PROCESSING AND ANALYSIS OF THE DATA OBTAINED USING PHOTOGRAMMETRY FOR 3D SCANNING

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Abstract: Nowadays, 3D scanning can be considered a tool that can be easily used by anyone. There are a lot of 3D scanning methods in which time and money are invested so that they can become more developed, but in the next pages one of the most cost effective to obtain a 3D model, photogrammetry will be described. The method of processing, data gathering (photographs) and an analysis of surface deviation will be presented.
Keywords: 3D scanning, photogrammetry, scanning errors, surface deviations of scanned models

1. Introduction. 3D Scanning

Since the '60s or '70s, scientists and engineers have searched for 3D scanning techniques. The first technique was discovered back then, which is projecting light on the surface of the object to be scanned. Afterwards, in the '80s, the first triangulation scanning techniques were discovered, and in the 2000s, there was the greatest technological advance, due to increased computation power compared to the previous decades [1].

Nowadays, there are very diverse techniques, more complex and more precise, and the prices of many scanners are accessible to anyone. In the following pages, one of the most cost effective and easiest to use methods will be presented, one which uses photogrammetry. The main purpose is to determine the errors and deviations of a 3D scanning using photogrammetry using smartphones and professional cameras instead of using professional scanners, with the advantage of reduced or even zero costs, and easiness of obtaining a 3D model [2]. Also, we can consider this method a tool which could satisfy our needs at home, because, once the 3D model is obtained with scanning, any broken or deteriorated object could be replaced with 3D printing, using dedicated design tools like Creo or Catia, even with added improvements to the model. The main disadvantages to using this method are low precision, long scanning times, and high complexity of the 3D model computing software, compared to other 3D scanning methods currently existing [3].

In an industry such as, for example, automotive, no compromises can be made in terms of precision and time scanning, so in the following pages the errors and scan deviations will be determined.

2. Photogrammetry

Photogrammetry is a measurement and modelling technique for objects, by using photographs. This is based on the principle that relative point positions from a scene can be deduced out of different captured perspectives from photos made at variable angles (fig.1). These photos must cover the object in its entirety and offer enough details to allow the 3D information extraction [4]. Once these photos are taken, using specialized photogrammetry programs, common reference points are analyzed (such as corners), to determine their positions in space. The algorithm estimates the geometry and tridimensional structure of the object by triangulating the corresponding points (fig.2).

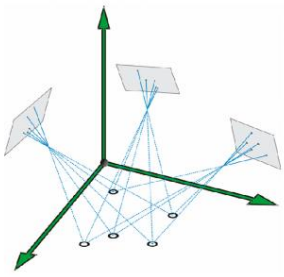

Fig. 1. Different positions and angles for capturing photos [5]

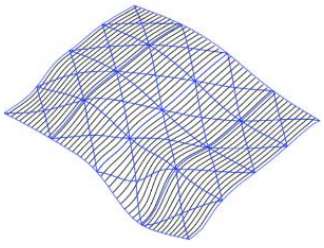

Fig. 2. Triangulation of points on a surface [6]

The more precise these estimations are, the more the generated 3D model's quality will be better, so a series of conditions will be necessary, some of the most important being:

- High number of photos
- Many varied angles

- Photo quality as good as possible
- Well textured surfaces

3. Methods Used. Setup

Processing and reconstructing the 3D model using photogrammetry requires obtaining photos with any device and processing these with some dedicated software. In the following two photograph capture techniques will be mentioned, namely the photograph obtaining method using smartphones and the application MetaScan, and the second method being that of obtaining photos using professional cameras. The photos will be processed using the Colmap software, which will generate a cloud of 3D points. The .ply file generated by Colmap will be imported in the dedicated program to generate and refine the 3D model, namely Mashlab.

Due to the fact that this technique uses the photogrammetry's principles, it must ensure a series of conditions to raise the chance of success of a scan:

- Good light, without shadows and reflections
- Edges and corners well highlighted
- High numer of photos
- Many and diverse angles

Taking into account all these conditions, the quality and precision of the scan can be dramatically increased. Therefore, a very small investment is needed to ensure these conditions. This being said, in fig. 3 we can notice the stand that will be used to satisfy all the conditions mentioned above.

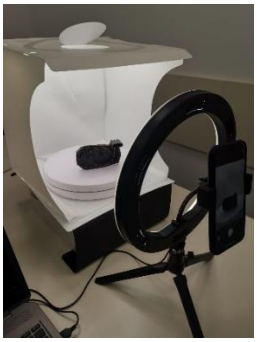

Fig. 3. Photo booth with controlled conditions

The stand is comprised by:

- Photo tent: ensure the right illumination of the part
- Tripod: ensure the right positioning of the photography device. Offers extra light
- Rotating table: ensure the part's photography angle change
- Smartphone Iphone XS

For the second method, the setup is the same, but the tripod and the photography device is changed, being a Canon 750D (fig.4).

Fig. 4. Photo booth with controlled conditions

To determine the scan errors, there were chosen products made by Vitesco Technologies Engineering with a high complexity and small dimensions.

3.1. Processing and Reconstruction the 3D Model Using Smartphones

As mentioned above, processing and reconstructing data will be made with the Iphone XS smartphone and the dedicated program Metascan. The setup can be observed in fig. 3.

Fig. 5. Cogwheel-Metascan

Fig. 6. Cogwheel - mesh

In fig. 5 and 6 the result of scanning a cogwheel with the big diameter having 45mm and the tooth height being around 3mm can be seen, so it is a part with small dimensions and a high complexity. On the surface of the part some red lines can be noticed, being due to the fact that the part has a light color and generating the 3D model can be difficult in these conditions.

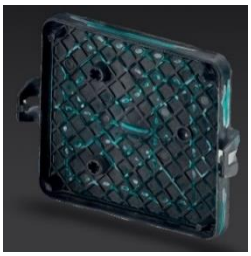

Fig. 7. Plastic cover

Fig. 8. Plastic cover - mesh

In fig. 7 and 8 the plastic cover of an NOx sensor is presented. The external dimensions of the cover are

75mm x 60mm x 14mm, so, it is a part with small dimensions.

In the above scans it can be noticed that the quality is pretty good despite the small dimensions, and the parts have a rather high complexity.

In fig. 9 and 10, the result of a much bigger scan is presented. This scan was done outside, in conditions of uncontrolled light.

Fig. 9 Scanned statue

Fig. 10 Scanned statue – mesh

3.2. Processing and Reconstruction the 3D Model Using Professional Cameras

Just as it was mentioned above, in this case a professional camera will be used to obtain higher quality photos, so a more precise 3D model. Another advantage of this technique is the fact that we have the possibility to manually refine it.

After taking the photos, the point cloud will be generated with the help of Colmap program, and it will be imported in Meshlab, where the refining of the model will take place.

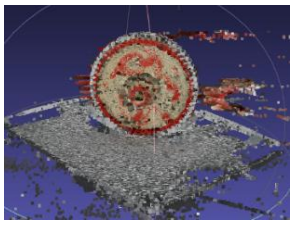

Fig. 11. Cogwheel-Meshlab

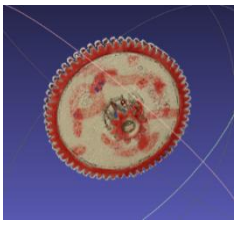

Fig. 12. Cogwheel rafined

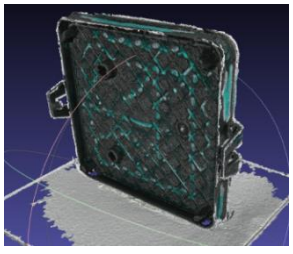

Fig. 13. Plastic cover Meshlab

Fig. 14. Plastic cover

In the above figures the same objects were scan, using different techniques. It must be mentioned that the whole process was lengthier and required powerful computing resources.

4. Determining Scan Errors and Deviations Using GOM Inspect

After obtaining the parts 3D models using both techniques, they will be compared with the ideal models (.STP files) of these parts to determine surface deviations. For this fact, GOM Inspect software will be used.

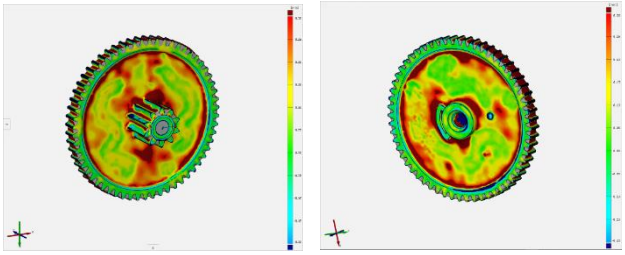

Fig. 15. Surface deviations - Smartphone method

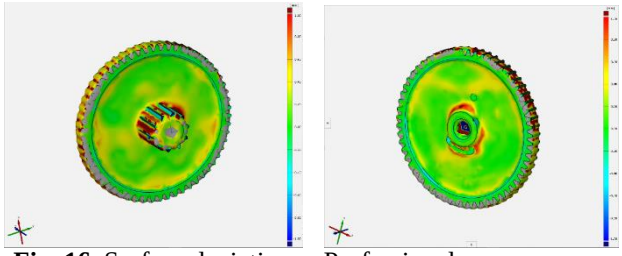

Fig. 16. Surface deviations - Professional camera method

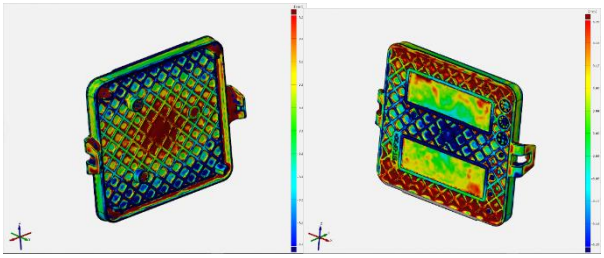

Fig. 17. Surfaces deviations - Smartphone method

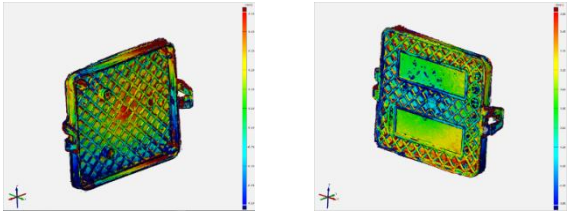

Fig. 18. Surface deviations - Professional camera method

In case of the cogwheel in fig. 15, we have a dimensional deviation of -0.693mm / + 0.792mm and for the cogwheel in fig. 16 we have a deviation of -0.539mm / + 0.587mm. In the case of the cover in fig. 17, we have a deviation of -0.707mm / +0.777mm and in the case of the cover in fig. 18 we have a deviation of -0.519mm / +0.451mm.

As it can be seen in the above pictures, the surface deviations in case of the 3D models obtained with the help of professional cameras are smaller than those models obtained using smartphones, due to the superior quality of the camera. It must be mentioned that the scanning technique using cameras require a higher time to process and refine the model, and also high computing power of the computer that performs the generation. The scanning method using smartphones, despite having a bigger scan error, has a portability advantage easiness of usage and a very low price.

5. Scaling the 3D Model

Another very essential fact that has to be mentioned is the fact that the 3D model obtained by any of the forementioned methods, require a re-scaling, due to the fact that the 3D model obtained using a smartphone generates a model 20% bigger than the real object (fig. 19) and the scanning method using professional cameras.

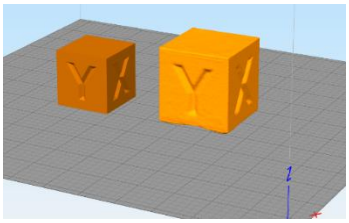

Fig. 19. Rescaling an object

Rescaling can be done with any type of CAD design software or any slicer type program.

6. Conclusions

Today, among the many advanced technologies, the part reconstruction technology is also available. These technologies are numerous with each having its own advantages and disadvantages. In what was presented before, we see two of the most cost effective ways to perform 3D scans, namely methods that rely on photogrammetry.

This process is based on three dimensional reproduction of parts using photographs from which some key points are extracted in order to create a cloud of three dimensional cloud. If one of the above scanning methods is to be used, one must know exactly the goal to be reached and from what rabate can be made. If you want to invest as little as possible, then the most suitable scanning method is the one with smartphones.

It must be mentioned the fact that precision will be affected by the phone's camera quality and by the external conditions, such as light. The quality of this method's scan can be raised but an investment to control the parameters such as luminosity, angle, etc. will be needed. Although, if there is a possibility to invest and if a higher precision is wanted, then the best method is the one in which photographs are obtained using professional cameras and this is due to the superior photo quality, and the possibility to manually refine, but it has to be kept in mind that model generation and refine softwares require high computational resources and a long processing time.

6. References

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