EEWWW!! : Tangible Interfaces for 3D Navigation into the Human Body

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ABSTRACT
Tangible interfaces have the potential to support learning for non-expert users, ease 3D navigation, and foster collaboration. We developed two physical devices aimed at school children for navigating a 3D virtual model of the human body. Results from a 40 subject user study suggest that these devices can encourage collaboration and improve the learnability of a navigational interface.

Keywords
Spatial visualization, 3D navigation, tangible media, user interfaces for kids, educational technology.

INTRODUCTION

We present the implementation and evaluation of two tangible navigational devices for the Visible Human Project® dataset [4]. Our devices are designed to provide middle school and high school biology students with a more intuitive and learnable interface for navigating through cross-sections of the human body. We hypothesize that use of a 3D interface for navigation through a 3D object should provide a substantial improvement over traditional monitor and mouse interfaces, which provide only a 2D representation.

Previous work has explored the use of tangible aids for 3D navigation such as data gloves and the 3D mouse [6]. Representations of tangible objects to be used as navigational reference points in conjunction with a navigational device have been studied in a single-user scenario for experts such as neurosurgeons [3]. The impact of the 3D representation in a collaborative setting for non-expert users has not been previously studied.

IMPLEMENTATION

We implemented two physical devices to navigate through the human body using the Visible Human Project dataset. (Both devices use the same on-screen visualization.) The dataset reveals cross-sectional images of the inside of the human body. The Visible Human Project® [4] provided data from a male body that was frozen and imaged into 1 mm horizontally spaced Computed Tomography (CT) slices. Our devices are built on top of an applet that performs database retrieval and slice interpolation. The Visible Human Server Project [2] at the Ecole Polytechnique Fédérale de Lausanne (EPFL) provides an applet for real-time navigation through the dataset [1]. Images are retrieved from the parallel Visible Human Slice Web server [5], which allows Web clients to obtain slices of arbitrary position and orientations. The applet takes its input from a mouse and keyboard. We replaced the applet's input module with a custom module for input from a sensor on our physical devices. The 2D navigation aid as well as the data slice from the applet is then projected on a screen near the physical device.

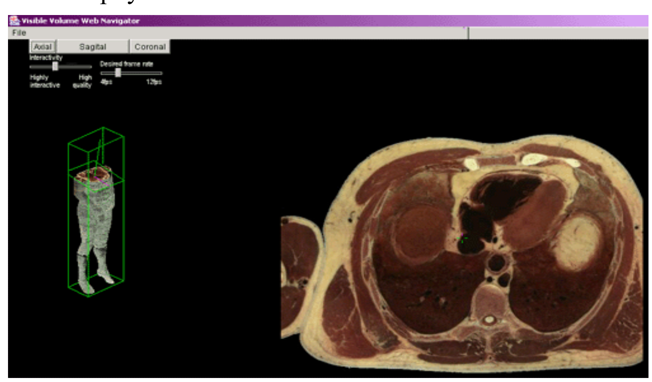

Figure 1: Visible Human Server slice navigation applet.

Both of the tangible navigational devices send the Visible Human Server applet input representing the plane of the slice it should display. Design A (Figure 2, left), has an adjustable arm that can be rotated 180 degrees along the device's baseboard, a fork that represents the image slice plane, and a 30-inch 2D model of a body. Given the position of the fork in Figure 2, the applet would display a horizontal slice of the chest area that is slightly tilted (similar to the image in Figure 1). Design B (Figure 2, right), consists of a transparent 3D model of the body and a free-moving, handheld fork. The forks in each device represent the slice plane. To sense this information, we used a Flock of Birds® sensor mounted to the fork. It

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reported x, y, and z location coordinates, and the u, v, and w orthogonal tilt vectors, allowing us to retrieve and display human body slices of arbitrary location and tilt on the projected display.

Figure 2: Design A (left) has an adjustable arm, a fork representing the slice plane, and a 2D body. Design B (right) features a 3D body model and free-moving fork.

EVALUATION

To determine the advantages and disadvantages of using physical devices for navigation, we performed a user study with 40 middle school science students, comparing our two physical devices to the standard monitor and mouse interface to the computer applet.

The students were split into two groups of 20 in a room with the two physical devices and a standard computer running the applet. We introduced our project to them and then let them freely use the devices and applet for one hour while observing their interactions, difficulties, and preferences. Afterwards, they filled out a survey. We collected surveys from 27 of the 40 students in our user study. They were asked which device was easiest to use, which they thought was the best aid to learning, which one they preferred, and for comments about the devices.

Results from student survey (%)	Ease of use	Aid to learning	Preferred overall
A: Adjustable arm	4	0	4
B: Free-moving fork	66	34	62
C: Keyboard/mouse	26	31	19
A and B equal	n/a	4	4
No answer/none	4	31	11

Table 1: Results from our student survey. Results are shown as percentages.

Overall, the students preferred Design B, the free-moving fork. The standard computer interface, though less popular than the free-moving fork, was preferred over Design A, the fork mounted on a supporting arm. Free-form comments provided by the students through the surveys indicated that most (66%) found the free-moving fork device of Design B easiest to use, and that the 3D nature of the model in Design B made it easier to navigate through the body and find specific body parts. The standard computer keyboard and mouse interface was preferred to the adjustable arm, partly because the standard interface was very familiar, and had additional functionality that was not supported by the physical devices: zooming and rotating and moving slices on the screen. For Design A, the adjustable arm physical device, students pointed out that while the larger 2D model was useful and that the arm held the fork still allowing greater resolution, the arm's stiffness and large size made it difficult to move. Students tended to collaborate more when using the physical devices, pointing to parts of the body and saying "move it here." With the standard computer interface, the students tended to sit down one at time and not interrupt a student using the machine. Students using the standard computer interface also had trouble interpreting which slice they were viewing when the slice was at an odd angle that the 2D screen interface could not easily depict; this was not a problem with the physical devices. Students learned the physical devices more easily; they simply walked up to them and began moving them around. For the standard computer interface, an instruction sheet listed the various mouse and keyboard commands for navigation. Some students needed additional help, and all of them had to read the instructions before they were able to perform the same tasks that were learned effortlessly using the physical interfaces.

CONCLUSION

Both physical devices aimed at allowing school children to navigate through image slices of the human body. Results indicated that the free-moving fork device increased the ease of navigation and that both physical devices improved navigation learnability and promoted student collaboration when compared to a regular monitor and mouse interface.

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