Updating the probabilistic density function related to an uncertain parameter of a model for producing voice, using Bayesian approach

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ABSTRACT

The aim of this paper is to use the Bayesian method for updating a probability density function (pdf) related to the tension parameter of the vocal folds. This parameter is mainly responsible for the changing of the fundamental frequency of a voice signal, generated by a mechanical/mathematical model for producing voiced sounds. Three parameters are considered uncertain in the model used: the tension parameter, the neutral glottal area and the subglottal pressure. These uncertain parameters are modeled by random variables and their prior probability density functions are constructed using the Maximum Entropy Principle. The output of the stochastic computational model is the random voice signal and the Monte Carlo method is used to solve the stochastic equations allowing realizations of the random voice signals to be generated. For each realization of the random voice signal, the corresponding realization of the random fundamental frequency is calculated and the prior pdf of this random fundamental frequency is then estimated. Experimental data are available for the fundamental frequency and the posterior probability density function of the random tension parameter is then estimated using the Bayes method.

Modelling The vocal folds model used here is the one created by Ishizaka and Flanagan. Details about the model and the stochastic solver can be found in Cataldo et al. (2009). The process to generate involves a lot of quantities which should be controlled. The three main parameters responsible for these changings are the area at rest between the vocal folds, the subglottal pressure and the tension parameter (q). The three parameters are modelled as random variables and the random variable Q is associated to the parameter q. The goal is to update the pdf of Q, using experimental data. Voice signals produced by one person have been analyzed and their statistics have been compared with simulations. A voice signal corresponding to a sustained vowel /a/ has been recorded from one person and 1,800 frames were obtained from this signal, each one with 0.01 of length. For each frame, the corresponding fundamental frequency has been calculated.

The estimation of the posterior pdf of the random variable Q is given by the Bayes formula (Soize, 2010):

$$P_Q^{\text{post}}(q) = L^{\text{bayes}}(q) P_Q^{\text{prior}}(q) \tag{1}$$

in which

$$L^{\text{bayes}}(q) = \frac{\prod_{\ell=1}^{\nu_{\text{exp}}} p_{F_0|Q}(f_0^{\text{exp},\ell}|q)}{E_Q\left\{\prod_{\ell=1}^{\nu_{\text{exp}}} p_{F_0|Q}(f_0^{\text{exp},\ell}|Q^{\text{prior}})\right\}}\,. \tag{2}$$

The conditional pdfs $P_{F_0|Q}$ were generated by the model. Figure 1 displays the graph of the prior and the posterior pdf of Q for the values The prior pdf for Q used here was an uniform pdf.

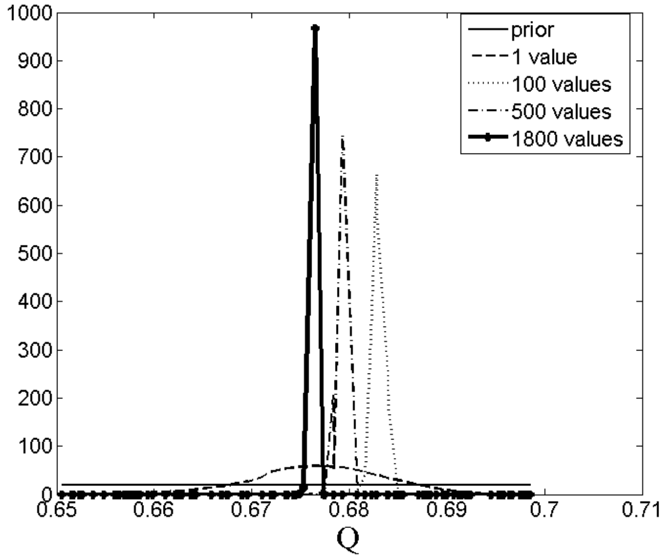

Figure 1: Announcement Folder

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