High-Speed Color Videoendoscopy of Human Voice Production

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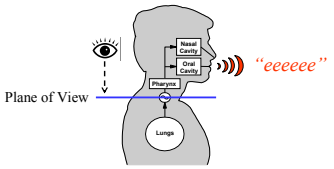
INTRODUCTION

The primary purpose of this project is to **develop improved high-speed color videoendoscopy-based methods** for the visualization and automatic measurement of vocal fold vibratory characteristics. These developments will facilitate the clinical and research application of this technology and begin establishing the clinical validity, practicality, and relevance of high-speed color videoendoscopy in the functional evaluation of vocal fold pathology.

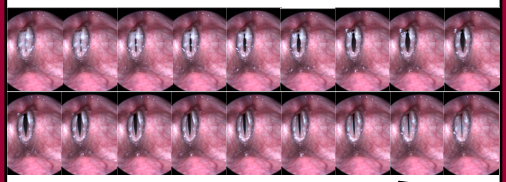
MOTIVATION

The current standard for clinical voice assessment is the use of stroboscopy which relies on tracking a stable fundamental frequency to create a highly averaged (smoothed) estimate of vocal fold vibration. Thus stroboscopy is incapable of capturing the details and/or irregularities in vocal fold vibration that may be central to gaining a better understanding of normal and disordered vocal mechanisms.



Endoscopy via Videostroboscopy

High-Speed Videoendoscopy



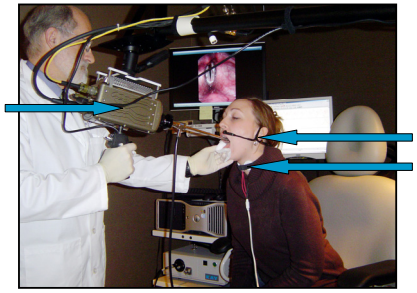
HYPOTHESIS

• It is hypothesized that the **higher temporal resolution** and registration of **true intra-cycle glottal dynamics** by high-speed viewing will provide new insights into the biomechanics of laryngeal sound production.

• Particularly when **combined with other simultaneous measures**, high-speed viewing may enable clinicians to make more accurate functional assessments of the pathophysiology of voice disorders, leading to important refinements in the diagnosis of vocal fold pathology.

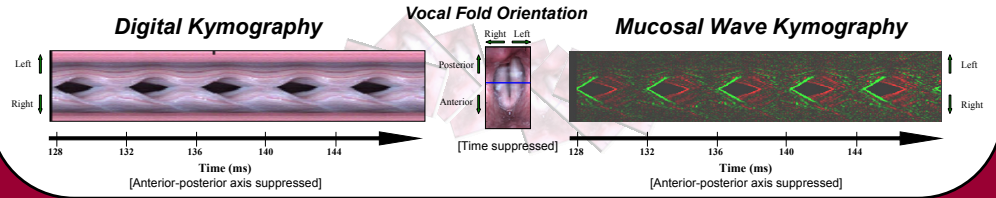
NEW HIGH-SPEED IMAGING TECHNOLOGY

High-Speed Video Camera
- 8,000 frames per second
- 320 pixels x 480 pixels
- 42-bit RGB color



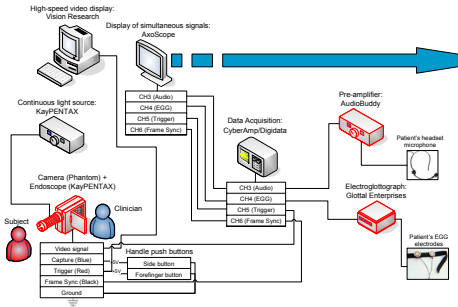
• ***Digital kymography*** facilitates examination/comparison of the cycle-to-cycle symmetry characteristics of the two vibrating vocal folds at one location in the anterior-posterior axis.

• ***Mucosal wave kymography*** facilitates the examination of the mucosal wave by automatically tracking, color coding, and displaying the upper and lower edges of the vocal folds during vibration. The mucosal wave represents the deformation in the superficial layers of the vocal folds that is responsible for normal voice production. This type of image processing not only facilitates subjective viewing, but will also enable the quantification of the speed of mucosal wave propagation. Green = opening phase; Red = closing phase.

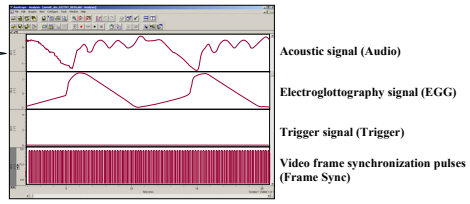


CORRELATIONS AMONG SIGNALS

Sound Booth Wiring Schematic



Screen Shot of Simultaneous Signal Acquisition



Issues:

• Temporal synchronization of all channels with video

• Estimation of acoustic propagation time from vocal folds to microphone to synchronize the acoustic signal with signals at the source level (EGG, video, and synchronization pulses)

APPLICATIONS

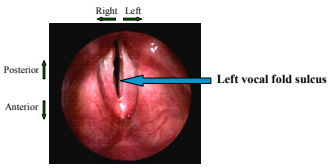
Surgery and Bio-Implants

• The need to optimize high-speed color digital imaging for clinical and research use is more pressing than ever because of the recent acceleration of efforts to **develop surgical methods and bio-implants** for repairing damage (e.g., scarring) to the superficial vibrating layers of the vocal folds, a major factor in most voice disorders.

• These efforts to restore the delicate biomechanical properties of vocal fold tissue need the type of increased accuracy that high-speed imaging can potentially provide to assist with more precisely **defining/mapping specific damaged areas** to target for repair and/or reconstitution of vocal fold tissue pliability, and for accurately assessing the impact of such interventions on the fine temporal details of vocal fold vibration.

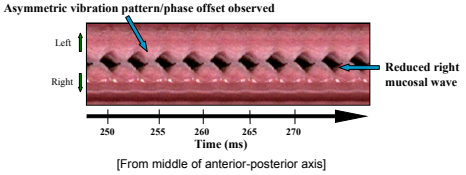
• If this project succeeds, we believe that **new methods will be adopted in clinical practice** to improve the assessment of voice disorders and will become a particularly valuable and necessary tool for the development, evaluation, and continued improvement of advanced phonomicrosurgical procedures.

Imaging of Vocal Fold Scarring



Adult male with bilateral vocal fold sulcus (scarring/loss of superficial lamina propria). Symptoms include chronic vocal fatigue and dysphonia that worsen with increased voice use.

Digital Kymography



ACKNOWLEDGEMENTS

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Thanks also to **James Heaton, PhD**, for helping with the setup of the high-speed sound booth.