Relation-Based Parametrization and Exploration of Shape Collections

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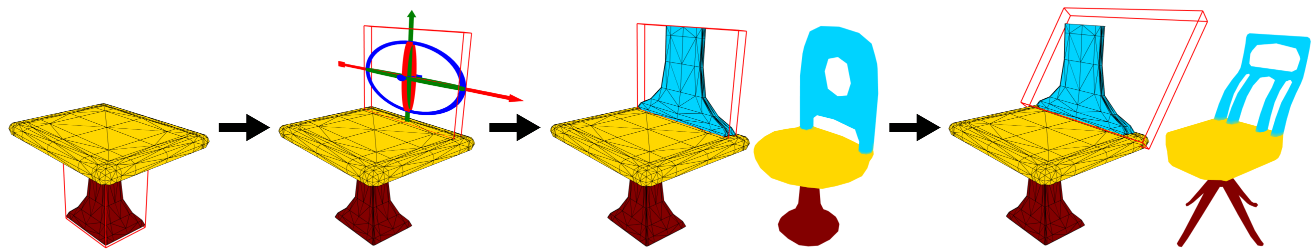

Figure 1: *Exploration of a shape collection using structural changes. We can delete or copy-and-paste parts to change the structure of the current shape. This makes it possible to explore the collection from any initial shape, even when it is missing parts that exist in other shapes. In this example we copy the leg of the seat and turn it into a backrest to find other chairs with differently angled backrests.*

1 Introduction

With online repositories for 3D models like 3D Warehouse becoming more prevalent and growing ever larger, new possibilities have opened up for both experienced and inexperienced users alike. These large collections of shapes can provide inspiration for designers or make it possible to synthesize new shapes by combining different parts from already existing shapes, which can be both easy to learn and a fast way of creating new shapes.

But exploring large shape collections or searching for particular kinds of shapes can be difficult and time-consuming tasks as well, especially considering that online repositories are often disorganized. In our work, we propose a relation-based way to parametrize shape collections, allowing the user to explore the entire set of shapes by controlling a small number of parameters.

2 Our Approach

Given a set of co-segmented shapes of the same family as input, we first compute a structural graph of each shape where nodes correspond to parts and edges correspond to adjacencies or symmetries between parts. We compute a number of spatial features for each adjacency edge, consisting of the horizontal and vertical distance, the relative scale and the angle between the adjacent parts. Similarly to [Fish et al. 2014], we use these features to differentiate between shapes, but we additionally consider correlations between them and how much they contribute to the variability of the shapes. For every relation (meaning a set of all adjacency edges between the same types of parts) that exists in the collection, all corresponding edges are embedded into a feature space. We then perform PCA to find the one or two directions of the greatest variation which we then use to form our exploration parameter space. Furthermore, we investigate the advantages and disadvantages of using non-linear methods for this dimensionality reduction instead.

To explore the collection, we first select a relation by picking a pair of adjacent parts from any initial shape. We then change the exploration parameters associated with the corresponding adjacency edge to find other shapes in the collection. A visual representation of these parameter changes is provided as a way to quickly understand the effects of altering the parameters. The first selected part is represented by its oriented bounding box, which is translated, scaled or rotated relative to the second part, based on how the parameter changes correspond to changes in the feature space.

Instead of exploring the collection by changing just the parameters of a single relation, we can also take into account multiple relations to find shapes with more specific part arrangements (Figure 2). Furthermore, we provide a way to change the structure of a shape by deleting parts or copy-pasting existing parts and changing their part categories (Figure 1). The added parts can then be used normally for exploration. This makes it possible to find any shape in the collection from any initial shape even when it does not contain all parts that are possible for the shape family.

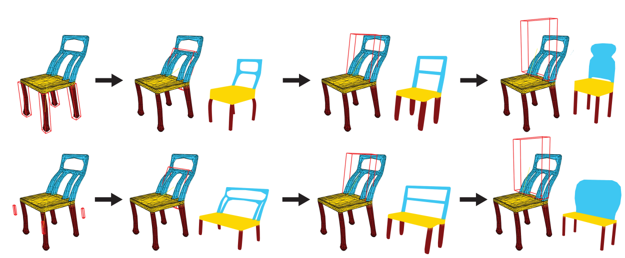

Figure 2: *We search for different shapes by changing the backrest of the initial shape. In the bottom row, we additionally alter the legs to be further apart. This results in chairs (top) and benches (bottom) with differently angled backrests.*

References

FISH, N., AVERKIOU, M., VAN KAICK, O., SORKINE-HORNUNG, O., COHEN-OR, D., AND MITRA, N. J. 2014. Meta-representation of shape families. *ACM Trans. Graph. 33*, 4 (July), 34:1–34:11.

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