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Glotto Vibrato Graph: A Device and Method for Recording, Analysis and Visualization of Glottal Activity

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Abstract

Opening and closing of the glottis is the primary and the most crucial step in converting airstream into speech sounds. The opening and closing process results in glottal vibration, filtered through the oral and nasal cavities to produce a variety of speech sounds. In this work we demonstrate the working of Glotto Vibrato Graph (GVG), that records, analyzes and visualizes the glottal activity with the help of a single low-cost hardware-software package. The measurements are carried out by using piezo electric sensors to detect glottal vibration. A modular graphical computer software based on custom algorithm is used for the analysis and visualization. Results from the low cost GVG are comparable to results obtained from proprietary electroglottograph (EGG) devices.

Index Terms: glottal signal recording, bio-medical device, glottal vibration

1. Introduction

The need for estimating glottal movement in the medical field, led to the use of invasive methods of endoscopic video recording of glottal movement [1, 2]. Considering the need for trained professionals in conducting such recordings, non-invasive methods, such as, electroglottography (EGG), were introduced. However, both invasive and non invasive systems are cumbersome and cost intensive. Apart from that, invasive methods, such as the endoscopic method, may have noise introduced by the the natural movement of other oral parts. On the other hand, EGG signals may be impeded by idiosyncratic physiology, such as thick neck muscles. [3].

The device demonstrated in this work is the Glotto Vibrato Graph (GVG), which, uses a piezoelectric sensor to pick up the glottal vibration through contact from the font of the hyoid bone of the larynx. The major processing is done on the digitized signal from the sensor in a graphical computer software designed specifically for this device. The block diagram representation of the system is displayed in Figure 1. The sensor is tightly placed in front of the hyoid bone of the larynx with an elastic velcro band, in order to capture the glottal vibration. Speech signal is camputed simultaneously using a microphone attached to the band. The speech signal acts as a reference to the glottal signal while processing and visualizing the glottal activity.

The graphical user interface is user-friendly facilitating speech and glottal activity recording, analysis and visualization. Apart from recording and saving the data, real-time visualization of the glottal activity and speech is also enabled. This feature allows the user to adjust the GVG sensor or the microphone for perfect placement during recording. The interface and the data analysis suits built along with the device enable speech researchers and professionals provides a cost effective solution for glottal event recording. Data collected and the visualizations of the data can be saved for later analysis.

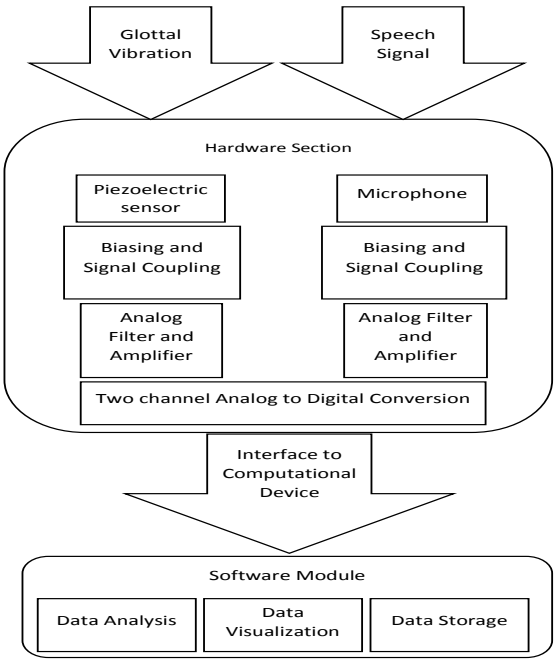

Figure 1: *Block diagram representation of the system.*

2. Hardware

The hardware of GVG is designed for signal acquisition, signal conditioning, basic amplification and digitization of the analog signals. The unit contains a sensor band and an electronic box which is connected to a computer with a USB cable. The sensor band and the electronics box are also connected through wires.

2.1. Sensor band

The sensor band is fabricated with elastic velcro patches where the detachable sensor is mounted with a flexible plastic casing to avoid skin contact. A semi-flexible mount is used to mount the

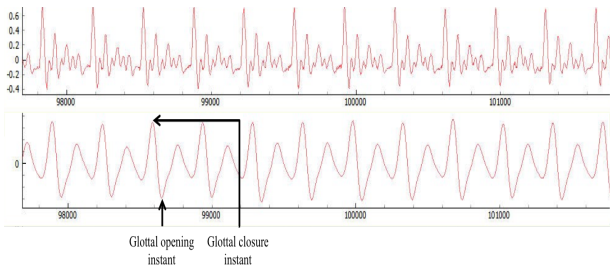

Figure 2: *Screenshot of the interface showing the speech waveform on the top panel and the glottal instants on the bottom panel.*

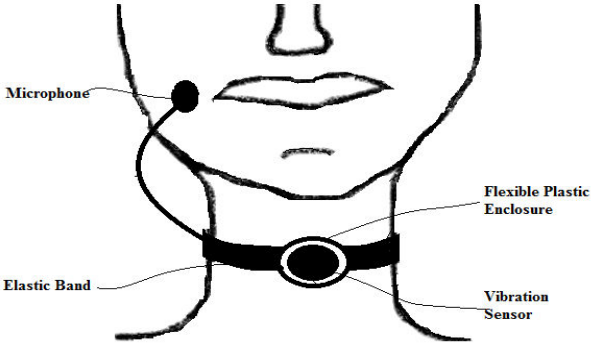

Figure 3: *Placement of the sensor and microphone.*

microphone to the sensor casing. The microphone is positioned near the user's mouth. The elasticity of the band allows it to be used by a variety of users ranging from children to adults, without the need for any major change.

2.2. Electronics box

The electronic box encloses the analog and digital circuits of the system. The circuit has an analog, a digital and a power regulation unit. The box is connected to the computer over a USB cable. The sensor and microphones are also connected to the circuit with shielded wire to avoid electrical noise. The power distribution system distributes the power from USB to the analog and digital components with required voltage and current ratings. This unit also makes the signal immune from power line noise.

The analog circuit does the preconditioning of the input glottal vibration and speech signal. The preprocessed signal is then filtered and amplified for digitization. The analog to digital conversion circuit converts both glottal vibration and speech signal to high-resolution digital signal in separate channels and encodes the same to be recognized by the computer over a USB protocol.

3. Software section

A Python-based application is designed to record, store and analyze the signal. The features of the application are as follows.

- Real-time visualization of the waveforms and intensity levels at the time of recording.
- User-friendly system for display and reproduction of the signals (glottal vibrations and speech)
- Options for basic signal processing like filtering, cropping, amplification etc.
- Signal analyzing tools like frequency spectrum, spectrogram, zero crossing over, Pitch plot etc are integrated.
- The glottal instances and glottal flow graph are the important signal processing measures of the system.
- User management system is integrated to manage the recordings, users and the respective prompts (or transcripts) of the recording.
- The glottal vibration, speech and the derived signals can be saved as audio files, while the graphs can be saved as image files.
- The application is written in a modular way to allow easy incorporation of new modules for signal processing, feature extraction or visualization.

4. Placement of the sensor

The Piezoelectric sensor enclosed within the flexible plastic enclosure must be placed on in font of the hyoid bone of the larynx and locked tightly with the velcro for a good quality recording. Real-time signals can be displayed in the application facilitating proper placement. The sensor placement can be seen in Figure 3.

5. Signal quality

The signal is recorded with a sampling frequency of 48000 Hz at 16-bit resolution. Glottal vibration and speech are digitized in two separate channels.

6. Conclusions

The GVG device is designed to reduce complexity and cost of glottography. It may not provide the same level of information as an optical glottography but it can be used as an introductory tool for speech research and medical application.

7. Acknowledgements

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8. References

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Note: The work presented in this article is used for filing an Indian Patent with application no 201831012457 dated 02/04/2018.