

# ARGUS: HARNESSING INTRAOPERATIVE NAVIGATION FOR AUGMENTED REALITY

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**Abstract**— *Augmented reality techniques can be used to provide a display of additional information to the surgeon during an intervention. Such additional graphical representations can include organs, risk structures or operation plan elements like planned points or trajectories.*

*We describe a novel approach to the design of an augmented reality application for surgery. While most experimental systems for augmented reality in medicine rely on specific hardware and software components, our design only uses existing, commercially available medical equipment. We show that all information necessary for generating an augmented image can be obtained from a device for image guided surgery (IGS). Thus the transition from an experimental state into the clinical practice is facilitated.*

**Keywords**— *Augmented Reality, Image Guided Surgery, Minimally-invasive Surgery*

## Introduction

Augmented reality (AR) denotes a set of techniques that aim at combining real images with virtual graphical elements. The prerequisite for a useful reality augmentation is the correct spatial positioning and orientation of the graphical objects. Two types of augmented reality systems can be distinguished: While video see-through AR systems continually acquire a digital video stream, optical see-through reality is based on the use of specialized translucent display devices [1].

The support of surgical interventions has long been in the focus of augmented reality research [2]. While many experimental AR systems have reached a very good quality in terms of tracking accuracy, image generation latency and graphical quality, they often rely on specific hardware. This can be problematic when used in an actual medical scenario. Electromagnetic tracking systems are disturbed by metallic objects like surgical instruments, and they can interfere with medical equipment. Dedicated optical tracking cameras, as well as other devices from VR or engineering applications, can require tedious setup procedures and take up a lot of space. Head mounted displays or stereo shutter glasses can deteriorate the user's perception of the surroundings, and they can limit the range of motion. Moreover, practical problems like certification for use in a medical setting or working in a sterile environment usually have not been solved for such specialized devices.

We propose a novel augmented reality system for medicine, which is based solely on existing image guided surgery equipment.

## Methods

We use a *VectorVision* image guided surgery device as basis for our AR application. The device is produced by the BrainLAB company and is commercially available (see Figure 1).



Figure 1: VectorVision IGS device (diagram)

In order to exchange data with the intraoperative navigation system, we employ the so-called *VectorVision Link* library. Using this data interface, many different kinds of information including the position and orientation of tracked surgical tools can be exchanged with the IGS system [3]. In order to harness these capabilities, we attach an infrared marker clamp to the webcam used in the augmented reality system. This is shown in Figure 2.



Figure 2: Webcam with attached infrared marker spheres

Since the image guided surgery system only registers the infrared marker clamp relative to a hypothetical surgical tool, it is necessary to compute a transformation to the camera coordinate system. We have devised a simple one-step calibration procedure to do this [4]. The user is only required to measure the spatial position of the corners of a

special marker pattern taken from the ARToolKit library [5]. This can be easily performed using a pre-calibrated pointer tool provided by the IGS system (refer to Figure 3).



Figure 3: Definition of a marker corner by the user

When the user triggers the calibration, the transformation matrix is computed. From that point of time, the webcam is tracked exclusively by the intraoperative navigation system, providing a large trackable area and a very good accuracy.

In addition to tracking the webcam, the IGS device also provides support for several other tasks necessary for generating augmented images. Patient registration is performed by the VectorVision system using one of several registration modes. These include the matching of anatomical landmarks or a 3-d point cloud generated using a handheld laser device. The image guided surgery system has a built-in pipeline for the import and processing of medical datasets in the standard DICOM format. Moreover, operation plan data comprising planned points, trajectories and 3-d objects can be exchanged with the augmented reality application.

## Results

We have implemented a novel augmented reality system, *ARGUS*, that is based on image guided surgery. During the operation of the system, a digital video stream is acquired from a webcam in real-time, and virtual graphical objects are drawn over it.

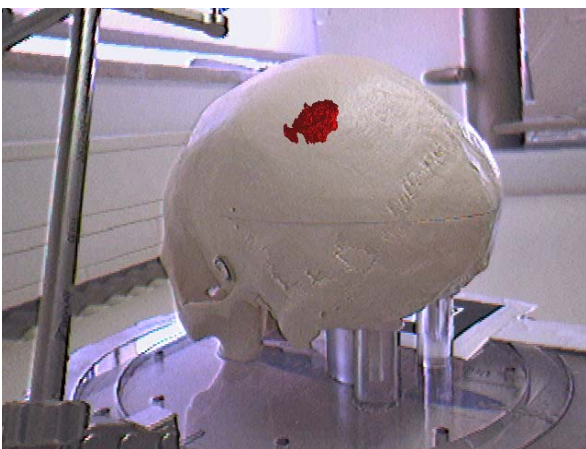


Figure 4: Virtual tumor model drawn over camera image

An example of a reality augmentation is shown in Figure 4. Here, a virtual tumor model, which was manually posi-

tioned, is overlaid over the camera image. A plastic skull and its MR dataset were used to obtain a useful patient registration for the image guided surgery system.

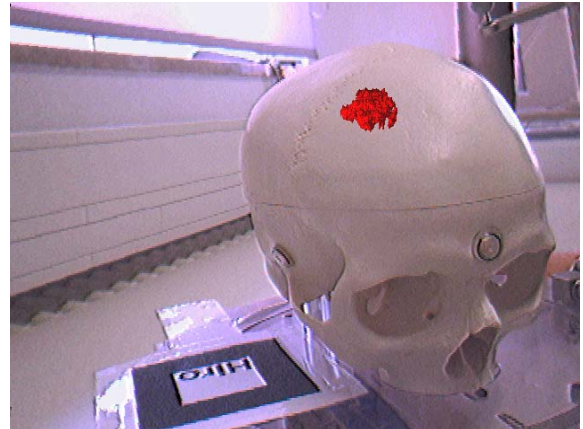


Figure 5: Correct spatial alignment of virtual object

Figure 5 illustrates the correct spatial positioning and orientation of the graphical model. This is made possible by the combination of patient registration information, the tracked tools information from the IGS device, and our calibration step.

## Discussion

We have presented a new approach to building a medical AR system. Since we only use existing, proven and certified medical equipment, we expect that the transition from an experimental state into the clinical practice is facilitated.

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