Ein Verfahren zur präoperativen Planung roboterunterstützter, minimal invasiver Operationen

A Preoperative Planning Procedure for Robotically Assisted Minimally Invasive Interventions

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Purpose

The use of teleoperated robots in the operating room (OR) for minimally invasive interventions has been investigated closely in the past years both in abdominal and heart surgery.One key aspect necessary for a successful intervention is preoperative planning, done by the surgeon in order to prepare the intervention and to decide about the best access to the surgical site. In case of robotically assisted interventions the results of these decisions must be transfered also to the robotic equipment. Ports and robots must be placed such that no collisions between the robotic arms occur, the robotic system always provides sufficient dexterity, the view at the surgical site is optimal and the patient's trauma becomes minimal. The different criteria which must be met for an optimal port and robot placement can hardly be satisfied using a trial and error approach or just by experience. For that reason the use of optimization algorithms for preoperative planning seems to be necessary to ensure a high quality of interventions in the context of robotically assisted minimally invasive surgery.

Material and Methods

The preoperative planning strategy which utilizes optimization algorithms is depicted in Fig. 1. It was developed for the DLR minimally invasive robotic surgery (MIRS) system which is shown in Fig. 2 together with the DLR laserscanner. The system consists of three light-weight, kinematically redundant, impedance controlled surgical robots (two of them equipped with sensorized and actuated instruments, the third one holding the laparoscope) and a master console. The master consists of a stereo video screen and two PHANToMs as kinesthetic feedback devices.

The DLR planning tool utilizes an integrated approach where the problem of optimal port and robot placement is solved in one step exploiting general measures of manipulability and accuracy.

During the patient specific planning process, the surgeon can preposition the necessary OR equipment and determine the area of interest on the resp. organ as well as potential port locations on the skin of the patient (with automatic determination of the intercostal space). This is done by simply drawing on the respective organs as depicted in Fig. 3.

In order to set up the automatic optimization procedure, optimization parameters have been identified, significant optimization criteria were formulated and a suitable optimization procedure for the problem has been developed.

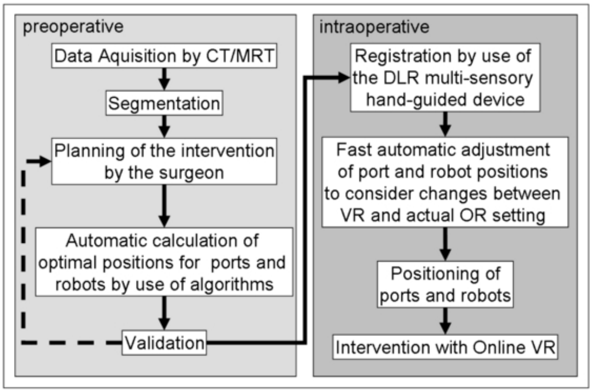
The surgeon can then verify the optimized OR setup in a virtual environment by moving the robots interactively or automatically inside the workspace.

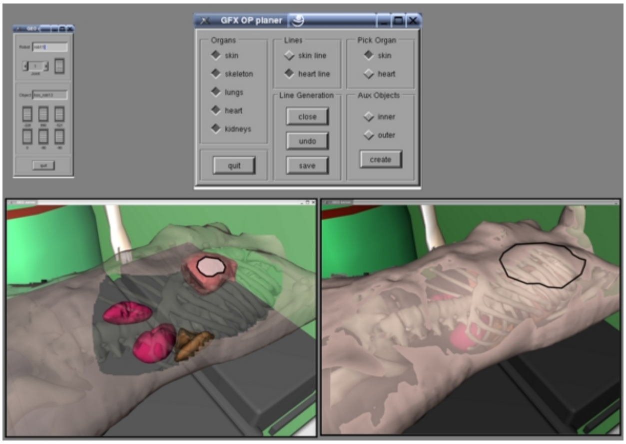
Registration is done using the DLR handheld laserscanner by matching the preoperative with the scanned data. Thus, fiducial markers can be avoided. Furthermore, the laser scanner relies on an infrared tracking system which can also be used to position ports and robots. First trials with a plastic phantom using rigid registrationproove the ease and speed of this method.

Results and Conclusion

First evaluations on a prototypical setup demonstrated the feasability of the chosen methods and suggest that the proposed computer assisted preoperative planning and registration procedures will lead to shorter setup times in minimally invasive robotic surgery.

DLR-Approach to computer-assisted MIRS: Planning





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