Generative modeling from Architecture to Archaeology

Potentials and challenges in the present and future scenarios

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Introduction

Procedural modelling and Architecture

The advanced methodology of the parametric design helps to obtain a dynamic approach and manages the complexity of the various geometrical shapes [Tedeschi, 2014]. It speeds up the processes and consents achieving results previously unthinkable. The most compelling advantage for the design activities is that the results of the parametric design procedure are immediately visible. Another benefit worth to be mentioned therefore is that it is effortless to have numerous variants of the same project by just adjusting some basic parameters. The parametric design procedure consequently becomes more accurate and faster, allowing to explore an infinite variety of possible solutions.

Currently, there are numerous programs and plugins for significant software in commerce that allow parametric design. For instance, Grasshopper is a plugin for McNeel Rhinoceros 3D and is a visual editor for scripting [Grasshopper, 2020]. Grasshopper is based on visual programming, based on algorithmic logic, that quickly produces 3D models. It introduces the user to a visual programming approach. The main difference between raw text coding and visual programming is that there is an environment using an abstraction based on nodes and wires, and it is no longer based on simple text. In this way, building the algorithm is much more intuitive: rather than typing codes, the graphical manipulation of the nodes permits to create parametric relationships. In a visual programming approach, the nodes represent the various components and the wires all the dependency between them. Another available option for parametric design may be found in Autodesk Dynamo [Autodesk, 2020] that runs as a standalone program but also as an add-in within Autodesk Revit. Dynamo is likewise based on visual programming that allows creating complex geometries. Still, the difference with Grasshopper is the option to develop parametric relationships and to manage parametric data inside a BIM (Building Information Management/Modelling) project.

These two generative platforms allow automated generation of geometries. Dynamo makes it possible to perform takeoffs and develop specific BIM projects and to have multiple alternatives to the parametric elements. Moreover, it enables high-quality visualisations of what the other options would look like. Dynamo standalone allows managing data during the design process and connects the explorations to other design tools. Recently, it has been developed Grevit, that allows designing in Grasshopper elements for BIM usage directly into Autodesk Revit [Grevit, 2020]. The geometry created in Grasshopper can be changed to a BIM element in the project. However, it is an ongoing product still under development.

Dynamo and Grasshopper are very similar in their functions and interface logic; the difference between these two alternatives is that in Dynamo the geometries created have additional properties for each element, making them more compliant with a model for BIM development. Grasshopper creates mostly pure geometric data, immediately usable in modelling based on geometric shapes and analogies/simulation of the reality (Fig. 1). Both of these methods of design have their respective merits and are both efficient tools with

a well-developed interface and robust programming. The user may choose which tool to use depending on the desired results and the context/teamwork in which the modelling is going to be implemented.

Procedural modelling and Archaeology

The use of procedural modelling tools and their derivations may be applied efficiently in the archaeological procedures [Bolognesi, 2019]. However, for the time being there hasn't been wide adoption of these methods, and relevant case studies in this field are still yet to come.

The “programming” nature of the software is probably keeping archaeologists from testing these solutions on their researches, or they are just demanding others to do some testing that is simply aimed at the production of final 3D digital models. Instead, the possibilities may look extremely interesting, from the creation of “random” variation on a starting model (i.e. an amphora and its possible variations) to the adaptation of a model on terrain (like a series of houses or a porch) or to the use of procedures for exploring the fitting of fragments or the analysis of sparse or dense data coming from other sources.

At the present moment, most of the experiences close to the archaeological fields may be found in the built heritage modelling for BIM applications. This context has yet developed various solutions for passing from a digital survey point cloud to reasonable parametric modelling (like the “As-Built” module from Cam/2 Faro is offering).

From here to have more enhanced use of generative 3D models, the passage should be of extreme benefit for virtual archaeology. Just to make an example: the modelling of all the “minor” urban tissue in a digital reconstruction or the variation of mosaic patterns, or a set of columns, capital with the possibility of interactively editing the variation in shape, size, proportions.

Opportunity and possibilities

The particular features of these tools may lead to new and interesting research. The approach to “programming” from the architects is not that far from the one required from archaeologists, for both the use of the “visual programming” interface may be extremely practical and not too complex to learn for the archaeologists acquiring a logic well exploiting the procedural modelling and the versatile “visual programming” solution, should be of extreme interest and capable of opening the way to better understanding and significant improvements in the use of data and their reporting.

It is possible to define three ways/main cases in which procedural modelling may be an excellent tool for the archaeologists:

- Virtual reconstruction modelling. It happens in all the situations where a full model has to be defined to present the original (hypothesised) aspect of a place. In this case, the use of procedural/parametric modelling may efficiently generate all the minor/secondary parts reducing the time needed for the overall 3D modelling.
- Evaluation of the variations. Starting from a series of fragments, the tracing of a “completion” may be studied not only on the base of linear, or simple curves but explored in a set of possible results.
- Treatment of an existing set of information, this may happen when using existing models. Like it is for the analysis of specific existing urban environments (i.e. with the use of virtual crowd tools for simulating mobility across urban areas) that applied to reconstruction hypothesis may turn to be a valid check/experiment in verifying the possibilities.

Challenges

In this scenario, the implementation of Artificial Intelligence solutions may be of great innovative help in automating procedures and revealing new research paths. Even if the simple above-mentioned taxonomy may define a wide range of possibilities, it is clear that once entered the logic, and the workflow of procedural modelling, the users (archaeologists as well as architects) may define their solutions. Orienting case studies and finding answers (or new questions) is a part of the research, and these digital tools may be a dynamic solution to re-read and re-discover ideas, hypotheses and formulate new perspectives.

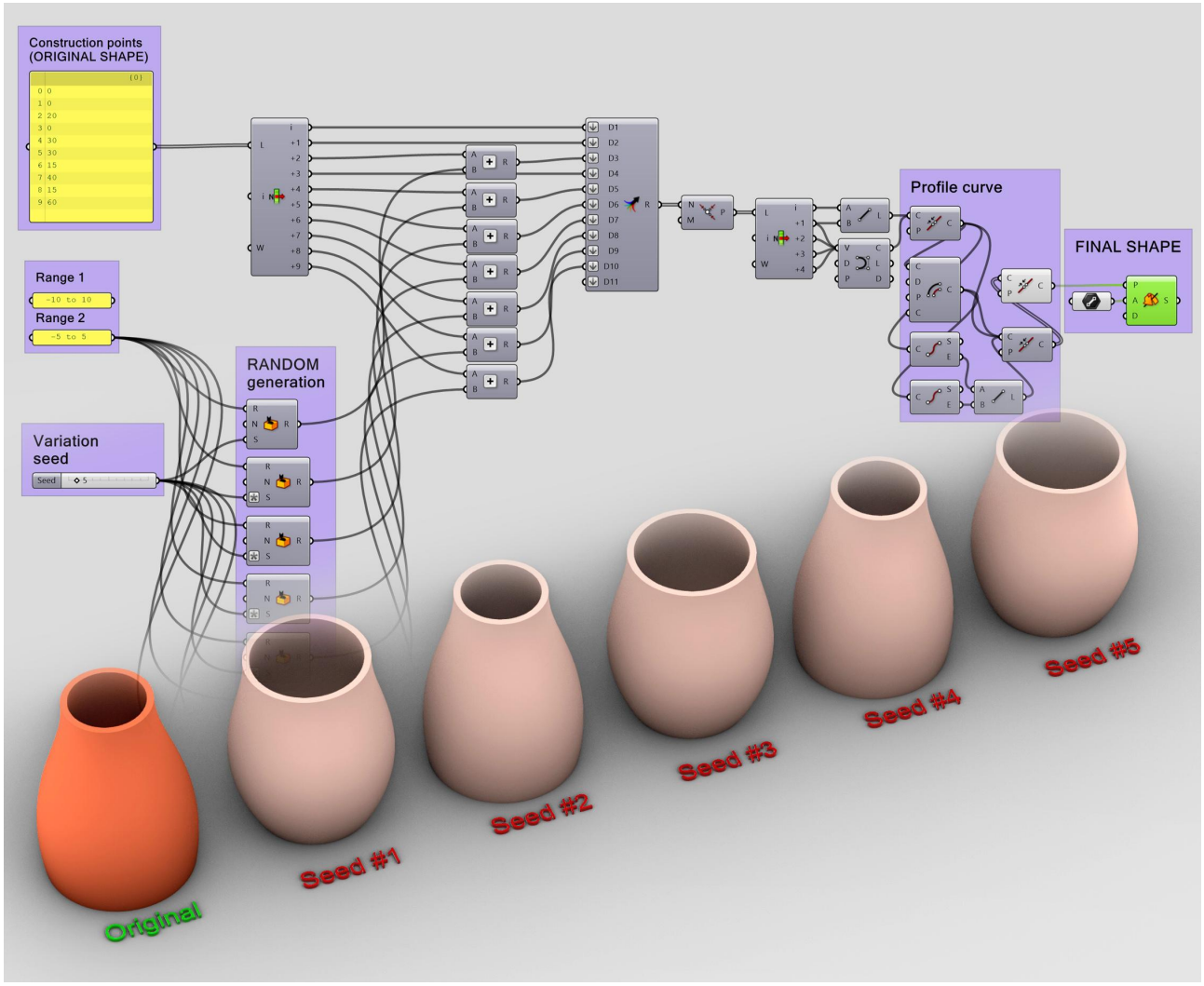

Fig. 1. A sample of digital procedural modelling applied to reconstruction of pottery, the modelling procedure allows to have from slightly to strongly different resulting shapes in automatical way. An interesting solution adding effective stochastic effects if applied to scenarios for multimedia representation.

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