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Configuration Punctuation as a Decrypting Method for Architectural Building Facades Morphology

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Abstract

Shape grammars has been studied for 47 years, but its potential in the practise and education of art, architecture, and engineering is still untapped. Similarly, while reverse engineering is well-established in some engineering disciplines, its application in architectural design remains under-represented [1-15]. This paper develops a novel method that combines the power of shape grammars as a parsing tool in reverse engineering to decode the morphogenesis of visual compositions in architectural design by combining the two domains. The combined power is demonstrated by decoding the formal language of a case study's façade design, from which a seemingly simple set of rules can yield surprisingly complex compositions. The language rules can then be used to reconstruct parts of the case. façade. Most shape grammars in the architectural literature are applied to formal historical precedents, but the subject of this paper's morphological analysis is contemporary and has a style that exhibits non-orthogonal configurations that appear to be far from being standardised or subject to regulatory tectonic rules. The façade derivation grammar is explained and re-synthesized in various computations to investigate emergent articulations that demonstrate predictive, synthetic, and generative abilities in addition to traditional analytic abilities.

Introduction

Understanding the morphogenesis of visual compositions is important for architects in both practise and education. Externally, such compositions are primarily aimed at producing visually appealing products on the planar and spatial levels. Building facades are the main interface between a building and its viewer that stimulates the first impression in architectural exterior design, where designers tend to focus on morphology and aesthetics more than other design considerations.

Shape grammar is a systematic algorithmic formalism for analysing and deriving the morphology and topology of design products. Shape grammar formulations and implementations have been linked to many morphogenesis agents of design products, including morphology, aesthetics, and topology of visual compositions. Notably, one of the earliest applications of shape grammars was in the compositional language of paintings where aesthetics and morphology were major subjects. Similarly, in an architectural plan The main composing canvas for configuration and façade design is a two-dimensional planar medium. The primary design tasks in plan configuration are function-driven, whereas in façade design they are form-oriented and aesthetics-centered. As a result, parallels between paintings and facade designs can be drawn. Shape grammars and form computations are frequently used to explain the structures and derivation processes of facade designs. However, the majority of these examples concern the orthogonal designs of classical buildings.

Reverse engineering is used in many engineering fields to study existing products and understand their structures, functions, operations, and assembly processes. Reverse engineering serves as an analytical tool, allowing for the subsequent generative application of its findings. With reverse engineering's dual functionality in analysis and synthesis, it is a valuable practical and educational resource for engineering design knowledge development, recycling, and implementation.

Subjective Heading

This paper introduces a shape grammar that can function as a reverse engineering tool to explain the morphogenesis of façade compositions, thereby combining shape grammars, reverse engineering, and façade design studies. The grammar is intended to broaden the scope of shape grammar as a descriptive tool that allows designers to associate final product parts with their generative rules. This research could help with Knight and Stiny's proposal to "make grammars". The rules in this latter proposal can be used to assemble, manufacture, or materialise design components into physical products.

The power of shape grammars as a composition decoder, synthesis encoder, form generator, morphogenesis interpreter, and assembly descriptor is highlighted in this study. For demonstration, it studies one of Saudi Arabia's most iconic buildings in contemporary architecture. The study focuses on the chosen precedent's façade design. This part of the building design was chosen for its distinct character; its composition appears at random, and it is not subject to any surface standardisation scheme. The façade composition reveals its highly organised system and standardised structure through a simple shape grammar comprised of a few primitive lexicons and simple syntactic rules.

Discussion

Deductive, inductive, and abductive reasoning are employed in the study. To analyse and decode the case study configuration, as well as to deduce the rules and grammars underlying the generation of its facades, deductive reasoning is used. Inductive and abductive reasoning are used to demonstrate some possible computations and derive new

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compositions by applying the rules in various combinations. According to the research's ontological and epistemological assumptions, design knowledge is embedded in physical products and is created by devising theoretical and visual constructs that reproduce reality. An analogy between design compositions and formal languages improves knowledge visualisation in these constructs. The methodological assumption is consistent with reverse engineering concepts, in which vocabulary elements and synthetic rules can be traced back and concluded from a decomposition of existing physical product designs.

Shape grammars is a visual study domain that deals with the morphological language, numerical relationships, and topological structures of design products, as well as the incremental and recursive processes that generate them It is a multidisciplinary field that combines linguistics, computation, algebra, mathematics, and design. Shape grammar, in its most basic form, is concerned with the constituent components of a form, as well as their spatial arrangements and proximity inter-relationships. Shape grammar, like natural language, typically emphasises rather than the semantic, symbolic, or semiotic levels of design compositions, the lexical (vocabulary elements), syntactic (grammars and structures), and sometimes pragmatic level (contextual effects in context-sensitive grammars) When shape grammar rules are applied to a given subset of vocabulary elements, original forms are regenerated and new artefact forms are created. A formal language is the set of all forms generated by applying a specified set of rules to a specified set of vocabulary elements. It may correspond to a visual style.

Shape grammar studies, which were concerned with form-making in planar compositions, emerged in the early 1970s. Early examples concentrated on two-dimensional art products like paintings .The analysis of the paintings of Richard Diebenkorn and Georges Vantongerloo and Fritz Glarner continued the emphasis on planar compositions (Knight, 1989). Similarly, shape grammars were used for the analysis and synthesis of planar compositions, such as the Chinese ice-ray lattice designs and Stiny and Mitchell's Palladian grammar. Later scholarly works shifted to three-dimensional form grammars, beginning with kindergarten grammars for designing with Froebel's building blocksstumbling blocks .Several examples of 3D grammars followed, including Frank Lloyd Wright's architecture the Queen Anne house design the Gill, and the Siza grammar.

Shape grammars are useful for form analysis and synthesis. They can be used to explain other layers of design, such as functional aspects, in addition to morphological interpretation. Rules can be written within the functional scope to determine, parse, or generate subsets of a language that meet specific criteria, such as measurement parameterization and the assignment of topological and spatial proximity relations among the designated vocabulary components.

The majority of proposed architectural shape grammars are unrestricted or context-free. Some examples, however, represent restricted or context-sensitive grammars Eilouti and Al-Jokhadar are examples of the former, and Eilouti and Al-Sha'ar are examples of the A parametric shape grammar is a production system that consists of the typical "if-then" rules combined with some geometric operations in a more flexible and adaptable version. These operations include translation, rotation, reflection, and scaling, and they can be used to match the rule's "if shape" to create a new shape that replaces the old one in the "then shape." The dimensions and angles of the original shape can be parametrized to generate a wider range of shapes and compositions.

Shape grammars provide a link between form analysis and synthesis in all formats. In the former, architectural precedents are analysed using deductive reasoning .whereas vocabulary elements can be re-synthesized using inductive and abductive reasoning by following various combinations of rules in various orders to generate original or novel designs. As a result, precedent designs can be adapted to generate new emergent configurations. As such, shape grammars serve as a mechanism for precedent and case-based designs as well as an agent for design computing in which grammatical rules can be applied. transformed into computerised software codes and commands Transformation, substitution, and hybridization can be used to adapt precedent designs in design computing applications .Such an adaptation increases the power of shape grammars by extending the element of emergence, which can enrich the existing morphogenesis resources and boost creativity and novelty in emergent designs.

The scope of this research is limited to parametric context-free shape grammars for planar architectural compositions. The grammar is intended to operate as a procedural and incremental system, with a link to more operational versions that may be linked in a future extension to "making grammars," where its steps can be implemented using forward engineering to assemble similar façades or their parts.

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Reverse engineering, as used in this study, is a top-down case-based approach to knowledge retrieval, development, and potential translation into new designs. It extracts knowledge from an existing human-made product and uses that knowledge to create a new product or part that is similar to or inspired by the original The knowledge gained from reverse engineering processes can then be used to design similar products using a bottom-up forward engineering approach. As a result, reverse engineering serves as both an analytical tool and a problem-solving technique. It offers a method for conducting systematic analysis and synthesis of design products. It is used in software, bio-medical, chemical, computer, mechanical, civil engineering, manufacturing, and industrial applications.

The creation of shape grammars for an existing case or precedent design can assist designers in generating parts or a plethora of random whole compositions from which they can select some forms as their final articulations or inspiration resources for future product generation. Shape grammars, like reverse engineering, serve as an interdisciplinary link between various fields of knowledge. It connects architecture to algebra, linguistics, mathematics, and computer design. Krawczyk, for example, proposed cellular automata to generate organised patterns from random data. which architectural forms are possible to derive Similarly, Dore and Murphy proposed a semi-automatic grammar-based programme for modelling building facades. Furthermore, principles of computation and finite state automata were used to explain the morphogenesis of some spatial compositions in architecture, such as three-dimensional compositions Mamluki school plan designs.

Conclusion

Shape grammars and reverse engineering principles can be combined to create an analytical and generative tool for the morphogenesis of architectural forms. Form analysis and synthesis are well-known in architecture and design literature The genesis of novel designs in most grammar applications is based on a computational derivation of many possible composition combinations, allowing a designer to view alternatives of form configurations from which the strongest candidates can be selected based on his/her prescribed criteria.

Engineers use reverse engineering to identify the components of a system, attempt to conclude their structures, and determine how the components relate to one another in order for the entire system to function and achieve its functional goals. An object is decomposed in this method to discover its inner structure, the function of all parts, and how the parts work together. Furthermore, it seeks to extract knowledge from the system's architecture and deduce design principles while requiring little or no additional knowledge of the procedures involved in its original production.

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Conflict of Interest

The authors declare that they are no conflict of interest.

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