

Virtual Reality-Driven Intervention for Alleviating Pain in Pediatric Patients

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Abstract - Endorphins are the natural painkillers produced by the body. They are released by the hypothalamus and the pituitary gland. They are produced by the body during pleasurable activities and other activities such as exercise, meditation, laughter etc. In this work, these conditions are created by a virtual reality (VR) environment and employed to create a distraction which is a very effective and efficient way of managing pain. This distraction in combination with the release of the endorphins, is expected to have an effect on the sensation of pains in pediatric patients. This study develops a VR system and investigates the effectiveness of virtual reality distraction and no distraction at all in reducing pain and anxiety during a medical procedure in a pediatric population. Pediatric patients aged 4 – 10 were examined for validation of the system and they showed varying degrees of pain relief.

Keywords: Pain, Virtual Reality, Pediatric Care, Pain Management, Assistive Technologies.

I. Introduction

Distraction involves competition for attention between two activities requiring mental processing. The aim of distraction is to divert attention away from unpleasant stimuli. Even though the pain is still present, the attention of the individual is taken by the more demanding task. It is a common non-invasive technique used by health care professionals to manage and attenuate anxiety, and possibly pain, during painful procedures in pediatric patients. It is an effective intervention for a range of populations facing various acute painful medical procedures [1][2], even though the degree of its efficacy varies across individuals.

There are other forms of pharmacological methods of pain management such as topical anesthesia, vapo-coolant sprays and analgesics which are categorized into opioids and acetaminophens. Distraction is a form of non-pharmacological methods which pediatric pain can be reduced in hospitals. Other non-pharmacological methods include hypnosis, music, psychological interventions and the use of virtual reality (VR).

Unlike other methods of pain management, VR has the unique ability to manipulate how the brain processes pain by

engaging the senses with powerful immersive experiences. It makes use of advanced programs and system, such as a Virtual Reality Headset to create the immersive feeling for its user. So, it is simply an illusory environment, designed to give users the impression that they are in an environment other than their current environment. Some qualities of VR that makes it attractive are: immersive, believable, interactive and being computer generated.

Virtual reality has seen various applications in the field of medicine. In [4], VR was applied in care of pediatric patients with cancer. It showed great potential in reducing pain scores, pulse rates and distress scores. It however was less effective in reducing other indicators such as fear, anxiety and distress scores. Good results were obtained when VR was employed to aid pre-operation pediatric patients [5][6]. The results show, with a high confidence level, that VR is an effective means of reducing anxiety in patients undergoing elective surgery. Radiation therapy patients have also benefitted from VR [7]. In that study, thirty children and adolescents were recruited and a high VR acceptability and satisfaction was reported by radiation therapists, patients and parents. There was a notable improvement in the understanding of radiation therapy, lower anxiety before the radiation therapy procedure in patients and also their parents. Only one child (3.33% of participants of the study) required general anesthesia. In hematology, the pain, fear and anxiety of drawing blood, occasioned by the insertion of needles, were also reduced by the introduction of VR [8].

Other advantages which virtual reality brings to the field of pediatrics include:

- Virtual reality distraction is an established pain management intervention and is useful in diminishing pain and behavioral distress in pediatric patients, particularly those undergoing invasive medical procedures (e.g., during vaccine or medication administration and drawing blood).
- It has been shown to overcome phobias by immersing the person in the created world
- It makes it easier for cancer patients to receive chemotherapy.

- It can help manage social phobias and alleviate anxiety related to different clinical settings.

This paper presents the developmental procedure of a VR system for use in pediatric pain management. It looks as the development of the VR environment and a system performance is carried out afterwards.

II. Design Considerations of a Pediatric VR system

Although the platform targets children between the ages of 4 – 10 years, it should also be of use to people who are older. Consequently, the virtual environment is inspired by the popular candy crush mobile game which cuts across all ages. For ease of access, it will also be designed for the android platform.

Some design considerations for this work include:

- **Constraints:** Some constraints in this work are:
 - User constraints: What kind of user is it for? High end VR experience or wide accessibility experience?
 - Hardware constraints: What limitations can the platform place on user experience? A mobile device is to be used so the only constraint is on the capabilities of the mobile device.

- **Graphics constraints:** What are the current limitations of the gaming engine, and how will this affect the style and the graphical ability of the target device?
- **Scale and Space:** How much space do you have? Unlimited or within a confined space? How close am I to objects? 20 metres is the limit to stereoscopic separation, meaning that parallax will be lost past this point. Contrast, 0.5 metres becomes straining on the eyes due to constraints of the hardware’s fixed depth of field.
- **Spatial Audio:** How can spatial audio be utilized to enhance immersion, as well as acting as an attention or action cue? For example, if the characters were setting fire to a building to your left you would hear fire sound effects coming from that region.

Other considerations include: health and safety – ensuring safe and comfortable use of the device, cost – which should not be prohibitive hence limiting access, maintainability – device should have some robustness and not needing frequent maintenance, and reliability.

The VR development tools used for this work are:

- Unity - Unity is a cross-platform game engine developed by Unity Technologies [9]. The screenshot of the unity software is shown in Fig. 1.

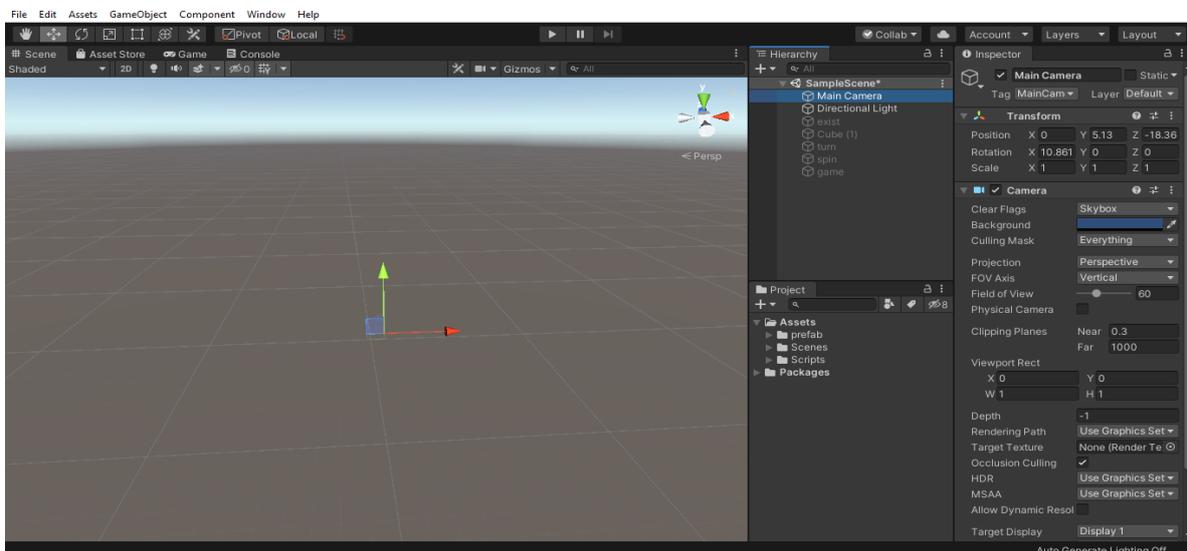


Figure 1: Screenshot of Unity Game Engine

- Android Software Development Kit (SDK) - Used for application development on the android platform [10].
- Android Native Development Kit (NDK) –is a set of toolsets that allows us to use native code languages like C/C++ in our Android Application [11].
- Android Java Development Kit (JDK) - Is a development environment for building applications, applets, and components using the Java programming language [12].
- Gradle – Is an open source build system that automates a number of build processes and prevents many common build errors[13]

- Google VR SDK – This provides the fundamental tools to design, build, and test VR experiences. They are the building blocks to create VR experiences such as mobile apps, marketing experiences, training simulations etc. [14]
- Modelling Tools – Blender – This is a program used for 3D modelling, animation and rendering [15].

III. VR Environment Development

The first step is to model the objects that will be in the environment. This can be achieved either by scanning real objects or by creating them within the modelling tool. An example of a modelled environment is shown in Fig. 2.

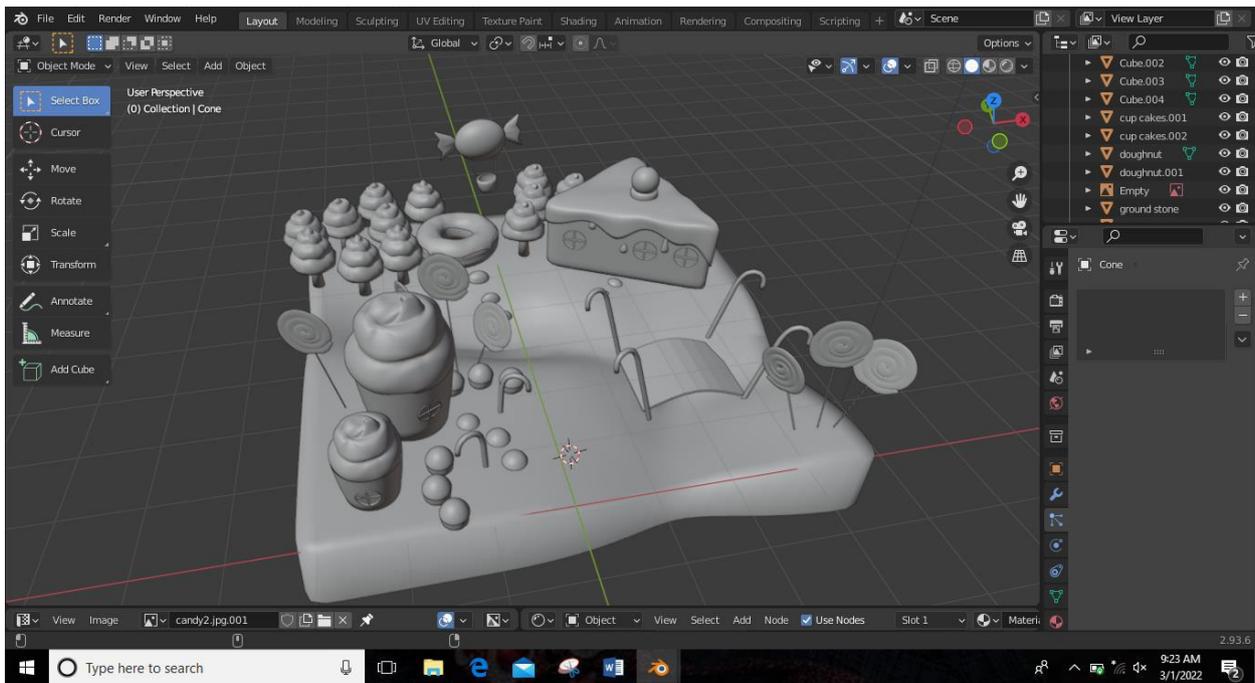


Figure 2: Candy Land with All Assets in the Scene

The next step is the UV mapping which is the mapping of 2D texture on 3D objects then followed by texturing. The product of these steps is shown in Fig. 3.

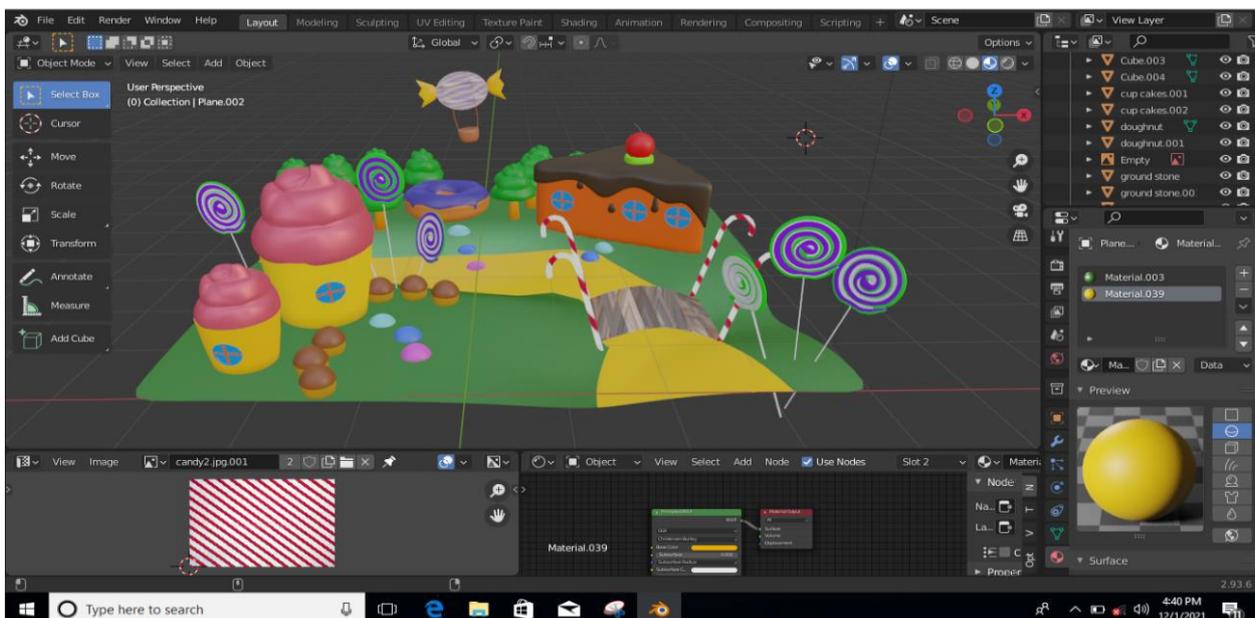


Figure 3: Textured Objects

Rigging is the setting up the 3D model for animation. It is used to add controls to objects usually for the purpose of animation. Animation and rendering involved giving the images movement and generating the finished image respectively.

The rendered image is then exported to Unity engine to enable launch in and android device. These are shown in Fig 4 and Fig 5 respectively.

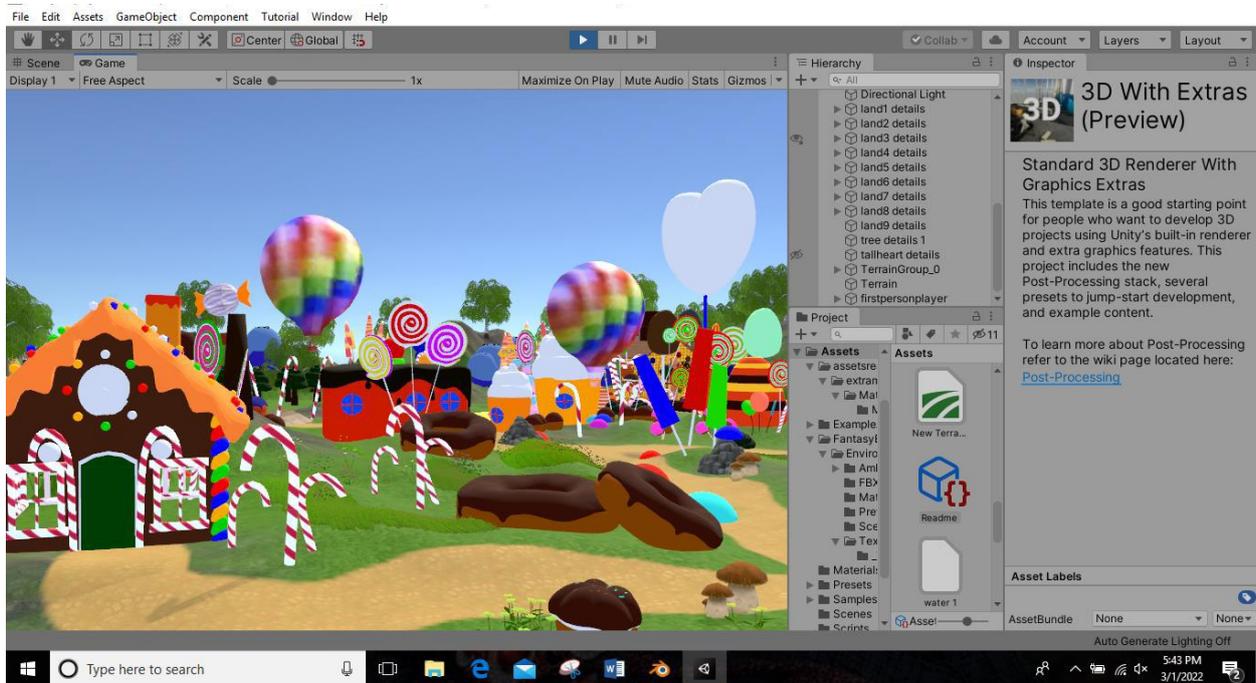


Figure 4: Rendered Image in Unity



Figure 5: On an Android Device

IV. Efficacy Study

The purpose of this study is to determine the effectiveness of the designed system on pain management. The study was conducted at the Medical Centre in the University of Nigeria, Nsukka and Chidubem Pediatric

Hospital, Nsukka.4 (2 males and 2 females) pediatric patients aged 4-10 years, who were undergoing painful procedures like immunization and blood withdrawal were recruited. The patients were split into 2 groups: one with the VR and the other without the VR. The 2 patients in the VR group were given a brief tutorial on how to wear the VR headset and how

to interact with the VR environment. The helmet and the earphones were worn immediately before the procedure and removed immediately after the procedure. The patients' pain or fun experience were rated on a scale of 0 – 10 and are presented in Table 1.

Table 1: Patient experience with VR system

Patient	Pain Perception		Fun Perception	
	VR	No VR	VR	No VR
Patient 1	2		9	
Patient 2	1		7	
Patient 3		8		0
Patient 4		7		1

The patients with VR recorded significantly less pain (as little as 1) than the patients without the VR equipment (as much as 7). This can be directly be linked with the patient's perception of the use of the VR equipment being fun(as much as 9) unlike the patients without the VR equipment with a fund perception of as little as 0. It can therefore be said that the patients who had less pain most likely were sufficiently distracted and also had the production of endorphins from their experience of the use of the VR equipment hence the reduced sensation of pain.

V. Conclusion

This work has looked at the use of virtual reality for pain reduction. It leveraged on the distraction from the generated images in the VR equipment as well as the pleasure derived from the use of this equipment which stimulate the release of endorphins which act as the body's natural pain killer and relaxant. From the test results, it can be concluded that VR is very effective and efficient method of non-pharmacological pain management technique. Further studies could focus on older patients as well as specific kinds of pain.

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