Augmented Reality in Medicine – A view to the patient's inside

Dr.-Ing. Michael Schnaider, Bernd Schwald

German Abstract

Minimal-invasive Chirurgie hat in den vergangenen Jahren zunehmend an Bedeutung gewonnen. Den unübersehbaren Vorteilen für den Patienten steht allerdings die eingeschränkte Sicht des Chirurgen auf die Operationsregion entgegen. Den Chirurgen in die Lage zu versetzen, die präoperativ gewonnenen medizinischen Bildmodalitäten auch während der Operation effektiv zu nutzen, ist das Ziel des Projektes Medarpa. Die Nutzung von Technologien der Erweiterten Realität (Augmented Reality) macht es möglich, dem Chirurgen während der Operation ein virtuelles Fenster in das Innere des Patienten zu öffnen. Durch die visuelle Überlagerung des Patienten mit geeignet aufbereiteten 3D-Volumendaten sowie weiteren Einblendungen wie Instrumentenposition oder zuvor segmentierte Behandlungsregionen (z. B. Tumorregionen) nimmt der Chirurg gleichzeitig den Patienten und die unterstützende Information wahr. Typische Zusatzinformationen sind unter anderem Navigationshilfen für das Setzen von Bestrahlungssonden oder für die Biopsie. Das Medarpa-System besitzt dazu statt der mit ergonomischen Einschränkungen verbundenen Head Mounted Displays ein speziell entwickeltes, frei bewegliches AR-Fenster (transparentes Display), mit dessen Hilfe die Überlagerung passgenau auf den Patienten realisiert wird. Die medizinischen Bilddaten sowie die Lage des genutzten Operationsinstruments werden intraoperativ auf dem Display angezeigt und unterstützen so den Chirurgen bei der Navigation. Das Medarpa-System wird derzeit an drei verschiedenen Kliniken in unterschiedlichen medizinischen Anwendungsfeldern evaluiert.

Motivation

Minimal invasive surgery has become increasingly recognized over the past fifteen years, and, compared to invasive surgery, it offers the patient a number of advantages. The avoidance of large incisions typically results in a reduced loss of blood, significantly less postoperative pain, faster recovery, better cosmetic results, and alike.

However, minimal invasive surgery confronts the physician with a limited view to the region of intervention. Though diagnosis and treatment planning are based on various forms of medical image modalities like MRT, CT etc., these modalities are available only as distinct information sources other than the patient himself. The central problem remaining is the lack of spatial reference between the pre-operatively acquired medical image data and the patient during the intervention. This correlation between the treatment region and the pre-operatively acquired medical data is an unsupported process with considerable cognitive workload for the physician.

The Medarpa project, funded by the German Ministry of Education and Research (BMBF), addresses this limitation by introducing a navigation support system for minimal invasive surgery. By utilizing novel technologies such as Augmented Reality (AR), the Medarpa system virtually offers a window into the patient's inside. It provides both the pre-operatively acquired medical data for the individual case of the patient and the instrumentation used at the time of intervention and directly in the place of the treatment. Therewith AR allows enriching the visual perception of a physician by superimposing helpful information into his field of view, i. e. fusing the visual perception of the surrounding real environment (the real patient) with a visual perception of a supplementary task-supporting virtual environment (e. g. medical image data and visualization of medical instruments).

Unlike applications utilizing Virtual Reality (VR) technology for supportive purposes, AR applications still retain the physician's natural perception of the region of intervention. However, many existing AR solutions use Head Mounted Displays (HMDs) for the fusion of the real and the virtual scene, resulting in a cumbersome technical setup to be worn and still limiting the field of view and reducing mobility due to the wired equipment. Therefore, most physicians tend not to accept such solutions for their routine work. The implementation of the Medarpa system took these and other ergonomic constraints into account. Consequently, the HMD has been substituted with a novel transparent display device, the so-called AR window.

Figure 1: The Medarpa AR Window

The Medarpa System

In cooperation with an interdisciplinary team of partners with distinct medical and technological backgrounds, ZGDV and Fraunhofer IGD have designed the Medarpa system for everyday clinical routine, easy handling in sterile environments, optimal ergonomics, and touch-free tracking. The prototype of the Medarpa system has been realized as a compact and movable all-in-one system allowing a maximum of

Figure 2:
The Medarpa system presented at MEDICA 2003

Figure 3: Cadaver test at the Johann Wolfgang Goethe University hospital

flexibility in the operating room. The important interface device is the before mentioned AR window, acting as a window into the patient's inside. This AR window is mounted on a swivel arm and it is freely moveable to virtually cover arbitrary parts of a patient as needed.

To maintain correct superimposition of pre-operatively acquired medical image modalities with respect to the physician's perspective, the positions of the AR window and the physician's head with respect to the patient are determined using the optical tracking system EOS, developed by ZGDV. Instrument tracking in contrast is determined by off-the-shelf electromagnetic tracking to avoid occlusion problems below the AR window.

A specialized visualization module features real-time rendering of various kinds of volumetric 3d medical image data (CT, MRI, fused image modalities, etc.). At the same time, polygonal data such as visual representations of the medical instruments or planning data can also be rendered. This hybrid rendering approach was the foundation to realize precise navigation support when, for example, penetrating a biopsy needle, or when implanting irradiation probes into a malignant tumor.

The Medical Test Beds

Designed as a multi-purpose system, the Medarpa system can support different medical applications in different settings. Currently, the system is being evaluated at the three partner hospitals located in Frankfurt of the Main, Offenbach and Nuremberg, and it is applied to three different medical applications.

Surgical Scenario

This robot supported heart surgery scenario covers the support of the so-called closed chest surgery using the DaVinci robot system at the University hospital Frankfort of the Main. Instead of large incisions of the chest, up to four small ports need to be penetrated into the chest area. The Medarpa technology intends to help the surgeon to determine the optimal port placements by visualizing the reachable region.

Radiation Oncology Scenario

The interstitial brachytherapy at the Hospital Offenbach offers the possibility to irradiate a malignant tumor inside the body. For the implantation of irradiation probes, hollow needles have to be placed to reach the interior of the tumor. During the implantation phase, the physician so far verifies the needle insertions by repeated CT scans. With the Medarpa system, the needle insertion could take place under real time control, because the physician observes the location of the currently implanted needle and the tumor at the same time.

Bronchoscopy Scenario

The treatment of tumors performed by the Hospital Nuremberg in the chest and lung area requires precise guidance to the affected area to take transbronchial biopsies. This scenario is quite similar to the one described above. A projection of the biopsy needle with a virtual reproduction of its hidden parts is shown on the AR window as well as the interior of the area of intervention to guide the puncture.

Points of contact

Dr.-Ing. Michael Schnaider
Bernd Schwald
ZGDV Darmstadt e.V., Germany
Email:
michael.schnaider@zgdv.de
bernd.schwald@zgdv.de