynamics. Therefore, the goal of this work is to program a high-quality simulation model, which describes the emerging dynamics during HEI faithfully. For the development the physics engine MuJoCo (Multi-Joint dynamics with Contacts) is to be used, which was specifically designed to simulate complex dynamical systems in contact-rich environments [2]. This environment has previously been used, for instance, as a physics simulator to benchmark reinforcement learning algorithms in OpenAI Gym. Additionally, for the simulation to be broadly applicable, an accurate representation of the physical properties of the human musculoskeletal system [3] and exoskeleton rigid body dynamics has to be implemented. The tasks of the research internship are outlined as follows:

Work schedule:

- Literature research on soft contact modeling with constraints
- Literature research on anatomy of human upper extremity
- Implementation of physical HEI model with soft contacts in MuJoCo
- Evaluation of simulation results

Bibliography:

[1] A. Schiele. An explicit model to predict and interpret constraint force creation in pHRI with exoskeletons. In *2008 IEEE International Conference on Robotics and Automation*, 2008.
[2] E. Todorov, T. Erez, and Y. Tassa. Mujoco: A physics engine for model-based control. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2012.
[3] K. Saul, W. Murray, and S. Delp. A model of the upper extremity for simulating musculoskeletal surgery and analyzing neuromuscular control. *Annals of biomedical engineering*, 2005.

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