3D scanning of the interior of Juma Mosque in Khiva

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Abstract: In 2022, a team of scientists from the Lublin University of Technology, supported by partners from Uzbekistan, scaned the interior of famous Juma Mosque in Khiva (Uzbekistan) in 3D technology. Due to the 213 columns supporting the roof, this mosque is clearly distinguishable from other architectural objects scanned so far. Work on the digitization of the interior took place without closing the mosque, so in conditions of intense tourist traffic. The article presents an approach to the optimization of the scanning process, which allowed to reduce the number of scans performed by nearly 8 times and to short the time of their execution to two working days. The obtained results are very difficult to process with modern software and hardware, mentioned in the paper.

Keywords: Silk Road, laser scanner, 3D interior digitalization, Juma Mosque in Khiva

Introduction

The Juma Mosque in Khiva, in the Khorezm area, was a unique case during the archiving process of buildings by 3D scanning. A laser scanner was used for the purpose to record points at a distance of up to 350 meters, and then, with the photographs taken, build textures containing information about the colours of the object. The software dedicated to the scanner allowed to combine multiple scans into one three-dimensional model [1].

The mosque itself was destroyed and rebuilt in 1788 by order of Abdurahman Mehtar and has a unique style and size – it has completely open space interior, built on a rectangular plan with dimensions of 56 x 43 m and has a height of 4 m [2]. The roof is supported by 213 wooden carved columns evenly spaced in the form of a square mesh with its spaced at appr. 3.15 m. Most of the columns are carved in individual patterns, and the age of the columns varies, from the 10th to the 21st century. The only natural source of light in the mosque are two 5 x 5 m roof windows – Fig. 1a.

Methodology and materials

Due to the varied sculpting of the columns, it is important to capture the carvings around the perimeter of the column. It was necessary to set the scanner to scan each column from four sides. Scanning columns individually in this way would require nearly 1000 scans, so it was necessary to optimise the scanner settings to include as many columns as possible in close proximity to ensure high resolution, however, setting the columns in the form of a square grid complicates the setting of the scanner due to the columns obscuring one another.

The second problem during the scanning was the volume of tourist traffic – the execution of all scans took two working days, during which tourists often entered the scanner's field of view, in particular during the texture mapping process.

Fig. 1b shows the positioning of the scanner used in the scanning process, showing the shaded areas. This arrangement ensures that at least four sides of each column are covered with scans from scanning positions not farther than the second row in relation to the column being scanned. In this way, the number of necessary scans was reduced to 127.

Another problem was the shape of the columns, a significant part of the carving being located in the lower part of the column at a significant angle of inclination in relation to the length of the column. This problem was solved by configuring the scanner stand to be positioned as close to the floor as possible.

a) b) c)

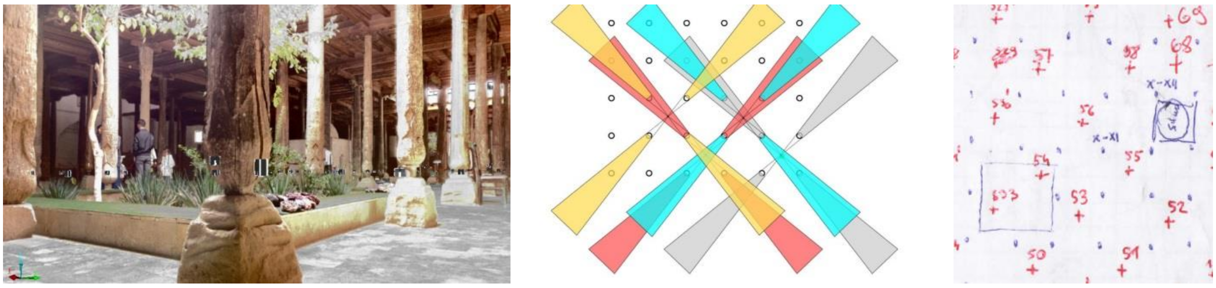

Fig. 1. Juma Mosque: a) the interior of the mosque, b) the arrangement of the positions of the scans taking into account the shaded areas, c) a fragment of developed and used scan plan (red color indicates scanner positions, blue - columns and other interior elements)

Results

Ultimately, the size of the collected data was 27 GB. The processing and positioning of individual scans required the use of specialised software and a computer with significant hardware resources (16-thread Intel I9 processor, 64GB of RAM, high-performance NVIDIA RTX2080 graphics card), but nevertheless data merging took 6 hours, and the next 4 hours was the procedure of cleaning up the scans of unwanted artefacts created as a result of performing the scanning with tourists in and out of shot.

The end result was a merged and cleaned point cloud with a size of 2 182 million points.

Conclusions

The applied procedure when scanning such a complex object proved successful. Despite the ongoing tourist traffic, it was possible to obtain a high-resolution model of the entire mosque. Unfortunately, due to hardware and software limitations, it is not yet possible to create a mesh model of the entire interior of the mosque, which is necessary, for example, when creating virtual reality applications or 360^{o} panoramas from different places.

The performance issues that arise in processing such a large number of scans will become less relevant as more and more powerful computer hardware and more advanced algorithms develop.

References

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