Estimation Theory Application to the Processing of Small Noisy Bioelectrical Signals

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Many bioelectrical potentials are small and often being lost in a background noise. It is necessary to develop the appropriate methods to separate such small signals from the noise. In this study, estimation theory was applied to improve the conventional methods, since there are many biosignals that can be regarded as a stochastic process. The Kalman filtering method combined with the averaging procedure was applied to recording of human visually evoked cortical potentials (VECPs) elicited by checkerboard pattern reversal stimuli.

The experimental results indicated that both statistics and frequeucy structure of the spontaneous brain wave activity were unchanged even by falling visual acuity artificially with lens defocusing. Based on these frequency structures, following models of spontaneous brain wave activity were employed to design the Kalman filters; 1) the superimposed output of four lightly damped oscillators (α, β, θ, and δ bands); 2) the output of one oscillators; 3) a first order Markov process; and 4) a white noise process. Among these four models, the second proved to be practical for shortening processing time. Application of these filters enabled to decrease the averaging time from 1/5 to 1/10 compared to that of conventional averaging procedure.