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ALTERNATIVE METHODS OF THREE DIMENSIONAL DATA OBTAINING FOR VIRTUAL AND AUGMENTED REALITY

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Abstract: Reverse engineering and spatial digitization became more popular recently. The popularity grows with the devices which are capable to scan the human figures, cars, parts of the buildings or even bigger objects in a single process. In general, scanning devices sometimes present disproportionate costs as the usual additional software often tops the half of the hardware price. Text of this paper is focused on the alternative device which can use very affordable software applications to generate the same results as the most expensive scanning equipment. Particular parts of this article briefly describe the principles of non-contact three dimensional scanning using the Kinect device, the process of data processing in alternative software applications and possibilities of their further utilization.
Keywords: Kinect, virtual reality, 3D data

INTRODUCTION

In area of Reverse Engineering there is lot of publications. Advantages of the methods related to the reverse creation of virtual models are unquestionable. Thanks to this modern method it is possible to create virtual models of existing products really fast. Although no discussion runs about the difficulties connected to the processing of obtained data. Every device prefers certain data format, what can be noticed also in the area of software provided for data processing. Only few suitable supportive software applications can be found, while at the same time every platform proclaim unreal, almost limitless backward compatibility. Certain solution for the future could be probably found in the creation of unified procedures for collection and also for processing of the spatial coordinates with respect to the exploited digitization method and their utilization. The usual basic steps of digitization process using 3D scanners and their low cost alternative is shown on Fig. 1. The diagram shows possible workflow steps, however individual parts can be skipped depending on used equipment or on specific surface shape of digitized component. By using the most modern facilities individual steps are abbreviated only to scanning process and export to desired software. There is no need of scene preparation or additional data collection.

SELECTED NON - CONTACT SCANNING DEVICES

In the industrial practice there are several devices used for digitization of larger objects such as cars and building interiors. We focus a little also to the contact 3D scanners, although for their slowness and difficulties we omit them, as while scanning the production machines the worker must assure the fact that he wouldn't impede the normal run of the operation. For these reasons, the most effective way is to use a non-contact laser 3D scanner such as FARO LS 880.

≡ FARO LS 880

Select equipment is preferentially dedicated to the digitization of the interiors and exteriors of the buildings as for the data collection it utilizes very powerful laser beam. The principle of scanning itself lies in emission of laser beam in the direction against the scanned object. This beam is then received back in the scanning device for processing. The scanner evaluates particular obtained points and comparing the time period between emission and receiving it calculates the relevant distance [2]. These measurements are realized thousand times in a second.

The accuracy of the scanning device on distance of eighty meters lowers from one millimetre to three. While scanning larger spaces, the scanner must be moved in order to provide the possibility to catch the scene from as many views as possible. Therefore in preparation stage we place few reference balls all over the workshop. We use them for joining the partial clouds of points. Use of this device is suitable especially for large production halls however for our conditions by reconstruction of a small manufacturing cell it is inconvenient since the sensor responds on items in radius larger than 0.7 meters and because of the size of used tripod the blind zone is significantly larger in tight spaces.

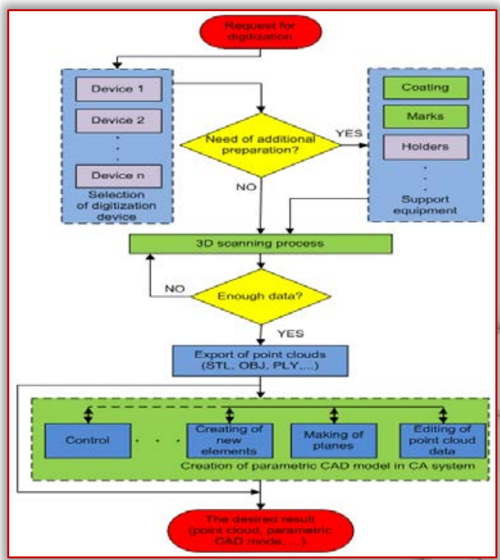

Figure 1: Diagram of basic steps of digization process

≡ ZS SCANNER 700

ZScanner 700 will serve for this comparison as a connection member between FARO LS and Kinect as it has common features with both of them. It is a commercial 3D laser non-contact scanner with higher precision (up to 50 microns), but at the same time it is a manual device such as Kinect. Unfortunately it does not have own power source so it is limited by the reach of power cable. Another disadvantage concerning the price is its operational distance - the optimal distance is around twenty centimetres from the pair of captioning cameras, what is not suitable for digitization of the halls or unsafe large environments. The device works on the base of triangulation where red laser light is projected to the digitized surface and then captioned in real time by the pair of the cameras. Used laser is rather weak, thus the scanned surfaces need to be prepared by matte spray which also is time consuming and some parts may not be painted for operational reasons. [3]. Also the surface of scanned bodies needs to be treated with certain amount of reflex marks that assure the right location of the device (at least three point marks need to be recorded at all times) as the case greatly multiple preconditioning phase and the scanning process from minutes to days, due to the need for later removal of paint and marks. On the other hand this allows the detail scanning of machine parts.

≡ KINECT

Alternative device Kinect was primarily designed as non-contact game controller for gaming device Xbox 360, but thanks to its parameters and mostly thanks to its depth sensor and USB communication bridge it became popular in many areas, such as 3D digitization (capturing device), robotics (obstacles recognition), movie industry (motion capture) and virtual reality (non-contact controller). Kinect captures the spatial and colour data simultaneously with possible frequency up to 30 frames per second, while it is able to capture the point cloud with density around 300 000 points in each frame, and, in contrast to the ZScanner through the protective glass in a laboratory [4, 5]. Thanks to this speed and relatively short continuance time of the sensor at one spot it can collect enough data for computer to create the compact web of points of scanned object. Infrared (IR) emitter consists of coherent radiation source and generator of random integrated points in the direction of light trajectory. Receiver is configured to catch the radiation from the illuminated area and on the base of changes in achieved pattern the processing unit creates the map of curvature of digitized body. Thanks to the built-in RGB camera, to the particular groups of captured points the system can also add the information about the colour. Yet because of data limits caused by used USB 2 interface Kinect recalculates the data captured in 1280x1024 pixels resolutions realizing internal processing to the smaller resolution of 640x480 [6, 7]. Data can be taken also in the mode with high resolution but data flow must have lowered to the 15 frames per second or less, what would be not suitable from the viewpoint of manual scanning device.

From the viewpoint of spatial digitization the Kinect device is suitable for obtaining the bodies in interiors (exteriors only at night). Disadvantage can be also found in the fact that the working range of the device for assuring the accuracy of 1 millimetre is at distance of around one and half meter. Helpful seems to be the upgrade of the device in the form of so-called glasses, which we developed at the Faculty of Manufacturing Technologies, what can improve the range of the sensor capturing. At the same time we have to mention that there are some Kinect-like devices already on the market, such as PrimeSense PSDK, ASUS Xtion Pro, ASUS and WaviXtion.

USAGE OF RAW 3D SCAN SCAN DATA

Despite the excellent hardware properties Kinect has a huge weakness associated with a control software. There is lot of various applications, but they usually make only the captioning of basic views or very limited space areas. Possible cause can be found in the fact that main propagators of these alternative 3D digitizing systems are the small groups of enthusiasts, who can barely challenge the international companies. Despite this fact, first attempts can be observed such as SCENET from FARO Company. The issue that one of the leaders in the field of spatial digitization takes concern of is that simple alternative device supports and highlights the ideological correctness of its use [8]. There are excellent applications such as ReconstructME and KinFu, having the basics of data processing built on the very Point Cloud Library (PCL) project, which is focused to the creation of procedures for processing of 2D/3D images and point clouds. Exception from this course is presented only by KinectFusion from Microsoft Corp [9, 10, 11]. For our purpose we use Scanet software that served for captioning and processing of the data from Kinect.

Skanect in newer version 1.5.0 besides the collecting of spatial data and textures records also the location of the device with every frame. By gaining more data the software core can achieve higher accuracy while joining and positioning particular records what is very important for further processing. Another improvement is that not all data have to be processed in real time using the graphical chip (as it used to be). Only the optimal views are generated that allows us to scan the space with real-time overview. Rest of the data is stored at HDD for later processing [12]. This improvement allows us to digitize faster much larger areas as the optimization of the position of other point clouds and following allocation of the textures from the record can run with use of weaker hardware elements and time savings in offline mode. In next step the collected data need to be processed for further use. The best format seems to be PLY, but in digitization of large bodies we have to take into account the data severity as this PLY format in comparison to other formats. 13, 14]. Spatial information after corrections are useless in some applications, as lot of them requires the time consuming remodeling and substitution of some parts of scans with CAD models. At the Faculty of Manufacturing Technologies we use these data beside the standard ways also in direct form [15]. Our created and simplified model is after the definition of some parameters (floor recognition) suitable for simple visual presentation. We use three basic views as shown on Fig. 2 - perspective view, ground plan and 3D overview. This provides us with the walk through the digitized environment from the viewpoint of first person. Thanks to the photorealistic imaging the user easily accepts the projected environment as a part of reality, while the visual feeling is supported by scene created on the background [16, 17].

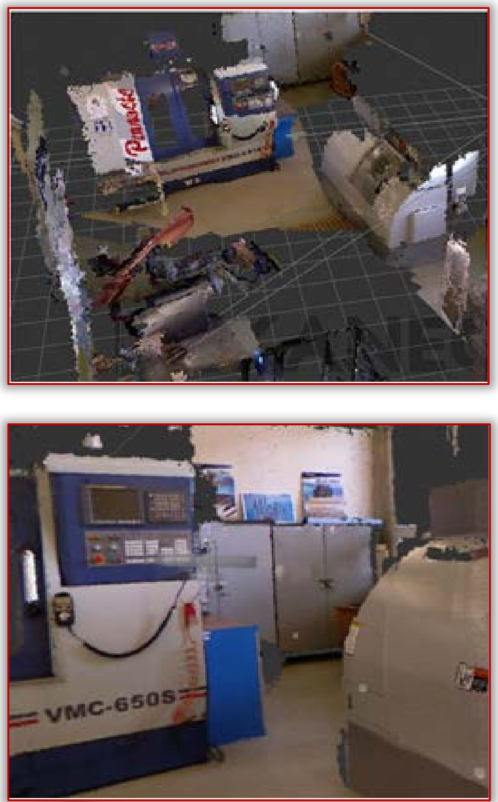

Figure 2: Diagram of basic steps of digization process

As shown on Fig.2, captured data (points, polygon mesh) of complements obtained by Kinect have the color information. By usage of Faro LS 880 additional investment is needed into the camera with adequate facilities. Despite its price Kinect offers full digitizing alternative suitable for 3D digitization of smaller spaces. Due to the specific conditions the only drawback was the time needed to manually capture the whole scene (capture of scene on Fig.2 took two minutes, detailed model up to two hours) but with plenty of detail, since its optimum operating distance is forty centimeters. Digitizing time could be significantly reduced (less than ten minutes) if the surfaces where captured on longer distance but with greater error (at five meters up to four centimeters) which would by sufficient for a visualization of the workplace.

SUMMARY

This article pointed to possible utilization of price-accessible device Kinect together with basic software applications in the area of demanding spatial digitization of interiors of industrial operations. It proved that simple alternative concept can partially challenge the known professional devices while coming up with little purchase price. Thanks to its mobility we can use the device for easy and fast scanning of hardly accessible places without special preparation of sensing surfaces, but with increasing uncertainty when operating at a larger distance as one and a half meter. Considerations are found even among the producers of superior scanning systems who recently started to support this product by their own software solutions. Commonly used scanning devices have wider view angle and working range, but their price forces the potential customers to realize 3D digitization with use of outsourcing methods, practically selling their own know-how to the competition. In the end it is suitable to remind that spatial information do not have to go through the difficult process of transformation as the raw often presents the sufficient base for presentations and educational purposes.

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Note

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