Two topics in biomechanical tongue modeling

The human tongue is a very complex anatomical structure. It's generally described as consisting of seven paired muscles, which interdigitate with each other in complex ways. The tongue is served by an unusually large number of motoneurons and sensory neurons, indicating both very fine motor control and very precise proprioceptive information. All of this raises the question: how does the nervous system control the tongue, and how can researchers begin to understand that?

To begin to deal with these problems, I built a finite element model of the tongue, based on cadaver data. The model accepts a muscle activation pattern as an input, and produces as an output the deformed posture of the tongue. Such a model is not actually in itself very helpful, however, because it produces atomistic results: particular muscle activation patterns lead to particular tongue postures. To get a better handle on the tongue, I took something of a machine learning perspective. I used principal component analysis to get at the major components of tongue posture, using a systematic sample of every possible tongue posture. The basic finding is that tongue posture can be pretty well represented by just seven parameters ($r^2 > 0.99$). These seven parameter can be calculated from a small set of postures, and generalize quite well to larger data sets. It's also possible to bypass the biomechanical model and predict tongue posture directly from muscle activation, using a basic predictor like a linear model or a neural network. This suggests that in spite of the complexities of the tongue, representational strategies are available to organisms to deal with this complexity.

As a secondary topic I'll speak a bit about my current work at Queen Margaret. The goal is to take the existing tongue model, and fit it to the anatomy of a living speaker. This presents a number of challenges, such as (i) how to normalize between speakers with fairly different anatomy, (iii) how to account for the differences between cadaveric data and in vivo data. I'll talk about how I've normalized the data, and the development of the model to this point.