Image Deblurring of License Plate

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Abstract - *Fast motion of vehicles may lead to difficulty in identifying the licence plate by surveillance camera. Due to rapid motion of car the picture perceived by the camera develops a blur. To reduce this blur a BID (Blind Image Deconvolution) technique is proposed in which blur kernel is estimated using the parameters angle and length of blurred input licence plate. The proposed system has tried to bring the idea of designing a robust method for motion blur estimation. The aim of this work is the retrieval of latent image which reduces the strain on human eyes in recognizing the blurry licence plate.*

Key Words: BID, Hann windowing, Histogram equalization, Hough transform, Cepstral method, NBID

1. INTRODUCTION

Image Restoration is basically an operation or set of operations performed on noisy input image to estimate a latent clean and noise free output image. Noises found in image are mainly gaussian noise, salt-and-pepper noise, camera mis-focus etc. Motion blur occurs due to prolonged exposure time which creates blurry artifacts. It is the effect of relative motion between camera, objects and scene. Licence plate is an identification number that peculiarly identifies the vehicle owner. It can be useful in identifying problematic vehicles like in road accidents or catching any rule violating vehicle. But due to the speed of the vehicle, at exposure time it causes blur of the snapshots captured by the surveillance camera. This results into unrecognizable, undetectable and deterioration of image leading to loss of some image information. In such cases we can use image de-blurring to recover any useful clue from the snapshots for identification of car's licence plate.

The retrieval of such blurred image can be done by using non blind restoration and blind restoration [1]. In non blur restoration the information about the kernel is known, whereas in blind image restoration the kernel information is unknown. The blurring can be mathematically represented as

$$B(x, y) = (k * I)(x, y) + G(x, y) \qquad (1)$$

where B denote the blurred image, I is the sharp image we intend to recover and k is the blur kernel; G is the additive noise (usually regarded as white Gaussian noise); and $*$ denotes convolution operator [1]. In blind restoration, kernel k and sharp image I are unknown. Blind image restoration problem can be categorized into two ways: uniform BID and non-uniform BID [2]. Non-uniform image restoration is accomplished by interchanging the methods that caused the blurring of image i.e. first finding the PSF and then performing de-convolution whereas in uniform BID finding PSF and image restoration both are done simultaneously.

In this paper, pre-processing operations on blurred input license plate image have been performed and deblurred it using BID method by estimating blur angle and blur length. For angle estimation, Hough transform is used and for estimating blur length Cepstral method is used.

2. RELATED WORKS

Blurring has become a problem of great concern with many computations required to retrieve latent image. Estimating blur from real world image is a tedious task. Many algorithms and methods have been proposed to overcome the blur problem. Lucy-Richardson algorithm [7] where an iterative procedure is used for recovering the latent image with known PSF. Neural network approach [7] uses back propagation approach for image restoration. Maximum likelihood where PSF and covariance matrices are found [7]. Deblurring by ADSD-AR [7] in this the system is trained with a series of compact sub-dictionaries and assign adaptively local patch as sub-dictionaries as a sparse domain. Mohammad Tofighi et al. [10] used SVD (Single Value Decomposition) to recover image and kernel. Image is been recovered by using Row-Column Sparsity (BD_RCS). Yuanchao Pai et al. [4] proposed a graph based blind image deblurring by converting an image patch into signal on weighted graph.

3. PROPOSED SYSTEM

In this proposed system we have tried to design a user friendly licence plate image deblurring system. The central idea of this system is to try to get the licence plate image in human readable format. The proposed system has mainly three modules: First is the pre-processing stage. Second and third part is the blur angle and blur length estimation respectively and the last module is the NBID i.e. deconvolution.

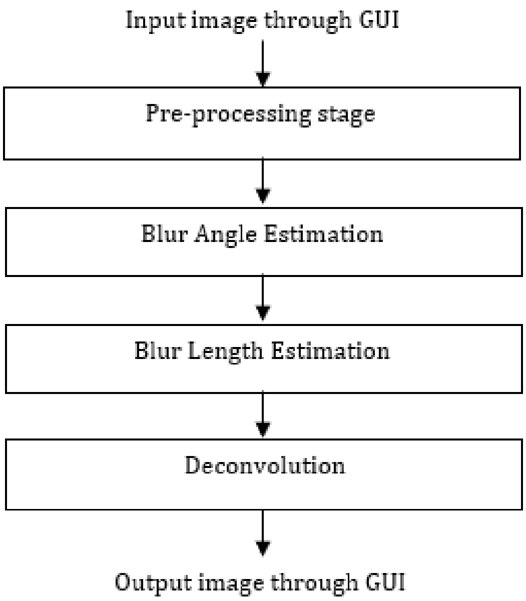


Fig -1: Block diagram of proposed system

3.1 Pre-processing Stage

Pre-processing stage is the cleansing stage. The aim is to eliminate noise or distortion from the input image and making it simpler to carry out all processing operations. In pre-processing following operations are done i.e. grayscale conversion, Hann windowing and histogram equalization.

3.1.1 Grayscale Conversion

Grayscale images are those whose pixels carry only intensity information. Grayscale images reduce the computation by storing all information in 8 bits per sampled pixel. Converting the input images into grayscale make it uncomplicated in identifying the edges and other information. A luminosity method for Grayscale is used. Grayscale conversion is done in 3 steps:

1) Obtaining the RGB values.

2) Calculating the weighted mean using luminosity formula: 0.3R + 0.59G + 0.11B.

3) Replacing the old values of R,G,B with the calculated weighted mean.

3.1.2 Hann Windowing

Windowing is a mathematical function in which only a certain specified interval has a value rest are close to zero. Intervals having constant values are known as rectangular window. Windowing is done to limit the image size and to reduce boundary artifacts. Boundary artifacts occur due to sudden change in the pixels along the border. By removing unwanted frequencies/noise directional characteristics become clear. In this study, we are using Hann windowing, among all the available windowing function because it has very low aliasing [9]. It is formulated as

$$W(n) = \frac{1}{2}\left(1 - \cos\left(\frac{2\pi n}{N-1}\right)\right) \quad (2)$$

3.1.3 Histogram Equalization

Histogram equalization is the additional pre-processing step done to alter the contrast of the image. In this we not only stretch range of image but also have to determine equal pixels in all gray values. In this we first find pdf (Probability Distribution Function) and cdf (Cumulative Distribution Function) and then we round off the pixel values with the formula of

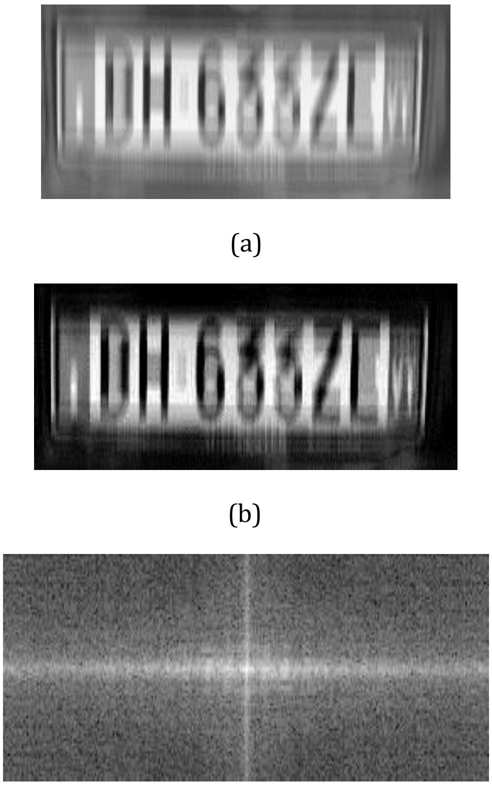
$$F = (L-1) * S_k; \quad (3)$$

where S_k is the cdf and L= the no of possible intensity values.

Considering a discrete grayscale image {r} and let nk be the number of occurrence of gray level k the pdf can be given as

$$P(r) = nk/N \quad (4)$$

where, N is the total number of pixels.



(a) (b) (c)

Fig -2: (a) Output of Grayscale Conversion (b) Output of Histogram Equalization (c) Log spectrum of blurred image

3.2 Estimating the Blur Angle

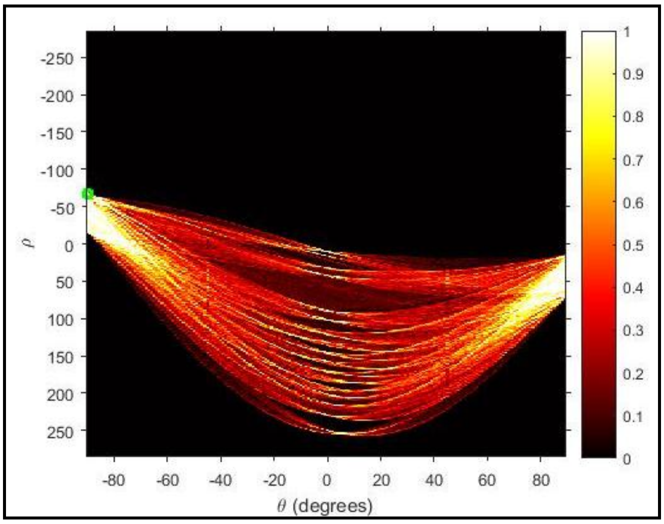
The first step towards estimating angle is transforming the image from spatial domain to frequency domain. Now why frequency domain? Frequency domain gives you control over the entire images, where you can improve and smoother attributes of image very easily. An idea presented by authors in [2] states motion blur in frequency domain has a dominant occurrence of black strips which can be detected. In this the blur is estimated by means of Hough transform. The idea illustrated by authors in [6] states that the spectrum of blurred images are anisotropic in nature and are biased within the direction perpendicular to the direction of blur.

Hough transform is mainly used for detection of lines, shapes and edges in an image. The proposed system uses log spectrum of the given image and then Hough transform is applied on it.

Algorithm: Motion Blur Angle Estimation

1) Compute the Fourier transform F(u,v) of the pre-processed image F(x,y).
2) Compute the log spectrum of the output of step 2.
3) Compute the inverse Fourier transform of log spectrum.
4) Find the edge map of step 3 using any edge detection method (here canny edge detection is used).
5) Let α_{min} & α_{max} be minimum and maximum values of motion blur angle.
   Initialize accumulator array A(r α) to zero.
   Repeat for each edge point (x_i, y_i)
   Repeat for $\alpha = \alpha_{min}$ to α_{max}
   {
   $r = x_i \cos\alpha + y_i \sin\alpha$
   $A(r, \alpha) = A(r, \alpha) + 1$
   $\alpha = \alpha + 1$
   }
6) Find the max value in the accumulator array which is perpendicular to motion blur angle.

(a)



(b)

Fig -3: (a) Detection of Hough Line after Canny edge detection (b) Detection of Hough peak

3.3 Estimating the Blur Length

The obscure length is evaluated using cepstral transform method. The cepstrum is defined as

$$c\{f(x,y)\} = F^{-1}\{\log|F\{x,y\}\} \quad (5)$$

where F is the DFT and F^{-1} is the IDFT.

Here a 1D cepstrum, extension of 1D i.e. 2D is used for filtering process and image registration process. As logarithm operators are used the cepstral features are invariant to amplitude changes and as cepstral transform is carried out in Fourier domain it is invariant to translation shift. In frequency domain it is observed that uniform motion blur has a periodic pattern by zero crossing of sine function [2]. Cepstrum or Cepstral mainly works on quefrency. With the image in quefrency the image is turned by the angle found in previous module. Collapse the 2D into 1D cepstral by taking average of the columns.

Algorithm: Motion Blur Length Estimation

1) Determine the cepstral of input image F(x,y).
2) Rotate the cepstral by the angle estimated in previous module in the inverse direction.
3) Collapse 2D matrix into 1D by taking the average of columns.
4) Find the distance of first negative peak from the origin which will be the blur length.

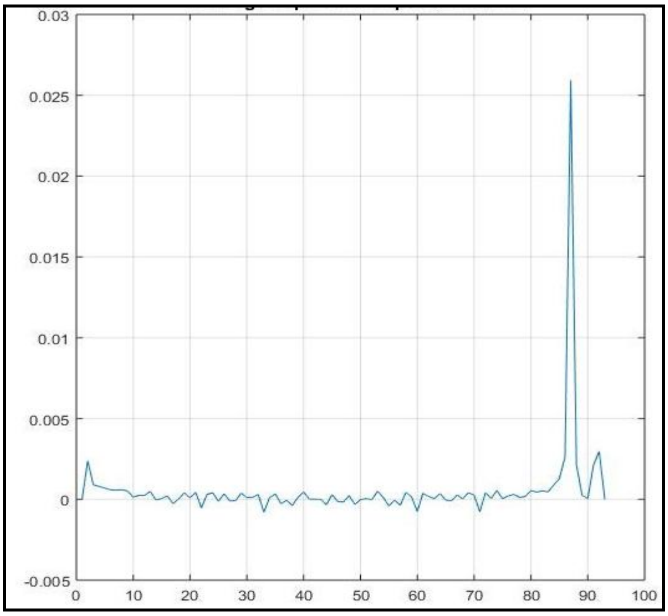


Fig -4: Average of pixels in Cepstrum domain

3.4 Deconvolution

Here NBID method is used to get back the original deblurred image. NBID using Lucy-Richardson is used. In NBID as the kernel or psf is known and we get our blur kernel by creating a psf of obtained blur angle and length.

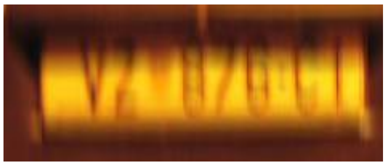
4. RESULTS

The experimental results are implemented by using MATLAB R2015a, NetBeans with OpenCV libraries. The pre-processing part is carried out using NetBeans with OpenCV libraries. The estimation and de convolution part is implemented using MATLAB. Dataset is a mixture of few manually taken blurred images and few synthetically created blurred images.

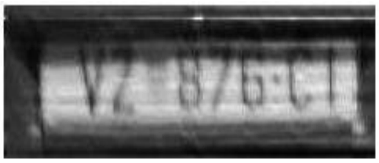
(a)

(b)

Fig -5: (a) Input blurred image by θ=90°, l=15 (b) Output deblurred image after 80 iterations with θ=88°, l=14



(a)



(b)

Fig -6: (a) Input blurred image by θ=91°, l=15 taken at night time (b) Output deblurred image after 80 iterations with θ=89°, l=14

5. CONCLUSION

The proposed system has tried to emerge with a parametric method to deblur the licence plate image. The information lost due to blurring is restored by estimating a blur kernel. For this, Hough transform and Cepstral transform are used which are considered as efficient algorithms. Along with this, the characteristics of motion blur are also taken into consideration while founding the blur kernel. After estimating the kernel, NBID method is applied to get a deblurred licence plate. The proposed system is able to restore the blur licence plate image in human readable form.

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