The Speech Articulation Toolkit (SATKit): Ultrasound image analysis in Python

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Purpose

A free, open-source collection of Python 3.x methods for high-throughput quantitative analysis of ultrasound imaging data

- We focus on lingual and laryngeal ultrsound here, but our methods are adaptable to any 2D grayscale image data (video, MRI), in theory
- Designed to work with AAA raw scanline data: large user base; already a locus for development [1]

Our initial focus is on **non-contour methods** for ultrasound analysis

- Automatic tongue surface contour extraction (e.g. [13, 6]) is increasingly fast and accurate
- But not the only approach, or even a suitable approach, for all data types or research questions

Have a look

We are still developing SATKit, which is hosted on GitHub at **giuthas/satkit**

Scan to visit the repo:

Or, use this URL:

git.io/JIPVA

Feedback, requests, etc. are appreciated!

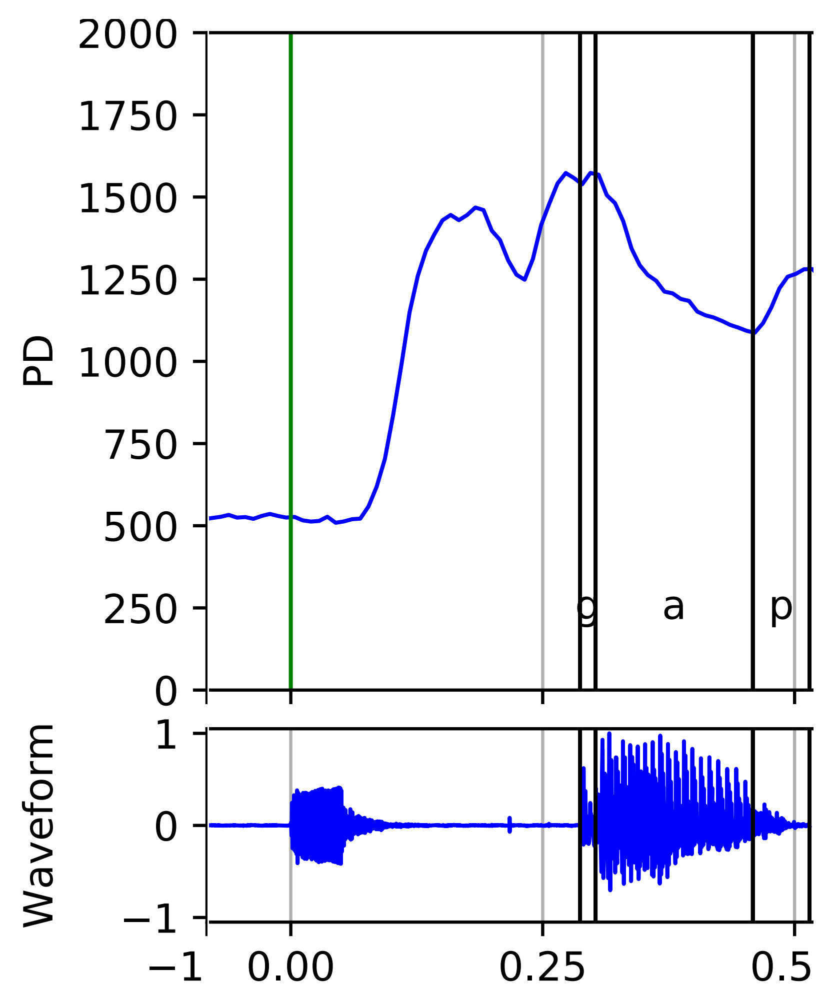
Pixel difference

Euclidean distance in terms of pixel intensity between pairs of images

- Captures **change** over entire image: surface contours, but also internal musculature
- SATKit implements two pixel difference methods from Palo [10]
  - Whole-image method: calculates PD over all matched pixels in pair of images
  - Scanline-based method: calculates PD for each column of pixels (more localised measure)

Among other things, well-suited to locating onset of articulation

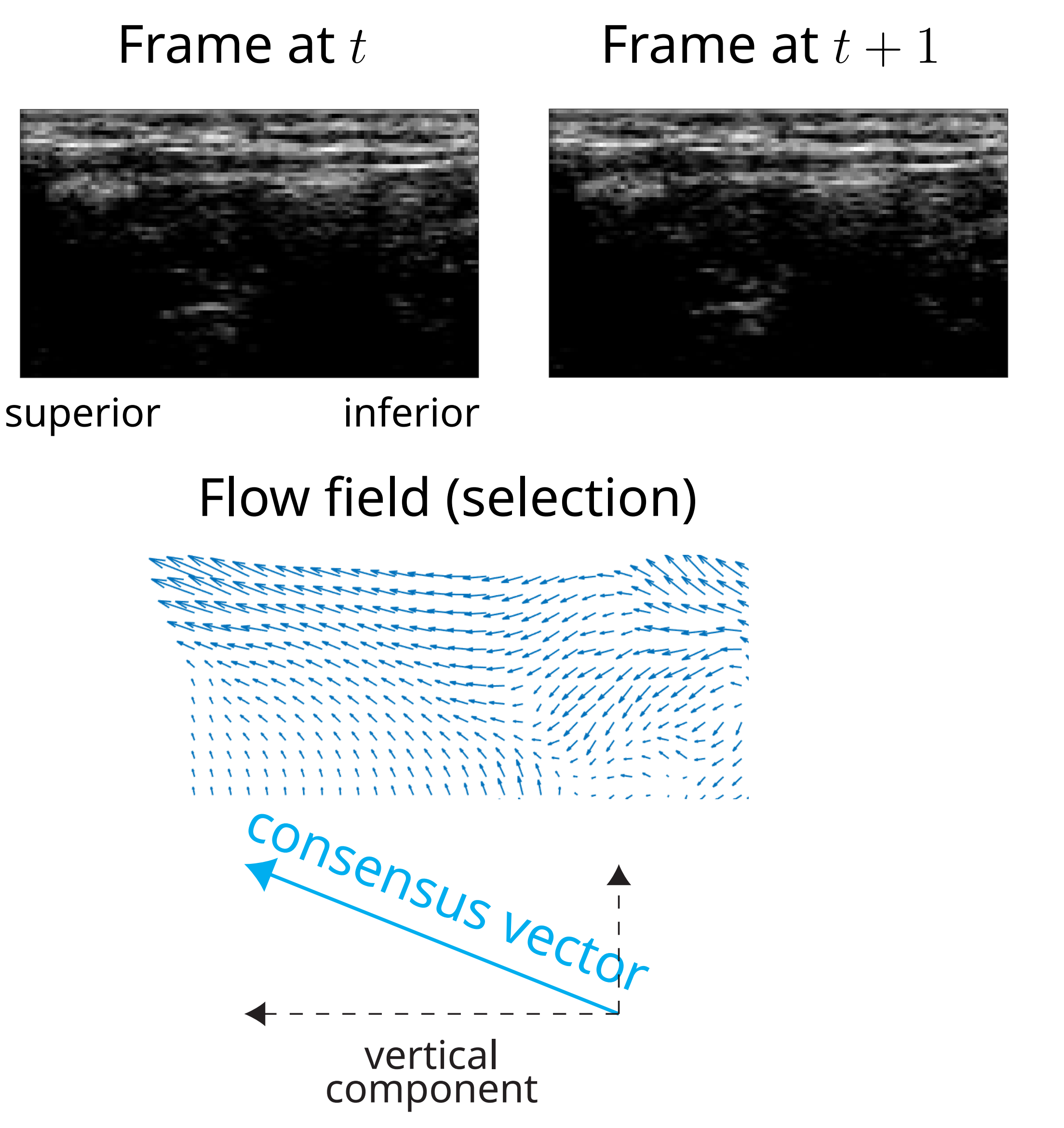
PD changes after go-signal (0s), but before release of /g/, in 'gap'



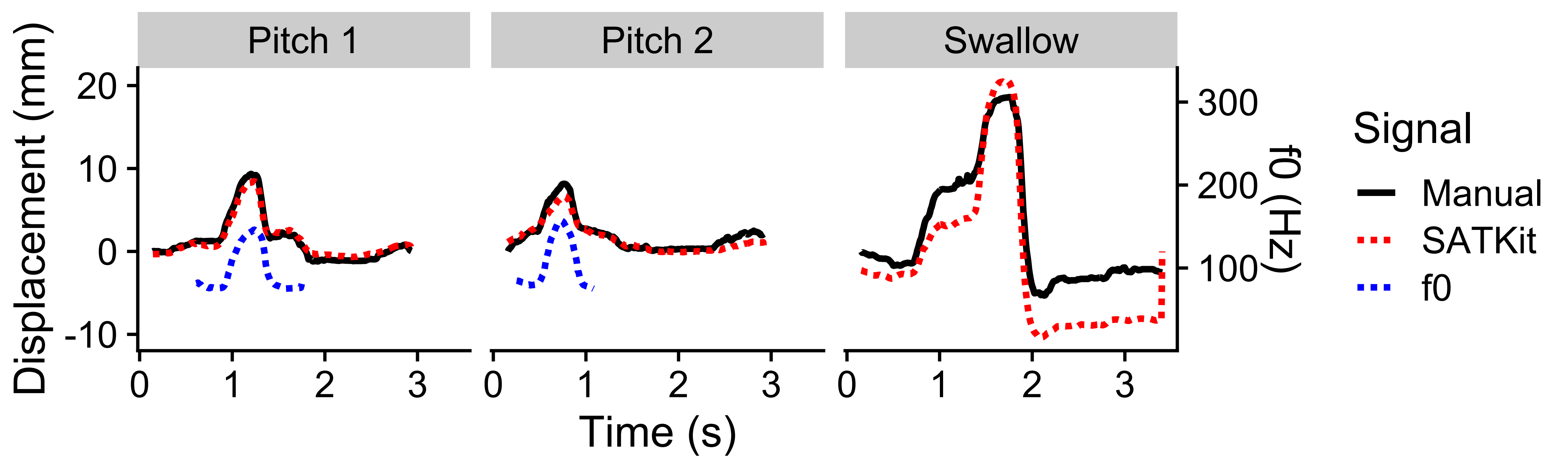
Optical flow

Characterizes direction and magnitude of **apparent motion** between pairs of frames [4]

- Especially well suited to laryngeal data (no single surface to track)
- SATKit implements method similar to Moisik et al. [9], but using dense optical flow, resulting in a **flow field** (one flow vector per pixel)
- **Consensus vectors** obtained by averaging entire fields or regions of interest; can be decomposed into horizontal/vertical velocity components
- **Displacement** can be estimated from cumulative integration of velocity signal



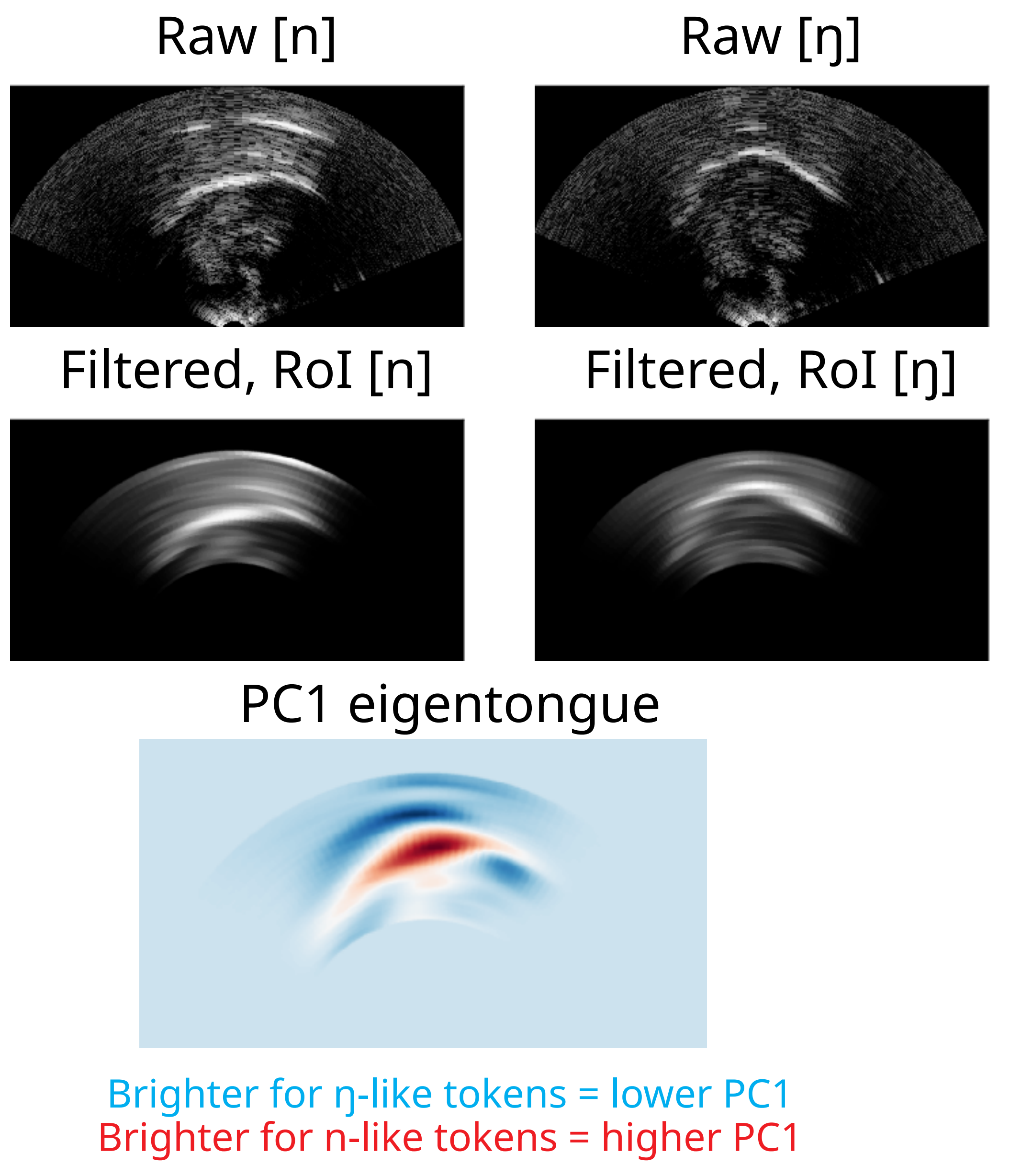
Estimated vertical displacement of larynx closely tracks manually validated displacement; covaries tightly with f0



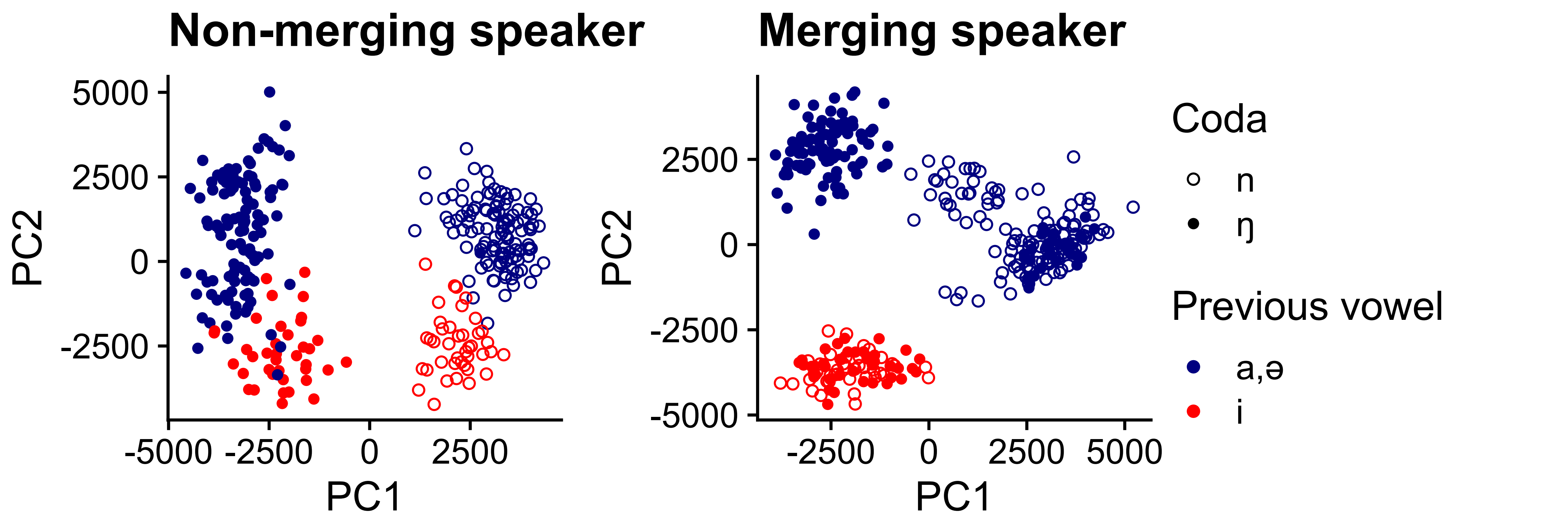
Dimensionality reduction

Discovers important, orthogonal **dimensions of variation** in a data set: here, patterns of covariation in pixel brightness [5, 8, 3, 7]

- SATKit uses principal component analysis (PCA) from scikit-learn [11]
- Utilities to support:
  - Filtering and applying region of interest masks
  - Reshaping and rescaling to eigentongues [5] or eigenlarynges, which help with interpretation of PCs
  - Linear discriminant analysis (LDA) can be used to generate time-varying articulatory signals from PCs, à la [8, 12]



Mandarin /n/–/ŋ/ contrast (see above); data from Faytak et al. [2]



Coming soon

- Separable GUIs and analysis functions
- Improved features (i.e. region of interest selection for pixel difference and optical flow methods)
- Additional documentation and sample data; unit testing

Acknowledgements

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Poster PDF with **references**:

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