Automatic Muscle Generation for Physically-Based Facial Animation

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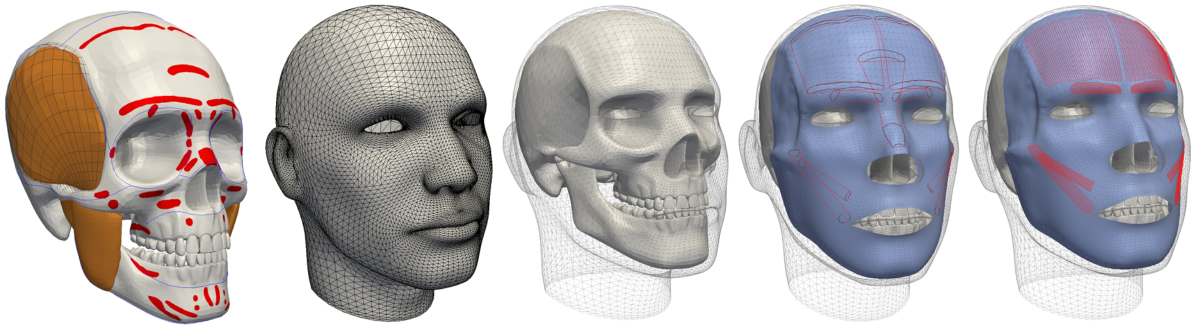

Figure 1: *L-R: (1) generic skull plus muscle attachment regions (red), temporalis and masseter (brown), and aesthetic region boundaries (blue) (2.) typical head model (3.) generic skull fitted to head model (4.) SMAS-plane (blue) and mutual tangents and convex hulls (both red) of muscle attachment regions (black) (5.) muscle fibres (red) as boundary-value straightest geodesics.*

Introduction

Physically-based facial animation (FA) techniques are notoriously difficult to create, reuse, and art-direct. We address these shortcomings by proposing a rig-builder that automatically generates bony and soft-tissue substructures for any given head model. In an earlier work, [Aina 2009] presented a method for fitting a generic skull to any given head model as a first step toward automated rig-building. Here, we outline work done since, and give an overview of a method for creating muscles of facial expression (mimic muscles), and other soft-tissues in the gap between a given head model and a fitted generic skull.

Relevant human facial anatomy

1. The subcutaneous tissues of the human face are uniformly divided into a superficial and deep portion by the Superficial Muscular Aponeurotic System (SMAS) [Larrabee et al. 1997]. The SMAS sends fibrous extensions to the dermis, envelopes the mimic muscles, and acts as a distributor of force for the muscles. The SMAS overlays the masseter and temporalis muscles, and the temporal fascia.

2. The mimic muscle system consists of about 40 muscles. Some variation in the number, size, symmetry, length and shape of mimic muscles is frequently observed between and within individuals. Mimic muscles are thin, sheet-like bundles of oriented, contractile fibers, that are attached to the skull at one end, and to the dermis at the other.

3. The human face can be divided into facial aesthetic units. Within each unit, the skin has fairly uniform histology, color, thickness etc. [Larrabee et al. 1997].

Method

SMAS construction The SMAS represents a plane on which mimic muscles lie, and is constructed as a variational implicit surface (VIS). In order to construct this surface, the masseter and temporalis muscles, and the temporalis fascia geometries are added to the generic skull. The boundaries of the facial aesthetic units are subsequently defined on the generic skull and the masseter, and used to select groups of vertices on the forehead to act as point constraints for creating for the VIS. The outermost facial aesthetic unit borders also act as point constraints, and define the extent to which the VIS is triangulated. All point constraints are offset from the generic skull.

Muscle construction Each mimic muscle is modeled as a sheet of fibers stretching from an origin on the skull to an insertion beneath the SMAS. Accordingly, the generic skull is given UV-information in order to map a multi-layer texture defining the anatomically established, or artistically-decided, origins and insertions for real or imaginary muscles. The border of each muscle attachment region is converted to 3d using a reverse texture mapping process. These additions to the generic skull are one-time operations, applicable to any head model, but can be tweaked if required.

The lateral extents of each muscle are constructed as the mutual geodesic tangents connecting its origin and insertion regions. This is done by first constructing the geodesic convex hull of each attachment region, and then their joint convex hull, using a newly developed version of the divide and conquer algorithm for discrete manifolds. Any number of muscle fibers can subsequently be constructed as boundary-value straightest geodesic interpolated between a pair of mutual tangents.

[Polthier and Schmies 2006] originally defined a straightest geodesic as the solution to an initial value problem. We however, have developed a method for constructing straightest geodesics between pairs of points using a euclidian path heuristic. As a fallback, we also provide a technique for approximating the straightest geodesic in the neighborhood of hyperbolic vertices, and term this approximation the straightest-possible geodesic. Straightest geodesics are used instead of conventional geodesics for two important reasons. First, the straightest property of the former best describes the orientation of muscle fibers. (It makes sense to construct muscle fibers "linearly" because they contract linearly.) Second, conventional geodesics do not guarantee the straightness property, and also perform extensive surface exploration, the cost of which would be prohibitive for the multiple-source multiple-destination path computations required by the problem at hand. For example, constructing the 5 muscles shown above in Figure 1 requires 1100 geodesic computations.

References

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