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RESEARCH ARTICLE

Anisotropic Morphological and LLSURE Based Edge Preserving Image Filtering

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Abstract— ***This paper gives a new filtering technique for high quality edge preserving image filtering. Filtering is perhaps the most important operation of image processing and computer vision, and it is used extensively in a wide range of applications, including image smoothing and sharpening, noise removal, resolution enhancement and reduction, feature extraction, and edge detection. The anisotropic morphological filter is based on the shape and orientation of structuring element at each pixel. The Anisotropic Morphological filters are employed on binary and gray-level images for improvement of anisotropic features such as coherent, flow-like arrangements. This paper also presents a review on various filtering techniques emerged recently. The survey is represented in tabular form for quick reference.***

Key Terms: - Edge preserving image filtering; Stein's unbiased risk estimate (SURE); Anisotropic morphological filter; Diagonal normalized steepest descent; Noise level function

I. Introduction

Filtering is perhaps the most important operation of image processing and computer vision, and it is used extensively in a wide range of applications, including image smoothing and sharpening, noise removal, resolution enhancement and reduction, feature extraction, and edge detection. The simplest filtering should be explicit linear translation invariant LTI filtering, which can be implemented using a convolution mask. To reduce these undesirable effects of linear filtering, a variety of edge-preserving filtering techniques have been proposed over the past few years. Since taking into account local structures and statistics during the filtering process, edge preserving filtering is non-linear and can preserve the image details and local geometries while removing the undesirable noise.

Edge-preserving smoothing filters are wildly used as useful tools for a variety of image editing and manipulation tasks, most of them are originally proposed to remove noise while preserving fine details and geometrical structures in the original image. LLSURE filter is based on a local linear model and the principle of Stein's unbiased risk estimate SURE.

This filter has a fast and exact linear-time algorithm whose computational complexity is independent of the filtering kernel size; thus, it can be applied to real time image processing tasks. In this case, the filtered output in a local window are considered as a very simple affine transform of input signal in the same window, and the optimal transform coefficients are determined by minimizing the SURE. The LLSURE filter has the edge preserving smoothing property that can filter out noise while preserving edges and fine-scale details. Moreover, it is very simple and has an exact linear-time algorithm which can be applied to various image processing tasks.

II. LITERATURE SURVEY ON EDGE PRESERVING IMAGE FILTERING

In signal processing, an image processing filter is a device or process that removes from a signal some unwanted component or feature. There are many different bases of classifying filters and these overlap in many different ways.

A. Diagonal Normalized Steepest Descent

Diagonal Normalized Steepest Descent (DNSD) is a single iteration of the Jacobi algorithm which yields the bilateral filter. Noise removal is a practical problem raised in many systems. Apart from the trivial application of removing noise prior to presenting the signal to a human observer, pre-smoothing a signal and noise removal may help to improve the performances for many signal-processing algorithms, such as compression, detection, enhancement, recognition, and more. The bilateral filter uses a novel penalty functional. For this functional the diagonal normalized steepest descent is used. Based on this observation, the bilateral filter can be improved by speed-up its smoothing operation. The bilateral filter can be extended to treat more general reconstruction problems such as image restoration, image scaling, super-resolution, and more.

B. Noise Estimation Using Noise Level Function

Noise is strongly dependent on the image intensity level. The noise level can be called as a function of image intensity, the noise level function (NLF). Since it may not be possible to find image regions at all the desired levels of intensity or color needed to describe the noise level function, the Columbia camera response function database is used to model the NLF using principal components and bounds on derivatives. These principal components serve as a prior model to estimate the NLF over regions of missing data. The inferred NLFs are useful for computer vision algorithms that require knowing the noise level to set algorithm parameters or to select a relevant training set. Using the NLF noise estimates to set algorithm parameters, the results achieves robust over a wide range of image noise levels.

C. Clone Brushing For Image Based Modeling

Clone brushing one of the most powerful tools for the seamless alteration of pictures. Clone brush interactively copies a region of the image using a brush interface. This is often used to remove undesirable portions of an image, such as blemishes or distracting objects in the background. The user chooses a source region of the image and then paints over the destination region using a brush those copies from the source to the destination region. Clone brushing has its limitations when object shape or perspective causes texture foreshortening. Only parts of the image with similar orientation and distance can be clone brushed. Artifacts also appear when the intensity of the target and source regions does not match.

D. Tone-Management Technique

The issues of workflow and efficiency are becoming prevalent among professional users. The workflow describes the full process from image capture to printing and can include multiple software stages and manual retouching, all requiring much effort. Reducing the user work is critical to professionals, and many manuals and tools are dedicated to optimizing and automating all steps. The Tone-Management Technique focus on the tonal aspects of photos decoupled from their content. This demonstrates the wide range of looks that this approach can produce. This provides simple controls and enables both global and local tone management. In addition to direct manipulation, users can transfer the look of a model picture.

The aspects such as the intensity distribution at different scales, spatial variations, and the amount and distribution of detail are critical to the look of a photograph. This inspires the use of a two-scale decomposition to control large scale effects and the texture distribution. This quantifies the look of an image using histograms over this decomposition, which affords both interactive control using a curve interface, and the ability to automatically transfer visual properties between images. The histograms of the components of a model image are forced upon a new input because this explores strong stylistic variations. It tends to perform larger modifications to the input than tone mapping.

E. Low Level Visual Processing For Stylization And Abstraction Of Photograph

The stylization and abstraction of photograph describes a computational approach to stylizing and abstracting photographs that responds in explicit terms to the design goal of clarifying the meaningful visual structure in an image. This approach starts from new image representations that recognize the visual parts and boundaries inherent in a photograph. These representations provide the scaffolding to preserve and even emphasize key elements of visual form.

A human user interacts with the system to identify meaningful content of the image. But no artistic talents are required, nor even a mouse: the user simply looks at the image for a short period of time. A perceptual model translates the data gathered from an eye-tracker into predictions about which elements of the image representation carry important information. The simplification process itself can now apply an ambitious range of transformations, including collapsing away details, averaging colors across regions, and overlaying bold edges, in a way that highlights the meaningful visual elements. The stylization and abstraction of photograph's application relies on the fact that human eye movements give strong evidence about the location of meaningful content in an image. This approach uses low-level visual processing to form a hierarchical description of the image to be transformed. The style of output will be a line drawing uniformly colored regions with black lines.

F. Pseudo-Quantization Implementation For Real-Time Video Abstraction

Automatic, real-time video and image abstraction framework abstracts imagery by modifying the contrast of visually important features, namely luminance and color component. The contrast can be reduced in low-contrast regions using an approximation to anisotropic diffusion, and artificially increase contrast in higher contrast regions with difference-of-Gaussian edges. The abstraction step is extensible and allows for artistic or data-driven control. Abstracted images can optionally be stylized using soft color quantization to create cartoon-like effects with good temporal coherence. The significant advantage of the pseudo-quantization implementation is temporal coherence. In standard quantization, an arbitrarily small luminance change can push a value to a different bin, thus causing a large output change for a small input change, which is particularly troublesome for noisy input. With soft quantization, such a change is spread over larger area, making it less noticeable. Using the gradient-based sharpness control, sudden changes are further subdued in low-contrast regions, where they would be most objectionable.

G. Bilateral Filter Based On A Signal Processing Interpretation

Fast approximation technique of the bilateral filter is based on a signal processing interpretation. From a theoretical point of view, the notion of homogeneous intensity has been introduced and a new approach of the space-intensity domain is demonstrated. These concepts can be applied beyond bilateral filtering, and that these contributions will inspire new studies. From a practical point of view, this approximation technique yields results visually similar to the exact computation with interactive running times. This technique paves the way for interactive applications relying on quality image smoothing.

The bilateral filter is nonlinear filters that smooth a signal while preserving strong edges. It has demonstrated great effectiveness for a variety of problems in computer vision and computer graphics, and a fast version has been proposed. This signal-processing perspective allows developing a novel bilateral filtering acceleration using a down sampling in space and intensity. This affords a principled expression of the accuracy in terms of bandwidth and sampling. The key to the analysis is to express the filter in a higher-dimensional space where the signal intensity is added to the original domain dimensions. The bilateral filter can then be expressed as simple linear convolutions in this augmented space followed by two simple nonlinearities.

H. Edge-Avoiding Wavelets

Multiscale decompositions using these new wavelets show a diminished response to strong edges at the transformed coordinates which results in a reduced inter-scale correlation. This allows avoiding halo artifacts in band-independent multi-scale processing, freeing us from taking any special precautions. The new wavelets encode, in their shape, the edge structure of the image at every scale. This can be used to implement an edge aware interpolation, normally solved via implicit data-dependent formulations, at the cost performing two transforms and their inverse.

Table I
Comparison Table On Literature Survey

Name	Method	Performance
On the origin of the bilateral filter and ways to improve it	Diagonal Normalized Steepest Descent	The noise will be removed and help to improve the performances for many signal-processing algorithms, such as compression, detection, enhancement, recognition, and more.
Noise estimation from a single image	Estimate the noise using the residual	Achieved robust results over a wide range of image noise levels.
Image-based modeling and photo editing	Clone Brushing For Image Based Modeling	Permits the distortion-free copying of parts of a picture and discounts the effect of illumination on uniformly textured areas
Two-scale tone management for photographic look	Tone-Management Technique	Analogy approaches enable the imitation of texture or stylized images in a purely data-driven fashion.

Stylization and abstraction of photographs	Low-Level Visual Processing	This renders a new image using transformations that preserve and highlight the visual elements
Real-time video abstraction	Pseudo-Quantization Implementation	Effectiveness in naming abstracted faces
A fast approximation of the bilateral filter using signal processing approach	Based on a signal processing interpretation	Enables a speed-up of several orders of magnitude while controlling the error induced.
Edge-avoiding wavelets and their applications	Edge-Aware Interpolation Scheme	Effectiveness on various computational photography applications such as multi-scale dynamic range compression.

III. METHOD

A. Efficient edge-preserving smoothing filter using Local Linear SURE based (LLSURE) Filter

The filter is based on a local linear model. In a local neighborhood around every position, the filtered output image patch will be assumed which is a very simple affine transform of input image patch in the same position. For every local neighborhood, the optimal transform coefficients will be determined by minimizing the mean square error estimate. All the filtered output image patches are then averaged together to obtain the final filtered result.

B. Extended LLSURE Filter with Joint Filter

LLSURE filter is extended to the joint LLSURE filter. The joint LLSURE filter will reduce the noise and smoothen an input image based on the edge information of the guidance image. Joint LLSURE filter can provide much better result than the LLSURE filter in which only the no-flash image is used. The joint filter can capture more significant edge information by considering the content of a guidance image.

C. Multi-scale edge-preserving decomposition

Multi-scale edge-preserving decomposition is often required in many applications of computational photography. The decomposition consists of a coarse piecewise smoothed version of the image, along with a sequence of difference images capturing detail at progressively finer scales .Using the LLSURE filter, multi-scale edge-preserving decomposition will be constructed. The image is repeatedly smoothed, and the resulting coarsened images tend more strongly towards piecewise constant regions separated by strong edges.

D. Anisotropic morphological filters

The anisotropic morphological filter is based on the shape and orientation of structuring element at each pixel. The orientation is specified by means of a diffusion procedure of the average square gradient field, which normalizes and make bigger the orientation information from the edges of the things to the homogeneous areas of the image; and the shape of the orientated structuring elements can be linear or it can be given by the space to relevant edges of the objects. The Anisotropic Morphological filters are employed on binary and gray-level images for improvement of anisotropic features such as coherent, flow-like arrangements. The orientated structuring components of the filter vary over the space according to a vector field.

The robust information on the structuring elements from an impenetrable and regular direction field can be found from the image. The discrete morphological processing is regularly and locally adapted to some features that already are present in the image, but that this processing aspires to highlight. The creativity of the filter is that the spatially-variant anisotropic numerical openings/ closings are computed from their direct algebraic characterizations. Advanced filters based upon successive openings and closings can be used for augmentation of anisotropic images features such as coherent, flow-like structures. The orientation field is calculated once from the original image, and then, for hands involving sequential openings/closings the matching orientation field is used.

IV. CONCLUSION

This paper presents a filtering technique involved in Edge Preserving Image Filtering. Filtering is perhaps the most important operation of image processing and computer vision, and it is used extensively in a wide range of applications, including image smoothing and sharpening, noise removal, resolution enhancement and reduction, feature extraction, and edge detection. The simplest filtering should be explicit linear translation invariant filtering, which can be implemented using a convolution mask.

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