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硕士学位论文

基于MAP的图像超分辨率重建算法研究

The Research of Image Super-resolution  
Reconstruction Algorithm Based on MAP

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## 摘要

随着图像智能化处理在各个领域的日益广泛应用，人们对图像的分辨率和清晰度提出了更高的要求，当前通过传感器捕捉的图像分辨率逐渐满足不了日益增长的需求，同时由于光学器件的物理局限性和昂贵的成本价格，因此基于软件思想的图像超分辨率重建的信号处理技术应运而生。超分辨率重建 (Super-Resolution Reconstruction, SRR) 技术利用已有的低分辨率成像系统，通过信号处理的方式来提高图像的分辨率，这种技术在国内外学术界和商业上得到了极大的重视和深入的研究，具有重要的理论和应用价值。

本文对于图像超分辨率重建的问题主要围绕着最大后验概率 (Maximum A Posteriori, MAP) 的方法进行了一些研究和改进，主要完成的工作内容包括：首先，引入了一种基于关键点滤波 (Critical-Point Filters, CPF) 的图像配准方法。相对于传统的光流估计方法，经过测试，关键点滤波图像配准能更有效地表达各种非平移的运动，如旋转、缩放等，同时实现了图像的自动配准，因此可以更有效地计算出低分辨率图像序列的运动矢量。

然后，对基于MAP正则化的超分辨率重建算法进行研究。首先对保真度项和正则化项进行了分析和比较，给出了基于关键点滤波图像配准的重建算法，该算法结合了L1范数的保真度项和总变分算子的正则化项，并采用了关键点滤波配准方法。经过测试，表明了基于关键点滤波图像配准的重建算法的有效性，特别在视频图像序列的测试中效果更佳。最后在此重建算法基础上加入了自适应正则化参数，经过测试，表明了自适应算法取得较优的重建结果。

最后，对MAP/POCS混合算法进行研究和改进。首先对传统的混合算法进行了分析，得出传统方法只是简单地结合两种算法。然后针对传统算法的缺点进行改进，把POCS的残差约束集合加入到基于关键点滤波图像配准的MAP正则化算法中，在每一次迭代重建中，对重建的图像的像素点进行约束，可以更好的结合两种算法的优势。经过测试，表明了改进的MAP/POCS混合算法的有效性。

**关键词：**超分辨率重建；MAP；关键点滤波；自适应；MAP/POCS

## Abstract

With intelligent image processing increasingly wide range of applications in various fields, the higher requirements of the resolution and clarity of the image had been proposed. Currently the resolution of the image captured by the sensor gradually failed to meet the growing demand, at the same time due to the physical limitations of the optics and expensive cost price. Therefore, based on the software implementation of image super-resolution reconstruction of signal processing technology emerged. Super-resolution reconstruction using existing low-resolution imaging system, to improve the resolution by the image signal processing. This technology has been a great deal of attention and in-depth research in the academic and commercial, has important theoretical and practical value.

In this paper, it carried out some research and improvement of image super-resolution reconstruction around the MAP method, mainly to complete the work includes:

Firstly, this paper introduces an image registration method based on the critical-point filters. Compared with the traditional optical flow estimation method, after the test, the critical-point filters can more effectively express a variety of non-translational motion, such as rotation, scaling, while achieving the automatic registration of the image, so we can more effectively calculated motion vector between the low-resolution image sequence.

Secondly, this paper researches the MAP-based regularization super-resolution reconstruction algorithm. First of all, this paper analyses and compares the data fidelity term and the regularization term, and presents a reconstruction algorithm based on the critical-point filters registration. The algorithm combines the L1 norm fidelity term and total variation operator regularization term, and with the critical-point filters registration method. After the test, the results show that the

effectiveness of the reconstruction algorithm based on the critical-point filters registration method, particularly in the natural scene sequence test better. Finally, On the basis of the reconstruction algorithm based on the critical-point filters registration method joined the adaptive regularization parameter, after the test, the results show that the adaptive algorithm to obtain the optimum reconstruction results.

Finally, this paper researches and improves the MAP/POCS hybrid algorithm. First of all, this paper analyses the traditional hybrid algorithm, learns that the traditional method of simply combining the two algorithms. Then, to improve the traditional algorithm, the POCS residual set of constraints were added to the reconstruction algorithm based on the critical-point filters registration method. In every iterative reconstruction, the pixels of the image reconstruction were constrained, so it can be better combined with the advantages of the two algorithms. After the test, the results show that the improved MAP/POCS hybrid algorithm is effective.

**Keywords:** Super-Resolution Reconstruction; MAP; Critical-Point Filters; Adaptive; MAP/POCS

## 参考资料

- [1]S.C.Park,M.K.Park,M.G.Kang,Super-resolution image reconstruction: A technical overview[J]. IEEE Signal Processing Magazine, vol. 20, no. 3, pp. 21-36, 2003.
- [2]Cheeseman.P,Kanefsky.B,Kraft.R.,Stutz.J,Hanson.R.Super-resolved surface reconstruction from multiple image[R].NASA Ames research Center,Moffett Field,CA,Tech.
- [3]Hunt B.R.,Sementilli P.J.Description of a Poisson imagery super-resolution algorithm[A].Astronomical Data Analysis Software and System I,Worrall D.M.,Biemserfer C.,Barnes.J,Eds.,Astronomical Society of the Pacific,San Francisco,Calif,USA,1992,25:196-199.
- [4]Sementilli P.J.,Nadar M.S.,Hunt B.R.,Poisson MAP super-resolution estimator with smoothness constraint[A].In:Proceedings of SPIE Neural and Stochastic Methods in Image and Signal Processing II,1993,2032:2-13.
- [5]Schultz RR,Stevenson RL.Extraction of high-resolution frames from video sequence[J].IEEE Transactions on Image Processing,1996,5(6):996-1011.
- [6]Schultz RR,Stevenson RL.A Bayesian approach to image expansion for improved definition[J]. IEEE Transactions on Image Processing,1994,3(3):233-242.
- [7]Hardie R.C.,Tuinstra T.R.,Bognar J.,Barnard K.J.,Armstrong E.,High resolution image reconstruction from digital video with global and non-global scene motion[A].In:Proceedings of the IEEE International Conference on Image Processing,Santa Barbara,CA,1997,1:153-156.
- [8]Elad M.,Feuer A.Restoration of a single super-resolution image from several blurred,noisy,and under-sampled measured images[J].IEEE Transactions on Image Processing,1997,6(12):1646-1658.
- [9]Hong M.C.,Kang M.G.,Katsaggelos A.K.A regularized multi-channel restoration approach for globally optimal high resolution video sequence[A].SPIE VCIP,San Jose,CA,1997,3024:1307-1317.
- [10]Hong M.C.,Kang M.G.,Katsaggelos A.K.An iterative weighted regularized algorithm for improving the resolution of video sequences[A].In:Proc.Int.Conf.Image Processing,1997,2:474-477.
- [11]Hardie R.C.,Barnard K.J.,Bognar J.G.,Armstrong E.E.,Warson E.A.High resolution image reconstruction from a sequence of rotated and translated frames and its application to an infrared imaging system[J].Optical Engineering,1998,73(1):247-260.
- [12]Nguyen N.X.Numerical algorithms for image super-resolution[D].California:Stanford University,2000.
- [13]Nguyen N.,Milanfar P.,Golub G.Efficient generalized cross-validation with applications to parametric image restoration and resolution enhancement[J].IEEE Trans.Image Processing,2001,10(9):1299-1308.
- [14]Capel D.,Zisserman A.Super-resolution enhancement of text image sequences[A].In:Proc,Intl.Con.Patt,Recog.,2000,1:600-605.
- [15]Rudin L.,Osher S.,Fatemi E.Nonlinear total variation based noise removal algorithm[J].Physica D,1992,60:259-268.
- [16]Elad M.On the bilateral filter and ways to improve it[J].IEEE Trans.on Image Processing,2002,11(10):1141-1151.
- [17]Farisiu S.,Robinson D.,Elad M.,Milanfar P.Fast and robust multi-frame super-resolution[J].IEEE Transactions on Image Processing,2004,13(10):1327-1344.
- [18]Tomasi C.,Manduchi R.Bilateral filtering for gray and color images[A].In:Proc.of the 6th Int ' l Conf.on Computer Vision,1998.839-846.
- [19]Ng M.K.,Shen H.F.,Lam E.Y.,Zhang L.P. A total variation regularization based super-resolution reconstruction algorithm for digital video[J].Accepted by EURASIP Journal on Applied Signal Processing,2007,Article ID 74585.
- [20]Gilboa G,Sochen N.A.,Zeevi Y. Forward and backward diffusion processes for adaptive image enhancement and denoising[J].IEEE Transactions on Image Processing,2002,11(7):689-703.
- [21]S.Babacab,R.Molina,A.Katsaggelos.Variational Bayesian super resolution[J]. IEEE Transactions on Image

Processing,2011,20(4):984-999.

[22]Chan T.,Marquina A.,Mulet P.High order total variation-based image restoration[J].SIAM Journal on Scientific Computing,2000,22(2):503-516.

[23]Meyer Y.Oscillating patterns in image processing and nonlinear evolution equation[R].Volume 22 of University Lecture Series,AMS,Providence,2001.

[24]王程,王润生.基于MAP框架的图像序列超分辨率和模块匹配[J].计算机学报,2003,26(8):961-967.

[25]苏秉华,伟其,牛丽红,刘广荣,刘明奇.基于Markov约束的泊松最大后验概率超分辨率图像复原算法[J].光子学报,2002,31(4):492-496.

[26]张新明,沈兰荪.在小波变换域内实现图像的超分辨率复原[J].计算机学报,2003,26(9):1183-1189.

[27]张新明,沈兰荪.基于多尺度边缘保持正则化的超分辨率复原[J].软件学报,2003,14(06):1075-1081.

[28]程燕.图像超分辨率重建关键技术的研究[D].上海:上海交通大学,2007.

[29]Keller J, 1976. Inverse problems[J]. American Mathematical Monthly, 83(2): 107-118.

[30]S.P.Kim,N.K.Rose,H.M.Valenzuela.Recursive reconstruction of high resolution image from noisy undersampled multiframes[J],IEEE Trans.on Accustics Speech and Signal Processing,1900,38(6):1013-1027.

[31]H.Ur,D.Gross.Inproved resolution from sub-pixel shifted pictures[J].CVGIP: Graphical Models and Image Processing,1992,Vol.54(2):181-186.

[32]M.Irani,S.Peleg.Improving resolution by image registration[J].CVGIP:GRAPH.Model Image Process,1991,53(3):231-239.

[33]M.K.Ozkan,A.M.Tekalp,M.I.Sezan.POCS-based restoration of space-varying blurred images[J].IEEE Trans IP,1994,3(4):450-454.

[34]G.T.Herman,H.Hurwitz,A.Lent,andH-P.Lung. On the Bayesian approach to image reconstruction[J]. Information and Control , 42(1):60 – 71, 1979.

[35]Hardie.R.C, Barnard.K.J, Armstrong.E.E. Joint MAP registration and high-resolution image estimation using a sequence of undersampled images[J]. IEEE Transactions on Image Processing, 1997, 6(12).

[36]Michael.E.T,Bishop.M. Bayesian image super-resolution[J]. Proceedings of Advances in Neural Information Procecdings systems, 2003, : 1279-1286.

[37]Schultz R R, Stevenson R L. A bayesian approach to image expansion for improved definition[J]. IEEE Transactions on Image Processing, 1994, 3(3): 233-242.

[38]Rudin L, Osher S, Fatemi E. Nonlinear total variation based noise removal algorithms[J]. International Journal of Imaging Systems and Technology, 1992, 60(1):259-268.

[39]Capel D, Zisserman A. Super-resoluton enhancement of text image sequences[C].Proceedings of the International Conference on Pattern Recognition, 2000.1600-1605.

[40]Farsiu S, Robinson M D, M E, et al. Fast and robust multiframe super resolution[J]. IEEE Transactions on Image Processing, 2004, 13(10): 1327-1344.

[41]姚庆栋,等. 图像编码基础[M]. 北京: 清华大学出版社,2006.

[42]J.R.Bergen, P.Anandan, K.J.Hanna, et al.Hierachical model-based motion estimation [C]. Computer Vision: Europe,1992,237-252.

[43]J.Y.Bouquet. Pyramidal implementation of the Lucas Kanade feature tracker description of the Algotithm[R].Inter Corporation, Microprocessor Research Labs,2002.

[44]Lindeberg.T. Scale-space theory : A basic tool for analysing structuresat different scales[J].Journal Applied Statistics,1994,21(2):223-261.

[45]Y.Shinagawa and T.L.Kunii,Unconstrained automatic image matching using multiresolutional critical-point filters[J].IEEE Trans.on Pattern Analysis and Machine Intelligence,1998,20(9):994-1010.

[46]张贻雄. 视频压缩算法及基于嵌入式MPSOC的视频编码研究与实现[D]. 浙江: 浙江大学,2009,19-28.

[47]G. Aubert, P. Kornprobst. Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations [M]. New York:Springer, 2001.

[48]Farsu S, Robinson D. Fast and Robust Multiframe Super Resolution[J]. IEEE Trans on Image Process,



2004,13(10): 1327-1344.

[49]Farsiu S, Robinson D, Elad M, et al. Robust shift and add approach to super resolution[C]. in Proc. SPIE Conf, Applications of Digital Signal and Image Processing, 2003,pp:121-130.

[50]C. R. Vogel, M. E. Oman. Fast Robust Total Variation Based Reconstruction of Noisy Blurred Images [J]. IEEE Transactions on Image Processing, 1998, 7(6): 813-824.

[51]Lee E, Kang M G, 2003. Regularized Adaptive High-resolution Image Reconstruction Considering Inaccurate Subpixel Registration[J]. IEEE Trans Image Processing, 12(7): 826-883.

[52]Huanfeng Shen, Ping xiang Li, Liangpei Zhang, et al. 2004. A MAP Algorithm to Super-Resolution Image Reconstruction[C]. ICIG,pp: 544-547.

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