Procedural Spline-Skeletons for Organic Structures and Adaptive Architecture

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1. Introduction

We present the theory for a novel system to create and animate high-quality plants as well as other skeletal structures in general. The foundation of our desired system is the combination of spline-aligned skeletal animation together with a context sensitive grammar. This provides seamless geometry near forking branches and allows high-quality real-time animation. It further shows applicability to create variations of creatures and can be used to adapt architecture to the surrounding environment.

2. Proposed Method

In conventional systems, all parts (branches, leaves, root etc.) which are used to create a plant are rigid and usually do not fit together very well when assembled. Hence, gaps or sharp, unnatural edges in the final plant will be observed often. This is the point where our research begins. Our planned system equips each part with an inner spline-skeleton (see Fig.1, right side) and requires all connectable parts to fit together exactly, as described in Maierhofer et al. [2] as direct-merge mesh attachment. This avoids gaps and preserves the flexibility to adjust all parts individually (see Fig.2, right side). Spline-based deformation further provides high-quality animations, free from unwanted artifacts such as collapsing geometry and the candy-wrapper effect, which occur by using conventional skeletal subspace deformation. An example for the output of our system can be seen in Fig. 1, left side. Our proposed method also is not only restricted to plants; it might be used to create and animate any 3D object which can be created from connectable parts. For example humans or creatures, where body-parts might be replaced at random for crowd simulation might be possible as well. It can also be used for various architectural structures which might also contain flexible parts such as hanging bridges or roads that have to be adapted to the surrounding land- or cityscape (see Fig.2, right side).

3. Contributions

Our system lists the following contributions:

- **Skinned Spline Skeleton enhanced parts**: The parts used for the procedural generation contain an inner spline-skeleton, which allows a very flexible and high quality adjustment. The required deformation algorithm is described in [1]. Since the algorithm in [1] is capable of real-time animation, also our proposed method is capable of real-time animations.
- **Easy Animation Control**: The animation can be controlled easily, as only the splines control points need to be modified.
- **Adaptive Architecture**: As for the parts, also architectural parts might be used. There, the purpose is, to create flexible roads, highways and other structures that can be assembled from parts. The purpose is, to adapt them flexible to the surrounding landscape or cityscape.
- **Pseudo-Random Creatures**: The Rules of the grammar in combination with the skeletal-rigged parts are also very suitable for creating a large variety of different creatures. Body-parts can be represented as production rules of the grammar, and hence allow the creation of a large set of creatures from only a few parts.

3. References

[1] Sven Forstmann, Jun Ohya: Fast Skeletal Animation by skinned Arc-Spline based Deformation, Eurographics 2006, Vienna, Austria

[2] Maierhofer, Stefan: Dissertation about Rule-Based Mesh Growing and Generalized Subdivision Meshes, Technical University Wien, Institute for Computer-graphics and Algorithms, January 10, 2002

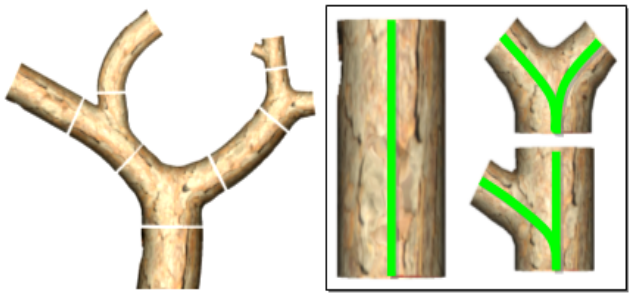

Fig. 1: Our novel tree design together with the three used parts. The inner spline skeleton of the parts is emphasized in green

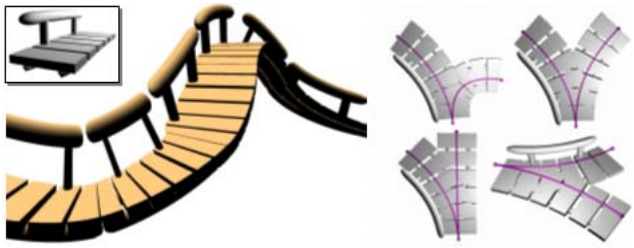

Fig. 2: A spline-aligned path created procedurally from repeating one bridge-model. To create flexible branches, we show four examples on the right-hand side.