Kinect for Interactive AR Anatomy Learning

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ABSTRACT

Education of anatomy is a challenging but crucial element in educating medical professionals, but also for general education of pupils. Our research group has previously developed a prototype of an Augmented Reality (AR) magic mirror which allows intuitive visualization of realistic anatomical information on the user. However, the current overlay is imprecise as the magic mirror depends on the skeleton output from Kinect. These imprecisions affect the quality of education and learning. Hence, together with clinicians we have defined bone landmarks which users can touch easily on their body while standing in front of the sensor. We demonstrate that these landmarks allow the proper deformation of medical data within the magic mirror and onto the human body, resulting in a more precise augmentation.

Keywords: Augmented Reality, Kinect, Anatomy Learning.

Index Terms: H.5.1 [Multimedia Information Systems]: artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and presentation]: Interaction styles—evaluation/methodology; I.2.1. [Applications and Expert Systems] —medicine and science

1. INTRODUCTION

The General Medical Council recently proposed standards for effective teaching and learning of medical students [1]. They stated that: *"...medical schools should take advantage of new technologies…. to deliver teaching."* By combining computer models of anatomical structures with custom software we can present students with new ways of interacting with anatomy that could not be achieved during cadaveric dissections or in static images and diagrams [2]. AR systems have the advantage that information can be embedded and/or superimposed upon reality. This allows for a more close-to-reality presentation of medical knowledge and offers opportunities for new and interactive learning context. The user can spatially relate virtual objects to the reality. However, developing AR systems is challenging. The integration of real and virtual objects requires accurate calibration, advanced visualization and user interfaces [3-5].

The goal of this paper is to propose a more precise user-specific learning environment. Together with orthopedic surgeons we have defined anatomical bone landmarks which users can touch easily on their body while standing in front of any sensor. These landmark positions allow the deformation and interpolation

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of the medical data correctly within the magic mirror and onto the human body, resulting in a more precise augmentation. A user study involving surgeons and anatomy experts confirm our hypothesis.
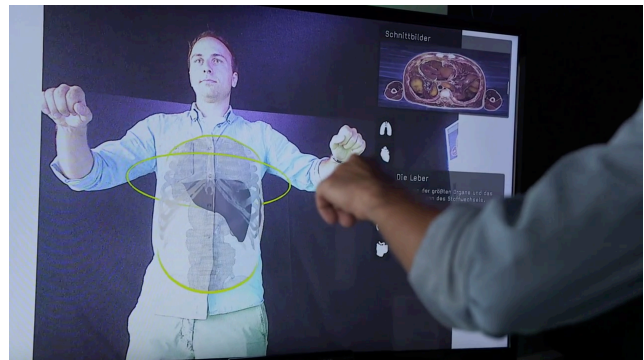

Figure 1: The AR Magic Mirror technology from our team.

2. CURRENT AR MAGIC MIRROR SYSTEM

Mirracle is our AR magic mirror for medical education. It creates an illusion that the user is standing in front of a mirror, which augments virtual anatomy information to the user's image [6-8]. Mirracle uses the Visible Korean Human (VKH) and Visible Human Project (VHP) dataset, which consist of CT/MRI volume and full-color photographic slice images, and renders 3D anatomy organs using ANATOMIUM model. The user controls mirracle through hand gesture and speech command. It can superimpose an in situ visualization of bones from CT volume and 3D organs from ANATOMIUM on the user's body. It also shows the selected slice image from CT, MRI or photographic volume corresponding to the relative position of the user's left-hand and body (Figure 1).

In our system, we take the torso as a rigid entity. In the existing version, we directly use the Kinect skeleton information to compute the scale factors and transformation matrix between VKH volume and user-specific torso. However, Kinect sensor offers an imprecise skeleton pose from depth image. This limits the precision of our magic mirror offering users false anatomical positions overlaid onto their body, resulting in a poor medical learning environment. The same inaccuracies would exist if we had alternatively considered projectors to display human anatomy directly on a user's body [9].

3. INTERACTIVE METHOD

We believe to have proposed a first technique in improving Kinect accuracy, which uses the interaction of users with their own anatomy within an AR setting. The use of intuitive interactions

such as finding the targeted anatomy within the AR framework is a new approach in improving accuracy of AR system.
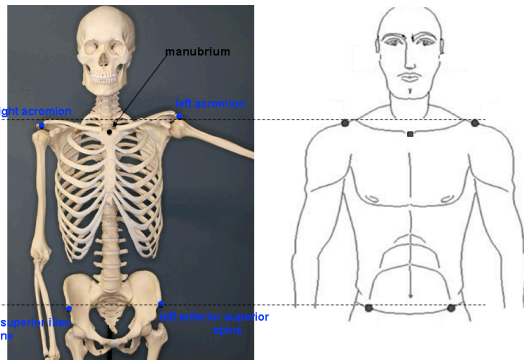

Figure 2: Selected anatomical points for Kinect skeleton improvement and subsequent CT deformation, interpolation, and augmentation.

Together with orthopedic surgeons, we have defined five bone landmarks that can easily be touched on the human body. These are: *left and right acromion, left and right anterior superior iliac spine,* and the *manubrium* (Figure 2). Subsequently, we display a virtual mark around the 5 bone landmarks, and the user modifies it according to their body and confirms by clicking a virtual button or via voice command to input user-special anatomical information.

In the new platform which integrates user-specific anatomical landmark selection, we take the torso joint from Kinect-skeleton as the anchor point. Translations from torso joint in Kinect-skeleton to user-specific bone marks are computed. The shoulder/hip skeleton joints are linearly modified according to these translations. In addition, we have the accurate position of the five selected bone marks in the CT volume. A linear interpolation was executed to estimate torso point in the CT volume to complete the improved overlay. Then the scale factors and transformation matrix were computed to render the anatomical image onto the user's body.

4. EVALUATION

Participants: In total seven participants were included in our study (2 orthopedic surgeons and 5 last-year medical students with more than five semesters of anatomy education).

Evaluation 1: To assess the precision of our method we asked them to interact with (i) the existing AR magic mirror platform and (ii) the new platform which integrates user-specific anatomical landmark selection. For each platform, participants were asked to provide a numerical offset in cm, if any, on how far specific bone landmarks or organs were with respect to their own body. We provide a ruler when the user thinks it is difficult to estimate the offset. The evaluation between the 2 systems is the same except for the user-specific anatomical landmark selection. Every user has 5 minutes to get familiar with this system. The anatomical targets during evaluation were defined as: the anterior superior iliac spine, manubrium, heart and liver.

Evaluation 2: Participants were then asked to compare the existing AR magic mirror platform to the new one by responding to the following question [10]: *Is the new version more precise than the old AR magic mirror, and would it have stronger impact for medical education learning?*

Results from both evaluations show the impact of interactively improving the Kinect skeleton to increase precision for a better visualization of anatomy. The offsets of specific anatomical landmarks decreased significantly and the average was about 1cm. For the last question, there was a unanimous response that the new method, which adjusts the Kinect skeleton, is more accurate than the existing AR magic mirror version.

5. CONCLUSION AND DISCUSSION

This paper presents a general method to interactively improve and correct the Kinect skeleton for anatomy education purposes. Our method suggests the AR interaction of user and his anatomy to correct parameters of the system. This novel idea and approach could result in new methods for all magic mirrors.

One appealing feature of the system is that with the Kinect we are using inexpensive standard hardware. In the future such a system could be made available to students, or patients who have to do rehabilitation exercises at home. A thorough validation of our method, via medical experts, demonstrated improved precision of anatomical landmarks and opens the avenue to future improvements in medical education. Together with the community, we hope to initiate such discussions in integrating exciting user-interaction and gaming concepts within our system.

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