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Ultrasound tongue imaging (UTI) is a non-invasive technique that enables researchers to study, more or less directly, the articulation of the tongue during speech at appreciably high resolution. The quantitative analysis of UTI data has represented a challenge for a long time. Since the publication of the seminal paper by Davidson (2006), statistical modelling of whole tongue contours has been mostly dominated by the use of Smoothing Splines Analysis of Variance (SSANOVA), which undoubtedly brought a conspicuous advancement to our understanding of the articulation of speech sounds. Mielke (2015) and Heyne & Derrick (2015) showed that fitting SSANOVA with tongue data in polar coordinates (rather than cartesian coordinates) produces more reliable results. However, SSANOVA comes with some limitations, e.g. separate models are fitted for different phonetic contexts even within a single speaker, and the model implementation used in most UTI studies does not include random effects. On the other hand, recent developments in the statistical and programming worlds have increasingly favoured the use of Generalised Additive Models (GAMs) and their mixed-effects counterpart (GAMMs, Wood, 2006), a highly flexible solution which extends standard generalised linear models for the modelling of non-linear effects with the inclusion of random effects.

This paper will offer a review of GAMMs fitted to tongue contours in polar coordinates. An introduction to UTI and GAMMs will open the paper, followed by a general overview of polar tongue contours GAMMs. Polar GAMMs fitting, significance testing, and model plotting will be illustrated by means of an example pilot study that compares tongue contours of voiceless and voiced stops of 4 Italian speakers. A brief tutorial will show how to fit polar GAMMs with the R package `rticulate`, which has been developed by the author to streamline polar GAMM fitting in R using the `mgcv` package. While the paper will focus on model fitting in R, the overview provided will be relevant to a more general public. The paper will conclude by discussing the limitations of the current implementation of polar GAMMs (such as across-speaker normalisation) and its future directions.

References

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