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DEVELOPMENT OF HANDY AND COST-EFFECTIVE 3D MODELS FOR ANATOMICAL STUDIES.

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Abstract

This study demonstrates the possibility of creating 3D stereoscopic models using only a mobile device and the PolyCam 3D app, which is easier, more affordable, and simpler than utilizing a workstation. It was successfully shown that a different method of producing photogrammetric models can be deployed. These models can be 3D printed, and its recent applications in the engineering and medical training sectors have emphasized the potential economic benefits in a broader sense. The vast benefits presented by photogrammetry mean that it may still be used to facilitate anatomy learning in the future and as such, harnessing photogrammetry skill could even prove to be very handy not only in anatomy but in other fields like engineering and production.

Keywords: 3D stereoscopic models, PolyCam 3D app, photogrammetry, anatomical studies.

1.0 Introduction

Human anatomy has been the foundational basis of medical education for centuries. Cadaver-based instruction alongside didactic lectures has long been the standard method for such education (Parker, 2002). Many medical institutions are resorting to new methods of teaching anatomy to reduce the expense of using cadaveric material. The field of medical knowledge is constantly expanding, though, and many medical schools are abandoning the conventional paradigms of teaching anatomy in favor of more recent sciences, technology, and resources (Johnson et al., 2012). To save the expense of employing cadaveric materials, medical educators and institutions are turning to innovative techniques for teaching anatomy (Mclachlan et al., 2004). The development of emerging technology has given anatomical studies a more practically applicable perspective. Virtual reality applications, 3D-printed anatomical models, 3D computer models (Lim *et al.,* 2016), Radio imaging, computer-assisted learning, and cross-sectional anatomy have almost (and in some institutions, entirely) replaced dissection-based learning.

Prior to now, the application of photogrammetry in anatomy was primarily limited to measuring specific organs or structures (Dirven et al., 2008), but it is currently becoming more broadly used across a variety of industries. However, the education sector has yet to accept it and make use of its wealth of advantages. Its applications are currently widely used in the toy, architectural, and electronic industries. Despite the lack of agreement, many experts agree that 3D computer models have the potential to be affordable, acceptable additions to conventional anatomy curricula (Keedy et al., 2011). This viewpoint is held for a number of causes. First, it is notable that digital 3D anatomical models are available as reference tools for preoperative planning, intraoperative visualization, and sizing or pre-fitting medical equipment for both routine and highly complex procedures, 3D printed anatomical models are being used by healthcare professionals, institutions, and organizations all over the world (Chepelev et al., 2017). The amount of time surgeons spend in planning and performing surgeries is frequently reduced, which lowers patient risk, anxiety, and recovery time while also dramatically reducing operating room costs. Dissection and prosection have been adopted since the inception of anatomical science, but in light of changing social and ethical standpoints, the emergence of new health concerns, and the unsustainable costs involved with teaching using cadavers, new resources are required to maintain a high level of anatomy knowledge for those planning to enter the surgical field. Cadaver-based anatomy courses are not available in all medical institutions, as maintaining cadaveric materials requires financial, ethical, and safety considerations (Raja & Sultana 2012). While students have access to digital learning resources whenever and whenever they choose, physical cadavers and prosections are only permitted in laboratories. As one study pointed out (Pujol et al., 2016), digital libraries of anatomical specimens would offer frequent access to anatomical variations that might be challenging to find in the laboratory. Physical cadaveric materials are filthy and stinky and are difficult to move. Additionally, when inspected by security personnel, cadaveric materials are not security compliant due to ethical considerations. Cadaveric materials are not biosecure in the sense of being harmful to human health. This research attempts to provide handy and cost-effective 3D models for anatomical studies.

2.0 Materials and methods

2.1 Materials:

An Android-powered smartphone, a gaming PC, and Polycam® version 1.0.7 were utilized as the core tools for making 3D hand models utilizing photogrammetry and 3D printing technologies. The specimen which was used to create the 3D model was a plastinated hand model, macerated humerus and femur.

Fig 1a: A plastinated hand model

Fig 1b: Android powered smartphone

Fig 1c: Polycam logo

2.2 Methodology

2D Photo capture

The specimen was positioned on an 80cm high stool outside, with 1 meter of floor space between the stool and the operator with 0^o-180^o of clearance laterally, where 90^o was the primary area of interest to capture. Floor clearance allowed sufficient room for the operator to move around the object during the capture process.

Using the mobile device, the Polycam® 3D application was launched, and a fresh capture was chosen by clicking the "+" button in the lower-right corner of the screen. After focusing the camera's field of view, the user kept a 30 cm space between the object and the phone while bringing it to the top of the specimen. Three different angles were used to shoot the photos superior bilateral and inferior.

For each model, the same position for taking the photos was repeated as the specimen was positioned upright and turned upside down. 2D pictures were taken at 0, 45, 90, 135 and 80 degrees. 105 shots of 2D photos were taken for the humerus model, 113 shots were taken for the femur model and 205 shots were taken for the cadaveric hand model.

The phone's camera should have at least 18 megapixels. We took extra shots of locations that retained significant information, such as the palmer surface of the hand, which revealed muscle structures and other intricate structures in bones. When collecting photos, we tried to overlap each image by at least 50%. During the photo shoot, the operator moved around the object rather than moving the object itself.

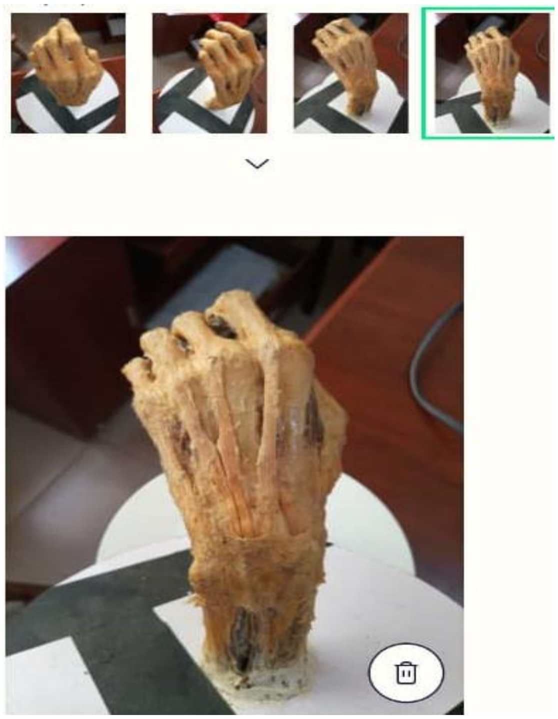

Fig 2a: Photo capture of prosected hand

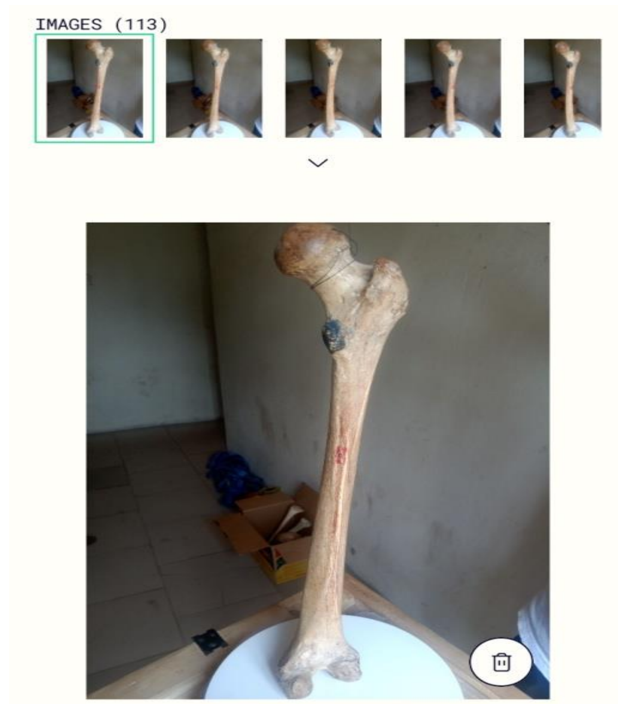

Fig 2b: Photo capture of femur bone

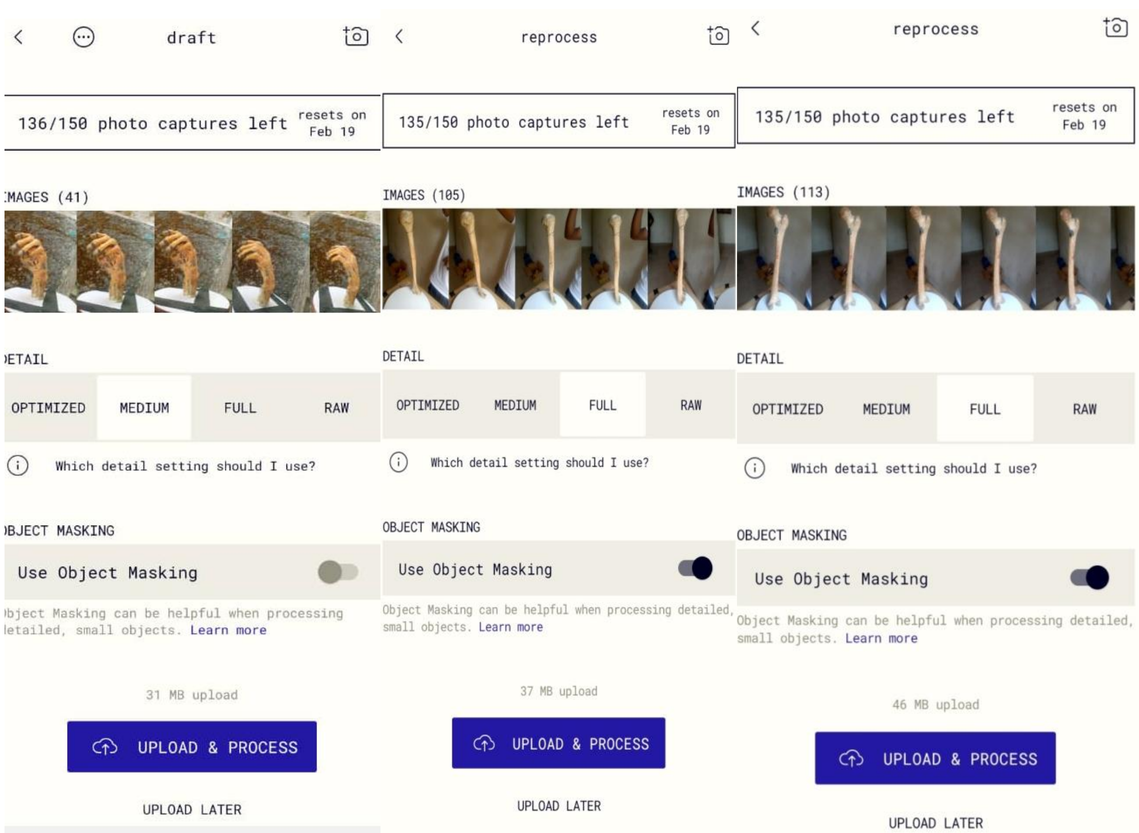

Fig 2c: Photo upload and processing

Convert 2D images into a stereoscopic 3D model

The photogrammetry program automatically converted the captured images from 2D to 3D when they were uploaded by pressing the "upload button". The software's mask capability was engaged, and it automatically converted 2D stereoscopic models to 3D ones. This took roughly twenty minutes.

Fig 3: Virtual 3D model of the hand, humerus and femur.

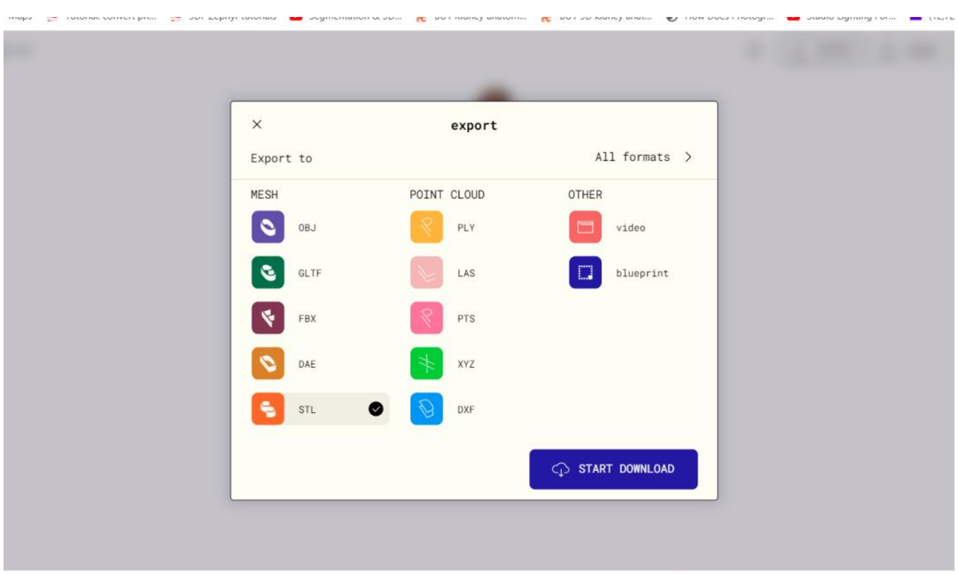

Fig. 4: Showing export of digital model to STL file

Produce virtual 3D models that can be used in other applications.

The stereoscopic model was exported at this point into an STL file format, which is the only one that applications other than the polyCam 3D app can understand.

3.0 Results and observation

After carefully photographing the item of interest using the PolyCam App, three 3D models of the object were successfully created (as shown in figs. 5a, 5b and 5c). To determine the viability of generating 3D printed models, a precise timetable was developed: photo taking required 5–10 minutes each model, image uploading and processing required 20–30 minutes, for a total of roughly 40 minutes for one model and 2 hours for the three models.

Utilizing photogrammetry to create 3D models has a comparatively low cost. Given that every modern day student possesses an Android phone, the sole financial expense for creating the interactive models for this study was the license fee for the photogrammetry program.

The 3D stereoscopic models showed a variety of anatomy suitable for pre-med courses. For studying and revisiting anatomical structures inside or outside of the lab, the level of detail provided excellent visibility.

Figure 5a shows a prossection of a cadaveric hand in stereographic form. Structures like the tendons of the flexor digitorum profundus muscle, flexor carpi ulnaris, and flexor capiradialis can be seen on the palmer surface, while the tendons of the extensor digitorum and extensor digiti mini muscles can be seen on the dorsal surface.

The model displayed in fig. 5b is a femur bone. The femoral head, greater and lesser trochanters, the patellar trochlea, the lateral epicondyle, and the medial epicondyle are all plainly visible structures at the anterior surface. The femoral head, greater trochanter, intercondyloid fossa, medial condyle, lateral condyle, medial epicondyle, and linea aspera may all be seen clearly when looking at the posterior side.

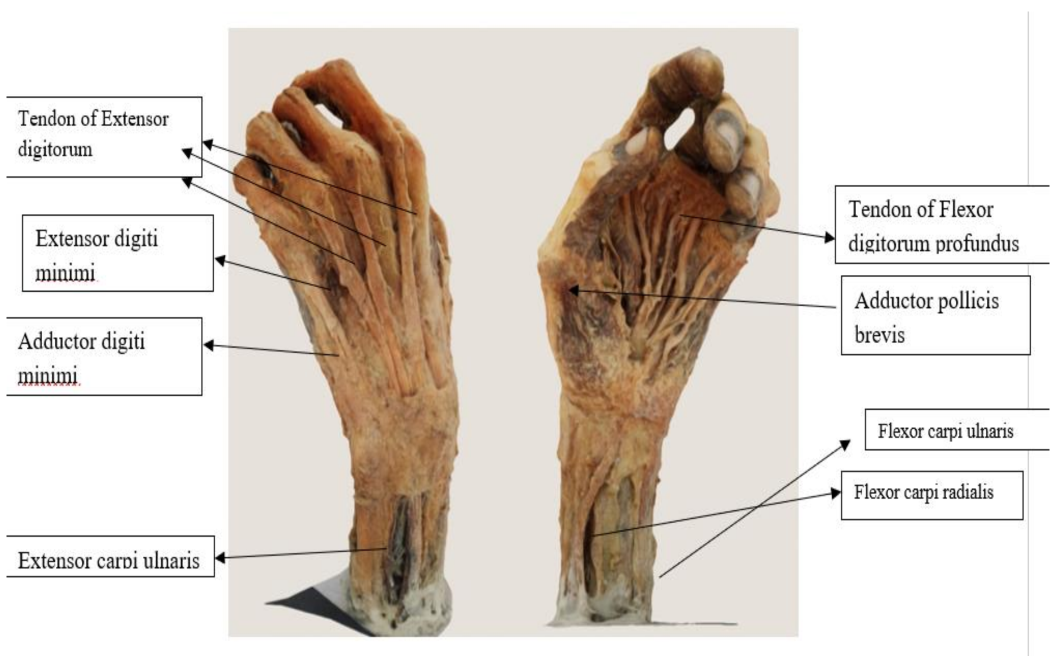

Fig 5a: Dorsal and palmer hand

Fig 5b: Femur bone. (Posterior and anterior views)

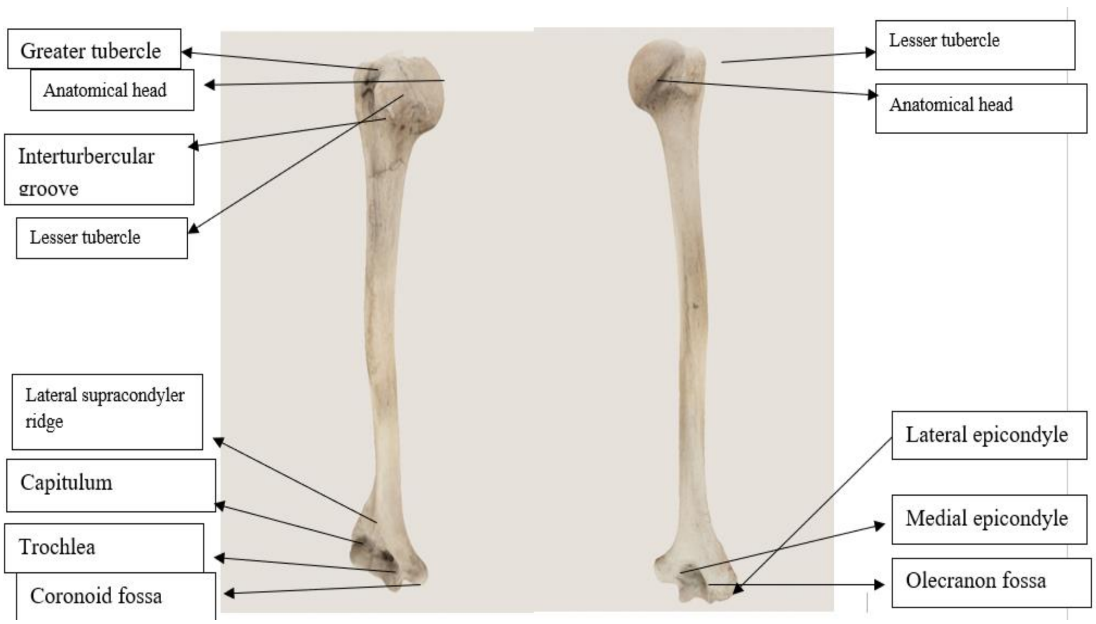

Fig 5c: Humerus bone (Anterior and posterior views)

Fig 5c clearly shows a 3D virtual model of a humerus bone, from the model, structures like the greater tubercle, lesser tubercle, intertubercular groove, anatomical head, surgical head, coronoid fossa, lateral supracondylar ridge, trochlea, capitulum, lateral epicondyle and medial epicondyle are clearly depicted at the anterior surface while at the posterior surface structures like the anatomical head, surgical head, greater tubercle, trochlea, olecranon fossa, lateral epicondyle and medial epicondyle are distinctly visible.

4.0 Discussion

The creation of 3D models from 2D images has been done by many researchers (like that of Aldis et al., 2018, Dhumale et al., 2018, and Marcin et al., 2021), however most typically the image capture setup is done using a workstation that includes a digital camera, lighting tool, and turn table. For this study, however, only an Android mobile device with the PolyCam 3D App loaded was employed for the photo capture and ultimately for the full production of the final 3D stereoscopic model. This setup is frequently expensive and unattainable for certain researchers.

Similar to the work of Salazar-amarra et al. (2016), this study sought to build a low-cost method for producing 3D models utilizing photogrammetry employing a mobile device and licensed software.

According to the study's findings, the tendons of the flexor digitorum profundus muscle, the flexor carpi ulnaris, the flexor capi radialis, and the tendons of the extensor digitorum and extensor digiti mini muscles can all be clearly seen in digital 3D models. These results are consistent with those of Aldis et al., who found that features like coronary artery protrusion and blood pooling in the posterior lungs are clearly discernible in photogrammetrically generated 3D models (Aldis et al., 2018).

All modern mobile devices have an integrated accelerometer and gyroscope sensor, which are automatically run by the application to guide the operator in a 3D position during the photo capture sequence (Salazar-amarra et al., 2016). This is the rationale for using a mobile phone for making photo captures through the PolyCam application. As a personal tool rather than a piece of medical equipment, mobile devices in today's market are also outfitted with quicker processors, quick networks and connections, high-quality cameras, and additional functions.

5.0 Conclusion

This study has demonstrated that it is possible to successfully capture and create 3D stereoscopic models using only a mobile device and the PolyCam 3D app. This method is easier, more affordable, and simpler than utilizing a workstation. In general, this study has shown a different method of producing photogrammetric models. These models can be 3D printed, and its recent applications in the engineering and medical training sectors have emphasized the potential economic benefits in a broader sense.

Digital 3D models, however, might provide an innovative, accurate, and efficient replacement to cadaveric materials in light of challenges including the high maintenance costs of cadaveric materials, increasing health concerns, and ethical concerns.

The vast benefits presented by photogrammetry mean that it may still be used to facilitate anatomy learning in the future and as such, harnessing photogrammetry skill could even prove to be very handy not only in anatomy but in other fields like engineering and production.

6.0 Limitations

1. Access to cadaveric material is ultimately necessary for the initial phase of the model's developmental process.

2. Photogrammetry can only capture detailed anatomy to the level of its original specimen. Since the output is only as good as the input, therefore only high quality prossections can be selected for image acquisition and processing.

3. If students only have access to "scaled" models, it could lead to a lack of understanding of real size and relation to other anatomical components.

4. Without the permission of the donor, 3D modeling of the body may lead to a lack of "reasonable informed consent", which is ethically questionable.

5. The photogrammetry app used for this study only work in selected models of phones and as such not all phone types can be used to create 3D models.

6. the photogrammetry application only work when there is internet connection and as such this may pose a challenge to those in area of poor or no internet availability.

7. The 3D application is not entirely free software, one has to subscribe with money in order to gain access to all the features in the application.

7.0 Recommendation

In the world at large, photogrammetry and 3D printing technology are cutting-edge and still in their infancy. Although they have several uses in the toy, construction, and electronics industries, these technologies have not yet been fully utilized. Students should do in-depth research in this field and efficiently use this technology, not just for the study of anatomy but also for other purposes.

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