STERIO - Reconstruction of 3D Scenery for Video Games Using Stereo-photogrammetry

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Abstract—In this paper, the main assumptions of the STERIO project are presented, which main goal is to develop a complete technology of faithful reconstruction of the real world sceneries in a virtual world of video games using stereo-photogrammetry methods. The proposed approach should be cheaper than competitive laser scanning, and at the same time faster and more accurate than existing methods based on photogrammetry. Such technology will significantly speed-up at a reasonable costs the process of construction of 3D scenery based on locations from real world. Thus, the presented solution should be interesting for many small independent game developers.

Index Terms—stereo-photogrammetry, 3D scanning, video games

1 Introduction

Modern 3D video games require hard use of high quality 3D assets both for game characters as well as level scenery. In the traditional approach, all such assets are created by 3D artists or bought from a store. The first approach is a very labor-intensive task while the second one, does not guarantee originality of the assets, which is easily recognized by players. Situation becomes more complicated in case when game concept requires that action took place in allocation that represents a real world one or similar to real locations. In such a case, handmade modelling seems to be non-creative yet time and labor consuming task that could be replaced by automatic machine work. This was not a big concern when 3D graphics complexity calculated in real time in gaming industry was very limited by CPU and GPU units strength. Main goal for 3D artists was intelligent simplification of the scene or even to trick human minds to see more than it was really shown. Nowadays players expect photorealistic graphics quality, similar to 3D scans.

The video game development market is evolving at a very dynamic pace what forces programmers all over the world to keep adapting to new systems, platforms and user preferences, and continue improving existing programming. For this reason, development studios require new, better, and most importantly faster methods of handling such issues as real world digitalization, which is based on converting real places into the digital ones and implementing them in 3D game engines.

If limited to 3D scanning, inanimate objects, there are several possible solutions available including methods based on lasers, structured light RGB-D sensors, and photogrammetry [1], [2]. Unfortunately, all of mentioned solutions have some drawbacks that limit their usage in video game industry, especially by small and medium developer teams. Handmade 3D modelling requires a lot of human labor that increase with the model complexity. Laser based scanners are very precise as to geometry scanning but are very expensive and does not support textured models. RGB-D scanners, based mostly on the structured infrared light patters like Microsoft Kinect or Intel RealSense, provide complete 3D models of usually enough quality but are limited to small distances of about several meters. There are no standards of development affective or affect-aware software [3], [4]. Finally, photogrammetry methods can provide high quality textured models but require numerous input data and high computational costs.

In this paper, the main concept of the STERIO project is presented, which aims to overcome problems of above approaches by using the stereo-photogrammetry methods, which, under some assumptions, can offer reliable scanning of textured objects at reasonable financial and computational costs.

2 Background

The video game sector is one of the most dynamically developing fields of entertainment. Newzoos analyses show that in 2016, its global revenue reached USD 99.6 and at the current growth pace (6.6% per year), the global value of the game market could reach USD 118,6 billion by 2019 [5].

Such a big market is created both by well-recognized big development studios with a huge budget for AAA productions as well as by small development studios, passionate, and creative teams that often have insufficient production resources and are limited by a shortage of professional, top-standard technology. The small development studios often have put years of work into creation of a quality product sufficiently developed for commercialization purposes.

Nowadays, most video games are developed using game engines but only few big development studios are able to develop their own ones. Most video games developers use one of a few commercially available game engines such as Unity or Unreal Engine. There is no available any reliable data about financial share of each engine on the market, but

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with no doubt Unity 3D is the leader engine in and medium-sized developer studios. According to market Statista in 2012 62% of game developers in UK declare that they use Unity 3D [6]. According to Unity enterprise Unity 3D is currently the most popular game engine, with the total number of registered developers reaching roughly 4.5 million [7]. Even if only a small part of them are active in professional game development and distribution it gives a great number of smaller studios (with up to around a dozen members) developing action, adventure, shooter, and/or FPS games, which should be interested in purchasing modern but low-cost 3D technologies and solutions.

Market dynamics force teams of programmers to keep adapting to new player expectations and preferences. This usually entails the need for the newest, most expensive technologies and/or higher production costs to speed up and improve the developed game. It is also the reason why video game development studios require new, better, and most importantly faster methods to handle problems appearing in the development process. One such problem is the effective and precise recreation of real places in the digital world. Currently, the game developer has two options to recreate a room, as an example, and define the parameters of the objects within it in 3D graphics.

The first, is to take photos of the room with a wide-angle lens, merge them into one frame with dedicated software, and manually calculate the size of specific objects, their shapes, the location in the room, and relative positioning of other objects, to use as the basis for arranging the objects and importing them into the graphical module of the 3D engine.

The second solution is to apply 3D laser-scanning technology, which provides a very precise and detailed image. Depending on individual preferences, numerous scanners may have to be used simultaneously. Using this technology, the scanned room is uploaded into a special program for processing the images created by the laser scanner and used as the basis for creating the rooms map. This form of digitalization eliminates the need for manual calculations and the recording of specific parameters as that data is collected during the 3D laser-scanning stage.

The first of the aforementioned solutions entails lower financial outlays for dedicated equipment, but is very labor intensive on the side of the employees. This method for room digitalization is used mainly by small development studios that cannot afford the second option (laser-scanning technology), which requires not only high capital costs (professional scanners manufactured by such companies as Artec or Creaform can cost as much as $50.000), but also competent operators and professional, expensive software adapted for processing the images produced by the scanners. When this method is chosen by game developers, it always considerably simplifies the recreated world and produces an inferior visual effect, which is why it is usually applied in low-budget productions.

This is a reason why we are attempting to create an innovative method using and integrating stereoscopic photography technology (stereo-photogrammetry) into the Unity 3D game engine. In the next section, the main assumptions of the STERIO project are presented. Finally, some conclusions and future works are given.

3 The STERIO project

The STERIO project aims at the development of technology and a subsequent prototype of a programming tool for the effective development of 3D graphics using stereoscopic photography [8], [9]. The result of the project will allow for faithful recreation of real world scenery in the virtual world of video games. Applying the proposed technology will allow for more effective and less costly location generation for games in real places. The productions developed with this technology will provide the impression of movement in the real world, which will improve the emotional experience of the players and generate demand for the proposed solution. This method will have a big advantage over the indirectly competitive 3D laser-scanning technology as it produces a similar effect with fewer resources and shorter production time, which can reach even up to 40% . The savings come from using a stereoscopic unit composed of a system of two standard cameras (semi-professional, digital, single lens reflex cameras). To facilitate operation, the technology will first be integrated with the most popular Unity 3D engine.

The end result will be a technology (including methods, algorithms, prototype of the programming tool, and plug-in for the Unity 3D engine) that supports video game production, i.e. 3D graphics generation through the conversion of stereoscopic images into 3D objects subsequently used by the game engine. To achieve the aforementioned goal, the project will be carried out in 4 stages:

1) The development of optimal stereoscopic image production and the configuration of hardware for reference purposes
2) The development of algorithms for converting stereoscopic data into properly defined 3D objects
3) The development of the tool prototype for video game producers to be used as a plug-in for the Unity 3D engine
4) The development of a reference game for experimental verification of the result and final proof of its effectiveness.

The main purpose of proposed solution is to support and improve the video game development process with an original method to recreate reality in a digital world. In this project, both the method and technology dedicated to the Unity 3D engine will be developed to improve rendering of 3D space in video games. This technology will be an application, a plug-in for the Unity 3D engine, used to import and analyze stereoscopic photos for point clouds and convert them into 3D objects. The proposed tool and method will support the development of video games for various platforms and devices. At first attempt, the technology will be dedicated to the Unity 3D engine, the universal nature of which allows for the development of games for most of the currently available platforms and devices. This innovation in the process and technology of 3D object digitalization, will serves as a somewhat competitive solution for the considerably more expensive laser scanning technology and can be used for purposes other than video game development, e.g. architectural visualizations, simulations and other. This approach will constitute creative technology for the benefit of image production development and automation, as it is a technique for digitalizing and processing multidimensional

objects and consequently improving the development of creating 3D objects from the ground up.

Because the STERIO project focus on reconstruction and modelling of real places in the digital world, the final results will be important mostly to developers of 3D FPS (*first person shooters*) or other action games. However, the advantages of the technology, especially the little time required to develop 3D graphics, will make most teams deem such a tool necessary. STERIO is directed mainly at teams, which:

- prioritize a faithful reconstruction of reality,
- specialize in low-budget productions and release many games commercially in production cycles that are as short as possible,
- demand low-cost technology to considerably accelerate their development work yet still simultaneously provide the user with a high experience level,
- reject purchasing the expensive and labor-intensive 3D laser-scanning technology as it does not meet their needs or exceeds their investment potential,
- see a different value in the proposed technology, e.g. potential for its evolution to adapt it to their own needs or to be combined with a different internal tool, etc.

It is also important that the technology proposed by the Applicant relies on the development of a plugin for Unity 3D the most popular and universal video game engine.

It should be noted that the STERIO technology can be successfully integrated with other game engines, but Unity 3D was chosen for the purposes of this project because of the projects commercialization strategy.

4 The proposed approach

The technology developed in the STERIO project will be based on margining 3D images [10]. 3D images will be acquired with the use of stereo cameras. Developers of games in order to take advantage of STERIO project will only need to have a pair of cameras. The pair of cameras will have a function of a stereo camera. Thus, cameras will need to be fixed beside each other on a camera rig. As cameras may be of a different quality with regard to the game development budget, both professional and amateur equipment can be used. Therefore, the technology will be suitable for low-cost game development.

The technology is designed for making 3D models of buildings interiors. This kind of a 3D model can be used as a map in a 3D game. The technology developed in STERIO project makes it possible to develop games with maps reflecting real buildings. Developers in order to acquire a 3D model of interiors of the building will have to make a series of images of these spaces. Images need to be taken from different points and angles. Each stereo-image will provide a 3D image of the scene. The application created in the project will process input images and generate a 3D model. Input data to the application is a series of pairs of images made by a stereo camera used by game developers.

In order to improve the quality of 3D images stereo cameras have to be calibrated. The reason for performing calibration is such that stereo cameras create distortions in images. For example, a kind of a distortion is such that straight lines visible in the shape of real objects are bend in images. This distortion is particularly intensive when fish-eye lens are used. The calibration performed in the STERIO project will be based on taking a series of images of a precisely defined exemplary pattern. The application will analyze the distortion created by cameras and it will reduce them be transforming images.

The technology developed in the STERIO project is based on stereo-cameras. There are also technologies which create a 3D model on the basis of a series of images taken from different points of view with the use of a single camera. However, using stereo cameras instead of a single cameras will result in better quality of 3D models. Moreover, 3D models created in the STERIO project can be directly used as maps in gave development process.

5 Conclusion and Future Work

In this paper, the concept of using stereo-photogrammetry methods to perform reconstruction of the real world sceneries for creation of virtual world in video games was presented. The proposed approach can significantly reduce the time required to develop an FPS game approximately by 20-40%. Since the main costs of game development are the labor costs for programmers and 3D graphics engineers, this will also entail roughly 20-40% savings in the total production costs. Furthermore, reducing production time will allow for the development of more games in the same time, thus increasing potential revenue. Thanks to planned results of the project, the development potential of a small or medium studio will increase due to receiving a comprehensive tool for faithful reproduction of reality in video games.

Thanks to STERIO, development studios will have the opportunity to recreate places from the real world in the digital world in a few simple steps. The first is to properly take stereoscopic photos of a specific room with the stereoscopic imaging system. The next is to use the application (plug-in) to import and analyze the stereoscopic photos to create a 3D map of the room, which will include all parameters necessary to provide the user with the best possible experience mainly the shape and arrangement of individual objects inside the room in an absolute sense and with respect to each other. Digitalization with the proposed technology will allow development studios to minimize the time necessary to develop a video game, consequentially reducing associated costs. Furthermore, this solution will make the places recreated in the digital world seem authentic and will provide the player with a more realistic experience and positive sensations, thus contributing to the commercial success of the given production.

The performed initial experiments confirmed that faithful architectural restoration is possible by the means of photogrammetry. Unfortunately, this approach has also some disadvantages including high computational complexity and significant problems with a point cloud construction in case of lacking salient points in paired images. By proposing the use of stereo-photogrammetry we hope to overcome these limitations due to earlier, more reliable and precise reconstruction of a point clouds.

The development of STERIO project may lead to a new trend in gaming industry. The project makes it possible to

acquire at low cost a 3D map resembling a real building. Therefore, it is possible to popularize games with these kind of maps. The action of the game can take place in a building which is known to a player such as a train station. Moreover, 3D maps reflecting real buildings can also be prepared to existing games. Therefore, game development studios can prepare and sell these kind of maps.

Our future work within the project will focus on several problems including: point clouds matching, and reliable complexity reduction of the reconstructed mesh. Although, at the first stage STERIO tools will be compatible with Unity environment, the technology will be also integrated with other game engines such as Unreal Engine etc.

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