Utilization of Modern Optical Methods for Creation of Digital Model of Human

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Abstract. The aim of the paper is to describe the methodology of creating a digital model of human using an optical 3D scanner. This methodology consists of several main phases, such as preparing the scan for human movement, scanning in the shortest possible time, and processing the data obtained by scanning. The data processing itself is divided into other sub-phases, which describe the individual steps necessary to create a digital model. The paper describes obstacles that need to be eliminated or minimized during 3D scanning in order not to disrupt the integrity of the model and to create a digital model.

1. Introduction

Currently, modern optical measurement methods can be divided into three groups, optical 3D scanning, laser 3D scanning, digital photogrammetry. In this paper we focus on creating a digital model of human. But the human body cannot be completely immobilized. Even when not moving, one has to breathe, creating movement that reduces the quality of the point cloud obtained. For this reason, it is necessary to choose the method as quickly as possible, with this requirement it is possible to avoid digital photogrammetry, which is time consuming. An important aspect is also the safety of the person being scanned, when scanning with a laser scanner is dangerous for the eyesight. Therefore, the most suitable method is 3D optical scanning, which scans the surface of the scanned object using structured light and does not endanger the health of the person being scanned.

The Artec Eva Lite handheld 3D scanner was used to create highly detailed and accurate scans, which does not scan texture or colors in this version. This optical scanner is suitable for acquiring 3D data of objects up to 3 m in size, such as archaeological artefacts, sculptures or works of art.

2. Related Work

3D scanners are usually used to acquire 3D models, which are usually static. An example can be study[1], which describes process[2,3] of application of 3D scanning and acquired data processing to get model of a building.

There are various purposes of acquisition of 3D data. Usuall purpose is simple visualisation, but there can be also project-specific purposes. In construction industry acquired 3D data can be used for obtaining[4] and sharing[5] data for building information model or can be used to obtain useful data for construction projects[6,7]. These data can be defined based on project priorities and scope[8,9].
Another example of 3D scanning applications is in craniomaxillofacial surgery[10]. It can be expected that importance of acquisition of 3D models using 3D scanning will be growing with continuous implementation of industry 4.0 principles[11,12].

3. 3D scanning and data processing
For the scanning of living creatures, in our case humans, it is very important to prepare the scan itself. Division of the scanned object into parts, suitable selection of overlays. All of these actions aim to ensure that the actual scanning takes place in the shortest possible time.

For overlapping scans, the best figure for the overall figure is the fuselage area, which is the easiest to scan - there are no protruding parts and the scanner works at a uniform distance. Thus, each individual scan begins in this part of the body and then scans further away from it. During the scanning process, we can monitor the captured dots on the display. The problem areas are hair that is too fine for us to use the optical 3D scanner, and therefore we chose an account that will make hair compact. Another such part is the eyes, which should be closed while scanning the face, although the optical scanner is not dangerous for eyesight. The last element is shiny metal objects such as earrings, piercings or belt buckles, but these items can be put away before scanning.

During scanning, the movement of the person being scanned cannot be detected. We do not reveal these movements until the data is processed. Figure 1 shows the raw data of all scans. There are eleven of them in total and all overlap. In order to eliminate the deviations caused by motion, we chose the reverse procedure of data editing. The classic approach is to combine individual scans into one point cloud before cleaning, smoothing and modeling the point cloud. In our case - human scanning - we first modify the individual scans and then join them one by one.

Figure 1. Raw data from optical 3D scanner
The whole process of data editing is demonstrated graphically in Figure 2. All tasks are performed in the software by delivery together with the used 3D Artec Eva Lite optical scanner called Artec studio 11, which allows most tasks to be performed automatically due to the shape difference of the scanned object, in our case mainly due to precise pre-scanning preparation and sufficient overlap of individual scans. In the first phase of data processing, we need to eliminate point noise. These are the points outside the main model that always occur during scanning and need to be removed. This part is fully automatic and is not time consuming. Using an optical scanner does not create too many of these points, unlike a laser scanner.

The second phase of the data processing process is to smooth the scan. Scanning smoothing refers to the unification of the surface of the model into a triangular mesh at our preferred density. At this stage it is already possible to see the form of an almost final virtual model of the part of the object from which the scan originated. This process is fully automatic but the time required increases according to the size of the scan.

Figure 2. Process of data editing

The next step is to combine individual scans. This part is the most complex in this type of model, in our case man. Joining takes place one scan at a time. Scans need to be carefully selected to build on and to contain areas that need to be replenished. It may happen that the same area in two scans does not correspond positively to each other during scanning. This is caused by the movement of the person being scanned during scanning. Here it is necessary to select the most suitable scan very sensitively and to delete this part from the others in order to avoid duplication in the final scan. This can be seen in Figure 3. These deviations occur most frequently in the hands and feet, as it is impossible to hold them for several minutes, then in the chest area because of the person's breathing and neck area, especially children bending their heads down for a short while in a virtual model it is not easy to attach a head to the body.

The next part is to fill the holes in the model, which can occur for various reasons listed at the beginning of the article. Here again we use the automatic function, by means of which the model is enclosed in one unit. In our case, there were no holes in the model, but we know from experience that this can happen.
Figure 3. Duplication of scans due to the movement of a person during scanning

All described parts of editing data from 3D scanner were done automatically by software. In the final model, however, there are errors that can be seen in Figure 4 and need to be corrected manually. These are not scanned hair, poor connection of hands or feet. These places tend to be in places where the scanner cannot get high-quality images (armpits, lower chin, etc.). The work is sensitive to the scanned person to make the virtual model as accurate as possible.

Figure 4. Combining scans from both scanning

In our particular case, we performed the entire scan of the person twice independently of each other. This tactic was chosen intentionally due to the age of the person being scanned and the
assumption that they would not stand still throughout the scan. Both scans contained parts that could not be joined precisely because of the movement of the person being scanned. In the first model, there was a doubling of the left arm, which would be very complex to model and we could not guarantee the accuracy of the model. The second model had very damaged legs, which could not be modeled even at the loss of accuracy model. The compromise was to use the highest quality of each model and combine both into one digital twin, which can be seen in Figure 4.

4. Conclusions
Precise recognition is even more important when scanning a person than when scanning static objects to reduce the scanning time. Each additional minute increases the risk of the person being scanned and thus decreases the quality or totally degraded data. The process of data editing is the same as when scanning static objects but the individual parts are performed in another order. Instead of the usual combination of scans and then cleaning, smoothing and finishing, the point cloud was first cleaned and smoothed, and then some parts of the selected scans were joined and deleted to make the digital model as accurate as possible and eliminate inaccuracies caused by whether by breathing or balancing. The final step remains to model parts that cannot be scanned perfectly. The resulting model in our case consists of two separate scanning processes, in each of which there was a certain movement, which depreciated the resulting model.

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References
[1] Prušková, K.; Dědič, M.; Kaiser, J., “Possibilities of Using Modern Technologies and Creation of the Current Project Documentation Leading to the Optimal Management of the Building for Sustainable Development,” Central Europe towards Sustainable Building (CESB19), 2019.
[2] Myslín, J., Kaiser, J., “State based milestones in process modeling methods based on behavioral approach”, Education Excellence and Innovation Management through Vision 2020: From Regional Development Sustainability to Global Economic Growth, pp. 3598-3606, 2017.
[3] Kaiser, J., “Process Modeling for BIM,” Central Europe towards Sustainable Building 2016 - Innovations for Sustainable Future, pp. 781-788, June 2016.
[4] Prušková, K.; Kaiser, J., “Implementation of BIM Technology into the design process using the scheme of BIM Execution Plan,” IOP Conference Series: Materials Science and Engineering, vol. 471, 2019.
[5] Rádl, J.; Kaiser, J., “Benefits of Implementation of Common Data Environment (CDE) into Construction Projects,” IOP Conference Series: Materials Science and Engineering, vol. 471, 2019.
[6] Rádl, J.; Kaiser, J., “Realization Processes of Road-building Projects in the Czech Republic: Necessary Information to Execute Processes,” IOP Conference Series: Materials Science and Engineering, vol. 603, 2019.
[7] Rádl, J.; Kaiser, J., “Information Insufficiency Problems in Construction Projects,” Vision 2020: Sustainable Economic development, Innovation Management, and Global Growth, pp. 5059-5070. 2017.
[8] J. Myslin and J. Kaiser, “Priority of Requirement and Method for Definition of Project Scope,” Int Business Information Management Assoc, pp. 4002-4013, 2017.
[9] K. Prušková, "Reducing failures rate within the project documentation using Building Information Modelling, especially Level of Development," Building Defects 2017, MATEC Web of Conferences, Vol. 146, 2018, ISSN 2261-236X.
[10] Kantor, J., “Comparison of three-dimensional scanner systems for craniomaxillofacial
imaging,” Journal of Plastic, Reconstructive & Aesthetic Surgery, vol. 70, pp. 441-449, 2017.

[11] Budský, P.; Kaiser, J., “Industry 4.0 Impact on Enterprise Information Systems,” Education Excellence and Innovation Management through Vision 2020, pp. 5639-5646, 2019.

[12] K. Prušková, "The mutual relations between level of development and project documentation stages in Czech Republic’s legislation," 17th International Multidisciplinary Scientific Geoconference SGEM 2017, Conference proceedings, Vol. 17, Nano, bio and green - technologies for sustainable future, Issue 62, pp. 821-826, 2017, ISBN 978-619-7408-13-3.