DOCTORAL THESIS

Investigations on models and algorithms in variational approaches for image restoration

Fang, Yingying

Date of Award:
2020

Abstract

Variational methods, which have proven to be very useful to solve the ill-posed inverse problems, have been generating a lot of research interest in the image restoration problem. It transforms the restoration problem into the optimization of a well-designed variational model. While the designed model is convex, the recovered image is the global solution found by an appropriate numerical algorithm and the quality of the restored image depends on the accuracy of the designed model. Thus, a lot of efforts have been put to propose a more precise model that can produce a result with more pleasing visual quality. Besides, due to the high-dimension and the non-smoothness of the imaging model, an efficient algorithm to find the exact solution of the variational model, is also of the research interest, since it influences the efficiency of the restoration techniques in the practical applications. In this thesis, we are interested in the designing of both the variational models for image restoration problems and the numerical algorithms to solve these models.

The first objective of this thesis is to make improvements on two models for image denoising. For the multiplicative noise removal, we designed a regularizer based on the statistical property of the speckle noise, which can transform the traditional model (named by AA) into a convex one. Therefore, a global solution can be found independent of the initialization of the numerical algorithm. Moreover, the regularization term added on the AA model can help produce a sharper result. The second model is improved on the traditional ROF model by adding an edge regularization which incorporates an edge prior obtained from the observed image. Extensive experiments show that designed edge regularization has superiority to increase the texture of the recovered result and remove the staircase artifacts in the meanwhile. It is also presented that the edge regularization designed can be easily adapted into other restoration task, such as image deblurring.

The second objective of this thesis is to study the numerical algorithms for a general nonsmooth imaging restoration model. As the imaging models are usually high-dimensional, the existing algorithms usually only use the first-order information of the image. Differently, a novel numerical algorithm based on the inexact Lagrangian

function is proposed in this thesis, which exploits the second-order information to reach a superlinear convergence rate. Experiments show that the proposed algorithm is able to efficiently reach the solution with higher accuracy compared to the state-of-the-art algorithm.

Keywords: Variational methods; Image restoration; Convex model; non-smooth; high-dimension; Numerical algorithms;

Table of Contents