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# Character Modelling with Sketches and ODE-Based Shape Creation

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**Abstract.** Character models have enormous applications in industry. Efficient creation of detailed character models is an important topic. This paper proposes a new and easy-to-use technique to quickly create detailed character models from sketches. The proposed technique consists of two main components: primitive deformer and shape generators. With this technique, 2D silhouette contours of a character model are drawn or extracted from an image or sketch. Then, proper geometric primitives are selected and aligned with the corresponding 2D silhouette contours. After that, a primitive deformer is used to create a base mesh and three shape generators are used to add 3D details to the base mesh. The primitive deformer and three shape generators are developed from ODE-driven deformations. The primitive deformer deforms the aligned geometric primitives to exactly match the 2D silhouette contours in one view plane and obtains a base mesh of a character model consisting of deformed primitives. The shape generators are used to add 3D details to the base mesh by creating local 3D models. The experimental results demonstrate that the new technique can quickly create detailed 3D character models from sketches with few manual operations. The new technique is physics-based and easy to learn and use.

**AMS subject classifications**: 15A12, 65F10, 65F15

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## 1. Introduction

Character models are widely applied in virtual reality, computer animation, and video games etc. How to create detailed and realistic character models efficiently with fewer manual operations is of practical significance.

Character modelling can be divided into geometric modelling, physics-based modelling, and sketch-based modelling. Geometric modelling studies methods and algorithms without involving physics for the mathematical description of shapes. Physics-based modelling investigates how to create motions and deformations of objects with the laws of physics. Sketch-based modelling explores techniques and interfaces of drawing two-dimensional (2D) strokes of three-dimensional (3D) objects and converting the drawn 2D strokes into 3D models automatically. It also includes drawing 3D curve networks and surfacing 3D curve networks to obtain 3D models.

Geometric modelling can be further divided into polygon [36], subdivision [32], and Non-uniform rational basis spline (NURBS) [40] modelling. They are computationally more efficient than physics-based modelling and can create more detailed shapes than sketch-based modelling. However, they create less realistic models, are difficult to learn and use, and require a lot of time and manual operations.

Physics-based modelling approaches [35] such as the finite element method [26] and mass-spring systems [20] consider underlying physics and can create more realistic shapes of 3D models. However, they involve heavy numerical calculations. Ordinary differential equation (ODE) based modelling [47] is physics-based and has a potential to create more realistic shapes. It avoids heavy calculations of existing physics-based modelling approaches.

In comparison with geometric modelling and physics-based modelling, sketch-based modelling [37] is more efficient, straightforward and involves much fewer manual operations. Sketch-based modelling method is a way that enables the user to construct 3D models using a sketch interface. It can be divided into template-based one, direct creation, and primitive-based generation. The biggest problem with sketch-based modelling is its incapability in creating detailed character models.

As discussed above, all state-of-the-art existing methods have their advantages and disadvantages. Sketch-based modelling can significantly reduce manual operations in geometric modelling, ODE-based modelling can avoid heavy numerical calculations in physics-based modelling and tackle the incapacity of sketch-based modelling in creating detailed 3D models. Based on these considerations, this paper will combine ODE with sketch-based modelling to develop efficient shape generators, and use them to create local shapes from user's drawn sketches for adding 3D details to coarse base models obtained from the primitive deformer proposed in [30, 31]

With this method, we use primitives to quickly obtain initial 3D meshes. Then, we use the primitive deformer [30, 31] to deform these primitives to the required shapes by fitting their silhouette contours to 2D sketches. Next, these deformed primitives are smoothly connected together to create a coarse base model. Finally, shape generators proposed in this paper are used to add 3D details to the coarse base model.