Online 3D Knowledge Management System for Human Anatomy

Vladimir Georgiev[1], Lyubomir Milkov[2], Yavor Angelov[1], Stanimir Dimitrov[1]

[1] Shield UI Ltd, Sofia, Bulgaria
[2] Technical University, Sofia, Bulgaria
vlado80@gmail.com, lyub_milkov@yahoo.com,
yashinaki@gmail.com, stanchino@gmail.com

Abstract. This paper describes an online environment for showing the human body in an interactive 3D format. By using that platform, various groups of medical personnel, patients and students can fully manipulate models of digitized male, female and child bodies. The highest level of detail available for the objects being displayed allows users to view any specific part, system and organ, show how certain condition affects the human body, add annotations and render animations. The paper also draws attention on the current challenges in the industry and how they are approached.

Keywords: e-Health, e-Learning, 3D, Human Anatomy, Medicine

1 Introduction

The emerging field of e-Health, which aims to introduce digital processes in modern healthcare, outlines the need for various domain-specific software applications. The industry fosters an increasing demand for a wide range of services like electronic health records, doctor-patient systems, telemedicine, electronic prescriptions, health knowledge management and others. Furthermore, the use of Internet to deliver these services to the already-existing computer-literate public allows the use of modern web development technologies for building the required applications.

Online healthcare providers face several challenges when building consumer applications. In most of the cases, the specific services needed by patients are often not clear in the initial phases of a project, which makes it impossible to tell how well the solution will be accepted by its users. To tackle that problem, methods for preliminary modelling of user acceptance have been suggested [1]. By making sure that all parties understand their role and are aware of their needs, e-Health provider organizations achieve better results like improved clinical decision-making, increased efficiency, stronger communication between physicians and patients, etc.

Adoption of e-Health tools is also impeded by several other major barriers. They include a considerable amount of upfront costs, great system complexity and lack of standards for exchanging clinical data between organizations [2]. There are also privacy and security concerns, hindering the implementation of IT in healthcare. Because these services are provided as web-based Internet applications, many doctors and patients fear that their data will not be secure enough. For overcoming these obstacles, several incentives have been identified. They suggest that for mitigating the costs, companies specialized in providing specific software, as well as governments should step in. These vendors should be working together towards certification and standardization of their applications, for better data exchange. Legal barriers should be removed and security of medical data improved, in order to convince practitioners and patients of the software benefits over traditional healthcare processes.

2 Motivation

The current project is another manifestation of a permanent trend over the last decade for increasing the degree of digitalization in healthcare processes, which tends to serve two main purposes - reduce administration and development effort, and provide access to unique human anatomy-related data and functionality.

Contemporary IT platforms take advantage of development and user interface tools, into which decades of development were invested, in order to reduce both the cost and speed of development and at the same time - greatly reduce the cost of administration. Content management systems, cloud storage, UI components, client-side plugins and libraries for 2D and 3D visualization and rendering [3] are both extremely complex in their underlying architecture and very flexible in exposing an intuitive API for rapid development and automation of processes. All these technologies come into play in securing the next generation platforms, like the online environment described in [4], with reduced cost, low maintenance and larger user base. In addition to that, such platforms are available for access on any device and environment - from desktop computers, to mobile devices. This eliminates a number of constraints related to accessing this product/knowledge base, such as - location, user verification, user management and administration, information protection and backup, collaboration, and knowledge transfer.

There are other recently released platforms that provide similar functionality, like [5] and [6], but they have several drawbacks. One of them is that they are both commercial systems, not available for free to the general public and the academic society. These systems lack advanced user management functionality, needed for extending privileges and support team-based services. There is also no content provided for the 3D materials, like descriptions and annotations of human anatomy parts. Last, these systems seem to be developed as general-purpose Software-as-a-Service applications, intended to provide the 3D rendering functionality to other parties, which would build their specific business case on top of it.

In addition to the unique advantages of providing the described medical platform, our project addresses the ever-increasing demand for products, which provide centralized healthcare systems with secure, reliable and fast way to share, collaborate and educate. The development process used coincides with the team's culture and motivation and thus forms a natural drive to draw the maximum out of technology and subject this to an inspiring cause.

3 Functional and Technical Characteristics of the System

The initial implementation of the medical platform provides solutions to a number of problems that have been identified by patients, practitioners and learners. First, the platform automates the whole process of user management and administration. This allows users to easily register and access the system and take advantage of its full spectrum of functionalities. At the same time, the system allows easy user roles management, allowing administrators to track usage, restrict access content and etc. The second group of users - editors - can manage the information displayed for each model, define custom views of individual body parts and share them with other users. The non-registered users only have access to the general information sections of the system.

Another important feature of the platform is the automation of support. More specifically, it is a self-serviced solution for technical and usage inquiries, as well as automation of notifications and newsletters. Additionally, the system exposes options for defining custom events and triggers for full control over the automation process and user management. This allows administrators to configure specific actions to be executed like sending an email to a user that has been living in the system for a year or has not logged in for a long time.

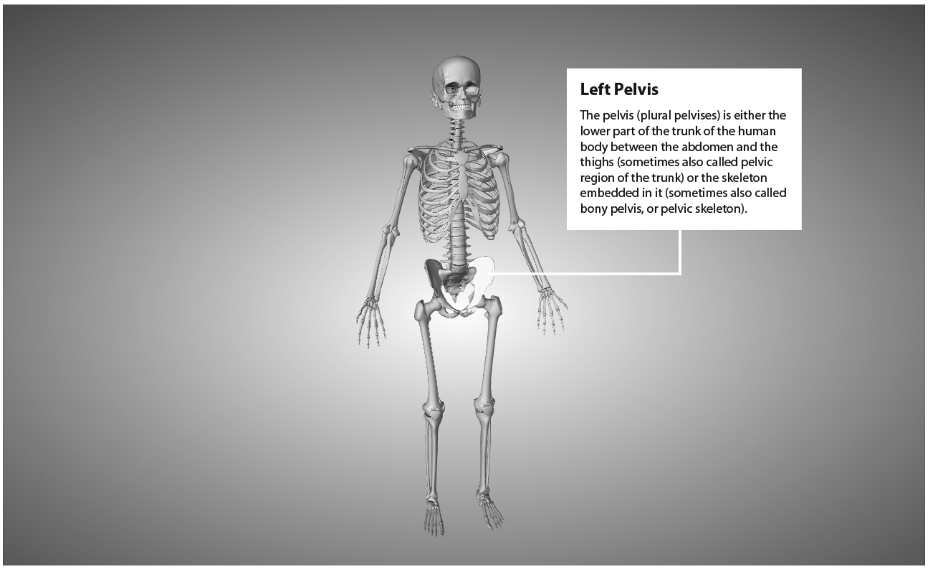

Fig. 1. Annotation shown for a part of the human skeletal system

The main focus of the medical platform is the enablement of users to access a large set of 3D visualizations of all parts of the human body. Users are able to engage in an immersive and fully interactive experience with each human system, part or organ, add and save annotations for each element, record audio descriptions or review the already available knowledge base. The platform allows users to freely rotate and zoom in and out the objects being displayed. Combined with the highly detailed three-dimensional models of all human parts - organs, bones, veins, etc. - this gives them a unique opportunity to observe the human anatomy in any aspect and ratio. Fig. 1 shows a male human body skeletal system being visualized, with a certain part selected and described. It is the central part of the application interface that allows direct interaction with the visualized anatomy – zooming, rotating, selecting objects, etc. In addition to that, there are several other user interface elements that allow viewers to quickly manage the objects being displayed. One of them displays all organs in the human body, grouped under the respective systems and gives the ability to show and hide individual organs and whole systems, for purposes like improving visibility and contextual display. Another is used for finding and moving the focus to a certain organ, in a search box providing auto-complete suggestions. The rest cover functions needed for content annotation. Such types of visualizations are the essence of a next generation tool, which allows unlimited options for interactions over the existing static content of text, images and 3D models. Critical for such functionality is also the availability of the platform to run on any modern device and operating system, due to its web-based architecture.

The described environment is a cloud application, running on different servers and designed to be scalable on demand. All of its functionality is accessible through a set of APIs, which are currently used by the front-end JavaScript executed in the client web browsers. They include management functions like user authentication and management, 3D asset retrieval, annotations, etc. To render the three-dimensional models, the ThreeJS library [7] is used. It supports the visualization of hierarchical models and easy showing and hiding of whole groups of objects on the scene. This allows the framework to toggle the visibility of whole human body systems with a single operation, without worrying about which object belongs to them. All of the user-facing functionality of the platform, including the 3D rendering part, can be executed in any browser on any device. It does not require the installation of any additional modules or plugins, and thus is made available to all user groups.

Indispensable for the success of the platform are a few additional assets. First, the team in charge of developing the platform has deep understanding has a solid track record of data visualization [8]. This includes development of complex data visualization components like charts and data grids, and many smaller and robust UI widgets for presenting rich user interface scenarios. Further, the team has deep knowledge and experience of 3D visualizations and rendering in the browser, which is central to this medical project. Additionally, the Shield UI team has put its whole UI and UX skillset into providing a tool that is fast, responsive and easy to use. This ensures that all users - from novice to administrators, make the best out of the product.

4 Conclusion and Future Work

The web 3D knowledge management system we developed is a unique and complete environment for sharing information related to the human anatomy. Initially designed to serve the needs of professional medical personnel in the healthcare industry, it will also serve other groups of users like students and patients. The next phases of development include extending the system with a learning module to offer online education capabilities to medical students. The improvements will allow to group users in classes and assign them an instructor, who will be able to build various learning materials referring to the human body anatomy – displaying individual organs, whole systems, conditions, effects, etc. The prepared materials will be made available in the system, as well as integrated into other systems, like third-party learning systems or other electronic sources. This functionality will also allow doctors to create patient-specific views of parts of the human body and illustrate how a condition, disease, or operational intervention affects it.

Another planned improvement of the platform is the research and introduction of an object-oriented database system [9] for storing the complex hierarchical data for the human anatomy. Because of the heterogeneous nature of the information in the system and the lack of knowledge what will be stored in the future, a more efficient method for preserving and querying the data was requested. We will evaluate an object-oriented database engine for storing the raw 3D model assets and the various information required for each contextual view presented for each individual user.

References

1. Wilson, V., Lankton, N., Modeling Patients' Acceptance of Provider-delivered E-health, Journal of the American Medical Informatics Association, July 1, 2004
2. Anderson, J., Social, ethical and legal barriers to E-health, International Journal of Medical Informatics, Volume 76, Issues 5-6, Pages 480-483, May-June, 2007
3. Georgiev V., Mitreva E., 3D Environment for Virtual Collections, Proceedings of Third International Conference for Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, September 18-20, Bulgaria 2013
4. Georgiev V., A Web Application for Creating and Presenting 3D Object Expositions, Proceedings of Fourth International Conference on Digital Presentation and Preservation of Cultural and Scientific Heritage, Veliko Tarnovo, September 18-21, Bulgaria 2014
5. BioDigital: 3D Human Visualization Platform for Anatomy and Disease - https://www.biodigital.com/
6. Zygote::Home - https://www.zygote.com/
7. three.js – JavaScript 3D Library - http://threejs.org/
8. Shield UI Main Website, http://www.shieldui.com, 2013
9. Milkov L., Achieving High Concurrency In Object Oriented Databases, International Scientific Conference Computer Science, 2009