mirracle: An Augmented Reality Magic Mirror System for Anatomy Education

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ABSTRACT

We present an augmented reality magic mirror for teaching anatomy. The system uses a depth camera to track the pose of a user standing in front of a large display. A volume visualization of a CT dataset is augmented onto the user, creating the illusion that the user can look into his body. Using gestures, different slices from the CT and a photographic dataset can be selected for visualization. In addition, the system can show 3D models of organs, text information and images about anatomy. For interaction with this data we present a new interaction metaphor that makes use of the depth camera. The visibility of hands and body is modified based on the distance to a virtual interaction plane. This helps the user to understand the spatial relations between his body and the virtual interaction plane.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Artificial, augmented, and virtual realities—;

1 INTRODUCTION

Knowledge about human anatomy is an important part of education, especially for medical professionals. Teaching anatomy is difficult and often a large amount of effort is expended, e.g., when doctors present demonstrations in dissection courses, when creating illustrations and plastic models of anatomy or by utilizing 3D computer graphics. We present a novel way of intuitively teaching anatomy using an augmented reality (AR) magic mirror system displaying anatomical structures on the user's body. Furthermore we present a new concept for gesture-based interaction.

Figure 1: The system consists of a display device, a color camera and a depth camera. The user is tracked and a CT dataset is augmented onto the user.

2 METHODS

The mirracle system, which is presented in this paper, has mainly been developed for education of anatomy in classrooms, museums or exhibitions. It focuses on bones and a small number of important organs of the abdomen, namely liver, lungs, pancreas, stomach and small intestine. Figure 1 shows a photo of the mirracle hardware setup. The first component of our system is a display device. The second component is a color camera mounted next to the display surface. The third component is a depth camera which is placed next to the color camera. Our system uses the Microsoft Kinect which is sold as an add-on for the Xbox 360 video game console to enable games using gestures and body movement as input. It consists of a color and a depth camera.

2.1 AR In-situ visualization of human anatomy

For an intuitive visualization of organs we use the concept of a magic mirror. The camera image is flipped horizontally and shown on the screen such that the user has the impression of standing in front of a mirror. Virtual objects can be added to the image of the real scene. The magic mirror concept has been used previously to augment virtual shoes [4], shirts [3] or knight's armors [5] onto the user. For tracking the user, previous systems have been using markers [5, 3] or required the user to wear a shirt with a rectangular highly textured region [6].

While previous systems have augmented objects onto the user, our system extends the magic mirror concept for training of anatomy. It creates the illusion that the user can look inside her body. We augment a volume visualization of a CT dataset onto the user. To allow a correct augmentation of the CT, the pose of the user has to be tracked. This is done based on the depth image using the NITE skeleton tracking [1] software. Our system could use a CT scan of the user. However a CT of the user is usually not available. Therefore we use the Visible Korean Human dataset (VKH) [8]. This dataset consists of a CT scan, a MR volume and a photographic volume which has been acquired by stacking up cryosections. The CT volume is scaled to the size of the user and augmented onto the user. For visualization of the bones a transfer function is used as bones can be distinguished easily in the CT volume based on the voxel intensities. For the organs a segmentation of the VKH is used. The augmentation uses contextual in-situ visualization [2] such that the virtual objects are only shown through a circular window as is shown in figure 1. This leads to a better perception of depth, compared to a simple augmentation of the whole CT.

2.2 Gesture based interaction for slices

Medical volumes are usually visualized by showing slices that are aligned with the axes of the volume. A volume can be seen as a stack of sagittal slices starting from the left side and going to the right. When the system is in sagittal slice mode the user selects the current sagittal slice by moving the right hand from left to right. To switch to a transverse slice mode the user has to move the hand up or down, respectively front or back for the coronal slice mode. The current slice is shown on the right part of the monitor while a green rectangle is augmented onto the user. This rectangle visualizes the pose of the current slice. The system can switch between slices from the CT or the photographic volume.

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[1] www.openni.org

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2.3 Frosted glass interaction metaphor

In addition to the AR in-situ visualization of anatomy we want to display text, images and 3D models to provide more information about anatomical structures. To do this, our system switches to a mode, where no magic mirror visualization is used, but the whole screen is used to display additional information. In this mode the interaction metaphor of frosted glass is used which is described below. Over the last years, multi-touch surfaces have become very popular. As they are used in many mobile phones people have become familiar with this kind of interaction. Gestures, like zooming by framing a target area by two fingers and moving these fingers are known to most people. At the first glance it seems as interaction using depth cameras would enable the same kind of gestures in a touch-free setup. However, there is an important difference.

One example is the zoom gesture. The first step is selecting the area to zoom. This step does not yet involve touching the surface but the user only decides which area to zoom and moves the fingers towards the points framing this area. Directing the fingers to these points is easy as the image and the fingers are in the same 3D space. The second step is confirming the selection and starting to zoom. This is done by touching the surface with both fingers. As a physical surface is touched the user receives haptic feedback about this action. The zooming itself is performed by moving both fingers and the zoom interaction is ended by taking the fingers away from the display.

A similar interaction metaphor can be used in touch-free interfaces by introducing a virtual interaction plane between the user and the display. Such an interface introduces several problems compared to touch-based interaction. While in touch-based interaction points on the display device are touched, in the touch-free interface the hands and the image are at different locations in space. Therefore, selecting the two points that frame the zoom area is less intuitive and the haptic feedback is missing. We propose a novel interaction method to address these problems. We are using the metaphor of frosted glass. When looking at frosted glass, objects that are far behind the glass are not seen. Objects that are closer to the glass are seen blurred and with low contrast and objects that touch the glass are seen well. When using the frosted glass metaphor for a user interface, information like text information about an organ is drawn onto the frosted glass. The hand of the user is drawn as if it would be behind the frosted glass. An illustration of this visualization is shown in figure 2. By using this interaction metaphor the hands of the user and the display are brought into the same space, such that actions like selecting a point are more intuitive. The haptic feedback of touching the surface is replaced by a visual feedback.

Figure 2: In the left image the hands of the user did not touch the virtual interaction plane, yet. In the upper right the zoom gesture has started.

Using the frosted glass metaphor, we are able to display additional information. To provide high detail visualization of organs polygonal models are used. As an example, a model of the small intestine is shown in figure 2. Using the frosted glass interaction metaphor, the user can rotate and zoom. The system can also show additional text information and images about the organs. For this purpose we render HTML files.

3 Results

The first version of the mirracle system was developed in the beginning of 2011 and included the AR visualization of bones but not the gesture based interaction or the other modes. Starting from February 2011 the system has been shown to the public at several occasions. We presented a version of the system where the gesture based selection of slices has been added. It was shown e.g. during the open day of a hospital and in a school. The feedback of the users, especially from children has been very positive. While the AR in-situ visualization attracts the attention of people, it turned out that most users would spend much more time using the volume slicing feature to understand where different organs are. During the demo phase our system was used by many people and proved to be robust. The additional polygonal models and text information have been implemented but they have not been used in a large presentation of the system, yet.

4 Discussion

A magic mirror system would also be interesting for students of sports who have to know about the locomotor system and muscles. A functionality which is still missing for such an application is simulation and visualization of deformation and motion. For visualizing motion inside a patient or phantom Baillot et al. [1] modeled knee joint motion. We plan to extend our system with similar methods. Another application is communication between patients and doctors. This is very important, however doctors often have problems in correctly communicating issues to the patient. Recently, an AR system using a mobile projector to augment anatomy on the skin of the patient has been proposed by Ni et al. [7] for this purpose. Also the magic mirror could be used for patient communication and education allowing the doctor e.g. illustrating different steps of a surgery on the patient.

For the frosted glass metaphor we believe that it will also be important for other applications. Touch-free gesture-based interaction are an important trend in user interfaces. Therefore we believe that systems like the one described in this paper will find their way into daily use very fast and advanced methods to provide intuitive user interfaces will be of high importance.

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