博士論文（要約）

Bayesian Methods for Multivariate and Time Series Data

（多変量および時系列データに対するベイズ統計手法）

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Abstract

This thesis consists of three parts and studies Bayesian methods for multivariate and time series data. Although Bayesian statistical methods are powerful and widely used, the selection of prior distributions is not straightforward. We consider two different approaches to the prior selection problem. One approach is to define some objective criterion on the goodness of prior distributions and develop good priors based on it. The other approach is to focus on some characteristics of data and translate them to the form of prior distributions. We take the former approach in Part I and the latter approach in Part II, respectively. Part III presents a data analysis research that motivated the methods in Part II.

In Part I, we investigate Bayesian shrinkage prediction for multivariate data. First, we develop singular value shrinkage priors for the mean matrix parameters in the matrix-variate normal model, which are superharmonic and provide minimax predictive densities. They are a natural generalization of the Stein prior and work well when the true value of the parameter has low rank. Next, we construct priors that asymptotically dominate singular value shrinkage priors, and develop numerical methods for computing Bayesian predictive densities in regression problems. Finally, we investigate Pitman closeness properties of predictive densities.

In Part II, we consider Bayesian modeling of time series with oscillation components and propose a method for decomposing time series into such oscillation components and estimating their phases. The proposed method is based on Gaussian linear state space models that represent oscillators with random frequency fluctuations. The model parameters are estimated from data using the empirical Bayes method and the number of oscillators is determined using the Akaike Information Criterion. Therefore, the proposed method accomplishes a natural decomposition of the given time series in a data-driven manner. Application to real data shows interesting results.

In Part III, we analyze experimental data from neuroscience. When watching an ambiguous figure that allows multiple interpretations, our interpretation spontaneously switches between possible ones and such spontaneous switching is called perceptual switching. We propose a point process modeling approach for investigating the effects of spontaneous brain activity on perceptual switching. Specifically, we modeled perceptual switching during Necker cube perception using electroencephalography (EEG) data and explored the relationship between the spontaneous brain activity and the perceptual switching using point process models. The results demonstrate that spontaneous occipital alpha activity suppresses perceptual switching to the non-attended interpretation.