HoloAnatomy: A Mixed Reality Approach to Medicine

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Abstract
HoloAnatomy is an innovative educational tool developed for Microsoft HoloLens 2, designed to help medical students understand human anatomy. Using mixed reality, HoloAnatomy allows students to explore and interact with detailed 3D models of the human body. Intuitive gestures allow users to control body systems by zooming in on specific structures. This tool allows multiple users to view and interact with the same 3D body model and enables users to work with the same 3D model regardless of location. Students using this tool demonstrate faster learning and better retention of information compared to traditional teaching methods. HoloAnatomy represents a significant advancement in the state of the art in healthcare education.

Keywords
Multimodal Interaction; Human Anatomy; Microsoft HoloLens 2; Mixed-Reality;HoloAnatomy

Introduction
HoloAnatomy is an educational tool developed for Microsoft HoloLens 2, utilizing Microsoft's Reality Toolkit and created by Case Western Reserve University. It was released on April 11, 2016, in the Microsoft Store. The primary goals of this application are to assist

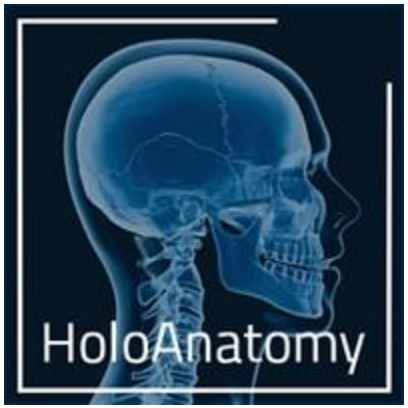

Figure 1. HoloAnatomy Logo

Figure 2. HoloAnatomy Demo

medical students in learning human anatomy by enhancing learning efficiency, improving retention, providing accessibility, and offering unprecedented detail of anatomical structures that traditional methods, such as human dissection, cannot adequately demonstrate.

In this application users can create sessions (teachers) or join sessions(students). These sessions simulate anatomy lessons and, in these sessions, a 3D model of a human anatomical structure is displayed next to the teacher’s slideshow. These models correspond directly to the anatomical structures shown in the slideshow.

Using HoloLens 2 Mixed Reality, students can explore and interact with these 3D models in an immersive environment. Users can manipulate these models using intuitive gestures. This allows viewing in more detail specific parts of the human body such as organs, nerves, muscles and bones.
One of HoloAnatomy's unique features is its ability to support collaborative learning. Multiple users can view and interact with the same 3D body model simultaneously. Either in the same physical location or connected remotely. This feature enhances the learning experience in the anatomy lab. Allows for remote learning and serves as a valuable tool for surgery demonstrations, where real-time interaction and visualization of complex processes is essential.

Interaction Architecture

The HoloAnatomy’s intecration architecture is show in Figure 3 which shows the user interaction with the “Main InterFace” and a session of this application

The main interface is controlled by hand gestures (air tap), which allows users to set up the pod, the ceiling view and create/join sessions.

In a session, a 3D model of a human anatomical structure is displayed on every participant's HoloLens device, like in Figure 2. All participants in the session can interact with the 3D model in real time, using hand gestures like "air tap" to manipulate the model. Additional other intuitive hand gestures are used to rotate, zoom, or grab anatomical structures for closer examination are also supported. Every participant's HoloLens display is instantly updated with any modifications made to the model.

Teachers also have the ability to interact with the slideshow using an "air tap" gesture, which updates the slides on each participant's device. If there are remote students in the session, a representative 3D avatar will be displayed in the shared virtual space. The state of these remote avatars is updated in real time as remote students move through their physical environment. Communication with remote participants is facilitated by the HoloLens microphone, while audio feedback and responses from the remote student are received by the HoloLens speaker.

Additionally, users can create demo sessions guided by a narrator. During these sessions, users will listen to the narrator's instructions and explanations through a HoloLens speaker. Interactions in these demos can be done through voice commands. Processed through the HoloLens microphone, these voice commands allow the user to manipulate the 3D models displayed in the session.

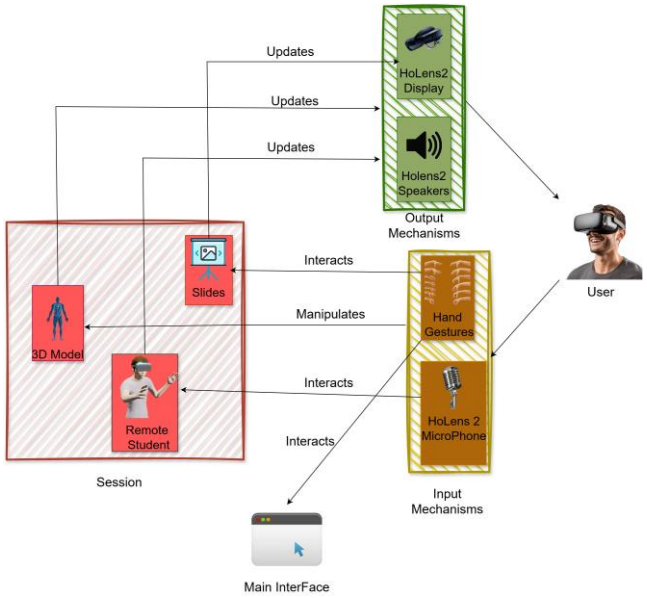

Figure 3. HoloAnatomy Interaction Architecture

Modalities

In HoloAnatomy we find four categories defined in Bernsen's taxonomy: Linguistic Modality, Arbitrary Modality, Analogue Modality and Structure Modality.

Linguistic Modality

STATIC GRAPHIC LANGUAGE

In HoloAnatomy we see static text, labels or keywords that can be viewed in a slideshow or from the main interface (Figure 3).

ACOUSTIC LANGUAGE

This model emphasizes spoken discourse. This discourse includes voice interactions between the user with remote users or with the narrator from the demo sessions.

Analogue Modality

ANALOGUE STATIC GRAPHIC

The slides and its images presented in a slide show are an example of this format.

DYNAMIC ANALOGUE GRAPHICS

The 3D human anatomy models displayed in this application can be classified into dynamic images that can be manipulated by the user. For example, the user can grab a bone from the human skeleton.

Arbitrary Modality

Users can use hand gestures to interact with the application. It serves as a custom layout for controls and navigation.

Structure Modality

This method can be observed in 3D models of the human body. which is structured around various organ systems

Critical Analysis

For the critical analysis of HoloAnatomy, the SWOT methodology (Strengths, Weaknesses, Opportunities, and Threats) was used.

Strengths

The intuitive interactions of the HoloAnatomy 3D models make it easier for users to learn and retain information about human anatomy. It is two times faster than traditional human dissection.
This has been proven in various studies [4]

Another strong point of this application is that it allows remote users to join a session, There is great value in distance learning, allowing students and teachers to interact with 3D models in real time regardless of physical location

Weaknesses
This application does not record the student's academic performance. That feature could be useful to track the students progress throughout their lessons.

Another weakness is that this application is only available for Microsoft HoloLens 2, which limits the number of users. Not only for equipment but also the price. It currently costs around 3,900 euros.

Opportunities
The remote feature of this application can create opportunities for medical students who can't attend lessons and learn from home or with students from different countries/regions.

The new way of teaching with HoloAnatomy, using mixed reality, can help and encourage students who struggle with traditional teaching methods to learn and study.

Threats
With the evolution of mixed reality applications, headsets and educational apps, this could pose a threat to HoloAnatomy because this app is exclusively for Microsoft HoloLens 2. Since this tool has been successful, rival companies may develop other medical applications for their devices or even for the Microsoft HoloLens 2. There are already other applications that use 3D models to explain human anatomy, such as Complete Anatomy and Visible Body.

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