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„Controlling robot movements in computer assisted surgery: Path planning and simulation by means of an adaptive operation room-model“

H. Gölte, G. Reinhart
Institute for Machine Tools and Industrial Management, Munich University of Technology, Garching, Germany

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Controlling robot movements in computer assisted surgery: Path planning and simulation by means of an adaptive operation room-model

Dipl.-Ing. H. Götte, Prof. Dr.-Ing. G. Reinhart
Munich University of Technology, Institute for Machine Tools and Industrial Management (iwb), Garching, Germany

Introduction:
During surgery, i.e. insertion of knee implants, bone material has to be removed. In conventional therapy, surgeons use templates to guide a hand-held saw. Therefore accuracy is limited by the surgeon's skills and dexterity. By introducing a robot system, therapy delivery can be simplified while being more accurate. Our robot system uses a saw mounted on a guiding device fixed on the manipulator's hand. During surgery the hand is guided to preoperatively planned cutting planes. Hence the surgeon freely moves the saw to remove bony material, only limited by the guiding device keeping the movement within the cutting plane.

Methods and results:
Since the medical robot system operates in close interaction with the patient and the staff, safety for humans and the surgical setup is a major concern. Careful path planning of collisionfree movements is required, taking into account obstacles, ie. the OR-light, the OR-table, equipment and the staff standing close to the situs. These obstacles change their positions during surgery. To meet the changing environment, their locations are dynamically examined by sensors, i.e. a real time vision system, and updated in a 3D-model of the operation room. Based on this adaptive model, movements are planned, simulated and visualized to the staff before execution.
Furthermore, a concept for guarding the execution of real robot movements is pursued: the undergoing motion will be compared with the planned trajectory by evaluating real time joint data from the robot controller or by tracking the end effector's position with the real time vision system. The resulting final position can be redundantly verified, before surgical steps are performed on the patient with the guided bone saw.
Intraoperative usage starts with patient registration. A common C-arm is used to acquire highly accurate initial patient position data. Permanent rigid patient immobilization is not necessary, because knee movements in between surgical steps are tracked with the real-time vision system.

Conclusion:
This approach combines the robot's high accuracy with the surgeon's expertise. It is expected to provide high overall accuracy, lower complication rates and safe interaction between humans and machine.