# Designing point cloud-based datasets of processed stone surfaces for bridging knowledge through robotics and neural networks

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Existing research acknowledges that robotics can perform a number of important tasks in cultural heritage studies. These include automating documentation (Marchello et al. 2023) and replicating tools and processes for experimental archaeology (Pfleging 2019). This study shows how combining robotic fabrication and AI-based technologies can yield new insights into heritage research by bridging the gap between digital and physical data. The developed framework contributes to recent discussions on data relevancy and materiality.

The primary objective of digitalization in cultural heritage workflows is to increase accuracy and speed through automation. On the other hand, digital technologies introduced new notions such as systematization, flexibility, integration, and large data management. Current endeavours in heritage modelling are centred on finding practical methods to manage large amounts of unstructured, irregular and unique data (Rossi and Palmieri 2020; Cotella 2023; Yang et al. 2023). How to best utilize digital technologies not only as a tool but also as a systematic computational approach that extracts information from unstructured data is still an open field of research. Feature engineering applications on point cloud datasets are case-specific by nature. This study is based on dataset design experiments with real-world point cloud data of historical stone surfaces.

Hand-crafted stone surfaces emerge as a result of mostly improvisational and unique stoneworking styles. The main objective of the study is to investigate the type of data structures that can help study the characteristics of complex surfaces with the help of neural networks. The case study consists of stone surfaces in repetitive geometric forms. Surface models of the numerous stone surfaces produced by carving the same geometric design can thus be fed into supervised learning algorithms. Experiments include extracting and structuring data associated with repetitive patterns with the case-specific data augmentation approach. The findings contribute to the discussions on the difficulties of handling real-world data with parts in varying states of deterioration. The entire data flow from point cloud data processing to toolpath generation for a six-axis industrial robotic arm has been accelerated by combining it in a single parametric modelling environment. This method allows for a two-stage evaluation of the dataset's structure. First, the reconstructed surfaces based on the neural network input and output datasets are compared with the photogrammetric mesh model. The findings associate the number of points in the input and output datasets with the efficiency of neural networks and their ability to reconstruct the surfaces. Secondly, robotic manufacturing results give physical-model-based feedback on the precision of surface reconstruction.

The dataflow framework of this research has implications for learning from past crafts, promoting creativity, and enhancing production capacity in the cultural industries.

## References


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