How to model face and tongue biomechanics for the study of speech production?

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ABSTRACT

Speech is a motor task during which speaker communicate a message using temporal variation of an acoustic signal that is shaped by orofacial gestures, while listeners perceive this message using both the auditory perception of the acoustic signal and the vision of the articulatory gestures. In order to study this motor task, scientists try to collect and to analyze a large amount of kinematic data measured on the final effectors such as face, jaw, tongue, velum, and vocal folds. These observations are considered to characterize the behavior of the peripheral motor system during different tasks and under variable conditions, and their interpretation largely contributed to the elaboration of major theories of motor control. Nevertheless, one must keep in mind that peripheral signals are in fact the result of a often complicated interaction between the motor control system and the peripheral apparatus. Both systems do contribute to shape the measured signals. In order to properly infer motor control strategies form these signals, it is important to assess the possible contribution of the physical systems. In this framework, an interesting approach, which is complementary to the experimental one, consists in building up physical models of the peripheral apparatus, in controlling them according to specific motor control model, and in comparing the obtained simulations with experimental data.

This talk will focus on the physical modeling of two speech articulators, namely the face and the tongue, which behaviors are very specific compared to other articulators. Indeed, facial and lingual tissues are non isotropic and deform themselves at high velocities. The biomechanical modeling of such tissues is therefore very complex and requires a strong attention, especially in the framework described above, i.e. the use of realistic physical models of speech articulators in order to evaluate motor control strategies. A short review of biomechanical models proposed in the literature will be exposed, with a more specific focus onto facial biomechanics (an important concern for the AVSP community). Then, the physically based methods used to model soft tissues will be presented and discussed. In this framework, the Finite Element model of the face we have introduced in the context of computer-aided maxillo facial surgery will be described and its use for speech production will be discussed.