Testing procedures and acquisition systems for contact sensor¿based vocal monitoring devices

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Testing procedures and acquisition systems for contact sensor–based vocal monitoring devices

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Declaration

I hereby declare that, the contents and organization of this dissertation constitute my own original work and does not compromise in any way the rights of third parties, including those relating to the security of personal data.

Federico Casassa
2019

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Testing procedures and acquisition systems for contact sensor–based vocal monitoring devices

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The goal of the research activity described in this dissertation was to find new solutions for vocal monitoring, specifically concerning the improvement of the data acquisition device and the development of test systems and test procedures to estimate the uncertainty related to the measurement arrangements.
Voice disorders, from simple vocal dysphonia to vocal fold nodules, could affect those professionals who use voice in a sustained way for long intervals, e.g. actors, singers, call-center operators. Monitoring the vocal activity of these people during a normal working day is useful to identify incorrect vocal behaviour, and possible voice disorders.
The device used for this procedure (long-term voice monitoring) is called "vocal dosimeter". It allows to record vocal data while the monitored subject performs his/her normal activities.

The first part of the work deals about the improvement of the Voicecare vocal dosimeter, developed at the Politecnico di Torino, DET Department, in collaboration with TEBE research Group. The system is capable to record the vibration signal at the base of the neck, which is directly connected to the phonation. The acquired signal, post-processed, could provide information about the voice use and possible vocal disorders of the monitored subjects. One of the goals was to lower the uncertainty related to the instrument by searching for a better contact sensor, so three of them were selected to be tested with the one already used on the dosimeter. For this purpose in vivo test procedures was developed, useful to select the best contact sensor, but also to obtain information about the uncertainty related to the sensor itself. They were used to acquire different vocal tasks performed by various test subjects in a semianechoic room. While, the tests gave some good results but exposed that there was more work to do in evaluating the frequency response of each sensor used for this particular task. Due to the biological variability, this kind of test performed on human subjects does not provide a strong reference for a correct sensor comparison and evaluation.
Alongside, enhancements were made on the data logger section of the vocal dosime-

ter. The existing micro-controlled board used on the original one was replaced with a more powerful one, and the increased computing power has allowed to real-time estimate some vocal parameters, which are usually obtained by postprocessing the data. Also, a programmable gain amplifier was implemented on the input channels: the automation of the gain has helped to reduce the saturation and to improve the acquisition quality.
The system was tested in order to define the uncertainty in the parameter estimation, and to tune the gain automation algorithm.

In the second part of the dissertation, the issues emerged after the tests for the selection of a new contact sensor has been dealt. The in vivo tests suffered from lack of repeatability due to the biological variability and to the absence of a strong reference. For this purpose, a phonatory system simulator has been developed and tested, with the aim of obtaining an apparatus that provides a stable reference to test and evaluate contact sensors to be used for voice monitoring.
Such apparatus must provide a stable relation between a vibration on a skin-like material and an acoustic output. The simulator has been characterized and tested in terms of measurement repeatability and agreement with the true phonatory system response, and a method to evaluate the sensors load effect has been proposed.

The tests on human subject helped to resolve some problems related to the data acquisition in vocal monitoring (vocal task to be performed, contact sensor attachment method) and the results obtained were used to better calibrate the acquisition system.
The work on the data logger improved the acquired signal quality (less saturated frames, more data to process, real-time parameter estimation with better accuracy) and the development of the phonatory system simulator has provided a test system for the contact sensors and for the acquisition system to be used for vocal monitoring. The simulator has proved to be a stable reference on which repeatable measurements can be performed, and it has already been used to improve the calibration of the contact sensor channel of the Voicecare, to obtain the uncertainty related to the defintion of the calibration function.