Interactive, Musculoskeletal Model for Animating Virtual Faces

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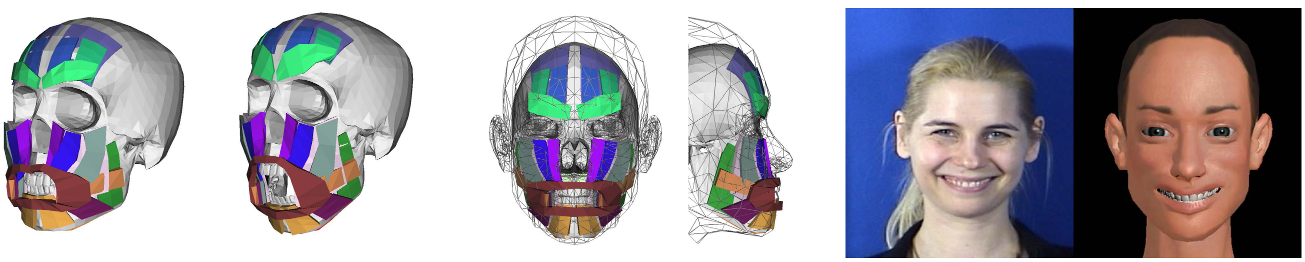

(a) (b) (c)

a) A facial muscle map on top of an input skull. b) Fitting of muscles and skull inside a target mesh. c) Interactive animation from inferred contractions of real muscles.

1 Introduction

The simulation of facial movements is a difficult task because the complex and sophisticated structure of the human head involves the motion, deformation, and contact handling between bio-tissues that are viscoelastic, nonlinear, anisotropic, and structurally heterogeneous. This makes it hard to formulate a mathematical model able to represent the biomechanical inner workings of the face. Nonetheless, high accuracy and precision are required because, as humans, we are used to observe and decode facial expressions from the moment we are born, and we are expert at easily detecting the smallest artifacts in a virtual facial animation.

We propose a muscle-based approach for facial animation based on the stable and robust position-based dynamics (PBD) schema introduced in [Müller et al. 2006]. This allows for avoiding the overshooting problem typical of force-based systems solved explicitly, and it enables to define complex yet interactive systems.

2 Our Approach

The virtual facial model is organized in layers, where each layer represents a particular part of the face and influences the layers placed above of it. The bottom layer is the bony layer, composed by the upper skull and the jaw; then, there are several layers of facial muscles and fatty tissues. For example, if the jaw depresses and opens, all the muscles connected to it will deform accordingly. On top of the skull, there are several muscle layers; our system allows for the definition of how many muscle layers are needed and each muscle influences the muscles of the layers placed above of it.

The physical simulation is computed according to the Position-based Dynamics (PBD) approach introduced in [Müller et al. 2006]. PBD allows to impose constraints of geometric nature on a deformable surface, like volume preservation of a closed surface or maintaining the distance among two nodes of the mesh during deformation. This permits for modeling the virtual anatomical structures without the use of internal and external forces, which simplifies the deformable model but still allows for defining anatomical behaviours (e.g., muscle bulging under contraction), and produces unconditionally stable simulations.

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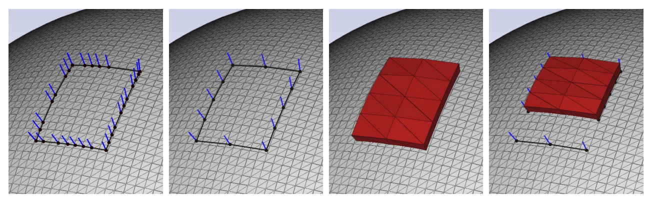

Figure 1: *Sketching and contracting a muscle.*

We provide the artist with an interactive tool to sketch the shape of the muscles directly on the bony structure and to the already existing muscles.

Once the muscoloskeletal structure has been defined, it is fitted into the skin through a RBF morphing (Hardy multiquadrics). The surface of skin is bound to the muscles and to the bones with additional geometric constraints. Our system employs a Gauss-Siedel iterative scheme to solve the geometric constraints and animate the simulated face model. The output of this method is a muscle based model which is able to generate facial expressions and can be applied to a wide range of input face meshes varying in shape, connectivity, and dimensions [Fratarcangeli 2012].

The complete facial model allows for any number of muscle and passive tissue layers; muscles can actively contract, and each layer influences the deformation of the layers on top of it. The contraction of each muscle is controlled by a single, scalar parameter; this allows for finding easily a mapping between muscle contractions and the motion of facial landmarks tracked from a human subject. We use this mapping for transferring the motion from real actors to virtual heads and evaluate the quality of the produced animations.

References

FRATARCANGELI, M. 2012. Position-based facial animation synthesis. *Computer Animation and Virtual Worlds 23*, 3-4, 457–466.

MÜLLER, M., HEIDELBERGER, B., HENNIX, M., AND RATCLIFF, J. 2006. Position based dynamics. In *Virtual Reality Interactions and Physical Simulations (VRIPhys)*.