Reconstruction of noisy and blurred images using blur kernel

Vijayan Ellaplan and Vishal Chopra
School of Information Technology Engineering, VIT University, Vellore – 632014, Tamilnadu, India

E-mail: evijayan@vit.ac.in

Abstract: Blur is a common in so many digital images. Blur can be caused by motion of the camera and scene object. In this work we proposed a new method for deblurring images. This work uses sparse representation to identify the blur kernel. By analyzing the image coordinates Using coarse and fine, we fetch the kernel based image coordinates and according to that observation we get the motion angle of the shaken or blurred image. Then we calculate the length of the motion kernel using radon transformation and Fourier for the length calculation of the image and we use Lucy Richardson algorithm which is also called NON-Blind(NBID) Algorithm for more clean and less noisy image output. All these operation will be performed in MATLAB IDE.

1. Introduction

Number plate of a car is really important part of a car with car license plate one can easily recognize the car. If somebody attempted any crime using that vehicle and crime investigation department knows vehicle’s license number than information of vehicle owner would be easy to fetch via RTO. This number plates have a big hand in identifying the over speeding racing or rash driving vehicles, these vehicles cause trouble for common people who used to drive patiently and safely. Now-a-days we have CCTV cameras on every road or on crossing with speed detector systems, if any vehicle like bike, car, truck over speed than that system will be capturing them and detect the image of there vehicle’s license plate and find out who’s vehicle it is and generate the penalty slips. These systems are directly connected to the RTO databases.

Sometimes we get the blurred image because of over speeding of vehicle or it can be because of slow shutter speed of our camera or CCTV. That blur image could look like this –

![Fig 1(Fast Moving vehicle’s Blurred license plate)](image)

This image has blurred with Gaussian method, This can be done by applying horizontal scale line and after that if we don’t get proper blurred image then we apply vertical blurred image.

The following image have motion blur, this blur occurs because of either low camera shutter speed or because of moving object speed.
From last some years a popular algorithm called Lucy Richardson algorithm is in use to get the deblurred image. This algorithm get lots of positive reaction from the researchers or from it fields.

\[ B(x,y) = (k \ast I)(x,y) + aG(x,y) \quad \text{eq. (1)} \]

Variables of image \((B,I,K)\) represent the blurred image, where \(G\) is representing noise which is also called Gaussian noise, in this algorithm \(\ast\) represents the blur operator. In the following algo 2 varriable \(k\) and \(I\) both are anomalies for algorithm, \(k\) stands for kernel which is not estimated yet and \(I\) stands for image. \(K\) is also called point spread function.

In this paper we are introducing a image deblurring system which will give us a human readable deblurred image, which is clicked by cctv camera or it can be any shaken camera picture. Our main motivation is to fetch the clean and sharp picture out of our system which can be recognized by the human. So the work of blur kernel is to calculate the length and the angle of the image. after getting estimated coordinates we move forward for more sharp and smooth image of the licence plate no. for that we have to apply lucy richardsons’s NBID (non-blind) algorithm , after applying blur kernel if we do not get the proper human understandable image then we apply NBID algorithm , which is used to make our raw image sharp and smooth . we also can apply some filters to make our output image more readable and reliable.

**Challenges we face while getting a deblurred image**

- Cameras which are installed in public area or personal area are used to capture the big images which includes there surrounding like other vehicle road, birds, house, shops, people and such object. where the car’s license number take really small place. To get the license plate image only from it super image is also very complex.
- Just because of over speed of our vehicle our systems blur kernel size became very large, and the result of speed destruction of edge information our license number plate. This can cause difficulty or can make our system more complex to restore image.
- The license plate blurred image have edges in horizontal and vertical blur motion. Just because of this our systems assumption algorithm may also not work.

2. **Related Work**

There are so many systems available at present Like VBM4D which first do get motion compensation using image’s block region matching and then filters will be applied. In the filtering the whole images conversion based on DCT and WAVELETES.

In VBM4D they first match the blocks of the image and in the block matching they used to match frames of image and when the matching is done then we go for wavelets and DCT to get the final result which is to get noise less image or to remove the region which have the noise.

But this system have its own drawbacks –

- This System uses block matching and then it uses frame matching for more accurate image restoration which is a real drawback of this algorithm/system, because it would take much more time and it will make system more complicated.
- Main weakness is excessive blurring of image which can be results in the image’s geometry and texture removal.

**A. Gaussian Method**

In image processing Gaussian method is also known as Gaussian image smoothening method. This function is used to get a blurred image and also used to remove the details from the image and adds noise into it. So its result would be blurred image[1] [2].
3. **Proposed System** –

The proposed technique is based on image deblurring problem which can be reduced to parameter estimation problem. The quasi-convex property of sparse representation coefficients with kernel coordinates are used to fetch the blur kernel estimation. This estimation used to architect a coarse and fine algorithm for computation of angle and length efficiently. and the blur length estimation is done by radon transformation using the Fourier domain.

**Advantages:**

- This algorithm makes our system more efficient to find motion angles independently.
- It also check the sub pixel of the pixel which results in more accurate restored image.

**Image Processor:**

A image processor always store, segmentation, representation and interpret it and finally shows the results of image. This block diagram will show how the image processor really works: The first step of this sequence is get image using the digitizer, it will digitize the image. After this our image will be sent to next processes. Next step is pre-processing, the work of preprocessing is to make our image noise less, enhance it. Now the next part segmentation which is used to partition our image in regions and get the raw pixel data, which have the data of boundary regions. Now the representation is to make our image pixel data useful which is done by subsequently by our computer. Reorganization is like a label which is assigned by information provider which is purely based on objects. Interpretation is used to assign meaning to the remembered objects. The knowledge base is like a coordinator which is used to control the interaction between the module of the flow diagram.

FIG1.1(Fundamental Flow of Image Processor)
B. **Angle Estimation for Linear Uniform Kernel**

Sparse representation always has received little attention in parameter inference. Parameter calculation is also used in optimization of Bayesian view. To get the calculation of angle we need to solve the following equation

\[(\theta, I) = \arg\min_{\theta, I} \{-\log p(I) + \lambda \| k\theta * I - B \|_2^2 \} \]  \text{Eq. (2)}

In this following equation B is referred to Blurred noisy image and I referred to Latent image which will be restored and \( p(I) \) is the prior Sharp image. *Coarse-To-Fine Algorithm*

**Algorithm**: Step 1: Blurred image as B, Initial Theta \( \theta \), and length \( l \)

Step 2: While Converged Not Do

Step 3: Generation of linear kernel

Step 4: Solving Eq. 3 using kernel to get blurred img

Step 5: Solving Eq. 4

Step 6: Return

Step 7: Else Ladder

Step 8: END and OUTPUT

*FIG 1.2 Block Diagram*
\[ X = \text{argmin} \{ I |TV + \lambda 2|k\theta - B||^2_F \} \quad \text{Eq. (3)} \]

[3] To solve the equation number 3 we set \( \lambda \) as 500. It could happen that we get different values in final deblurred result compared to the initial results. In this equation we calculate the coarse angle estimation which is used to find the complexity of image and according to that only. [5] [6] the another parameter of algorithm is \( \theta \) angle. Our simulation image have blur that is because of fast moving vehicle, mostly the angle of motion of moving object must be in [70,110]. After this we come to our next equation number 4, the sparse representation coefficient \( \sum |a_i| \) can be computed by solving:

\[ \min a_i \sum |a_i| \text{s.t. } \Omega_i X = D a_i \quad \text{Eq. (4)} \]

In this equation we apply sparse representation on overlapped patches. And these patches must be in size of 8x8 are sampled every 6 pixel along horizontal and vertical axes. And the sum of absolute value of all patches’ sparse representation coefficients is regarded as the final score.

C. Length Estimation

[4] Once the direction of motion has been fixed, we can rotate the blurred image to make this direction horizontal. Then the uniform linear motion blur kernel has the form

The core of length estimation is to estimate the distance between 2 nearby zero points of frequency response of kernel. In frequency domain, the uniform blur model can be:

\[ FB(u,v) = F_k(u,v)FI(u,v) + FG(u,v) \quad \text{(2)} \]

where \( F \) denotes the Fourier transform operator.

[5] In most of the situations it is difficult to find out the zero points in frequency response in observed domain. Just because of noise it would be difficult to figure out the zero point of the \( F_k \) which would not denote the zero point of \( F_b \).

Radon transformation on fourier domain used to collect the integral sums of methods of images straight lines. The main work of the radon transformation is to get the calculation of motion blur kernel. This is used when our image is full of noise. In our system we follow that radon transformation which is used to apply on the image centers.

Algorithm: Length Estimation:

Input: Take blurred image As B Coordinate, And Output of Algorithm as 20

1. Extend B into square image
2. Apply modified radon transformation over angle \( \theta \) where Rlog \((|FB|)(p)\) denotes the result.
3. Fit Rlog \((|FB|)(p)\) with thre order polynomial function through least square error method, the fitting result is Rlog \((|FB|)(p)\)
4. Getting results of the two consecutive results of local minimums.
5. Getting the computed length.
6. Output: the length Of kernel is : \( L \)

D. Lucy Richardson Algorithm:

[1] [2] After getting coordinate from coarse-to-fine and radon transformation on fourier domain we go for lucy Richardson algorithm. This algorithm is pretty famous in scientific field because of its robustness. That is why we are using to get a very clear and robust image. This algorithm give us a very sharp and smooth which would human understandable. This algorithm will be applied by all the iteration which is a part of blur kernel. Blur kernel includes coarse to fine and radon transformation on fourier domain.
Algorithm :

Input: Blurred image As B, kernel As k, the balance parameter λ

1: First Initialize the bergmen multipliers bx and by, parameter e.
2: while not converged do
3: argmindx will be solved by gradient descent method
4: argmindx{ |dx|+ 2|dx−∇x| −bx|2 F}, it will be solved by shrink age method
5: argmindy{ |dy|+ 2|dy−∇y| −by|2 F}, it will be solved by shrink age method
6: After following calculation update bergmen multiplier
7: if reach the max-iteration
8: converged and return the values
9: endif
10: end while
11.Restored image

4. Implementation and Experiment :

In Implementation phase we 1st converted our image into .mat file. Then we blurred our mat image using Gaussian smoothing method for simulation purpose. Then we go for blur kernel which includes the coarse to fine and radon transformation on fourier domain. Coarse to fine are used to get the motion angles from the image and the Radon transformation on fourier domain is used to get the length of the motion blur in image. It takes its adjacent motions as estimation. It assumes according to data estimated from image that how many times it should be iterate that we can get human readable image or human recognizable image, it could be in-between 40-60 iteration. After this we go for Lucy Richardson algorithm. Before applying lucy algorithm we get a raw image estimation then we apply lucy Richardson algorithm which used to smooth our image and make our image more pixel sharp so that it would be more crispy and human readable. To add more readability we added a Filter to control which control the contrast, hue, saturation of image which would let us a quality image as output.

| BID Algorithms | Time(Sec.) |
|----------------|------------|
| NSBD[7]        | 11.84      |
| FSR[8]         | 135        |
| HQMD[2][3]     | 736        |
| Our system     | 370        |

Table 1.1 Comparison of different algorithms

We applied our system on some synthetic car’s license number plate and blurred that with Gaussian method and then we applied our system on it and got the 60 to 70% clear and crisp image. This experiment is done on system which have intel core i5 4th generation 64 bit processor with 8 gb of ram and 2Gb of Graphics card. This system is implemented in MATLAB script R2015b. Here are the results :
5. Conclusion

In this paper we worked on car’s license plates. Sometimes we get blurred image of the fast moving vehicle which may be crossing it’s speed limit for a particular area. This image probably clicked by CCTV cameras. Sometimes CCTV camera unable to take clean picture of car’s license plate so the result would be blurred and noisy image. To get noise less image we apply our algorithm, Our algorithm is more robust and efficient them algorithm available at present, our algorithm can be operated on very large blur kernel efficiently. As we can see our blurred input image which is unrecognizable because of motion. Now that image can be human understandable, that is why our system is more efficient then any available systems. we proposed an algorithm which works on license plate images parameters. These all parameters are assumption of our algorithm, the license plate deblurring problem can be reduced to a parameter estimation problem. An interesting quasiconvex property of sparse representationcoefficients with kernel parameter (angle) is uncovered and exploited. Now this estimation used in to find in angle’s efficiently by coarse to fine algorithm. And the length estimation of our license plate is done by using radon transformation on Fourier domain. Then Lucy Algorithm will be applied and in order to get more clean and human understandable image we added controls to increase and decrease hue, saturation so that we can use it accordingly. [11]To use them i have added filter algorithm based on Local mean, Global Mean based on filter mean.

Filter Algorithm –
Step 1: Read Gray .MAT image
Step 2: Initialize our process with 3x3 sub image
Step 3: Calculate Local mean, Global Mean using Mean Filter
Step 4: Finalize the pixel of input image.

**FIG 1.4** (Images After Applying Filter)

Comparison in RGB Histogram –

**FIG 1.5** (Original Image RGB Histograms)

**FIG 1.6** (Blurred Image Histograms)

**FIG 1.7** (Restored Image Histograms)
References

[1] Efficient image deblurring via blockwise non-blind deconvolution algorithm Neng-Chien Wang; Jian-Jiun Ding; Li-Ang Chen; Ronald Y. Chang 2015 10th International Conference on Information, Communications and Signal Processing (ICICS)Year: 2015

[2] Blind deblurring for dermoscopy images with spatially-varying defocus blur Yanan Lu; Fengying Xie; Zhiguo Jiang; Rusong Meng 2016 IEEE 13th International Conference on Signal Processing (ICSP)

[3] A Spectral and Spatial Approach of Coarse-to-Fine Blurred Image Region Detection Chang Tang; Jin Wu; Yonghong Hou; Pichao Wang; Wanqing Li IEEE Signal Processing Letters Year: 2016, Volume: 23, Issue: 11

[4] Image deblurring with blur kernel estimation in RGB channels Xianqiu Xu; Hongqing Liu; Yong Li; Yi Zhou 2016 IEEE International Conference on Digital Signal Processing (DSP) Year: 2016

[5] A Comparative Study for Single Image Blind Deblurring Wei-Sheng Lai; Jia-Bin Huang; Zhe Hu; Narendra Ahuja; Ming-Hsuan Yang 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Year: 2016

[6] Deblurring Saturated Night Image With Function-Form Kernel Haifeng Liu; Xiaoyan Sun; Lu Fang; Feng Wu IEEE Transactions on Image Processing Year: 2015, Volume: 24, Issue: 11

[7] Efficient blind image deblurring method for palm print images M. Saad Shakeel; Wenxiong Kang IEEE International Conference on Identity, Security and Behavior Analysis (ISBA 2015) Year: 2015

[8] Framelet-Based Blind Motion Deblurring From a Single Image Jian-Feng Cai; Hui Ji; Chaoqiang Liu; Zuowei Shen IEEE Transactions on Image Processing Year: 2012, Volume: 21, Issue: 2

[9] Blind deconvolution using a normalized sparsity measure Dilip Krishnan; Terence Tay; Rob Fergus CVPR 2011

[10] Unnatural L0 Sparse Representation for Natural Image Deblurring Li Xu; Shicheng Zheng; Jiaya Jia 2013 IEEE Conference Computer Vision and Pattern Recognition Year: 2013

[11] Contrast enhancement and brightness preservation using global local image enhancement techniques Archana Singh Sanjana Yadav; Neeraj Singh 2016 Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC) Year: 2016 Pages: 291 - 294