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D6.1. VIRTUAL ENVIRONMENTS FOR MIS TRAINING

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1. Summary

This deliverable is part of Work Package 6 (WP6): *Creation of learning content*, which is focused on providing contents for the project using the guidelines and tools defined within the new paradigm of model-based creation. Apart from the 3D anatomical models and the virtual reality (VR) environments, VR tasks and 3D-printed models for minimally invasive surgical training, additional learning material for medical and surgical training will also be provided as part of the MIREA learning platform.

In this document we present and describe the design and creation of virtual scenarios and tasks for skill training within the MIS-SIM environment for medical education. These tasks will be developed following the methodological guidelines defined in Deliverable 3.2 (D3.2) of the Work Package 3 (WP3). These learning contents will not only include models that will be uploaded to the MIREIA platform (https://mireia.avaca.eu/), but also uploaded on their own in .ZIP file format. The tasks will be available to be downloaded and loaded back into the MIS-SIM editor for modification or run through the MIS-SIM's execution mode. The 3D models that will compose the different tasks, will be either created on 3D rendering software or from data models extracted from CT/MR scans. They could be used for learning medical anatomy or training skills in VR and Mixed Reality (MR).

The added value of these provided learning contents is the flexibility to generate new tasks from the pre-existing ones, being able to adapt to the user either in immersive or non-immersive VR environments.

Finally, the validation studies to be carried out in WP7 will further add data about the generated contents and ready-to-use tasks and models for training activities that will expand the available learning content further for the community (users) of MIREIA.

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2. Introduction

Virtual environments are compositions of meshes placed in the three-dimensional space and rendered through the graphics hardware. The MIS-SIM environment is capable of the creation of these scenarios with objects that interact with each other independently of the meshes used for rendering. This abstracts a generic layer that makes the environment capable of creating almost any kind of training exercise independently of the topic. However, to create medical education tasks, a set of partners' proprietary contents and open-access databases will be used to provide the 3D models as explained in deliverable D6.2 and D6.3 of this Work Package for the additional material.

In the following sections, the key steps for designing and generating the virtual environments focused on technical and non-technical skills in Minimally Invasive Surgery (MIS) are described. This material will, as set out in the objectives of WP6, be uploaded and stored in the MIREIA repository and adapted for use through virtual training simulators.

3. Virtual Reality key concepts

The following subsections focus on the key concepts to consider when designing the virtual environments that will be uploaded to MIREIA platform. Even if, as mentioned previously, the MIS-SIM editor can generate any kind of task, these virtual scenarios need to be adapted to be able to run smoothly on VR headsets. Hence, even the generated models from imaging studies (CT and MR scans) used in the validations will require some optimizations to keep the used memory and resources by the CPU and GPU as low as possible. In addition, the scenarios cannot be based exclusively on displaying medical content provided by proprietary work but must be composed of 3D models that envelop the user in the immersive experience.

3.1. Interaction, immersion and virtual presence

VR possesses unique characteristics that stem from users being enveloped by and conducting activities in other environment while consuming VR contents. These characteristics are frequently described as immersion, virtual presence, and interactivity. Immersion is viewed by some researchers as a psychological state where the user has a feeling of being absorbed by the virtual world, which is closely related to the presence. Presence is usually described as "the subjective experience of being in one place or environment, even when one is physically situated in another". On the other hand, interactivity can be perceived as the degree to which users can influence the form of the mediated environment. Therefore, when designing the virtual environments, the content creator needs to consider these characteristics and try to adapt the scenarios to them.

3.2. VR environments

One of the key differences between VR and similar technologies such as Augmented Reality (AR) or Mixed Reality (MR) is how the user perceives the mixture between the virtual and the real

worlds. In AR and MR, the virtual models are visualised on top of the real world. For this reason, the learning contents can only focus on generating models and images which will be rendered. On the other hand, the VR environments require to also provide the visual information of the world where the user is immersed in (an operating room, hospital, patients' house…). There are cases where a simple two-dimensional (2D) bitmap is used to provide it as an environmental map that surrounds the user and simulates a 3D scenario. However, this technique may not be the most effective when the user needs to move around the scenario making the position of perspective to change. Some areas of the bitmap end up distorted from the rendering view and the 3D effect gets lost, leading to unrealistic results and less immersive environments. A solution for this is modelling props and surround models for the scenario. These models are not mandatory for performing the tasks but they will provide the user a better feeling of presence and immersion. The interactivity comes into place with those models the user can interact with based on its inputs (grabbing through button press, hand-tracking; controller inputs…) to complete the tasks objectives.

3.3. Optimizations for the 3D models

Tasks created in the MIS-SIM environment are intended to be executed on a PC. However, as the editor allows exporting content to Unity Engine, these learning contents can be used in stand-alone Virtual Reality devices such as Facebook's Meta Quests or PICO devices. These devices have limited computational capabilities but being VR, they maintain the same requirements as if they were connected to a PC. Therefore, they need to maintain a minimum refresh rate of 72Hz, being recommended to reach 90Hz or 120Hz in the best case even having to compromise the graphic load.

The 3D models generated from medical imaging (CT/MR scans) usually have a high polygon count, exceeding one million polygons. The aforementioned devices should not exceed 100K polygons rendered in real time to maintain refresh rates while interacting with objects in the environment. It is important to note that when rendering 3D models of the environment that surrounds the user to give a sense of presence, the total polygon count will increase. This means that less margin is available for the number of polygons of the interacting models and they need to be optimised.

MIS-SIM has an integrated decimation algorithm that will reduce the number of polygons of any 3D mesh it uses according to parameters that the content creator can configure as he/she sees fit.

4. 3D contents for VR environments

The following are some data sources regarding medical contents that can be utilised as material to create scenarios and interactable objects for VR tasks to use through virtual training simulators.

4.1. Medical Studies, videos and Illustrations

There are several sources that provide imaging studies that could be used as sources of the medical contents that can be used to create the 3D models for VR environments or visualised in the 3D

space. Some of these sources are listed in D6.2 and D6.3. These sources provide anatomically realistic models that can be used for learning anatomy and helping students to identify possible pathologies in immersive scenarios that resemble real-life situations.

The MIS-SIM editor has a built-in tool to import segmented imaging scans and automatically import them as either textures or 3D volumes, generating the meshes on the fly and optimising them to be used in immersive VR.

4.2. Anatomical models

In the same way that medical studies with scans can be used, anatomical models created using 3D modeling software can be used. There are several sources that provide anatomical models that could be used with the MIREIA platform tools. Some of them are mentioned below:

SciePro

SciePro – Medically Accurate 3d Models – SciePro

SciePro is a company which creates and sells publicly or by demand, medically accurate models based on anatomist and medical experts information. The provided organ and anatomical structure models generated by SciPro have high-resolution textures and optimised topology for rendering within Unity Engine.

Asset Stores (Unity Asset Store, Epic Games Store, TurboSquid…)

There are multiple platforms that provide 3D models for virtual environments. Most of the contents are not free but offer life-time access to detailed models that can be used to understand the relation between different anatomical elements and structures as well as for making the surrounding environments.

4.3. VR Tasks

UPM will provide VR tasks that can be run on Meta Quest stand-alone devices in APK format, as well as medical image-based projects that can be run using the MIS-SIM editor for the study of anatomical structures and identification of pathologies. These VR environments will be composed of an immersive scenario generated by UPM using Blender, which will simulate a room in a medical centre (Fig. 1). The interactive 3D models in these tasks will be generated by CT using the MIREIA platform tools and will be optimised to obtain good performance in VR. The main added value of the MIS-SIM generated VR tasks is having a modular solution that allows the users to not only create custom tasks without strong software development experience, but to be able to share and adapt them to the participants in immersive and non-immersive scenarios. Some of the features to interact with these objects in the 3D space are:

Interaction and object manipulation

The user will be able to grab objects with his/her hands by using the VR device hand-tracking if available or with the VR controllers. There will be physical buttons that can be pressed like if

they were present in the real world. In the case of non-immersive tasks, the interaction will be performed through the mouse and keyboard inputs and the main rendering display will be the computer monitor.

Translation through the environment

The user will be able to move by tracking the real body position and translating the movement to the virtual world.

Metrics

Metrics will be saved on the device and cloud server to be analysed in WP7 tasks.

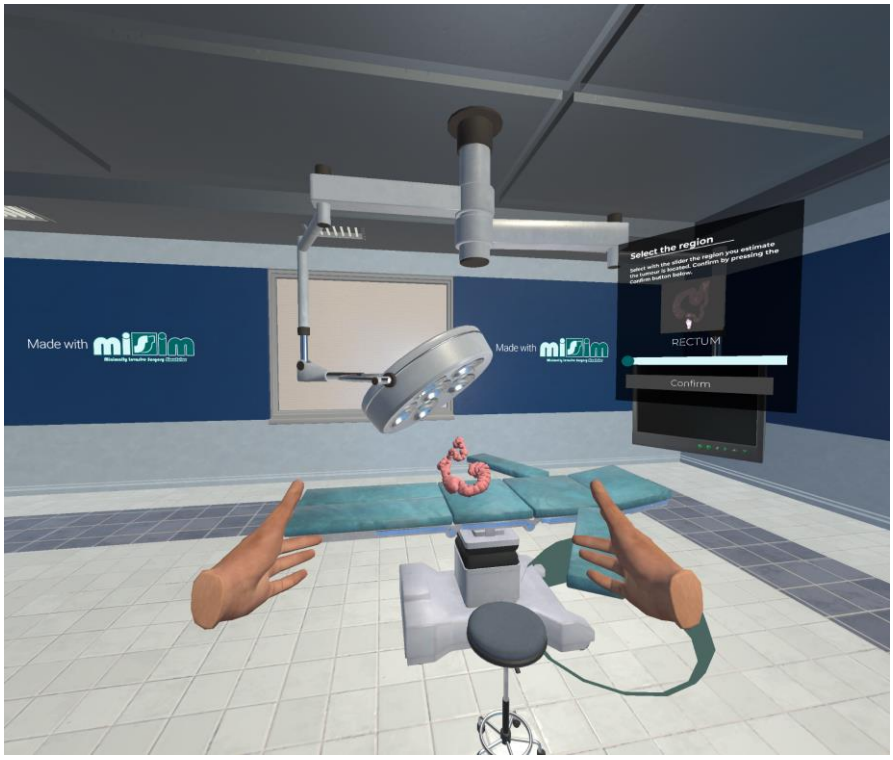

Figure 1. A virtual environment where the participants perform the lesion diagnosis in the virtual colon model.

5. References

Mütterlein, J. The Three Pillars of Virtual Reality? Investigating the Roles of Immersion, Presence, and Interactivity.

A. McMahan, "Immersion, Engagement and Presence: A Method for Analyzing 3D Video Games", in Wolf, M.J.P. and B. Perron (eds.), Video Game Theory Reader, Routledge, New York, NY, 2003, pp. 67-86.

B.G. Witmer, and M.J. Singer, "Measuring Presence in Virtual Environments: A Presence Questionnaire", Presence: Teleoperators and Virtual Environments (7:3), 1998, pp. 225- 240.