DOCTORAL THESIS

Numerical algorithms for data analysis with imaging and financial applications

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Abstract

In this thesis, we study modellings and numerical algorithms to data analysis with applications to image processing and financial forecast. The thesis is composed of two parts, namely the tensor regression and data assimilation methods for image restoration.

We start with investigating the tensor regression problem in Chapter 2. It is a generalization of a classical regression in order to adopt and analyze much more information by using multi-dimensional arrays. Since the regression problem is subject to multiple solutions, we propose a regularized tensor regression model to the problem. By imposing a low-rank property of the solution and considering the structure of the tensor product, we develop an algorithm which is suitable for scalable implementations. The regularization method is used to select useful solutions which depend on applications. The proposed model is solved by the alternating minimization method and we prove the convergence of the objective function values and iterates by the maximization-minimization (MM) technique. We study different factors which affects the performance of the algorithm, including sample sizes, solution ranks and the noise levels. Applications include image compressing and financial forecast.

In Chapter 3, we apply filtering methods in data assimilation to image restoration problems. Traditionally, data assimilation methods optimally combine a predictive state from a dynamical system with real partially observations. The motivation is to improve the model forecast by real observation. We construct an artificial dynamics to the non-blind deblurring problems. By making use of spatial information of a single image, a span of ensemble members is constructed. A two-stage use of ensemble transform Kalman filter (ETKF) is adopted to deblur corrupted images. The theoretical background of ETKF and the use of artificial dynamics by stage augmentation method are provided. Numerical experiments include image and video processing.

Concluding remarks and discussion on future extensions are included in Chapter 4.

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