光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林

光学精密工程 2013, 21(12) 3272-3282 ISSN: 1004-924X CN: 22-1198/TH DOI:10.3788/OPE.20132112.3272

信息科学

基于广义线性运算和双边滤波的红外图像增强

贾宏光1，吴泽鹏1,2*，朱明超1，宣明1，刘慧1

1.中国科学院 长春光学精密机械与物理研究所，吉林 长春 130033；
2. 中国科学院大学，北京 100049

摘要： 针对传统的基于反锐化掩模法的红外图像增强方法噪声干扰较高且有光晕现象，提出了基于广义线性运算和双边滤波(BF)的红外图像增强方法。首先，通过双边滤波得到图像的基础层部分。接着，设计了广义线性运算模型，并在这个运算模型下对图像细节进行了非线性分割、去噪和自适应放大。最后，将经过动态范围压缩的图像基础层和自适应增强的图像细节层非线性叠加，得到最后的增强图像。另外，针对传统评价增强图像质量的平均对比度指标的缺点，提出了由局部到整体的改进平均对比度评估方法。3组对比实验观察和定量分析表明，本文提出的方法在对红外图像有效动态范围压缩和细节放大的同时，很好地抑制了红外图像的干扰噪声和光晕现象，得到的结果非常适用于实际红外热像仪的后端图像处理。

关键词： 红外图像 图像增强 广义线性运算 双边滤波

Infrared image enhancement based on generalized linear operation and bilateral filter

JIA Hong-guang1, WU Ze-peng1,2, ZHU Ming-chao1,XUAN Ming1,LIU Hui1

1. Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033,China;2. Uiversity of Chinese Academy of Sciences,Beijing 100049,China

Abstract: As classical infrared image enhancement methods based on Unsharp Masking（UM） suffer from terrible noise interference and halo effect, a new approach based on generalized linear operation and Bilateral Filtering (BF) was proposed here. Firstly, the elemental part of the image was extracted by using the BF and then operation models based on generalized linear operation were designed for the following enhancement. In the new operation scheme, the image details were nonlinearly segmented, denoised and amplified and the dynamic range of the elemental part was compressed while the detailed part was enhanced adaptively. Finally, the enhanced image was obtained by adding the processed elemental and detailed parts together nonlinearly. Furthermore, an assessment method for image quality was presented. Unlike the classical metric which only considers the average contrast enhancement, the modified one involves both local and general average contrast enhancements. Both the comparison experiments and measurement index indicate that the proposed method can compress the dynamic range of infrared images, amplify their details, and suppress the noise interference and halo effect. This technique has a significant contribution to the posterior image processing of thermal infrared cameras.

Keywords: Infrared image image enhancement generalized linear operation Bilateral filter

收稿日期 2013-01-03 修回日期 2013-03-02 网络版发布日期 2013-12-25

基金项目:

中国科学院知识创新工程国防科技创新重要项目

通讯作者: 吴泽鹏

作者简介: 吴泽鹏（1988-），男，浙江丽水人，硕士研究生，2011年于中国科学技术大学获得学士学位，主要从事红外图像增强和跟踪技术的研究。
作者Email: wuzepeng@mail.ustc.edu.cn

参考文献：

［1］金伟其,刘斌,范永杰,等.红外图像细节增强技术研究进展［J］.红外与激光工程,2011,40(12):2521-2527. JIN W Q, LIU B, FAN Y J, et al.. Review on infrared image detail enhancement techniques ［J］. Infrared and Laser Engineering, 2011,40 (12):2521-2527. (in Chinese) ［2］吴家伟,武春风,庹文波. 红外图像实时显示增强系统设计［J］.光学 精密工程,2009,17(10):2612-2619. WU J W, WU CH F ,TUO W B. Design of real-time infrared image enhancing system ［J］.Opt. Precision Eng.,2009,17(10): 2612-2619. (in Chinese) ［3］张晓龙，刘英，孙强. 高精度非致冷长波红外热像仪的辐射标定［J］. 中国光学，2012，5(3):235-241. ZHANG X L,LIU Y,SUN Q. New method for eliminating non-uniformity background of IR image ［J］.Chinese Optics,2012,5(3):235-241.(in Chinese) ［4］刘火平, 孟维平, 宋立维,等. 红外图像序列中不均匀背景消除新方法［J］. 液晶与显示,2012,27(4):539-544. LIU H P, MENG W P,SONG L W, et al.. New method for eliminating non-uniformity background of IR image ［J］.Chinese Journal of Liquid Crystals and Displays,2012,27(4): 539-544. (in Chinese) ［5］孙海江，王延杰，刘伟宁.基于自适应平台阈值和拉普拉斯变换的红外图像增强［J］.中国光学，2011，4（5）：474-479. SUN H J,WANG Y J,LIU W N. Enhancement of infrared images based on adaptive plat form threshold and Laplace transformation ［J］.Chinese Optics,2011,4(5):474-479.(in Chinese) ［6］黄梅, 吴志勇, 梁敏华,等. 暗背景下低灰度图像的实时增强［J］.液晶与显示,2011,26(3):374-378. HUANG M, WU ZH Y, LIANG M H, et al.. Real-time enhancement method of low gray image under dark background ［J］. Chinese Journal of Liquid Crystals and Displays,2012,26(3):374-378. (in Chinese) ［7］PIZER S M,AMBUM E P,AUSTIN J D, et al.. Adaptive histogram equalization and its variations［J］. Computer Vision,Graphics,and Image Processing,1987,39(3):355-368. ［8］ZUIDERVELD K. Contrast limited adaptive histogram equalization ［J］. Graphics Gems IV,1994, 474-485 ［9］REZA A M. Realization of Contrast Limited Adaptive Histogram Equalization

(CLAHE) for real-time image enhancement ［J］. Journal of VLST Signal Precessing Systems for Signal,Image and Video Technolgy,2004,38(1):35-44. ［10］BRANCHITTA F,DIANI M, CORSINI G,et al.. Dynamic-range compression and contrast enhancement in infrared imaging systems ［J］. Opt. Eng., 2008, 47(7):076401. ［11］BRANCHITTA F,DIANI M,CORSINI G,et al.. New technique for the visualization of high dynamic range infrared images ［J］. Opt. Eng.2009,48(9): 096401. ［12］TOMASI C,MANDUCHI R. Bilateral filtering for gray and color images ［C］. Proceedings of the 1998 IEEE International Conference on Computer Vision, New Delhi, India, 1998, 839-846. ［13］ELAD M. On the origin of the bilateral filter and ways to improve it ［J］. IEEE Transactions on Image Processing, 2002, 11(10):1141-1151. ［14］DURAND F, DORSEY J. Fast bilateral filtering for the display of high-dynamic-range images ［J］. ACM Trans. Graphics, 2002,213:257-266. ［15］PARIS S,DURAND F. A fast approximation of the bilateral filter using a signal processing approach ［J］. International Journal of Computer Vision，2009, 81(1):24-526. ［16］WEISS B. Fast median and bilateral filtering ［J］. ACM Transactions on Graphics (TOG), 2006,25(3):518-526. ［17］ZUO CH,CHEN Q,et al.. Display and detail enhancement for high-dynamic-range infrared images ［J］. Opt. Eng. 2011, 50(12):127401. ［18］DENG G. A Generalized Unsharp Masking Algorithm ［J］. IEEE Transactions on Image Processing, 2011,20(5): 675 - 684. ［19］SHVAYTSER H,PELEG S. Inversion of picture operators ［J］. Pattern Recognition Letters, 1987,5(1):49-61.

本刊中的类似文章

1．穆治亚 魏仲慧 何昕 梁国龙.采用稀疏表示的红外图像自适应杂波抑制[J]. 光学精密工程, 2013,21(7): 1850-1857

2．孙伟 李大健 刘宏娟 贾伟.基于大气散射模型的单幅图像去雾[J]. 光学精密工程, 2013,21(4): 1040-1046

3．张士杰 李俊山 杨亚威 张仲敏.湍流退化红外图像降晰函数辨识[J]. 光学精密工程, 2013,21(2): 514-521

4．许辉 张俊举 袁轶慧 张鹏辉 韩 博.红外与可见光图像融合系统的探测概率[J]. 光学精密工程, 2013,21(12): 3205-3213

5．米曾真, 谢志江, 陈涛, 楚红雨, 范兵.重轨图像增强与边缘提取的关键技术[J]. 光学精密工程, 2012,20(7): 1645-1652

6．韩希珍, 赵建.结合偏微分方程增强图像纹理及对比度[J]. 光学精密工程, 2012,20(6): 1382-1388

7．秦翰林, 周慧鑫, 刘群昌, 赖睿.采用多尺度隐式马尔可夫模型的红外图像背景抑制[J]. 光学精密工程, 2011,19(8): 1950-1956