Abstract

In this thesis, we study a variational approximation approach for Gaussian process (GP) regression, allowing the spectrum of the covariance function to be subjected to a sparse approximation. This approach takes into account uncertainty in covariance function hyperparameters, which allows the model to be robust to overfitting. First, we focus on the variational Bayes algorithm for fitting sparse spectrum Gaussian process regression models. The assumption of factorized distributions allows us to obtain mean field updates for our variational parameters. In the event of nonconjugate models, nonconjugate variational message passing is employed to derive the updates. Second, a technique of accelerating convergence in nonconjugate variational message passing by varying the step sizes in the gradient ascent method is also introduced. Third, an effective adaptive neighbourhoods approach technique is used in obtaining predictive inferences as it helps to speed up the computational process and can better handle nonstationarity. After describing these ideas in the literature, we make modifications to the algorithm by placing a horseshoe prior on the lengthscales before proceeding to obtain updates and predictive inferences. We show that accuracy is generally well preserved in the modified algorithm with relevant covariates in the data, while significant improvements in the empirical results are observed in the presence of irrelevant covariates.

Author's contribution:
The ideas in the thesis are described in the manuscript by Tan, Ong, Nott, and Jasra (2015). The modification was proposed by my supervisor. I have provided the derivations for several stated expressions under Section 2.4 in detail. I have modified the updates in the original algorithm to accommodate the implementation of the horseshoe prior on the lengthscales. I have done all the necessary modifications of the program codes to incorporate the new ideas.

Keywords:
Local Gaussian process, sparse approximation, horseshoe model, variational Bayes, nonconjugate variational message passing, adaptive neighbourhood, bound optimization.

Implementation Software and Hardware:
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