

August 2014 QE

1. (20 points) Human EEG recordings contain signals generated by the brain and a wide variety of noise and artifacts. Some artifacts are of technical origin; the others originate from interfering physiological processes unrelated to brain activity. List the most common types of physiological artifacts observed in EEG recordings. Briefly describe their origins and characteristics.
2. (30 points) A common strategy to remove physiological artifacts from EEG recordings requires the acquisition of reference signals that purely characterize the interfering physiological processes of no interest to the study of brain activity. Such reference signals can be used to estimate and then remove the physiological artifacts. Briefly describe (or design) one or multiple artifact processing method(s) that would serve this purpose. State the underlying assumptions made in the method(s).
3. (10 points) Human EEG often exhibits some rhythms that appear as oscillatory signals confined to specific frequency bands. The occurrence of such rhythms largely depends on behavioral and mental states (e.g. sleep and wakefulness). List the common brain rhythms, their respective frequency ranges and corresponding brain states.
4. (20 points) The EEG signal is often non-stationary with time-dependent spectral content. Describe a nonparametric spectral analysis method to extract the joint time-frequency information about the EEG signal.
5. (20 points) Evoked potentials (EPs) constitute an event-related activity which occurs as the electrical response from the brain to various types of sensory stimulation. Individual EPs have a very low amplitude and hidden in the ongoing EEG background activity. Suppose that in an experiment, a human subject receives 1000 instantaneous visual stimuli delivered at known and well-separated times. The background EEG is assumed to be stationary random Gaussian process with the average amplitude of $100\mu\text{V}$. Individual electrical responses to separated stimuli are assumed to have fixed waveforms, durations and amplitudes, which are known to be $5\mu\text{V}$ on average. In this case, describe the method to extract the evoked potential from the recorded EEG and estimate the signal-to-noise ratio of the extracted evoked potential.