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4 The visualization of the construction of the human eye

4.1 Introduction

In the twenty-first century, the e-learning platforms and computer simulators of the human body revolutionized medicine science. Simulators, serious games, and virtual atlases contribute to the fact that studying medicine is no longer an arduous and boring duty but is becoming an incredible adventure, a virtual journey inside the human body that a young adept of medicine can repeat over and over without any concern about making a mistake that will result in an irreversible injury of a patient. Students of medicine prefer watching a three-dimensional medical exhibit on a computer screen rather than a flat photograph in a book. When a person does not have spatial imagination, such a virtual model is a very useful solution [1].

Contemporary facilities in medicine consist not only of professional computer models realized by modern graphics but mostly of animation, which, combined with graphics, provides an ideal tool that enables not only a student of medicine but also an ordinary patient to understand complicated medical issues. Nothing can develop imagination better than a moving image that reflects human organism in perfect detail. This enables patients without any medical preparation to understand processes taking place in their organisms.

Computer applications used in the process of studying medicine can bear the character of serious games as well as computer simulators that, using mathematical models saved as computer programs, emulate a self-played physical phenomenon. However, nowadays serious games are mostly video games whose main purpose is education through entertainment.

Clarc C. Abt phrased the idea of serious games in the book *Serious Games* in 1975. In the introduction, he claimed, "We develop serious games in such a way to give them a clear and well-thought educational aim and not to dedicate them mainly to entertainment."

This chapter is given over to an authorial educational game aimed to help in studying the anatomy and physiology of the human organ of sight and understanding the mechanics of vision. The game is supposed to support studying of the correct and pathological anatomy of the organ of sight. Its user can be a high school student as well as a medical student. The interaction in the game is organized in single player mode. Steering in the game is accessible using mouse and keyboard. The interface is based on the Polish language. Anatomical structures inside the game are described in Polish as well as in Latin. Specialist literature—textbooks [2–4] and anatomy atlas [5]—were used as a source of serious content. The basic, assumed method of

studying is practicing skills. A player can take a test to check his/her new skills. Models made in 3ds Max program show the anatomy of the organ of sight in a very clear way, including, for example, the proportions of its particular structures or the positioning of these structures toward one another. The assumption was to enable a player to rotate the models intuitively, zoom, and divide into parts using a mouse to uncover the inner structures [1].

4.2 Overview of the existing solutions

The market offers many computer applications of the anatomic character enabling to study three-dimensional models of the human eye. These solutions can be payable as well as free. Some of them assume contractual anatomical precision. There are three samples of English-language anatomic applications presented in this chapter. They were chosen based on the quality of mapping of the anatomy and the functionality of the models. The first is the application created by Cyber Science 3D, which created its three-dimensional interactive version in cooperation with the publisher of one of the most popular anatomic atlases, *The Netter Atlas of Human Anatomy*. The atlas is available in a free beta version as well as in a paid version (14 days for free, then $5 monthly). None of them is dedicated to mobile devices. The free version allows to manipulate the model (rotating, zooming in/out, and unfolding into parts), check English names of particular elements, and make reference points visible. The application offers a lot of models depicting some parts of the human body [6].

The second of the presented applications is the application created by Anatronica Interactive Anatomy 3D, which can be used in an online version. (The browser must support the Unity Web Player plug-in. Also, a Flash technology version is available.) It can also be used after downloading a desktop Pro version (both of the versions are free of charge). The online version contains only a male model, whereas the Pro version contains a female model as well. Moreover, in the Pro version, models of better quality are used. In the application, all systems of the human body are available. On the model, the visibility and half-translucency of particular elements can be turned on/off, and the Latin names of those elements can be checked as well. The entire model can be rotated and zoomed in/out. In addition, there is a possibility of searching particular anatomical structures by their names, too. Finally, a user's knowledge can be checked by a test of single-choice questions. The last update of the project took place in December 2015 [7].

The last of the presented applications is the Eye—Practical Series by the 3D4Medical. Its aim is to help understand how the human eye works and what the vision defects and eye diseases consist in. The issues of the work of the eye and the concept of the refractive error are explained by 19 animations free of charge. Additional animations concern the eye diseases and the methods of treating them, but they are only available after the purchase from the level of the application. The cost of

the application is \$7.99. The animations can be stopped at an arbitrary moment, and a note/drawing with a pen can be made on the stopped picture. Moreover, there is an available interactive model of the eye, which can be used to check the names of particular structures (both English and Latin ones) as well as the pronunciation of these names. A user's knowledge can be tested using the quiz. It has two modes: the "drag and drop" and the test of multiple-choice questions [8].

4.3 Presentation of the written application

The design of the presented game assumed the execution of models of the correct and pathological anatomy of the organ of sight in full view as well as in cross section, enabling to see the sagittal plane [1]. The models of eyeball, muscles, nerves, and eye socket bones were performed using the 3ds Max program [9]. Their behaviors were programmed in Unity [10]. The development environment used while making the design was the MonoDevelop Unity. The pictures representing views seen by a patient with functional disorders of the organ of sight were edited using the Gimp program [11]. After starting the game, the user can choose one out of four options, which are marked with the following buttons: Model anatomiczny, Quiz, Przegląd zaburzeń, and Wyjście. Clicking the Model anatomiczny button takes the user to the part of the game where he/she can get familiarized with the correct anatomy of the eye. The presented model of the eye consists of the eye socket bone, muscles, nerves, eyeball, and other elements that cannot be counted to any of the above-mentioned categories. The user can display the model in full view (Fig. 4.1) or in hemisection showing the right part of the eye socket (Fig. 4.2). Switching between views is possible, thanks to the
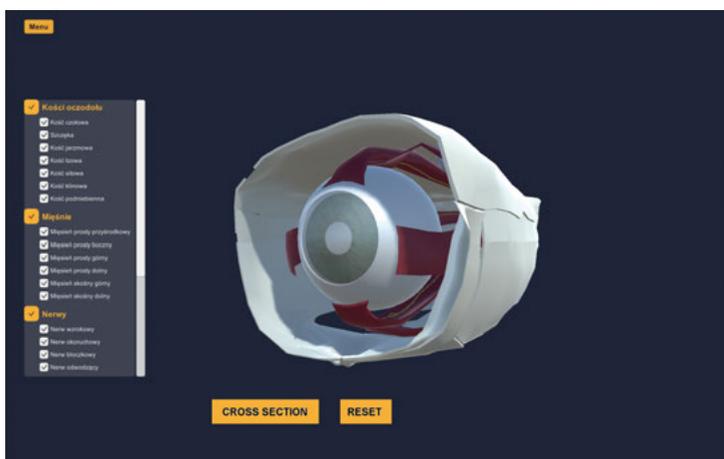

Fig. 4.1: The anatomic model window—full view [1].

buttons at the bottom of the screen. The model can be rotated using the arrow keys or W, S, A, and D keys as well as zoomed in/out with a scroll of a computer mouse.

Pointing a particular element with a mouse pointer makes it highlighted in blue and displays its name at the top of the screen (Fig. 4.2).

Pressing the space key while a particular structure is highlighted allows to separate it and deactivate other elements of the model. Moreover, at the same time, the description of this structure is displayed on the right side of the screen (Fig. 4.3). Clicking the right mouse button allows to go back to the previous window [1].
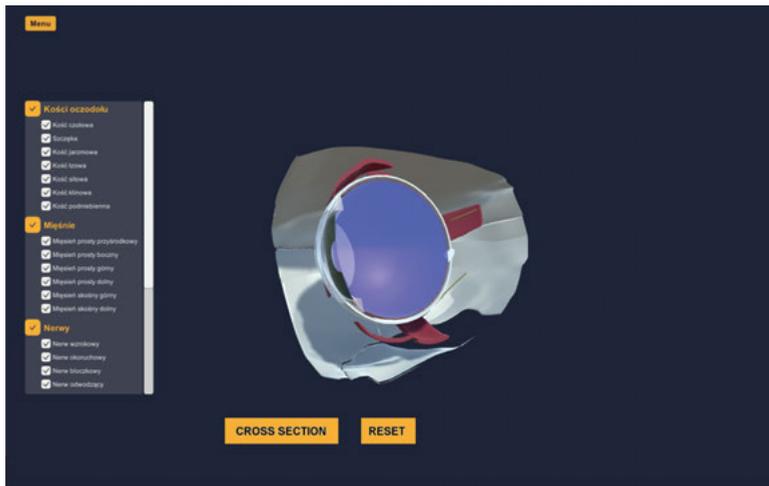

Fig. 4.2: The anatomic model window—hemisection [1].

Fig. 4.3: The anatomic model window—distinction of a structure [1].

The game allows to view the inner structures of the organ of sight, too. The player can do it in two ways—by double clicking the left mouse button or by selecting an appropriate switch in the menu panel on the left side of the screen. The action can be withdrawn by clicking the right mouse button or by selecting an appropriate switch in the menu panel. Clicking any of the following buttons *Kości oczodołu (Eye socket bones)*, *Mięśnie (Muscles)*, *Nerwy (Nerves)*, *Gałka oczna (Eyeball)*, and *Inne (Other)* causes accordingly turn-on or turn-off of all of the elements of the model that belong to the particular category (Fig. 4.4) [1].

The main button marked as *Quiz* takes the user to the quiz window. At the beginning, the user is asked to choose the language in which the names of the anatomical structures during the quiz will be presented. There are two options to choose from—Polish or Latin (Fig. 4.5a). At the end of the quiz, the user is informed about the result that he/she obtained (Fig. 4.5b, c). The test can be repeated or a new test can be taken [1].
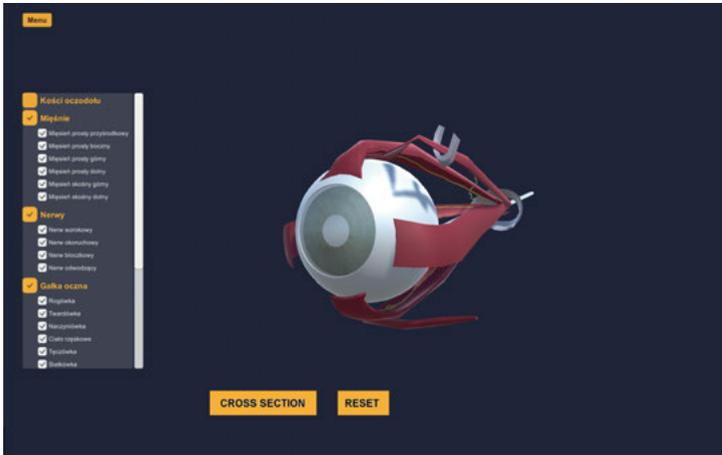

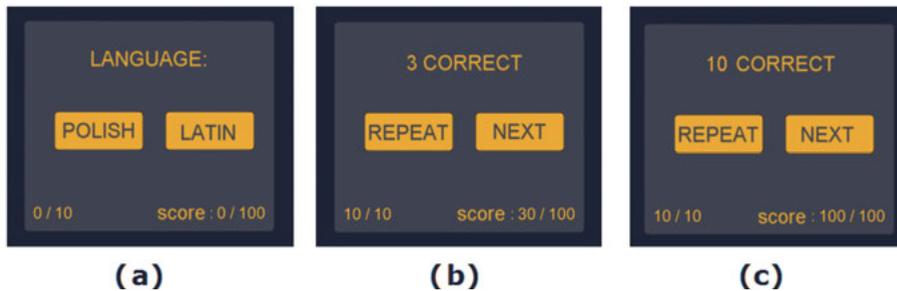**Fig. 4.4:** The anatomic model window—the eye socket bones tuned off [1].

Fig. 4.5: Extracts of the quiz window: (a) choice of the language, (b and c) the end of the quiz [1].

Each quiz consists of 10 questions in which one out of four answers should be marked. While solving the quiz, the number of the question and the result obtained so far are displayed under the current question (Figs. 4.6 and 4.7) [1].
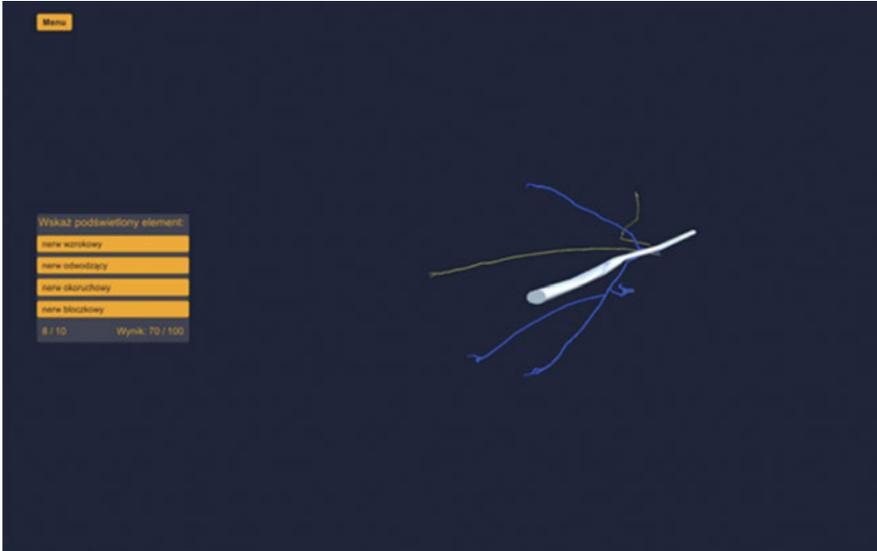

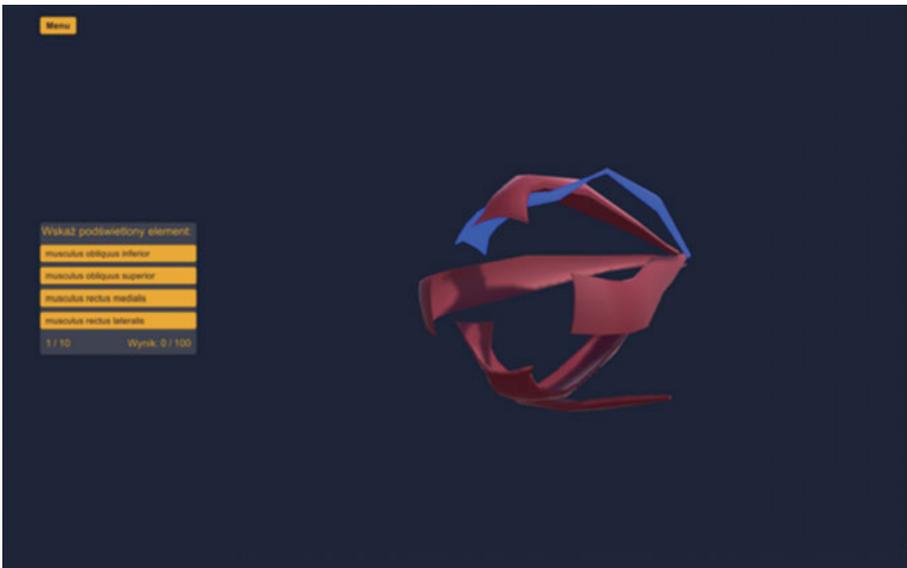**Fig. 4.6:** The quiz window—questions concerning Polish terminology [1].

Fig. 4.7: The quiz window—questions concerning Latin terminology [1].

The last option available is the *Przegląd zaburzeń (Overview of disorders)* button that takes the user to the part of the game dedicated to disorders of the organ of sight. The user can get familiarized with three eyesight defects and four diseases [1]. The application allows to get familiarized with particular defects and the way of perceiving the world by a person with such a defect. Figs. 4.8 and 4.9 present the disorder panel of myopia and astigmatism.
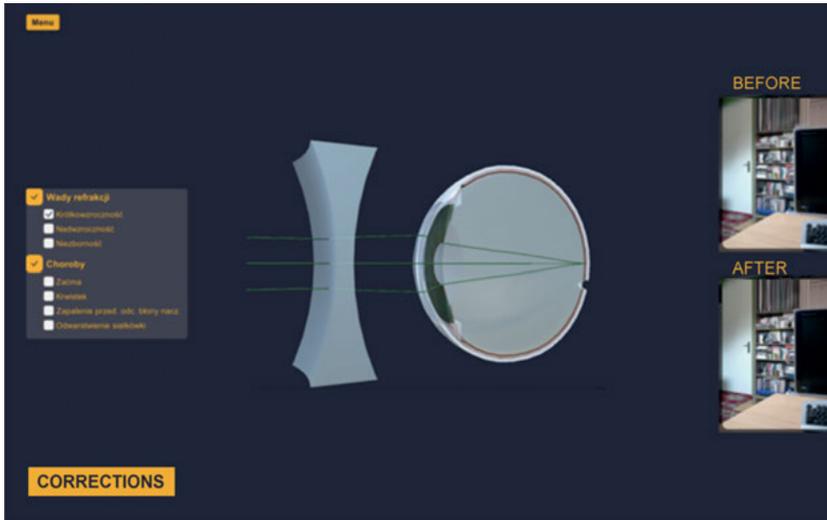

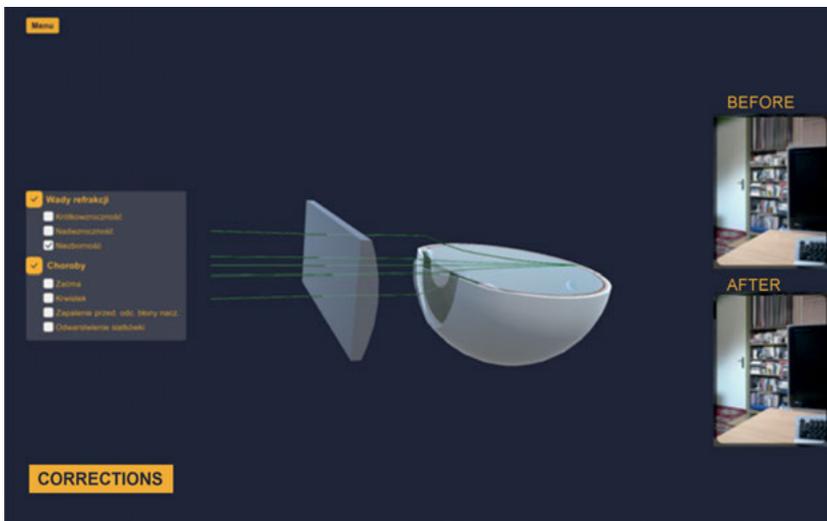**Fig. 4.8:** The window for disorder of myopia "before" and "after" correction [1].

Fig. 4.9: The window for disorder of astigmatism "before" and "after" correction [1].

The user can always go back to the main menu after clicking the "Menu" button, which is visible in the upper left corner of the screen or pressing the "Esc" key. The application can be quit after clicking the "Wyjście" (Quit) button.

4.4 Summary

The presented game belongs to the category of serious games in which the main role is to teach through playing. The demonstrated application is dedicated to pupils, students, and all other persons who are interested in getting acquainted with anatomy of the human eye and defects of the organ of sight. In the future, the game can be extended by elements of a model of the correct anatomy (of e.g., lacrimal apparatus, conjunctivas, eyelids, and vascularity) as well as by a greater number of defects and diseases. The application was tested by second-year medical students at the Jagiellonian University Medical College within the course "Simulation in Medicine." The students did not report any negative remarks, their attitude was rather positive, and they expressed an interest in the subject. They were of the opinion that it was an interesting alternative to medical picture dictionaries, and learning through playing is an interesting solution.

Based on these remarks, it can be concluded that serious games are the future of science and, for certain, an interesting alterative to classic handbooks.

4.5 References

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