Template Matching Approach on out of focus Blurred images using Iterative Wiener Filter and Neural Network

G.Gayathri,  
PG Scholar,  
Arunai College of Engineering,  
Tiruvannamalai, India.

Nelavala Rajesh  
Assistant Professor,  
Arunai College of Engineering,  
Tiruvannamalai, India.

Abstract - Barcode technology plays an important part in people's daily lives. Out-of-focus image blur are not handled properly by most modern devices which is based on barcode scanning technologies. In existing system, spatial domain template matching approach is used. This works entirely on spatial domain which is capable of reading linear barcodes from low-resolution images containing severe Out-of-Focus blur. This approach fails to decode barcodes that is affected by image blurring. The result produced by this system is also often too blurred. To detect the barcode that are affected by image blurring, the frequency and spatial domain template matching is proposed. This system works on both spatial and frequency domain where denoising and deblurring of linear barcodes can be carried out by Adaptive filter and Iterative Wiener Filter respectively. In Iterative Wiener Filter, the knowledge about point spread function is not necessary while deblurring. Here templates are generated by extracting some features in an image and stored in database as reference templates. With these reference templates, template matching is performed. This system can handle highly-degraded barcode images containing out of focus blur.

Keywords: Out-of-focus, Spatial domain, Denoising, Deblurring.

I. INTRODUCTION

Linear bar codes have spread to virtually all industries (e.g., retailers, military, airlines, overnight shipping, the medical field, and any business where tracking or monitoring is involved). The term symbology is used in barcode industry to denote the particular bar coding scheme, while the term symbol denotes the printed bar code itself. In all cases, the information is encoded in the width of the bars (dark) and spaces (light), but in different ways.

Devices that are used to read barcodes are all-around which can be in the form of pen type readers, laser scanners, or LED scanners. One new kind of barcode reader is camera-based readers which have gained much attention recently. Some images that are captured by cameras often have low quality and produce blurred images. Motion blur and noise are the common problem for images taken under low light conditions.

Unfortunately, some images taken by cameras are often of low quality which frequently produces blurred images. Only few cameras have flashes so motion blur and noise are an extremely common problem for pictures taken in low light conditions. All of these factors, possibly combined with low image resolution, make barcode reading difficult in certain situations.

But, when the images are taken in different light conditions or when the barcode is not close to the camera, barcode readers have poor performance. So, the users usually use apps for barcode reading to get improved accuracy. The fixed-focus lenses are not applicable on mobile devices for linear barcode scanning systems. This is mainly due to enormous edge interaction arises by Out-Of-Focus (OOF) blur while capturing barcode images. The barcode images are mostly affected by noise, geometric distortion, blurring and so on. On comparing these factors, geometric distortion and noise can be easily controlled and reduced using image processing but image blurring is the only factor that degrades the performances of barcode recognition. When the camera does not have auto focus or macro mode, the image blurring is high in camera based imaging system.

Due to two issues, severe OOF blur are not able to handle by some of the barcode scanning systems. One of the issues is that features are not invariant towards image blur that are used for barcode localization. In this system, peak locations, extrema locations and zero crossing of second-order derivative are features that are used. Due to some edge interaction, shifting effects may be arises in these features. Another issue is that image blur at different levels are not accounted because the reference templates used are fixed for template matching.

In this paper, reference templates for image blur at different blur levels are accounted in order to perform template matching in efficient manner. Nearly 15 image images with different blur levels are taken and feature are extracted. The extracted features are trained using neural network and made stored in database. Then the testing process is made with the help of these trained features. The images are made compared with database and if the image is in database, the authentication is made. If not, unauthenticated message will be displayed.

II. METHODOLOGY

The proposed method of image deblurring has the following steps:

1. Read the input image.
2. Performs preprocessing in noised and blurred images.
3. Extracting the desired features in the input image.
4. Generating the database with the help of features that are extracted.
5. Training the extracted features.
6. Testing the trained features that are stored in database.

The proposed block diagram is shown in Figure (1).

Iterative Wiener Filter works well for Gaussian Blur, Motion Blur, etc. The proposed system also works both in spatial domain and frequency domain. Spatial domain approach only does the intensity compensation while the
frequency domain approach does intensity compensation, magnitude compensation and phase compensation. Also by Spatial domain, denoising of an image can be performed very perfectly whereas deblurring of an image could not be performed. By Frequency domain approach, denoising and deblurring of an image can be performed very accurately. By applying Iterative Wiener Filter, the size of an image is calculated. For each pixel, the filter response coefficients using Gaussian Filter is calculated. Blur estimation can be done by applying circular convolution. The spatial domain image is then converted into frequency domain image in order to deblur the image. Deconvolution process is applied on the blur image to deblur using X and Y directional derivative that is calculated using Gaussian Filter.

For template generation, feature like mean, median, variance, standard deviation, minima, maxima, mode and covariance are calculated. These values are stored in the database and it is called template database generation. Templates for various blur levels are generated and they are stored in database.

(A) ITERATIVE WIENER FILTER

The Iterative Wiener Filter is the most important technique used for removing blur in an images that are affected by linear motion or unfocussed optics. In Wiener filter, deblurring an image is done only when the Point Spread Function (PSF) is known. From the signal processing point of view, poor sampling will be occurred due to linear motion in a photograph. In front of the camera, the intensity of a single stationary point is indicated for each pixel in a digital representation of the photograph. Lamentably, a given pixel will be a mixture of intensities from the points along the camera’s motion line, if the camera is in motion and the shutter speed is too low. This is a two-dimensional analogy to

\[ G(u,v)=F(u,v)H(u,v) \]  

In equation (1), F is the Fourier transform of an ideal version of a given image, and H is the blurring function. Image restoration tool described here will work in same manner for cases with smudge due to incorrect focus. The selection of blurring function is the only difference in this case. There are series of sinc function in parallel in two dimensional Fourier transforms on a line perpendicular to the direction of motion in case of motion. In some circumstances, the inverse filtering gets affected because at some values of x and y, the sinc function reaches. This problem can be solved by iterative wiener filter.

Iterative Wiener Filter works well for Gaussian Blur, Motion Blur, etc. Iterative Wiener Filter is a threshold based method in which each iterations removes the noise and blur present in an image. When iteration increase, the noise amplification increases which reduces the noise and blur. Iteration stops when peak signal to noise ratio becomes 50dB. Threshold value is set to 128 in which the pixel above the threshold value is considered as black and the pixel below the threshold value is considered as white. Here, scanline segmentation clustering centroid pixels are calculated by grouping a certain amount of pixels.

(B) GAUSSIAN FILTERING

Gaussian filtering is used to blur images and remove noise and detail. For smoothing images, Gaussian filtering is the best choice. In one dimension, the Gaussian function is given equation (2):

\[ G(x)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{x^2}{2\sigma^2}} \]  

Where \( \sigma \) is the standard deviation of the distribution is assumed to have a mean of 0.

Two dimensional Gaussian function should be used when working with images. This is simply the product of two 1D Gaussian functions and is given in equation (3):

\[ G(x)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{x^2+y^2}{2\sigma^2}} \]  

By a Gaussian function, Gaussian Smoothing is the result of blurring an image. It is also known as Gaussian blur. After introducing the blur, the filter response coefficients for each pixel are calculated using Gaussian filter. By applying circular convolution, the directional derivatives are also calculated using Gaussian filter. In deconvolution process, using these X and Y directional derivatives that is calculated by Gaussian filter makes an image deblur very effectively.

(C) SPATIAL TO FREQUENCY DOMAIN IMAGE USING FFT

There are three basic steps to frequency domain filtering:
• Using the Fast Fourier transform, the image must be transformed from the spatial domain into the frequency domain
• The resulting image must be multiplied by a filter that usually has only real values.
• The filtered image must be transformed back to the spatial domain.

The Spatial domain image is transformed to Frequency domain image using Fast Fourier Transform. The transformed images are multiplied by a filter that contains only real values. The low frequency components represent general shape of an image. High frequency components are needed to sharpen the edges and provide fine details. At Frequency domain, it is not instructive, sometimes, it is useful to observe power spectrum of frequency domain image. In Fourier domain image, each point represents particular frequency contained in the spatial domain image. Fourier domain image has much greater range of frequency than the image in spatial domain. The result is efficiently operated when it is operated in frequency domain.

(D) FEATURE EXTRACTION

Feature Extraction is the process of defining a set of features or image characteristics which will most efficiently or meaningfully represent the information that is important for analysis and classification. For any barcode recognition system, feature extraction stage is one of the important components. Depending on the choice of feature extraction and feature selection method that are employed on the data, the performance of the classifier gets improved. The feature extraction stage is designed to obtain a compact, non-redundant and meaningful representation of observations. It is achieved by removing redundant and irrelevant information from the data. These features are used by the classifier to classify the data. It is assumed that a classifier that uses smaller and relevant features will provide better accuracy and require less memory, which is desirable for any real time system. Besides increasing accuracy, the feature extraction also improves the computational speed of the classifier.

(E) TEMPLATE DATABASE GENERATION

Template is a pre-developed layout in electronic or paper media used to make new images with a similar design, pattern, or style. These templates can be generated by some features mentioned above in deblurred image which is obtained by deconvolution process. The features are calculated as follows:

i) Mean

Mean is calculated by averaging the pixels in an image. Mean is denoted by \( \mu \) and it is given in equation (4),

\[
\mu = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} F(i, j)
\]  

ii) Variance

Variance is the average of the squared difference from the mean. It first calculates the mean then it subtract mean and square the result. Then work out the mean of those squared difference. Equation (5)

\[
\sigma^2 = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [F(i, j) - \mu]^2
\]  

iii) Standard Deviation

The Standard Deviation is a measure of how spreads out numbers are. Standard deviation is just the square root of variance and it is given in equation (6)

\[
\sigma = \sqrt{\frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [F(i, j) - \mu]^2}
\]  

iv) Maxima and Minima

Maxima and Minima are calculated when the function goes to high point or low point. In smoothly changing functions, a low point (minimum) or high point (maximum) are calculated where the function flattens out.

v) Covariance

Covariance is used to describe the linear relationship between two variables. Covariance for two set of values \( x \) and \( y \) can be found as given in equation (7)

\[
\text{Covariance} = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - x_{\text{avg}})(y_i - y_{\text{avg}})
\]  

vi) Mode

The number which appears most often is considered as mode value. Mode is mainly calculated to measure how far a set of numbers are spread out.

(F) TEMPLATE MATCHING

There are many techniques that are used for classifying objects. Here template matching technique using Hamming distance is carried out. The main concept of template matching is to compare one portion of an image with other. For recognition, the sample image that is similar to source image is used. On comparing to the source image, if the template image has small standard deviation, template matching is used. To identify printed characters, characters and other simple objects, templates are mostly used.

III. IMPLEMENTATION

(A) SUMMARY OF THE PROPOSED SYSTEM

Steps that are involved in the proposed system is as follows:

1) Read input image that contain noise
2) Denoised image is obtained when Adaptive filter is applied to input image
3) Denoised image is made blur using Gaussian function \( G(x) \)
4) Blurred image is applied to Iterative Wiener Filter
5) Calculate the size of an image
6) Calculate the Filter response coefficients using Gaussian Filter

ISSN: 2348 – 8549  www.internationaljournalssrg.org  Page 45
7) Apply the circular convolution method to estimate the blur on the image
8) Convert the spatial domain image into frequency domain image by applying FFT
9) Calculate the X and Y directional derivatives using Gaussian filter coefficients
10) Apply the deconvolution process on the blur image to deblur using the X and Y directional derivatives
11) Calculate the Template Features (Mean, standard deviation, mode, variance, covariance, median)
12) Generate the template database
13) Apply template matching to obtain the result

IV. EXPERIMENTAL RESULTS

The barcode images that are affected by noise and blur can be removed by Adaptive filter and Iterative Wiener Filter. This is implemented using MATLAB and its output is shown below. After denoising and deblurring of barcode images, the features of an image is extracted and stored in database as templates. Following figures explains the above content.

Figure (2) Input image

The input image shown in Figure (2) consists of salt and pepper noise is a category of noise which includes unwanted, almost instantaneous sharp sounds. Noises of the kind are usually caused by electromagnetic interference, scratches on the recording disks, and ill synchronization in digital recording and communication.

Figure (3) shows the Iterative Wiener Filter. The adaptive filtering has been applied widely as an advanced method compared with standard median filtering. The Adaptive Filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. Classification of pixels as noise is made by filter on comparing every pixel in an image to its surrounding neighbor pixels. The threshold and size of the neighborhood is adaptive.

Figure (4) Blurred image

Figure (4) shows the denoisy contrast enhanced blurred image. The denoised image is made blurred by Gaussian function. By applying Gaussian function to an image, the edge can be preserved without blur during deblurring process. An adjustment in image statistics is made using Adaptive Contrast Enhancement which uses a modified histogram equalization procedure. Increment in dynamic range or brightening the dark regions of an image are the decision made using is procedure. As a consequence, features in dark areas are improved without affecting mid and bright pixels, for dark images. The dynamic range of the scene is improved for the images with average brightness. Thus it is adaptive and provides a localized contrast enhancement effect which is not applicable with traditional contrast stretching based approaches. A high degree of workability is provided by this implementation.

Figure (5) shows the denoisy contrast enhanced deblurred image. Circular convolution method is used for deblurring an image which uses both blur kernel estimation and unblurred image restoration. Blur estimation can be made by pixel by pixel on the edges of an image. The deconvolution process is made by the calculation of directional derivatives. For this spatial to frequency domain conversion is made. A high quality de-blurred result is produced in low computation time.

After deblurring an image, features extraction is made which is the process of defining a set of features or image characteristics which will most efficiently or meaningfully represent the information that is important for analysis and classification.

Figure (5) Deblurred image
The features calculated here are mean, median, variance, standard deviation, maxima, minima, mode and covariance shown in Table 1. These features are grouped as templates and these are stored in database called template database.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean</td>
<td>7.4433e-016</td>
</tr>
<tr>
<td>2</td>
<td>Median</td>
<td>2.9700e-004</td>
</tr>
<tr>
<td>3</td>
<td>Standard deviation</td>
<td>0.0665</td>
</tr>
<tr>
<td>4</td>
<td>Variance</td>
<td>1.7871e-004</td>
</tr>
<tr>
<td>5</td>
<td>Maxima</td>
<td>0.6593</td>
</tr>
<tr>
<td>6</td>
<td>Minima</td>
<td>-0.5957</td>
</tr>
<tr>
<td>7</td>
<td>Mode</td>
<td>-0.5957</td>
</tr>
<tr>
<td>8</td>
<td>Covariance</td>
<td>4.8762e-004</td>
</tr>
<tr>
<td>9</td>
<td>Template</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0665</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.5957</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6593</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.5957</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0005</td>
</tr>
</tbody>
</table>

Table 1 Extracted features

The calculated features are trained using Neural Network where the minimum squared error gets minimized in each epochs. These trained features are stored in database. After training process, the testing process should be performed.

![Testing Image](image1)

![The authenticated Image](image2)

Figure (6) Testing image

Figure (6) shows the testing image. In testing process, the barcode images that are nearly close to the trained features are made as class 0. Class 0 indicates the image given as input is authenticated. If the image is not close to the trained feature, class 1 display which means the input image is unauthenticated. Here there are 15 images are taken as sample images. In these 15 images, 10 images are trained and stored in database. If the input is selected from these 10 images, it is compared with database. Authentication is made when the given image is matched with the image that is stored in database. Other than these 10 images, the image which is given as input is made unauthenticated and displays the image is not in database.

V. CONCLUSION

In most cases barcode will in blur due to out of focus in capturing device. To overcome this, there are many techniques available. Template matching is the best technique. In existing approach, spatial domain is used which is mainly used for denoising. But deblurring is not efficient and only intensity compensation can be made. So, the approach that works in both frequency and spatial domain is proposed. Here denoising and deblurring can be efficiently made by Iterative Wiener Filter where knowledge about point spread function is not necessary while deblurring. By this deblurred image, the features like mean, median, variance are calculated and stored in database as template. Two processes, training and testing is carried out using neural network. Authentication is made in testing process with the help of trained features.

REFERENCES