Shape grammars: a critical review and some thoughts

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ABSTRACT

Shape grammars are generative formalisms that produce shapes in specified styles. Little critical work has been done to examine the assumptions that shape grammar researchers make about architectural form and its generation, the methodology they employ, the underlying formalism they use, and consequently the adequacy of this formalism to describe architectural form. After establishing the criteria for evaluating the adequacy of a given generative formalism, this paper applies them to the evaluation of the shape grammar formalism. The paper demonstrates that, in its present state, shape grammar leaves a great deal to be desired in terms of its descriptive power and its generalizability. The paper concludes by exploring some of the desired characteristics for languages of architectural form.

1 INTRODUCTION

Shape grammars are generative formalisms that allow spatial computations to be carried out on shapes. Their development parallels and to a great extent was influenced by attempts to represent formally and implement many aspects of human competence (e.g., natural language understanding and decision-making) on computers. Little critical work has been done to examine the assumptions that shape grammar researchers make about architectural form and its generation, the methodology they employ, the underlying formalism they use, and, consequently, the adequacy of this formalism to describe architectural form. After establishing the criteria for evaluating the adequacy of a given generative formalism, this paper applies them to the evaluation of the shape grammar formalism. The paper demonstrates that, in its present state, shape grammar leaves a great deal to be desired in terms of its descriptive power and generalizability.

The paper starts by summarizing the main types of generative formalisms and the criteria used for assessing their adequacy. Then it proceeds to outline the components of the shape grammar formalism and its utility for representing architectural style. The next section assesses shape grammar according to the criteria that are generated in the previous sections. The paper concludes by exploring some of the desired characteristics for languages of architectural form.
2 GENERATIVE FORMALISMS: SOME DEFINITIONS

Generative formalisms are finite specifications that describe an infinite number of objects in a given language. A generative formalism is defined by specifying an alphabet of uniquely defined symbols, usually denoted as $\Sigma$ and a set of operators for manipulating them to generate new symbols. For example, given a language on linear strings of symbols, a reasonable operation would be one that concatenates two strings to generate a third. The set of all possible compositions that can be derived from an alphabet $\Sigma$ is denoted as $\Sigma^*$. Finally, a language over $\Sigma$ is any subset of $\Sigma^*$.\footnote{1} Obviously, there are as many languages as there are subsets of $\Sigma^*$. Research on languages usually concentrates on those that can be defined formally using grammars. Grammars are generative formalisms that consist of a set of production rules that apply to an alphabet $\Sigma$ and produce proper subsets of $\Sigma^*$.

There are a number of techniques for writing grammars. In this paper, for the sake of uniformity, we will use a technique called the Backus-Naur Form (BNF) to describe the different types of grammars formally. There are four components for a grammar. They are written in the following form:

1. A finite set "T" of terminal symbols that correspond to the individual elements that make up the expressions in the language.

2. A finite set "V" of non-terminal symbols that denotes the sub-phrases of the language.

3. A start symbol "T" which is a symbol that belongs to the set of non-terminal symbols and is used to denote the complete expressions accepted by the language according to the grammar.

4. A set of rewrite rules "R" in the form $\alpha \rightarrow \beta$, where $\alpha$ is a non-terminal symbol and $\beta$ is a sequence of zero or more symbols that are either terminal or non-terminal. For example, a rewrite rule in the form $S \rightarrow \text{NP VP}$ means that whenever the string $S$ is encountered, it can be replaced by the strings $\text{NP}$ and $\text{VP}$, or vice-versa. If there are more than one rule that start with the same symbol, the symbol "T" will be used to separate their right-hand sides.

This section reviews the main characteristics of string-based languages. Such languages exhibit a number of formal characteristics that make them of interest in many areas of investigation. For instance, in computer science these languages constitute the foundation of the theory of computation (Lewis and Papadimitriou 1981). Moreover,
natural languages form a special class of these languages. Its study can be enhanced by understanding the properties of string-languages (Allen 1995). In architecture, much of the work on shape grammars extends grammars that were developed to describe linear strings of symbols to handle two and three dimensional shapes (Stiny and Gips 1978). Research on the formal properties of string-languages has resulted in the development of a hierarchy of finite representations. The following paragraphs establish the main characteristics of this hierarchy.

The most restricted languages are those that can be expressed by regular expressions. Regular expressions, usually denoted as \((a^* b^*)\), are capable of representing and generating any sequence of a symbol followed by any sequence of another symbol. The validity of a regular expression in a given language can be determined by running the string through a finite-state automaton. Simply defined, a finite state automaton is a computing device that consists of a finite number of states. It reads a string of symbols from left to right and, depending on the state of the current symbol, it crashes, jumps to a new state, or terminates. The set of strings that a finite state automaton accepts are said to belong to the language it describes. Using the BNF notation an example of a regular grammar that would generate expressions that belong to the set \(\{b, c, bb, bc, bbb, bbc, ...\}\) would be: \(T = \{b, c\}, V = \{S, a\}, I = S, a \rightarrow ba b c\).

Regular expressions cannot describe languages of the form \((a^* b^*)\). These languages belong to a class of languages known as context-free languages and are represented using context-free grammars. Those grammars incorporate information about the structural properties of the language they describe. Formally, the BNF notation can be used to write a context-free grammar \(G\) as a quadruple \((\Sigma, V, R, S)\), where \(\Sigma\) is an alphabet, \(V \subset \Sigma\) is a set of terminals, \(R \subset (\Sigma - V) \times \Sigma^*\) is a finite set of rewrite rules, and \(S \in (\Sigma - V)\) is a start symbol. For any \(A \in \Sigma - V\) and \(w \in \Sigma^*\), a rewrite rule can be written as \(A \rightarrow w\) if and only if \((A, u) \in R\). The symbol \(u\) can be any expression of the form \(xAy\).

Devices that implement context-free grammars are known as pushdown automata. A pushdown automaton is a special kind of finite-state automaton that has storage for intermediate states. It can be defined using a finite set of states, an alphabet of input symbols, an alphabet of intermediate symbols, an initial state, a set of final states and a transition relation. The following is an example of a context free grammar that generates simple English sentences: \(S \rightarrow NP \ VP \ S\) and \(S, NP \rightarrow Art \ N \ N, \ VP \rightarrow V \ NP \ V, N = \{John, Mary, chair\}, V = \{saw, moved\}, Art = \{the, a, an\}. Some of the sentences the can be generated using this grammar are \{John saw Mary, John saw Mary and Mary moved the chair, the chair moved the Mary and the John moved the chair, ...\}.

The problem with context-free grammars is that, by definition, they are context independent. The reader probably noticed that some of the sentences above do not make any sense but they are acceptable given the rules of the grammar. Formally, context-free grammars cannot describe languages of the form \((a^* b^* c^*)\). Languages of this form require
more general generative formalisms known as context-sensitive grammars. These
grammars allow for more than one symbol to occur on the left-hand side of the rule and at
least as many symbols to occur on the right-hand side. By definition, a context-sensitive
grammar encompasses all the languages that can be described by context-free grammars,
and, in turn, all the languages that can be described by regular grammars. The rewrite
rules of a context-sensitive grammar have the form $\alpha \beta \rightarrow \gamma \delta$, where $a, b, c, d$
are symbols or sets of symbols, $\alpha$ is a non-terminal symbol and $\beta$ could be a terminal or a
non-terminal symbol. More general languages can be described by devices called Turing
Machines. They use recursively innumerable grammars that allow for unrestricted
rewrite rules. Both sides of the rewrite rule can have any number of terminal and non-
terminal symbols of any type and order.

This classification of grammatical formalisms is not a discrete classification but,
rather, continuous. The generative capacity of a formalism (i.e., the range of languages it
can describe) allows for the description of an unlimited range of languages. It can be
increased or decreased (Allen 1995). For instance, by augmenting a context-free
grammar with feature rules (rule schemata), it is possible to increase its generative
capacity to approximate that of context-sensitive grammars. Such grammars cannot be
represented using the BNF notation because it does not allow for features to be ascribed
to the rules. A generalized form of BNF known as Definite-Clause Grammar (DCG) is
now commonly used for representing generative formalisms. The problem that formal
language researchers face continuously is the selection of the grammatical formalism that
matches the language under investigation.

3 LEVEL OF GRAMMATICAL DESCRIPTION

The purpose of research in formal grammar is to find finite specifications that describe an
infinite set of objects. The notion of grammatical level refers to the process of assessing
the degree to which a specific grammatical formalism describes a body of data accurately.
It states that a grammar describes the utterances or forms generated in the language and
nothing else (Chomsky 1965). Researchers agree that evidence from specific areas of
investigation provides a way of comparing and evaluating the descriptive as well as the
generative power of these grammatical formalisms. Because most of the pioneering
research in this area has been done on natural languages, the discussion that follows will
focus on the problem of selecting a particular grammatical formalism to describe the
structure of a particular natural language. It will then be generalized to account for other
domains such as architecture.

In linguistics, Chomsky (1963) suggested two requirements for determining the
applicability of grammatical theories to natural languages. The first, is the
appropriateness requirement. It states that the sentences generated by a linguistic theory
1. T is a finite set of terminal shapes.

2. V is a finite set of labeled shapes in the form (s, l) where s ∈ S and l ∈ L is a finite set of labels associated with s. L is a finite set of labels for the grammar.

3. I is a labeled shape from (S, L) called an initial shape.

4. R is a finite set rewrite rules of the form A → B, where A is a labeled shape in (S, L) and B is a shape that belong to either T or V.

The following will explain some of the characteristics of this definition. Like other formalisms that describe languages, shape grammar is based on the precise specification of an alphabet of shapes and the operations that can be performed on them. Shapes can be defined as sets of line segments. However, to insure the uniqueness of the representation, shapes were defined as sets of maximal line segments that are constructed from the union of connected and collinear line segments (Stiny 1980). Stiny and Gips (1972) proposed the subshape relation to partially order the universe of shapes (i.e., the set of all possible shapes composed of maximal line segments). A shape is said to be a subshape of another, if and only if, every maximal line in the first shape is embedded in some maximal lines of another. Given that shapes have continuous dimensions, it can be concluded that there is an infinite number of shapes that can be embedded in a particular shape. Similar to string expressions, shapes can be modified to generate other shapes through the use of operators. For instance, the shape union operator applies to two shapes and results in a shape composed of the maximal lines that are produced by applying reduction rules to the set of lines generated from the union of the two original shapes.

The aforementioned definition of shape grammar consists of four main components: (1) a finite set T of shape vocabulary known as the terminal nodes. The elements of this vocabulary correspond to complete representations of architectural objects such as plans, sections, elevations, or three-dimensional models. (2) a finite set V of non-terminal shapes. These correspond to the intermediate nodes in a string grammar or the phrasal categories in natural language grammars. In architecture, they represent incomplete representations of architectural objects. (3) an initial shape I that belongs to the set V of non-terminal shapes but not to the set of terminal shapes. (4) a finite set R of rewrite rules of the form A → B. Parsing and derivation are two important considerations when one deals with grammars. For these operations to work, the terminal and non-terminal symbols of a grammar should be defined uniquely. In shape grammar, a shape rewrite rule consists of two shapes. When this rules is applied to a shape s, the shape on the left side of the rule replaces every occurrence of every similar shape in s with the shape on the right side of the rule. However, given the above definition of a
shape as a set of maximal line segments, it is impossible to distinguish between terminal and non-terminal shapes. This creates an inconsistency with regard to the definition of grammars. To remedy this problem Stiny and Gips (1972) introduced the notion of a labeled shape.

A labeled shape is an ordered pair of a set of maximal lines and a set of labeled points. Given the previous definition of a grammar, labeled shapes stand for non-terminal symbols and unlabeled shapes stand for terminal symbols. Stiny (1980) has generalized the definitions of shapes to include labeled shapes. For instance, according to the subshape relation, a labeled shape is said to be a subshape of another if the first shape is a subshape of the second and the set of labeled points associated with the first shape is included in the set of labeled points that is associated with the second.

Although capable of generating a wide range of architectural forms, the above definition of a shape grammar is too restrictive. The reason for this is that it does not allow for the parameters of a shape to vary. In other words, shapes defined using the above grammar have fixed proportions and topologies. To increase the generalizability of the above grammar, Stiny (1980) introduced the idea of families of shapes by allowing for parametric variation in the way their coordinates are defined. A shape rewrite rule defined parametrically includes functions that specify the relations between the endpoints that make-up its maximal line definition. In the same manner he extended the definition of labeled points to include that of parametrized labeled points. The result of applying a parametric function to a parametrized labeled shape is a shape that belongs to the family of the shapes defined by the parametric relation.

As defined so far, shape grammars are procedures for enumerating the shapes in the language defined by the grammar. To increase their descriptive power, additional criteria have to specify the attributes of the generated shapes. This has been achieved through augmenting the shape rules with description functions (Mitchell 1990).

5 EVALUATION OF THE SHAPE GRAMMAR FORMALISM

When first introduced, shape grammars were viewed as a general solution to the problems pertaining to architectural form and its generation. For instance, they were seen as: (1) formalisms that connect architectural form and meaning (Stiny 1985), (2) formalisms that facilitate the articulation of aesthetic judgments (Stiny and Gips 1972), (3) formalisms that facilitate the conduct of computations on shapes (Stiny 1976), (4) generative devices that represent the search space of all solutions to a given design problem (Gips and Stiny 1980), (5) formalisms that make translations from one design language to another possible (Knight 1981), (6) devices that define architectural language in the same sense that grammars for natural language capture the structure of natural language, and (7) formalisms that represent architectural style.
Recently, however, several of these claims have been reexamined. For instance, the association with linguistic grammars is now considered to be misleading and imprecise. It leads to the belief that architectural languages should be lexically-based and that they ought to have a semantic and a pragmatic component (Krishnamurti and Stouffs 1993). Moreover, the idea that innovative designs can be generated by the application of rules of shape grammar has been repeatedly criticized (Krishnamurti and Stouffs 1993). Likewise, the claim that shape grammars allow for aesthetic judgments to be formalized has not been tested. Some researchers, pointed out problems in the methodologies that lead to the formulation of the grammar itself (Mitchell 1992). Among other things, this paper is concerned with assessing the descriptive power of the shape grammar formalism and the methodologies used for deriving the rules of a shape grammar to outline their limitations.

The purpose of research in formal grammar is to find the grammatical level that describes the forms generated in the language and nothing else. Domain-specific knowledge provides criteria for selecting the best among a set of grammatical formalisms. Thereby, the assessment of the adequacy of the representational power of the shape grammar formalism requires establishing criteria that are relevant to the field of architecture. The discussion that follows will focus on two claims that have been made concerning the capabilities of shape grammars: the representation of visual style and the capturing of the design process.

Shape grammar researchers hold that the identification of the attributes and rules that govern the spatial organization of shapes contributes significantly to the conduct of research on architectural form and its making. They argue that a shape grammar not only facilitates the description and derivation of forms that share stylistic similarities, but also makes the conduct of design studies easier and more systematic. Usually, in architecture, style is characterized by examining precedent. Many architects believe that, by studying the morphological structure of existing buildings, it is possible to extract the rules that have informed their creation. Prior to the introduction of shape grammars, approaches to the study of precedent were occupied with the notion of correctness of the produced forms rather than the process of achieving an accurate representation of the architect’s knowledge of form-making. Being the ones concerned directly with form-making, architects strove to formalize rules for generating buildings according to specific aesthetic proclivities. Historians and theoreticians, interested in analyzing and describing visual organizations tried to prove that certain styles were superior to others. Although often characterized as formalist theories, the problem with these approaches is that they were never purely formal. More often than not, they were theories of taste characterized by blurring formal judgment about style with emotion, individual biases, and aesthetic preferences. Inherent in such theories is the assumption that certain forms of architecture or even particular styles are better than others.
The situation is not unique to architecture. Coincidentally, traditional approaches to defining grammars for natural languages also aimed to codify language in terms of rules that conform to an acceptable standard of excellence (i.e., a preferred style). These grammars were prescriptive insofar as they lay down rules for the correct use of a language. The notion of the correctness of grammatical description is now criticized by Chomsky (1963), Allerton (1979), and Haegeman (1993) among others for (1) being eminently faced with odd cases that the grammar cannot describe and (2) because it is based on subjective criteria, which make it almost impossible for different researchers to formalize the same set of descriptions for the same set of data. Chomsky proposed that a grammar is not a structure of higher-order concepts and principles constructed from simpler elements by "abstraction" or "generalization" or "induction." Rather, it is a rich structure of predetermined form constructed by the language faculty, a property of the human mind (Chomsky 1975). As noted earlier, the problem for linguists, becomes one of selecting the correct grammatical level that accounts for the sentences of a particular language and not one of the correctness of the grammatical description of that language.

When researchers formulate the rules of a shape grammar, they undertake an approach similar to that of formulating a traditional natural language grammar. The process followed is simply to decompose a given set of forms into individual shapes. The shapes and the relations between them are stated as shape rewrite rules that can be used to rearrange the shapes to generate new forms. The traditional notions of style were employed to formulate a working method for identifying selected basic elements (i.e., vocabulary of architectural elements) and selected schemes (i.e., rules for composing the elements) underlying a certain composition. At the formal level, there are two problems with this approach. First, it makes the unique definition of the vocabulary of form difficult. Second, it generates classificatory conventions that are not necessarily aspects of the form-making process itself.

Further attempting to adhere to the definition of grammars for natural languages, Stiny and March (1981) noted that the forms described by a shape grammar should not be confused with the idea of the universe of designs, which contains descriptions of all possible designs of a certain highly generalized kind. They added that languages of designs defined by shape grammars are proper subsets of the set of all possible designs in the universe of shapes. They went on to declare that, intuitively, such languages are analogous to sets of sentences comprised of letters, numerals, and punctuation in some specific natural language or specific fragment thereof pertaining to a particular area of discourse. However, considering the way grammars for natural language are stated, the analogy is not as direct as it may appear to be.

In natural language, when a grammar is said to describe a subset of the universe of languages that can be derived from a given alphabet, the grammar still does not describe the style in which the language is going to be used later on. A grammar is said to characterize the competence of the user of the language to generate any sentence in that
language but cannot, and is never intended, to account for the user’s performance. In other words, grammars do not provide a recipe for using the language, but describe the limits of what can be accepted as a grammatically correct utterance in that language. Hence, they leave room for the user’s preferences regarding specific linguistic forms and utterances to determine how he or she may use a language.

The unorthodox use of language to indicate style in shape grammars, and the use of formalisms that were invented originally for describing the structure of language to describe style is one of the major problems of shape grammars. Languages are not styles. However, a particular use of language suggests the existence of style. In both linguistics and architecture, when the focus shifts away from trying to come up with the rules that govern taste, it begins to move gradually toward representing the structure of the language itself and not the style in which it can be used. The nature of the grammar that results from this approach is descriptive rather than prescriptive. Using descriptive grammars, style can be defined as a particular use of the language.

As noted earlier, given that they are enormously complex systems, one of the first requirements of formulating a grammar for a natural language is the development of levels of representation. Instead of describing a language totally at the level of phonemes, linguists use methods of analysis, such as the immediate constituent method, to divide sentences into components that become the forms the structure of which is described by grammars. Moreover, they subdivide the problems into a number of levels of abstraction such as word morphology, syntax, semantics, and pragmatics. Languages of form are no less complex than natural languages. Nevertheless, shape grammar researchers choose to study form in its totality. The idea of levels of representation is absent from the definition of a shape grammar.

One of the properties of grammars is that they can be used to recognize and parse valid expressions in the language they define and to filter out invalid ones. Accordingly, shape grammars are advocated as suitable for both analysis and generation. Stiny stated: “while no parsing algorithms have been developed, shape grammars seem applicable to the analysis, as well as the generation, of shapes” (Stiny and Gips 1972: 1463). However, as it turns out, it is virtually impossible to use shape grammars to analyze forms. This is because there is no explicit way of characterizing what constitutes a vocabulary of shapes. The rules of shape grammar use labels to distinguish between terminal and non-terminal shapes. But in real life, shapes have no labels associated with them. Without parsing strategies grammars cannot be used to determine whether or not a particular shape belongs to the language described by the grammar.

If the intention is to describe style, shape grammars should allow representations of forms to be structured, classified, and compared. In reality, the analysis is conducted by the researcher manually and prior to the formulation of the grammar. Having no parsing strategies, it is impossible to use shape grammars to structure precedent. Having
no explicit way of structuring representations of forms, it is impossible to use them to classify and compare precedent.

The literature on shape grammars assumes that design is a mode of computation. Shape grammar researchers argue that by defining the shapes that constitute a form and the operations that can be used on them, shape grammars make possible the explicit statement of the designer's intentions about a design as well as the systematic analysis of these intentions and their consequences. Consequently, they facilitate the derivation of new designs in the same language. Thinking of design in this way reduces a designer to the status of a finite state automaton. However, as form-makers, designers make rules that they occasionally break. Limiting the use of grammars to describe styles is of no practical value in enhancing the form-making performance of designers. A more reasonable approach, may be to define languages of form that facilitate the creation of tools that make the exploration of a variety of form-making solutions without specifying a procedure (a recipe) for arriving at those solutions. In other words, grammars should target those aspects of a form that correspond to the designers' competence and not his or her performance.

6 CONCLUSIONS

The previous sections outlined the characteristics of generative formalisms and discussed the methodology of matching a particular level of grammatical description with a body of data. As well, the definitions underlying the rules of shape grammar and the methodologies for their selection were discussed. Finally, the limitations of shape grammars were illustrated. Those can be summarized in the following:

1. The rules of shape grammar are, by definition, prescriptive and biased towards generation. The underlying assumption is that knowledge of design can be reduced to a kind of procedural knowledge. However, like other procedural approaches to knowledge representation there is no clear connection between the knowledge of the structure of the object represented and the actual production rules used in its generation. Moreover, because knowledge related to the solving of a problem is hard-coded in the rules that make up a grammar, the utility of shape grammars in design is limited. Conceptually, thinking of design in this way reduces a designer to the status of a finite state automaton.

2. Another limitation of shape grammar, that is related to the first point, concerns the definition of style procedurally rather than declaratively. Shape grammars are based on the assumption that style in architecture is equivalent to language. However, one can argue that there exist universal principles that govern the
generation of form (e.g., rules of physics, statics, structural principles, among others) and rules that specify the aesthetics proclivities of individual designers which indicate the choices they make at certain stages of the form-making process. Procedural approaches make little distinction between the two types of knowledge.

3. Shape grammars lack the notion of levels of representation. Without such concepts of levels of representation and dependencies among these levels, shape grammars are bound to lead to combinatorial explosions when implemented on computers. The reason for this is that each new shape grammar rule adds a number of parameters to the equations that define the shapes, in turn, this leads to an exponential increase in the number of dependencies between the parameters, thereby making the problem of selecting the next rule to apply intractable.

4. To describe style more fully, shape grammars should allow representations of forms to be structured, classified, and compared. In reality, the analysis is conducted by the researcher manually and prior to the formulation of the grammar.

A more reasonable approach, may be to define languages of form that facilitate the creation of tools that make possible the exploration of a variety of form-making solutions without specifying a procedure (a recipe) for arriving at these solutions. In other words, grammars should target those aspects of form that correspond to the designers’ competence and not his or her performance. This would require a move from procedural to declarative approaches for representing knowledge of architectural form and its making.

As form-makers, architects are usually concerned with the creation of forms that solve specific form-making problems. At the same time, they are faced continuously with new problems characterized by increasing complexity. It seems reasonable to think of design as consisting of two activities, that which is normally called design and that which is denoted by the term form-making. Form-making entails making decisions about architectural forms and their generation. It assumes a level of competence that architects have about the structure of architectural form and its generative properties. The study of form-making involves the establishment of explicit and systematic links between the structure of architectural form (i.e., the elements of form and their relations), its attributes (compositional principles such as symmetrical balance), and its determinants (behavioral, natural, legal, and technological). In addition to form-making, design encompasses processes and considerations that inform the form-making decisions of designers. It involves applying principles, beliefs, and judgments concerning the designer and his or her cultural context that are not necessarily aspects of the structure of form.
As a way of understanding the underlying rules and structures of architectural form, without limiting creativity, form-making studies should aim to enhance the competence of architects by: (1) furthering their understanding of the structure of architectural form (i.e., its morphology) and of the nature of its attributes and determinants (i.e., the requirements of commodity, firmness, and delight) as well as (2) building tools that aid designers to explore and evaluate their form-making decisions both systematically and effectively. The first objective of form-making studies can be achieved by furthering the theoretical understanding of architectural morphology. The second can be attained by exploring knowledge representation languages that describe and facilitate reasoning about such knowledge of architectural morphology.

Accordingly, style could be understood as an effect of language’s use. Grammars that represent knowledge of architectural morphology do not define style. Rather, they define languages. A particular use of a language allows for patterns to be created, and, thus produces a sense of style. According to this viewpoint, one way to define style would be to use morphological analysis techniques to extract and classify the features of a form that give a sense of style.

In the literature, one of the early attempts to apply these ideas to form-making was Steadman’s approach to the study and analysis of building plans (Steadman 1983). He suggested that, at the level of the parti, all architectural plans can be represented using a dimensionless, topological representation coupled with a set of transformation rules involving proportions to produce actual plans. Another approach, was introduced by Liu (1992). His work demonstrates that architectural form can be described, analyzed, and derived based on the universal properties of its geometric structure and its spatial structure. The geometric structure represents the parti of the design, and is composed of lines that define spaces. The spatial structure is a representation of the plan itself. It encompasses information about the wall-to-wall, wall-to-column, and column-to-column relations.

The alternative approaches to representing languages of architectural form which were briefly introduced here, allow for the description of forms as well as the exploration of new ones without reference to a particular style. They allow for style to be identified as patterns that emerge through the analysis of the arrangements of the elements of forms. In addition, they incorporate more knowledge about the structure of a form in the definition of style. Ultimately, they should lead to a deeper understanding of the attributes and morphological properties of architectural forms and their interactions.

7 NOTES

1 For a detailed mathematical treatment of languages the reader is referred to Ross and Wright (1992) and Lewis and Papadimitriou (1981).
The reader is referred to Stiny and Gips (1972), Stiny (1976), and Stiny (1980) for a detailed treatment.

8 REFERENCES


