CHAPTER 2
VOXEL MODELLING

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2.1 INTRODUCTION

Augmented reality (AR) has recently emerged as a popular technology for seamlessly merging virtual content with the real world in real-time. Despite its potential benefits, current AR systems rely on traditional input devices such as a mouse or touch screen, which may not provide a natural and intuitive experience for users (Halim & Ismail, 2022). To address this issue, real-hand gestures have been proposed as an alternative way of interacting with virtual objects in AR environments.

Real-hand gestures in AR refer to the use of one's hands to manipulate and engage with virtual objects in real-time providing a more natural and intuitive mode of interaction. Nonetheless, incorporating real-hand gestures into AR systems (Ismail et al., 2022), particularly in three-dimensional (3D) modelling, can pose challenges. In this regard, voxel-based modelling, which involves representing objects using 3D pixels or voxels arranged regularly or irregularly, has been suggested as a solution for representing virtual objects in 3D space.

This study is an extension of our work (Fadzli & Ismail, 2019) and aims to develop a prototype for an AR voxel-based modelling editor that employs real-hand gestures as the primary input modality. The proposed system allows users to model objects in real-time and modify 3D objects using real-hand gestures. The effectiveness of the proposed system will be

evaluated in terms of usability, performance, and user satisfaction. The study's results will contribute to the development of more natural and intuitive ways of interacting with virtual content in AR environments.

2.2 VOXEL 3D MODELLING

A voxel is a 3D element that resembles a two-dimensional (2D) pixel. In the context of volumetric modelling, an object is delineated through a collection of 3D spatially arranged voxels, which may exhibit regular or irregular geometrical characteristics. The most prevalent and straightforward manner of representing voxels involves utilising cubic voxels organized within a standardised grid that is precisely aligned with the coordinate axes. The domain of computer graphics has experienced a substantial expansion in the realm of volume visualisation, primarily propelled by the analysis of volumetric datasets produced within the context of scientific and medical research endeavours. Volume visualisation systems are deployed to generate high-fidelity visual representations from multi-dimensional, grid-defined datasets comprising scalar and vector values. Their principal objective is to gain a deeper understanding and insights into scientific inquiries.

In the realm of 3D computer graphics, a voxel denotes a value within a regular grid situated in three-dimensional space. Analogous to pixels in a 2D bitmap, voxels usually lack explicit position encoding with their values. Instead, rendering systems deduce a voxel's position by considering its relationship to neighbouring voxels within the data structure composing a volumetric image. Voxel is a concept commonly used in volume visualisation, similar to that used in voxel-based modelling. Nonetheless, within computer-aided design (CAD) applications, the voxels typically employed are binary models, serving to depict solely the occupancy status of objects. Voxel-based modelling has been limited due to the extensive memory and processing requirements needed for sufficient voxel-resolution models (Aleksandrov et al., 2021). Recent advancements in computer hardware and architecture have led to faster processing speeds and cheaper memory, making voxel models now possible on desktop systems.

2.3 DEVELOPMENT GUIDELINE

The development guideline has been illustrated in Figure 2.1. It consists of three stages. The voxel modelling has been executed in Phase Two. However, the data gathered in the first phase serves as the foundation for the development of both the real-hand gesture interaction technique and the basic functionalities of the 3D modelling editor. The techniques and features defined in this phase will serve as the foundation for the subsequent phases of the project. The study of hand gesture interaction techniques in AR environments and the basic features of 3D modelling editors will provide insights into the challenges and opportunities associated with the development of the system.

The second phase of this application development is centred around an emphasis on designing and building the real-hand gesture interaction technique while concurrently developing the prototype application that encompasses the 3D modelling editor. The prototype is designed and developed based on the grounds of the knowledge and insights gleaned from the previous phase. The principal goal of this phase is to create a fully operational prototype application that seamlessly integrates the newly devised hand gesture interaction technique and the 3D modelling editor.

Throughout this phase, the development and coding process for generating hand gestures is executed with meticulous attention, prioritising precision, and reliability to ensure the effectiveness of the newly designed hand gesture interaction technique. Moreover, the development of the AR prototype application is also done in parallel, to make sure that the 3D modelling editor technique is seamlessly integrated into the AR environment. The successful integration of these two techniques is a critical aspect of the development process, as it ensures that the prototype application functions smoothly and can be used for its intended purpose.