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Network-Informed Bayesian Anomaly Detection by using Gaussian Processes

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Anomaly detection identifies cases that deviate from a common behavior or pattern in data streams. It is of great interest in a variety of fields, e.g., from biology recognizing uncommon observations in genetic data, to financial sectors identifying frauds through unusual economic activities. Detection of anomalies can be formulated as a binary classification problem, distinguishing between the anomalies and non-anomalies. In many instances (particularly in financial frauds), available information comes from two sources: covariates characterizing the profile of a case and the network connected to others. In this work, we develop a binary Gaussian process classification model that utilizes information from both sources. We follow the Bayesian paradigm to estimate the parameters and latent states of the model and to naturally quantify the uncertainty for their true values. To derive the covariance matrix of the Gaussian prior distribution of the latent states, we employ kernel functions that model the relationships implied by any available covariates as well as by the network structure of the problem at hand. We develop a bespoke Markov chain Monte Carlo algorithm to obtain posterior samples, enhancing efficiency while reducing complexity in terms of tuning parameters requirements. The performance of the proposed methodology is examined via a simulation study, while an application to real data illustrates its use in practice.

Type of presentation

Talk

Classification

Both methodology and application

Keywords

Anomaly Detection, Bayesian Statistics, Gaussian Process, Network, Supervised Learning

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