A New Class of Multichannel Image Processing Filters: Vector Median–Rational Hybrid Filters

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SUMMARY   A new class of nonlinear filters called Vector Median Rational Hybrid Filters (VMRHF) for multispectral image processing is introduced and applied to color image filtering problems. These filters are based on Rational Functions (RF). The VMRHF filter is a two-stage filter, which exploits the features of the vector median filter and those of the rational operator. The filter output is a result of vector rational function operating on the output of three sub-functions. Two vector median (VMF) sub-filters and one center weighted vector median filter (CWVMF) are proposed to be used here due to their desirable properties, such as, edge and details preservation and accurate chromaticity estimation. Experimental results show that the new VMRHF outperforms a number of widely known nonlinear filters for multispectral image processing such as the Vector Median filter (VMF) and Distance Directional Filters (DDF) with respect to all criteria used.

key words: rational functions, vector rational filters, vector median filters, vector median–rational hybrid filters

1. Introduction

Multichannel image processing is investigated in this paper using a vector approach [10]. This has been proved to be more appropriate for vector-valued signals compared to traditional component-wise approaches. The suitability of such a technique is often credited to the inherent correlation that exists between the image channels [10]. In the vector approach, each image element is considered as an m-dimensional vector (m is the number of image channels). Color image pixels are often represented by three-component vectors, $m = 3$, whose characteristics, i.e., magnitude and direction are examined. The vector's direction signifies its chromaticity; while, its magnitude is a measure of its brightness. A number of vector processing filters have been proposed in the literature for the purpose of color image processing [2], [11]. One class of filters considers the distance between the vector space between image vectors; typical representative of this class is the "vector median filter" (VMF) [1]. A second class of filters, called "vector directional filters" (VDF) [16], operates by considering the vectors' direction. VMFs are derived as maximum likelihood estimators for an exponential distribution [1]; while, VDFs are spherical estimators, when the underlying distribution is a spherical one [16]. A third class of filters uses rational functions in its input/output relation, and hence the name "vector rational filters" (VRF) [6]. There are several advantage to the use of this function. Similarly to a polynomial function, a rational function is a universal approximator (it can approximate any continuous function arbitrarily well); however, it can achieve a desired level of accuracy with a lower complexity, and possesses better extrapolation capabilities. Moreover, it has been demonstrated that a linear adaptive algorithm can be devised for determining the parameters of this structure [9].

In this paper, a novel nonlinear vector filter class is proposed: the class of vector median-rational hybrid filters (VMRHFs). This is an extension of the nonlinear rational type hybrid filters called median-rational hybrid filter's (MRHFs) recently introduced for 1-D and 2-D signal processing [7], [8], based on rational filters [9], [15]. The VMRHF is formed by three sub-filters (two vector median filters and one center weighted vector median filter) and one vector rational operation. VMRHF are very useful in color (and generally multichannel) image processing, since they inherit the properties of their ancestors. They constitute very accurate estimators in long- and short-tailed noise distributions and, at the same time, preserve the chromaticity of the color image. Moreover, they act in small window and require few number of operations, resulting in simple and fast filter structures.

This paper is organized as follows. Section 2 briefly reviews rational functions and vector rational function filters. In Sect. 3, we define the vector median-rational hybrid filter (VMRHF) and point out some of its important properties. The proposed filter structures are presented in Sect. 4. Section 5 includes simulation results and discussion of the improvement achieved by the new VMRHF. In order to incorporate perceptual criteria in the comparison, the error is measured in the the uniform $L^*a^*b^*$ color space, where equal color differences result in equal distances [14]. Section 6 concludes the paper.

2. Rational Function and Vector Rational Function Filters

A rational function is the ratio of two polynomials. To be used as a filter, it can be expressed as:

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Advances in Low-Level Color Image Processing M. Emre Celebi,Bogdan Smolka,2013-12-17 Color perception plays an important role in object recognition and scene understanding both for humans and intelligent vision systems Recent advances in digital color imaging and computer hardware technology have led to an explosion in the use of color images in a variety of applications including medical imaging content based image retrieval biometrics watermarking digital inpainting remote sensing visual quality inspection among many others As a result automated processing and analysis of color images has become an active area of research to which the large number of publications of the past two decades bears witness The multivariate nature of color image data presents new challenges for researchers and practitioners as the numerous methods developed for single channel images are often not directly applicable to multichannel ones The goal of this volume is to summarize the state of the art in the early stages of the color image processing pipeline **Color Image Processing** Rastislav Lukac,Konstantinos N. Plataniotis,2018-10-03 Color Image Processing Methods and Applications embraces two decades of extraordinary growth in the technologies and applications for color image processing The book offers comprehensive coverage of state of the art systems processing techniques and emerging applications of digital color imaging To elucidate the significant progress in specialized areas the editors invited renowned authorities to address specific research challenges and recent trends in their area of expertise The book begins by focusing on color fundamentals including color management gamut mapping and color constancy The remaining chapters detail the latest techniques and approaches to contemporary and traditional color image processing and analysis for a broad spectrum of sophisticated applications including Vector and semantic processing Secure imaging Object recognition and feature detection Facial and retinal image analysis Digital camera image processing Spectral and superresolution imaging Image and video colorization Virtual restoration of artwork Video shot segmentation and surveillance Color Image Processing Methods and Applications is a versatile resource that can be used as a graduate textbook or as stand alone reference for the design and the implementation of various image and video processing tasks for cutting edge applications This book is part of the Digital Imaging and Computer Vision series **Nonlinear Signal and Image Processing** Kenneth E. Barner,Gonzalo R. Arce,2003-11-24 Nonlinear signal and image processing methods are fast emerging as an alternative to established linear methods for meeting the challenges of increasingly sophisticated applications Advances in computing performance and nonlinear theory are making nonlinear techniques not only viable but practical This book details recent advances in nonl **Computer Analysis of Images and Patterns** Wladyslaw Skarbek,2003-06-30 Computer analysis of images and patterns is a scienti c eld of longstanding tradition with roots in the early years of the computer era when electronic brains inspired scientists Moreover the design of vision machines is a part of humanity s dream of the arti cial person I remember the 2nd CAIP held in Wismar in 1987 Lectures were read in German English and Russian and proceedings were also only partially written in

English The conference took place under a di erent political system and proved that ideas are independent of political walls A few years later the Berlin Wall collapsed and Professors Sommer and Klette proposed a new formula for the CAIP let it be held in Central and Eastern Europe every second year There was a sense of solidarity with scienti c communities in those countries that found themselves in a state of transition to a new economy A well implemented idea resulted in a chain of successful events in Dresden 1991 Budapest 1993 Prague 1995 Kiel 1997 and Ljubljana 1999 This year the conference was welcomed at Warsaw There are three invited lectures and about 90 contributions written by more than 200 authors from 27 countries Besides Poland 60 authors the largest representation comes from France 23 followed by England 16 Czech Republic 11 Spain 10 G many 9 and Belarus 9 Regrettably in spite of free registration fees and free accommodation for authors from former Soviet Union countries we received only one accepted paper from Russia   **Multimedia Image and Video Processing** Ling Guan,Sun-Yuan Kung,Jan Larsen,2000-08-23 Multimedia stands as one of the most challenging and exciting aspects of the information era Although there are books available that deal with various facets of multimedia the field has urgently needed a comprehensive look at recent developments in the systems processing and applications of image and video data in a multimedia environment   *Visual Communications and Image Processing '96* ,1996   **Image Processing** Yung-Sheng Chen,2009-12-01 There are six sections in this book The first section presents basic image processing techniques such as image acquisition storage retrieval transformation filtering and parallel computing Then some applications such as road sign recognition air quality monitoring remote sensed image analysis and diagnosis of industrial parts are considered Subsequently the application of image processing for the special eye examination and a newly three dimensional digital camera are introduced On the other hand the section of medical imaging will show the applications of nuclear imaging ultrasound imaging and biology The section of neural fuzzy presents the topics of image recognition self learning image restoration as well as evolutionary The final section will show how to implement the hardware design based on the SoC or FPGA to accelerate image processing   **Visual Communications and Image Processing** ,1996   **Visual Communications and Image Processing '93** ,1993   **Nonlinear Image Processing** ,1998   Applications of Digital Image Processing ,1999   **Computer Analysis of Images and Patterns** ,2001   Multispectral and Hyperspectral Image Acquisition and Processing Qingxi Tong,Yaoting Zhu,Zhenfu Zhu,2001   **Multidimensional Signal Processing Workshop** ,   The IEEE 2000 Adaptive Systems for Signal Processing, Communications, and Control Symposium ,2000 The proceedings of the Symposium on Adaptive Systems for Signal Processing Communications and Control 2000 It addresses fundamentals of adaptive and learning systems signal processing radar sonar wireless communications pattern recognition chaos and more   *Optical Metrology for Arts and Multimedia* Renzo Salimbeni,2003   *1998 IEEE Symposium on Advances in Digital Filtering and Signal Processing* ,1998   **Sixth Multidimensional Signal Processing Workshop** ,1989   Proceedings, International Conference on Image Processing ,1995   *Image and Signal Processing for Remote*

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