

Design of a planning tool for augmented reality supported placement and tracking for a teleoperator in heart surgery.

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Introduction

The diploma thesis is part of heARt (heart surgery enhanced by augmented reality techniques) and is one of two projects in the PORT subproject. The PORT project is a planning, placement and tracking environment for the arms of any teleoperator in minimal invasive heart surgery. This new technology aims to reduce the duration of the operation and the amount of injury to the patient's body.

Current Situation

Currently the setup of the surgery uses the da Vinci teleoperator from Intuitive [2]. At present, the placement of the three arms of the teleoperator (i.e. one camera arm and two manipulator arms) into the patient's body is done without any knowledge of the actual location in respect to the patient's interior. The planning of port placement is done by the surgeon using the CT (computer tomography) model. Using his memory and imagination form the planning process the surgeon places the arms at the desired position and orientation. At present, the use of the teleoperator supports the operation, but does not support the precise placement of the ports. Therefore, a system has to be designed to plan and guide the placement process. Furthermore, during the whole operation the surgeon has no precise knowledge of the arms in respect to the patient's interior.

Visionary Scenario

In the desired scenario the surgeon uses an interactive planning tool. Initially, the planning tool proposes a placement of the three arms in the CT model based on a selected region of interest. This initial fit can be manually adjusted by the surgeon.

The placement process in the surgery room is supported by augmented reality techniques, which enable the projection of the placement location and orientation through a real time video stream of the patient's thorax, displayed on an external monitor. Throughout the operation the CT model of the patient's thorax will be augmented by the teleoperator arms and screened on an external monitor in the surgery room (see Joerg's abstract for details).

User Interface

The UI (user interface) provides an intuitive way to navigate interactively within the application as well as display the surgeon's requested views of the patient's thorax. The surgeon will be able to switch between several views like sagittal, frontal, transversal plane, and a 3D view of the scene. The UI will be realized in AmiraDev [1], which allows the user to add or create new components for visualizing and processing data based on existing modules.

Iterative Steps

Initially, the surgeon will mark his/her region of interest, i.e. the area, which he/she will perform the

operation in. Therefore, the teleoperator arms are supposed to be inserted only one time. Once the region is confirmed, the application computes the best fit for the teleoperator ports (see later). If the surgeon is not satisfied by the supposed fit, he/she can adjust it to his/her needs.

Computing Best Fit

Following important aspects limit the decision process of finding the best fit: the distance to organs, the accessibility of the whole region of interest, and the available/allowed poses of the teleoperator arms, limited by the shoulder, rip, and ilium (hip) bones. For the computations all of these constraints need to be fulfilled. An optimal solution will be found solving the estimation problem such as LSE (least square estimation). The best solution will include a maximal distance to organs, and a wide margin of the poses of the teleoperator arms as well as the region of interest. If the surgeon adjusts the computed fit manually, the constraints will be checked as well. In case of a violation a warning will appear/occur.

References

- [1] Amira developer edition v3.0. http://www.amiravis.com/amira_dev.html.
- [2] Intuitive surgical da vinci robotic surgical system provides hospitals and patients the benefits of minimally invasive surgery. <http://www.intuitive.com>.

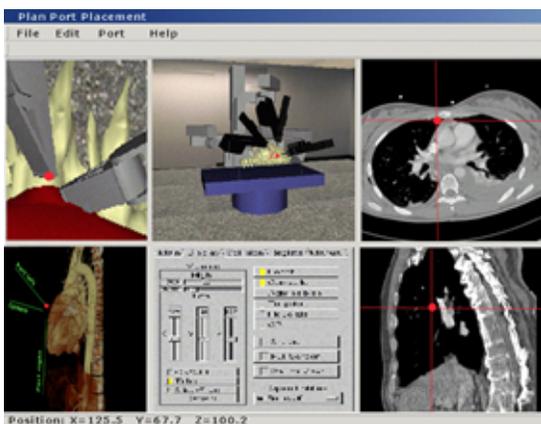


Figure 1: Mockup for a user interface for the port placement planning tool.