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A Novel Approach of Image Restoration Based on Segmentation And Fuzzy Clustering

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Abstract

Image restoration is the process of restoring or deblurring an image which has been undergone certain degradations. In this paper, we proposed a method for image restoration based on segmentation and fuzzy clustering. This Method consider the similar image pair which having common feature corresponding to degraded one in another. This proposed method firstly partition the image into specified segments and then it will use fuzzy clustering to cluster the segment based on their PSNR value and provide the segmentsthat needs to restore which will further used for accuracy of method.The performance of the system is evaluated on the basis of PSNR value. The proposed method shows the higher efficiency compared to existing methods.

Keywords: *Image Restoration, Segmentation, Fuzzy Logic, PSNR value*

1. Introduction

Image restoration is the process of restoring the original image from the observed image that can be degraded or blurred by some external sources. In image restoration, the main emphasis is to obtaining a deblurred image from a corresponding blurred one. There are numbers of factors that are responsible for blurring in the image like atmospheric turbulence, bad focus and motion between camera and original image. Generally when intensity of an image point is spread over several pixels, it goes blurred. This blurring is defined by a well-known operator called Point Spread Function (PSF) [1, 3]. Generally blur in the image is not uniform over an entire image. The amount of blur is different in different directions. The maximum amount of blur in the image is at the center of the image. So it is necessary to deblur the center part of an image compared to corner segments [2].

In past decays, several techniques for image restoration are proposed. Each technique restores the image having different type of blur. Some techniques restore the Gaussian blur, some restore the motion blur and some restore the out of focus blur. In 2007 [4], Mohsen Ebrahimi Moghaddam proposed a technique to estimate the out of focus blur. This method is based on a mathematical model. In 2009 [5], Feng, Jun and Hong proposed a restoration method based on PSF estimation.

In this paper, they concentrated on Gaussian blur in images. They estimated PSF for the Gaussian blur parameter. In 2009 [6], Rajeev Srivastava and D. Roy proposed a technique which was based on the motion blur estimation by using PDE's equations. In 2009 again [7], Sun Shaojie and Li proposed a method for single blurred image due to camera shake. In 2012 [12], Ms.S.Ramya and Ms.T. Mercy Christial proposed a blind deconvolution algoritm for restoration of gaussian blurred images.In 2013 [9], Kishore Bhagat and Puran Gourproposed a method for the estimation of motion blur parameters. All these proposed techniques are used for image restoration but the common property of all these restoration techniques is that

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it considers the whole image and then applying the algorithm for deblurring. This is not the case always. Sometimes we need to deblur only some portions or segments of the image by which the time complexity of image restoration system has been reduced.

In 2013 [13], Jiangyong Duan, Gaofeng Meng, Shiming Xiang and Chunhong Pan proposed a method for image restoration which wasbased on finding the similar image pairs by applying SIFT (Shift Invariant Feature Transform). After extracting the similar image pairs, they estimated the blur kernel for restoring the image.

Through this paper, we are going to propose a new method which is based on segmentation and fuzzy clustering which extract common feature corresponding to a blurred one. This method will identify those segments that need to be deblurring with the help of fuzzy clustering. We will discuss our proposed method further.

We will discuss our paper in different sections. In section 2 we will explain the overall proposed methodology of our restoration system. Further In its subsection 2.1 we will discuss the algorithm and architecture of proposed methodology. In subsection 2.2 we will describe some basic aspects and algorithm of segmentation. In subsection 2.3 we will demonstrate the fuzzy based clustering that extract the blurred segments according to membership levels of PSNR values. In subsection 2.4 we will describe the deconvolution method for restoration of extracted segments. In section 3 performance evaluation are discussed. In section 4 we present a conclusion.

2. Proposed Method for Image Restoration

The overall architecture of proposed Method is shown in the Figure 3,which demostrate all the processing steps which are used.

2.1 Algorithm and Architecture for Proposed Methodology:

Following steps are used in proposed method. Its Internal methods&algorithm will be discussed further-

1. Read the input image I and blurred image B.
2. Convert the image from RGB to Gray, if they are in RGB.
3. Segment both the images using segmentation algorithm and calculate the PSNR values.
4. Store all the segments and their PSNR values of input image and blurred image in therespective database.
5. Find appropiate clusters using fuzzy algorithm.
6. Extract blurred segments i.e. features from the databse by applying the suitable similarity measurement.
7. Apply the deconvolution algorithm to restore the blurred segment.

In the above algorithm we discussed all the steps that will be used to restore the blurred segments. All these steps can be easily understood by the architecture of the proposed method. The architecture of proposed methodology is shown below in Figure 1.

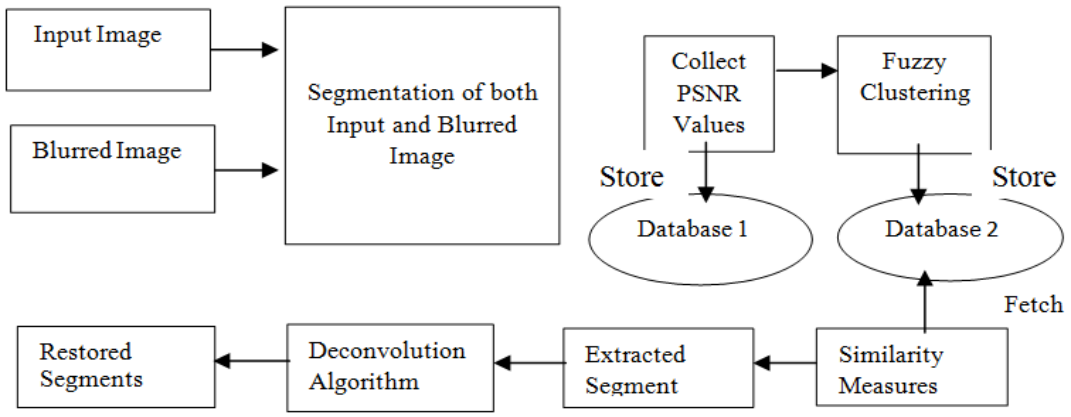


Figure 1. Architecture of Proposed System

2.2 Image Segmentation

Image segmentation is the process of segment the image into several parts that can be used to extract useful information form an image. Image segmentation is very versatile research area in the field of image processing. In 2007 [10], Hassan Mahmoud, Francesco Masulli and Stefano Rovetta proposed segmentation based registration of medical images. In this paper, we utilize the property of image segmentation to find the segments which needs to be deblurred. The amount of blur is not scattered uniformly in any blur images. It is found maximum at the center and minimum at the corners. It may be possible that an image is partially blurred. In that case, we do not need to deblur the whole image. Instead of deblurring whole image, we have to deblur only those portions of image which have blurred commonly.

For extracting similar blur regions we have to apply image segmentation. After that we will divide both the input and blurred image into desired number of segments. For our method, we are dividing our both image into 16 segments. Number of segments depend on the image size. If the number of segments is not according to size of image then it will increase the time complexity of image. On the other hand, we will unable to visualize the image.

The segmentation algorithm used for segmenting an image is stated as follows:

2.2.1. SegmentationAlgorithm:

1. Read the Original image I.
2. Read the Blurred image B corresponding to I.
3. Segment the original image into desired number of segments ($I_1, I_2 \ldots\ldots I_{16}$)
4. Segment the blurred image into desired number of segments($B_1, B_2 \ldots\ldots B_{16}$).
5. Find the PSNR values of every segment of the original image and blurred image.

2.3 Fuzzy Based Clustering

Clustering process provides a way to cluster a dataset into different sub-clusters based on their common property. Clustering algorithms can provide a better organization for the maintenance and retrieval of multidimensional data. Clustering algorithm follows the nearest neighbor search algorithm for creating the clusters or classes. The elements in the same class exhibit the same property. In each class, different similarity measures are used to decide

which memberbelongs to the corresponding class. During the literature, Ebrahimi Moghaddam and Mansour Jamzad 2007 [11] proposed a method which used fuzzy logic for identification of motion blur parameter. In fuzzy based clustering, each element belongs to acluster and associated with a set of membership levels. The membership value of each element belongs to a specific class in fuzzy based clustering. In the proposed method, Fuzzy based clustering is applied on PSNR values which were calculated through the segmentation algorithm. Each PSNR value corresponds to a fuzzy class and represents by a set of membership levels. Figure 2 shows the basic architecture of our fuzzy based clustering algorithm which is applied on PSNR values and shows the five basic membership level *i.e.*, Very low PSNR, Low PSNR, Medium PSNR, High PSNR, and Very high PSNR.

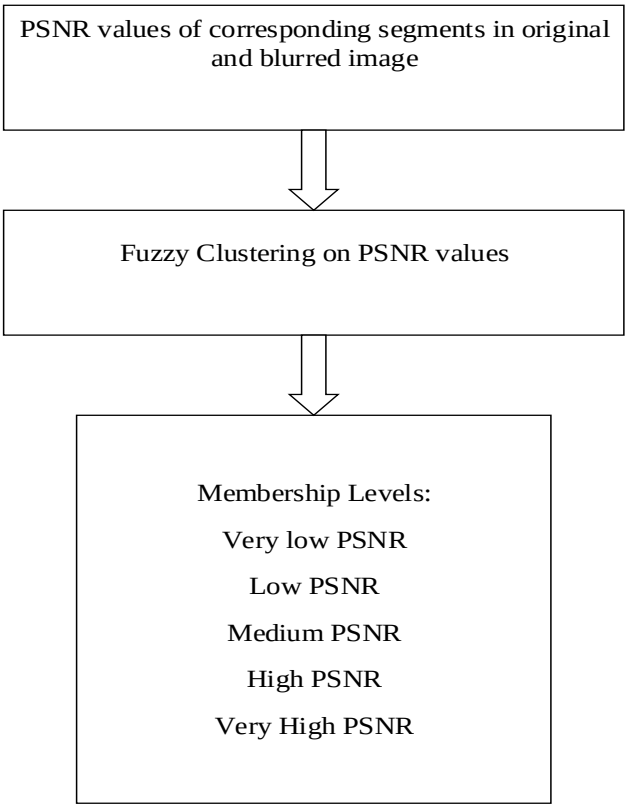


Figure 2. Fuzzy Clustering on PSNR Values

2.3.1. Algorithm for Fuzzy Based Clustering:

Input: sequence of data $P_{1,}P_2 \dots \dots P_{16}$
Where,
$P_i$denotes the PSNR value of each segment and n denotes the number of segments.
Output: different membership levels of PSNR values.
Step 1. First we calculate the value of $C_{min}$and C_{max}. The C_{max} is maximum value and C_{min} is minimum value of PSNR
$C_{min}$is represented as:

$$c_{min} = \min\{P_1, P_2, \dots \dots P_n\}$$

$C_{max}$is represented as:

$$c_{max} = \max\{P_1, P_2, \dots \dots P_n\}$$

Step 2. Now compute the value of different classes as:

$$c_i = c_0 + \frac{i}{6} \times (c_{max} - c_{min})$$

Step 3. Set $U = 0$. For each PSNR value update the value of μ_{ij} using following predefined conditions.

Condition 1. If $P_i \leq C_1$ then $\mu_{ij} = 1$ and $\mu_{i,j\neq 1} = 0$

Condition 2. If $C_j < P_i \leq C_{j+1}$then compute,

$$\mu_{ij} = \frac{(C_{j+1} - P_i)}{(C_{j+1} - C_j)}$$

$\mu_{i,j+1} = 1 - \mu_{ij}$ And $\mu_{i,k\neq j,j+1} = 0$

Condition 3. If $P_i < C_5$, $\mu_{i,k\neq 5} = 0$and$\mu_{i,5} = 1$.

Step 4. Now we shift the classes if they vary in their values. The shifting of classes can be done as follows:

$$c_j = \frac{\sum_{j=1}^{n} u_{ij} x_j}{\sum_{j=1}^{n} u_{ij}}$$

Step 5. If the value of C_j remain unchanged then algorithm stops, otherwise it goes to step 3.

2.4 Image Deblurring

Image deblurring is the process of restoring the image which has undergone certain degradation. In recent era, all the image restoration algorithm had applied on the whole image. If the image is partially blurred then this approach will failed abruptly. In this section, we emphasizes on the restoration of segments of a blurred image rather than the whole image. Firstly we extract the segments of a blurred image which needs to be deblurred. Segments are extracted on the basis of membership levels of PSNR values which we calculated in the fuzzy based clustering algorithm. We will consider those segments which have the membership values of PSNR into first three membership levels *i.e.*, Very low PSNR, Low PSNR, Medium PSNR. After that we extract the segments whose PSNR membership values falls into those three levels. After thatwe will apply restoration algorithm on the segments of an image which we have extracted [12].

2.4.1 Deblurring Algorithm:

1. Extract the segments of blurred image from the database which have the PSNR membership values in the specified range.

2. For a =1:N

Step 1 - Estimate the Blur parameter of blurred segment.

Step 2 - For every blur parameter of the corresponding segments, apply the deconvolution algorithm to get the restored image.

Where,

A is the number of loop based on N, number of segments

3. Algorithm stops automatically, if number of segments exceeds the value of N.

2.4.2 Flow Chart of Deblurring Algorithm:

The deblurring algorithm described above can be visualized by flow chart. The flow chart of algorithm used in deblurring of blurred segments is shown below in Figure 3.

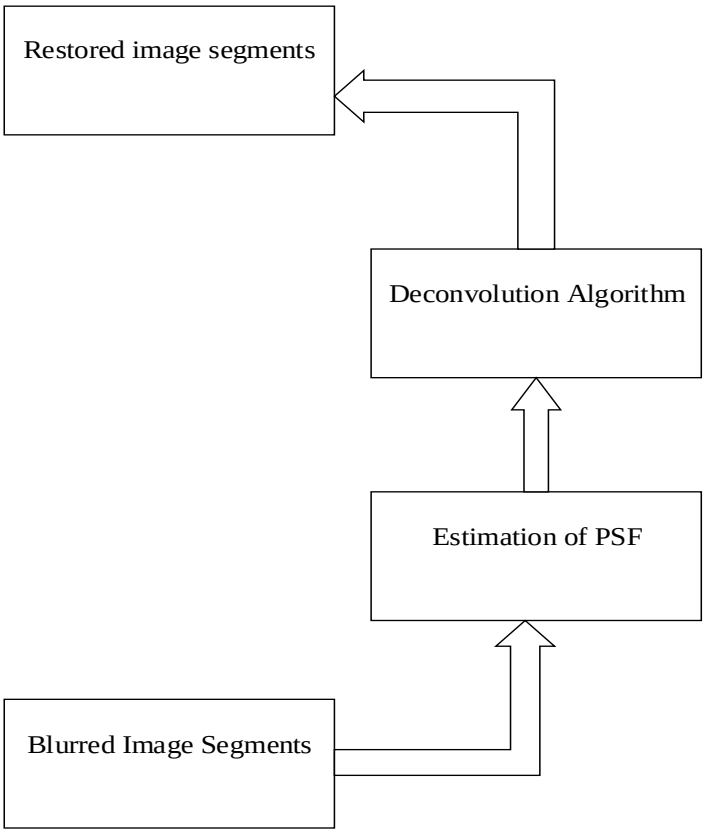


Figure 3. Flow Chart of Deblurring Algorithm

3. Perfomance Evaluation

The evaluation of restored image is a crucial situation in the image restoration system. Several different methods for performance evaluation is used by the researchers. The most common and popular method which is used for evaluation of restored image is peak signal-to-noise ratio (PSNR). The better the PSNR value, the better the image. PSNR is defined by the Mean Square Error (MSE) and MSE is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

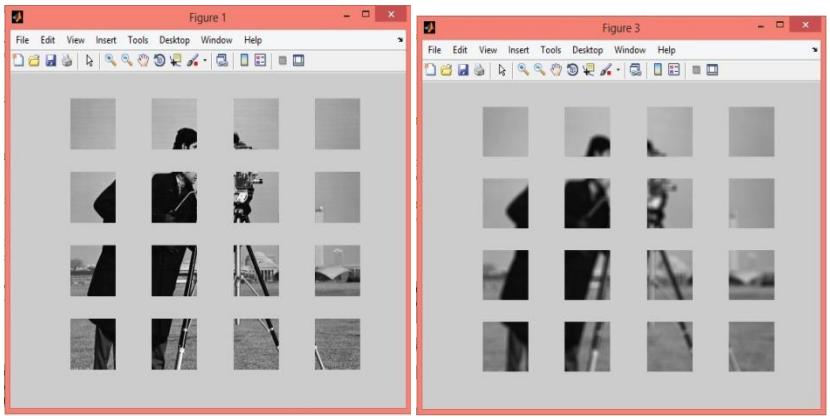
PSNR is defined as:

$$PSNR = 10log_{10}\left(\frac{{MAX_I}^2}{MSE}\right)$$

Apart from it the performance of propsed system is calculated on the basis of number of segments extracted. The lesser the segments extracted, the lesser the time it takes to compute the restored image.

We simulated our proposed method in the MATLAB version 2013a. There are several standard images in the MATLAB toolbox. We took one of those standard images to demonstrate our proposed method. We demonstrate our method on the "cameraman.tif" image which has resolution of 256x256. At first we applied segmentation algorithm on both input image and its corresponding blurred image. During segmentation, we assigned a name

to each segment of input and blurred image, say I11, I12 and B11 and B12 respectively. Along with segmentation of both the images, we also calculated PSNR values between each corresponding segments and stored it in the database. The initial segments of original and blurred image are shown below in the Figure 4.



(a) **(b)**

Figure 4. Segments of (a) Original Image (b) Blurred Image

After applying the segmentation algorithm and calculating the PSNR values between each segment of input and blurred image, we applied fuzzy based clustering on the calculated PSNR values for extracting blurred segments.This fuzzy based clustering form the different membership levels for each segments. We extract the blurred segments with the help of these membership levels by applying suitable similarity measurement. The extracted blurred segments are shown below in the Figure 5.

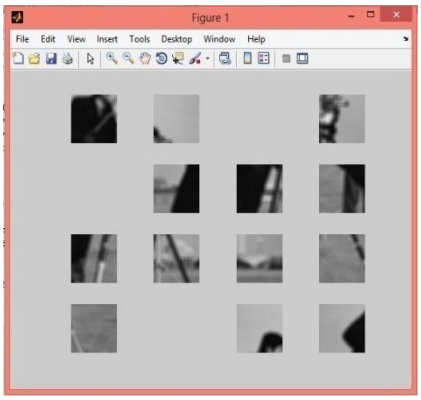


Figure 5. Extracted Segments for Deblurring

After extracting the blurred segments, Blind deconvolution algorithm is applied on these segments and their improved PSNR value is calculated. Figure 6 below shows the deblurred segments after applying the deconvolution algorithm.

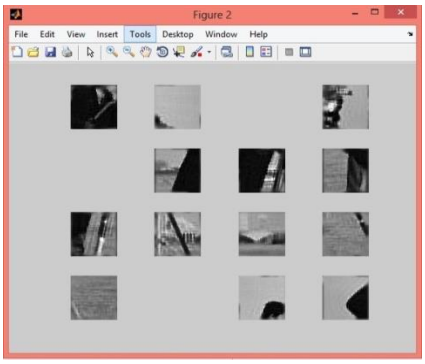


Figure 6. Deblurred Segments

Table 1. Result Comparison with Existig Method

Segment ID	Existing Method Result[13]	Proposed Method Result
B12	11.2379	14.5614
B13	13.5408	14.6057
B14	08.7906	11.9067
B21	13.5639	21.3572
B23	05.6691	09.8768
B31	12.6662	13.7231
B32	06.0541	09.2849
B33	11.4427	14.0649
B34	06.8948	10.8248
B41	05.3970	09.0276
B42	14.0385	15.9844
B43	09.4629	15.2675
B44	10.5226	18.2963

The PSNR values between blurred and restored image are shown in the table above. It shows that the PSNR value of each segment has increased when it restored. So the higher the PSNR, the better the image. The Table shown above depicts a mathematical representation of improved PSNR values as compared to old PSNR values. It can be represented graphically in the form of bar graph so that we can visualize it easily. The figure below shows the bar graph representation of old and Improved PSNR values.

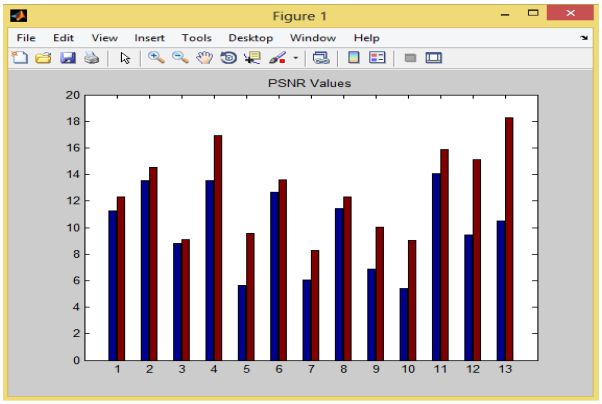


Figure 7. Comparison of PSNR Values Through Bar Graph

4. Conclusion and Future Work

The main objective of the proposed method is to develop an image restoation system that works on the concept of feature matching. The proposed method is based on two steps. Firstly it segments both the input and blurred image and cluster those segments based on PSNR values. Secondly it retrieves segments having low PSNR values.

In proposed method, segmentation is used to find segments of the image that needs to be deblurred.Fuzzy based Clustering is used to reduce the number of segments for deblurring.

The proposed method combines the segmentaion and fuzzy clustering with deconvolution method. This will increase the accuracy and efficiency of restoration system. This proposed method is better than other existing method for image restoration.

We just provided one way to utilize features of two similar image pairs for restoring the image. The more powerful algorithms can be developed in the future. As a future work, we can use another powerful deconvolution scheme to restore the image more accurately. We can also deal with the time complexity of the system which will increase when the number of segments will increase.

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