PhD Dissertation Defense

3D DYNAMIC MODELING OF THE HEAD-NECK COMPLEX

By

Daniel A Sierra Bueno

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Abstract:

A 3D dynamic computer model for the movement of the head-neck complex during gaze shifts is presented. Images from the Visible Human Project and previous reports in the literature are used to create anatomically correct representations of the diverse elements forming the complex. Bony structures are considered as a set of interconnected rigid 3D bodies following the Newton-Euler laws of movement. SimMechanics for Simulink-Matlab is used to represent their dynamics.

For the muscle modeling, Enderle's homeomorphic linear muscle model, developed for the rectus eye muscle, is fitted to reflect the dynamics of muscles in the head-neck complex, specifically in muscles involved in gaze shifts. Parameter values for the different muscles in the neck region are obtained by optimization using simulated annealing. These linear muscle models provide non-linear force-velocity profiles and linear length tension profiles, which are in agreement with results from the more complex Virtual Muscle model, based on Zajac's non linear muscle model.

Finally, the soft tissues, namely the ligaments, intervertebral disks, and facet joints, are modeled considering their physiological roles and dynamics. Optimization approaches are used to find the steady state activation of the different muscles.

In contrast with other head and neck models developed for safety research, this model is aimed to study the neural control of the complex during fast eye and head movements such as saccades and gaze shifts. In particular, the time optimal hypothesis and the feedback control are investigated using optimization techniques.