Waleed Alkefari

CSC 322

Dr. Bui

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Computer Graphics Project Report: Building 3D Models of Real-World Objects

Summary

The main objective of this project was to create a 3D model of a real-life object using two computer graphics software: Meshroom and MeshLab. A secondary objective was to establish the characteristics of an image that can be used in combination with the suggested software to create a 3D model successfully. The project was limited in scope by three constraints: first, only the two suggested software could be used in the modeling; two, the model should be of a real-world object; and, three, the model has to be created from scratch. After experimenting with three objects whose images failed to render satisfactory 3D models, a successful model was created based on an object whose captured images met various criteria, including being well lit, free of shadows and reflections, and had several angles of view.

Introduction

One of the areas of specialization in Computer Science with several interesting applications is 3D modeling. Specifically, 3D modeling falls under the broader subject of computer graphics and it involves representing real-life objects into their equivalent 3D digital form. This process is typically achieved using 3D modeling software, which are employed to manipulate points in the real-life object to form a collection of vertices that, collectively, form a solid 3D model. The resulting models can be manipulated to suit a particular need. For example, because 3D artists can add special effects onto 3D models or animate their creations, 3D modeling has found widespread application in films, engineering, architecture, computer games, and education. This project focused on generating 3D models from real-world objects using two computer graphics software: Meshroom and MeshLab.

My interest in this project, and hence the approach taken in this study, was inspired by my love for virtual reality (VR), which involves replacing the real world with a virtual one for the purpose of providing people with an immersive experience. As such, VR replaces the natural environment with a simulated one, thus, giving better and detailed views of the surrounding (Bennett University). Since VR models are created from objects in the real world, I was interested in recreating a typical modeling exercise by looking for and using objects in my immediate environment and producing their equivalent 3D representation. Thus, I experimented with various images before finding the most appropriate object to use in this project. For this reason, this study falls under the area of photogrammetry, which involves taking photographs from various locations to produce 3D coordinates of a point (Pillai). In the end, I used an object with minimal light reflection as it offered the best results.

Problem Statement. 3D modeling is one of the areas of Computer Science with widespread applications in the world today. However, creating such models is a complex and computationally expensive exercise, and, for this reason, is usually difficult for many undergraduate students to undertake. Thus, this project seeks to introduce the author to the field of 3D modeling using available software. However, it is limited in scope by three constraints: first, only the two suggested software could be used in the modeling; two, the model should be of a real-world object; and, three, the model has to be created from scratch.

Purpose of Study. The primary purpose of this project was to build a 3D model of a real-world object using two computer graphics software: Meshroom and MeshLab. A secondary and derived purpose was to establish the characteristics of an object that can be used in combination with the suggested software to create a 3D model successfully.

Analysis

Brief Literature Review. 3D modeling is widely applied in the world today. One of these areas is in the modeling if urban centers, which is important as about half of the human population lives in cities today (Aliaga 1). Creating such models of cities can enable applications such as predicting and visualizing the impact of future population changes, mapping urban locations and facilities, and creating models that can be applied to train emergency response personnel. 3D modeling and simulation can also be found in engineering and construction (Kheyfets and Vasilieva 1) and education and training through VR (Pirker et al. 1). VR, which is among the heavy users of 3D modeling and that serves as the inspiration of this project, traces its roots in the 1960s (Faisal 298). However, research into it only began two decades later with Lanier and Thomas Zimmerman who are credited with creating many of the VR concepts in use today (Faisal 298). Presently, there are several 3D modeling tools available to users and researchers,

including Blender, AutoCAD, and SolidWorks (Tang and Ho). This project makes use of two of these tools: Meshroom and MeshLab.

Method and Approach. As I wanted to design a typical VR experience, I decided to use objects in my immediate environment for this project. Since this was a photogrammetry experiment as well, I had to take several pictures of the item of interest from different lines of sight to capture the object from different angles. The first product I used was a coke can and I took about 35 images to be used within Meshroom. However, the end result was far from satisfactory because the can reflected light, which is unacceptable in Meshroom (see fig. 1 below).

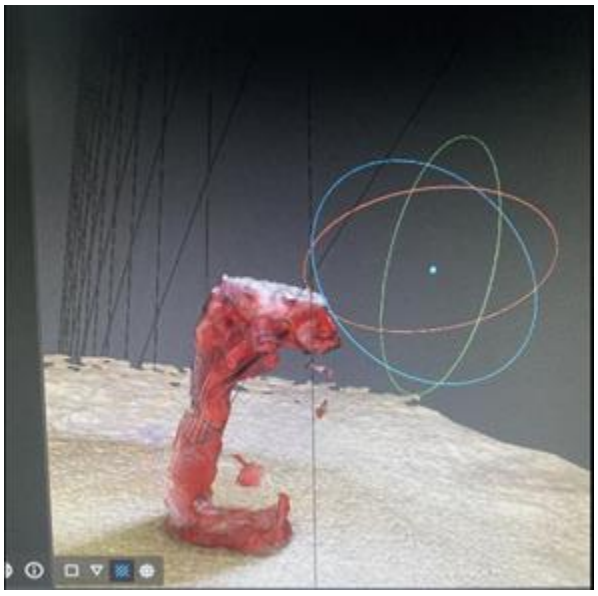

Fig. 1. Result from coke can

Meshroom requires that captured images should meet certain requirements. For example, they should be well lit, devoid of shadows and reflections, should be taken in diffuse of indirect lighting conditions, and that the photographer should move to a new position for each shot (Meshroom). With these guidelines in mind, I moved on to capture two more objects that also resulted in unsatisfactory 3D models. First, I used a subway sandwich which did not render well because of the way I saved my images. After taking about 45 photos using my phone, I uploaded

them on Discord, from where I downloaded them on my computer. However, Discord compresses and lowers the quality of images, which resulted in the poor 3D rendition in fig. 2 below. Based on this experience, I took a set of pictures (in HEIC format) of a burrito from Chipotle and saved them on my phone, later on I compressed them as a zip file and sent it to myself through WhatsApp. However, Meshroom does not accept this type of file, thus, I used an online image converter to get a JPEG. The end result in Meshroom was also unsatisfactory as some dark holes were present on the object and some parts were incomplete (see fig. 3 below and fig. 1 and 2 in Appendix).

Fig 2. Result from Subway sandwich

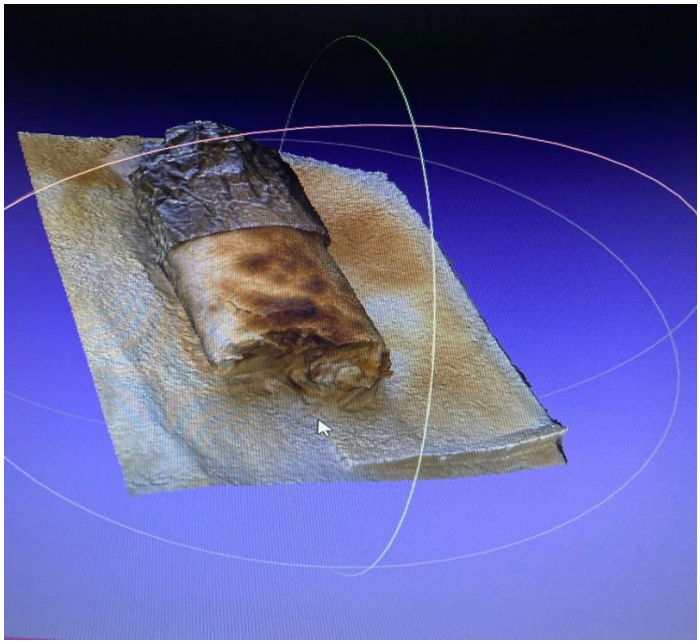

Fig 3. Result from a Chipotle buritto

After these failed attempts, I finally found an image with which I could work on Meshroom (see fig. 4). Importantly, this “Battlefield 1” object did not reflect light. Additionally, I determined a method to take JPEG images and keep their metadata.

Fig. 4. Final “Battlefield 1” original object used in the project

Modeling Assumptions. After getting the poor results based on the Subway sandwich and Chipotle burrito because of the reduced quality, I decided to test whether taking images JPEG images directly through my phone could improve the outcomes. I tested this idea on matchboxes (see fig. 3 in Appendix) and was satisfied with the color and shape of the resulting test 3D object. Subsequently, I used this knowledge and only took JPEG images of the "Battlefield 1" character object used in this project.

Implementation. After identifying the most appropriate object to use for the project, I walked around it to take shots at different angles as required by Meshroom. In the end, I took about 170 images, which I uploaded to Meshroom. Within this platform, the major configuration settings that I made were as summarized in the table 1 below. Finally, I downloaded the end result after deactivating all nodes except Texturing.

Table 1

Configuration Settings in Meshroom

Meshroom Node	**Configuration**
DepthMap	Set Downscale to 2
Meshing	Set the maximum number of points to 5000000 Activate the Custom Bounding Box and move it into the area of interest
MeshFiltering	Activate Keep Only the Largest Mesh
Texturing	Set Texture Side to 8192

Results. Fig. 5 below shows the initial 3D model created from fig. 4 within Meshroom. I imported the object into Meshlab and removed any extra parts that I did not deem necessary. The

final model, which I submitted to P3D, is shown in fig. 6. However, I acknowledge that the model is not perfect as I did not input many pictures into Meshroom and neither did I change some of the software's default settings.

Fig. 5. 3D model with extra parts

Fig. 6. Final 3D model

Conclusion

3D modeling is often a challenging and computationally-expensive exercise to undertake despite its widespread application within Computer Science. This project sought to create a 3D model from a real-world object from scratch using two suggested computer graphics software: Meshroom and Meshlab. The most significant challenge encountered in this process was capturing the most appropriate image to use within the software. After three failed attempts, I managed to overcome this challenge to create a realistic 3D model based on an object in my surrounding. In doing so, I learned that an image meant to be used in such a study should possess various qualities, including being well lit, free of shadows and reflections, and should have several angles of view. The resulting model can be used in various areas, one of which is VR, where users are immersed in a virtual world that mirrors the real one. With this gentle introduction to 3D modeling, I hope to expand my research into the fields of photogrammetry and VR.

GitHub Link: https://github.com/Alkefariw/CSC322fa22/tree/main/Final%20Project

Works Cited

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Appendix

Fig. 1. Additional 3D image view from the Chipottle buritto

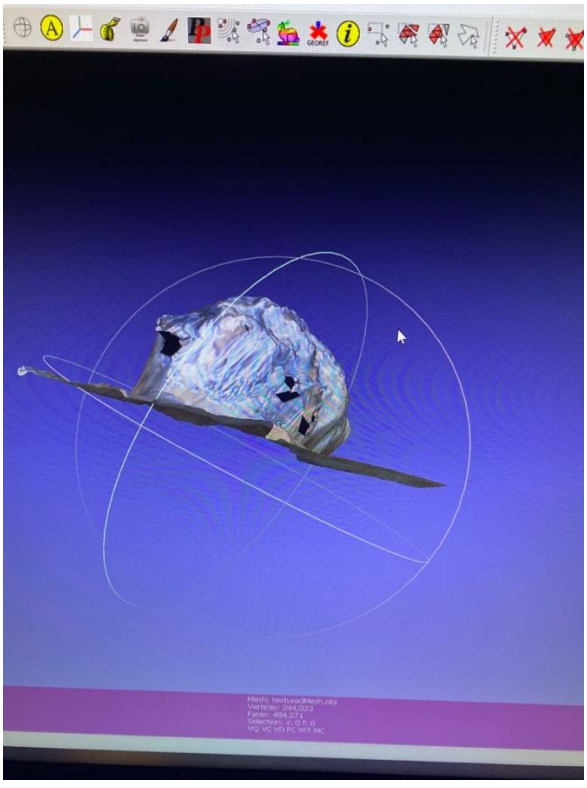

Fig. 2. Additional 3D image view from the Chipottle buritto

Fig. 3. Matchbox 3D image used for testing