Strain measurements in ex-vivo porcine vocal folds using DeepFlow

Raphael Lamprecht[1]*, Florian Scheible[1], Marion Semmler[2], Michael Döllinger[2] and Alexander Sutor[1]

[1]Institute of Measurement and Sensor Technology, UMIT - Private University, Hall i.T., Austria
[2]Div. of Phoniatrics & Pediatric Audiology, Dep. of Otorhinolaryngology, University Hospital Erlangen, Germany

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Introduction

The biomechanical properties of the true vocal folds play a crucial role in the phonation process. An ultrasound transducer directly placed on the vocal folds can measure the elastic properties by a quasi-static elastography approach. We already showed the feasibility of this technique in Lamprecht et al. [1]. Here we present an improved version of this approach.

Methods

An ultrasound transducer using a linear drive compressed the tissue of porcine vocal folds. To estimate the compressing force, a silicon pad placed between the transducer and the tissue (Fig. 1). The boundary between the tissue and the silicone was tracked by a Canny edge detection. Consequently, the acting force can be calculated with a lateral spatial resolution.

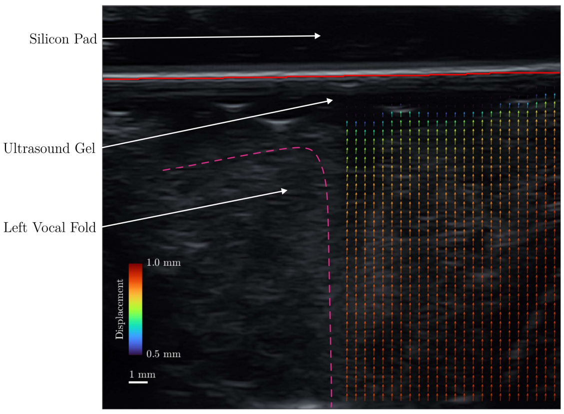

Figure 1: The vocal folds displayed in a coronary section. Left side: porcine vocal fold. Right side: Measured displacement in the tissue.

The displacement in the tissue was evaluated by DeepFlow, which is a trained neural network for optical flow estimation [2]. Using this, we were able to measure the displacement between the unconstrained and the loaded frame. The strain in the tissue was computed by a two-dimensional Savitzky-Golay differentiator [3, 4].

Results

We used two porcine larynges to test our algorithm. The displacement vector field in the tissue is shown in Fig. 1, whereas the color indicates the magnitude of the displacement. In the same figure, the border of the silicon pad is shown. Furthermore, Fig. 2 indicates the strain in the tissue in a user-defined region of interest. The color represents magnitude of the strain ε_{zz}, in which z is the direction of the compression.

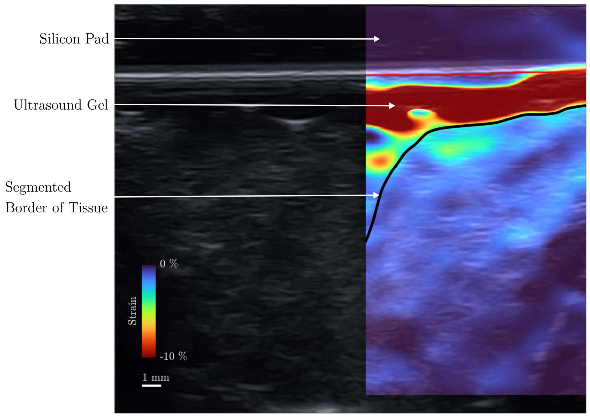

Figure 2: Strain ε_{zz} in the right vocal fold.

Discussion

We were able to show the feasibility of strain estimation in the vocal folds with DeepFlow, which is a major improvement of our previously presented approach [1]. In the future, a finite element model based on the body-cover-model [5] will be implemented to estimate the Young's Modulus of the tissue.

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References

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*raphael.lamprecht@umit.at