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A Novel Virtual Nasal Polyp Removal System Based on Computed Simulation

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Abstract. This paper proposes a simulation platform to train and study the specific nasal polyp removal procedure using a human anatomy atlas in the three-dimensional (3D) model, the Unity3D real-time development platform, this paper also compares articles in the field of simulation applied to medical studies. The standard procedure to remove paranasal polyps is Functional Endoscopic Surgery of the paranasal sinuses. A rigid optical fiber that guides the removal of polyps through instruments to restore adequate sinus drainage. Currently, many simulators are designed to simulate the performance of medical procedures such as these. The main purppose is to provide a new solution for training, planning and testing Medical procedures. Using the aforementioned platform, we built a polyp model using the virtual physics system called Metaball, together with Atlas3D we explored the anatomy of the six paranasal organs and we simulate their removal. The simulator applies the concepts of gamification, using the mouse and keyboard control system with a graphical interface for changing tools and timer. The tools were developed to simulate cutting and suction, functions common during the actual procedure. After field testing using the TAM and SUS, we obtained a satisfactory result of 80%, grade B. Finally, the results obtained through the techniques performed, presenting the functionality and usability of the software, and also a comparison of the systems developed in this study with the current works that follow the same theme. This preliminary study demonstrates the potential that culminated in the creation of an environment for the removal of paranasal polyps, partially validated by teachers and students, who had active and constant participation throughout the process, whether in the development of tools, of clinical cases, or in the training carried out.

Keywords: Virtual reality. Computer graphics. Surgery simulation. Biomedical engineering. 3D modeling.

1 Introduction

The surgery simulation is now an integral part of surgical education. Before that surgeon develop and acquire skills through practice, and these techniques are learned using animals, cadavers, dummy's, volunteers and patients. There are a lot of problems with these approaches: animals have a different anatomy, cadavers cannot provide the appropriate physiological response, most dummy's cannot be used twice, besides the high cost and there is a risk to the patient safety while the caregiver is learning.

The virtual simulation techniques have experienced a great progress in the last couple of years. It has been anticipated that such techniques could be very beneficial for medical training and presurgery planning. Receiving pretraining in a core set of surgical skills and procedures before novice practitioners are exposed to the traditional apprenticeship training model could reduce both the skill acquisition time and the risks patients are exposed to due to surgeon inexperience (PENG et al., 2019)

The recent advances in computer technology permit a new class of simulator to be developed using virtual patients with realistic anatomy and physiological responses. Real surgical or clinical simulation models are being developed based on anatomical images of real patients using exams like computed tomography and magnetic resonance imaging. These models may provide opportunities for anticipating the procedures that will be done in those patients, helping minimize eventual risks and complications (Nogueira Júnior; CRUZ, 2010).

One of the best things that was achieved with these simulations was, the patient safety is not compromised while the student is learning.

Neurosurgeons are increasingly demanding simulators whose capabilities guide them through procedures. Such simulators have led to significant advances in the management of neurosurgical disorders and thus to a significant increase in successfully treated neurological diseases. Realistic simulators combine medical imaging, segmentation, real-time volume rendering, physical modeling and simulation, collision handling, visualization, and haptics (WURM et al., 2011).

Advances in medical technology and changes in the practice of modern medicine are forcing a reevaluation of the profession's teaching methods. Surgical education uses the apprenticeship model, formalized as residency programs. In the United States, surgical residencies generally require five to seven years to complete (LIU et al., 2003).

The problem is exacerbated by rising health care costs. Health insurance carriers are encouraging participants to choose outpatient over traditional inpatient surgery (GLIED, 2003).

This paper presents a system designed to simulate the medical procedure of nasal polyp removal, offering an accessible and cost-effective training method for otorhinolaryngology students. Considering the high costs of traditional training methods, this work provides a practical and affordable solution for students to acquire essential knowledge and develop their skills. A key feature of this project is its emphasis on realistic simulation, leveraging advanced technologies such as Unity 3D to replicate real-life scenarios with sophisticated graphics capabilities. Additionally, any websites of the software manufacturers consulted during development should be included in the bibliographical references for transparency.

On the simulated disease is applied appropriate textures to match the real one, the polyp has touch sensitivity build with a physics simulator to provide realism to the procedure.

The system is developed for a computer, in order to facilitate the use and accessibility of the system, using common computer peripherals, keyboard and mouse, which is an important contribution in the area of healthcare in surgeries.

With the progress of the technology, simulations of real medical environments and user interactions can be achieved. In the following sections, we will present a brief overview of current systems of simulation of medical procedures, on various display platforms and then the simulator developed in this work. Along with the system architecture and technology and design techniques.

The remainder of this paper is organized as follows. In Section 2, methods for use of surgery simulators. Section 3 operations system developed. Section 4 presents the results obtained and Section 5 presents the conclusions of this paper.

2 Methods

It's known and scientifically demonstrated that the use of surgery simulators provides the practitioner with a fast method to developed the necessary skills. And this is despite the well-known limitations that nowadays surgical simulators have (MENA et al., 2015).

The high cost of the simulator is still a major concern, it is true that it helps students and even highly trained surgeons, but most simulators are linked to heavy hardware demanding a lot of space which may be inaccessible to many institutions. Trainees and experienced surgeons can benefit from surgical simulation;however,current models are expensive and impractical for widespread use (BARBER et al., 2018).

2.1 Human Atlas 3D Model

The Human Atlas, a 3D model representing the standard human body, was obtained in OBJ file format and serves as a foundational element in this project. Atlases of human anatomy play a crucial role in interpreting results, visualizing information, and processing data effectively (SHATTUCK et al., 2008).

The 3D Human Atlas used in this project was developed by [Insert Manufacturer Name Here], whose terms of use were adhered to in accordance with the manufacturer's licensing agreement. The usage of this atlas, whether in whole or in part, complies with the conditions specified for reuse, ensuring that the intellectual property rights and copyright of the original creator are fully respected. Details of the licensing agreement are documented in the project's references to provide transparency and alignment with legal requirements.

The complete model, as the standard human being had all organs, bones, veins etc. Therefore increasing his size on a total of 223,657 kB, when exported to unity it was hard to work with, causing an increasing demand of processing power.

After a simple refactoring, as shown in Figure 1, it was able to reduce his size to 145 kB total. Discarding all the non usable anatomy parts, since the objective of this work is a simulation of an nasal surgery, only the head and neck area is important. For consistence in the simulation the whole skin was kept as it is.

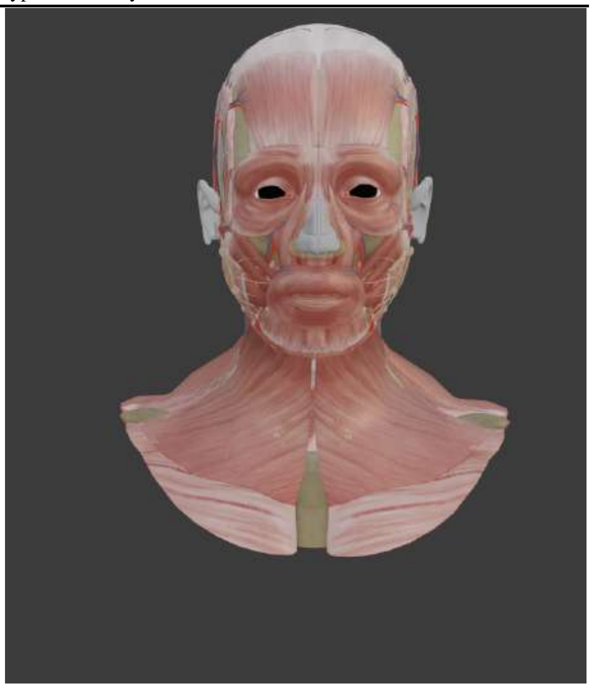


Figure 1: Atlas Human Head.

2.2 OBJ File Format

The OBJ file format is one of the most important file formats in 3D printing and 3D graphics applications. Obj is an open format for storage of geometry of objects, this format can use textures or colors to display models. This format has received its popularity because of simplicity of creation and storage of models and also because of its openness (OSTROVKA; TESLYUK, 2020).

It is the preferred format for multi-color 3D printing and is widely used as a neutral interchange format for non-animated 3D models in graphics applications. OBJ files are used by Wavefront's Advanced Visualizer application to define and store the geometric objects. Backward and forward transmission of geometric data is made possible through OBJ files. Both polygonal geometry like points, lines, texture vertices, faces and free-form geometry (curves and surfaces) are supported by OBJ format. This format does not support animation or information related to light and position of scenes. An OBJ file is usually an end product of the 3D modeling process generated by a CAD (Computer Aided Design).

Nowadays, computer-aided design/computer-aided manufacturing technology seems to be an interesting way to promote both business and safety, being more comfortable for patients and more accurate than traditional technology (BARENGHI et al., 2019).

The default order to store vertices is counter-clockwise avoiding explicit declaration of face normals. Though OBJ files declare scale information in a comment line yet no units have been declared for OBJ coordinates.

OBJ filetype as it is an open format, generally accepted as universal, and used in engines, development tools,and simulations, unlike binary files which can be software and platform specific (POSSEMIERS; LEE, 2015). OBJ is an ubiquitous 3D format that has wide software support in 3D modelling and 3D visualisation software (BILJECKI; OHORI, 2015).

2.3 Simulator

Simulation is a method or technique that is employed to produce an experience without going through the real event. Simulation opens up opportunities that are not available in real event learning, such as apprenticeships, and at the same time provides a multifaceted safety container for learning (SO et al., 2019).

It uses something called modeling to figure out the result of the simulation. A model is a representation of an object or process that describes and explains that phenomenon when it can't be experienced directly.

A model is not a full description of a particular context or phenomenon but an abstract rendering that is amendable to design and manipulation by the modeler (KNUDSEN; LEVINTHAL; PURANAM, 2019)

In science, we come up with lots of rules and laws to describe the world, and those models together allow us to create simulations. For example, we might study the way air molecules move when there is a heat source nearby and create a model to describe it. Then we can put dozens of molecules together and do a simulation.

The Figure 2 presents a flowchart of the system development, it starts with the model acquisition and ends with the simulation procedure.

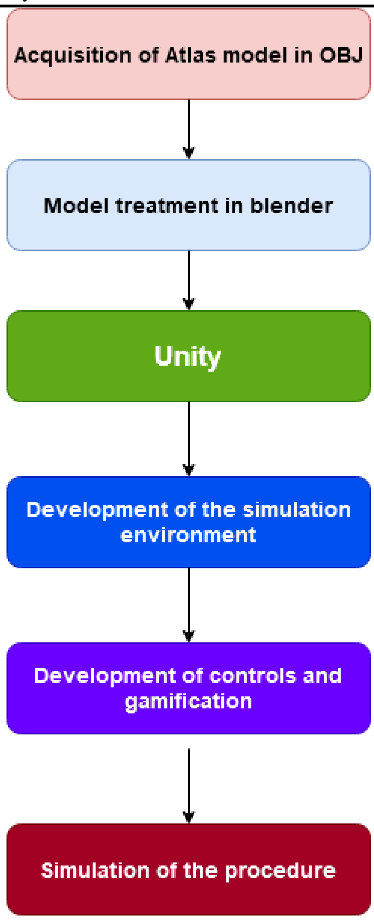


Figure 2: System development diagram.

2.4 Acquisition of Atlas

With the human atlas on Blender, the first thing that need to be done is discard all the exceed anatomy parts, there for only the head and neck area is important to the simulation.

Blender is a powerful 3D computer graphics engine, used in many modelings and medical simulation (DURRANT, 2019). The overall detail of the texture seen on blender will be reduce to match the low-end platform. This model has a 100 textures files and 80 materials applied to the objects, and they are classified by the anatomy parts, as: Hair, skin, veins, arteries, bones, muscles, organs lymphatic system and nervous system. In the current state this model require a high processing power, utilizing 5 GB of RAM (Random access memory) an overall of 78% the total system memory, the Figure 3 shows whats left underneath the skin.

This remodeling allows the model to be more efficient and light, reducing the processing power enables the building of a more accessible platform.

Removing all the useless anatomic parts we have 96 texture files and 30 materials applied, leaving a more efficient and light model. The result can be seen in Figure 3.

Materials control the appearance of meshes, curves, volumes and other objects. They define the substance that the object is made of, its color and texture, and how light interacts with it (BLAIN, 2019).

The new memory status shows the improvement, reducing almost half of the ram usage, utilizing only 48% of the total system memory, as seen in Table 1.

Table 1: System Performance.

Pre-treatment		Post-Treatment	
Memory Usage	78%	Memory Usage	48%
CPU Usage	7%	CPU Usage	4%

Figure 3: Human Head on Blenderm.

2.5 Simulation on Unity

Unity is a widely used cross-platform game engine that allows developers to create interactive 2D and 3D applications, including games, simulations, and virtual environments. It provides a visual editor for designing and arranging elements in a virtual space, combined with a robust scripting framework for implementing logic and interactivity.

In Unity, a scene represents a container that holds all the elements for a specific environment or level in the application. This can include objects such as 3D models, lights, cameras, textures, and scripts. Scenes are essentially like stages in a play, where all the components come together to form the visual and functional aspects of that segment of the application.

In this project, a new scene was created to house the imported model of the nasal anatomy. While configuring the scene, the realism of the textures was deliberately reduced to balance the application's visual fidelity and ensure it remains lightweight and accessible for a broader audience.

The Unity3D game engine provides a rich set of libraries and assets for user interactions, and custom C# scripts were used to provide a bird's-eye-view mode of 3D zoom, pan, and orbital display (LAKSONO; ADITYA, 2019).

A bed was added to match a real surgical procedure, keeping as simple as possible but without harming the realistic learning factor, in this stage only the model and the bed is running on unity, and the simulator controllers is ready to be build. Figure 4 shows the model and the bed imported on Unity.

The menu shown in Figure 5 will be visible though the whole procedure, the timer starts as soon the start button is pressed, the stop button stops the timer, reset button restart the whole operation and the end button closes the simulation. The orange button are used to swap the surgical tools.

2.6 Nasal Polyp 3D

One of the most important element on this simulation is the nasal polyp, it was applied on 3D Atlas to create an environment as real as possible.

To make sure the polyp 3D is similar enough to a real one, not only a good texture must be applied but the physics is also very important. In order to build a good and light physics, in this case a metaball deformer is the most suitable, using a script on MVS IDE.

A metaball, a kind of implicit surface, is a modeling technique for representing a smooth curved shape by using density distributions defined in a space (TAKAYAMA, 2017)

Metaballs, also known as blobby objects, are a type of modeling technique using implicit surfaces. We can

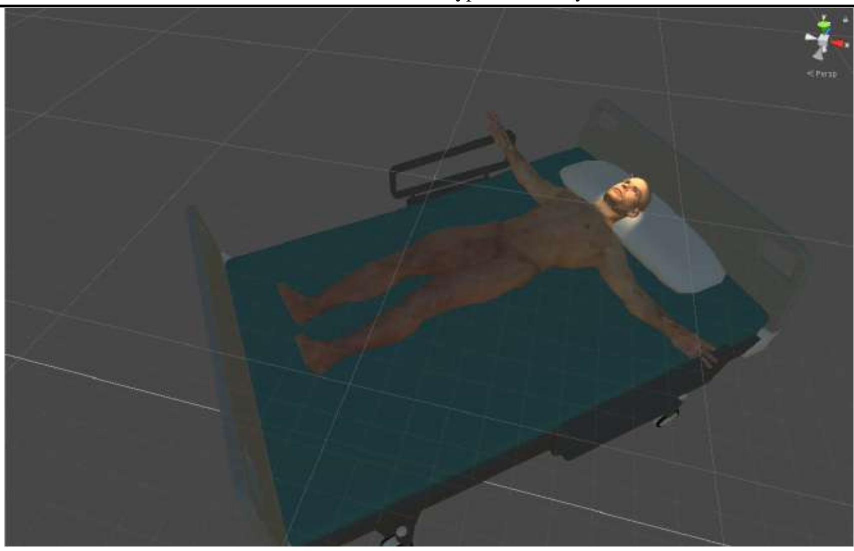


Figure 4: Atlas on Unity

Figure 5: Simulator main buttons.

imagine a metaball as a particle surrounded by a density field, where the density attributed to the particle decreases with the distance of its location. A surface can then be defined by taking an isodensity in this created field. The higher the value of this isodensity, the closer it will be to the generating particle. The powerful aspect of metaballs as a modeling tool is the way in which these density fields can be combined. By simply adding the influences of each metaball, we can obtain smooth fusions of these spherical fields of influence.

A system of metaballs is used tocalculate values in a scalar field, that can then definean isosurface which is rendered as a triangle mesh (STEEN, 2020).

The key to using metaballs is to define an equation to specify the influence of a given particle on a given point in space was used fields with exponential decay for each particle combined with a Gaussian curve of height b and standard deviation a. If r is the particle's distance to a certain field location, the particle's influence is $b * exp(-ar)$.

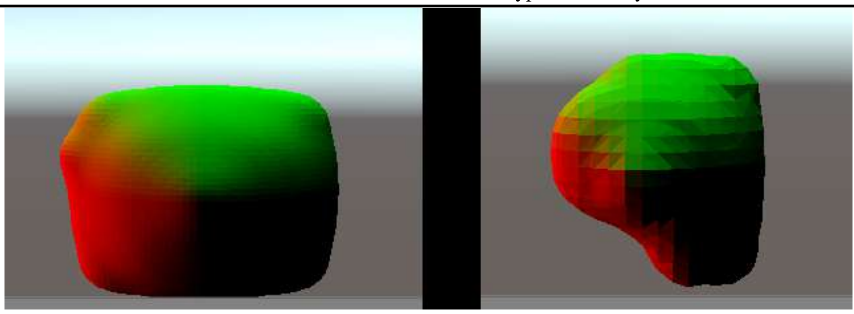
The metaball representation was first demonstrated by Nishita, Dobashi e Nakamae (1996) in which the clouds are defined by density fields, which are modeled by the metaballs. The refinement of cloud shapes was modeled by applying the Fractal method to metaballs (ZAMRI; SUNAR; KASIM, 2020).

The polyp build with the metaballs can simulate the deformation made by the microdDEBRIDER tool, giving greater reliability in the use of the software. As shown in figure 6, 6a represents the full anatomy of the polyp, and 6b is the result of the interaction with the microdDEBRIDER.

2.7 Final Model

Now we have the atlas model ready and our polyp with physics, we join them together applying the polyp into the nasal cavity, as shown in Figure 7.

The procedure can't be completed without the surgical tools, in this case the main tool to remove nasal polyps is a microdDEBRIDER. A simple cylinder build in Unity as well, as shown in Figure 8, using a light function and black edges to resemble the camera view, as the real procedure. In order to simulate the removal of the polyp a simple script was created using Trans-



(a) (b)

Figure 6: Polyp deformation.

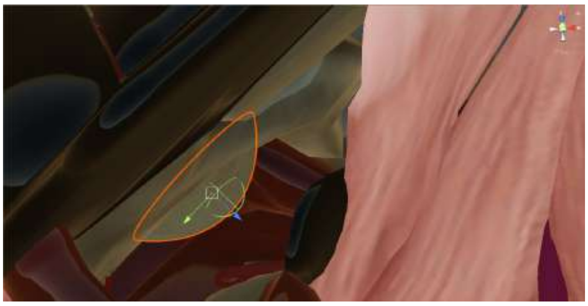


Figure 7: Polyp in nasal cavity.

form.localScale function available in Unity to simulate the vacuum-shaver, using metaballs to deform on contact, giving a good impression of the object being sucked on by the microdDEBRIDER.

Scripts are programs created with programming language supported by selected software. This methodology uses the game engine Unity 3D, therefore scripts were created using C#, which is a programming language supported by Unity 3D (GABAJOVÁ et al., 2021).

3 System operation

This simulation was developed using an 3D atlas model, with an didactic navigation system to identify the disease, and specialized tools to execute the procedure. The 3D file model (atlas) acquired for the application, as well as the modeled disease, were imported into the Unity software development environment, which allowed the development of gamification functions. All software is developed to have an interactive interface and, at the same time, maintained the easy use and access to resources by the user.

Figure 8: Endoscopic microdDEBRIDER.

The diagram shown in Figure 9 demonstrate the usability of the system, it shows the entire flow that the software user will go through. Starting with a screen selection, passing through the pathologie, until finalization occurs.

The Figure 10 is the first scene of the simulator, there are two options, for this work "Nasal Polyp Removal"must be selected.

In the same scene, a menu composed of a timer that starts counting when start button is pressed, and a set of buttons responsible for stopping, ending, restarting and selecting tools. In addition to these buttons, it is also

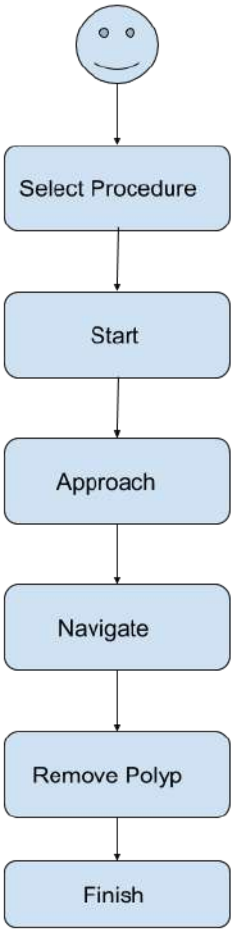


Figure 9: Usability diagram.

possible to observe.

For the proper usage of this simulator, the hardware must follow the requirement specified in section 2.5.

3.1 Start Procedure

On selection, a new scene will be shown, Figure 11, with the 3D model in the center.

To facilitate access to the simulator software commands, the standard mouse and keyboard are used. The commands developed, use the settings already existed games to promote greater ease and provide better navigation control in simulation. In Figure 12 an example of simulation is presented.

The navigation keys on the computer keyboard is used to control the camera which is responsible for the view during the navigation.

The controls are specified in Figure 13, 13a, represents the touch of the navigation key to the left when you want to move the camera to the left, Figure 13b, represents the touch of the key up navigation when you want to move the camera up, Figure 13c, represents the touch of the navigation key to the right when you want to move the camera to the right and Figure 13d, represents the touch the navigation key downwards when you want to move the camera downwards.

After the start button is pressed, the camera will change and a magnifier can be seen next to the nose, after pressed, the endoscope will be introduced into the nasal cavity. The system allows the simulation of the nasal endoscopy exam with poly removal, enabling navigation inside the paranasal cavity.

Into the paranasal cavity, the user can find many polyps, as shown in Figure 14. At this moment the DEBRIDER can be used to remove the polyp.

After the navigation and the user of the drbrider, the nasal cavity is cleared (As shown in Figure 15).

3.2 Realism assessment

Realistic health simulation has been a strategy explored in teaching laboratories and simulation centers to provide a reflective and transformative environment for the development of essential skills for patient-centered care, and achievement of the objectives and results proposed in this learning and improvement process.

Given the availability of high resolution medical imaging with different modalities,the interactive anatomical models reconstructed by patient-specific image data can be expected with increasing accuracy and realism (HAO et al., 2016).

To build an assertive surgery surgery simulator, a soft tissue deformation with collision detection algorithm must be applied, it is one of the most important elements to have.

The default linear elastic model of the interaction force has been replaced with a more realistic and physically consistent non-linear viscoelastic model (FAZIOLI et al., 2016). Figure 16 presents a comparison of mesh and texture modeling results.

4 Results

The validation tests were made with partnership of Unichristus university, due to Covid-19 restrictions we had a small sample of 20 medical students, of all our volunteers, ***63%*** have taken a monitoring class.

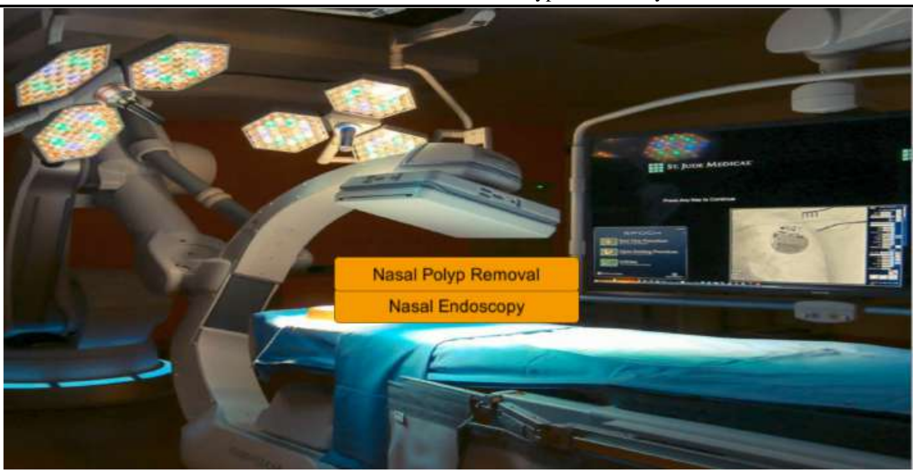


Figure 10: Menu Screen.

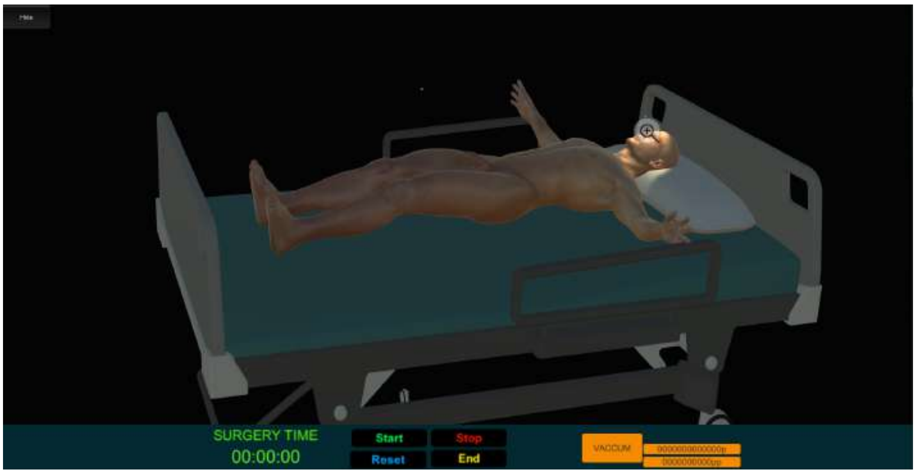


Figure 11: Start Screen.

Monitoring is a process based on clear aims and is performed to assess the quality of work, to show which targets and standards are achieved and which are not, and to clarify where improvement is needed (CHANGIZ et al., 2019)

After the volunteers tested the simulator, they had to fill tow forms, the first one was Technology Acceptance Model (TAM). In the literature, it is possible to identify several theories that try to predict the impact of technology in human behavior, however in this research we will use the Technology Acceptance Model.

TAM was proposed by Danevičius et al. (2018), being an adaptation of the model of the Theory of Reasoned Action (TRA). For being so universal, the TRA was specifically modified to create acceptance models in technology from information, as in the specific case of TAM. Table 2 presents the TAM results evaluation.

Table 2: TAM results evaluation.

	Real. eval.	Control. eval.	Simu. Utility
Agree	93.3%	79%	80.0%
Neutral		14%	13.3%
Disagree	6.7%	7%	6.7%

The tests had an average of 3 minutes per volunteer, after that we could collect the TAM results. In Table

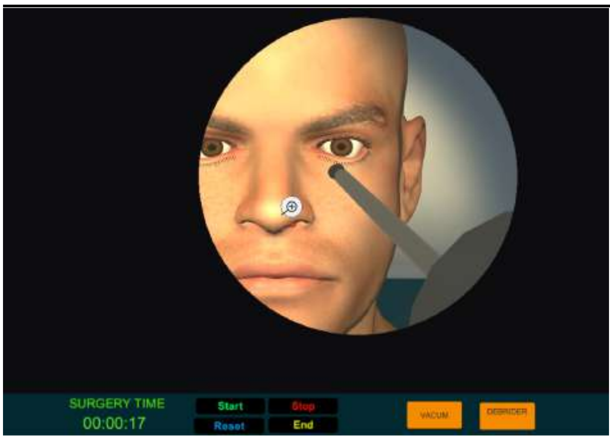


Figure 12: Endoscope Insertion.

2 under Realism evaluation we can see that more than 93% of the volunteers agreed that the simulation had a high fidelity in realism and anatomy representation. Under Controllers evaluation we had less acceptance due to the use of mouse and keyboard, we could not represent the real equipment in test.

In this last phase of TAM, Simulator utility, we asked if the volunteers were learning faster, if this simulator could be used to rehearsal a specific surgery, and if it could be used in the classroom. We had 80% of agreement, overall the technological evaluation was a success.

The second test applied was the SUS form, the System Usability Scale (SUS) provides a quick, reliable tool for measuring the usability. It consists of a 10 item questionnaire with five response options for respondents; from Strongly agree to Strongly disagree. Originally created by John Brooke in 1986, it allows you to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications.

To evaluate the SUS form we need two steps. Fisrt Step - Convert the scale into number for each of the 10 questions:

- Strongly Disagree: 1 point;
- Disagree: 2 points;
- Neutral: 3 points;
- Agree: 4 points;
- Strongly Agree: 5 points.

Second Step - Calculate:

- X = Sum of the points for all odd-numbered questions – 5;
- Y = 25 – Sum of the points for all even-numbered questions;
- SUS Score $= (X + Y) \times 2.5$.

The rationale behind the calculation is very intuitive. The total score is 100 and each of the questions has a weight of 10 points.

As odd-numbered questions are all in a positive tone, if the response is strongly agree, you will want to give them the maximum point which is 10 for each question. If the response is strongly disagree, you will want to give them the minimum point which is 0. By subtracting 1 from each of the odd-numbered questions, you ensure that minimum is 0. After which, by multiplying by 2.5, you ensure that the maximum is 10 for each of the questions.

Vice versa, for the even-numbered questions in a negative tone, if the response is strongly agree, you will want to give them the minimum point which is 0 for each question. If the response is strongly disagree, you will want to give them the minimum point which is 0. As such, by subtracting the points of each question from 5, you ensure that minimum is 0. After which, by multiplying by 2.5, you ensure that the maximum is 10 for each of the questions.

Applying the previous steps, we have ***80%*** scores, the Table 3 give us a grade ***'B'***, a good result.

Table 3: TAM results evaluation.

SUS Score	Grade	Adjective Rating
80.3	A	Excellent
68-80.3	B	Good
68	C	Okay
51-68	D	Poor
51	F	Awful

5 Discussion

Simulation as a technique and a tool in health science education never will be able to replace the patient, much less the essence of doctor-patient contact; without However, we can state the advantages that as a tool has in the fascinating world do of medical education. Secondly, we must clarify that the Simulation without the

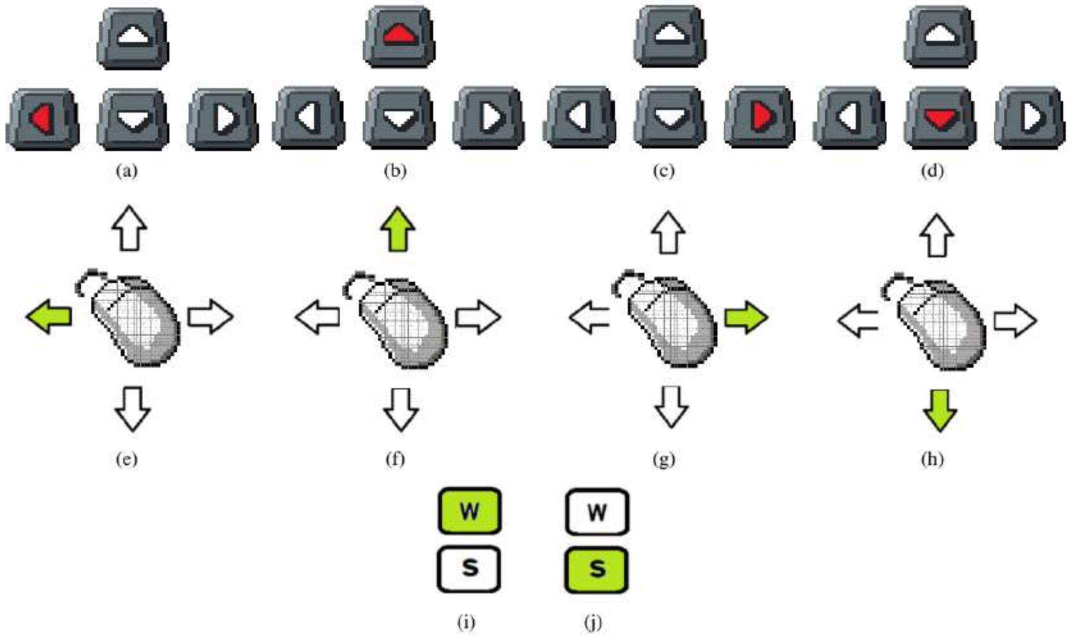


Figure 13: Simulator controllers.
(a) left navigation key on the keyboard, (b) key navigation key up the keyboard, (c) navigation key to the right of the keyboard, (d) navigation key down on the keyboard, (e) handling the mouse left, (f) handling the mouse forward, (g) handling the mouse backwards, (h) handling the mouse to the right, (i) alphanumeric key "W"on the keyboard and (j) alphanumeric key "S"on the keyboard, moving the camera to the desired directions.

Figure 14: Paranasal polyp.

theoretical and updated support of the processes clinical and/or surgical can become a practical component of knockoffs without the critical reasoning skill required located in specific contexts (LÓPEZ; SPIRKO, 2007).

However, the use of simulators can replace part of the current teaching methodology, as seen in the study ***'Can simulation replace part of clinical time? Two parallel randomised controlled trials'***

These RCTs provide evidence that clinical education in an SLE can in part (25%) replace clinical time with real patients without compromising students' attainment of the professional competencies required to practise. (WATSON et al., 2012)

We can use Marta Bez's work as comparison. Her work has as its objective proposing a model for the use of technological tools (especially simulators of clinical cases) as mediators of the implementing process of active methods of learning in the Medicine Teaching (BEZ, 2013).

In Bez's usability test, she's got a 85.71%, giving her an 'A' grade, we've got 80%, a 'B' grade. Now in Bez's Technology Acceptance, she's got a 93.33% score, we've got 93.00%.

And Lima's. Interpretation of the electrocardiogram (ECG) is essential for the identification of cardiovascular diseases, which are among the main causes of death

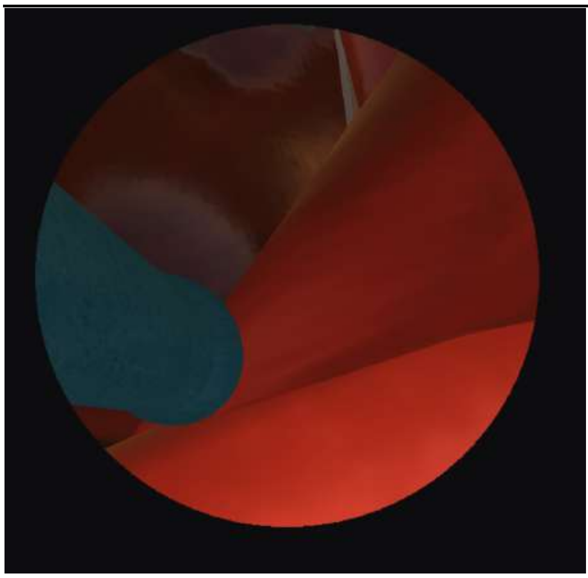


Figure 15: Nasal cavity cleared.

worldwide. The acquisition of this competence is essential in the training of general practitioners, and the use of new teaching tools, supported by technology, such as mobile learning, can facilitate the acquisition of this knowledge (LIMA et al., 2020).

In Lima et al. (2020)electrocardiogram simulation he's got a 85.3%, grade 'A'.

In FARIA's, he's got a 75.4 score, meaning a grade 'B'. OSCE 3D was developed with the participation of a multidisciplinary team composed of three professors of a medicine course and a computer course, an analyst of systems, a programmer and a graphic designer. the composition multidisciplinary of the development team had as objective to build a system that met the needs students with regard to self-learning (FARIA, 2019).

In Andrade's the SUS scale got a 75.8 score, also a 'B' grade. To measure the degree of satisfaction regarding the usability of a multicenter neonatal Health Information System (HIS), using the System Usability Scale (SUS) instrument. Identify if demographic factors can influence the evaluation, through SUS, of the perception of the usability of a HIS (ANDRADE, 2017).

Table 4 presents a summary of the comparisons results of the works mentioned above.

Table 4: TAM results evaluation.

Unity Simulator	Bez	Lima	Faria	Andrade
80.00	85.71	85.3	75.4	75.8
B	A	A	B	B

6 Conclusion

The main goal of this article was to develop a software capable of simulating the medical procedure of nasosinusal polyp. As Seen in Section 4 the functional simulator was successfully build, and the low-cost specification was kept, as seen in Section 2.4 the simulator runs in low-end environment.

The simulator was tested in a field assessment to ensure its usability and utility with a partnership with Unichristus University, leaving us with a solid 80.00% in our usability test and 93.00% in our utility test.

For ours specific objectives we've got:

- Develop a tactile responsive physic for the atlas model: The 'touch' physic is functional and interacts with the medical tools and user camera.
- Develop a responsive physic for the interaction with the polyp: As seen in Section 2.6 - Nasal Polyp 3D, we've got a robust physics applied to the polyp called Metaballs.
- Apply a consistent texture to the model: The texture of the Atlas was a crucial point in this work.
- Create endoscopic camera tool and Create microdDEBRIDER tool: Both tools can be seen in Section 3.2 in Figure 8

The contributions of this article are presented, according to the methodology, separated into aspects of research and action, according to parts of the Model Proposed. Methodological pillars: in terms of research, the review is highlighted here bibliographic on active learning methods. In terms of action, if the dissemination to the working group about active methods of learning, characteristics and forms of implementation.

Organizational pillars: in terms of research, the review stands out systematic analysis carried out on the use of Patient type simulators Virtual and publications made in periodicals and several conferences about this revision. In terms of action, the creation of clinical cases of the virtual patient, seeking interdisciplinarity and content integration.

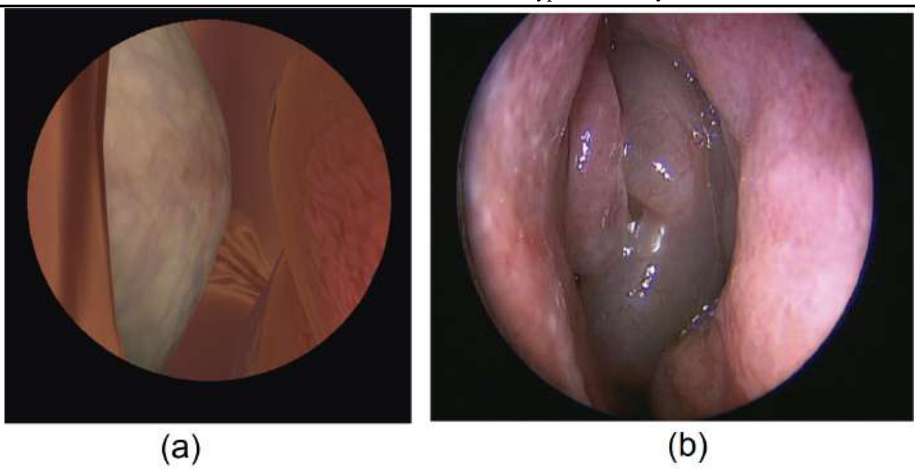


Figure 16: Comparison of mesh and texture modeling results: (a) polypose nasal model in unity simulator. (b) image of real nasal polyposis.

This paper culminated in the creation of an environment for the removal of paranasal polyps, partially validated by teachers and students, who had active and constant participation throughout the process, whether in the development of tools, of clinical cases, or in the training carried out.

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