A Comparative Study on Affordable Photogrammetry Tools

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Abstract

The objective of the Project MANEUVER (Manufacturing Education Using Virtual Environment Resources)[1] is to develop an affordable virtual reality (VR) framework to address the imminent demand for well-trained digital manufacturing (DM) professionals. One important part of Project MANEUVER involves studying, evaluating, and identifying cost-efficient ways to generate 3D solid models for use in VR frameworks. To this end, this paper explains the research effort to find alternative ways so that 3D solid model could easily be generated without using any costly 3D scanning technology. In this study, the project team identified two software tools that could help the manufacturing professionals and educators generate a solid model of several parts. These two software tools namely, Qlone and 3DF Zephyr Free were selected for this study based on factors such as ease-of-use, cost-effectiveness, and the cognitive load on users. Using case-studies these two software tools were used to generate 3D solid models and prototypes. Finally, their pros and cons collected throughout this study were reported.

Introduction

Photogrammetry[2] is the science of making measurements from photographs, specifically for recovering the exact positions of surface points. In this sense, it is defined that it is a technology turning the Real World into a VR play space. In the engineering field, this type of technology is used in lieu of computer-aided design and manufacturing (CAD/CAM) and additive manufacturing (AM) programs to design products. The traditional CAD/CAM approach to design and engineer parts and products is highly time-consuming and labor-intensive. On the other hand, access to photogrammetric software can make the design process more efficient and reduces the cost to the manufacturer. To investigate this technology further, we began searching for cost effective photogrammetry software tools with the capability of exporting for 3D Printing purposes.

Our goal was to find a software tool that easily allows novice users to explore the world of photogrammetry and AM, as well as reduces the emphasis placed on CAD/CAM programs for reverse engineering parts or products. During our search, we were able to find two software programs that met our criteria in cost effectiveness and quality of scan: Qlone[3] and 3DF Zephyr Free[4]. Although the initial part of 3D models was accomplished with Autodesk ReMake[5] that was not an option for us to use at the end due to its convergence to costly Autodesk ReCap[6]. ReCap is used to convert reality into a 3D model that is ready for further design and 3D Printing. Today, there are several other photogrammetry software tools available on the market, but not all allow direct exporting options for 3D Printing. Several programs exhibited substantial difficulties with

meshing, causing repeated computer malfunctions and unexpected program failure. Both Qlone and 3DF Zephyr Free provided easy-to-use interfaces with working meshing platforms.

Qlone

Qlone is a free photogrammetry software created by EyeCue Vision Technologies in 2017. The software is free to download to an IOS device but costs per export. The goal of this software is to be able to use one's IOS device to scan objects on the Qlone printable mat and make minor modifications with the intent to 3D print. Qlone's interface was very easy to navigate with its large, well-labeled icons and tutorial video provided on the main ribbon.

To get started with Qlone, you must download the Qlone app from Apple's App Store. Then, go to Qlone.pro and print off the 8x8 Qlone Mat. Once you have your desired object on the mat, you can open the app and start scanning. You must keep the entire grid on the mat in view of your camera to get a successful scan. This may take a few attempts to get the desired scan. To get the best results, we used bright overhead lighting and attempted to scan at a consistent and slow speed from top-to-bottom. This smoothed the rough edges a bit and made the color more like the finish of the original model.

After the scan has been made, the model can be modified with a few basic editing tools: erase, smooth, soften, amplitude, paint, and blur. While all the features given are useful and easy to use, additional features such as the ability to create holes, rounds and clean edges will surely be desirable and are recommended. Furthermore, being able to navigate only by means of rotation is quite challenging. A feature that allows the user to pan the model can be especially handy when navigating objects with holes, crevices, and other complex surface features.

Overall, our assessment of Qlone determined that this software performs moderately well at matching the material color and laying it appropriately on the model. The software has some problems with creating clean edges and suitable heights and depths. It also fails to recognize fine details, holes, and sharp edges. Using Qlone on a phone consumes a great deal of battery power, meaning fully charging one's phone prior to scanning or keeping a charging cord on-hand might be necessary; this somewhat defeats the purpose of the portability of phone-friendly software. With further development and improvements, Qlone could become an excellent tool for home users or STEM programs looking for a basic introduction to 3D scanning and printing.

3DF Zephyr Free

3DF Zephyr Free is a photogrammetry software created by 3Dflow. This software aims to allow users to reconstruct 3D models automatically and easily from photos. There are a few different versions including 3DF Zephyr Lite, Pro and Aerial; all of which vary in price, ranging from $149-$4200.

3DF Zephyr is only available as a computer download and uses pictures to make a mesh of the desired object. The Free version of the program limits users to uploading 50 pictures at a time. We recommend capturing as many pictures as possible so that the software has sufficient

number of reference points; the redundant photos will be automatically deleted. Taking pictures from a consistent distance and at multiple angles with bright lighting is vital to producing a quality model. On the whole, instead of having many poorly interpolated points, it is beneficial and recommended to have a larger number of highly accurate points/polygons.

3DF Zephyr is a little more advanced than Qlone, but there are plenty of tutorials available online to help navigate the interface. Although the mesh quality with 3DF Zephyr is highly accurate, this is a time-consuming process and entails a PC with high-end graphics rendering capabilities. Even though there are various factors and options pertaining to mesh quality, typically the higher the mesh quality, the longer the time take to generate the mesh. Considering the meshes that were generated for this study, the time period ranged from 3 hours (shortest) to 14 hours (longest).

3DF Zephyr Free does an excellent job at matching the material color and laying it appropriately on the surface model too. For enhanced accuracy and calibration, after the photos have been loaded, Zephyr is capable of verifying its database for optimized data, subsequent to which the user can decide on how the actual photo set can be processed. Even though basic editing tools were available, there was no need to use these considering the quality of meshes generated. Regardless the quality being higher, 3DF Zephyr Free also had trouble recognizing sharp edges and holes.

3DF Zephyr Free is a good tool for users seeking further knowledge about photogrammetry and additive manufacturing. However, this software is a little more advanced, and for novice users, we advise taking advantage of the online tutorials. We also believe owning a computer with appropriate specifications is necessary to use this software successfully.

Evaluation of Both Photogrammetry Software Tools

To properly assess Qlone and 3DF Zephyr Free, few objects with varying physical features were selected. The same printer, Ultimaker 2 Extended +[7], was employed for all the printed parts; the colors may have changed due to availability. Shown below are the comparative images illustrating both the 3D models and printed parts. The first part was a 3D solid model of a person's left hand as can be seen in Figure 1.

The hand sculpture we chose presented challenges with the rounds of the fingers and creases in the palm. Qlone proved to match the original sculpture color reasonably well, but had some issues with the fine details. It had problems recognizing the creases between the fingers and in the palm. However, the 3DF Zephyr Free model is practically identical to the original sculpture. It has all the creases as the original sculpture and the rounds of the fingers are consistent all the way down to the palm.

The castle sculpture as can be seen in Figure 2 was especially tricky with its unique style of building positions and window depths. Both programs did an excellent job at making a model in the software. Instead of creating actual depths for the windows, both programs created excellent

skins to mimic the fine details of the original piece. However, this flaw became very apparent when we 3D printed the pieces. The Qlone scan did not seem to recognize any of the fine details of the windows or the outlines of the buildings themselves. 3DF Zephyr Free did recognize the location of the windows, but did not accurately reproduce the depths. Scanning the castle sculpture proved that both Qlone and 3DF Zephyr Free have limits to what they can successfully scan.

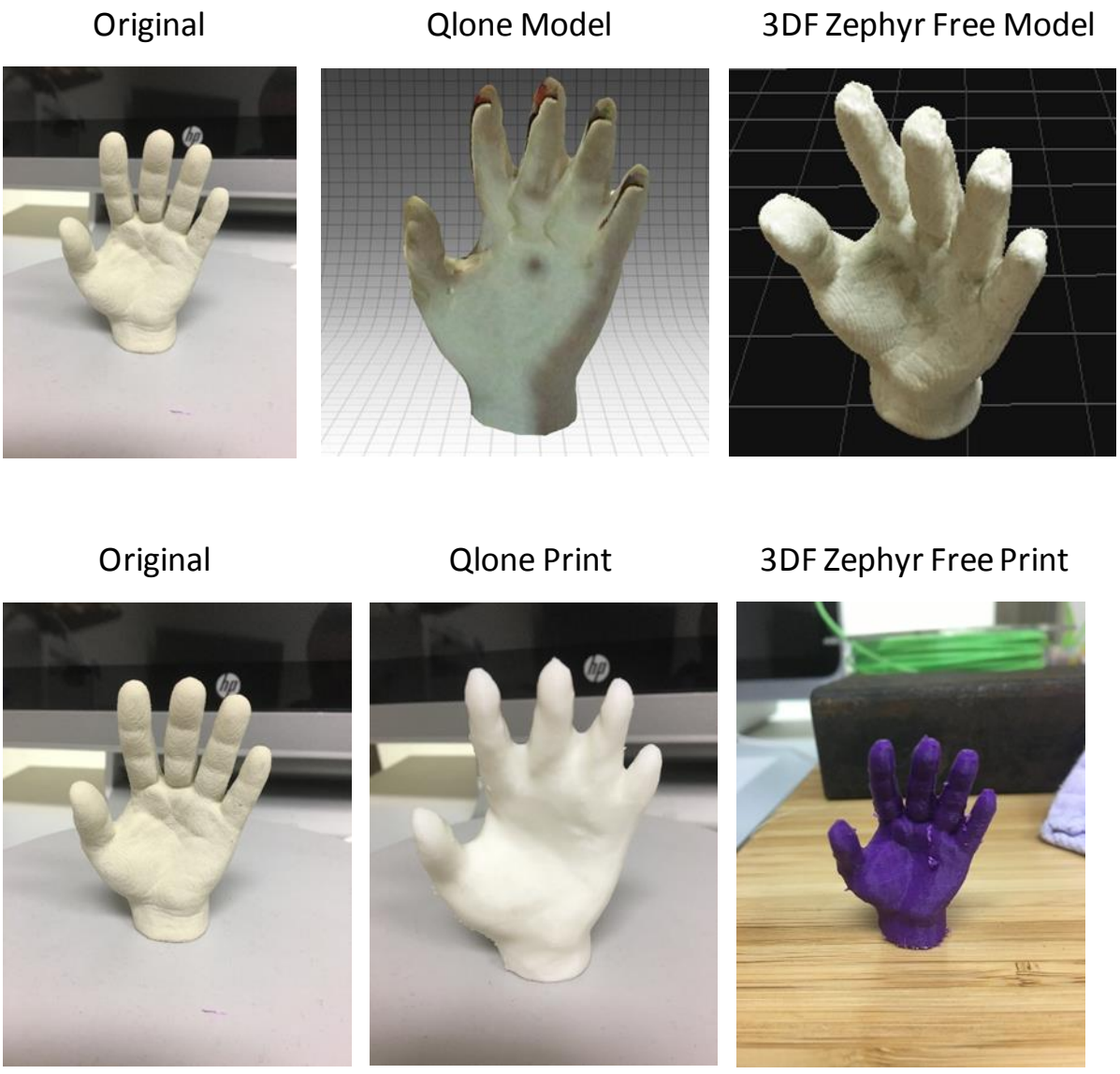
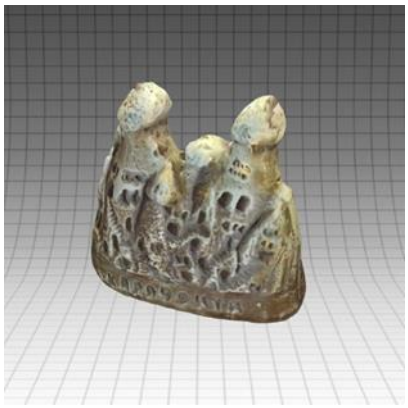


Figure 1: Qlone and 3DF Zephyr Free Software Tool Views of Left Hand (at the top)
3D Printed Views of Both Left Hands (at the bottom)

Original Qlone Model 3DF Zephyr Free Model


Original Qlone Print 3DF Zephyr Free Print



Figure 2: Qlone and 3DF Zephyr Free Software Tool Views of Castle (at the top)

3D Printed Views of Both Castles (at the bottom)

Discussion

All things considered, Qlone and 3DF Zephyr Free are both user friendly and affordable programs for novice users to consider. They both give users a cost-effective means to explore photogrammetry and produced sufficient quality scans for casual users. However, both programs proved to have flaws, but that is to be expected from software that is cost-effective.

Qlone's strength is in the fact that it is a phone app and can be used anywhere, given one has enough charge on their IOS device. What it lacks in quality is made up in mobility. Since Qlone is an app it makes it very easy for users to download and use on the fly. On the contrary, 3DF Zephyr Free provides opportunity for higher quality scans but is more complicated to use. The lack of mobility makes for a good trade when superior quality scans and meshes can be made. 3DF Zephyr requires more equipment and technological experience to use but the results are much more professional.

Overall, both programs provide good opportunities for amateurs to expand their knowledge of photogrammetry. Qlone and 3DF Zephyr Free are easy to download and access, given one has the correct equipment. 3DF Zephyr requires a computer and camera to use properly, but results in higher quality meshes. Qlone is a very user-friendly IOS app, but results in lower quality meshes. Both these programs enable users to explore and exploit the advantages of photogrammetry in a cost-efficient manner. Besides, they also reduce the emphasis on CAD/CAM programs for reverse engineering parts or products.

Conclusion

Conventional way of generating a 3D solid model for any CAD/CAM and AM application is usually to use a design software tool. Reverse engineering (or 3D scanning) tools are also popular in obtaining the 3D solid models. However, both options are usually costly, and it takes quite a bit of time to generate high quality solid models. This proof-of-concept study shows two intuitive photogrammetry software tools that could be learned and practiced easily. Both case studies presented showed that some decent quality end results could be obtained as long as the user makes precise recording and processing. Both studies have not been tested in any educational or laboratory setting at this time. It is hoped that the findings of this study are adapted and implemented in several engineering and technology institutions in the near future.

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