Interactive Shape Modeling and Dynamic Deformation Based on Spline Sculpting

Conventional geometric surface modeling software offers the designer shape interaction and manipulation through editing the associated control points, orders, knot vector and point clouds. Such modeling by indirect manipulation of algebraic and geometric parameters proves to be difficult and tedious, especially for novice designers. Researchers have instead explored direct ways through adding physical behavior to the traditional parametric surface patches. Those constraints, encoded as user-applied sculpting forces that modify the surface in predictable ways, impose the physical effects on the deformable models. However, to date, physically-based manipulation of B-spline represented shapes is not fully realized.

The goal of this research is to address this issue through further improving the flexibility and efficiency of B-spline surface modeling and manipulation in a 3D sketching environment. Firstly, the system allows user to construct a B-spline surface along arbitrary curves with respect to the user's design intention. This process highlights the method of the traditional illustration for depicting 3D subjects, where the creation of 3D objects is usually preceded by a sequence of drawing steps by using spline strokes. Secondly, I am trying to eliminate the need for the user to directly manipulate B-spline parameters by providing higher-level surface manipulation tools based on physical techniques. In this system, for each B-spline surface, a bar network is built from its control vertices. The physical effects imposed by user's free spline sculpting deform the model according to the geometric and parametric constraints. The minimization of the variation of the external forces has been used; as a result the least possible adjustment to the control vertices is involved. Shape operators have been realized to correlate between B-spline shape parameters and the physics-based sculpting framework; meanwhile, the research work illustrated the surface properties through defining geometric constraints (point, tangency, curve and surface area so on). Moreover, the spline strokes are freely controlled by 3D dragger metaphor, which will produce a sequence of dynamic deformations to facilitate the user to achieve the desired models.

Finally, the improvement from the lower geometric digital shape control to a grammar-based shape manipulation is presented, where the planar curve properties are obtained based on the analysis of the intrinsic curvature extrema (Leyton Grammar). And a set of semantic-based shape operators aiming at different curve properties, capsulated with group of geometric constraints, is defined to assistant designers for aesthetic curve control.

Keywords: Sketch-based, Constraint-based surface modeling, Physically-based deformation, Variable model, Dynamical control, semantic-based shape handling