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Research Article

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The Development of A 3D Interactive Model of Hemodialysis Machine Mobile Application for Learning

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Abstract

Hemodialysis machines are one of the crucial medical devices in biomedical engineering, treating patients with kidney impairment. Thus, the hemodialysis machine is one of the medical devices that are exposed to students of biomedical or medical engineering, and students are given a combination of hands-on learning and theoretical approaches. However, the price of the hemodialysis machine and the cost of maintenance lead the institution towards e-learning, thus requiring a new way of teaching or any addition with the use of technology to assist students in understanding the hemodialysis machine mechanically. This paper presents the first development process, which is the design of a 3D interactive model mobile application of a hemodialysis machine for learning to the readers as a part of the development process for the mobile app. The mobile app could help students gain a deeper understanding of hemodialysis machines using interactive 3D animation models. In this paper, the details of the development and design principles that will be applied to the mobile app will be exposed to readers. The findings in this paper are significant and contribute to the incorporation of a 3D interactive animation model in the learning process as well as enhance understanding and provide better learning outcomes.

Keywords: *Hemodialysis machine, 3D interactive animation, e-learning.*

1. Introduction

1.1. Hemodialysis machine

A hemodialysis machine is a medical device that is used to perform dialysis, which helps patients with kidney failure or impaired kidney function to filter blood through a dialyzer, also known as an artificial kidney, with built-in safety checks to be sure the process is safe and effective. The basic principle involved in dialysis is the movement or diffusion of solute particles across a semipermeable membrane (diffusion) [1]. Fresenius 4008 S is used as a model for the 3D interactive mobile application as it is widely used in hospitals and institutions and it is not far off from the latest model available in terms of functions.

Figure 1: Fresenius 4008 S hemodialysis machine.

1.2. 3D Interactive Animation

3D interactive modeling is the creation of 3-dimensional digit models that can be engaged with and manipulated freely in real-time. Unlike the usual 3D models that are static, interactive models give a more diverse and dynamic experience and, hence can be engaging for learning [2]. 3D interactive models are suitable to use for simulations or training as it is controllable, and less cost involved due to handling the 3D interactive models virtually and doesn't use physical sources. It is also customizable according to the user's needs, which is used to create a hemodialysis machine basics. The integration of 3D models in e-learning for hemodialysis machines has a significant impact on biomedical engineering education. The use of 3D interactive modeling could provide a comprehensive and higher understanding of the structure and functions of hemodialysis machines, providing insight into the anatomy of hemodialysis machines.

Figure 2: 3D animated hospital equipment.

1.3. E-learning

The fast progress of technologies regarding information spread and knowledge increases the interest in technological advancement toward people's needs, especially in education. Thus, eLearning was created. E-learning can be defined as running education through laptops, the internet, and one of the most popular smartphones [3]. By using the mobile application as a medium of learning, students can have full access to information in this case, about hemodialysis machine parts, procedure, reverse osmosis water system, and so on. The following is the advantage of e-learning versus face-to-face learning.

Table 1: Difference between face-to-face learning and e-learning.

E-learning	Subject	Face-to-face
Students could access educational content at anytime, anywhere at any. platform	Flexibility	Students need to follow schedules and go to physical locations set makes it hard for students with varied commitments
Allows students to progress according to their own pace and personalized learning experience	Pace of learning	Students need to keep up with a set pace which could differ for each student
Multimedia resources like videos, interactive	Learning resource	Relies on traditional teaching methods like lectures,
simulations, conventions, or any other online assessments		textbooks, and any printed documents
Can be accessed by anyone accordingly around the world	Accessibility	Constrained by the need for physical presence at a location
Various environments to cater to and less physical materials needed	Cost	Not much environment to cater to students and consumes a lot of physicals materials

2. Methodology

2.1. Block diagram of 3D interactive learning mobile app for hemodialysis machine

Figure 4 shows the concept development. The first process focuses on the research phase which is the pre-survey to identify the necessary features for the mobile application, parts of the hemodialysis machine, and reverse osmosis water system with both of its function, and its procedure of use. For the development process, the 3D modeling of the hemodialysis machine, adjustment of the 3D model using Blender software, development of the mobile app using Unity, and lastly, export to the Android platform. For the testing process, a post-survey is held as a qualitative measure of the completed app. Next, an analysis is made from the post-survey results, and lastly a recommendation for the next improvement.

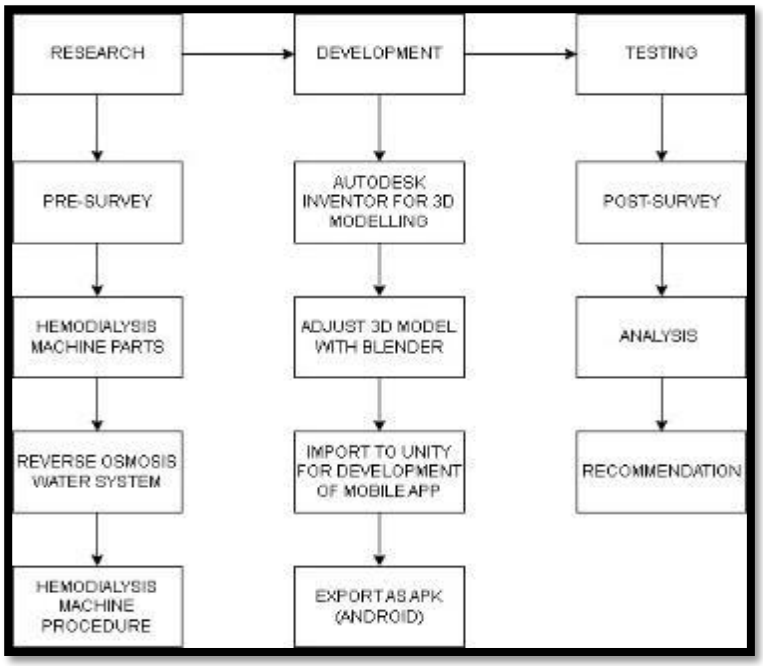

Figure 4: Block diagram of the mobile app development.

2.2. Autodesk Inventor

Autodesk Inventor is a CAD, a computer-aided design software used for 3D mechanical design which is suitable for engineering courses or projects that require accurate dimensions to execute and give stunning in-depth visuals in 3D with animations. It facilitates the 3D mechanical design and visuals, giving the engineers, inventors, and designers more detailed 3D models as well as testing the integrity of the model created before it is built as products or materials.

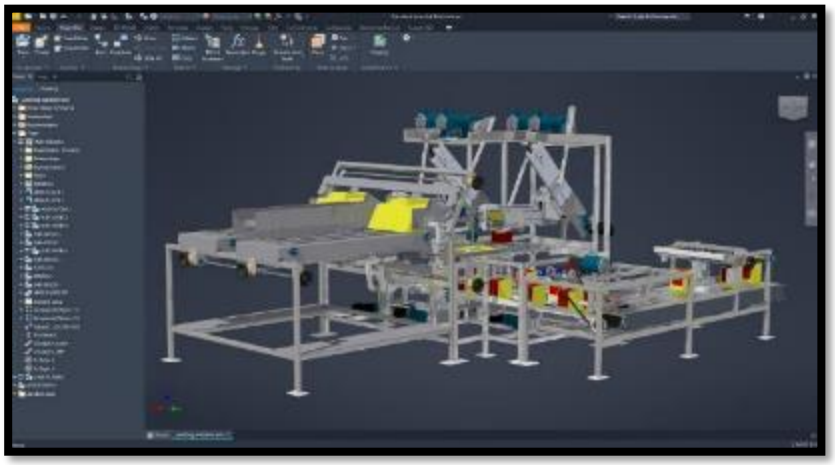

Figure 5: Autodesk Inventor software interface.

2.3. Unity 3D

Unity is a versatile game development platform. The ability to export to multiple platforms makes it the most suitable software to help in making the mobile app for hemodialysis machines. Even though the software is mainly used for making games, educational mobile apps or software could also be created using Unity due to its uniqueness in exporting to multiple formats or platforms [4].

Figure 6: Unity 3D software interface.

2.4. Blender 3D

Blender is an open-source creation suite, that offers a rendering engine to generate realistic and ideal images and animations. It has more capabilities when dealing with 3D models, which in this project, is used for adjusting the 3D model details and polygons until it is suitable for the mobile application.

Figure 7: Blender 3D software interface.

3. Results and Discussion

3.1. 3D Design

The hemodialysis machine created using Blender 3D is created by assembling small parts into one big part. For example, normal 3D usually takes a shape or form sculpted from a prefab shape provided in the Blender 3D software. However, to make it interactive, instead of sculpting an entire object from 1 block of shape, the object will be composed of individual sculpted objects for example the display below, the buttons, LCD, and LED display will be sculpted individually before being assembled into a full-fledged display. By then, each button could be edited and given a command by Unity 3D software for each button and displayed according to the design for mobile application development.

Figure 8: Hemodialysis machine display section designed using Blender 3D that is assembled and each button could be programmed individually.

Along the designing process, students are advised to engrave the symbols instead of creating another individual symbol design when engraved and create a backup file, as the symbols will stay on the buttons or descriptive parts, however, if the design uses stickers the sticker loss is probable from the file or in some cases of file corruption and there will be no symbol on the buttons, thus need to do a separate sticker while for the engraving, the only thing need to do is backup the file [5]. Another piece of advice is if there is no animation involved in certain parts it is advised to do the whole 3D in one go instead of individually sculpting the parts as it could waste time thus limiting the time to focus on the mobile application development process.

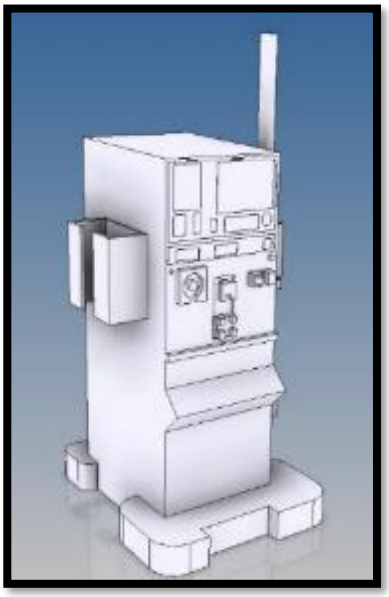

Figure 9: The whole base 3D of a hemodialysis machine. It is sculpted from one block instead of individually shaped and assembled

3.2. Development phase of mobile application

There are three phases in development the 1st phase is the adjustment of the 3D model using Blender. The model is ported into Blender to reduce its details and polygon count, to prevent over-detailing and lagging due to the heavy details of the 3D model. 2nd phase involves tagging the parts of the hemodialysis machine and the function with numbers for easy identification. The 3rd phase is the development of a mobile app using the 3D model. This shifts the project into importing the 3D model into Unity software in OBJ format [6] and beginning the coding of buttons, camera positions, and animations. G.U.I (Generic User Interface) design is also taken into consideration leaning into simpler and easy-to-understand for users or students.

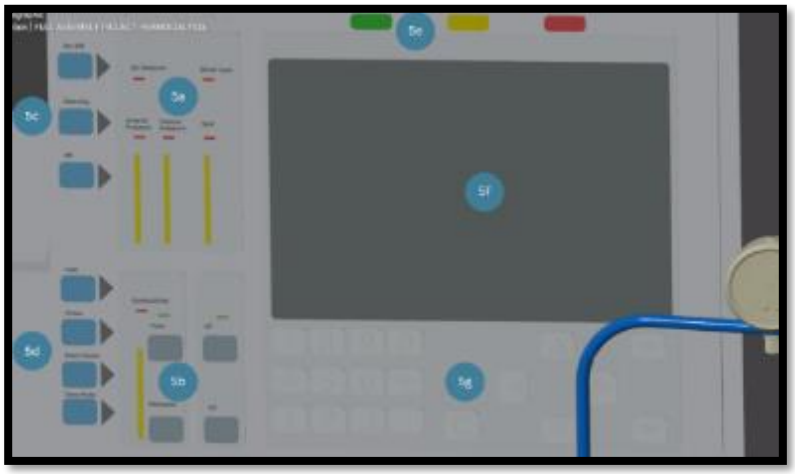

Figure 10: Number tagging and 3D model adjustment in Blender software.

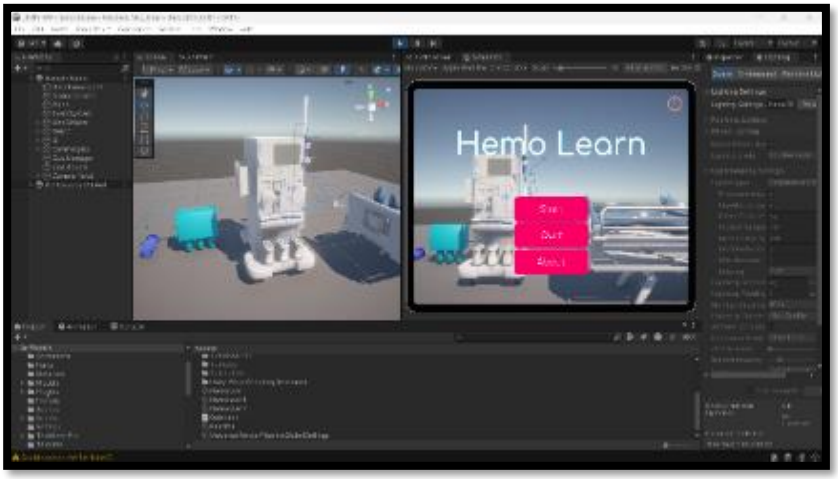

Figure 11: Development of the 3D interactive mobile app of hemodialysis machine for learning.

4. Conclusion

This paper demonstrates the uses of software like Unity, Blender, and Autodesk Inventor in making an interactive learning mobile app about hemodialysis machines. In 3D design, a specific technique is used like the engraving technique as it is suitable to be used for the mobile app development process. The development process, like model 3D adjustments, and development of mobile applications using Unity and export to the Android platform. This shows that Unity software could be used for learning content development with its wide range of platform exports. Blender also could be used to adjust the 3D model created using Autodesk Inventor software as too much detail could cause lagging when exported into the Android platform.

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