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A Novel Laplacian Pyramid Approach For Exposure Fusion

Samuel Joseph R
M.Tech. Scholar
Department of Electronics and Communication Engineering,Narasaraopeta Engineering COllege, Narasaraopet.

Narasimha Rao J
Associate Professor,
Department of Electronics and Communication Engineering,Narasaraopeta Engineering COllege, Narasaraopet.

Abstract:

The Dynamic range of a natural scene often spans a much larger scope than the capture range of common digital cameras. An exposure image only captures a certain dynamic range of the scene and some regions are invisible due to under-exposure or over-exposure. Variable exposure photography captures multiple images of the same scene with different exposure settings of the camera while maintaining a constant aperture. In order to recover the full dynamic range and make all the details visible in one image, high dynamic range (HDR) imaging techniques are employed to reconstruct one HDR image from an input exposure sequence. These generated HDR images usually have higher fidelity than convectional low dynamic range (LDR) images, which have been widely applied in many computer vision and image processing applications, such as physically-based realistic images rendering and photography enhancement. On the other hand, the current displays are only capable of handling a very limited dynamic range.

This Project proposes a new exposure fusion approach for producing a high quality image result from multiple exposure images. Based on the local weight and global weight by considering the exposure quality measurement between different exposure images, and the just noticeable distortion-based saliency weight, a novel hybrid exposure weight measurement is developed. This new hybrid weight is guided not only by a single image's exposure level but also by the relative exposure level between different exposure images. The core of the approach is our novel boosting Laplacian pyramid, which is based on the structure of boosting the detail and base signal, respectively, and the boosting process is guided by the proposed exposure weight. Our approach can effectively blend the multiple exposure images for static scenes while preserving both color appearance and texture structure.

Our experimental results demonstrate that the proposed approach successfully produces visually pleasing exposure fusion images with better color appearance and more texture details than the existing exposure fusion techniques and tone mapping operators.we have proposed a new method for removal of salt and pep per noise from gray seale images. In thisteehnique when the processing pixel is uneorrupted then it is left unchanged otherwise the neighbors are checked.

Introduction:

THE DYNAMIC range of a natural scene often spans amuch larger scope than the capture range of commondigital cameras. An exposure image only captures a certaindynamic range of the scene and some regions are invisibledue to under-exposure or over-exposure. Variable exposurephotography captures multiple images of the same scene withdifferent exposure settings of the camera while maintaining aconstant aperture. In order to recover the full dynamic rangeand make all the details visible in one image, high dynamicrange (HDR) imaging techniques [3], [22], [32] are employedto reconstruct one HDR image from an input exposure sequence.These generated HDR images usually have higherfidelity than convectional low dynamic range (LDR) images,which have been widely applied in many computer visionand image processing applications, such as physically-basedrealistic images rendering [32] and photography enhancement[30].In order to resolvethe contradiction between the HDR characteristic of real worldscenes and the conventional LDR display devices, a singleHDR image is first reconstructed from multiple exposureimages using HDR imaging techniques [3], [29] and then atone mapping image is generated with existing tone mappingoperators [9], [13], [14], [28]. Exposure fusion [18], [20], [23]–[25], [27], [30] is currentlya very active research area in the field of computer vision,as it offers the full dynamic range from an input exposuresequence.

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The general image fusion approaches usually use the multisensory or multispectral images as input [5], [16], while exposure fusion methods use the multiple exposure images asinput.

Fig. 1.2. CCD visual images with the (a) right and (b) left clocks out of focus, respectively; (c) theresulting fused image from (a) and (b) with the two clocks in focus.

Image Fusion:

The term fusion means in general an approach to extraction of information acquired in several domains. The goal of image fusion (IF) is to integrate complementary multisensor, multitemporal and/or multiview information into one new image containing information the quality of which cannot be achieved otherwise. The term quality, its meaning and measurement depend on the particular application. Image fusion has been used in many application areas. In remote sensing and in astronomy, multisensory fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images. Plenty of applications which use multisensor fusion of visible and infrared images have appeared in military, security, and surveillance areas. In the case of multiview fusion, a set of images of the same scene taken by the same sensor but from different viewpoints is fused to obtain an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene.

The multitemporal approach recognizes two different aims. Images of the same scene are acquired at different times either to find and evaluate changes in the scene or to obtain a less degraded image of the scene. The former aim is common in medical imaging, especially in change detection of organs and tumors, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim requires the different measurements to be much closer to each other, typically in the scale of seconds, and possibly under different conditions.

The list of applications mentioned above illustrates the diversity of problems we face when fusing images. It is impossible to design a universal method applicable to all image fusion tasks. Every method should take into account not only the fusion purpose and the characteristics of individual sensors, but also particular imaging conditions, imaging geometry, noise corruption, required accuracy and application-dependent data properties.

Image fusion is the process that combines information from multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The object of the image fusion is to retain the most desirable characteristics of each image. With the availability of multisensor data in many fields, image fusion has been receiving increasing attention in the researches for a wide spectrum of applications. We use the following four examples to illustrate the purpose of image fusion:In optical remote sensing fields, the multispectral (MS) image which contains color information is produced by three sensors covering the red, green and blue spectral wavelengths.

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Because of the trade-off imposed by the physical constraint between spatial and spectral resolutions, the MS image has poor spatial resolution. On the contrast, the panchromatic (PAN) images has high spatial resolution but without color information. Image fusion can combine the geometric detail of the PAN image and the color information of the MS image to produce a high-resolution MS image. Fig. 1.1 shows the MS and PAN images provided by IKONOS, a commercial earth observation satellite, and the resulting fused image.

Fig. 1.1. Image fusion for an IKONOS scene for Cairo, Egypt: (a) multispectral low resolution input image, (b) panchromatic high resolution input image, and (c) fused image of IHS.

Laplacian Pyramid:

An important property of the Laplacian pyramid is that it is a complete image representation: the steps used to construct the pyramid may be reversed to recover the original image exactly. The top pyramid level, LN, is first expanded and added to LN-1 to form GN-1 then this array i s expanded and added to LN-2 to recover GN-2, and so on. Alternatively, we may Write

$$G_0 = \sum L_{l,l}$$

The pyramid has been introduced here as a data structure for supporting scaled image analysis. The same structure is well suited for a variety of other image processing tasks. Applications in data compression and graphics, as well as in image analysis, will be described in the following sections. It can be shown that the pyramid-building procedures described here have significant advantages over other approaches to scaledanalysis in terms of both computation cost and complexity. The pyramid levels are obtained with fewer steps through repeated REDUCE and EXPAND operations than is possible with the standard FFT. Furthermore, direct convolution with large equivalent weighting functions requires 20- to 30-bit arithmetic to maintain the same accuracy as the cascade of convolutions with the small generating kernel using just 8-bit arithmeticcompact code.The Laplacian pyramid has been described as a data structure composed of bandpass copies of an image that is well suited for scaled-image analysis. But the pyramid may also be viewed as an image transformation, or code. The pyramid nodes are then considered code elements, and the equivalent weighting functions are sampling functions that give node values when convolved with the image. Since the original image can be exactly reconstructed from it's pyramid representation, the pyramid code is complete. There are two reasons for transforming an image from one representation to another: the transformation may isolate critical components of the image pattern so they are more directly accessible to analysis, or the transformation may place the data in a more compact form so that they can be stored and transmitted more efficiently.

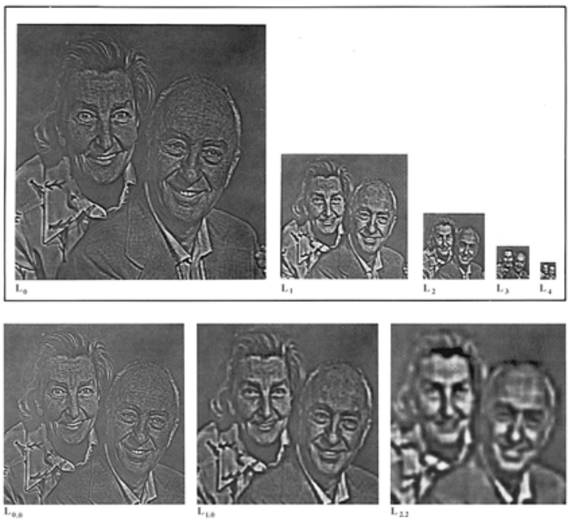

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Fig. 2:Levels of the Laplacian pyramid expanded to the size of the original image.

Note that edge and bar features are enhanced and segregated by size.

The Laplacian pyramid serves both of these objectives. As a bandpass filter, pyramid construction tends to enhance image features, such as edges, which are important for interpretation. These features are segregated by scale in the various pyramid levels, as shown in Fig. 4. As with the Fourier transform, pyramid code elements represent pattern components that are restricted in the spatial-frequency domain. But unlike the Fourier transform, pyramid code elements are also restricted to local regions in the spatial domain. Spatial as well as spatial-frequency localization can be critical in the analysis of images that contain multiple objects so that code elements will tend to represent characteristics of single objects rather than confound the characteristics of many objects.

(a)

(b)

Fig. 5. Pyramid data compression. The original image represented at 8 bits per pixels shown in (a). The node values of tbe Laplacian pyramid representation of this image were quantitized to obtain effective data rates of 1 b/p and 1/2 b/p. Reconstructed images (b) and (c) show relatively little degradation.

The pyramid representation also permits data compression.3 Although it has onethird more sample elements than the original image, the values of these samples tend to be near zero, and therefore can be represented with a small number of bits. Further data compression can be obtained through quantization: the number of distinct values taken by samples is reduced by binning the existing values. This results in some degradation when the image i s reconstructed, but if the quantization bins are carefully chosen, the degradation will not be detectable by human observers and will not affect the performance of analysis algorithms. Figure 5 illustrates an application of the pyramid to data compression for image transmission. The original image is shown in Fig. 5a.

A Laplacian pyramid representation was constructed for this image, then the values were quantized to reduce the effective data rate to just one bit per pixel, then to one-half bit per pixel. Images reconstructed from the quantized data are shown in Figs. 5b and 5c. Humans tend to be more sensitive to errors in low-frequency image components than in high-frequency components. Thus in pyramid compression, nodes at level zero can be quantized morecoarsely than those in higher levels. This is fortuitous for compression since three-quartersof the pyramid samples are in the zero level.

Data compression through quantization may also be important in image analysis to reduce the number of bits of precision carried in arithmetic operations. For example, in a study of pyramid-based image motion analysis it was found that data could be reduced to just three bits per sample without noticeably degrading the computed flow field.4 These examples suggest that the pyramid is a particularly effective way of representing image information both for transmission and analysis. Salient information is enhanced for analysis, and to the extent that quantization does not degrade analysis, the representation is both compact and robust.

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REMOVAL OF SALT AND PEPPER NOISE:

Our method is based on the basics of trimmed mean filter. In thecase of alpha trimmed mean filter (ATMF), trimming is symmetrie atboth ends for the values selected from a 3 X 3 window. So there maybe a case that along with noisy pixels some unconrupted pixels alsotrimmed which results in the loss of image details. In our case, we firstcheck the processing pixel whether it is conrupted or uncorrupted i.e.the first step is the impulse detection. When the processing pixel isunconrupted i.e. its gray level lies between the maximum andminimum gray level value then it is left unchanged. When theprocessing pixel is conrupted then it is passed through the proposedfilter.

Fig(a):noisy image

Fig(b):output image

In our approach we use the laplacian pyramid to divide the image into different layers i.e. base and detail layers and boost them separately and then combine to form the output image. The boosting is done under the guidance of the gradient vector and weight map w_i . The over and under exposed regions are identified and carefully adjusted so as to preserve the detail in the specific region. In the above equation the weight

$$P(x,y) = \sum_{i=1}^{N} K_i(x,y) \times H_i(x,y)$$

Where P(x,y) is the output image and Ki(x,y) is the weight map and Hi(x,y) represents individual layers in laplacian pyramid. And the hybrid weight to guide the laplacian pyramid is obtained by the following equation.

$$K_i(x,y) = \frac{E_i(x,y)\times V_i(x,y)\times J_i(x,y)}{\sum_{i=1}^{N} E_i(x,y)\times V_i(x,y)\times J_i(x,y)}$$

Three weights viz., global, local and perceptual weights are represented by E,V,J based on which the exposure level is calculated

Fig. 7. The First four are input sequence with different exposure levels and the fifth one Is exposure fused image of the above images.

Conclusion:

This paper has presented a novel exposure fusion approachusing BLP to produce a high quality image from multipleexposure images. Our novel BLP algorithm is based onboosting the detailand base signal respectively, and caneffectively blend the multiple exposure images for preservingboth color appearance and texture structures. A novel hybridexposure weight is also introduced, which incorporates thelocal weight, global weight and JND-based saliency weight.Visual inspection and quantitative performance evaluationboth demonstrate that the employment of the BLP modelhas brought a better fusion performance than the traditionalfusion approaches. Our proposed exposure fusion approachsuccessfully creates a visually pleasing fusion image withmore color and texture details. We therefore believe that ourfusion method will suffice to produce the results with finedetails for most practical applications The comprehensive perceptual study and analysis of exposurefusion algorithms will make an interesting subject forfuture work. For instance, we can create a benchmark ofinput exposure images and conduct a user study to comparea representative number of state-of-the-art exposure fusionmethods. In terms of the computational efficiency, we wouldlike to extend our exposure fusion algorithm with GPU implementationfor real-time applications in future work. Thereare many more tone mapping approaches as well as publicresearch data of exposure images that we have not mentioned,and we can implement and compare more tone mapping operatorsin future.

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However, we believe that the aforementionedexperimental results suffice to validate the effectiveness of theproposed approach. We will investigate further extensions ofthe exposure fusion for detecting the moving objects [22], [35],[36] of the dynamic scenes in the future work.In this paper, we have proposed a new filter to overeomeblurring in ease of large window size and poor noise removalin smaller window size. This filter shows better result thanmean filter like ATMF and variants of MF in terms of PSNRand IEF. The proposed filter is tested for different densities ofnoise and it shows eonsistent result over the range of noisedensities. This filter is useful for rem oval of salt and peppernoise even in the ease when image is eorrupted by high densityof noise.

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