A new imaging system for evaluating disordered vibration of the vocal folds

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Introduction:

The vocal fold vibration determines the voice quality in human voice generation. Therefore, understanding of the vibration characteristics of vocal folds is quite important especially the disordered vibration. Historically, one convenient method of observing the vibration of vocal which are too fast to be observed directly by the human eye, appearing only as a blur, is using the stroboscopic phenomenon, which has been known since about 1830. However, the stroboscopy is used to observe the periodic other than the disordered movement. To evaluate a disordered vibration of the vocal folds a high-speed imaging system is necessary. However, a two-dimensional high-speed imaging system currently cannot provide enough image resolution to evaluate irregular vocal fold vibrations, due to the limitation of transmission speed and storage volume[2].

Videokymography registers the movements of the vocal folds with a high temporal resolution on a line perpendicular to the glottis and provides an applicable solution[1]. However, the current existing videokymographic system (developed in Groningen), has its intrinsic drawbacks, such as lack of position information about from which part on the vocal folds the images are taken and lack of data in the blanking interval caused by using TV-norms. Therefore the development of a new imaging system is significant and imperative.

The paper presents a new imaging system, which is based on the idea of the current videokymography. The new imaging system includes the kymographic function and stroboscopic function. In kymographic function, a two dimensional video, on which the position of the scanning line is shown, and a line scan without the blanking interval will be obtained synchronously. In stroboscopic function, a two-dimensional color video registration shows the movements of the vocal folds in still or slow motion.

Methods:

Two kinds of image sensor are applied, one of which, color area CCD, is used to capture two-dimensional stroboscopic image, and the other one, monochrome linear CCD, is for kymographic image sampling. The position of linear CCD is fixed on the reflective center of area CCD.

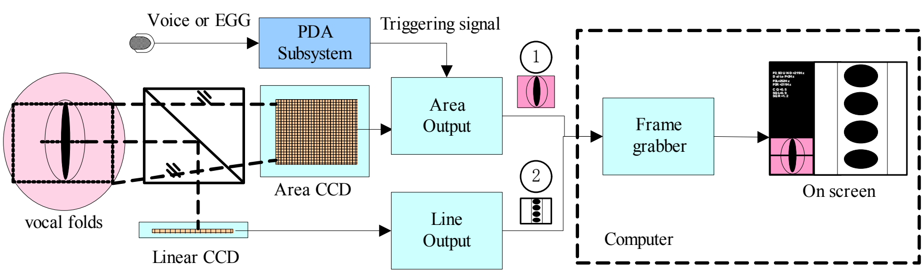

Fig. 1. Schematic diagram of the new imaging system. There are two channel inside the system, two dimensional stroboscopic image channel (1) and kymographic image channel (2). To get stroboscopic image, a subsystem based on pitch detect algorithm (PDA) is embedded to obtain the vibratory fundamental frequency of the vocal folds and to trigger electronic-shutter of area CCD. The frame grabber digitizes the video signals and transfers them into the host computer, on which storage, display, and further numerical analysis are preformed.

For triggering the stroboscopic function, a digital signal processor (DSP) platform is adopted, in which a robust pitch detection algorithm (PDA) that based on autocorrelation is used. This system provides output triggering pulses that related to the fundamental frequency (F0)[2].

Result and discussion:
The first prototype of the new imaging system is built. In kymographic mode, it can provide 8000 lines with 625 pixels and 25 two-dimensional frames with 768 x 576 pixels per second at the same time. In stroboscopic function, it shows 25 two-dimensional color frames per second with768 x 576 pixels. The range of fundamental frequency determination is from 50 to 500 Hz.

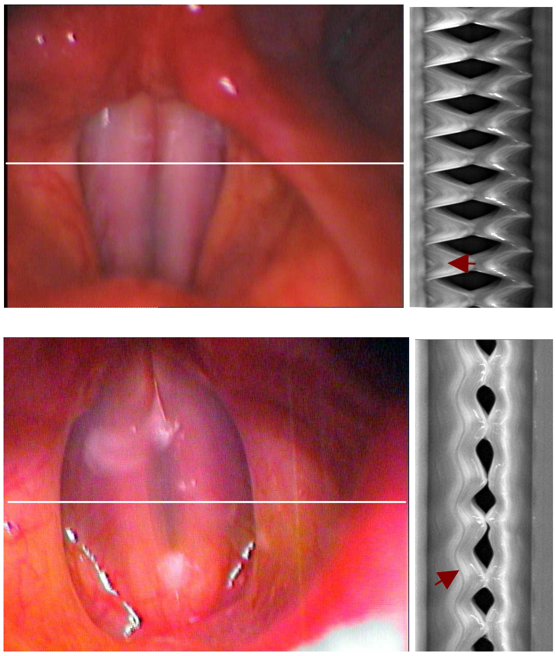

Fig. 2. The experimental result from the two subjects. On the two dimensional image of the vocal folds (left side), the white line shows the scan position of the kymogram (right side). The arrow on the kymogram points the texture of the mucosal wave (top right) and the blood vessels (bottom right) on the vocal folds. The two kymograms show the regular (top) and disordered (bottom) vocal-fold vibrations, respectively.

Two subjects are tested by using the new prototype. Fig.2. shows the experimental result. A high sensitivity linear CCD sensor is used inside the prototype, which dramatically increases the image quality. The capillary blood vessels on the vocal folds can be clearly presented. It is a big advantage of the new imaging over the current vocal-fold vibratory imaging system. The high quality image will provide more vibratory details of the vocal folds and much reliable vibratory data for the further analysis.

References:
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