FACULTY
OF APPLIED SCIENCES
UNIVERSITY
OF WEST BOHEMIA

Evaluating the quality of the glottis closure

BIOMEDICAL INFORMATICS GROUP

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
FACULTY OF APPLIED SCIENCES
UNIVERSITY OF WEST BOHEMIA
PILSEN, CZECH REPUBLIC

Pavel Nový
novyp@kiv.zcu.cz
Senior Researcher
Research areas:
- Signal and image processing
- Biomedical data analysis
- Audiology and phoniatry

Tomáš Ettler
thritton@kiv.zcu.cz
Junior Researcher
Research areas:
- Signal and image processing
- Medical data processig and analysis
- Database systems

Lukáš Kroupa
kroupal@students.zcu.cz
Student
Research areas:
- Signal and image processing
- Database systems

František Vávra
vavra@kma.zcu.cz
Senior Researcher
Research areas:
- Statistical methods and analysis
- Application of information and cybernetics theory in biomedical areas

Jiří Pešta
pestaj@fnplzen.cz
Expert of Otorhinolaryngology
Research areas:
- Audiology and phoniatry
- Signal processig

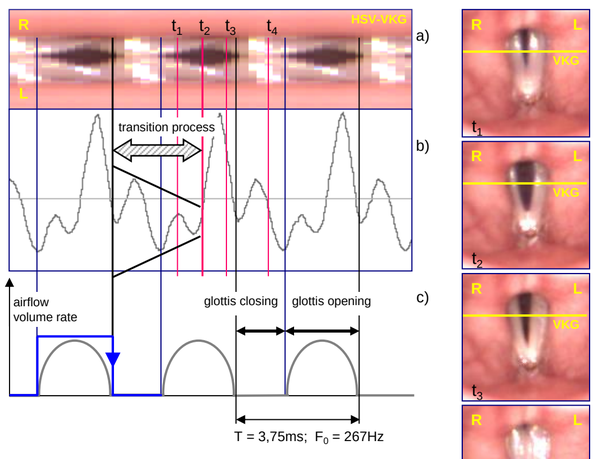
Introduction

The aim of this work is to present new knowledge, which would be useful for evaluation of the quality of the glottis closure. The source of knowledge is the analysis of one period of the laryngeal tone record, which is obtained by measuring the changes of the sound pressure, through the microphone placed in front of the patient's mouth.

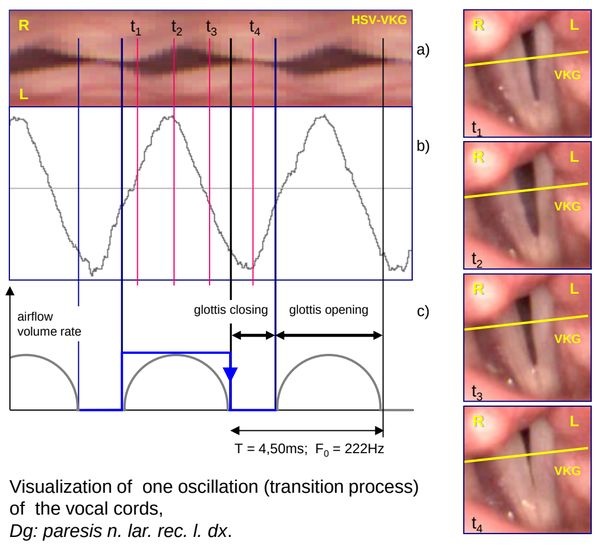
Common examination methods with new knowledge expressed by SCORE value can be used to evaluate the vocal cord function and determine the diagnosis of voice disorder.

Approach and Methods

The principle of the method is the Fourier analysis of one period of the laryngeal tone recording to detect the transition process as a response to pressure pulse. This process is caused by closure of the glottis. The regression SCORE model is used to evaluate the quality of the glottis closure. The variables in the model are standardized amplitudes, which are calculated from the coefficients of Fourier series. The parameters of SCORE model are the coefficients, which are derived by comparison with the expert rating of individual records. The expert rating consists of the results of medical examination of voice quality as well as experience of the evaluating expert.



Visualization of one oscillation (transition process) of the vocal cords,
Dg.: good closure of the glottis.



Visualization of one oscillation (transition process) of the vocal cords,
Dg: paresis n. lar. rec. l. dx.

The method is based on expansion of one period of the laryngeal tone recording using trigonometric series for defined finite number of its members.

Following signal description is devised:

$$X(k) = \sum_{i=0}^{15}\left(a_x[i]\cos\left(i\frac{2\pi}{L}k\right) + b_x[i]\sin\left(i\frac{2\pi}{L}k\right)\right)$$

$X(k)$	…	k - th sample of the periodic curve of interval $k \in \langle 1, L\rangle$;
L	…	length of the phonation recording in samples;
k	…	position of sample on periodic curve X[k];
i	…	i - th member of Fourier series;

Coefficients of Fourier series are then :

$$a_x[i] = \frac{2}{L}\sum_{k=1}^{L}\left(X[k]\cos\left(i\frac{2\pi}{L}k\right)\right)$$

$$b_x[i] = \frac{2}{L}\sum_{k=1}^{L}\left(X[k]\sin\left(i\frac{2\pi}{L}k\right)\right)$$

For these coefficients of Fourier series we can create invariants which describe the shape of the curve independently on its position and relative to its shift. For amplitude spectrum after normalization applies:

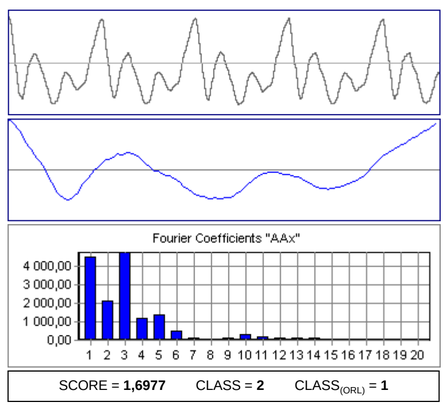
$$a[i] = \frac{AA_x[i]}{\sqrt{\sum_{j=1}^{15}(AA_x[j])^2}} \qquad AA_x[i] = \sqrt{(a_x[i])^2 + (b_x[i])^2}$$

Regression model of weight function is used to evaluate quality of the glottis closure:

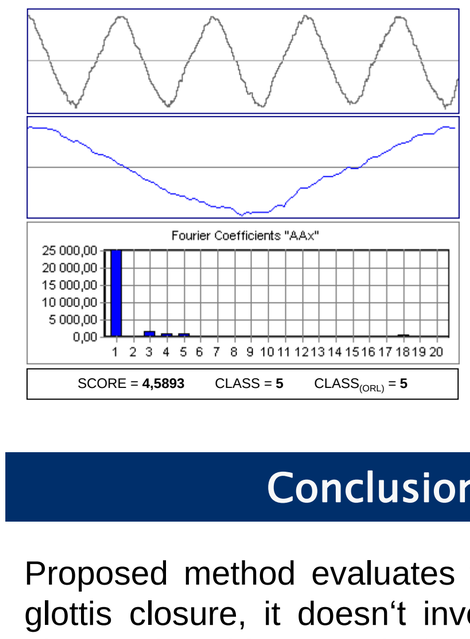
$$SCORE = \alpha_0 + \sum_{i=1}^{6}\alpha_i \lg(a[i])$$

Parameters of weight function α_j are chosen according to expert classification $CLASS_{(ORL)} \in \langle 1\text{–}5\rangle$:

$$SCORE = 1{,}0789 * \lg(a[1]) - 0{,}0864 * \lg(a[2]) - 0{,}4306 * \lg(a[3]) - 0{,}2736 * \lg(a[4]) - 0{,}0971 * \lg(a[5]) - 0{,}1905 * \lg(a[6]) + 0{,}7629$$



Results of glottis closure analysis:
SCORE = 1,6977
Classification = 2
ORL-Expert Classification = 1
Dg.: good closure of the glottis.



Results of glottis closure analysis:
SCORE = 4,5893
Classification = 5
ORL-Expert Classification = 5
Dg: paresis n. lar. rec. l. dx.

Conclusion

Proposed method evaluates the quality of the glottis closure, it doesn't investigate cause of observed problems and It's not dependent on strength of phonation.
Resulting distribution of class estimation error is based on 625 tested recordings of phonation:

$$ERR = CLASS - CLASS_{(ORL)}$$