International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 08 – Issue 02 || February 2023 || PP. 82-87

Photogrammetry Server for Metaverse Education

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Abstract: The metaverse is gaining importance in modern information technologies, media, and communication, with content creation methods for the metaverse increasingly making way into teaching curricula. However, including real-world objects in the metaverse and virtual reality is a major challenge. Although photogrammetry is widely used to create three-dimensional objects, finding practical solutions for education remains challenge. The present paper describes an easily applicable solution that enables students to create 3D high quality models from images. Students and educators can quickly generate new objects for the metaverse without the burden of managing complex photogrammetry software workflows.
Keywords: metaverse, virtual reality, education, photogrammetry, reality kit

I. INTRODUCTION

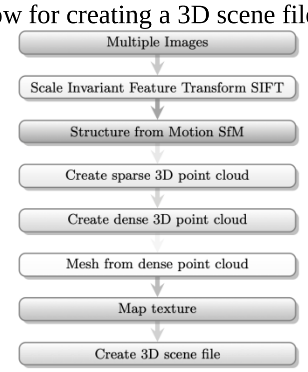
The Metaverse is growing in importance[1]. Major organisations in the information and technology industry (IT) have heavily invested in this technology and expect it to become a good business opportunity in the future[2], [3]. Neologism is used to converge multiple technologies such as virtual reality (VR), augmented reality (AR), non-fungible tokens (NFT), multimedia, and gaming into a new ecosystem. Major IT-companies have announced big projects for job creation [4]. Hence, the metaverse has also become an important topic in education[5]. Authoring platforms and tools are useful for imparting various skills required for content creation and preparing future content creators.. One of them is 3D remodelling or methods for capturing elements from the physical world and adding them to the metaverse and virtual reality.

3D game engines are used to simulate interactivity in virtual worlds[6]. Therefore, scanned or photographed objects must be transformed into reusable 3D models. This transformation is usually achieved in two ways: 3D modelling, which is designing and texturing 3D objects from scratch using specialized software, or scanning real-world objects to recreate 3D models. Since scanning devices such as laser scanners are expensive, low-cost photogrammetry has become a popular method for 3D remodelling[7]. To simplify the creation of 3D scene files for content creation for the metaverse, this paper describes a method for generating photogrammetry sessions.

II. PROBLEM

Photogrammetry uses a series of algorithms to detect the shape and texture of an object to recreate a 3D model. Much research has been published on different methods and performance of multiple algorithms under various lighting situations[8], [9]. Figure 1 shows a workflow example to create a 3D scene object.

Fig. 1. Workflow for creating a 3D scene file from an object



Implementing such a workflow can be difficult for educators because the wide choice of available tools can be very confusing. In addition, computer hardware has a significant influence on the performance of the workflow. Many tools also require manual intervention and often the repetition of the processes. Commercial applications and services offer solutions to a certain extent; however, they are typically not free, require registrations, and can have limited applications due to copyright restrictions .

To teach content creation efficiently for the metaverse using real objects, photogrammetry solutions should meet the following requirements:

- Simple setup and accessibility
- No additional software licenses
- Easy operation
- Efficient computation and reproducible results
- Creation of ready to use 3D scene files

III. PRESENT TECHNOLOGIES

Tools and libraries for the workflows of 3D remodelling have been available for a long time. They are constantly improved and new tools continue to emerge. This paper does not present an exhaustive overview but demonstrates only exemplary and widely used solutions in photogrammetry:

3.1 Visual SfM

This software is a visual user interface for different programs and tools such as sift, multicore bundle adjustment, or PMVS/CMVS [10]. The software can perform sparse and dense cloud reconstruction from multiple images.

3.2 Meshlab

Meshlab is a powerful open-source tool for manipulating 3D data and models[11]. It can be used in conjunction with Visual SfM to create meshes from photogrammetry[12]. Mastering the vast set of functions and features requires a steep learning curve. Further, considerable experience with the tool is necessary to achieve satisfactory results.

3.3 Polycam

Polycam is an iOS application that allows the use of either Light Detection and Ranging (LiDAR)[13] or photogrammetry for in-device or server-based 3D model reconstruction.

3.4 Reality Kit

Reality Kit is a software component of iOS and macOS operating systems[14]. It contains functions for creating and visualizing assets for virtual reality (VR) and augmented reality (AR). The included photogrammetry module takes advantage of Apple’s own hardware such as the M1 processor, thereby enabling other applications to offerVR and AR features.

Table 1 shows a summary of the principal features of the above software tools. Except for Reality Kit, all the programs have a graphical user interface. While Visual SfM generates only a point cloud, other programs can provide results as a 3D scene file.

TABLE I: OVERVIEW OF PHOTOGRAMMETRY TOOLS

application	Specialdfty	features			
		UI	model	system	required
Visual SfM	images to pt. cloud	yes	pt cloud	win/osx	
Meshlab	pt. cloud to mesh	yes	mesh	win/osx/ linux	
Polycam	lidar scanning app	yes	mesh	iOS	
Reality Kit	Apple framework	no	mesh	iOS/osx	M1

IV. PROPOSED METHOD

This section describes the implementation of a photogrammetry server by making Apple Reality Kit accessible over the internet via a simple file transfer protocol (FTP) client. Users can upload images and download a 3D scene file in Universal Scene Description (USD) format. These files are ready to use in metaverse authoring[15], [16]. The photogrammetry server setup comprises the following steps: Selection of a dedicated computer, installation of the photogrammetry session program, managing user access, and creating a run action file and folder action script:

4.1. Setup Dedicated Computer

As discussed in the previous section, Apple Reality Kit requires a new generation Apple computer with an M1 silicon processor. An entry level Apple Mac Mini meets the basic requirements for education purposes. The operating system provides the necessary system components and user management tools.

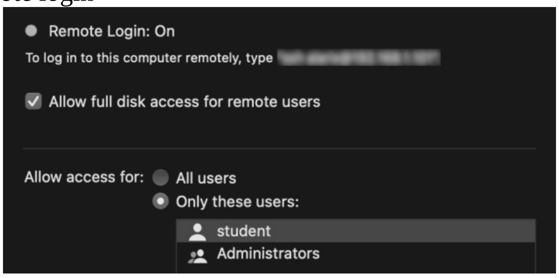
4.2. Install Photogrammetry Session Program

To use the photogrammetry features of Apple Reality Kit, a small command line program must be implemented. Apple provides this program as a free sample code of Reality Kit together with detailed instructions and documentation on the Apple Developer Website[17], [18]. Using Apple's own free development and compiler software XCODE, the sample code can be compiled to a Unix command line tool[19]. The resulting binary executable is moved to the folder /usr/local/bin/ and can later be executed from a command line terminal or script.

4.3. Create a user for File Transfer Protocol (FTP) access

If the dedicated computer is located behind a modem or router with a fixed IP address, incoming connections can easily be forwarded to the photogrammetry server. Students and educators can access the server by typing in the internet address directly. Additionally, a domain name server (DNS) can be used to forward an uniform resource locator (URL) to the specific IP address. To allow only a specific user to access the server, a new user must be created. For this setup, the new user is named "student." In the server system settings, the user "student" receives permission to remotely login to the server. Figure 2 shows the dialog in the sharing panel. Ssh access is granted to the user "student."

Fig. 2. Sharing setting for remote login



Ssh login permission can be a security risk and must be handled with care. However, the security aspects of remote login and detailed user access management are beyond the scope of this paper.

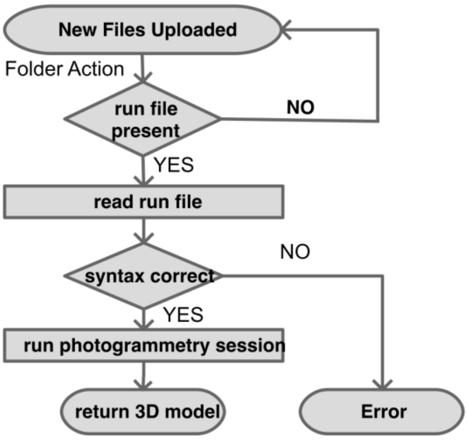
4.4. Declaring a Folder Action

The principal functionality of the photogrammetry server is achieved by using the feature of the folder actions of the mac operating system. These are managed from within the context menu of each folder. If such an action is installed, the system constantly monitors the specific folder for changes. As soon as a change is detected, a script or program can be executed. In this server example, a script is assigned to the folder to which the user connects and uploads images for a photogrammetry session.

After logging in, the user may upload a set of images. However, since the folder action is triggered each time the contents of the upload folder are changed, the script can be executed many times even before all necessary images have been uploaded.

To avoid this behaviour, the script connected to the folder action tests for the presence of a file named run.txt. Only if this file is present and syntactically correct, the photogrammetry process is started. Figure 3 shows the flow diagram of the folder action.

Fig. 3. Folder action script flow diagram



The folder action script is listed in the code below. It is executed every time a change in the upload folder is detected. It first tests if a file named run.txt is present. If this is not the case, the script gently exits without any further action. If the file is present, the script reads two lines of the text file: The first line contains the identification number for the job, which in this case is the student identification number. The second line contains the filename the user wants to attribute to the generated 3D model. If the syntax requirements are not met, the script exits with an error. If the syntax requirements are met, the image files are moved to a new directory and the photogrammetry session is started. When the task is complete, the folder and images it contains are removed. The following code 1 shows a simplified version of the folder action script:

code 1

```
#!/bin/bash
cd /Users/student/Pictures/watch
FILE=./run.txt
FNAME=""
if [ -f "$FILE" ]; then  # file found
read FNAME STUDENTID <<<$(cat $FILE)
if ! [[ "$FNAME" =~ ^[0-9a-zA-Z]+$ ]]; then
exit 1          # file name error
else
            mkdir $FNAME      # create images directory
rm $FILE #  remove run file to avoid loop
            mv ./*.jpg $FNAME/# move images to image directory
            /usr/local/bin/Hello Photogrammetry ./$FNAME .
\/$FNAME.usdz
\-d reduced      # start the photogrammetry
              rm $FNAME/*.jpg   # delete the images
rmdir $FNAME      # remove images directory
fi
fi
```

4.5. Run Action File

The run action file is a simple text file named run.txt. It contains two lines of text — the first contains an identification number that can be used when users login and the second contains the desired filename of the 3D model. The photogrammetry session is executed only when the run action file is present. The file is immediately removed at the beginning of the folder action script to avoid multiple loops.

Consequently, the proposed method allows users to set up an easy-to-handle server for photogrammetry. The server is used in university classes as part of the teaching process for the metaverse. Students and educators can upload images using a simple FTP program. After sending a batch of images, the user creates a text file named run.txt containing an identification number as well as the name for the new 3D model. As soon as this file is present on the server, a new photogrammetry session is started. After the process is finished, the uploaded images are removed to free space and a 3D model is created. Users can use the same FTP program to download the 3D model. The file is ready to be used in metaverse authoring applications such as Blender[20].

V. FUTURE RESEARCH

As proof of principle, the previous steps described how to use the features of the folder actions to trigger a custom script when users upload files to the photogrammetry server. Additional features and enhancements can be added in future, such as detailed action logging, robust error handling, job notifications, and implementation of different parameters for resolution and model quality.

VI. CONCLUSION

The present paper described how an entry level Apple computer with a new generation M1 processor can be used to build an accessible and operable photogrammetry server for metaverse teaching. As part of the operating system, the photogrammetry functionality does not require additional software licenses and allows the users full control and ownership of their content. The proposed solution achieves reproducible and efficient results. It helped create industry standard files that can be easily used in the metaverse content creation process. The proposed solution allows many students to take advantage of the efficient image procession algorithms provided by Reality Kit. Further, the time required for mesh and model creation is reduced, which leaves more time for the actual metaverse content creation with its interactivity and logic.

VII. ACKNOWLEDGEMENTS

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A5B8102066).

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