How to "GetContours" from Ultrasound Imaging

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Background: Automated methods for extracting 2D tongue surface contours from sequences of ultrasound images are continuing to improve in sophistication and accuracy, ranging from 'snake' active contour models (Kass et al. 1988) as implemented in *EdgeTrak* (Li et al. 2005) and *SLURP* (Laporte & Ménard 2018), deep neural networks as implemented in *Autotrace* (Fasel & Berry 2010) and *DeepEdge* (Chen et al. 2019), and Markov random field energy minimization as implemented in *TongueTrack* (Tang et al. 2012). However, a need remains for simple interactive tools that can be used to seed and propagate tracings of the tongue, and to validate these methods through comparison of automatic and manual tracings.

GetContours (Tiede 2020) is a MATLAB-based platform that provides straightforward click-and-drag positioning of anchor points controlling a cubic spline fit to a displayed ultrasound image of the midsagittal tongue surface. This fit – the "contour" – provides a discretized representation of the tongue suitable for subsequent analysis. Contour fitting may be either interactive, driven by image forces, or automated through image sequences.

Features: *GetContours* provides support for loading from and navigating within DICOM sequence and movie source formats, including visualization and playback of co-recorded audio if available. *Praat* TextGrids (Boersma & Weenink 2019) labeled on associated audio can be imported to identify and annotate articulatory events of interest, allowing rapid selection of key frames within image sequences. The program supports image pre-processing on loading (e.g. cropping, resizing, or custom enhancement), and tools for image filtering, averaging and contrast scaling. Optional 'plug-in' procedures provide automated tracking through image sequences, including implementations of *SLURP* and the *EdgeTrak* snake algorithms.
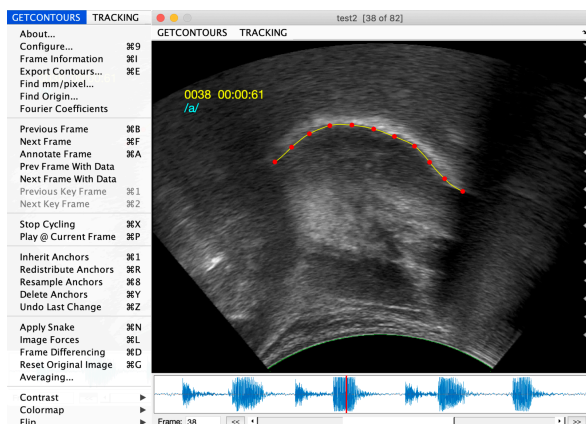

Figure 1: *GetContours interface showing primary menu options. New control points (red dots) controlling the fitted contour (yellow line) may be inserted by clicking, repositioned by dragging, or removed by control-clicking.*

Anchor points controlling the fitted spline are inserted by clicking on the displayed image for the selected frame. Existing points may be dragged to new positions, or deleted by control-clicking. Anchor points may also be automatically redistributed for equal spacing along the contour, or repositioned as driven by image forces using the Laporte & Ménard (2018) implementation of the *EdgeTrak* snake algorithm.

All data, including contours, anchor points, annotations, and (optionally) source images are saved automatically to a MATLAB-format .mat file, which may be reloaded to continue processing in a subsequent session. Contours may also be exported to tab-delimited text files encoding frame, time, annotation, and the position of each contour point (relative to the upper left corner of the image). If the mm/pixel and probe arc origin have been established (using the built-in interactive tools) contour coordinates are also output in mm coordinates relative to the probe arc circle center, which is normalized vertically and independent of image cropping or scaling. A separate procedure (*ReshapeContours*) is available to reformat output into wide (one contour per row) or *EdgeTrak*-compatible spreadsheet form.

Discussion: Like the WASL platform (Lulich 2020) *GetContours* relies on plug-in components to extend its functionality. Currently these take two forms: image pre-processors modify the image prior to display, providing for example extended contrast enhancement or filtering options; and sequencing plug-ins use interactively placed seed points to initialize automatic tracking through subsequent frames. Plug-ins support customization: besides those already developed, templates exist showing how users with specialized needs can develop their own plug-in interfaces to the *GetContours* platform.

In addition to extracting contours, the *GetContours* package provides ancillary tools supporting head correction of contours using co-recorded video. One approach relies on blue dots affixed to the forehead and probe recorded with frontal video. The *DotsTrack* procedure supports automatic tracking of dot positions through the video sequence, which is time-aligned with ultrasound using cross-correlation of common audio. The resulting signals can be used to reposition extracted (probe-centric) contours to a coordinate system relative to the head, thus correcting for possible jaw displacement.

Conclusion: *GetContours* provides an easy-to-use yet powerful and extensible platform for obtaining tongue surface contours from ultrasound imaging data.

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