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Modelling primary auditory cortex hemodynamic response using fMRI data

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This project presents the modeling of the hemodynamic response of the primary auditory cortex using fMRI data. fMRI can be used to map the areas of the brain that are active during a task. The changes in the cerebral blood flow (CBF) and blood oxygenation level with neural activities in the brain are detectable by fMRI techniques. It is an indirect measure of neural activity. Different models are used to describe the relationship between the neuronal activity and the CBF, the cerebral blood volume (CBV) and other hemodynamic parameters. Mathematical models for this hemodynamic response are described as the blood oxygenation level dependent (BOLD) signal as a function of changes in the cerebral oxygen extraction fraction (E) and the CBV. The nonlinearities in the hemodynamic response due to neural activity will contribute to the nonlinearities in the BOLD signal. The techniques that are used to model the nonlinearities of the BOLD signal can be categorized as physiological models, data driven approaches and various parametric estimation techniques.

The most commonly used physiological model is the Balloon Model proposed by Buxton et al. in 1998. This is used as a basis to depict the dynamic change in deoxyhemoglobin during a neural activation coupling with the CBF and the oxygen metabolism. Here, the venous compartment is compared to a distensible balloon. The inflow to the balloon fin is the cerebral blood flow while the outflow from the balloon spout is an increasing function of the balloon volume. The balloon model is considered as the most accurate model up to date to model the hemodynamic response.

In this research, the primary auditory cortex of the brain is modeled in MATLAB© using the Balloon Model as the reference. A frequency sweep lasting 0.75s was used as the stimulus to obtain fMRI data from 20 subjects around the auditory cortex. Data for a specific stimulus paradigm is extracted and analyzed in order to obtain the distributions of optimal parameter values of the balloon model to fit the model to the signal obtained from the extracted data.