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Airway-tissue boundary segmentation in the upper airway images recorded by real-time magnetic resonance imaging

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Introduction

Objective: automatic segmentation of airway and tissue in the upper airway images recorded by real-time magnetic resonance imaging (rtMRI) in order to assist image analysis for speech production study.

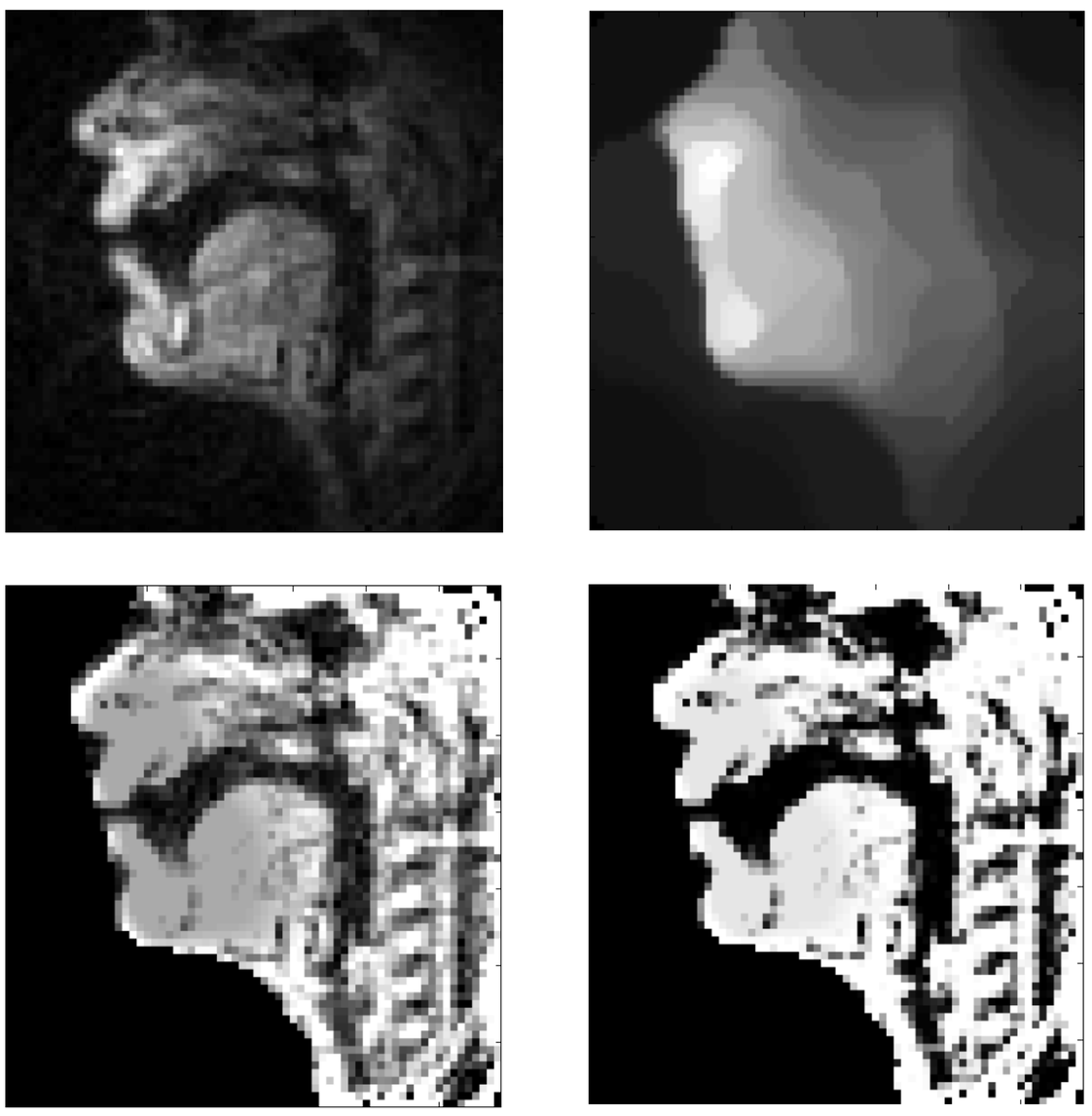
Challenges:

- Complex structure of the vocal tract
- Grainy noise
- Non-uniform sensitivity of the tissues in head and neck
- Rapidly varying irregular vocal track shape

Our approach:

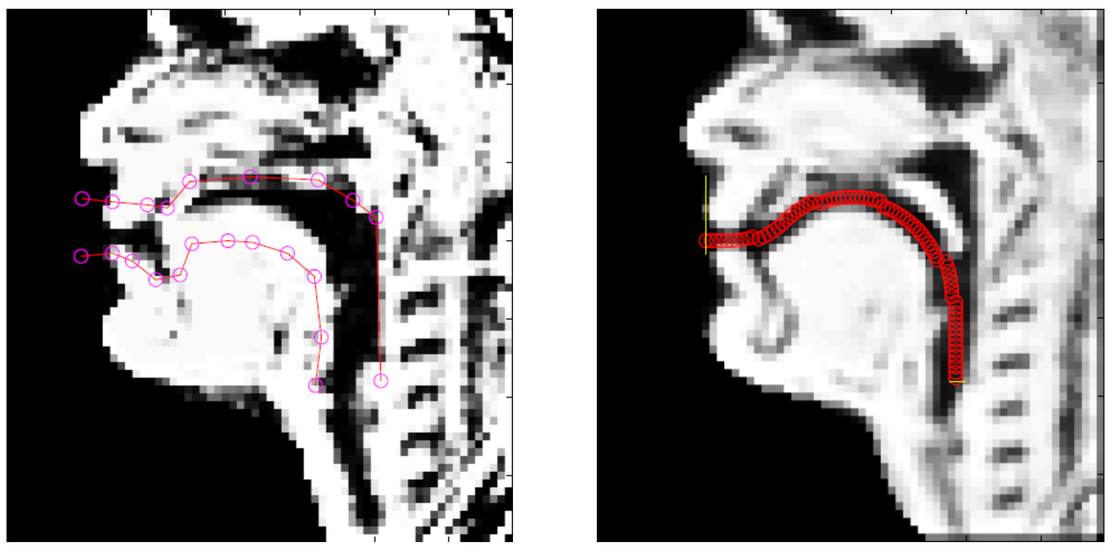
- A data-driven way of enhancement of MR images
  - Multi-resolution-based pixel intensity correction
  - Noise suppression by sigmoid-kernel function
- Accurate estimation of the path between airway-tissue boundaries by applying roughly defined constraints, followed by simple search of tissue boundaries.

MR image enhancement



1. Original image (O)
2. Intensity map (S): created by a morphological closing
3. Intensity correction by O x (1/S)
4. Intensity warping by sigmoid-kernel function: highlighting tissues and suppressing grainy noise

Airway-path estimation

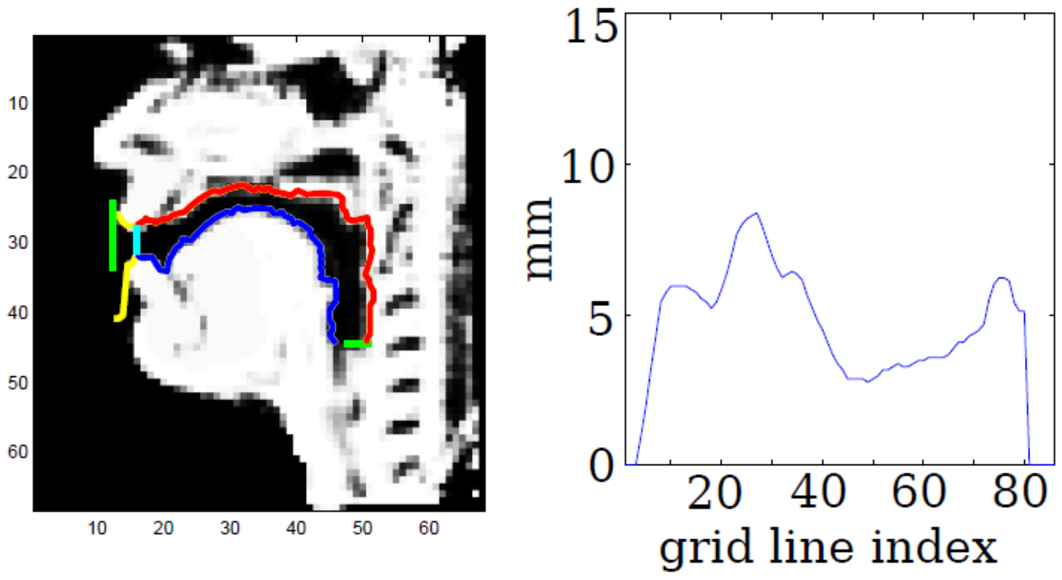


- Airway path line is found under the constraints of spatial smoothness and manually defined regions.
- In the Viterbi algorithm on this problem:
  - States Q = [q1, …, qN]: N bins in each grid line
  - Transition score from qi to qj: T(i,j) = 1/dist(qi,qj)
  - Likelihood score of qi at grid k:
    L(i,k) = 1/(pixel intensity of qi)
    L(i,k) = 0 where qi at grid k is outside the manually defined constraint regions.
- solution (state sequences with maximum cost):

$$Q^\star = \underset{[S^{k=1},\ldots,S^{k=K}]}{\arg\max} P^1_{S1} \prod_{k=1}^{K} T(S^k, S^{k+1}) \times L(k, S^k)$$

where $S^{k=n}$ the optimal state index for n-th frame and $S^k \in \{1, \ldots, N\}$, P^1_i be the prior score of qi at k=1.

Airway-tissue segmentation



- Find the pixel whose intensity is over threshold for each grid by searching from the estimated airway path to the right-top or left-bottom sides
- Euclidean distance between airway tissue boundaries in each grid line.

Contact information, sponsors etc.

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