The Autopointer: A New Augmented-Reality Device for Transfer of Planning Data into the Operating Room

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Introduction

To transfer preoperatively planned data into the operating room (OR), registration is necessary as well as a method to localize the planned data in the OR. This data may comprise e.g. entry point positions into the human body in case of minimally invasive interventions or cutting trajectories. State of the art methods for localization are e.g.:

- The robot itself is used as a pointing device (exploiting the forward kinematics) to position other devices and the workpiece with respect to each other.
- An optically tracked pointer is used to find positions in the OR, assisted either by a VR representation of the scene where the pointer is visualized, or by simple commands ("move right/left/up/down...").
- The plan is projected with e.g. video or laser projectors.

This work presents a first prototype of the autopointer, a new patent pending device using a handheld optically tracked laser scanner to localize preoperatively planned data in the operating room (OR).

Methods

The beam of a laser is deflected by a deflection unit. Laser and deflection unit are housed in a handheld device which is localized with a tracking system. If e.g. a point P on the patient surface has to be transferred from the preoperative plan into the OR, registration provides the transformation matrix T to obtain the point coordinates P_{OR} in the OR coordinate system (defined usually by the tracking system): $P_{OR}=T*P_{preoperative}$. Then, with the known (and constantly updated) position of the autopointer relative to P_{OR}, the deflection unit can deflect the laser beam such that it automatically points onto P_{OR}.

As deflection unit, a Scanlab ScanCube 7 is used. It is equipped with position-controlled high speed galvo-scanners for two-axis-deflection. The scanner is fast enough to project various data, including complex cutting trajectories and multiple symbols at the same time. The autopointer is optically tracked using the ART navigation system.

Results

The system is portable and thus only takes up valuable OR space while needed. It can be easily interfaced with any tracking system used in the OR that is able to measure the 6-DoF pose of an object. As opposed to video projectors, laser light is visible even in the presence of strong lighting as used in the OR. The first mock-up of the system shows accuracy better than 1 mm in a distance of 0.5 m. Optimization of the tracking target and use of more accurate tracking systems will further increase the accuracy. The control loop currently is fast enough to compensate for motions with a velocity below 5 cm/s. Various information such as arrows, crosses, words, or trajectories can be projected directly onto the patient.

Conclusion

The first prototype of the autopointer shows very promising results. The implemented control loop allows for moderate motion of the autopointer while it keeps projecting the desired data in the right positions with accuracy below 1 mm. Since the major source of inaccuracy is the optical tracking system, advances in the tracking system accuracy will directly improve the autopointer accuracy.