ANALYSIS OF THE DISPLAY OF 3D IMAGE DATA OF INTERIOR SCANNED BY A 3D LASER SCANNER

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Abstract: *The article deals with the issue of 3D modeling of the interior and exterior. The text presents the methods and essence of 3D scanning and their use in many fields. Attention is paid to the experiment of 3D interior scanning with a laser 3D scanner and the quality of the scanned image. The following are the types of 3D digital data and the influence of the internal environment on the 3D model of point clouds. At the end of the article, the possibilities of using the resulting atypical 3D model to increase the quality of image data for further processing are presented.*

Key words: *3D model, 3D scanner, point cloud, 3D image, interior image*

1 Introduction

In recent years, the rapid rise of virtual reality technology and image digitization, in general, emphasizes the quality of graphic processing of image data. This data can be primarily created in a graphical environment or created from a natural scene or objects by photogrammetry or 3D imaging technologies of the actual environment using a 3D camera or 3D laser scanner. The process of capturing and processing a digital image emphasizes the quality of captured data, data transmission, and data compression. In each of the methods of creating a digital image, a specific process is created for the subsequent transfer of the image so that the actual scene and objects are best captured in each case. Actual scenes and objects transferred to virtual reality should be as close as possible to the perception of the image of the scene by the human eye in a natural environment. In this respect, it is also crucial to choose the device that best brings the transmitted virtually generated image closer to the human eye. The most important quantities can be assumed brightness (selected image value) and contrast in image preprocessing. Last but not least, the light (color) spectrum and the perception of colors by the human eye emphasize the quality of detail in a virtual environment. [1] In this environment, low image resolution values can be expected depending on the object's depth from the background perceived by the observer.

The digital image can theoretically be taken as a communication tool because it is currently widely used as a source of information along with a text message, especially for commercial use. Whether it is the advertising industry, art, [2] gaming industry, business, medicine, [3] forensic science, [4, 5] architecture, [6] Etc., especially in online web and application solutions, emphasis is placed on an attractive environment for users with an emphasis on as little information as possible in a text message. This trend to a change in the rules for publishing commercial media within the European Unity is likely to increase in the commercial sphere of media, where there is a free reduction of publicly available data and tightening of rules and rules of copywriting. The rapid advent of 3D technologies, augmented reality and virtual reality expands the possibilities of using digital images across disciplines and the growing interest in the use of these technologies not only in privacy but also in government and services, from criminology to culture and cultural heritage archives. [4, 6] Also, concerning the advent of 5G networks, where frequencies are being released for faster and more efficient data transfer with an emphasis on reducing their data volume and application to ever-expanding innovative technologies for use in practical life, it can be assumed that digital image is most available in the future. Information flows across all spheres.

This article deals with the theory of the 3D scanning method. Furthermore, the 3D scanner captured an image analysis of the possibility of displaying a 3D scene. This 3D shooting device is suitable for indoor and outdoor image capture and works with high resolution and image quality. The use of individual 3D models determines the further processing of the image and the purpose of its use.

2 Methods for 3D scanning

Methods for 3D imaging can be divided into two primary groups: active and passive. Active means those when there is some additional information to the scene, and usually, only other devices, such as a 3D scanner, are used by the sensor itself (camera/3D camera). Conversely, passive methods are those in which the only device is a stereo sensor (camera). The current issue is the combination of active and passive methods for 3D image and accurate image transfer. The basis of the active method is to add additional information to the scene. Information can be added using a laser or projector. These methods can be referred to as optical methods of distance measurement, respectively—depth of the object from the observer. Optical measurements are performed by a specific light beam, such as a laser beam emitted by a 3D scanner. Optical methods can be further divided into:

- Coherent: the general principle of coherent methods is interference (interaction and interweaving - wave characteristics).
- Incoherent: incoherent methods are based on triangulation (integration, combination). [1]

There is a projector, a measured surface, and a detector in the measuring system. The advantage of coherent methods is the ability to distinguish height differences in the order of micrometers or less. The fundamental problem of coherent methods is the complexity of implementing more extensive scene measurements. However, this problem is already solvable and applied to in-game systems. Coherent methods are mainly based on the projection of the optical structure onto the measured object and the subsequent evaluation of the deformations of this structure caused by the object's profile leading to the determination of the height distribution.

The output of passive methods is usually a depth map or a model of a 3D scene, and a pair of images is not available. The second image can be calculated using the Depth Map Rendering method. For this reason, the methods used to create 3D videos are not active. As a method on the border between active and passive methods, one can consider a method in which information is added to the scene captured by a stereo sensor using targets that can be used to find accurate correspondence between images, which is what 3D scanners have. [1]

2.1 Scanning device for 3D image analysis

The 3D scanner Leica BLK 360 laser scanner was used for experimental image data collection. This device captures an image of the surrounding natural world in the form of full-color panoramic images in HDR quality together with an accurate point cloud in a total of three minutes. In addition to manually controlling scanning, can control the scanner using Autodesk ReCap Mobile software on the iPad. The application can filter and register data in real-time (combine individual clouds into one coordinate system); you can freely add notes to the clouds in the form of captions, photos, videos, audio, or measure in the cloud. [7]

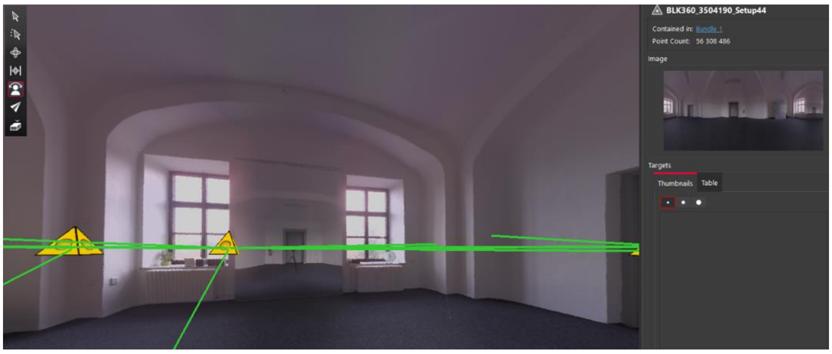

Fig.1: Image capture position connector

The computer application ReCap Pro allows data to be further exported in formats for CAD, BIM, VR, and AR applications. This scanner provides data up to a distance of 60 meters with a scanning range of 360 ° x 300 °. That can choose between three types of resolution settings:

- high (5 mm - 10 m)
- medium (10 mm - 10 m)
- low (20 mm - 10 m)

with 3D point accuracy 6mm - 10 m / 8 mm - 20 m.

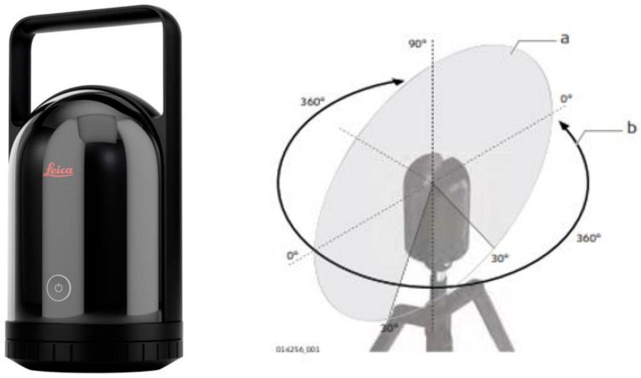

Fig.2: The design of the scanner and scanning range is 360° x 300° [7, 8]

Using the application is possible to filter and register data in real-time (combine individual clouds into one coordinate system) and arbitrarily add notes to the barefoot clouds in the form of captions, photos, videos, audio, or measure in the clouds. The computer application for working with this scanner allows data to be further exported in formats for CAD, BIM, VR, and AR applications. The device measures 16 x 10 cm and weighs just 1 kg. This scanner is one of the most compact scanners of its kind in the world. In addition to technology for scanning and recording HDR images, such a small device has an integrated memory for more than 100 scans and a battery life of up to 40 scans. [7]

2.2 3D scanning in the interior of a historic building

The interior of a historic building in the center of Zlin was chosen for the experiment. It is a former chateau chapel, which was divided into two floors. The interior did not contain furniture, and a large mirror was placed on one of the ball walls. The presence of a mirror in the interior was used to analyze the 3D image in this interior. Interesting optical properties of the scanned image with its reflection into space were assumed. The interior was captured in daylight without additional accessories to improve the quality of the 3D image.

Fig.3: Detail of a 3D image of an interior wall and the effect of daylight on image quality

The ceiling vault of the interior and atypical corners in this space assumed the degradation of the scanned image due to image noise. This phenomenon is manifested mostly in the corners of interiors with white walls. The noise in the corner of the interior is shown in Figure 3. These defects in a digital image can be mitigated to some extent by adjusting the brightness and contrast. These two basic functions and their correction can improve image quality for further image post-processing. However, improving the quality of the scanned image is not the subject of this study. The next chapter presents the options for displaying the scanned image by the scanning device regarding the type of display for other options for working with digital 3D images. Other image processing procedures and digital image quality requirements depend on the intended purpose and the final output of the digital 3D image. It can generally be the output of an online 3D presentation on a website, displaying the environment in virtual reality, 3D technical specifications, 3D printing, 3D simultaneous reconstruction of space, online stream, and other uses.

3 Experimental results of 3D interior image

The Leica BLK 360 3D scanning device allows flexible operation when capturing an image and various options for processing primary scanned image data. Requirements for the quality of scanned images depend on the further processing of the image data and the purpose of their use. The 3D actual image output options are mentioned in the previous chapter. The options for displaying the scanned data are shown in the following figures. All models listed provide specific information about the captured image. This specific information about the digital image of the natural environment is crucial for further processing the image data for the specific purpose of use.

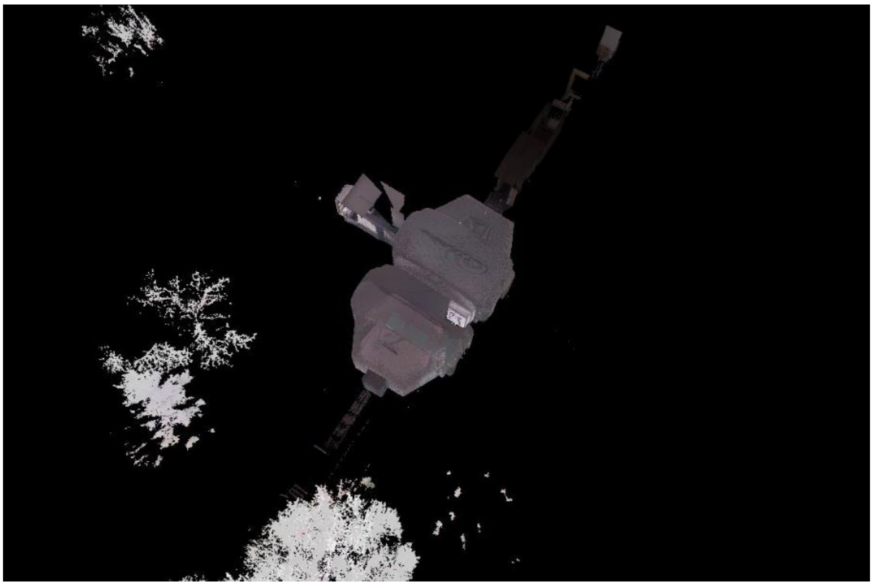

Fig. 4: Displays the original 3D digital image after scanning the interior with a scanner

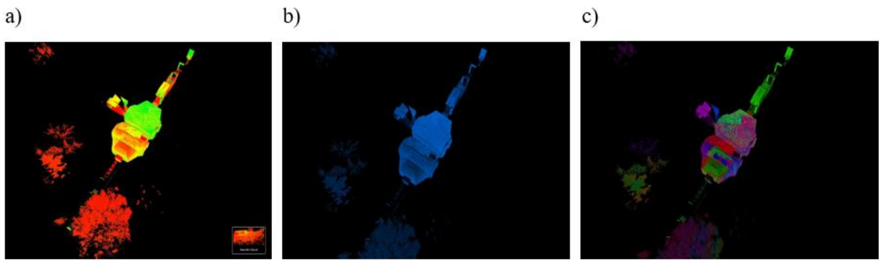

Fig. 5: a) Hue intensity display b) Display of a bundle c) Display according to the basic location of the device

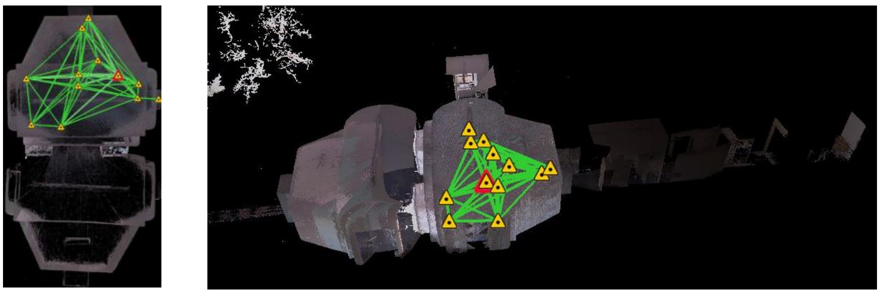

Fig. 6: 3D digital image and connector of interior image capture positions in floor plan and tilt angle

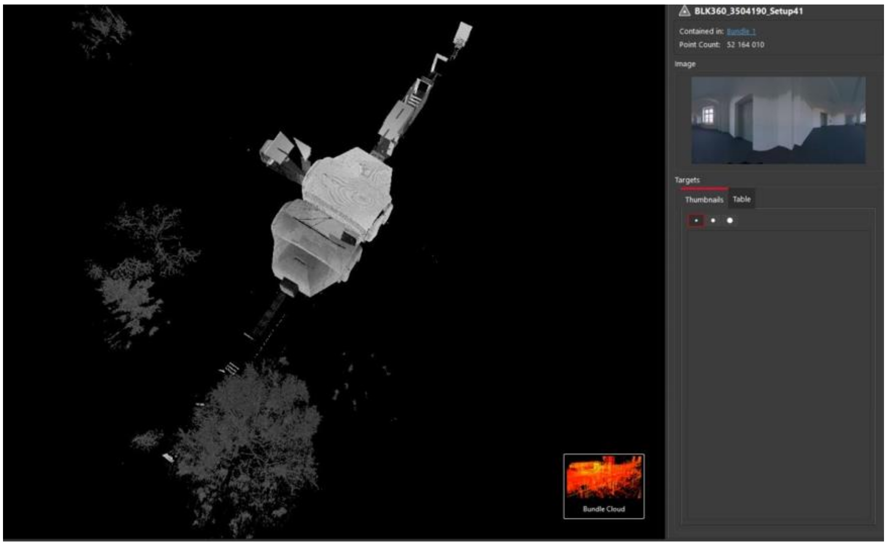

Fig.7: Grayscale display

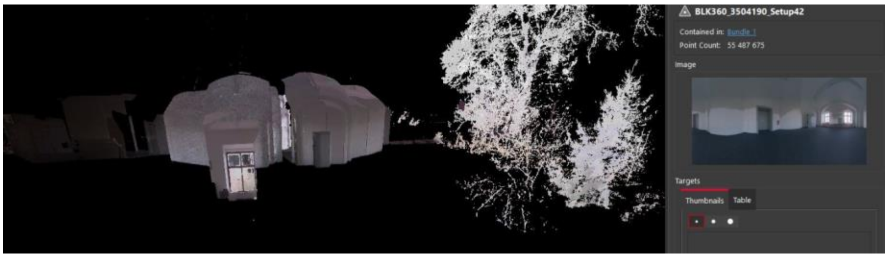

Fig.8: 3D interior view of a single point scan point place

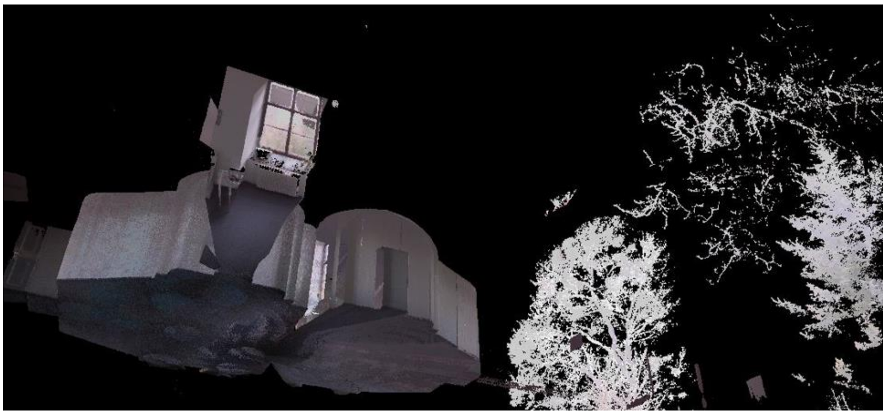

Fig.9: 3D scanned object and its surroundings in a 3D view of one bundle

It is essential to mention that the mirror placed on one of the walls in the interior played a crucial role in the resulting 3D display. Due to the mirror surface and the reflection of the laser beam, a dual mirror digital image was created. Another aspect that has appeared in the digital 3D image of the interior is the influence of the exterior on the resulting 3D model. It can be seen from the pictures that the scanning device had an overlap into the exterior of the historic building. This phenomenon was reflected in the display of trees around the building, as the figures shows.

4 Conclusion

The use of 3D models of interior and exterior is gaining in importance. There are more and more demands, especially on image quality and the possibility of further processing. 3D spatial scanning has applications in many areas. Presentation of spaces and interiors, documentation and archiving, computer graphics, development of computer games, forensics, simulation training spaces are just a shortlist of the many possibilities of using 3D space scanning.

This work focused on capturing a 3D image in the interior with a laser 3D scanner and the possibility of digital image output for further processing. The interior was scanned in the former chapel of the historic building. The interior was characterized by a vaulted ceiling and several elements on the white walls. Shadows formed noise around these elements and in the corners of the scanning room. In this case, it was a negative optical phenomenon that worsened the image quality. Due to the shadows, the noise was also more pronounced. The interior was photographed in daylight. The source of daylight penetrated the room through two windows. Another essential element in the interior was a large mirror placed on the wall between the windows. The optical phenomena caused by this element were generally reflected in the overall scanned 3D image. The reflection of the laser beam from the mirror surface created a duplicate image of the interior in the 3D image. This secondary image was inverse to the original image. That created a mirror effect of space.

This optical phenomenon, which was caused by the reflection of the laser beam, gave rise to another cloud of points. This point cloud of the duplicate image was of lower quality than the point cloud in the 3D model of the primary room. The duplicate point cloud was inverse to the primary point cloud and was also characterized by an inverse description of the image information. Although this same effect appears to be undesirable, it can also be potentially beneficial for improving the quality of the primary 3D image of the interior. It could be assumed that by transforming the secondary point cloud and occluding it with the primary 3D point cloud, it would be possible to suppress undesirable phenomena in the digital image—especially noise caused by shadows. Another solution for a significant improvement of the transmitted image in connection with the details of the virtual environment could be a suitable combination of scanning methods in connection with a suitable optical system in the initial and final display process as a subsequent graphical image correction not only in terms of perceived colors but especially in terms of transmission quality in detail in the image.

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