Augmented Visualization of the Patient's Organs through a Sliding Window

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Abstract

Augmented Reality technology has the potential to bring the visual advantages of open surgery back to minimally invasive surgery increasing the physician's visual knowledge with information gathered from patients' medical images. In this paper is presented a medical Augmented Reality application which is able to guide the surgeon in the operating phase through the visualization of anatomical structures of interest with the aim to prevent erroneous disruption of some organs during surgical procedures. Since the simple augmentation of the real scene cannot provide information on the scene depth, the visualization of a sliding window is provided in order to allow the occlusion of part of the organs and to obtain a more realistic impression that the virtual organs are situated inside the patient's body.

1 Introduction

Image-based techniques used in order to reconstruct 3D models of organs may be able to provide medical information which is difficult to detect on CT slices. In particular, imaging methods such as CT, MRI, and ultrasound scan can make the safe guidance of instruments through the body possible without direct sight by the physician. The idea of Minimally Invasive Surgery (MIS) is to reduce the trauma for the patient by minimizing the incisions and the tissue retraction. Since the incisions are kept as small as possible, the surgeon does not have direct vision and is thus guided by camera images. Augmented Reality (AR) technology has the potential to bring the direct visualization advantage of open surgery back to minimally invasive surgery and can increase the physician's view of his surroundings with information gathered from a patient's medical images[1]. In medicine Augmented Reality technology makes it possible to overlay virtual medical images onto the patient, allowing surgeons to have a sort of "X-Ray" vision of the body and providing a view of the patient's anatomy. In this paper is presented an Augmented Reality system that can guide the surgeon in the operating phase through the visualization of anatomical structures of interest. It is possible to visualize the internal organs of the patient by means of 3D models of the anatomy built from the medical images of the patient. Since the simple augmentation of the real scene cannot provide information on the depth of the scene, the visualization of a sliding window is provided in order to allow the occlusion of part of the organs and to obtain a more realistic impression that the virtual organs are inside the patient's body. In the developed application the Polaris Vicra of the NDI Inc. has been used as optical tracking system and Ogre3D as graphics rendering engine.

2 Sliding window and scene occlusion

To allow a proper integration of the virtual scene (consisting of a 3D model of the organs of a patient obtained by its CT images) in the real scene an appropriate chain of rigid transformations has been implemented. The system designed is monitor-based; the augmented scene appears on a monitor and uses a point-based (or fiducial-based) method to register or to identify some points on the virtual scene and to overlay these on the corresponding points on the real ones. The simple augmentation of the real scene cannot provide information on the

depth of the scene, because, although the organs are properly positioned within the dummy, they appear to be positioned on its surface (Figure 1).

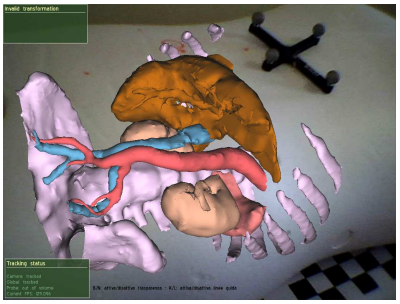

Figure 1: The augmented scene without depth perception

Depth perception is still a major problem in many Augmented Reality systems when virtual objects have to be superimposed on real images. Although virtual objects have been correctly positioned in the scene, visually they are overlapped with all real objects, creating a situation which is not sufficiently realistic. In particular, this effect is not acceptable for surgical AR applications and it is necessary, in addition to a proper positioning of the organs in the virtual scene, to ensure correct visualization and to get an intuitive view on the anatomy of the patient. The solution proposed is based on the "dark matter" method and consists in a virtual window overlaid onto the real skin of the patient, in order to create the feeling of getting a view on the inside of the patient [2]. The window enhances perceptive information permitting a partial view of the 3D model of the patient's organs and giving the real impression that the virtual organs are placed inside the abdominal area and not on the body surface. Only through this virtual window can the internal organs be seen. A 3D model of the external surface of the body has been built in order to occlude part of the organ's model; this model should be rendered only in the z-buffer (or depth-buffer), but not in the color-buffer, while virtual organs are rendered in the classical way. In addition, the surgeon can slide the visualization window onto the surface of the patient's body and to locate it in a precise position which provides a view of the organs of interest. The sliding window that permits the visualization of a part of the organs is shown in Figure 2.

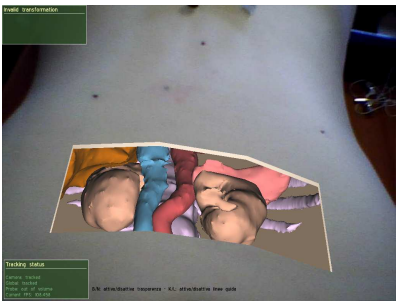

Figure 2: Sliding virtual window

3 Conclusion and future work

We present an AR medical application based on fiducial points allows obtaining a correct positioning of the virtual organs built from CT images. Furthermore, in order to provide the visual impression that the virtual organs are properly positioned inside the body and not on its surface, a partial view of these is provided using a virtual window sliding on the patient's body surface. The obtained result provides a realistic visualization and a correct impression of depth. The development of a real-time tracking of surgical instrument during the real procedure and the measurement of the distance information of the instrument from a specific organ is in progress. This improvement will provide the surgeon with important help to further enhance performance during the real surgical procedure. In addition the development of an algorithm to obtain an automatic registration of the fiducial between the real and virtual scene is also in progress.

References

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