A Survey on Image Enhancement using Image Super-Resolution and Deblurring Methods

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***Abstract* - Image enhancement is challenging is in image processing area and it can resolve this problem using the some high-resolution methods. This paper given an overview of the resolution image and methods of removing blur noise from the noisy image. The noise image and low-resolution image problem can be solved using different methods of the Super-Resolution and de-blurring techniques.**

***Keyword* - Image enhancement, Super-Resolution, Image de-blurring, Frequency domain, Spatial domain, Point Spread function (PSF), Degradation model, Blur Kernel.**

1. INTRODUCTION

Super-Resolution and Deblurring is an approach to produce High-Resolution image from a number of low-resolution images. Super-Resolution can be used for image enhancement and minimizing the blurred effect in images. Image processing consists of many images which are part of some image data and high frequency or detail lost due to a situation : like focal point of camera is not properly adjusted, may be some lighting defect or there are some cameras that have a low sensor cell. This type of detail that is lost can be retrieved using Super-Resolution method. Basically, the super-resolution reduces noise from the image when it is noisy, blurred, in motion etc. Image Super-Resolution method is divided into mainly two different parts - one is the Frequency Domain and other is Spatial Domain method. The Super-resolution improves and enhances the quality of the image but cannot improve recognition.

De-blurring method is used to produce the highest quality image by removing the blur from the degraded image as much as possible using Point spread function. This method can remove the blurred noise from the normal image and can be used in the face recognition of image processing. Image can be constrained or unconstrained. The problem with unconstrained image can be a posing problem, blurred face, or illumination problem. In Image de-blurring, first we need to look upon the recognition problem. The recognition problem refers to restoration of the image. De-blurring method estimates the blur kernel or PSF for the noisy and blurred image and it can improve the quality of the image.

De-blurring image enhancement technique has a number of methods that have been described in this paper. This method has been introduced by the different ways to remove the blurred noise from the image. Section 3 shows the type of the method used for De-blurring. This method is categorized into Blind Deconvolution, Lucy-Richardson method, De-blurring with Blurred/Noisy Image Pairs, and De-blurring with Motion Density Function. De-blurring is used in different ways – in the Medical field, Image processing, improved vision, and face recognition. In this paper, Section 3 categorises de-blurring techniques.

After de-blurring, we need to use Super-Resolution technique for the image enhancement. Image enhancement refers to producing a high quality image. The stages required to perform this task are – image registration, restoration, and interpolation. This paper gives an overview of all the methods which are used in image enhancement and its different uses. Image Super-Resolution is used in the image processing application, identification and Recognition. Both Image Super-Resolution and De-blurring are used for Image enhancement. In this paper, Section 2 describes the Super-Resolution Methods which are categorized into mainly two parts - Frequency Domain and Spatial Domain method. Spatial Domain method gives a more accurate result than Frequency Domain method. Section 3 discusses the De-blurring methods. There are different techniques for De-blurring – most commonly used method is Blind de-convolution method to retrieve degraded image. Section 4 Classifies and compares all the methods to determine which method is better than the each other. This paper shows image enhancement using De-blurring and Super-Resolution.

2. Super-Resolution Methods

Image Super-Resolution method was first proposed by T sai and Huang [1]. It can enhance a degraded and noisy image. We use De-blurring for improving Low-Resolution images also. Super-Resolution is categorised into the Frequency Domain method and Spatial Domain method [27]

Fig.1 shows the Flow diagram of SR image. There are three steps to complete Image SR or Image enhancement.(Set of Low-Resolution image is used for Single Image SR)- image Registration, Interpolation and Restoration. Final step is to remove noise from the Image and estimate the SR. Super-Resolution method has many techniques described in[5] of this survey on various SR methods. This paper categorized these techniques using various papers, modified the methods, demonstrated the features, and highlighted the improving work in this field.

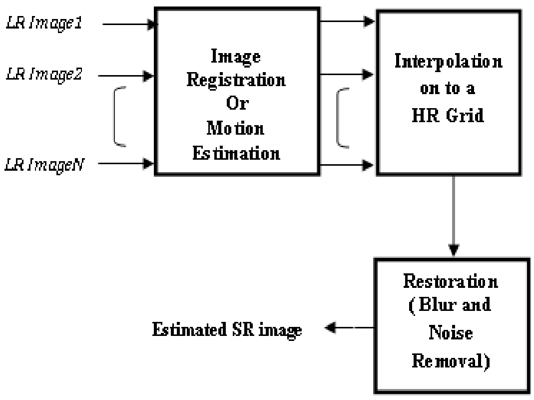

Figure-1: Flow Diagram of the Super-Resolution [2]

FREQUENCY DOMAIN METHODS

Frequency domain approach makes Low– Resolution image reconstruct into a High-Resolution Image. Tsai and Huang [1] first derived a system of equations that describe the relationship between LR images and a desired HR image by using the relative motion between LR images. The frequency domain is based on three principles:

1) The shifting property of Fourier transforms.

2) Relation between Continuous Fourier transform (CFT) of original image and Discrete Fourier transform (DFT) of observed Low-Resolution Image.

3) The assumption that original High-Resolution Image is band limited.

Frequency domain method (In [2]) first transforms low-Resolution image into DFT Domain and combines them and observed low–resolution images. Various methods under frequency domain technique:

Restoration via Alias Removal -In this method, first spatial image reconstruction is done using frequency domain method. This approach was presented by R.Y. Tsai and T.S. Huang [1]. High-Resolution image is obtained by estimate matrix of image using Inverse Fourier Transform. This method restores the image from the alias image. This method only considers the transition between images so that the method ignores the noise effect of the image [5].The frequency domain formulation is based on shift and aliasing properties of Continuous and Discrete Fourier Transform for the Reconstruction of the band-limited image from a set of under-sampled and aliased image that are observations of the images. The Shift and Aliased properties are used for formulating a system of equations which is related to aliased Discrete Fourier Transform (DFT) coefficients of Observed Image to sample of the Continuous Fourier Transform [2] of the unknown image.

In [6], a Method based on the model introduced by Tsai and Huang is Taylor series expansion which is used to calculate the transition variables. This method is simple and computationally attractive, but faces the problem of Assumption of the Ideal-Sampling of the Image. Sometimes this method may get noise or blur effect of image.

Recursive Least Squares (RLS) -Least Squares are implemented in a recursive manner to improve computational efficiency. In [8], the utilized frequency domain theoretical framework and global translation observation model, which is proposed in [2], extends the formulation to consider observation of Noise and Spatial Blurring effect. Frequency Domain Reconstruction method precedes the two solution methods- Recursive Least Squares and Weighted Recursive least squares. Recursive Solution approach is computationally attractive, and the least squares formulation has the advantage of measuring robustness in some under determined system cases. This RLS method addressed the problem of noise and blurring effect [2],which can take some levelled approach to solve the problem.

Firstly, the stabilizing function (squared error) is unrealistic for images, tending to result in overly smoothed solutions [2]. Secondly the use of an estimate of the unknown solution leaves un-answered questions as to the stability of the proposed recursive solution method by R. Ramya, Dr. M. Senthil Murugan [2].

Recursive Total Least Squares(RTLS)- Recursive Total Least Squares Method is the Extension of the Recursive Least Squares method that provides some robustness to error in observation model, in case the super-Resolution reconstruction, to get result from the error in motion estimation [2, 9].This Method was developed by Bose, Kim and Valenzuela [9] to extend the idea of including robustness to errors to get the result from error in the translation motion estimation required for the specification. This method clearly justifies the motion estimate needed for accurate Super-Resolution reconstruction as much as possible. The Total Least Squares Method Used for the Reconstruction or Restoration is shown in the Image [10, 5].Also this method solves the problem of Least Squares method (where the addition of the noise, which is the observation model) to minimize the noise and error of the image. This method can minimize the error.

Multichannel Sampling Theorem Methods -This reconstruction method implementation is achieved in the spatial domain method, but the technique is fundamentally related to the frequency domain because of the shift property of the Fourier Transform that translates the source image [2]. In this method, which is actually implemented in spatial domain, there is some consideration of the Point Spread Function (PSF) which is fundamentally included in the frequency domain method. So, Ur and Gross [11] consider some linear degradation to include the effect of the blur point Spread Function and global translation which is considered as delay in the method. That Observation the operation of the blurring effect and translation that the commutative and assuming[2] the single blur effect of the common for all channel, this observation shows that the Super-Resolution problem is divided into some distinct process which involves the “merging” of the under-sampled signal into single-band limit function; this is the “de-blurring” of the merged signal. De-blurring and merging process are different from each other, but there is a possibility that the some closed solution is derived for the merged signal from the under sampled and degraded channel outputs.

In this method [5], the original signal of the image was converted into the discrete signal. This discrete signal is known as sampled signal from the original signal and that signal is passed through some R linear filter and produces the result of the interpolation signal. Let us consider equation.1 [5] the function f (x). There is a band-limit of-**σ** <ω<**σ and** this is passed through the linear channel R, where the output is sampled t the rate of2σ / R (under-sampled at 1/R of the Nyquist rate) to produce R discrete signals **yr**(**mT**),T =R/2σ,m∈ Z, r ∈{1,2,...R}.In this theorem, **Yr (mT)** is passed through the linear filter with impulse function hr(.) and the total output of the filtering is shown in the equation [5] below:

$$\hat{f}(x) = \sum_{r=1}^{R} \hat{f}_r(x) = \sum_{r=1}^{R} \sum_{m=-\infty}^{\infty} y_r(mT).h_r(x-mT) \tag{1}$$

Where fˆ(x) is a sampled version of f(x) meeting the Nyquist criterion and which may be interpolated to recover f(x) exactly [5]. This equation shows the output of the blurred image. There is a unique solution for the problem in multi-sampling method. This method reconstructs the noisy image and the equation gives filtered image.

Table 1: Frequency Domain Methods

Sr No.	Methods	Remarks	References
1.	**Restoration Via Alias Removal**	Using inverse Fourier transform, the high resolution image obtained	ElhamKarimi, KavehKangarloo, Shahramjavadi [5].
		Drawback of this method: Assumption of Ideal sampling	R. Ramya, Dr. M. SenthilMurugan [2].
2.	**Recursive Least Squares (RLS)**	Improve computational efficiency	R. Ramya, Dr. M. SenthilMurugan [2].
		This method implements, simultaneously, the tasks of interpolation and noise filtering of the input images by applying the recursive least squares	N. K. Bose, H. C. Kim, and H. M. Valenzuela [9].

3.	**Recursive Total Least Squares (RTLS)**	Minimized the error	R. Ramya, Dr. M. SenthilMurugan [2].
		Recursive Total Least Squares method extension of the Recursive Least Squares which is known to provide some degree of robustness to error in observation model	Elham Karimi, Kaveh Kangarloo, Shahram javadi [5]. R. Ramya, Dr. M. SenthilMurugan [2].
		This method used for the reconstruction or restoration of image	Bose, N.K.; Kim, H. C.; Zhou, B. [10].
4.	**Multichannel-Sampling Theorem Methods**	This reconstruction method implementation is achieved in the spatial domain method, but the technique is fundamentally related to the frequency domain.	R. Ramya, Dr. M. SenthilMurugan [2]. H. Ur and D. Gross [11].

SPATIAL-DOMAIN METHODS

The Super Resolution method [4], which is observed and formulated, reconstructed the effect on Image in Spatial Domain Method. This method can accommodate global and non-global motion effect in image. There are different types of motion blur like- Motion Blur, Optical Blur, spatially varying PSF etc. Spatial Domain Method has one important factor that constraint easier to formulate [3].Spatial Domain Spatial domain reconstruction allows natural inclusion of (possibly Non-linear) spatial domain-priori constraints (e.g.Markovran-domfields or convex sets) which result in bandwidth extrapolation in reconstruction [4].

Spatial domain approach improves the frequency domain method. In the frequency domain method, there is a problem with the frequency domain formulation. Another problem with frequency domain method is that it regularizes super-resolution which is difficult to express in the FDM. There exist various techniques for solving the frequency domain method problem. The solution methods are: interpolation, deterministic regularized techniques, stochastic methods, iterative back projection, and projection onto convex sets, etc.

Iterated Back Projection (IBP)

Irani and peleg [12] introduced this method which is Super-Resolution Reconstruction approach. Iterative Back Projection method updates the estimate SR reconstruction by Back Projecting error between simulated low-resolution images and observed LR images. This process decreased the energy of error.Fig.2 shows IBP Algorithm's process.

This method has no unique solution for the correct estimation because there is some ill-posed inverse problem and difficulty in choosing back projection error factor. The process of Iterative Back Projection approach starts with input of LR image. The initial HR Image is gotten from the input LR image by dividing the pixels. After that is generated, the Observed LR image undergoes Degraded and Down-Sampled process with initial HR image [13, 14]. This simulated Low-Resolution Image minimized from the Observed LR image for estimating LR image. High-Resolution image is obtained for the Estimation of the error; which is done by passing from the filter for back projecting error between simulated LR image and Observed LR image [14].

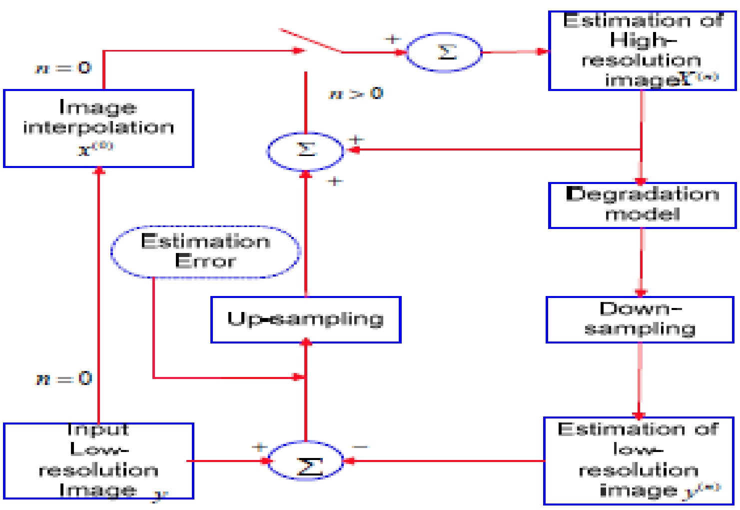

Figure 2: Simple IBP Algorithm [14].

Non-Uniform Interpolation Based Method- Interpolation method uses the Low-Resolution image with down-sampled process to produce High-resolution image [5].This approach reconstructs the image from the irregular and noisy images. This method consists of three types of stages which reconstruct the image. Fig.3shows the scheme for the super-resolution using interpolation method [15, 17]:

1) Registration of the image

2) Interpolation/Reconstruction on the image

3) Restoration (deblurring)

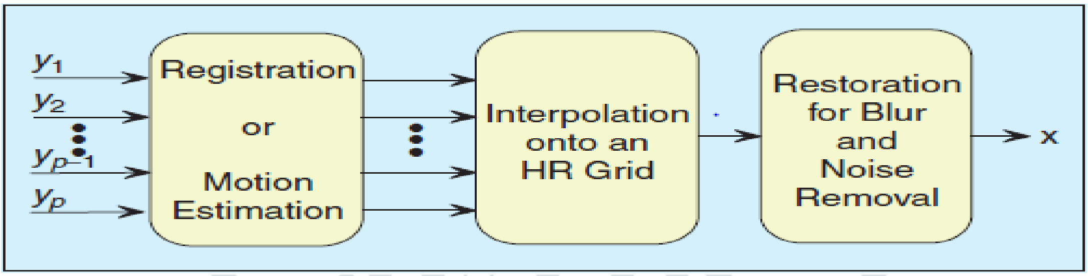

Figure-3: Process for super-resolution [15]

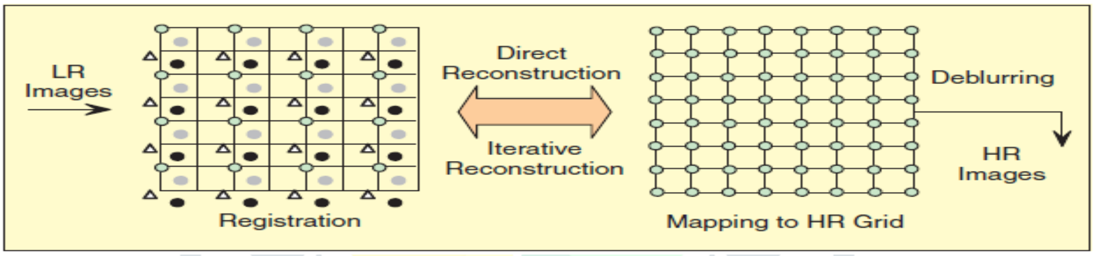

Figure 4: Registration-Interpolation Based Reconstruction method [16]

Fig.4 shows the approach process wherein the first step includes estimation of motion information or Registration such that the High-Resolution image on some sampling point is obtained. Then, after iterative reconstruction procedure, some uniform sampling points are produced. The non-uniform interpolation obtains the High-Resolution image. After this, Restoration is introduced to remove blur and noise from the image. Restoration is one type of the problem that considered presence of noise in image. In this method, registration of the image is required for determining the offset between images with the accuracy down when fraction of the small pixel[17].The Interpolation method is cheaper in computational cost compared to the other methods for the super-resolution techniques. This method is applied when the presence of blur and noise are constant in the Low-Resolution images. The advantage of this method is that it is applicable to real-time application because this approach has low computational load [2].

The Interpolation/Reconstruct of this method is applied in the example shown in the Fig.5 [15].The Interpolation method performed iteration for every Low-Resolution Image to produce the SR image. The reconstruction approach in this method is Interpolation, result of which is shown in example of Fig.5.

There are four LR images taken for the simulation, considering noise in the image. In Fig (a), image is interpolated by the nearest neighbourhood method from the Low-Resolution image observation. In (b), part image is produced by bilinear interpolation and then this non-uniform interpolated image from the LR images appears in (c). Part (C) used wiener filter for the de-blurring of the image restoration as shown in part(d).

In fig.5 show (a),(b),(c) and (d) are improvements of the LR image using interpolation, restoration of the image and de-blurring of image using wiener filter[15].

Set Theoretic Methods- Set Theoretic Methods are for the Reconstruction of the images. There is a considered space of the SR image, which is intersected with the set of constraint set to represent the characteristics like positivity, accuracy of the data, smoothness and bounded energy [2].The projection onto convex sets (POCS) is the set theoretic method that uses spatial domain observation model. POCS iterative produced a result that locates any point on the SR images that satisfy all convex constraint sets [2, 5].

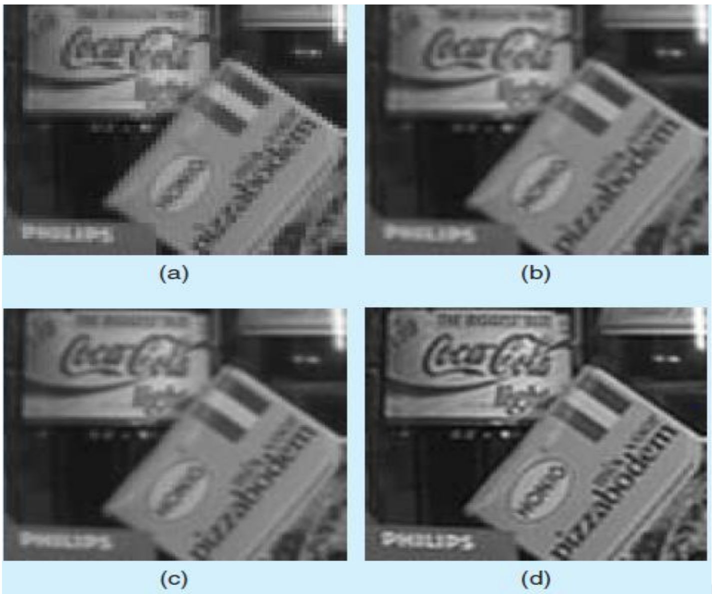

Figure 5: Non-Uniform Interpolation SR reconstruction result: (a) nearest neighbour interpolation, (b) bilinear interpolation, (c) no uniform interpolation using four LR images, and (d) de-blurring part (c)[15].

The set theoretic method also uses reconstruction approach for the super-resolution. This Reconstruction is used in Bounding Ellipsoid method [5] to bind the constraint sets. The centroid of the ellipsoid taken as the SR estimate point is infeasible when direct computation is performed hence they use iterative solution. These methods have non-uniqueness in solution for the image, which is a disadvantage of the method [7].Also, the method depends on the solution of the initial guess and also high computational costs are involved in this method.

Projection onto Convex Sets (POCS) - POCS method is based on the linear model which describes the relation between the High-Resolution and Low-Resolution images. POCS algorithm allows the prior information and then applies it to the movement estimation. But, this POCS method is strict with accuracy of the movement estimation [16].The POCS method gives result in the iterative manner. Each iteration shows variation in image. This iterative behaviour incorporates prior information of the solution into the reconstruction process. POCS algorithm solves the restoration and interpolation problem with the estimation of the SR image [19].

In the POCS method, every Low-Resolution image gets a corresponding High-Resolution image. The POCS algorithm solves the ill-posed inverse problem and also the problem with reconstruction of the image. The corresponding HR images don't exploit full information, but use fusing of the HR images, then enhance with the image resolution and get high-resolution image [18]. Super-Resolution using POCS method constructs SR image in different stages, where it uses LR image for Secondary image reference for these estimation and then POCS iteration is applied on this image [18].

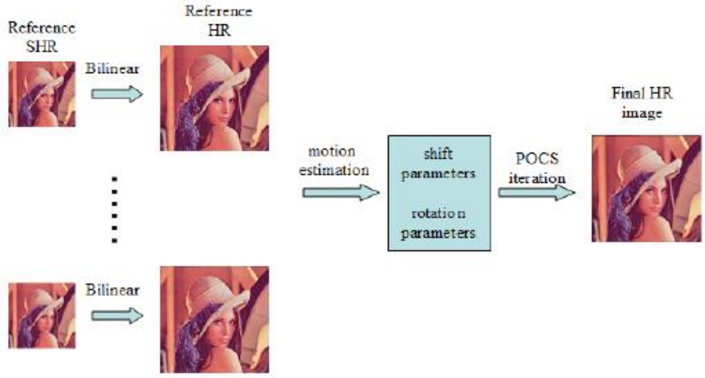

Figure 6: The Process of super-Resolution using POCS method [18].

The process for the SR image using projection onto convex sets first generates the reference image of the corresponding HR image of the LR image using bilinear interpolation method. Figure-6[18]shows the working of POCS method which is applied in the iterative method. This POCS method working shown in the Fig.6 implies that first each Low-Resolution image (suppose this LR image is X) gets corresponding High-Resolution intermediate image as Y. This intermediate image Y is assumed as a Secondary High-Resolution image and we indicate some Z as target Super-Resolution image. The degradation model describes the relation between idea image and secondary high-resolution image (SHR).

In this process, one bilinear method is used for generating HR reference image from the corresponding SHR (reference image[18]).The SHR has some additional pixel to hide information in the SHR image. This information or image is used for the motion estimation between the image and reference image and that estimation must be accurate. This estimation is done using Keren's algorithm for shift estimation and rotation parameter. After the step of estimation, iterative method is applied for every pixel until the completion of the iterative times and final SR image [18] is produced.

Optimal and Adaptive Filtering -Optimal and Adaptive Filtering is inverse filtering approach for the image reconstruction. This method has the limitation of priori constraints compared to POCS method [7].Adaptive filter is used for the image super-resolution. This method considers primary completion, as various filtering are sub-optimal in terms of inclusion of priori constraints [2].G. Jacquemod, C. Odet, and R. Goutte [20] proposed the deconvolution restoration approach assuming sub-pixel translation motion. Deconvolution filter is used for the restoration of the merged observation image produced. The adaptive filtering technique involves a kalman filter used for the application of the super-resolution reconstruction [2]. Kalman filtering is efficient in linear image error estimation because this method incorporates with this filter. This method can't incorporate with the nonlinear image because this nonlinear image has modelling constraints which provide the bandwidth extrapolation that do not support this method of image super-resolution [2].

Table 2: Spatial Domain Methods

Sr No.	**Methods**	**Remarks**	**References**
1.	**Iterated Back Projection (IBP)**	Drawback - No unique solution for accurate estimation because the ill-Posed inverse problem	M. Irani and S. Peleg [12].
		Minimize energy of error	Rujul R Makwana, Nita D Mehta [14].
2.	**Non-Uniform Interpolation Based Method**	Advantage of this approach has low computational load and makes real-time application possible	Pandya Hardeep1, Prof. Prashant B. Swadas, Prof. Mahasweta Joshi [16]
		This approach complete reconstruction image process in three stage: -registration -interpolation -restoration	Gilman, A., Bailey, D.G., Marsland, S.R [17].
		This method applied when blur and noise are same for all LR image	Gilman, A., Bailey, D.G., Marsland, S.R [17]. R. Ramya, Dr. M. Senthil Murugan [2].
3.	**Set Theoretic Methods**	Represent characteristics of SR image : accuracy of data, smoothness and bounded energy	R. Ramya, Dr. M. Senthil Murugan [2].
		Disadvantage of this method is Non-uniqueness solution	Elham Karimi, Kaveh Kangarloo, Shahram javadi [5]. R.SudheerBabu, Dr.K.E.Sreenivasa Murthy [7].
4.	**Projection onto Convex Sets (POCS)**	Type of Set theoretic method -Solve the interpolation and restoration problem with the estimation of SR image -Also solve ill posed inverse problem	W. Xie, F. Zhang, H. Chen and Q. Qin [19]. R. Ramya, Dr. M. Senthil Murugan [2].
		POCS method present iterative process to produced HR image using shift and motion parameter	Xiaoqing Su, Shutao Li [18]. R. Ramya, Dr. M. Senthil Murugan [2].

5.	**Optimal and Adaptive Filtering**	Inverse filtering approach to reconstruct image	R.SudheerBabu, Dr.K.E.Sreenivasa Murthy[7]
		This method can't incorporate non-linear images because non-linear image provide extrapolation bandwidth that do not support this method	R. Ramya, Dr. M. Senthil Murugan [2]. G. Jacquemod, C. Odet, and R. Goutte [20].

3. De-blurring methods

Deblurring methods refer to producing noise free images. This technique is demonstrated to estimate blur kernel and it is to be applied in the various applications of image processing. De-blurring has many types of blur signals removed during the process. These methods consider motion blur, camera shake, etc., for the purpose of sharpening images from distortion. This paper describes the survey of all de-blurring methods and also calculates the accuracy using PSNR signal. This is the restoration process of de-blurring which uses degradation model for the addition of some noise to implement deconvolution on the non-blind images. It can successfully remove blur effect from the images.

Blind Deconvolution method - was proposed by Kundur, D. and Hatzinakos, D. [21]. Kundur, D. and Hatzinakos, D. introduced two approaches for the blind deconvolution method: Projection based blind deconvolution and Maximum likelihood restoration. In this method, restore the image and use point spread function (PSF).This process starts with the initial estimation of the true image and PSF. The starting of the method finds the PSF estimation and that is followed by the image estimation. Blind deconvolution method simply recovers the blurred image to get result as a sharp image from the noisy blurred image. Following is the algorithm for the restoration of image using unknown PSF. The blind deconvolution algorithm is more effective when noise or blurred image (distortion or damaged image) information are unknown. Estimate the blurred operator like PSF that is used for the estimation of true image and de-blurred image [23].

Figure-7 shows the working of blind deconvolution algorithm and image restoration of the degraded/blurred image using this algorithm. Image de-blurring is a basic task to deconvolute the corrupt or degraded image with the PSF which is the Deblurred image.Figure-7 shows the complete process of the Blind Deconvolution method to enhance the blurred image. The input is an original image and uses degradation model for the addition of some noise for implementation of the Blind Deconvolution algorithm.

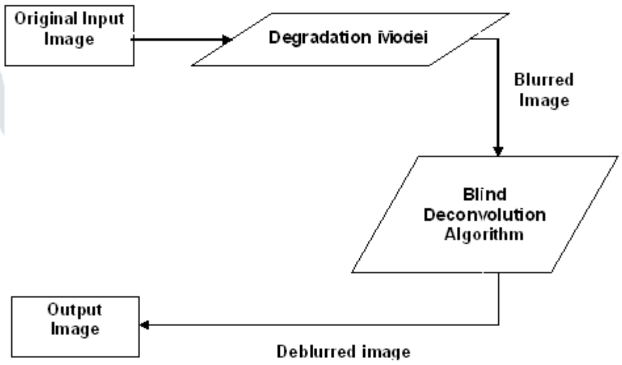

Figure 7: Process of the Deconvolution algorithm [24].

Then, De-blurring of this image is done to get the output of the enhanced image. We can also apply super-resolution technique after this process to get the High-Resolution quality of image.

Lucy-Richardson Algorithm Technique - Lucy-Richardson (LR) Algorithm used the *deconvlucy* function for the de-blurred image. This is the applied method when we use the accelerated and damped and Lucy-Richardson algorithm.LR algorithm can be used when the PSF is known for the blurred image [26].This algorithm [25] maximizes the likelihood algorithm addressed as the complex image restoration. The Lucy-Richardson method can restore the complex or noisy image using PSF to convolve with the Spread function of the blurred image. The *deconvlucy* function implements maximum likelihood algorithm to improve the quality of the image by restoration process. Using the Function of Lucy-Richardson, we can improve some noisy effect and handle the degradation of image. These functions are used [25, 27]:

- Image Restoration to reduce the effect of noise of the image.
- Handling noise and Gaussian distribution.
- Improved significantly under sampled Images.
- Variation in non-uniform Images

The Lucy-Richardson [28] algorithm demonstrates the effect of motion on blurring of images in the modified algorithm to get better experimental results.

Neural Network Approach – proposed restoration of the degraded image. This method has parallel nature, so that the method continues work in situations even when the neural Network fails. This method can be interconnected with the element and then there is an interaction between the input images [28].Fig.8 shows the neural network.

The neural network provides the set of input output image examples to target the reconstruction of the blurred image. We can also use this network in blind Deconvolution process to de-blur the image, but that should be done before applying neural network method on the Blurred or degraded image [29].The neural network used for Back Propagation technique for the restoration of the blurred image can be explained. Back propagation uses much iteration for enhancing the distorted image and reaching accurate PSF. The neural network is used when the image is out of the focus and of low-frequency. Working of the method is like a multiprocessor of the computer system that involves the number of input and output of the images.

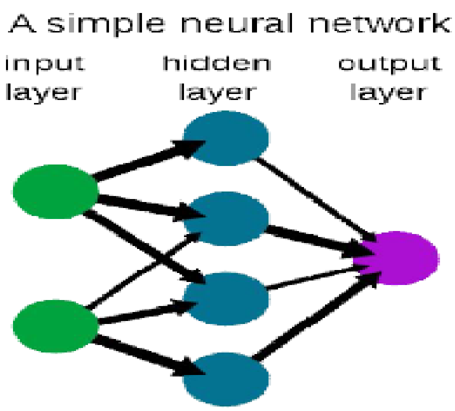

Figure 8: Simple Neural Network [28].

Fig.8 shows the back propagation method which uses two layers of connection in the network for the restoration of the original image [28, 30].

De-blurring with Blurred/Noisy Image Pairs - approach can de-blur the image using noisy image. It can estimate the blur kernel from the noisy image and blurred image. De-blurring is done with the noisy image in this approach. De-blurring of blurred image is done in three steps: First step is to find the blur kernel using blurred and noisy images. Using any one image to find blur kernel is difficult so we use both images. Second step is to estimate the kernel of non blind [32].Final step is for estimating deconvolution non-blind images to handle the non -sharp images are used deconvolution process for deblurring. This process obtains final high-quality images using pairs of noisy and blurred images. This approach demonstrates the effect on the low lighting images. Pairing of the images has advantage to produce the high-quality image from the blurred image. The Reconstructed image to get High-resolution image for estimate the accurate kernel [32].

Deblurring with Motion Density Function (MDF) - method uses single image deblurring to calculate initial blur kernel. This method uses motion density function to recover motion blur or low lighting poor images. The density function approach considered camera motion on the image and reconstruct this motion image using Motion Density Function (MDF) to recover single degraded image [31]. This method uses single image framework to initialize the recovery [33].There is a limitation on spatially invariants that the calculation of the blur kernel is not perfectly initialized.

Deblurring with Handling Outliers - approach analyses the Gaussian blur and some saturation pixels in this method. This method also uses blind deconvolution approach to referred blurred image. This deconvolution method work explicit to demonstrate Outliers model. Deblurring with handling Outliers has two types of categories on pixels of images: Inliers and Outlier pixels [34].Handling the deblurring using outlier produces or minimizes the Gaussian blur iteratively. Bar, N. Sochen, and N. Kiryati [35] proposed that image deblurring is difficult when the Gaussian or motion noise is present in the image and remove noise. The solution of these difficulties to restoration of image method can be used for the distortion nonlinear images. Impulse noise and blurred can be removed using outliers. The Outlier approach uses deconvolution reconstruction image to increase fidelity of an image.

Deblurring by ASDS-AR Image - Deblurring and Super-resolution by Adaptive Sparse Domain Selection and Adaptive Regularization [36] method is effective for deblurring the images. There is a sparse domain selection approach that assigns a local patch to some sub-dictionary used for the regularization of the image. Here, Autoregressive (AR) and regularization both represent the idea of the database patch for the local structure of an image and nonlocal image [31].The Sparse Domain selection and Adaptive Regularization method[40] has achieved to image restoration application and used optimization techniques. This method considers single image for the process of restoration and it has the different patches and images present in a single image. The Super-resolution and deblurring allow sparse domain method to propose the restoration image scheme and it can give much better result in sense of PSNR and state-of-art algorithm [37].The complexity of the optimization image uses a sub-dictionary. So, the method supports the deblurring process for the restoration of an image.

4. Conclusion and Comparison

This is a survey on two techniques are: One for removing the noise and another for removing the blur effect from an image. Many methods are proposed for solving super-Resolution and image deblurring by restoration or reconstruction and deblurring the image. There is a possibility of a better approach if we compare the PSNR of each method given by many researchers in different papers. So it is concluded that super-resolution and deblurring can be done in better way using spatial domain methods and ADSD-AR & Blind deconvolution methods respectively. Table 1 show the characteristics of Super-Resolution methods in their respective domain and table 2 shows a comparison of deblurring method on blur noise type and performance. So SR is effectively done with the Spatial Domain method because it is flexible to computation while Deblurring is effectively done with their Performance Based method.

Comparison Table-3:Super-Resolution Methods

Characteristics	Frequency Domain method	Spatial Domain method
Presence of Noise Model	Limited	Flexible compare to FD
Degradation of the Noise	Limited Degradation model	Unlimited Degradation
Presence of the Observation Domain	Frequency Domain	Spatial Domain
Type of Mode used for the Done Operation	Used Fourier Transform in Image	Image Pixels direct used
Performance	Good for the Specific application	Good for all application used for Super-Resolution
Mechanism Used For the Super-Resolution	De-aliasing	Used De-aliasing and Priori information of the image
Simple Understanding	Simplicity in Theory based	Complex in theory based and computational
Application Area	Limited in this Domain	Widely Used in SR application
Provide A priori Information of the image	Less of A priori info.	More Flexible and give priori information of image

Comparison Table-4: Deblurring Methods

Method of the Deblurring	Presence Of the Blur noise Type	Performance based on survey
Blind Deconvolution Method	Motion Blur type	Efficient for the Image Deblurring than the LR method
Lucy-Richardson Algorithm	Gaussian Blur	Efficient gives result
Neural Network Method	Gaussian Blur and Out-of-Focus Camera images	Most Efficient method for the Deblurred the image based on the Survey
ASDS-AR Sparse Domain Method	Presence of Gaussian Blur	Very Efficient method to used for the computation
Using Handling Outliers	Gaussian Blur	Efficient to handle noise
MDF method	Motion Blur	Handle the Blur in efficient way conclude on the Survey

REFERENCES

[1] R.Y. Tsai and T.S. Huang, “Multiple frame image restoration and registration,” in Advances in Computer Vision and Image Processing. Greenwich, CT: JAI Press Inc., 1984, pp. 317-339.

[2] “Comparative Study on Super Resolution Image Reconstruction Techniques” , R. Ramya, Associate Professor, Department of Computer Applications, Bharathiyar College of Engineering and Technology, Karaikal – U.T. of Puducherry. Dr. M.

SenthilMurugan ,Professor and Head, Department of Computer Applications, Bharathiyar College of Engineering and Technology, Karaikal – U.T. of Puducherry,Oct-2013.

[3] S. H. Rhee and M. G. Kang, "Discrete cosine transform based regularized high-resolution image reconstruction algorithm," Opt. Eng., vol. 38, pp. 1348–1356, Aug. 1999.

[4] "Super-Resolution from Image Sequences AReview", SeanBorman, RobertL.StevensonDepartmentofElectricalEngineering, UniversityofNotreDameNotreDame, IN46556, USA sborman@nd.edu.

[5] "A Survey on Super-Resolution Methods for Image Reconstruction", ElhamKarimi Department Electrical Engineering, Islamic Azad University, Central Tehran Branch Tehran, Iran. KavehKangarloo Department of Electrical Engineering Islamic Azad University, Central Tehran Branch Tehran, Iran.Shahramjavadi Department of Electrical Engineering Islamic Azad University, Central Tehran Branch Tehran, Iran.International Journal of Computer Applications (0975 – 8887) Volume 90 – No.3, March 2014.

[6] Kaltenbacher, E.; Hardie, R.C., "High resolution infrared image reconstruction using multiple, low resolution, aliased frames," Aerospace and Electronics Conference, 1996. NAECON 1996., Proceedings of the IEEE 1996 National , vol.2, no., pp.702,709 vol.2, 20-23 May 1996 .

[7] R. SudheerBabu, Dr.K.E.Sreenivasa Murthy, "A Survey on the Methods of Super-Resolution Image Reconstruction", International Journal of Computer Applications (0975 – 8887), Volume 15– No.2, February 2011.

[8] S. P. Kim, N. K. Bose, H. M. Valenzuela, "Recursive total least squares algorithm for image reconstruction from noisy, under sampled multiframes". Multidimensional Systems and Signal Processing, vol. 4, no. 3, July 1993.

[9] N. K. Bose, H. C. Kim, and H. M. Valenzuela, "Recursive implementation of total least squares algorithm for image reconstruction from noisy, under-sampledmultiframes," in Proceedings of the IEEE conference on Acoustics, Speech and Signal Processing, Minneapolis, MN, Apr. 1993, vol. 5, pp. 269–272.

[10] Bose, N.K.; Kim, H. C.; Zhou, B., "Performance analysis of the TLS algorithm for image reconstruction from a sequence of undersampled noisy and blurred frames," Image Processing, 1994. Proceedings. ICIP-94., IEEE International Conference , vol.3, no., pp.571,574 vol.3, 13-16 Nov 1994.

[11] H. Ur and D. Gross, "Improved resolution from sub pixel shifted pictures". CVGIP: Graphical Models and Image Processing, 54: 181{186 (March 1992).

[12] M. Irani and S. Peleg, "Improving resolution by image registration,"CVGIP: Graphical Models and Image Proc., vol. 53, pp. 231-239, May 1991.

[13] Milan N. Bareja and Chintan K. Modi "An Effective Iterative Back Projection based Single Image Super Resolution Approach", 2012 International Conference on Communication Systems and Network Technologies-2012.

[14] Rujul R Makwana, Nita D Mehta,"Single Image Super-Resolution VIA Iterative Back Projection Based Canny Edge Detection and a Gabor Filter Prior",International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3, Issue-1, March 2013.

[15] Sung Cheol Park, Min KyuPark,and Moon Gi Kang, "Super-Resolution Image Reconstruction: A Technical Overview". IEEE Signal Processing Magazine May 2003.

[16] Pandya Hardeep1, Prof. Prashant B. Swadas2, Prof.Mahasweta Joshi3 "A Survey on Techniques and Challenges in Image Super Resolution Reconstruction" ,IJCSMC, Vol. 2, Issue. 4, April 2013.

[17] Gilman, A., Bailey, D.G., Marsland, S.R," Interpolation models for image super resolution", 4th IEEE International Symposium on Electronic Design, Test and Applications, DELTA 2008.

[18] Multi-frame Image Super-resolution Reconstruction based on Sparse Representation and POCS Xiaoqing Su, Shutao Li ,International Journal of Digital Content Technology and its Applications. Volume 5, Number 8, August 2011.

[19] W. Xie, F. Zhang, H. Chen and Q. Qin, "Blind super-resolution image reconstruction based on POCS model", In International Conference on Measuring Technology and Mechatronics Automation (ICMTMA), pp. 437-440, Apr 2009.

[20] G. Jacquemod, C. Odet, and R. Goutte, "Image resolution enhancement using subpixel camera displacement," Signal Processing, vol. 26, no. 1, pp. 139–146, 1992.

[21] D. Kundur and D. Hatzinakos, "A novel blind deconvolution scheme for image restoration using recursive filtering," IEEE Trans. Signal Process., vol. 46, no. 2, pp. 375-390, Feb. 1998.

[22] A. Levin, Y. Weiss, F. Durand, and W. Freeman, "Understanding blind deconvolution algorithms," IEEE Trans. Pattern Anal. Mach. Intell., vol. 33, no. 12, pp. 2354–2367, Nov. 2011.

[23] AmandeepKaur,VinayChopra,"A Comparative Study and Analysis of Image Restoration Techniques Using Different Images Formats", International Journal for Science and Emerging Technologies with Latest Trends" 2(1): 7-14 (2012).

[24] Ramya, S.; Mercy Christial, T, "Restoration of Blurred Images using Blind Deconvolution Algorithm," IEEE, on Emerging Trends in Electrical and Computer Technology(ICETECT), pp.496 -499,2011.

[25] http://wwwrohan.sdsu.edu/doc/matlab/toolbox/images/deblurr8.html.

[26] CharuKhare, Kapil Kumar Nagwanshi"Implementation and Analysis of Image Restoration Techniques",International Journal of Computer Trends and Technology- May to June Issue 2011.

[27] S.S. Bedi1, RatiKhandelwal "Various Image Enhancement Techniques- A Critical Review",International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 3, March 2013.

[28] CharuKhare, Kapil Kumar Nagwanshi "Implementation and Analysis of Image Restoration Techniques",International Journal of Computer Trends and Technology- May to June Issue 2011.

[29] Neetin Kumar, Dr. Manish Shrivastava, Naazish Rahim "Image Deblurring Using a Neural Network Approach",International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 3, September 2012.

[30] Aizenberg I., Bregin T., Butakoff C., Karnaukhov V., Merzlyakov N. and Milukova O., "Type of Blur and Blur Parameters Identification Using Neural Network and Its Application to Image Restoration". In: J.R. Dorronsoro (ed.) Lecture Notes in Computer Science, Vol. 2415, Springer-Verlag, Berlin, Heidelberg, New York (2002) 1231-1236.

[31] Dejee Singh1, Mr R. K. Sahu"A Survey on Various Image DeblurringTechniques"International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 12, December 2013.

[32] L. Yuan, J. Sun, L. Quan, and H. Shum, “Image deblurring with blurred/noisy image pairs,” ACM Trans. Graph., vol. 26, no. 3, pp. 1–11,2007.

[33] A. Gupta, N. Joshi, C. Lawrence Zitnick, M. Cohen, and B. Curless, “Single image deblurring using motion density functions,” in Proc ECCV, 2010, pp. 171–184.

[34] S. Cho, J. Wang, and S. Lee, “Handling outliers in non-blind image deconvolution,” in Proc. ICCV, 2011, pp. 495–502.

[35] L. Bar, N. Sochen, and N. Kiryati Image deblurring in the presence of impulsive noise. International Journal of Computer Vision, 70(3):279–298, December 2006.

[36] W. Dong, L.Zhang, R. Lukac, G. Shi, “Image Deblurring and superresolution by adaptive sparse domain selection and adaptive regularization”, IEEE Trans. On Image Processing, vol. 20, no. 7, pp. 1838-1857, July 2011.

[37] WeishengDonga,b, Lei Zhangb,1, Member, IEEE,Guangming Shia, and XiaolinWuc, Senior Member, IEEE"ImageDeblurring and Super-resolution by Adaptive Sparse Domain Selection and Adaptive Regularization",IEEE Trans Image Process. 2011 Jul;20(7):1838-57. doi: 10.1109/TIP.2011.2108306. Epub 2011 Jan 28.

[38] JianZhang,IEEE, Debin Zhao, Member, IEEE, and Wen Gao, Fellow, IEEE,"Group-Based Sparse Representation for Image Restoration",IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 23, NO. 8, AUGUST 2014.

[39] ShitalHemantUmale,"A Review on Various Techniques for Image Debluring",IJCSMC, Vol. 3, Issue. 4, April 2014, pg.263 – 268.