CREATING 3D MODELS OF GAME ASSETS WITH THE USE OF PHOTOGRAMMETRY AND LOW-COST EQUIPMENT

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Abstract: *Photogrammetry, as a technique of deriving 3D spatial dimensions from multiple overlapping photographs taken at diffrent location, is an essential tool to produce 3D models through acquiring a 3D point cloud. It has became an essential tool for experts in various domains: cultural hertitage documentation, environmental planning, computer games. In this work, it will be described methods of acquiring 3D models and process of producing them for game technology with a use of the photogrammetry. It also aims to give an overview of possibilites and limitation of this method using low-priced or free-ware that can be applied. Aditionally, it presents a principle of combined application of laser scanning and photogrammetry.*

Key words: *3D models, photogrammetry, games, point cloud*

1. Introduction

Using 3D data capture for game development has recently achieved a remarkable success because of the way how fast a particular element of reality can be incorporated into a digital asset. For a small independent game studio producing a high-quality digital art is usually long and challenging path. 3D art requires considerable financial resourses, various set of skills, diversified professionals.

An impressive example for using photogrammetry in game industry is a game Vanishing of Ethan Carter, where the team captured a number of objects that are not able to be brought to a studio. With the use of available open-source or low-priced photogrammetry software it was possible to handle images taken from non-calibrated camera positions and achieve amazing results awarded a BAFTA prize for innovations in 2014.

2. Methods for acquiring 3D models

The most principal methods of producing 3D models are 3D scanning, which can be sub-catorised into laser scanning and strctured light scanning, and photogrammetry. Both methods automatically generate high number ofs of points that make up the dynamic surface of an object. In the first case, data is obtained by because of moving laser head or the structured light cameras along the object or its part being scanned. An alternative approach to 3D scanning is photogrammetry, where photographs are taken with a digital camera, camera locations are calculated, photographs are aligned and 3D point cloud is acquired. In short, photogrammetry technique uses triangulation of the same feature in different spatially shifted 2D photographs (Fig. 1).

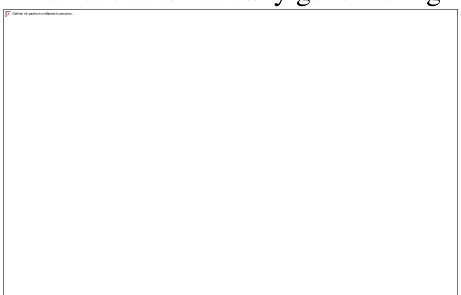

Fig. 1 Acquiring 3D coordinates from 2D photographs. (http://www.clemson.edu/)

Digital photography used with Agisoft Pfotoscan Sooftware (photogrammetry) is a tool comparable to other technologies available on the market (like stationary laser scanning), yet it economically accessible to smaller institutions with limited available resources (Fig. 1) The considerable benefit of phogrammetry over 3D scanning can be, firstly, much lower expenses as a cheap consumer camera can be used to capture the images (Fig. 2). Secondly, it requires much less time to obtain photographs in comparison to 3D scans and much less use expertise. Finally, it allows for easier processing as number of data points to calculate can be controlled.

Method	Agisoft Photoscan	Stationary LiDAR (laser scanning)
Technique	Digital photographs	Laser
Equipment – type	High mega pixel (12+) camera ($200-$2000), tripod ($100), remote shutter ($40), laptop ($1200), Agistoft Photoscan ($65 EDU), CloudCompare (free)	Leica ScanStation ($82000), C10 yearly maintenance ($10000), extra targets ($10000), Leica software ($12000), AutoCAD ($5000), shipping cost ($300-1000)
Total	~ $3500	~ $124000

Fig. 2 Comparison of estimated expenses while using digital photographs and laser scanner.

Througout this paper is presented a photogrammetric method that demands usses open-source software, a consumer grade camera and does not demand a specialist to perform.

3. The process of acquiring a 3D digital model

3. 1. Acquisition of photographs of an object.

A demanded number of photographs varies according to the complexity of an object and resolution recuired of the digital model. To produse 3D Cartesian coordinate, any given point has to be visible on minimum 3 photographs. Photographs should be taken minimum at every 15 degrees and overlap between them should be at least 50%.

3. 2. Production of sparse point cloud and determination of camera locations.

Having acquired a set of images for digitising, Photoscan not only searches for common points on the photograph and matches them but also finds the position of the camera for each picture and refines camera calibration parametres (Fig. 3). Sparse 3D point cloud, as an effect of photo alignment, will take part in 3D modelling procedure indirectly. It is the set of calculated camera positions that is necessary to continue further 3D modelling procedure.

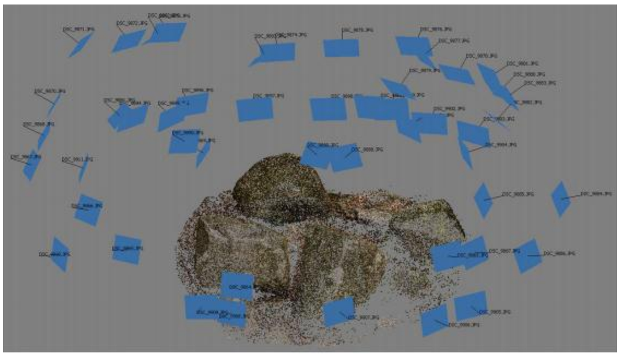

Fig. 3 Creation of sparse point cloud on the base of taken photographs (http://theastronounts.com)

3. 3. Production of dense point cloud based on previously calculated camera locations.

Based on the estimated camera positions and pictures themselves a dense point cloud is built by PhotoScan. This part is most computionally intensive. To create this, Photoscan uses mentioned elements to compute depth (distance) maps: for every pixel in the image (bus usally resambled to a lower resolution), the distance between camera and object is computed. Dense point cloud may be edited and classified prior to export or proceeding to 3D mesh model generation.

Figure 4 presents graphic dependency of 3D cloud point and total image size according to the image resolutions as a result of the experiment to produce a 3D model of a mining harvester (D, Hoffman, P. Hermanek, A. Rybka, I. Honzik, 2015, p. 12-15) by Czech University of Life Sciences.

They came to conclusion that the most suitable images for producing dense 3D cloud satisfactory enough to achieve 3D model are the ones with resolution higher than 8 Mpx. The most appropriate images that can be used in a photogrammetric method are those with resolution on 12 Mpx, characterised by the best ratio of the image size and number of reconstructed 3D model points.

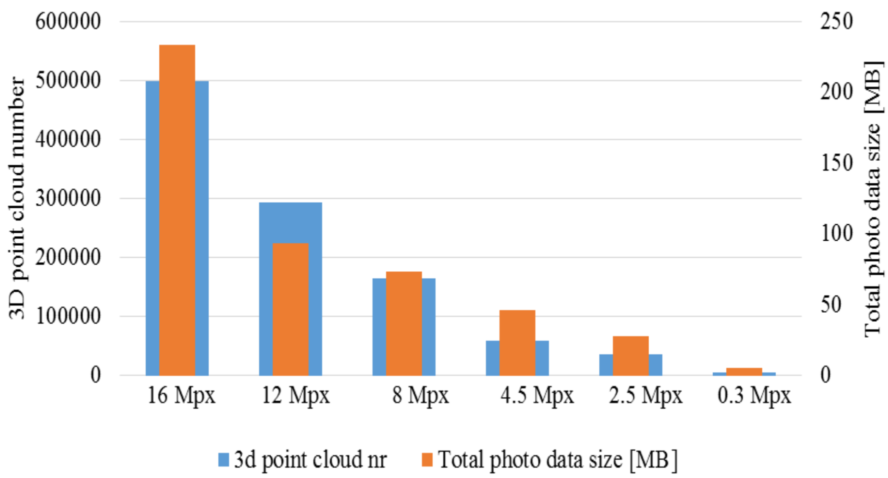

Fig. 4 Dependency of number of 3D cloud points, size of a photo and its resolution.

3. 4. Production of 3D mesh and post-processing.

Another stage is building mesh, which is the tool that creates polygons from the points, or lines that connect adjacent data points to one another. PhotoScan extrapolates data between all point of the cloud firstly. After that, number of made connections should be reduced in the process called mesh decimation to ensure appropriate size of the files.. Having built the mesh, it may be necessary to edit it and perform some corrections, removal of detached components, closing of holes in the mesh etc.

Fig. 5 Final in-engine game asset (http://theastronounts.com)

After the geometry is constructed, it can be textured or used for ortophoto generation. To obtain the best visual effects, it can be applied several texture mapping modes, which differ in dependency on how the object texture will be packed in the texture atlas. In this phase, for the successive generation of a photorealistic product, the geometric model is then enriched with the application of textures onto the generated surfaces. The textures are manually selected by the user (to avoid as much as possible the presence/absence of obstacles or occlusions) and automatically projected onto the 3D geometry by the software.

Figure 5 presents a final in-engine asset ready to use in the game. On the asset there were applied shaders n order to create the natural look and feel of the real object.

4. Combined use of laser scanning and photogrammetry

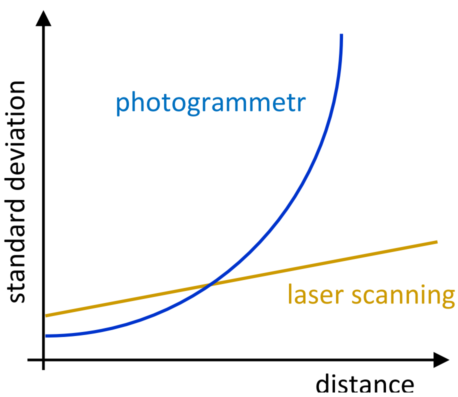

Fig. 6 Dependency of standard deviation and distance

Even though results obtained with photogrammetric method for the game industry were satisfactory, it is worthy to discuss a possible combination of laser scanning and photogrammetry. A laser scanning delivers a huge amount of points, but there is a difficulty in determination of edges as the surface is scanned in constant vertical and horizontal steps and it cannot be determined if the beam hits an edge or a particular point or not. In photogrammetry, it is troublesome to work with sparsely structured and low-contrast surface.

; to use the high density of points measured on the surface using a laser scanner and high-accuracy potential of close range photogrammetry.

In order to be properly combined in one product, the two data sets (point clouds) need to be related into a common reference system. The unified model is edited and at the last step, 3D model is rendered using the textures already existing and associated to the photogrammetric model and creating new ones for the laser scanner data.

The accuracies of two combined systems are different. The laser scanner measures the running time of the reflected light pulse. The distance measuring accuracy is conditioned by the measuring principle only slightly distance dependent. Against it the distance accuracy of the photogrammetric measurement depends strongly on the angle of intersection of the photogrammetric light rays. The standard deviation of the photogrammetric measurement is on short distances better than the laser scanner measurement, however rises faster with increasing distance (Fig. 6)

5. Conclusion

The intended result of this article was to present a cost-effective and simple digitisation method in order to procuce 3D models for game assets. It has been proved that photogrammetry is suitable technique for quick and efficient obtaining and extracting 3D point cloud data. Basic requirements such as consumer digital camera and a laoptop, together with availabe low-cost or free-ware software, make it extremely accessible for institutions with smaller budgets. Even it does not require years of schooling or job-related experience, it is vital to take care when capturing images to achieve good results. Having possibility to combine photogrammetry and laser scanning, it is possible to equalise conditioned disadvantages of one technology by the advantages of the second one, to form the overall system more efficiently.

The developers of The Vanishing of Ethan Carter, The Astronauts, used a lot of photogrammetry-generated assets to create the breathtaking world for their game. Even though a lot of the work is done by the software generating the 3D assets, there are a lot of factors that can go wrong if the user is inexperienced. Techniques that are valued in traditional photography can have negative consequences when working with photogrammetry. Shallow depth of field, highlights and noise can absolutely ruin a photogrammetry asset. Also, all of the lighting and shadows need to match, which means that changing weather conditions can prove to be highly problematic.

Nevertheless, summarising aspects like time duration, expenses and required knowledge, photogrammetry is an unquestionable winnter among other techniques.

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