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PEDAGOGIC POTENTIAL OF A PARAMETRIC SYSTEM BASED ON THE BOX PACKING CONCEPT

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In this study we examine pedagogic values of the Box Packing concept, a puzzle problem, initially published as a demonstration within the Wolfram Demonstration Project, gathering 27 identical boxes of any proportion, in a regular cubic body. Methodologically based on the content analysis of realized educational experiments, the research is aimed at enlarging possible use of mathematical/geometric concepts in architectural education, particularly in domain of parametric design. After briefly explaining the concept and original demonstration, and giving an overview of its usage in several courses in various contexts, highlighting pedagogic implications of its use (including development of capabilities to recognize architectonics in pure geometric form, acquiring basic modelling skills, manipulating geometric bodies, understanding parametric systems, materialization in various materials including recycled ones, etc.) we focus on its transposition into a parametric system created as a Grasshopper definition (visual algorithmic editor for Rhino 3D software, FIGURE), analyzing the creation of algorithm and characteristic elements of the definition and discussing their potential application in solving other parametric problems.

A selected set of generative concepts has been studied in recent years within the Chair for Mathematics, Architectural Geometry and CAAD, at the University of Belgrade, Faculty of Architecture. The Packing concept, as one of them, was recognized as the most expressive and comfortable for implementation in courses of parametric modelling because of its pedagogic potential. Mathematically speaking, packing is a concept with powerful organizational method in which a packed element's position in regard to its neighbours is determined by certain rules – close, but no overlapping. Generally, this concept encourages a sense of democracy where one element's inclusion implies either an understanding of every other element or possibly a readjustment of the entire population, so can be observed as a collective and emergent sense of space – close, but not too close. The Box Packing concept is a topological model where identity and position of each of the elements or parts of it within the system are determined exclusively through its relation with all other elements within the system. The concept described in the integral paper in detail, has been used in numerous different contexts, particularly educational but recently it started to be exhibited and promoted to industry, first of all to the regional cluster of natural stone producers. A special attention has been paid on creating a parametric system supporting the Box Packing modelling in Rhino 3D, using the Grasshopper plug-in. Building of a Grasshopper definition has been explained and analysed step by step. We are particularly interested in a range of possible learning outcomes, i.e. what the students could learn dealing with this concept within various courses including the Parametric modelling electives.

Further improvements of our system are connected with solving inverse problem – finding specific set of parameters which fulfil defined conditions (minimal or maximal volumetric occupancy etc.). Problem stated on this way (search for solutions) efficiently can be solved using genetic algorithms. Box-counting fractal dimension shows the degree to which a geometric shape enters space, in other words, the degree of its compactness or fragmentation in that space. In this sense, we got the results we expected. A visually higher compactness of space is followed by higher values of the fractal dimension. Complete compactness, with a side length ratio of 1:1:1, would correspond to the fractal dimension 3, which matches the Euclid's dimension. Box Packing with a visually linear structure has the lowest fractal dimension.

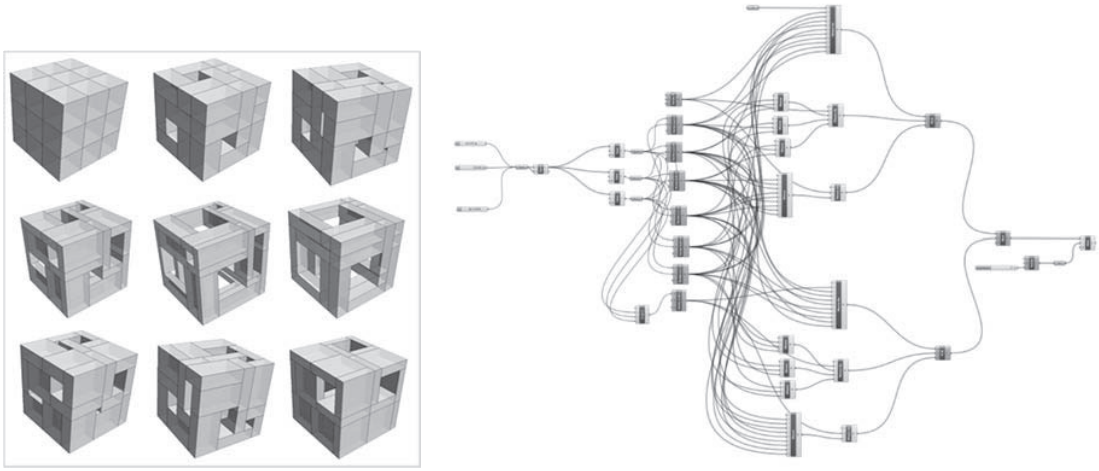

Figure 1 : Wolfram Box Packing variations and a parametric system developed in algorithm editor Grasshopper

Box Packing, applied in architectural education is primarily aimed at demonstrating how multidisciplinarity, in this case integration of mathematics and geometry, enriches design process. In this study we focused on pedagogic aspects of its use, ranging from mastering basic modeling techniques, various simulations, materialization in small scale models and real life objects. Introducing a complex algorithmic approach into the process of building parametric systems has been particularly highlighted and analyzed. It opens a realm of sophisticated programing techniques to architectural students, with a special attention on the combinatorics part. Finally, understanding more advanced techniques like genetic algorithms and abstract notions like fractal dimension, lead to another level of form finding approaches represented in fractalized initial form, promising some further and unexpected design results.

Keywords: parametric design; educational methodology; packing problems, algorithm