Of Windows and Light

Towards a constraint based reconstruction method for daylight simulation

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Daylight Simulation in ancient housing: Reconstruction issues

Daylight is a key factor in the analysis of ancient housing. Its availability structures and determines the various possible uses and functions of the built space in the course of the day as well as throughout the year. Depended on the mostly poor state of preservation of ancient housing architecture, the source of simulation data, 3D reconstructions, might often be on the one hand suggestive and visually impressive, on the other hand scientifically disputable due to the lack of evidence. In contrast, the analysis and simulation of daylight requires a feasible set of enclosed 3D reconstructions that are reliable especially in terms of openings, roofing and environmental space. Therefore, the project aims to develop a novel reconstruction approach that allows for parametrize these elements by accessing, analysing and filtering databases of digitally recorded openings.

The development of a data driven parametric reconstruction workflow is part of the BMBF-funded project "ΦΩΣ 4D – A Tool for Affordance-Based Daylight Analysis in Ancient Houses by Means of Simulation". Its aim is to develop a metric based on digital reconstruction and computer simulation that connects daylight with possible uses and functions in ancient houses and workspaces. The interdisciplinary joint project of the Technical University of Darmstadt and the University of Leipzig consists of four research groups including the disciplines of archaeology, building research, light sciences and ancient history.

The principles of Parametric Reconstruction

Parametric Reconstruction might be at first sight connected to the well-established method of parametric design in the field of architecture. Aside its primary function to generate new forms of design, parametrization guarantees the networked, collaborative and standardised exchange of three-dimensional building data. However, in contrast to modern architecture, ancient buildings are not normalised and standardised architectural elements. Furthermore, key elements such as windows and doors are mostly not preserved nor is ancient architecture normally preserved in its entirety - especially as far as residential architecture and simple living houses are concerned. In other words, we

are always dealing with a building stock that has survived only in fragments and bits of information, which must be considered and explained as best as possible when developing reconstruction proposals for daylight simulation. Strictly speaking, archaeological building research does not need to develop a method for parametric reconstruction, but rather a method of reconstruction with constraints. These constraints are provided by the architectural structures and single workpieces that are preserved on site. Due to their fragmentary state of preservation, it becomes a necessity to include further data in the reconstruction in addition to the detailed investigation of the in-situ evidence. With the combination of this data – the directly derivable conclusions on site and previous recorded data – reconstruction models of the former architectural design might become more reliable for daylight simulation especially in developing a daylight metric.

Parametric Reconstruction: Data basis and technical approach

In the initial phase, the project could use the data sets of the work by Lucia Michielin (2019) on Roman window and door openings of the imperial period in central Italy. In close cooperation with the author, a SQL database was accessible, that covers over 1800 openings dating from Early to Late Roman Empire. In order to be able to connect the database with geometric information, the 3D modelling software Rhino was used. With the integrated visual programming tool "Grasshopper", Rhino provides an optimal basis for applying data and constraints to 3D models. Within Grasshopper, code can be written and applied, too. This made it possible not only to read the entries contained in the database into Rhino using Python and SQL commands, but also to filter them by certain parameters. This provides the possibility to narrow down existing data to get more accurate results for specific time periods or regions. In order to filter the data, set more easily, the possibilities within the program environment were used and via selection windows and number sliders the desired filters can be adjusted.

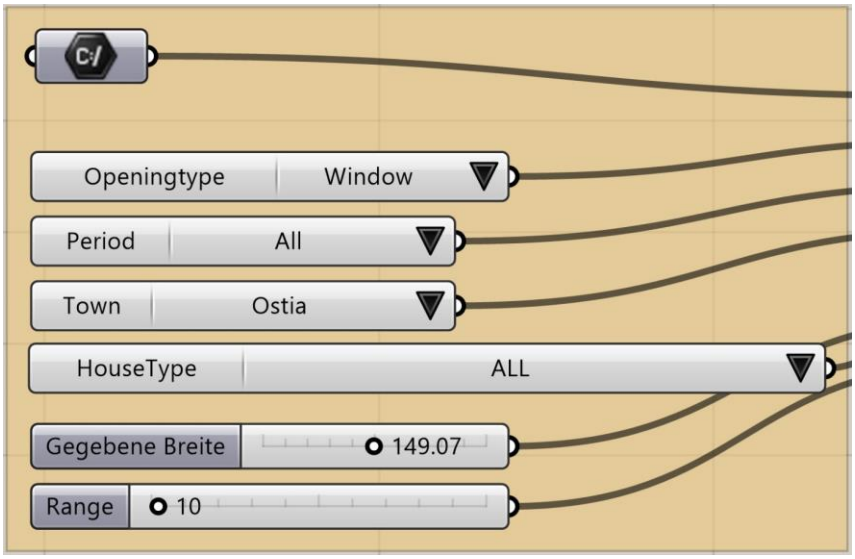
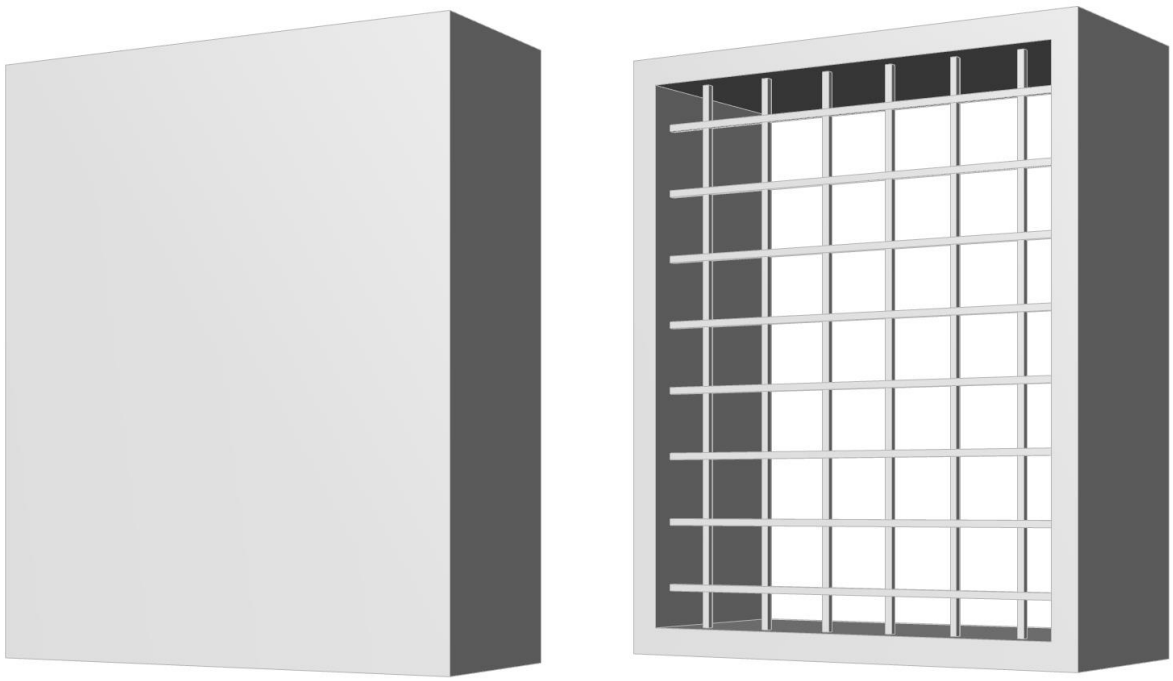


Fig. 1. Filtering Options to create a parametric opening by using the Michielin database (© Lucas Cornelius).

The filtered data set will eventually be used to generate the geometry of the opening. Different geometry types of the openings can also be preset and adapt to the underlying data. Therefore, it is possible to react on different states of preservation, e.g. in many cases there is information on the width of a window only, as well as on different periods and their needs.



a *b*

Fig. 2. Parametrically reconstructed window opening with different filter settings a) average width and height of all recorded windows in Ostia; b) average width and height of recorded windows in Ostia including grill remains (© Timm Glätzer).

Within the development process of the method, several potential problems could be identified and addressed as well, e.g. if the filter settings are too selective, the result might quickly become non-statistical and the geometry less meaningful. Since not every element of the database is recorded equally well, this might also lead to inaccuracies. The processing of different database types, as well as the storage of geometry data in the database, are still to evaluated in further steps.

Perspectives of the novel approach

Parametrics can not only be used to generate simplified abstract models, but also to accelerate the process of creating variants, which allows researchers to check the reliability and plausibility of many more variants during the reconstruction process and to improve them in iterative and often recursive processes.

By applying the method of parametric reconstruction with a stored database of existing architectural elements, uncertainties in the reconstruction can be somehow minimized, since the input values are data driven. Furthermore, it might guarantee a reconstruction close to the existing situation with quantifiable probability values, which in turn can be used to identify outliers and special cases. In this way, historical building research opens up new complexes of questions such as the need for change in window design. With this contribution, the project targets mostly the technical approach,

challenges and benefits of the novel method of Parametric Reconstruction in Historical Building Research and Archaeology.

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