Title	３次元生理学的舌モデルを用いた舌の健常時及び部分切除手術後の運動に関する研究
Author(s)	藤田，覚
Citation	
Issue Date	2008-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/4194
Rights	
Description	Supervisor:党建武，情報科学研究科，博士

Estimation of Tongue Movements for pre- and post-glossectomy based on a Computational 3D Tongue Model

Satoru Fujita, School of Information Science, Japan Advanced Institute of Science and Technology

The tongue has critical roles in the vital functions such as tasting, mastication, swallowing, and it is one of most important organ for speech communication. It also relates to sing that is valuable to enjoy life, and relates to development and learning when baby and parent communicate with voice. Therefore, any disorder of the tongue would affect quality of life (QOL) seriously.

This thesis discusses the methodology to reduce disorder of the tongue due to glossectomy, because glossectomy account for large part of causes for disorder of the tongue. Toward developing precise prediction system of disorder after glossectomy based on physiological tongue model, we studied elemental technologies for it.

Observations and analyses of the tongue have been carried out using imaging methods such as X-ray micro-beam, electromagnetic midsagittal articulography (EMMA) and tagged-cine-MRI, and electromyography (EMG) method have been used to observe activities of thick extrinsic muscles. The studies of the tongue functions have been performed using 2D and 3D computational models. However, the subject of those studies was mainly to investigate articulatory movements in normal speech which were assumed symmetric. Therefore, no model could produce large asymmetric movement to simulate disorders of the tongue. Additionally, our knowledge about relationship between 3D movements and muscle activities including intrinsic muscles is insufficient, even for basic movements such as protrusion and left-right bendings which are used to diagnose disorder of the tongue. Hence, it is difficult to accurately predict possible damage of the vital functions caused by glossectomy. If a precise prediction can be made on the postoperative functions, it would contribute to designing efficient procedures. It also helps patients establish informed consent on the functional aspects.

Our proposed model was designed for supporting system of glossectomy planning, by extending a tongue model of existing 2.5D physiological articulatory simulator. The model consisted of 7x11x11 layers of mass nodes, and trusses connecting the nodes. Soft tissues were modeled using spring and dashpot bound to trusses, and rheological model of sarcomere was adopted for muscle modeling (Morecki's model). Dynamics of the model was modeled based on displacement-based FEM (X-FEM), while the incompressibility of the soft tissues were realized by constraint to the whole volume of the tongue body and poison's ratio to virtual volume linked to each truss. Then, the model was able to produce movements based on muscle activities, and the volume was kept nearly constant during deformations.

Basic functions of the model were evaluated by activating individual muscles including extrinsic and intrinsic muscles, and the generated movements were consistent with anatomical knowledge. By HARP-MRI analyses for protrusion movements of the tongue, it was suggested that intrinsic muscles (vertical and transverse) are involved in protrusion, furthermore, anterior, middle and posterior part of the tongue muscles could be controlled independently as well as left-right wings of the tongue muscle bundles. According to these results and anatomical knowledge, basic movements such as protrusion and left-right bendings were realized after a number of simulations using the model with co-contraction in a manner consistent with muscular hydrostat, and thus muscle activation patterns for these movements were estimated. To apply the model to predict pre- and post-glossectomy situation of a patient who had tumor (hemangioma) in the tongue, the mechanical properties of the normal model are manipulated following the glossectomy plan by the doctor in charge, where the shape, stiffness, viscosity and musculature are altered according to the situation of tumors and resection. In the case of hemangioma, there was no distinguishable influence for both model simulations and the real cases. In the post-glossectomy, the same tendencies of influences in the simulations as in the real cases were observed: a deviation to the resected side in protrusion and differences between left and right bendings. These results suggest validity of the function of our model and the estimated muscle activation patterns although there were differences between the simulations and the real cases in the amount of deviations.

These results suggested that this model can be useful tool for studying tongue functions, and to predict disorders due to glossectomy by matching much more clinical data.