

iRay: Mobile AR Using Structure Sensor

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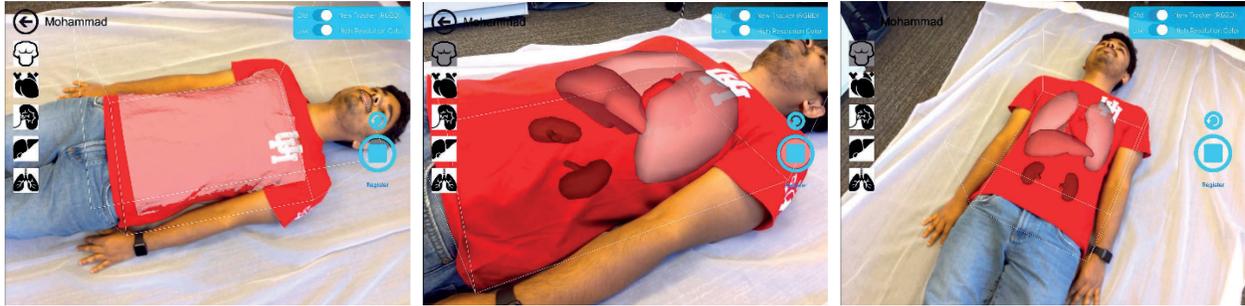


Figure 1: Overview of the iRay system.

ABSTRACT

Using depth information has become more popular in recent years, as it adds a new dimension to 2D camera views. We have developed a novel mobile application called iRay, which uses depth information to achieve highly accurate markerless registration on a mobile device for medical use. We use a Structure Sensor to capture depth information that is portable to iPad. Its SDK also provides SLAM data to track pose. ICP is applied to achieve highly accurate registration between the 3D surface of a human torso and a pre-scanned torso model. The experiments demonstrate our results under motion blur, partial occlusion, and small movements. This application has the potential to be used for medical education and intervention.

Keywords: Medical AR, Markerless Registration, Mobile AR, ICP, Structure Sensor.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – Artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and Presentation]: User Interfaces – Interaction styles; I.3.6 [Computer Graphics]: Methodology and Techniques – Interaction techniques; J.3 [Life and Medical Sciences]

1 INTRODUCTION

Medical Augmented Reality (MAR) is one of the most important application areas of AR and VR. It provides intuitive human computer interface to help physicians make better decisions in diagnosis or surgery [1]. Many applications have been developed for both medical training [2] and intervention [3]. For example, applications have been developed that combine data such as 3D CT scans or X-ray images into a direct view of the patient. In different applications, tracking and interactions were achieved with external

optical tracking systems [4], depth devices (Kinect) [5] or brain-computer interface (BCI) devices with a gaze tracker [6].

Among them, the “miracle” system [5, 7] is similar to our work, as both systems use depth information and show inner organs. However, “miracle” uses Kinect mainly to detect skeleton and hand gestures. Its registration is not accurate because the application is currently used for education and exhibition purposes. Our work, in contrast, applies ICP to achieve accurate registration. Also, our work is established on a mobile device such as iPad instead of a PC.

There are also some other research groups and companies that have built similar-looking mobile Apps, such as SurgeryPad [8], Virtuali-Tee [9], and others. They all use fiducial markers such as colored dots or a patterned T-shirt for tracking, which has limited registration accuracy.

2 IMPLEMENTATION

The only two hardware devices used for this work are a Structure Sensor and an Apple iPad.

We used the data from a Structure Sensor [10] as the depth and SLAM information provider. Its SDK can capture and rebuild the actual shape of the scanning area by depth and device pose. It uses SLAM to detect camera pose in a world coordinate system for 3D reconstruction. Thus, a developer can obtain both the 3D cloud points of the scanned surface and also active camera viewpoint changes.

We use ICP to register these 3D cloud points with a pre-scanned model, which is similar surface data previously scanned in a different situation by Structure Sensor. We will use 3D CT scan data instead in the future.

The camera viewpoint changes can be used directly with some eventual drift errors. Therefore, to maintain real-time constraints, we use ICP only when it is needed to compensate for these errors and not in every registration loop.

An Apple iPad is used as a mobile display, color camera input, and HCI device. Structure SDK supports Xcode programming very well, but it is not open source. Note that in this work we are not using Structure’s very new Bridge Engine, which appears to be very powerful for MR/AR design.

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Figure 2: Registration results.

3 RESULTS

The UI design and registration results are demonstrated in Figure 1. The current UI is very simple. There are some organ logos such as torso, heart, kidney, liver and lungs on the left side of screen. The user can select them to hide the visible organs or not. The torso is the pre-scanned model of the subject's torso surface, so the user can check the registration accuracy intuitively when the torso is visible.

In Figure 2, one can observe the augmented results from several different viewpoints. There is also some motion blur when the screen shot is taken. Sometimes the patient's hand is covering the torso, but the registration still works, which shows the robustness of the system.

4 CONCLUSION

In this short paper, we presented a mobile AR application using model-based registration aided by depth information from a Structure Sensor. The system works on an iPad with high accuracy in real time, which demonstrates the power of the new device.

More tests are needed for accuracy measurement and user feedback before it can be used in any medical environment. In addition, our system, in its current version, cannot handle movement by the patient. This is important, especially in diagnosis, but it may not be a problem during surgery when the patient is anesthetized.

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