論文の内容の要旨

論文題目 A SYNTHETIC APPROACH FOR DESIGNING BIOLOGICAL MODELS
（生物モデルをデザインするための統合的なインタフェース）

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（本文）We often observe objects with intricate structures in natural environment such as flowers, trees, venation patterns, vessel networks, and so on. It has been a great challenge in computer graphics to provide an efficient and intuitive modeling interface for such complicated biological models, since it is difficult and time-consuming to design them. Standard geometric modeling systems do not support to efficiently construct intricate structures of biological models. One existing solution is a procedural approach in which the user controls structures by generating rules. However, it is still difficult to intuitively design global features of the resulting model by procedural systems, since generating rules only specify local characteristics and a global appearance emerges as a collection of local structures. In this dissertation, we introduce a new paradigm, *integrating topology editors into sketch-based interfaces*, so that provide a guideline for designing intuitive and efficient modeling interfaces for biological objects with complicated structures. This paradigm is based on three principles; 1) to separate the modeling process into structural editing by topology editors and geometric editing by sketch-based interfaces, 2) to support the efficient repetitive pattern generation by topology editors, and 3) to support the intuitive geometry creation by sketch-based interfaces. We apply the paradigm onto five different cases and verify the effectiveness of the combination of sketch-based interfaces with topology editors.

Firstly, we present a *flower* modeling system that separates the modeling process into two aspect; structural definitions by topology editors and geometry creations by sketching interfaces. We design user interfaces for structure definitions based-on botanical knowledge; floral diagrams and inflorescences. Secondly, we present a modeling system for *flower arrangements*. We introduce hierarchical billboard representation to support a top-down modeling process. To begin, the user quickly design the overall appearance and coarse structure of the desired model as a collection of strokes on billboards placed in hierarchical structures. Then the user iteratively replaces each billboard with detailed hierarchical billboards or 3D geometries referring to the initial sketch as a guide. Thirdly, we present Sketch L-system, a *botanical tree* modeling system. We combine sketching interfaces and L-system which is a rule-based system commonly used for plants modeling. Complicated structures also exist inside animal body. Fourthly, we take *Purkinje fibers of the heart* as an example, and present a system for modeling them by combining an extended L-system and a sketching interface. Fifthly, we present a system for designing *element arrangements* such as distributed flowers, scales of a fish, and

feathers of a bird. In this system, we provide an example-based algorithm. Given an example pattern, our system analyzes the local relationship between elements and synthesizes a larger pattern which has a similar local appearance to the example. To support creative design activities, we introduce sketch-based interactions for controlling global features of the resulting patterns, such as underlying flow fields and boundary shapes.

In closing, we discuss what we got through these 5 experiments. We found three important points in designing interfaces that combine sketching interfaces and topology editors; 1) to design graphical interfaces for topology editors, 2) to provide immediate feedbacks when local parameters are manipulated in topology editors, 3) to customize interfaces specialized to target objects and nicely balance the generalities and limitations. Finally we discuss future research directions.