A rule-based method for generating bookshelf models

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Figure 1: *left: A generated bookshelf model. The books on its shelves are randomly placed and they vary every generation. middle: A large-scale library scene. Each bookshelf has a different layout of books. right: A floor layout of bookshelves varies from that in the middle image. Such variation is easily achieved by altering rules.*

1 Introduction

The more hardware performance improves, the more detail is needed in the production of 3D models. However, the modeling process becomes tedious if it is done manually. It is therefore important to generate contents procedurally or automatically, so as to produce such models efficiently. This paper proposes a rule-based method for generating bookshelf models. By applying different rules, we can easily vary the appearance or details of models.

2 Related Work

Grammar-based modeling covers many targets, from generation of natural shapes to architectural models. *CityEngine* extends L-System and applies it to generating road networks [Parish 2001]. Shape Grammar [Stiny 1980], Split Grammars [Wonka 2003], and CGA Shape [Muller 2006] are also used for shape, facade and detail modeling. There are automatic generation methods using a model input by a user, to generate a large complex-shaped model that resembles the user input [Merrell 2007; Merrell 2009]. These approaches are extensions of texture synthesis based on 3D geometry. There are also ways of combining procedural methods and interactive editing. In [Chen 2008], users can create a street network or modify an existing street network by editing an underlying tensor field.

3 Process Overview

Our approach is a combination of rule-based methods and procedural methods to generate bookshelf models. Considering repetitive patterns occurring in a scene with bookshelves and employing structural patterns, we can easily change from one scene to another.

We implemented our modeling script on *Structure Synth*[Christensen 2009]. In *Structure Synth*, we use a scripting language called *EisenScript* which is based on context free design grammar. *Structure Synth* allows us to edit scripts while checking preview results. This enables us to create or modify shapes, as in interactive procedural modeling approaches.

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3.1 Modeling bookshelves and books

Bookshelves consist of shelf frames and shelf boards, therefore, they are described as follows based on *EisenScript* notation:

```
rule bookshelf {
  shelf_frame
  N * { y height } shelf_board
}
rule shelf_frame { ... }
rule shelf_board { ... }
```

The rules are finally interpreted into primitives (such as *Box*), translation and rotation direction. Fig. 2 shows the rendering results. Books consist of pages and cover (jacket), and have rounded corners on their spines. We realized rounded corners by using *Cylinder* primitives. Fig. 3 shows modeling results for books.

Figure 2: *Bookshelves*

Figure 3: *Books*

3.2 Placing books in a bookshelf

In actual bookshelves, books are not always well-organized when placed. For example, there are books leaning over on other books, piled up randomly and so on. To achieve such placements, our method employs the term "lot", which is based on the concept of handling some books together as one block. We prepare some kinds of lots, and choose two of them to compose "pairs". Then, lots are placed in bookshelves. The composition of the pairs are achieved by choosing two lot rules according to their weight.

Lots' patterns are illustrated in Fig. 4 (left) from (a) to (d). We also prepare books with two different heights, and vary the books by choosing books according to their weight. Pairing of the lots is achieved by choosing two rules according to their weight, and combining them into a new rule. Fig. 4 (right) describes an example when choosing from lots illustrated in Fig. 4 (left) to compose a pair. The placement of paired lots in a bookshelf is achieved by placing some pairs on one shelf and building up to fill a bookshelf.

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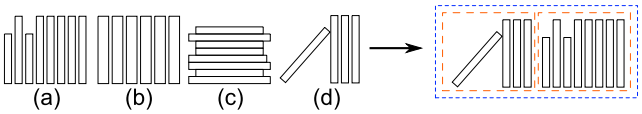


Figure 4: *Composition of lots, and a pair*

model \ lot weight	(a)	(b)	(c)	(d)	(d')
$(r1)$	15	1	1	1	1
$(r2)$	1	1	1	1	1
$(r3)$	3	1		1	1

Table 1: *lot weights of each model*

Fig. 5 shows rendering results of bookshelves. Table 1 shows lot weights of bookshelves from $(r1)$ to $(r3)$ models rendered in Fig. 5, where (d') is a lot in the direction of a book leaning over on other books is flipped. Fig. 5 $(r3)$ is the rendering result using bookshelves with lower shelves slanted.

In rule-based modeling, it is easy to vary the generated models by considering their hierarchical structures. Fig. 6 is obtained by changing the pair level structures of Fig. 5 $(r3)$.

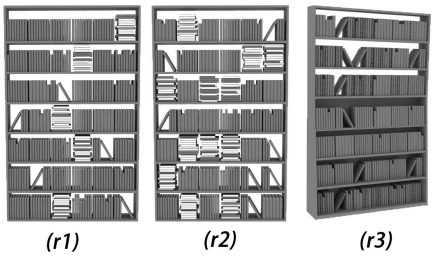


Figure 5: *Rendering results*

Figure 6: *Variation*

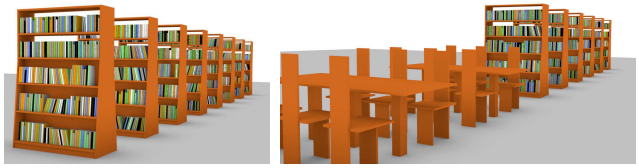
4 Results

From Fig. 7 to Fig. 9, we employ repetitive patterns to vary generated models by substituting applicable rules with other rules during repetitive placing of bookshelves. In Fig. 7(a), bookshelves are placed from back to front repetitively. Fig. 7(b) is obtained by substituting an equipment rule for a bookshelf rule along the way, employing a repetitive placement method. Fig. 8 shows a scene of a bookstore. Fig. 8(b) employs the substitution technique in the same way to place book lots facing customers.

Fig. 9 is generated by applying a rule that the bookshelves be placed so as to draw a gentle curve by rotating during repetitive placements. Fig. 10 shows a secondhand bookstore. In a secondhand bookstore, there are many books piled up on the floor. To show such characteristics, the application of "piles of books" is restricted only to the lower shelves, and the piled books are in front of the bookshelves. We modify the direction of spines of books to restrict the range of their angles, and prepare some rules so that books pile up randomly.

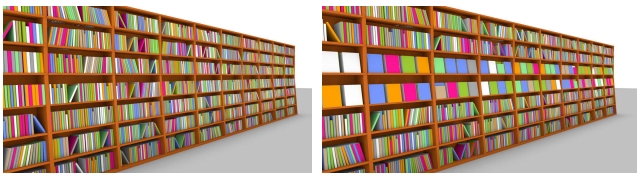
5 Conclusion

We have outlined a combination approach with both rule-based modeling and procedural modeling for generating bookshelf models. It allows wide variations to the generated models by adding rules or controlling rule weights, following the rule-based method.



(a) Bookshelves (b) Bookshelves and Desks

Figure 7: *Example of Library*



(a) Scene 1 (b) Scene 2

Figure 8: *Example of bookstore*

Also, we have shown how the generated models can easily be varied by employing structural patterns, such as repetitive patterns or hierarchical structure.

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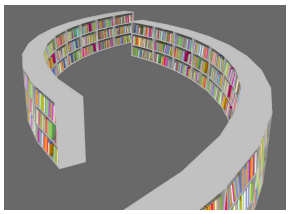

Figure 9: *Bookshelves in arc*

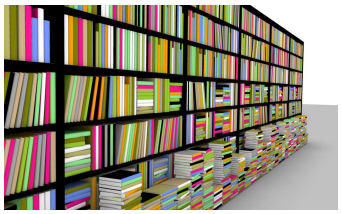

Figure 10: *Secondhand bookstore*