The main contributions of this thesis are briefly as follows:

i) We introduce novel Bayesian mixture models such as the Sparse Coding based Gaussian mixture and the Field-of-Gaussian mixture, to solve some machine learning problems on image datasets. The Bayesian mixture models addressed here are namely the Gaussian mixture model (GMM), Field-of-Gassian mixture (FoG), Dirichlet process mixture (DPM) and the Sparse Coding based Gaussian mixture model (sGMM). The first two models, GMM [2, 4] and FoG [3] are used to obtain Gaussian mixture based Fisher Vector and Bag-of-Words vector for image categorization datasets. DPM [5] is a Bayesian nonparametric model for model selection on image and signal datasets. Most recent fast DPM algorithms are usually based on Gibbs sampling. Here, we use a fast Bayesian approach to DPM. The last model sGMM [1] is inspired by the recently proposed Sparse Coding based Fisher Vector (SC-FV). Instead of using an off-the-shelf learner such as convex optimization, we use a Bayesian approach to estimate parameters for SC-FV on image categorization datasets.

ii) In order to model the datasets, approximating techniques such as variational inference or Gibbs sampling is necessary due to intractable true posteriors arising from the complex Bayesian mixture models. Due to computational inefficiencies and scalability issues, we propose a variant of variational inference known as the variational maximization-maximization algorithm which mainly update the modes of variational posteriors for iterative learning. Under conjugate priors assumption, our approach can usually lead to analytical solution for the learning of each presented mixture model here.

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