Video Registration using Fiducials for Surgical Enhanced Reality

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Abstract

Currently there is a need for a frameless guidance system to aid neurosurgeons in planning the exact location of a craniotomy and to define the margins of an exposed tumor. We have developed a new enhanced reality technique for planning and guiding neurosurgical procedures by merging live video images with three dimensional computer reconstructions of the skin and extra-or intracranial structures of patients derived from diagnostic MRI's. In some applications, the use of fiducials facilitates employment of the method.

1 Material and Methods

The process involves producing three dimensional renderings of MR images which can be displayed and manipulated in real time on computer workstations [1] [2]. A video camera is trained on the patient from the planned intra-operative perspective which can be selected by studying the 3D reconstructions. The images from the video camera and the 3D computer reconstruction are combined using a video mixer, thus permitting the two images to be superimposed. The rendering parameters of the 3D reconstruction are adjusted interactively, using a rendering of the skin for reference, until the two images are identical in terms of scale, position and rotation. This precise positioning is accomplished by aligning various surface landmarks, i.e., ear, nose, eyes, surface contours of the head or MR-visible fiducial markers attached to the skin. Once the video and 3D computer images of the patient's scalp surface have been aligned, the computer image of the skin is removed leaving the 3D image of the underlying cranial or spinal contents superimposed on the video image of the patient's skin. The surgeon then outlines the borders of the tumor and important cortical sulci or spinal anatomy on the patient's skin using indelible markers.

Alignment may be difficult if few surface landmarks are visible from the planned surgical perspective. This may occur, for example, when the surgical site is in the back of the head, or in the spine. In some cases, we have used the following method to facilitate alignment. Several locations are marked with tattoos on the skin of the patient in the vicinity of the planned surgical opening. Vitamin E capsules are attached to the skin, centered on the marks. A pre-surgical MR scan is taken, and the capsules are removed. During the surgical planning session, when the models of anatomy are prepared from segmented MR data, the capsules are also segmented and modeled. At the time of the surgery, the capsules are returned to their positions over the tattooed marks, and they are used as additional landmarks for the purpose of video registration.

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2 Results

This new technique has been applied to two patients, one with a brain tumor in the back of the head, and one with a spinal tumor. In both cases, the use of fiducials made video alignment significantly easier to perform.

Figure 1 shows a 3D reconstruction of the skin of a brain tumor patient with 3 modeled capsules visible. In the rendering, the skin has been partially cut away to make the tumor visible. Figure 2 show the patient in the OR with the three actual capsules visible.

3 Discussion

The procedure can be performed without any major interruption of standard procedures, making the procedure practical for use in any operating room. The preoperative markings permit the surgeon to plan adequate access and define the surgical target with minimal exposure of adjacent structures. Using this technique intraoperatively permits definition of tumor margins and localization of subcortical tumors.

References

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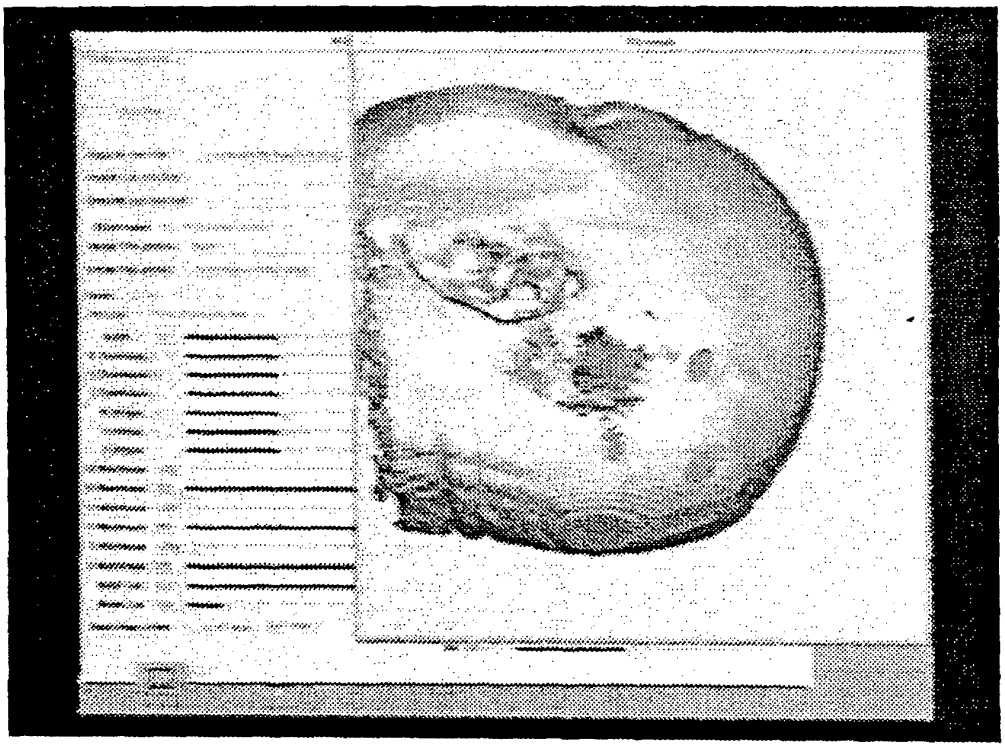

Figure 1: 3D Rendering of Anatomy with Capsules

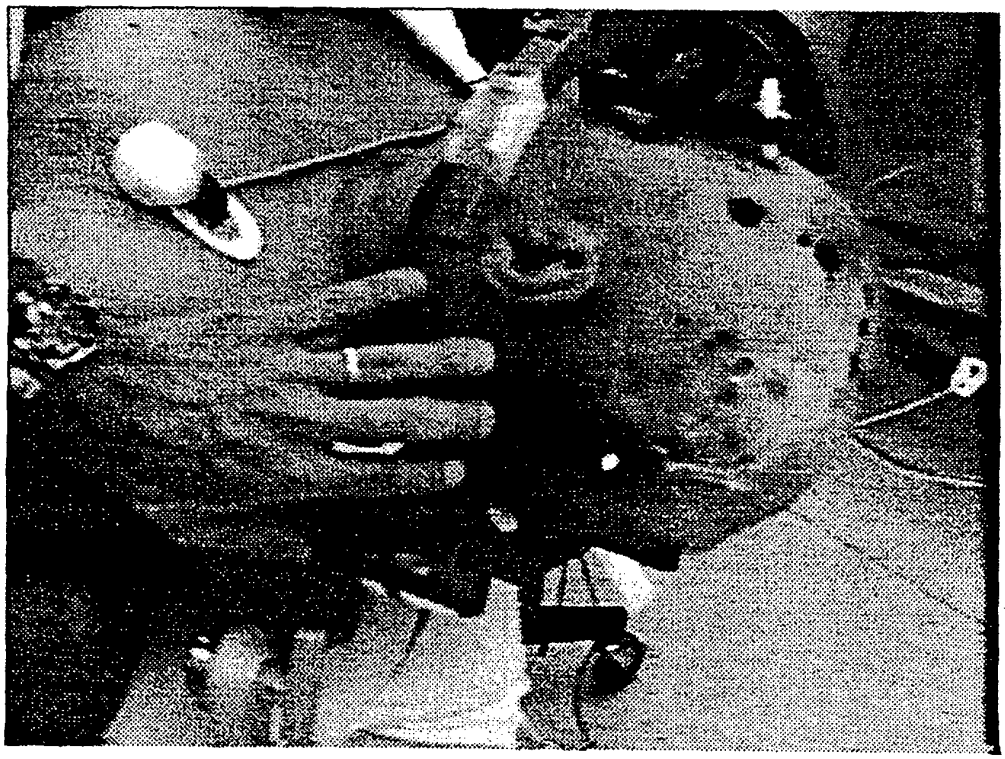

Figure 2: Video Image of Patient with Capsules