The Online Anatomical Human: Anatomical Knowledge Exchange on the Web

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Abstract

Human anatomy is complex and as early as the late bronze age, people have been trying to gain insights in the functioning of the human body. Nowadays, resources such as books and software are available to educate medical students, but these media usually have some restrictions; anatomical images in books present information from fixed views and do not allow readers to freely explore the information, while software tools often present an idealized average human anatomy.

In this work, we introduce the Online Anatomical Human (OAH), an online viewer and annotation system for anatomical information. It is based on real human anatomy and incorporates medical image data in linked 2D and 3D views. The goals of this anatomical online resource are two-fold. First of all, the OAH will serve as an educational platform available to anyone that has access to a modern web browser. Secondly, by making our work accessible to medical experts, we can ensure an increasing amount of information and, hereby, a gain in educational value of our tool.

Index Terms: I.3.8 [Computer Graphics]: Applications—; J.3 [Life and Medical Sciences]: Medical information systems—

1 Introduction

One of the oldest known papers on human anatomy, known as the Edwin Smith Papyrus, dates back to approximately 1700 BC and still today, most education on anatomy is based on books and even though some software exists, the presented anatomical models are often idealized. Furthermore, there are several cases in which is no consensus is reached amongst anatomical researchers regarding the exact configuration of certain anatomical structures, but current resources have no way of indicating potential alternatives. Even if a consensus is eventually reached, many outdated books remain accessible and it might prove futile trying to update all resources.

The Unified Anatomical Human (UAH) [1, 2] is a software system that was developed to allow anatomical researchers to store, query and visualize heterogeneous anatomical data using a schemaless database. Heterogeneous spatial and non-spatial data from different sources, as well as the complex relations between them can be represented. In the associated UAHViewer prototype, users can interact with this database using a 3D view linked with 2D slice viewers. Currently, the UAH database is focused on the human female pelvis and contains a 3D atlas of the pelvis built through manual segmentation of the Visible Korean Human dataset. The OAH interacts directly with the UAH database and provides a web-interface to explore and annotate anatomical structures within.

In this work, we present the Online Anatomical Human (OAH), an online viewer and annotation system for anatomical information, which extends the direction taken by the UAH approach. Similarly, it is based on real human anatomy and incorporates medical image data in linked 2D and 3D views, but runs entirely in a web browser. This property makes our OAH solution a good choice for educational purposes, as it is basically available to anyone with an internet-enabled device. Within OAH, a user can interact with the 3D model and 2D slices through real medical data sets to gain a better understanding and improve the mental mapping between the two domains. The latter is a critical skill since the advent of medical imaging modalities in clinical practice. Secondly, by allowing medical experts to share their knowledge via annotations and hyperlinks, we can enrich our representation to an online database and keep track of a variety of information, including the most recent developments. Finally, the 3D annotation system can have several additional purposes; it can be used to indicate anatomical landmarks, lines and regions, or to acquire different expert opinions on, e.g., optimal incision lines for surgical procedures, which makes our solution highly valuable for educational purposes.

Specifically, our contributions are as follows: 1) We present a prototype tool, the Online Anatomical Human, that is capable of providing the user with linked 2D and 3D anatomical information via a web browser for educational purposes. 2) We provide an open platform to enable users to annotate anatomical structures in 3D, leading to an evergrowing wealth of information. 3) We present additional 3D interaction techniques using a Leap Motion, which makes it possible to control the entire application via hand and finger gestures.

2 The Online Anatomical Human

The OAH interface can be seen in Figure 1. Users are able to interact with the 3D model and browse through the linked 2D cryosectional and segmentation slices on which the 3D model is based. Structures of interest can be selected from a nested list of all available elements or directly in the 3D view. Once a structure is selected, the non-selected elements become semi-transparent to prevent occlusion, but to also preserve an anatomical context. Query results from the UAH database, such as literature associated to the selection become available to the user as well.

To facilitate annotations, we offer three solutions, which allow the user to place them directly on the 3D mesh. First, landmarks can be placed by selecting a point on the surface. This type of annotation is suitable to label anatomical reference points or sub-labeling structures that are not identifiable by a specific bounded region. Secondly, regions can be annotated by brushing over the surface. This type of annotation can be used to annotate larger areas and sub-parts of a structure. Finally, lines can be added by either dragging a selection path over the surface or by specifying a begin-

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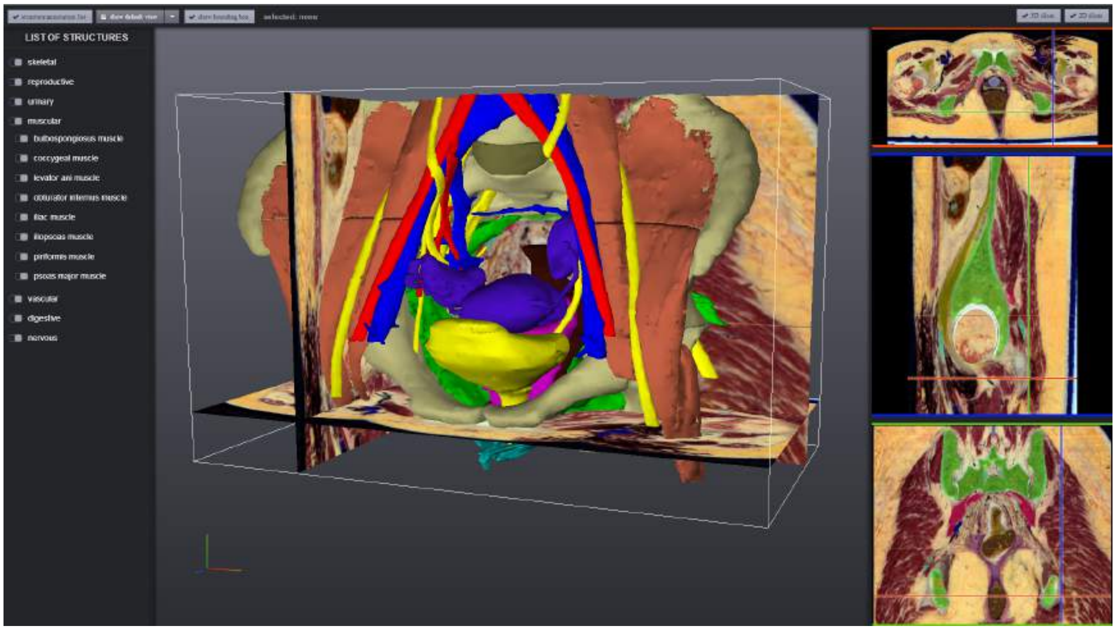

Figure 1: Main interface of the OAH. Left: List of anatomical structures available and their visibility settings. Center: 3D surface model with integrated 2D cryosectional slices. Right: Orthogonal cryosectional slices with segmentation labels overlaid for axial, saggital and coronal reformations.

and end-point for the line. This type of annotation is suitable to define edges or contours on the surface.

Technically, several challenges had to be solved to keep annotation response times interactive. Landmark placement is performed by ray picking, which finds a single location on the surface. For region annotations, the user first chooses a radius of interest. A region-growing process then extends the chosen location to match the radius. This region-growing process is performed using a breadth-first search. Since only neighboring faces and vertices are visited, region annotations do not overflow into disconnected mesh parts. To optimize performance of the face-selection process, we implemented an off-screen rendering technique. By drawing the faces of the model in uniquely distinct colors, a pixel readout can serve as a fast solution to determine the selected elements. For line annotations, we use a shortest path approach, in which the search path is restricted to the initial line input by the user. In other words, we pursue the line on the surface such that its projection corresponds to user-provided line segment on the screen. Thus, the line annotation on the surface appears exactly at the same location as the user input, but follows the shape of the underlying object in 3D. Examples of different annotations made in the OAH are shown in Figure 2. We investigated using the Leap Motion, a sensor that allows for user input via hand and finger motions and can be used alongside the keyboard and mouse. Unlike a mouse, it registers movements in 3D and, thus, is suitable for 3D interaction. The fact that the device works touchless, is particularly useful if OAH is used during anatomical dissection classes. A demo video of a region annotation using the Leap Motion controller is available here: `http://www.youtube.com/watch?v=y_JYiMwbjPI`.

3 Conclusion and Future Work

We presented the Online Anatomical Human (OAH), an online viewer and annotation system that is of interest to students as well as experts. Its online ability helps us keep the information up to date and accessible to everyone. The fact that the OAH is running in a standard web browser, will potentially allow the participants of the conference to connect to our server on the spot and to try the software out for themselves. We will demo the software and the

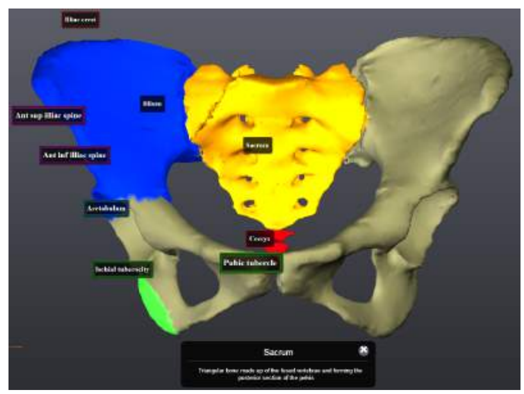

Figure 2: Example annotations of the os coxae featuring landmark points, regions and lines.

leap-motion interaction live at the event.

In the future, we would like to further extend and examine the educational capabilities of the OAH, e.g., via a user study with a large group of medical students. Furthermore, as indicated above, experts might disagree regarding certain annotations and visualizing their combined annotations is an interesting research challenge, which we intend to solve using uncertainty visualization methodologies. In particular, we want to show overlap and variations between the different opinions and support an intuitive way of exploring the various possibilities.

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