ANATOMYLAB: A COMPUTER GRAPHICS PROGRAM FOR REPRESENTING THE HUMAN ANATOMY

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ABSTRACT

AnatomyLab is an e-learning computer application. It helps students to study and become familiar with human anatomy by interacting with anatomical 3-Dimensional models, which represent subsystems in the human body. A new multilingual wikipedia lookup technique displays online information related to body parts or body sections in the language of the user choices. By adding custom contents, lectures for students can be created. As a result, anatomical contents can be exchanged by medical professionals and made available to patients.

1. INTRODUCTION

Shapes of bone and tissue structures in the human body are complex and follow complex spatial relationships. Since the origins of medical science, a profound understanding of human anatomical structures and related physiological functions has been an important factor when teaching medical professionals. So, it is not surprising that always new visualization methods played a crucial role in the improvement of medical professional education [1][2].

At present, visualization is based on real human bodies, plastics models, illustrations, charts and also on modern electronic media to some degree. Due to performance limitations of computers it is not possible to use full body 3-Dimensional models directly for educational purpose and eventually to substitute plastics models. Although the outcome of the discussed project would result in improvements in healthcare education globally, the major beneficiaries would be developing countries [3][4][5].

The first human full body 3-Dimensional anatomy models have been created about 10 years ago. In these models the surface of bones and organs is represented by a high number of small and flat facets through application of standard 3-Dimensional vector-graphics methods [6][7]. Subsequently, models can be visually examined on a computer system or converted into a plastics model by applying standard CAD/CAM production methods. Commonly, a model consists of 10 to 20 units which represent subsystems of the human body like skeleton, muscles, nerves, heart, lungs etc.

Since the early inception of full body 3-Dimensional anatomy models, the volume and level of detail has significantly grown, facilitated by increasing computer performance and improved software technology [8]. The largest existing anatomy model has a volume of 5 million polygons.

Despite all improvements, there are technical obstacles which make full body models limited useful for the training of healthcare professionals. The oversize models are so massive, that the full model cannot be interactively navigated anymore. While visual inspection of a single subsystem is possible in high detail, the observer cannot examine the relationship of the subsystem to its anatomical environment. This restricts the usefulness of the oversize model and reduces its value to extraction of relevant sections by graphics specialists, who further process these sections to illustrations or animations. If compromising, by reducing the volume of the model to a level that it can be navigated in full, it would be so incomplete and the level of detail would be so low [9]. While it is of limited interest to look just at the 3-Dimensional outer surface of the model, it would be very desirable to explore internal views of any body section interactively. The observer might want to reveal structures of interest and remove objects which obscure these structures. He might want to add and remove parts repeatedly until he has found his desired sectional view. However, a multi-million polygon model typically consists of several thousand individual anatomical objects. Isolating the desired sectional view would become totally impractical, since many hundred obscuring objects would have to be manually excluded from the image rendering process. Existing CAD viewing software cannot support the selection of visible objects in high-part count models efficiently.

Due to these technical obstacles, vendors of 3-Dimensional anatomy models serve a limited market and have no particular incentive to create more accurate models with higher level of detail, although, this would be very desirable for education of medical professionals and patients.

While the computer graphics industry has researched and developed sophisticated software technology to serve CAD markets and entertainment
markets, there is no particular focus to address graphics visualization in medical education.

Our general goals are researching and developing methods and techniques in order to advance teaching and learning methods in regards to healthcare education by fully exploiting the existing base technologies 3-Dimensional graphics visualization and information technology.

2. METHODS

The original full body 3-Dimensional model is given as a collection of Wavefront OBJ files. Each file represents one of 18 body systems. It contains polygonal surface meshes, material and texture qualities of bone and tissue surfaces. The 3-Dimensional model has been created by teams of 3-Dimensional model designers based on CT and MRI data from a real human body [10]. Designing the model requires very skilled designer work, as all organic surfaces of closely neighbored structures, thin layers and strings of tissue have to be perfectly aligned and scaled across all body systems.

The objects in a file are positioned and scaled in such a way that they match the anatomical environment in all other files and combine to a realistic interior of the full body. Although the polygon-count of the full model is so high so that it cannot be interactively navigated anymore, its information content is high, so that its visualization can provide insights into anatomical structures in highly details across the full body.

The original polygonal ASCII data, the material and texture data of the model has been compacted and embedded in the program in a form that sectional extracts can be quickly loaded for review.

Presently used interaction and navigation methods for 3-Dimensional model visualization have developed over many years [11][12][13][14], driven by CAD technology which historically has its focus on industrial product modeling and architectural modeling. In these models, both, the typical number of objects and the number of polygons are significantly lower compared to full body anatomical models.

Rotate-zoom-shift navigation in conjunction with individual selection of single objects to be included or excluded in the scene rendering process. Rotate-zoom-shift navigation is the dominating interaction method. The sole use of this method however, is very inefficient for models which consist of several thousand parts in a multi-million polygon anatomy model as shown in Figure 1.

In AnatomyLab, a cubically shaped section can be loaded exclusively. The cube can be defined interactively by marking a rectangular region in a ventral or lateral body view. All objects, which are fully enclosed in the resulting rectangular shaped tube, will be considered for loading. This process results in displaying a section of interest which represents an excerpt from the full model.

3. RESULTS

In AnatomyLab, customized contents can be added and shared via internet and anatomical Wikipedia articles can be displayed online. Sectional views into the body can be exchanged by AnatomyLab users worldwide. Added contents allow creation of lectures and presentations, which can be accessed via internet or local networks. Other innovative features like semantics based navigation and multilingual online lookup were added.

Since the early designs of full body 3-Dimensional models almost a decade ago, anatomical models have grown to become the giants among all existing 3-Dimensional models. Presentation of high-end full body models include all major body systems have thousands of parts and the total number of polygons, which represent the organic surfaces, exceed one million.

Unlike in architectural and industrial 3-Dimensional models, the surface geometry of organic structures does not follow elementary geometric laws. Tiny bone surface details, thin strings of muscles, blood vessels and nerves and thin layers of closely neighbored muscles and ligaments need to be properly scaled and accurately aligned. In years of work by experienced, skilled designer teams, accuracy and level of detail were refined based on MRI and CT scans and with support from medical professionals. In closed teamwork, more organs were added and highly accurate full body models were created.

The total size of the models has grown so tremendously, so that visualization has become a real challenge to both computer hardware and software. Limited by the performance of PC graphics hardware, the full model cannot be efficiently navigated anymore. Even, if body systems are loaded selectively, isolating a view of the desired section with available, universal 3-Dimensional viewer software is practically impossible. It would require cumbersome selection of the visible parts among the thousands of total parts.
Consequently, the gigantic models could not be used in a straightforward way for visualization and exploration of the human body. 3-Dimensional software specialists extract sections of interest and process it further to create animations, illustrations and movie scenes. Another obstacle, faced by model vendors who want to apply their products in new fields of application is that 3-Dimensional models can hardly be protected from illegal copying. Selling a 3-dimensional model has some similarity with selling a software application with the source code fully included.

Features in AnatomyLab cover fast sectional loading and dissection into customized building blocks. Three-Dimensional regions of interest can be quickly saved and recalled as shown in Figure 2. Anatomical views can be isolated by using various selection methods in combination. Three-Dimensional views, which can be saved to very compact subset files, can be exchanged between AnatomyLab users in order to share 3-Dimensional body views.

Users can add content in their own language and present it to a local or global audience. A content document, which might reside on a local area network or on a web server, can be attached to a 3-Dimensional view. AnatomyLab presents the 3-Dimensional view together with the view specific content document in a dual window. By adding custom contents, lectures for students can be created, and anatomical contents can be exchanged by medical professionals and made available to patients.

4. CONCLUSION

Anatomy teaching is undergoing significant changes due to time constraints, limited availability of cadaveric specimens and advances in computer-assisted learning. AnatomyLab offers many potential benefits and most notably to simulate the spatial relationships between anatomical structures. However, more research needs to be done to evaluate these resources before they are introduced into the medical curriculum.[3][4].

REFERENCES


