

A Framework for Visuo-Haptic Simulation of Puncture Interventions

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A framework for virtual reality based training of puncture interventions is presented. The system uses a haptic device with six degrees of freedom (6DOF) to enable realistic force sensations during needle insertions into virtual patients. A custom hardware setup improves the immersion into the virtual reality scene. A haptic volume rendering technique is used to compute the haptic needle forces combining information from labeled structures as well as original patient 3D-CT-data. To enable realistic needle behavior during a virtual angulation of the needle a bending algorithm has been developed. A manifold of different synchronized 3D and 2D visualization techniques give new insights into the anatomy of the punctured region. The 3D effect is enhanced by stereoscopic visualization. X-ray simulation enables the training of image guided needle insertions. An evaluation component rates the quality of virtual punctures to give the user feedback and improvement suggestions. Currently the system supports the training of three different puncture tasks: Lumbar puncture, Ascites puncture and percutaneous transhepatic cholangio drainage (PTCD). The lumbar puncture and the ascites puncture have been evaluated in a pilot user study with 55 participants. The questionnaire based study indicates a high user acceptance.

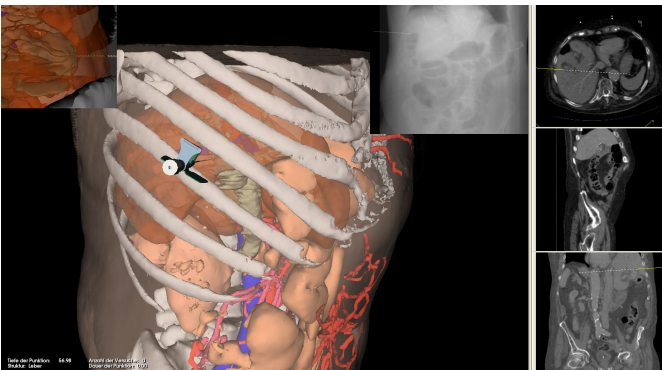


Figure 1: Graphical user interface for PTCD: The 3D view shows the different anatomical structures and the virtual needle. The side view (upper left corner) shows the structures near the current needle position. Slice viewers (right border) show the original CT data at the needle's position. In an x-ray simulation the needle is indicated by a white line.