

Intuitive Surgeon-Robot-Interface to Control Macro-Robots Hands-On



Figure 1: The user study setup with the macro-robot (7-DoF Kuka LBR iiwa) fixed via rails to the table and the mock-up skeleton with two trocars in front of it. Here the robot has two handles mounted that allow surgeons to move the tool as desired.



Figure 2: First prototype of handle aligned with the tool. This seems the most intuitive interface among the three that were tested.

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Typically, robots are rigid, and it is not safe for humans to collaboratively work with them. With the development of lightweight robots [1-3] and the introduction of force/torque sensors, users can now accomplish tasks. We suggest that hands-on control could be beneficial in the medical environment, where the advantages of a robot can be combined with the surgeon's expertise. Only a few hands-on controlled medical robots are on the market by now. To the best of our knowledge, no studies have investigated the requirements of intuitive user-interfaces for hands-on control of macro-robots.

We assume that the mounting location and orientation of the user-interface (handle) is crucial to intuitively move macro-robots hands-on. We designed and prototyped three different handles, which have a cylindrical shape but differ in size and mounting location. We compared them qualitatively with the help of a questionnaire in a user study, in which the participants moved a mock-up endoscope attached to the robot between two trocars using the built-in KUKA hand guidance mode (see Figure 1). We compared the time needed to complete the task, the end position accuracy, and the forces applied to the handle. The qualitative results indicated that a user-interface aligned with the tool (see Figure 2) seemed most intuitive for the participants. However, our quantitative results suggested that the combination of user-interface and controller was not suitable for small and subtle movements, but usable for large motions with low accuracy. In future work, we will employ a user-interface aligned with the tool with an admittance control mode that is currently being developed.

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