Figure 1. BodiPod system.

BodiPod: Interacting with 3D Human Anatomy via a 360° Cylindrical Display

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Abstract
We present BodiPod, a 3D 360° stereoscopic human anatomy browser. Our cylindrical display allows users to view a human anatomy volume at full scale from any perspective. Shutter glasses are only required if users want to examine the data stereoscopically. Users can change views simply by walking around the display volume, and interact with the human anatomy model inside the display through gesture and speech interactions, which include scaling, rotation, peeling, slicing and labeling. Our demonstration shows that using a cylindrical display has the benefits of providing stereoscopic rendering of human anatomy models at life-size scale that can be examined from any angle, while allowing interactions from an appropriate viewing distance.

Keywords
Cylindrical Displays; Human Anatomy; Organic User Interfaces

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces – Miscellaneous.

General Terms
Design, Human Factors, Organic User Interface.

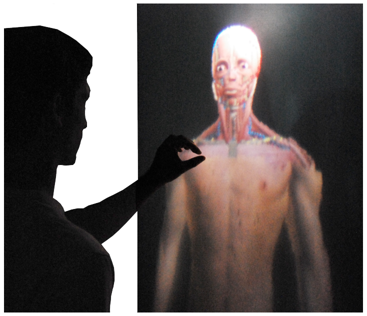

Figure 2. Peeling Interaction.

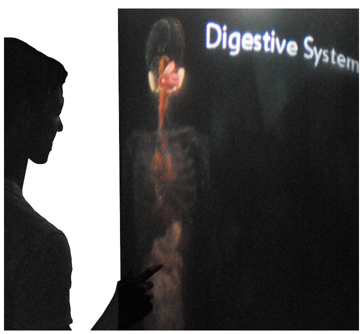

Figure 3. Pointing Interaction.

Introduction

With the evolution of new forms of display surfaces such as the Litefast MAGIC display [7], DynaScan's 360° display [4], OmniView [9], form factors and scales of display are becoming an increasingly important design element in problems of information visualization. This is because the shape of the display may in part determine what kind of data can be rendered, and how it is best interacted with [2]. E.g., in human anatomy classes, the use of traditional 2D display form factors for display of complex anatomical data may impact the learning process as compared to more traditional use of live-size human models or corpses, which can be examined at proper scale, using 360° views, and provide contextual views of all elements inside the body. While Virtual Reality (VR) solutions exist, which allow presentation of 3D human anatomical models to students, these are not situated in the real world: they require students to wear VR I/O devices impacting interactions in the classroom context.

In this paper, we examine the use of life-size cylindrical display form factors for the rendering of human anatomical data. Cylindrical displays have a number of interesting properties that suit visualizing the human anatomy: (1) Information rendered on cylindrical displays can be viewed from any 360° angle. (2) As compared to spherical screens [1], cylindrical displays provide limited distortion in the y-axis as display curvature does not taper off in that dimension. (3) Cylindrical display shapes fit data visualization problems where the information represented is taller than it is wide. With cylindrical displays, users can walk around a model without the display form factor impacting the distance to data points on the display, preserving the kind of natural proxemics that feature in normal medical diagnosis of patients. For this purpose, we built BodiPod, a lightweight and low-cost, 360° viewable interactive cylindrical display that uses off-the-shelf components to visualize 3D human anatomy models (Fig. 1). Our display provides full 360° motion parallax around its surface, and is capable of rendering 3D human anatomy models stereoscopically to multiple users through shutter glasses. Models are rendered via a 3D projector in the bottom of the display. A set of Kinects on top of the display track the location and gestures of users in front of the display, allowing the display to track and render different viewports that are in sync with the users' locations around the display.

Background

Historical solutions to visualizing real-time 3D data on a real reality display are varied. Volumetric display technologies include swept and static volume approaches. By rotating or oscillating a 2D surface such as LCD, LED or projected display [6], the swept approach renders slice of volumetric data at high speeds, and form full 3D imagery through persistence of vision. Static volumetric displays generate a 3D image using two scanned, intersecting laser beams to address voxels [3]. Resolution and sizes of these displays are limited. A simpler approach is to measure and compensate for motion parallax: the apparent shifting of 3D objects according to the viewpoint of the observer. Motion parallax allows the brain to aggregate spatial information over time into a continuum, as if occupying a volume [5]. When combined with stereopsis, it provides an effective means of rendering 3D information. However, traditional flat display form factors limit the application of motion parallax displays to 180-degree point of view scenarios.

Figure 4. Slicing Interaction.

BodiPod Implementation

Our cylindrical display allows for full 360° motion parallax, thus allowing multiple users (at present, two) to walk around the 3D visualization. The display surface consists of a 1.7 m tall hollow cylinder with a diameter of 75 cm, made of 6.3 mm thick acrylic. The acrylic was sandblasted on the inside and outside to create a diffuse projection surface. The cylinder is mounted on a wooden base that holds the projector, giving the entire system a height of approximately 2.0 m (see Fig. 1). A 1280*x*720 DepthQ stereoscopic projector in the base is pointed upwards to reflect off a 46 cm hemispherical mirror, allowing projection of an image across the entire display surface. Since only a circular portion of the image is displayed, the effective resolution of the display is approximately 407,150 pixels. Users can wear shutter glasses to view images stereoscopically.

User Tracking

Six Microsoft Kinect depth-sensitive cameras are used to track the location and gestures of users around the circumference of the display. These are mounted on top of the cylinder, pointed downwards. We use the Microsoft Kinect SDK drivers to process data in a C# application. Each camera provides 640 by 480 pixel streams at 30 fps with RGB and depth images. Each camera is connected to a single computer, which sends the user's skeleton information containing joint positions to a Microsoft XNA application that interprets gestures and controls rendering. After transforming the received skeleton data into the proper coordinate space, the XNA application calculates the angle between the user and the cylinder and updates the rendered camera angle.

Projection Distortion

The projected image is rendered using Microsoft's XNA 4.0 framework. A custom distortion class was developed in order to display undistorted images on the cylinder. By modifying the texture coordinates of this image to account for distortions introduced by the mirror, we can project an image onto the cylindrical display surface with minimal distortion. To allow for motion-parallax rendering, the rendered camera angle is synced with users as they move around the display. The system can, at present, render up to two viewports independently, which can be simultaneously viewed by many users.

BodiBrowser

Our BodiPod features BodiBrowser software that allows users to interact with a 3D human anatomy model sourced from TurboSquid [8]. This model features realistic, detailed and fully textured human anatomical sub-models that include skin, muscles, internal organs, nervous and lymphatic systems as well as the skeleton. The geometry can be subdivided as needed, allowing isolated views of any organ in the body.

Remote Gesturing Techniques

To allow users to interact with the BodiBrowser from a comfortable viewing distance, rather than using touch gestures on the surface of the display, we implemented a remote gesture set based on Kinect data. We developed the following gestures to interact with the models:

Peeling

A user can control what layer of the anatomy model is rendered through a peel gesture. A user can peel off a layer of the human anatomy by extending the left arm to perform a downward swipe action. Smooth blending

Figure 5. Labeling Interaction.

of peeling layers is supported to allow for partial revealing of layers (Fig. 2), and peeling only occurs up to the vertical position of the arm. Layers are unpeeled by reversing the direction of the gesture.

Point + Speech

In order to zoom the display into a specific sub-model (e.g., the heart, liver or brain), users can point at any part of the anatomical model and provide the speech commands: "Focus" or "Zoom" (Fig. 3). This will enlarge the specified organ into full view. Users can also provide speech commands without gestures, such as: "Show me the [Organ Name]" to achieve the same effect. The model goes back to full view by using the speech command: "Go back".

Proximity-based Slicing

One proximity-based interaction technique is position based slicing. When users provide the speech command "Start Slicing", and approach to within 2 m of the display, the display will render a slice of the data (Fig. 4). The slicing plane is controlled by the location and orientation of the head as measured by the Kinect cameras, and provides a way to examine volumetric data points, such as provided by MRI or CRT scans. "Stop Slicing" reverts interactions back to normal.

Proximity-based Labels

Another proximity-based interaction is *labeling*. When users provide the speech command "Show Labels", and are within 2m of the display, taxonomy labels appear over the human anatomy model that provide increasing detail about smaller organs as the user approaches the display. When a user is walking away from the display, only important taxonomy labels remain (Figure 5). "Stop Showing Labels" reverts interactions back to normal.

Pinch and Rotate

Users can zoom the human anatomy model via a bimanual version of the pinch gesture. Users can also rotate the model by extending their arm towards the model and performing a horizontal swipe gesture.

Conclusions

In this paper, we presented BodiPod, a 3D stereoscopic and motion parallax corrected cylindrical display for browsing full-scale human anatomical models. Our browser supports remote gesturing and speech interactions to allow users to interact with the model from an appropriate viewing distance. We foresee applications of our work as a remote diagnostic tool, and as a means of examining medical imaging data within the holistic context of the full-scale human body.

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