REGENERATING ARCHITECTURAL ELEMENTS USING AI
The Case of Muqarnas

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1. Methodology and Design Procedure

When dealing with muqarnas, we are actually facing a design problem that consists of three main issues that has to be considered; first is the components, second is the assembly knowledge, and finally functional knowledge. In this context Design Procedures (DP) is presented as a methodology that enhances the design capability of a parametric model to perform design variations by using shapes as parameters and thinking of parametric design as a general procedure. Consequently, a parametric model becomes a flexible tool allowing changes at the topological and geometrical levels.

In this case variations are carried out by changing the values of the parameters allowing these variations to be propagated through the dependent attributes. The attributes are controlled by a non-geometrical component that is called a parameter. A parametric model (PM) is a three-dimensional computer representation of a design constructed with geometrical sets of shapes that have some attributes (properties) that are fixed and others that can vary.

Parametric modelling exists in the following: 1. Shapes as Parameters: 2. Parametric Variations: 3. Model Constraints: 4. Geometrical Modelling as Procedures. 5. Parameterization of Geometrical Models.

Parametric Design (PD) is the process of designing with parametric Models in a setting and/or environment where variations are effortless, thus replacing singularity with multiplicity in the design process. Parametric Design implies the use of declared parameters to define a form. This requires thought in order to build a geometrical model embedded in a very sophisticated structure appropriate for the needs of the designer. Design process of the muqarnas will be solved according to a hierarchy of domain knowledge that goes into three main categories:

First: Components, Second: Assembly Knowledge, Third: Functional Knowledge.

First: Components. A Muqarnas composition depends mainly on grouping of components that affects relative orientation, relative position, aspect ratio, length, and size constraints. In principle, each component has an algebraic equation representing it. Each constraint also has an algebraic representation.

Second: Assembly Knowledge. The assembly of muqarnas components depends on a knowledge that is mainly related to parametric design. Parametric Design (PD) is the process of designing with Parametric Models in a setting and/or environment where variations are effortless, thus replacing singularity with multiplicity in the design process.

Third: Functional Knowledge. What are meant by function are the types of application we are getting from the assembly of muqarnas objects. These functions have the spatial configuration of: Arches, Column Capitals, Cornice, and Domes. For each of these functions we are dealing with a design task that depends on parameters and constraints.

2. The role of AI

In artificial intelligence there are mainly two design approaches; the top – down and the bottom – up approach. Top – down or bottom – up approach is represented as a process to decompose a big problem or a big structure into small pieces from top to bottom. The decomposed concept of knowledge is pre-programmed and stored into a large knowledge base. Then, inference techniques based on deduction, induction and or abduction are used to infer relevant concept or knowledge from given queries to solve a given problem. To get muqarnas assembled we will start dealing with the bottom – up approach that begins with a relatively small number of physical building components. As the combination of the building components is some times too large to determine the best solution thus, we need a thinking process from computer-aided design of geometric topologies and shapes that is based on the idea that design cannot proceed without zigzagging between the functional domain and the physical domain. This process combines the advantages of the top – down and the bottom-up approaches and consists of three sub – processes: 1.top-down decomposition process, 2.mapping process, and 3.bottom-up integration process.

Based on these issues a model-based design process could be transformed into a GUI interface that could be applied as a design module on any of the known design platforms. This application could be also applied to many alternative manufacturing ideas using CNC technology and applying these ideas on various materials such as wood, marble, plexi-glass, aluminium, or on combinations of these materials within one design.