T A

Č R

ABSTRAKT Z KONFERENCE 2017

Příloha k průběžné zprávě za rok 2017

Obsah: Abstrakt z konference The 12th International Conference on Advances in Quantitative Laryngology, Voice and Speech Research

Subbaraj PK, Švec JG, Vydrová J, Zitová B: Quantifying kymograpic waveform with Bezier curves. *The 12th International Conference on Advances in Quantitative Laryngology, Voice and Speech Research, October 17-21, 2017 Hong Kong* edited by E.Ma, E.Yiu, The University of Hong Kong: p.21 (2017).

Číslo projektu: TA04010877

Název projektu: **Automatické hodnocení videokymografických záznamů pro časnou diagnostiku a prevenci nádorových onemocnění hlasivek**

Předkládá: J. G. Švec

Název organizace: Univerzita Palackého v Olomouci

QUANTIFYING KYMOGRAPIC WAVEFORM WITH BEZIER CURVES

P. K. Subbaraj[1], J.G. Švec[1], J. Vydrová [2], B. Zitová[3]

[1]Voice Research Lab, Department of Biophysics, Faculty of Science, Palacký University, Olomouc, Czech Republic
[2]Voice and Hearing Centre Prague, Medical Healthcom Ltd, Španělská 4, Prague, Czech Republic
[3]Department Head, Research Scientist, Department of Image Processing, ÚTIA AV ČR, Prague, Czech Republic

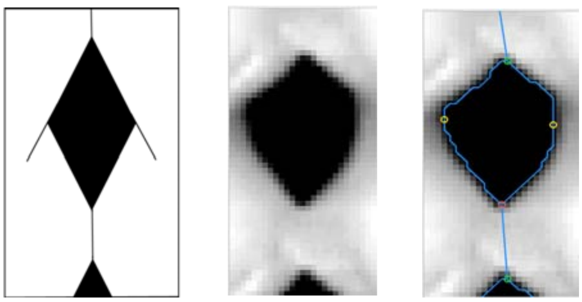
ABSTRACT

Kymographic waveform is a set of data points representing an approximate outline of the vocal fold edge movements obtained from kymographic images. For appropriate quantification of vibration parameters, the subjected waveforms should be as smooth as possible. However, in practice, they are often unsmooth due to digital quantization noise. Here we test the use of Bezier curves, known from graphics programs, for smoothly characterizing the shape of kymographic waveforms.

INTRODUCTION

Videokymography (VKG) is a cost effective high-speed imaging technique used in the laryngological examinations to study the complex vibratory patterns of the human vocal folds [1, 2]. It helps the clinicians in objectively evaluating the important parameters of the human vocal fold vibrations [3, 4]. Software tools have been developed erstwhile to automatically identify and quantify the vibratory features from the kymogram [3, 5, 6].

The glottal cycle in the kymogram is ideally expected to have well defined glottal edges. However, the glottal edges in the actual kymograms are highly pixelated due to the quantization and compression artifacts.



(a) (b) (c)

Figure 1 A glottal cycle in the kymogram (a) ideal (b) pixelization in the laryngoscopically captured VKG (c) influence of pixelization on the detected glottal edges.

This imposes a problem on the glottal edge detection algorithm to truthfully capture the glottal shape for further quantification. Bezier curves are the parametric curves used to model the smooth curves [7]. The shape of the curves can be controlled intuitively by adjusting the inner control points. Here, we propose to use Bezier curves to truthfully capture different shapes of the glottal edges using manual and automatic best fitting methods for accurate quantification of the kymographic parameters.

METHODS

A VKG Analyzer Software was used to obtain kymographic waveforms from images of patients with voice disorders captured by 2nd generation videokymographic (VKG) camera. Individual cycles from the kymographic waveforms were separated and ensemble averaged to smoothen out the abrupt changes in the peaks (Fig. 2).

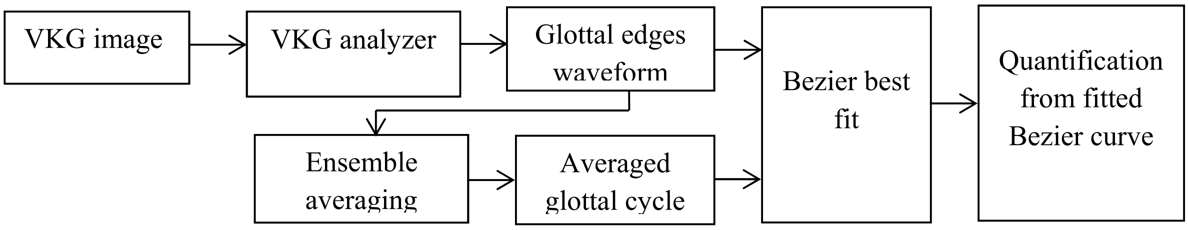


Figure 2 Glottal cycles are extracted from the VKG image and ensemble averaged.

Least square and non-linear optimization techniques were then used as then used as the best fit methods to optimally determine the inner control points of the Bezier curves. Cubic Bernstein polynomials were used to construct the Bezier curves. At the lateral peaks, sudden change of direction was allowed. In case of incomplete closure, additional Bezier control points were added in order to better capture the phenomena related to medial vocal fold shape in accordance with the mucosal wave theory. The fitted Bezier curves were used to automatically quantify a number of vocal fold vibration parameters.

RESULTS

The glottal width waveform was derived from the glottal edges waveform (Fig. 3). The derivative of the signum function of the glottal width waveform exhibited positive and negative spikes at the beginning and end of the glottal cycles. These spikes were then used to identify the start and end points of the individual cycles.

The modern VKG grabber duplicates each scanned lines and as a result of compression prior to storage these lines are no more identical. In order to eliminate the points pertaining to the duplicated lines, odd, even and average down-sampling were separately performed.

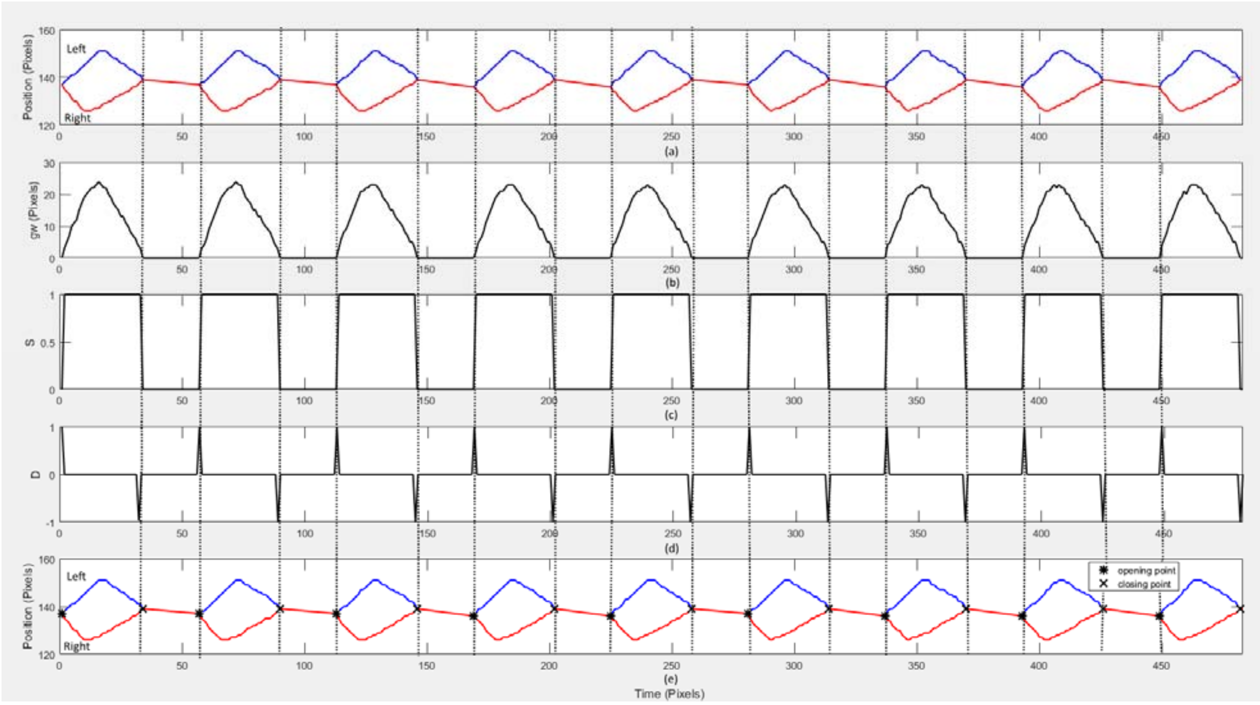


Figure 3 Identification of individual cycles: (a) glottal edge waveform (b) glottal width waveform (gw) (c) sgn(gw) (d) derivative of sgn(gw) (e) detected start and end positions of the glottal cycles from the derivative spikes.

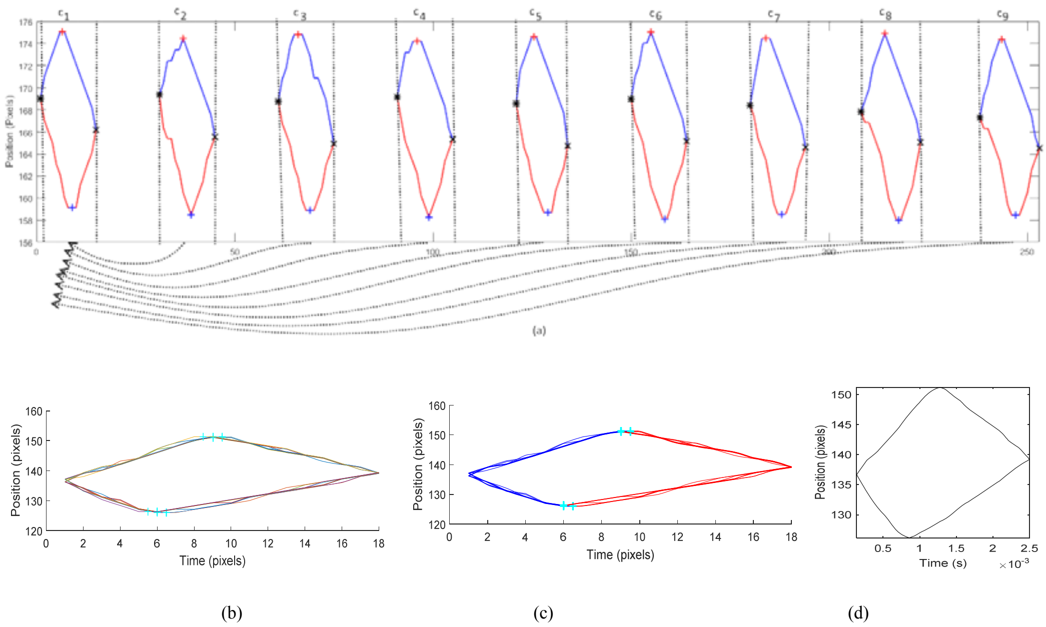
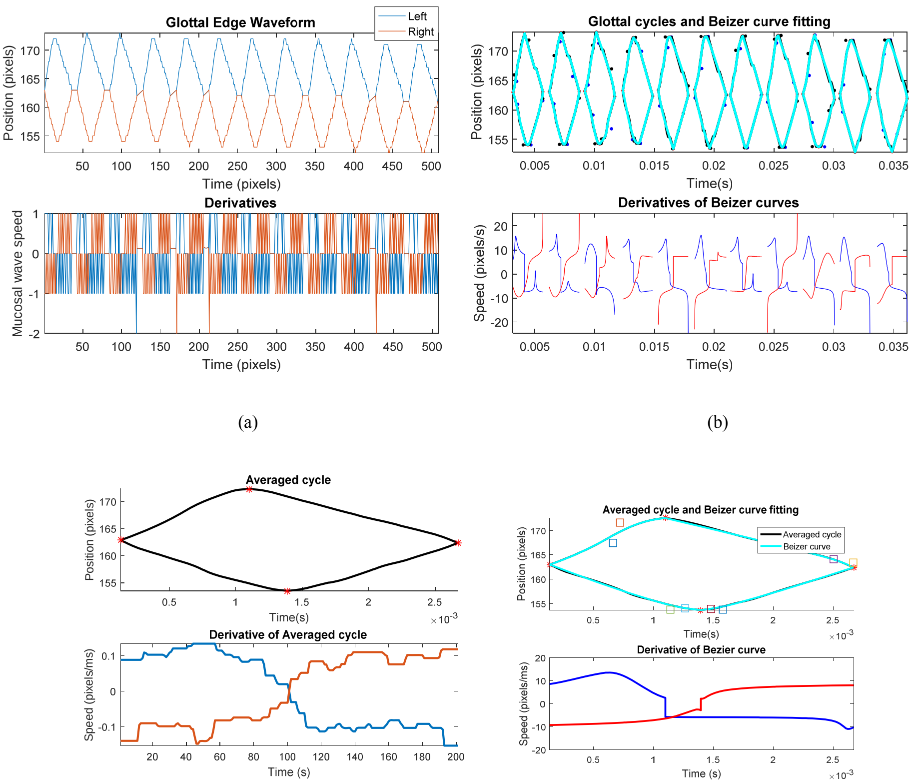


Figure 4 Individual cycles are time shifted with respect to the cycle 1 (a), aligned without (b) and with (c) cross correlation, (d) averaged glottal cycle

Also the values introduced by the contour detection algorithm corresponding to the glottal closure were eliminated by specifying them as not a number (NaN). To ensure that the starting and end points of the glottal cycles were not removed by this process they were duplicated to their adjacent points beforehand.

The glottal edges data were resampled with an equidistance of 0.5 units and linearly interpolated. The start and end positions of glottal cycle were calculated again by the same procedure described before. The lateral peaks in each cycle were identified and they were adjusted to the middle in case of a saturated or flat peaks. The quadratic fit of the peaks were used in the drift correction of the glottal cycles. The cycles were separated and aligned with respect to the first cycle and ensemble averaged (Fig. 4).

Separate Bezier curves allowed quantifying the lateral and medial movements of the two vocal folds corresponding to the opening and closing phases. Smoothness of the Bezier curve is evident from the results of their derivatives (Fig. 5).



(a) (b)

(c) (d)

Figure 5 Test of smoothness from the derivatives (a) glottal edge waveforms with discontinuities in the derivatives (b) Bezier curve fitting the glottal cycle waveform with smooth derivatives, (c) discontinuities in the derivatives for the averaged glottal cycle, (d) smooth derivatives for the Bezier curve fitted on the average glottal cycle.

CONCLUSION

Bezier curves allow quantifying features which are otherwise polluted by digital quantization noise and provide more insight into vocal fold behavior. The smooth shape allowed also estimating the vocal fold velocities through time derivatives and defining novel parameters such as sharpness of lateral peaks.

ACKNOWLEDGEMENTS

The study was supported by the Technology Agency of the Czech Republic project no. TA04010877 (2015-17).

REFERENCES

1. Novozamsky, A., Sedlar, J., Zita, A., Sroubek, F., Flusser, J., Svec, J. G., . . . Zitova, B. (2015). Image Analysis of Videokymographic Data. 2015 IEEE International Conference on Image Processing (ICIP), 78-82.
2. Qiu, Q., & Schutte, H. K. (2006). A new generation videokymography for routine clinical vocal fold examination. Laryngoscope, 116(10), 1824-1828.
3. Svec, J. G., Sram, F., & Schutte, H. K. (2007). Videokymography in voice disorders: What to look for? Annals of Otology Rhinology and Laryngology, 116(3), 172-180.
4. Sedlar, J. (2012). Image Analysis in Microscopy and Videokymography. (PhD Dissertation), Charles University, Prague.
5. Woo P. (1996). Quantification of videostroboscopic findings--measurement of the normal glottal cycle. Laryngoscope 106 (suppl.no.79): 1-27.
6. Mehta DD, Zanartu M, Quatieri TF, Deliyski DD, & Hillman RE (2011). Investigating acoustic correlates of human vocal fold vibratory phase asymmetry through modeling and laryngeal high-speed videoendoscopy. J Acoust Soc Am 130: 3999-4009.
7. Prautzsch, H., Boehm, W., & Paluszny, M. (2013). Bézier and B-spline techniques: Springer-Verlag Berlin Heidelberg GmbH.