Discovering functional units of the human tongue during speech from cine- and tagged-MRI

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Abstract

Tongue motion during speech involves synergies of locally deforming regions, or functional units. Determining functional units will provide an insight into the mechanisms of normal and pathological muscle coordination, leading to improvement in understanding of speech production and treatment or rehabilitation procedures. In this work, we present an approach to determining functional units using cine- and tagged-MRI. Functional units are estimated using a sparse non-negative matrix factorization (NMF) framework, learning latent building blocks and the weighting map from motion features from displacements and strain. Current models of gesture production suggest that, during speech planning, talkers select temporal frames prior to specifying the appropriate spatially fixed clusters. Our analysis is intended to parallel this process by using NMF to first identify temporal frames in the data based on changepoints in motion features, and then to identify the spatially fixed clusters for all the input quantities in each time frame. A spectral clustering is performed on the weighting map of each time interval to define the coherent sub-motions, revealing temporally varying tongue synergies. Synthetic and human tongue data including both controls and patients with glossectomy and amyotrophic lateral sclerosis are used to define subject/task-specific functional units of the tongue in localized regions.