BLUR DETECTION OF DIGITAL IMAGES IN REAL-TIME

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Abstract- Image processing is a science that uncovers information about images. Enhancement of an image is necessary to improve appearance or to highlight the specific information contained in the image. With the prevalence of digital cameras, the number of digital images increases quickly, which raises the demand for image quality assessment in terms of blur. Applications like Satellite communication and Medical imaging involves real time capturing of high definition images. If the image in such applications is corrupted or the information conveyed is not clear, it is necessary to recapture appropriate image. A model is required that recaptures image automatically if distortion is involved in the captured image. Based on the edge type and sharpness analysis using Haar wavelet transform, a new blur detection scheme is been proposed in this paper. This scheme could determine the presence of blur in an image and also estimate the extent of blur in the image. Analysis is carried out for both, database images as well as real time images and the results obtained demonstrate the effectiveness in estimating blur extent of an image using the proposed scheme.

Key words- **blur extent, region-based segmentation, super resolution, wavelet transforms**

I. INTRODUCTION

With the popularization of digital cameras, many home users have collected more and more digital photos. However, due to the lack of expertise, some of these images are of poor quality. One of the key factors that lead to quality degradation is blur. To help home users restore those photos or simply discard them, automatic blur detection is highly desirable. That is to judge whether or not a given image is blurred and to determine to what extent the image is blurred. Few research efforts have been made to judge whether or not a given image is blurred up till now. However, based on the explicit or implicit assumption that the given image is blurred, some existing methods can be used to determine the blur extent, which can be categorized into indirect and direct methods. Linear blur can be modelled as

$$G = H * F + N$$

Where, matrices G, F and N represent, respectively, the noisy blurred image, the original image and the noise, while the matrix H represents the blur function. Indirect methods rely on the reconstruction of blur function H when it is unknown, which are essentially blur identification and blur estimation. Blur function can be used as an indicator of blur extent, but the computational cost is very high.

In the present work a new blur detection scheme using Haar wavelet transform is proposed, which belongs to direct methods. It can not only judge whether or not a given image is blurred, which is based on edge type analysis, but also determine to what extent the given image is blurred, which is based on edge sharpness analysis. The proposed scheme takes advantage of the ability of Harr wavelet transform in both discriminating different types of edges and recovering sharpness from the blurred version. It is effective for both Out-of-focus blur and Linear-motion blur. Furthermore, its effectiveness will not be affected by the uniform background in images.

The proposed scheme is fast since it does not have to reconstruct the blur function H.

Digital image restoration is a field of engineering that deals with methods used to recover an original scene from degraded observations. The goal is to introduce digital image restoration to the reader, who is just beginning in this field, and to provide a review and analysis for the reader who may already be familiar in image restoration. The perspective on the topic offered here is to let the readers to know various methods of digital image restoration. It should be noted, however, that digital image restoration is a very broad field, and thus contains many other triumphant approaches that have been developed from different perspectives, such as optics, astronomy and medical imaging.

II. LITERATURE SURVEY

In the past few decades, there has been a large amount of related research on blur detection and its correction. There are various methods to detect the blur from the blurry images some of which requires transforms like DCT or Wavelet and some does not require transform.

Method 1: Blur Detection without using transforms

In paper [1], an algorithm is explained for automatic real time detection of blurry images. This algorithm is based on computing variance values of the local key points that are extracted from given images through implementing Scale Invariant Feature Transform (SIFT) algorithm in scale space. No transforms (DCT or DWT) are required and no edge locations need to be identified which are main techniques used in most existing methods.

In this algorithm only pixel values of the given images are directly employed. The main objective is to automatically detect blurry images for automatic labelling and potential removal. This algorithm does not help to detect the blur extent of an image where as using Haar wavelet transform it is possible.

Method 2: Blur Detection for Digital Images Using DCT

Blur detection for DCT in [2] uses a new solution to aim at exploiting the available DCT information in MPEG or JPEG compressed video or images while involving a minimal computational load , the technique is based on histograms of non-zero DCT occurrences, computed directly from MPEG or JPEG compressed images. For MPEG compressed video, the scheme is suitable for all types of pictures: I-frames, P-frames or B-frames.

The objective of blur detection in this application is to provide a percentage indicating the global image quality in terms of blur: 0% would mean that the frame is totally blurred while 100% would mean that no blur at all is present in that particular frame. This blur indicator characterizes the global image blur caused by camera motion or out of focus. Since its focus on analyzing MPEG compressed video data, it is desirable that the blur indicator can be directly derived from the DCT layer of an MPEG video bit stream.

Method 3: Blur Detection using MASW

Wavelet Transform is well known for its multi resolution analysis ability. Based on the important fact that local maxima of a wavelet transform detect the location of irregular structures, the authors of [3, 4] further use modulus-angle-separated wavelet (MASW) to detect Dirac-structure and step-structure edge respectively.

In [3], a significant property has been proved and applied to identify different structures of edges and an algorithm with the modulus-angle-separated wavelets (MASW) has been developed to extract step-structure edges from a multi-structure-edges image effectively.

The author [4] presents 3 significant characteristics of the local maximum modulus of the wavelet transform with respect to the Dirac-structure edges:

- Slope invariant: the local maximum modulus of the wavelet transform of a Dirac-structure edge is independent on the slope of the edge
- Grey-level invariant: the local maximum modulus of the wavelet transform with respect to a Dirac-structure edge takes place at the same points when the images with different grey-levels are processed
- Width light-dependent: for various widths of the Dirac-structure edge images, the location of maximum

modulus of the wavelet transform varies lightly under the certain circumscription that the scale of the wavelet transform is larger than the width of the Dirac-structure edges.

In practice, it is important to select the suitable wavelet functions, according to the structures of edges. The quadratic spline wavelet is utilized to characterize the Dirac-structure edges by wavelet transform.

III. BLUR DETECTION SCHEME

- Capturing of image in real time: Most image processing programs are designed to start by loading an image from a disk. Its hardware dependent for acquiring images directly from a digital camera or from a video source. After acquisition of image different processing methods can be applied.
- Images are often corrupted by random variations in intensity, illumination, or have poor contrast and can't be used directly. The following are the pre-processing techniques-
  1. Filtering: Transform pixel intensity values to reveal certain image characteristics
  2. Enhancement: improves contrast
  3. Smoothing: remove noises
  4. Template matching: detects known patterns
- Contrast enhancement: Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds. Contrast enhancements are typically performed as a contrast stretch followed by a tonal enhancement, although these could both be performed in one step. A contrast stretch improves the brightness differences uniformly across the dynamic range of the image, whereas tonal enhancements improve the brightness differences in the shadow (dark), mid tone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions.
- Gray scale image: The acquired digital image, when applied gray scale is the image in which the value of each pixel is a single sample, that is, it carries only intensity information. These images are also known as black and white, are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.
- Resizing: If the image size is very high, the system takes more time for processing, hence image resizing is necessary.

A. *Blur Extent Detection*

A wavelet based method is proposed to estimate the blur in an image using information contained in the image itself. The sharpness of the sharpest edges in the blurred image are detected, which contain information about the blurring.

B. *Decomposition*

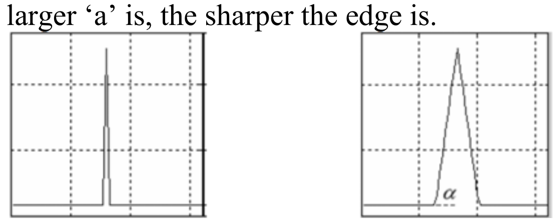
Decomposition operation applied to a source image produces four output images of equal size: approximation image, horizontal detail image, vertical detail image, and diagonal detail image. These decomposition components have the following meaning: The 'approximation image' is obtained by vertical and horizontal low pass filtering. The 'horizontal detail' image is obtained by vertical high pass and horizontal low pass filtering. The 'vertical detail' image is obtained by vertical low pass and horizontal high pass filtering. The 'diagonal detail' image is obtained by vertical and horizontal high pass filtering [7].

C. *Types of Edges*

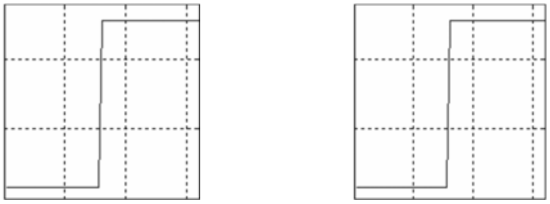
Different edges are generally classified into three types:

- Dirac-Structure
- Step-Structure
- Roof-Structure

Step-Structure is classified into A step-Structure and G step- Structure according to whether the change of intensity is gradual or not. A graphical description of different types of edges is given in Figure. Note that for G step-Structure and Roof-Structure edge, there is a parameter ‘a’ ($0 < a < p/2$) indicating the sharpness of the edge: the larger ‘a’ is, the sharper the edge is.



Dirac-structure roof-structure



Astep-structure Gstep-structure

Fig.1 Graphic Description of edge type

D. Basic Idea of Scheme

In general, most natural images contain all types of edges more or less, and most Gstep-Structure and Roof-Structure are sharp enough. When blur occurs, no matter whether it is caused by Out-of focus or linear motion, both Dirac-Structure and Astep-Structure will disappear, both Gstep-Structure and Roof-Structure tend to lose their sharpness. This scheme judges whether a given image is blurred according to whether it has Dirac-Structure or Astep-Structure, and uses the percentage of Gstep-Structure and Roof-Structure which are more likely to be in a blurred image to determine the blur extent. The whole structure of the scheme is shown.

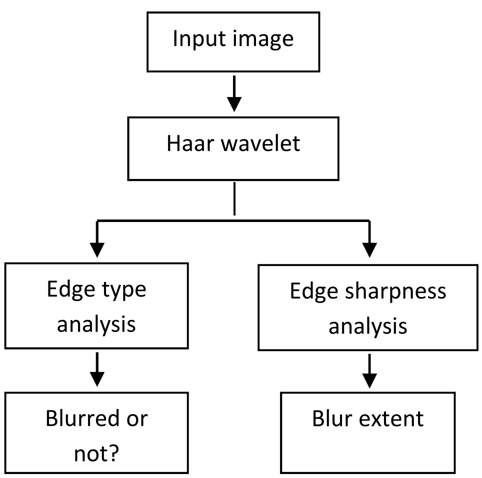


Fig.2 Structure of scheme

E. Blur Effect on Different Edges

Since there is not much noise in images acquired from digital cameras, the noise item N in can be neglected. The main blur functions H are Out-of focus and Linear-motion. In both cases, the convolution operation will change the edge property. An empirical comparison between the original edge and its blurred version is listed in table1. Note that in the blurred version, there is no Dirac-Structure or Astep-Structure. Furthermore, both Gstep-Structure and Roof-Structure tend to lose their sharpness.

Table 1. Blur effect on different types of edges

Original	After blur	Change of α
Dirac-structure	Roof-structure	
Astep-structure	Gstep-structure	
Gstep-structure	Gstep-structure	Smaller
Roof-structure	Roof-structure	Smaller

F. Edge Type and Sharpness Detection

Wavelet Transform is well known for its multi resolution analysis ability. Based on the important fact, the local maxima of a wavelet transform detect the location of irregular structures. Further use modulus-angle separated wavelet (MASW) to detect Dirac-Structure and Step-Structure edge respectively. However, MASW is very time consuming. So, we use Haar wavelet transform (HWT) instead, which is widely used. The detailed algorithm to detect edge using Haar wavelet transform [5] is listed below:

Algorithm1: HWT for edge detection

Step1: Perform Harr wavelet transform to the original image and the decomposition level is 3. The result is a hierarchical pyramid-like structure.

Step2: Construct the edge map in each scale

$E_{map}i(k,l) = \text{sqrt}\ (LH_i^2+HL_i^2+HH_i^2)$ where, i=1,2,3

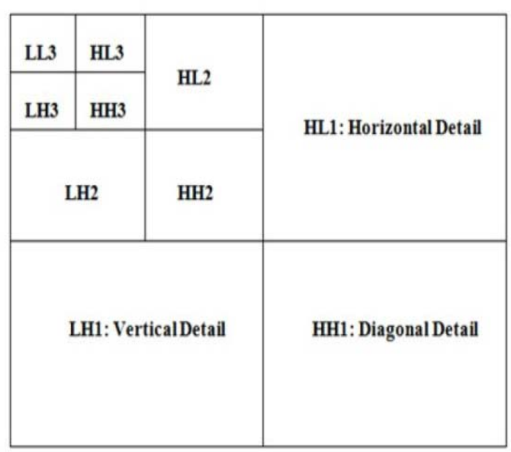


Fig.3 Decomposition of image

HHi is horizontal high-pass/vertical high-pass
HLi is horizontal high-pass/vertical low-pass
LHi is horizontal low-pass/vertical high-pass
LLi is iteratively split as shown

Step3: Partition the edge maps and find local maxima in each window. The window size in the highest scale is 2x2, the next coarser scale is 4x4 , and the coarsest one is 8x8 . The result is denoted as $Emax_i$ (i = 1, 2, 3). In algorithm 1, $Emax_i$ represents the intensity of the edge: the larger E maxi is, the more intense the edge is. For a given threshold, if $Emax_i(k,l)$ is labeled an edge point in the corresponding scale; otherwise it is labeled a non-edge point. Algorithm 1 is performed on different types of edges and that the effect is quite different. The relative intensity in different scales of different types is summarized in the table below.

Table 2. Effect of HWT on different types of edges

Another important property of Harr wavelet transform is its ability to recover the sharpness of the blurred edge when observed in small scale, the blurred Roof-Structure and Gstep-Structure will become thinner and thus recover their sharpness. The above two important properties of Harr wavelet transform lead to the following five rules:

Rule1: If, E max 1 (k, l) > threshold or, E max 2 (k, l) > threshold or, E max 3 (k, l) > threshold (k, l) is an edge point.

Rule2: For any edge point (k, l), if, E max 1(k, l) >, E max 2 (k, l) >, E max 3 (k, l) , (k, l) is Dirac-Structure or Astep-Structure.

Rule3: For any edge point (k, l), if, E max 1 (k, l) <, E max 2 (k, l) <, E max 3 (k, l), (k, l) is Roof-Structure or Gstep-Structure.

Rule4: For any edge point (k, l), if, E max 2(k, l) >, E max 1 (k, l) and, E max 2 (k, l) > E max 3(k, l), (k, l) is Roof-Structure.

Rule5: For any Gstep-Structure or Roof-Structure edge point (k, l), if, E max 1 (k, l) < threshold, (k, l) is more likely to be in a blurred image.

G. Proposed Blur Detection Scheme:

Based on the five rules obtained in the previous subsection, the detail of the scheme is given below:

Algorithm2: blur detection scheme.

Step1: Perform algorithm 1 on the given image;

Step2: Use Rule 1 to find all edge points. Let N_{edge} be the total number of them;

Step3: Use Rule 2 to find all Dirac-Structure and Astep-Structure edge points. Let N_{da} be the total number of them;

Step4: Use Rule 3 and Rule 4 to find all Roof-Structure and Gstep- Structure edge points. Let N_{rg} be the total number of them;

Step5: Use Rule 5 to find all Roof-Structure and Gstep-Structure edge points that have lost their sharpness. Let N_{brg} be the total number of them;

Step6: Calculate the ratio of Dirac-Structure and Astep-Structure to all the edges: Per= N_{da}/N_{edge} if Per > MinZero , judge that the image is un-blurred and vice versa, where MinZero is a positive parameter close to zero;

Step7: Calculate how many Roof-Structure and Gstep-Structure edges are blurred: BlurExtent=N_{brg}/N_{rg}. Output BlurExtent as blur confident coefficient for the image.

IV. EXPERIMENTAL RESULTS

In this section, some experimental results are

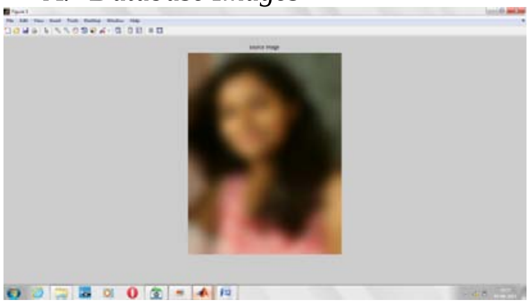
Types of Edges	Emax 1	Emax2	Emax3
Dirac-Structure	Highest	Middle	Lowest
Astep-Structure	Highest	Middle	Lowest
Gstep-Structure	Lowest	Middle	Highest
Roof-Structure	Lowest	Middle	Highest
	Lowest	Highest	Middle

shown. There are two parameters needed to be set: threshold and Min-Zero. Since human vision systems are not sensible to intensity below 30, we choose 35 as threshold. In ideal situation, Min-Zero should be set to zero. In practice, it can be chosen as a positive real number that is very close to zero. In this analysis, the Min-Zero value is set to be 0.05 and find out that the final accuracy only changes a little when Min-Zero varies between 0.01 and 0.1. The images used in the experiment are taken from database and real time. Haar wavelet transform accounts for most of the processing time. In practice, the time needed is mainly determined by the image size.

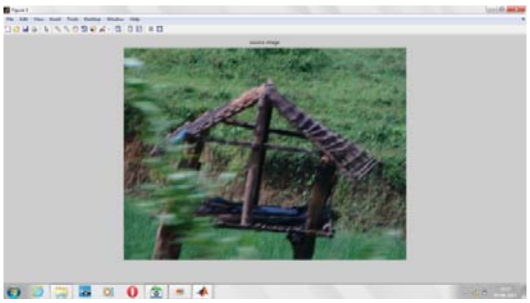
In section *A* below, images are taken from gallery and blur extent is calculated. Different images are considered like a complete blur image, an image captured in motion and a high resolution picture and respective blur extents are calculated.

In section *B* below, images are captured in real-time and blur extent is calculated. Different images are taken considering the illumination. Some pictures are taken in dim sunlight and some in bright light. It is observed that image is clear and its blur extent is less in bright light and blur extent is high when picture is captured in dim light.

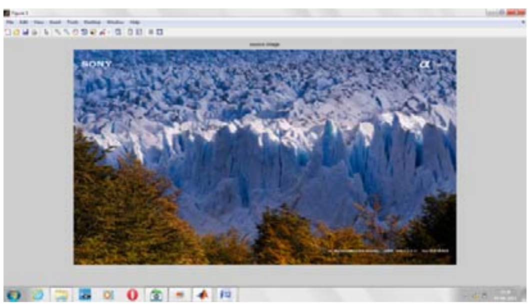
A. Database Images



1. Blur Extent = 100% and Image is blurred.

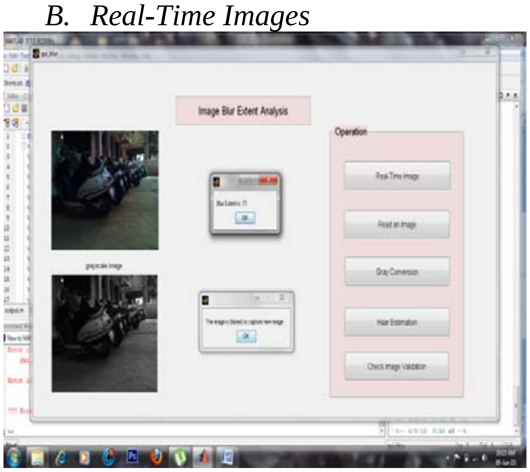


2. Blur Extent = 51% and Image is blurred.



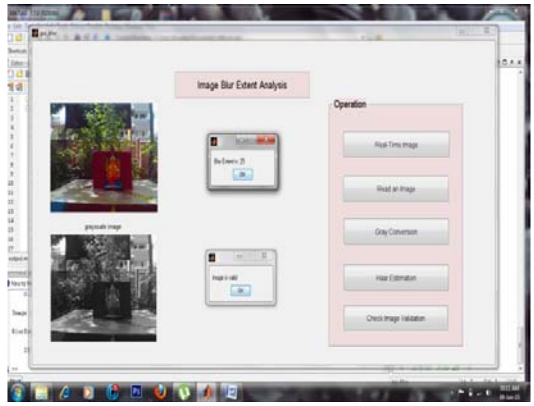
3. Blur Extent = 18% and Image is valid.

B. Real-Time Images



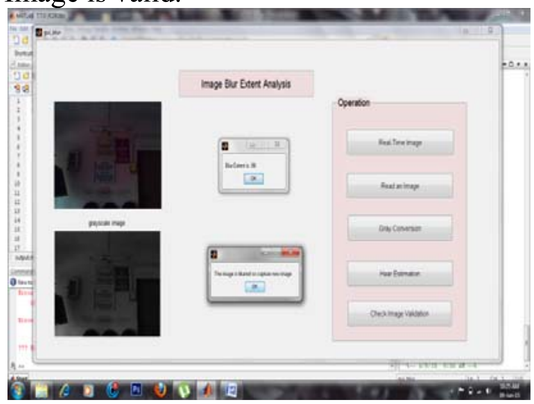
1. Blur Extent is: 71%

The image is blurred so capture new image.



2. Blue Extent is: 25%

Image is valid.



3. Blur Extent is: 98%

The image is blurred so capture new image.

V. CONCLUSION

A. Conclusion

This paper introduces a new blur detection scheme for images taken by digital cameras. The scheme makes use of the ability of Haar wavelet transform in both discriminating different types of edges and recovering sharpness from the blurred version. In general, any natural image contains all types of edges more or less. When blur occurs,

1) All Dirac-Structure and Astep-Structure will disappear.

2) Both Gstep-Structure and Roof-Structure tend to lose their sharpness.

The scheme judges whether or not an image is blurred according to whether or not it contains any Dirac-Structure or Astep-Structure. Blur extent is characterized by blur confident coefficient based on the percentage of Gstep-Structure and Roof-Structure which are more likely to be in a blurred image. Experimental results show that the proposed scheme is effective and efficient in estimating blur extent of an image. Depending upon the extent of the blur the image is either stored or discarded.

B. Future Scope

- Region-Based Segmentation

The technique used to detect blurriness of an image and its blur extent is based on edges present in the image. It considers entire image to calculate blur extent whereas sometimes it's needed to focus on certain part of images to get the précised information especially in medical images to locate tumours and other pathologies. So, region segmentation and region growing can be used to partition an image into regions. Region growing is a simple region based image segmentation method. Image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image.

Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp adjustment in intensity at the region boundaries. Edge detection techniques have therefore been used as the base of another segmentation technique. Region growing methods can correctly separate the regions that have the same properties defined. They can provide the original images which have clear edges with good segmentation results. So after getting required region of an image blur extent can be calculated to decide whether that image has to be discarded or saved.

- Super Resolution

When an image is captured and found blurred most of its fine details are lost. A camera user will be benefited if calculated blur extent is improved and then stored as an improved or as a de-blurred image. Applying a Photoshop sharpen filter may make the photo appear sharper, but such filters are lossy - they actually reduce the amount of fine detail in the image. Until recently, there was very little that could be done to improve the image after the shot. That has now changed. Now super-resolution process is developed which pulls unseen details from the nooks and crannies of a single digital photograph. This process can capture true detail which cannot be seen in the original image.

Super-resolution (SR) is a class of techniques that enhance the resolution of an imaging system. Super-resolution image reconstruction is currently a very active area of research, as it offers the promise of overcoming some of the inherent resolution limitations of low-cost imaging sensors (e.g. cell phone or surveillance cameras) allowing better utilization of the growing capability of high-resolution displays (e.g. high-definition LCDs). Such resolution-enhancing technology may also prove to be essential in medical imaging and satellite imaging where diagnosis or analysis from low-quality images can be extremely difficult.

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