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Virtual Reality Learning Environment in Embryology Education

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***Abstract*—**Educational technology is changing the way how students engage and interact with learning materials. This improved the learning process amongst various subjects. Virtual Reality (VR) applications are considered one of the evolving methods that have contributed to enhancing medical education. This paper utilizes VR to provide a solution to improve the delivery of the subject of Embryology to medical students, and facilitate the teaching process by providing a useful aid to lecturers, whilst proving the effectiveness of this new technology in this particular area. After evaluating the current teaching methods and identifying students 'needs, a VR system was designed that demonstrates in an interactive fashion the development of the human embryo from fertilization to week ten of intrauterine development. This system aims to overcome some of the problems faced by the students' in the current educational methods, and to increase the efficacy of the learning process.

***Keywords*—**Virtual reality, student assessment, medical education, 3D, embryology.

I. Introduction

MEDICAL education, training, and diagnosis can be dramatically ameliorated with advanced technologies, such as computer aided instruction, Tele-medicine, World Wide Web, Internet, Augmented Reality (AR), Simulation, and VR, by enhancing and facilitating interaction between the learner and the subject of the study, and providing the learner with more realistic models and situations that closely resemble real tissue and techniques, and doing so in an efficient, time-saving manner [1], [2]-[10].

This is especially relevant in subjects that require a high level of visualization of the spatial arrangements and three-dimensional (3D) relationships between different components such as human anatomy and embryology. These subjects are, however, still largely taught using traditional methods that do not particularly serve the purpose of enhancing visualization [1], [11].

From here emerges the need for novel educational methods that have the potential to overcome the limitations associated with the current system, and to put medical education on track with the advances in technology that are constantly emerging [1]. VR technology is one of the recent advances that has the potential to transform the educational process [12], [13], and this paper demonstrates the design of a novel VR system for the purpose of human embryology education, based on the needs and requirements of the intended users (medical students).

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II. Background

Various studies have researched the usefulness, advantages and challenges of VR for medical education, a topic of research that has gained popularity in the past years [11]. In medicine this technology facilitates several teaching and diagnostic activities. In turn VR teaching methods enable the students to investigate the human body and create a 3D mental picture of the human body structures and relationships. Real-time VR applications offer a rich, interactive, and highly engaging educational context. Notably, it can contribute to increased interest and inspiration in students, and effectively support skill development [14], [15].

One important field in medical education is the study of the anatomy and development of the human embryo, as this knowledge paves for understanding the 3D relations of human anatomy, as well as the pathogenesis of congenital defects and malformations. In the majority of medical schools, this subject is taught using traditional methods, such as two-dimensional images, models, or dissected embryo, all of which come with a number of limitations, such as insufficient visualization, lack of interactivity, lack of availability, and ethical limitations of use [11].

Several studies have suggested that the use of interactive 3D computer generated models in an interactive VR environment as a method for teaching the subject of embryology have the potential to enhance the educational process, by improving visualization, increasing flexibility of the learning process, reducing time and effort needed, and making learning more enjoyable [1], [11].

III. Implementation

This research aims to implement and research a VR application to aid human embryology education. An intensive investigation into the current Embryology teaching system in the Faculty of Medicine in the University of Jordan was carried out and the challenges this system faces were

characterized. The lecturers' and students' needs and requirements were identified and measured against the perceived training system, and limitations associated with current teaching modalities were defined [1].

Using Maya software and Unity engine, a VR system containing a model of the human embryo was designed, in close collaboration with medical experts to ensure the accuracy of the system's content. The human embryo model demonstrates in detail the development starting from fusion of the egg and sperm all the way to the tenth week of development, detailing the formation and growth of the embryo and vital structures within it. Relevant information regarding each stage of development was also added.

The Main Page user interface demonstrated in Fig. 1 contains four components; the Play Animation is the animated sequence video for embryo development life, the Start Course contains Simulation for each stage with relevant information, the About contains abstract about the system, and the Contact contains information about the developers.

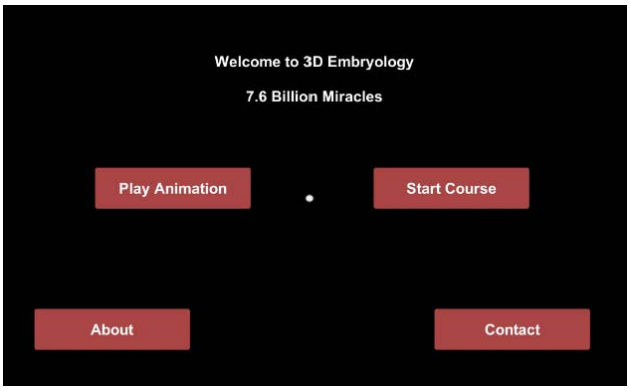

Fig. 1 Main Page User Interface

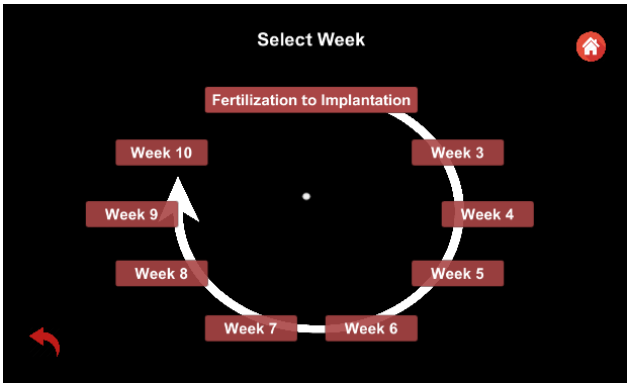

Fig. 2 Select Week User Interface

Select Week user interface (Fig. 2) contains simulations from Fertilization to Week 10. The user can select the stage of embryonic development from this interface, and gain access to details on embryo anatomy and development according to gestational age in an interactive manner, as the models can be manipulated by rotating, and zooming in or out on particular parts to enhance 3D understanding of the structures in question. By using the "view information" functionality, the user can access further information regarding each stage.

Figs. 3 (a)-(e) demonstrate examples of the stages of embryo development. Fig. 3 (a) demonstrates the earliest stage of the embryonic development, the fusion of the egg and sperm, aiming to illustrate the fertilization process.

Fig. 3 (b) shows one of the early stages of development during week 4 of embryonic life. The model demonstrates the surface anatomy of the embryo at this stage. Early landmarks such as the head and tail can be viewed. The model can be manipulated in all directions to see it from different angles and to visualize the 3D spatial arrangement of the structures, by rotating and zooming.

As the user moves through more advanced stages more and more details of the human embryo surface anatomy become apparent. Week 6 (Fig. 3 (c)) contains simulation for the human embryo showing more development facial form, hands and feet buds, and the early umbilical cord. At this stage, the head is larger than the body. Again, the user can make transformations on the model such as Rotate, Zoom and View information.

Week 8 interface (Fig. 3 (d)) contains an extra feature to demonstrate the early evolution of the nervous system, namely a simulation for the human embryo showing nerve cells that are branching out to connect with each another in the embryo's brain.

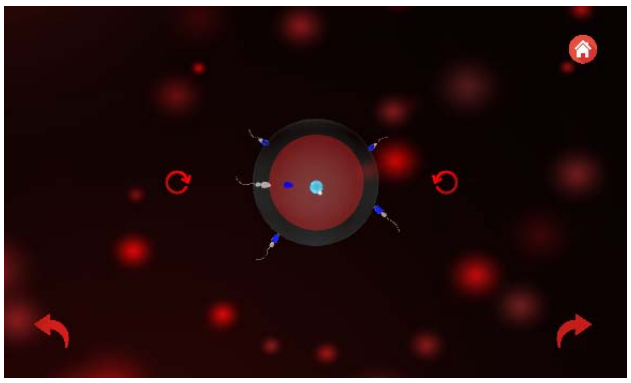

Fig. 3 (a) Fusion of egg and sperm

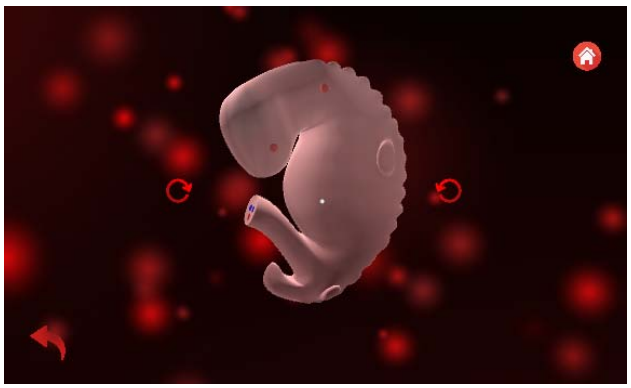

Fig. 3 (b) Week 4

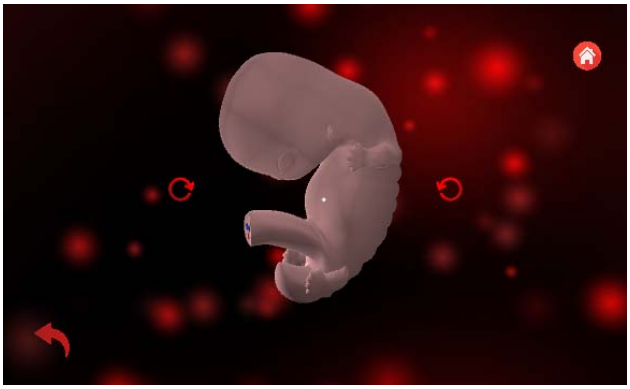

Fig. 3 (c) Week 6

Fig. 3 (d) Week 8

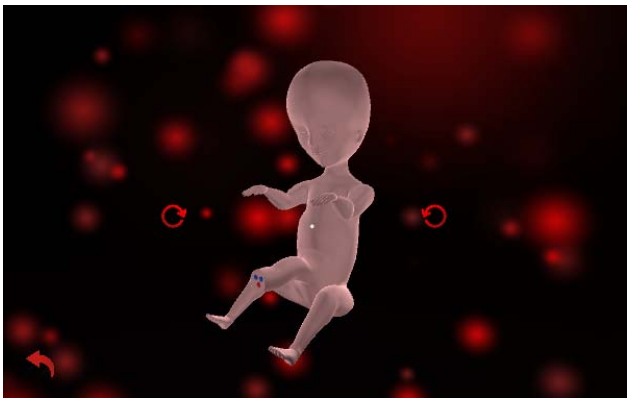

Fig. 3 (e) Week 10

The user can make transformation on the model such as Rotate, Zoom and View information.

Fig. 3 (e) demonstrates a screenshot of week 10, which is the final stage in the series of embryo development stages. It shows a surface anatomy that almost resembles that of a fully-grown individual, as at this stage the development of most of the body's organs and systems is complete.

The user can make transformation on the model such as Rotate, Zoom and View information.

By moving through the stages of development in a sequential manner, the user will gain a comprehensive understanding of the evolution of the human embryo, by learning the changes in the surface anatomy and vital anatomical structures via 3D visualization and manipulation, in addition to the provided additional information that clarifies the images further.

IV. Conclusions and Future Work

VR technology has the potential to contribute to the enhancement of medical education, as it adds value by improving visualization, enjoyability and efficiency of the learning process. The need for applying this particular technology to the process of teaching and learning embryology was identified through evaluating the currently used teaching methods. This paper details the development of a VR human embryo system to be used for the purpose of teaching the subject of embryology to medical students, as an addition to the currently used tools.

In order to evaluate the system further, future work will include a comparative study between traditional teaching methods and the novel VR embryology system.

Future refining of the system will also be undertaken, in the form of adding more details and layers to visualize the embryos internal structures.

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