REVERSE ENGINEERING A 3D MODEL OF AN ARCHAEOLOGICAL SITUATION IN THE HISTORIC TOWN HALL OF BANSKÁ BYSTRICA

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INTRODUCTION

This archaeological survey conducted in 2008-2009 at SNP Square 1, Banská Bystrica, was associated with the reconstruction of the current town hall. Although the contractor claimed there were no plans for digging during the work, many trenches were recorded due to monitoring of the construction. Their unplanned schedule prevented the implementation of any sophisticated excavation and documentation strategies. The survey yielded a broad volume of archaeo-environmental data, particularly highlighting the significance of the pit marked as O10 (*Miňo – Brezňanová – Fratričová, 2008)*. Given the information value of this feature, a novel approach to reverse documentation was attempted. In 2008, the situation of the pit was photographed in only eight digital snapshots, with some aimed at details, while others represented parts of the section, and a few provided an overall view from different angles. Due to the aforementioned constraints, it was impossible to accurately locate the situation in space during the fieldwork. Documentation was completed only via orthogonal method in reference to the building ground plan, which lacked absolute coordinates. Because this method was deemed insufficient given the importance of the data acquired, a reconstruction of the situation was performed using 3D based modelling with the aid of artificial intelligence (AI).

METHODS OF 3D MODELLING

The AI modelling was based on NVIDIA Nerf, working in Python programming language (Fig. 1). Methods of reverse engineering were employed in the process. The workflow utilized archival digital photographs from 2008 in ".jpeg" format, which is not the ideal source, as ".raw" format is more suitable and allows for further possibilities resulting in better outcomes. The photographs were analysed, sorted, and digitally remastered (white and grey balance; levels,

curves, and exposition adjustment), and digital depth and normal maps were acquired. Using the method of depth maps-based modelling, a polygonal model of the archaeological situation (MAS) was constructed (Fig. 2). Known objects in the images with known dimensions, in this case, ranging-poles (placed both vertically and horizontally) were used for relative reference. These were utilized to correct angles, dimensions, and deformations in the photographs. Another tool employed to control the results was fSPY add-on (Fig. 3) in Blender software (*Bešina 2023, 180-184*).

Fig. 1 The workspace in NVIDIA Nerf

Fig. 2 Example of a depth map model

Fig.3 Control of angles, dimensions, and deformations through the fSPY add-on in Blender.

Polygonal model of the current state (MCS) of the site was constructed as next. The MCS was referenced in absolute coordinates (S-JTSK, BALT reference systems) using a combination of a GPS receiver and a total station. The MCS was compared with the archival images, and common features were identified. An AI neural tool was used for control, with TensorFlow serving as one of the control mechanisms. TensorFlow is a free and open-source software library for machine learning and artificial intelligence. In both models (MAS and MCS), matching points were found and alphanumerically assigned. MAS and MCS were merged in the relative coordinate system, which was referenced in absolute coordinates derived from MCS. The merged model was positively confronted with the autopsy of the in-situ archaeologist (Fig.4). The finished model was interpreted in vectors so that polygons of archaeological features could be retrieved. The model was used to generate orthographic ground and section plans (Fig. 5) and can serve as a source for any type of metric figures and absolute coordinates. The finished model is used as a tool for popular interpretation of the site, as it has been published on the Sketchfab platform (*Online Supplementary Material 2*) and also available as an Augmented Reality application.

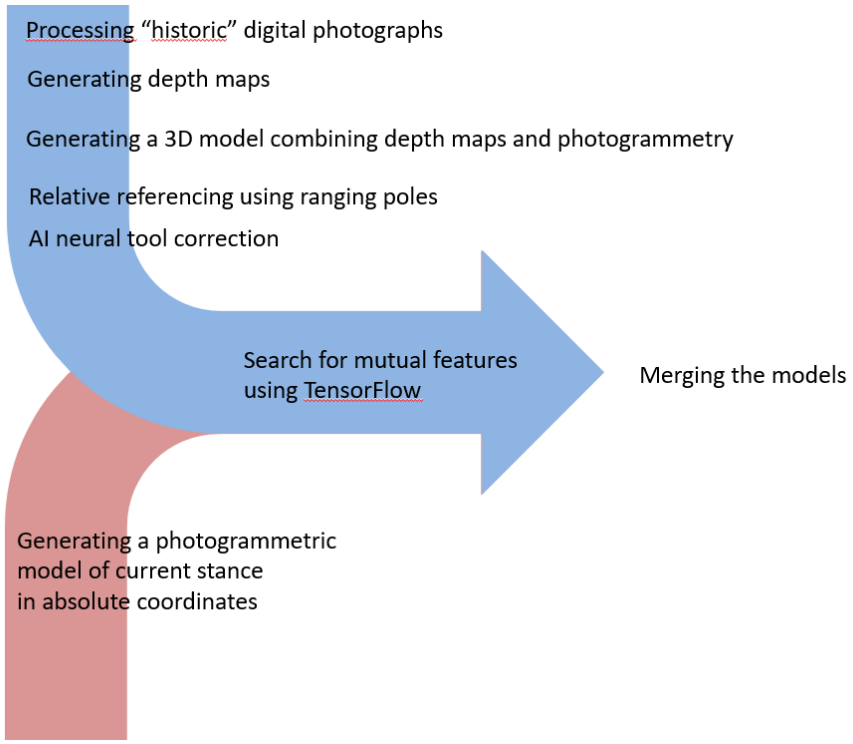

Fig. 4 Diagram of the workflow

Fig. 5 Finished model – cross-section render

CONCLUSION

The solution presented in this work shifts the boundaries of the possibilities of reverse restoration of original situations based on traditional documentation techniques such as photography and drawing. The method described in this paper proved feasible for recreating a three-dimensional image of the archaeological situation using a small number of photographs and depth maps as main tool. The model is characterised with high precision in three dimensions. The created result could be only used in relative coordinates if there were no possibility to supplement it with a precise model of the surrounding situation set in absolute coordinates, along with a set of existing matching points common to both parts. These could only be matched exactly using AI tools, which are just one tool that needs to be validated by other means. The use of AI in reconstructing documentation with higher precision from historic records such as photography or even video footage seems very promising. It can be stated that, thanks to the ability to train artificial neural system on relevant data, future outputs might be even more precise while requiring less input data. This was confirmed in instances where a lost detail of castle Šariš (Fig.5) was reconstructed by one of the authors with all necessary details and absolute coordinates from a single photograph. Archival video footage is also a useable source for applying this method. This approach was tested for 3D reconstruction of the partially perished base of a stove in cell 5 at medieval Kláštorisko site in Letanovce (Fig. 6). There is a broad range of application for this method in archaeology, from the re-evaluation of old excavations to heritage management practices.

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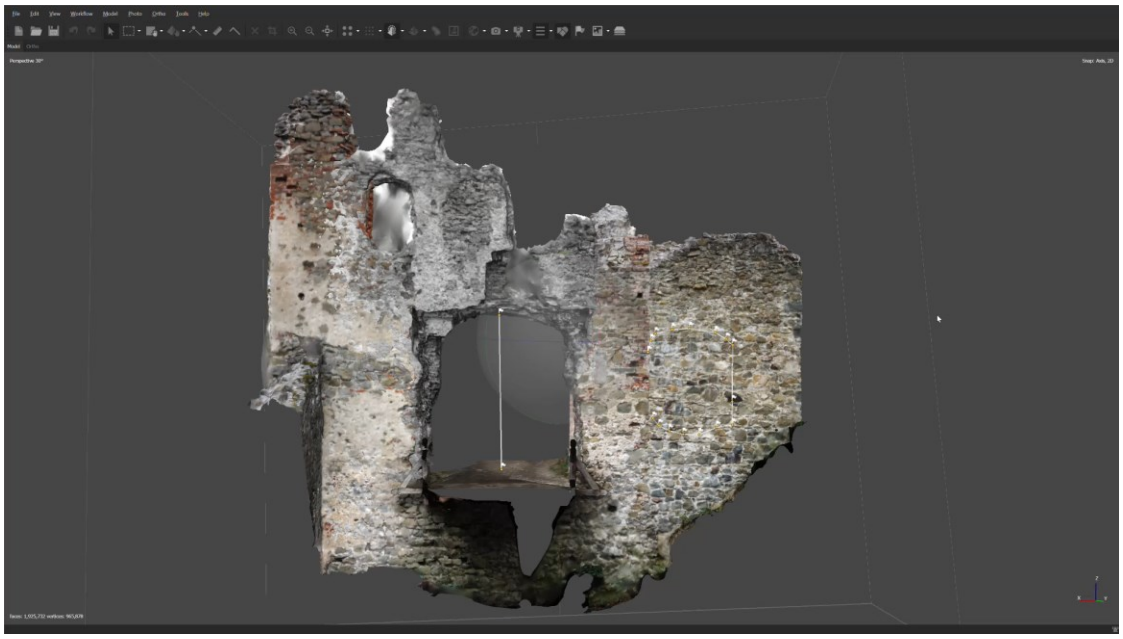

Fig.5 Reconstruction of the perished details of the gate and Castle Šariš, modelled from a single photograph.

Fig.6 3D reconstruction of the partially perished base of a stove in cell 5 at the medieval Kláštorisko site in Letanovce.