Exploring Design Motifs and Extending Visual Representation of Style

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ABSTRACT

The notion of generating artifacts using a design motif has a long history in the tradition of generative systems, however no formal definition currently exists. This abstract presents a formal definition that unifies these previous approaches, while also proposing several novel systems that incorporate the use of this definition, in a way that allows for generators switch the design motifs that they generate with.

Categories and Subject Descriptors

I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems—*Games*; I.3.5 [**Computer Graphics**]: Computational Geometry and Object Modeling

Keywords

Design Motif, Procedural Content Generation, Grammars

1. INTRODUCTION

Since the advent of the shape grammar [11], many attempts at generating designs that visually resemble hand-authored specifications have been made. These approaches range from work done by Pugliese and McCormack in generating artifacts with a particular brand identity [6, 8], to systems which generate buildings that invoke the principles of particular architects [1, 5, 12]. The individual systems are only able to generate one particular style of artifact - for instance, Koning and Eizenberg's prairie house grammar is only able to generate this one class of house, using the particular constraints given to these houses. However, they all aim to do a similar task - the generation of artifacts that share common and distinct visual elements, or design motif.

A *design motif* defines the features used in the design of a set of objects that classifies them as belonging to the same set. These features can be as simple as color schemes, or as complex as changing the size and shapes of various features in a design - such as a fireplace in a building. While individual motifs are simple to describe, no formal definition of design motif currently exists in the literature, much less one that could be embodied in a computational system. In order to correct this, I will start by building a generation that incorporates this definition in a simple, but expressive, domain - specifically, the domain of Lego structures - and generalizing from there.

However, this definition is still very limited in its current form. First and foremost, this is a very superficial definition of the aspects of the design - solely concerned with the outer appearance of the objects. As work on this progresses, the definition will similarly evolve, with the end goal of having a definition that incorporates not only notions of the semiotic domain of both the motif and object, but also incorporating non-visual aspects to allow this to apply to non-visual domains as well.

2. RESEARCH GOALS

My research aims to address the following questions:

- What is a machine-readable representation of a design motif?
- What algorithms can generate families of 3D objects that are consistent with families of similar design motifs?
- What evaluation approach is required to assess both the consistency of generated objects with respect to a motif, and their overall creativity as generated objects?

3. PROPOSED APPROACH

Legos are a very appealing first target for this research, because the company itself provides strong working examples of design motifs. Legos are typically marketed in kits - a collection of pieces that can be assembled to form a particular model, such as a car, a building, or a spaceship. But, more importantly, Lego has various groups of models that the company presents, called themes. These themes range from generic genres (i.e. Lego City, Lego Space) to focused subthemes (i.e., Lego Mission to Mars and Lego Space Police, both of which are variations on the generic 'space' theme) to licensed themes, based on other properties popular in the target demographic. While all of these all pull from the same set of bricks, Lego uses different design motifs to separate distinct sub-themes.

In addition, Legos have been used previously in generated systems - mostly focused on physical realization of struc-

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Figure 1: Two sample kits from the Space Police theme (Source: [9], [10])

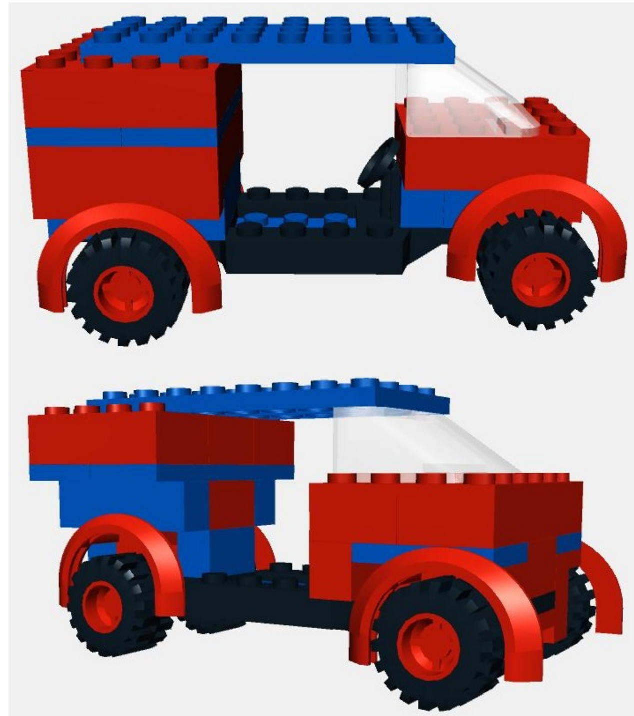

Figure 2: Sample output of the current generator.

tures and generating physically sound objects [3, 4, 14]. Legos also have some useful properties that we can exploit in this domain: they are a modular system that incorporates both simple rectangular bricks and elaborate decorative pieces. This allows designs that feature unusual shapes and curved portions with very little additional effort. Additionally, while most of the work on shape grammars has been focused on two-dimensional space, there is precedent for using them in 3D [2, 7].

For instance, Figure 1 shows two kits from the Space Police theme. The main vehicles in both of the images show common design principles - from the particular colors used for the different components, to the single axis of symmetry displayed.

Currently, a simple grammar that generates Lego car models has been constructed. This grammar incorporates a simple design motif - a color scheme and a few simple decorative elements. For each of the decorative elements, they have the binary option of being present or not present - and the color scheme is a simple ordered list of the colors of bricks to be included in the design. The first color is the primary color in the model, the second is the secondary, and so on.

The grammar is a mutli-stage process, comprised of three main parts. The first is the default 'car' grammar - it contains the information needed for the basic high-level structure - at this stage a car is comprised of wheels, a base, a compartment for the minifig, the front and back walls, and the roof. After this initial expansion, each symbol is passed through the design motif, which determines how the pieces will be realized as Legos. This process output another set of symbols that are converted into the Lego bricks by a third layer. With this, the process is designed such a way that design motifs and generators can be interchanged in a straight-forward way.

In order to generate the particular model, the grammar generates through several sections of the cars model - each expansion informing the next. At each step, the design motif is used in order to evaluate some decisions - for instance, the chose of brick color. Additionally, the design motif can force the grammar to expand in a particular way, in order to produce the desired output - an example of this being the inclusion of the wheel rim pieces at all. The example output can be found in Figure 2.

Over the course of the next year, I intend to expand the expressivity and range of the generator - while also building at least one other grammar in the space of Lego models that incorporates the same set of design motifs. As appropriate, I will continue to increase the complexity of the design motifs by adding more options to be specified within the motif. As the generator increases in complexity, the design motifs will start to be incorporated as a tool for carving away segments of the design space that the generator will operate in, as opposed to the simple inclusion or replacement steps that they currently take on.

Finally, a framework for evaluating how well a particular object exemplifies a given design motif is required. By their nature, the constraints of a particular design motif are both very vague and very specific. It is immediately obvious to a human observer whether an object belongs to a design motif or not, but automating this process will require research. On the specific constraints, a generated artifact will be kept will within the permissible space, but for the looser constraints, some evaluation will be needed to ensure that a generated artifact does not stray too far from its intended design.

4. EXPECTED ACHIEVEMENTS

First and foremost, I will build a formal definition of a design motif, complete with several generators that operate using the design motifs in the domain of Lego models and an evaluator that rates the artifacts to see how well they exemplify the space, drawing from previous research. As it stands, I have a strong starting definition for this concept, albeit a limited one. Currently, I focus solely on the concrete visual aspects of what a motif is composed of, without room to delve into what any deeper meaning - or to express this notion in other domains.

I plan on using some initial user studies to evaluate the finer distinctions between design motifs, incorporating psychological research on how humans categorize objects.

Using this, I hope to start expanding into other domains - currently, the domains that look most promising are those of generated architecture (thanks to all the groundwork previously lain in generating designs based on specific architects) and generation of assets for games across a variety of genres and game types. A lot of games currently, while having a large amount of different assets, eventually fall back on reusing the same content. A system for generating object that are consistent with a games given design motif would allow designers to reduce both the amount of hand-authored content, and the reuse of the content that they do create.

The last remaining step will be to describe a metric for evaluating how well a generated object exemplifies the design motif that generated it. As part of the ongoing trend in research into generators to construct artifacts that can comment of the objects that they produce [13], the final system should include a method by which it can evaluate the artifacts. Since the evaluation will be based on the design motif, it is possible to evaluate an artifact under similar design motifs - and by doing cluster analysis, the lines between two similar but distinct design motifs can be determined.

5. CONCLUSION

Generation using design motifs is an unexplored area of procedural content generation - while systems are in place that generate artifacts to match a particular design motif, there has been no work into expanding this into a more general case. This research aims to correct this gap, by starting in the domain of Lego models and then expanding into other domains using this groundwork. By incorporating the notion of design motifs in to grammars and grammar-like systems, artifacts that incorporate a notion of style can be generated in such a way that they can be checked against the given style - and similar ones - to ensure that the artifact is a good example of the motif used to generate it.

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