Super Resolution Reconstruction Based on Different Techniques of Registration and Interpolation

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ABSTRACT- Resolution enhancement can effectively achieved by process of Super Resolution(SR) techniques with advantages that still Low Resolution(LR) systems can be utilized and less costly. The main object of Super Resolution is to get high resolution, high quality image from Low Resolution images. The process of imagery, the factors including the motion between earth and the platform, atmosphere disturbance, out of focus, non-ideal sampling and so on, all can make the images noisy, blurred and degraded. Super resolution technology is the signal processing based method which can detect and remove the blur and noises caused by the imaging system as well as recover information.Super resolution imaging processes one or more low resolution images acquired from the same scene to produce a single higher resolution image with more information. Recently, it has been one of the most active research areas to get high-resolution image from a low-resolution image, and for the communication purpose it is necessary to compress the information. To achieve SR, first LR images should align properly and fused to get non redundant information. Image resolution can be enhanced by interpolation. In this paper, the various registrations, fusion and interpolation algorithms are designed and implemented which can be used to compress the information which is very helpful for the communication purpose. The performance analysis can be done by PSNR and MSE. The system is implemented using Matlab GUI.

Keywords - Super resolution, Registration, RANSAC, Fusion, and Interpolation.

I. INTRODUCTION

Super resolution is a process which construct higher resolution image using one or more low resolution images of the same scene. High-quality images and videos capturing and processing is critical in many applications such as medical imaging, astronomy, surveillance, remote sensing, and so on. Traditional high-resolution (HR) imaging systems require high-cost and bulky optical elements whose physical sizes dictate the light-gathering capability and resolving power of the imaging system. In contrast, the computational imaging system is one,which combines the power of digital processing with data gathered from optical elements to generate HR images. Artifacts such as disturbance, aliasing, blurring, and noise may be affect the spatial resolution of an imaging system.

Super resolution is the process of combining the one or more low resolution images to obtain a high resolution image. The basic idea behind SR is to combine the non-redundant information contained in multiple low-resolution (LR) frames to generate a high-resolution (HR) image. A closely related technique with SR is the single image interpolation approach, which can be also used to upscale the LR image. The resolution of a digital image can be classified in many different ways such as, pixel resolution, spatial resolution, spectral resolution, temporal resolution, radiometric resolution etc. As there is no additional information provided, the quality of the single image interpolation is very much limited due to the ill-posed nature of the problem, and the lost frequency components cannot be recovered. In the SR setting, however, multiple LR observations are available for reconstruction, making the problem better constrained. The non-redundant information contained in these LR mages is typically introduced by sub pixel shifts between them. These sub pixel shifts may occur due to uncontrolled motions between the imaging system and scene, e.g., movement of objects, or due to controlled motions, e.g., the satellite imaging system orbits the earth with predefined speed and path.

The basic problem is to obtain an HR image from multiple LR images. The basic assumption for increasing the spatial resolution in SR techniques is the availability of multiple LR images captured from the same scene. In SR, the LR images represent different ―looks‖ at the same scene. In that LR images are sub-sampled as well as shifted with sub-pixel precision. If the LR images are shifted by integer units, then each mage contains the same information, and thus there is no new information that can be used to reconstruct an HR image. If the LR images have different sub-pixel shifts from each other and if aliasing is present, and then ach image cannot be obtained from the others. In this case, the new information contained in each LR image can be exploited to obtain an HR image.

The major advantage of the super resolution approach is that it may cost less and the existing LR imaging systems can be still utilized. The SR image reconstruction is proved to be useful in many practical cases where multiple frames of the same scene can be obtained, including medical imaging, satellite imaging, and video applications. Synthetic zooming of region of interest (ROI) is another important application in surveillance, forensic, scientific, medical, and satellite imaging.

II. RELATED WORKS

Esmaeil Faramarzi, Dinesh Rajanand Marc P. Christensen.have proposed a unified blind method for multi-image super-resolution (MISR or SR), single-image blur deconvolution (SIBD), and multi-image blur deconvolution (MIBD) of low-resolution (LR) images degraded by linear space-invariant (LSI) blur, aliasing, and additive white Gaussian noise (AWGN). The proposed approach is based on alternating minimization (AM) of a new cost function with respect to the unknown high-resolution (HR) image and blurs, which improves the quality of blur. Blur deconvolution (BD) and super-resolution (SR) are two groups of techniques to increase the apparent resolution of the imaging system[1].

P B Chopade and P M Patil have proposed basic algorithms and their classification based methodology used to implement it. Due to its vast scope of applications researchers are developing a novel super-resolution algorithm for a specific intention based on single and multi-frame image resolution. In this survey, the basic concepts of the algorithms are explained and thentheir performance analyses through which each of these methods has developed are mentioned in detail[2].

Sonali Shejwal1 and Prof. A. M. Deshpande have proposed classification of SR various algorithms. Amongst which edge adaptive algorithms are particularly used to improve the accuracy of the interpolation characterizing the edge features in a larger region. This paper introduces a recent algorithm for image iterative curvature based interpolation (ICBI), and gives comparison with bicubic interpolation and the other interpolation algorithm. Comparative analysis of test images are performed on the basis of PSNR and RMSE metrics show effectiveness of edge based techniques[3].

A. Geetha Devi, T. Madhu and K. Lal Kishorehave proposed the various fusion algorithms such as averaging method, Principle component analysis (PCA) and wavelet based Fusion, scale Invariant-wavelet Transform, Laplacian pyramid, Filter Subtract decimate(FSD)pyramid[4].

Pandya Hardeep, Prashant B. Swadas and Mahasweta Joshihave presented limits on super resolution. In second part how to achieve SR and its advantages. In the first part they analyzed that super resolution becomes much more difficult as the magnification factor increases. From the analytical results of this paper which shows that the reconstruction constraints provide less and less useful information as the magnification factor increases. It is assumed that the images are noisy and down sampled [5],[7].

Min-Chun Yang and Yu-Chiang Frank Wang have proposed Learning-based approaches for image super-resolution(SR). In this paper, they present a novel self-learning approach for SR and advance support vector regression(SVR) with image sparse representation, which offers excellent generalization in modeling the relationship between images and their associated SR versions [6].

Michael Angelo Kandavalli and Raghavahave presented four main classes of methods to estimate the pixel values in HR grids, and interpolation-based approaches. In this paper, they are introduces interpolation-based approaches since both interpolation and filtering can be expressed in the form of a weighted sum. Frequency-domain approaches make explicit use of the aliasing relation between continuous Fourier transform and discrete Fourier transform [8].

Bahadir K. Gunturkand Murat Gevrekci haveproposed a Bayesian super-resolution algorithm based on an imaging model that includes camera response function, exposure time, sensor noise, and quantization error in addition to spatial blurring and sampling [9].

Niyanta Panchal, Bhailal Limbasiya, Ankit Prajapati have proposed review of different image registration methods and compare all the methods. Then next using various Super resolution methods which is generate high-resolution(HR) image from one or more low resolution images and lastly different image quality metrics reviewed as measure the original image and reconstructed image[10].

III. PROPOSED SYSTEM

The block diagram of the proposed system shown in fig: 3.1 give the high resolution image from low resolution image.

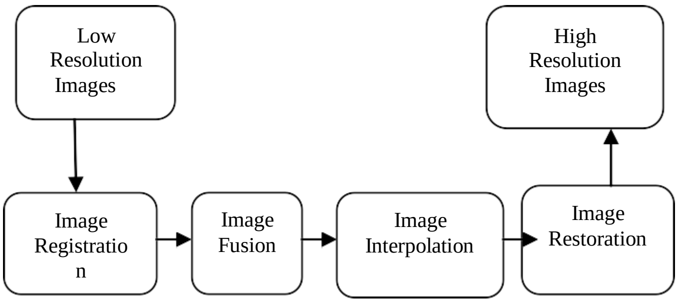

Fig 3.1: Block diagram of the system

Registration is the process of bringing all the shifted versions of low resolution images into a single plane with respect to a reference image. Feature based registration comprises of feature detection, feature matching, optimum transformation and up-sampling and provides better results in many applications. Image fusion is the process of integrating the information contained in all the low resolution observations into a single image. The resolution of the image is improved by preserving the finer details of the fused LR images during interpolation.

Different restoration technique has been employed for the reduction of noise, blur restore the images with high resolution. Several Super Resolution reconstruction algorithms are implemented. This technique can be efficiently implemented in critical applications like a medical imaging, facial recognition, bio-metrics and remote sensing to extract the finer details of the image.The detailed description of the each module is explained below:

Noise Module:

A noise is introduced in the transmission medium due to a noisy channel, errors during the measurement process and during quantization of the data for digital storage. Each element in the imaging chain such as lenses, film, digitizer, etc. contributes to the degradation. Therefore, Noise is any undesired information that contaminates an image. Hence, the received image needs processing before it can be used in applications. A different noise model includes additive, multiplicative and impulse types of noise. They include Gaussian noise, salt and pepper noise, speckle noise and Poisson noise. A quantitative measure of comparison is provided by the peak signal to noise ratio of the image.

Image Registration:

Image Registration is the process of aligning two different images of the same scene acquired at different times, different angles, and/or different sensors. It plays an important role in remote sensing and applied in wide variety of tasks such as image fusion, image overlay and change detection using different images of the same region. Conventional image registration techniques involving manual selection of control points (CPs) and that are used to estimate the geometric transformation model and that establishes a mapping between slave image and the master. Also the manual method needs an expert with a special skill to select the individual Control Points precisely for estimating the transformation model which is a laborious activity.

An automatic image registration is a technique which can solve the pitfalls of conventional methods. The automatic image registration requires an elaborate software framework and is a very challenging task itself especially when homogeneous features such as cloud, snow features are present in the images.Image registration in automatic mode requires sequential and iterative execution of different phases forgenerating quality registered data products. The main phase or the steps in image registration are as follows:

(a) Feature Detection:The method which computes the abstractions of image information. These objects are termed as the control points which are considered to be starting point or main primitive for image registration.
(b) Feature Matching:The step which maps and establishes the correspondences between features detected in the slave image and those detected in the master image.
(c) Model Estimate:This phase estimate the transform using master and the slave coordinates by employing the models. In this step the parameters of the mapping functions and aligning the sensed image with the reference image, are estimated.
(d) Image Resampling and Transformation**:**Resampling is a process that involves the extraction and an interpolation of gray levels from pixel locations in the original distorted image and their relocation to the approximate matrix coordinate location in the corrected image. The slave image is transformed by means of the mapping function.

Image Fusion:

In the field of Image processing, image fusion has received a significant attention for remote sensing, medical imaging, machine vision and the military applications. A hierarchical idea of image fusion has been proposed for combining significant information from several images into one image. The aim of image fusion is to achieve improved situation assessment and/or more fast and accurate completion of a pre-defined task than would be possible using any of the sensors individually. Mainly image fusion requires precise techniques and also good understanding of input data.

Image fusion is the process that combines information from multiple images of the same scene. The idea behind image fusion using wavelets is to fuse the wavelet decompositions of the two original images by applying fusion methods to approximations coefficients and details coefficients. By observing the performance of all the image fusion techniques, the DWT gives efficient results. Due to its orthogonality, DWT technique has been chosen for compression and decompression for the FPGA implementation of the image fusion technique.

Thus, we obtain a wavelet orthonormal basis:

$$S^{DWT} = \left\{ \phi_{N,j}, \varphi_{1,j}, \varphi_{2,j}, \ldots\ldots \varphi_{N,j} \right\}_{j \in z}$$

A discrete signal **x** can be described by these scaling function and wavelet function:

Wavelet Decomposition:

$$x(k) = \sum_{j \in z} s_{(N)}(j)\phi_{N,j}(k) + \sum_{i=1}^{N} \sum_{j \in z} d_{(i)}(j)\varphi_{i,j}(k)$$

Where s and d are wavelet coefficients.

Image Interpolation:

Transferring image from one resolution to another resolution without affecting the quality of image this process is called interpolation. It is also defined as approximating continues function‘s value using discrete samples. In the field of image processing, image interpolation is very important role for doing zooming, enhancement of image, resizing super resolution and many more. Based on considering the image features interpolation method can be classified into adaptive and non adaptive techniques. There are many interpolation techniques available, nearest neighbor, bilinear, bicubic and spline interpolation.

The general form for an interpolation function is as follows:

$$g(x) = \sum_k c_k u(d_k) \text{...equation 1}$$

Where $g()$ is interpolation function, $u()$ is the interpolation kernel, d_k is the distance from the point consideration, X_k and c_k are the interpolation coefficients. The c_k ‘s are chosen such that $g(X_K) = f(X_k)$ for all X_k. This means that the grid point values should not change in the interpolated image.

Nearest Neighbor Interpolation:

Nearest neighbor interpolation is a simplest method. It determines the gray level value from closest pixel to specified input coordinates, and assigns that value to output coordinates. This method does not interpolate values, it just copies existing values. For 2-D, the number of grid points required to evaluate the interpolation function is four.

For nearest neighbor interpolation, the interpolation kernel for each direction is:

$$u(s) = \{1 \quad |s| > 0.5$$

$$\{0 \quad |s| < 0.5$$

Where s =distance between interpolated point and grid point.

Bilinear Interpolation:

Interpolated point in a bilinear interpolation is filled with four closest pixel‘s weighted average. Two linear interpolations are performed in horizontal direction and vertical direction. It needs to calculate four interpolate function for grid point in bilinear interpolation.

For nearest neighbor interpolation, the interpolation kernel for each direction is:

$$u(s) = \{1 - |s| \quad |s| < 1$$

$$\{0 \quad |s| > 1$$

Where s =distance between interpolated point and grid point.

Bicubic Interpolation:

Interpolated point in a bicubic interpolation is filled with sixteen closest pixel‘s weighted average. From this method we get sharper image than bilinear interpolation. For bicubic interpolation, the interpolation kernel for each direction is:

$$u(s) = \{3/2|s|3 - 5/2|s|2 + 1 \quad 0 <= |s| < 1$$

$$\{-1/2|s|3 + 5/2|s|2 - 4|s| + 2 \quad 1 <= |s| < 2$$

$$\{0 \quad 2 < |s|$$

Where s =distance between interpolated point and grid point.

IV. SYSTEM IMPLEMENTATION

The proposed system is implemented in GUI with the help of guide which is shown in fig 4.1. The detailed description is explained below:

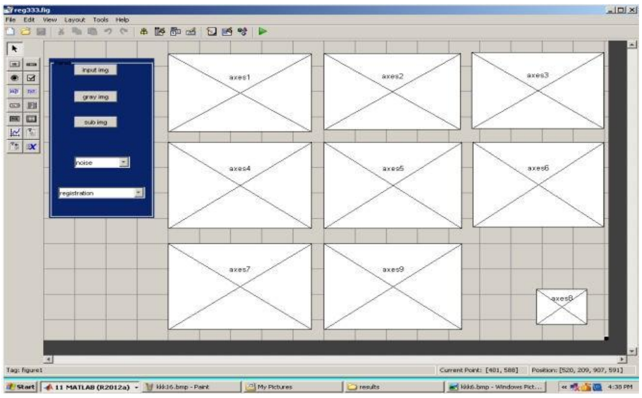

Fig 4.1: GUI guide for proposed system.

Here the image is selected either from library and then one of the various noises is added with the slider value to get the noisy image. The system also consists of popup menus to select registration algorithms.

V. RESULTS

The experimental results for registration, fusion and Interpolation algorithms with noise are shown below. Fig.5.1 shows the different noises applied to the image, which is common for both techniques.

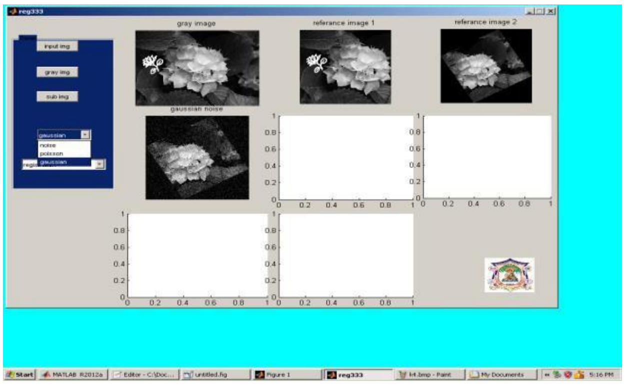

Fig 5.1: Adding different noises.

Case I: Conventional Image Registration

Fig5.2. shows the selection of control points conventionally or manually. Here input points of valid points and base points of valid points are selected.

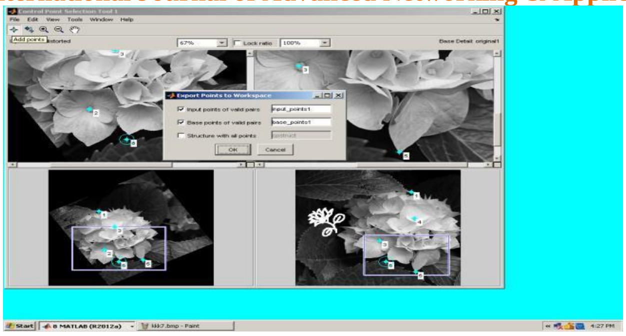

Fig 5.2: Selection of control points.

After selection of Control Points, applying projective,affine, and non reflective similarity transformation the results is shown in Fig5.3.

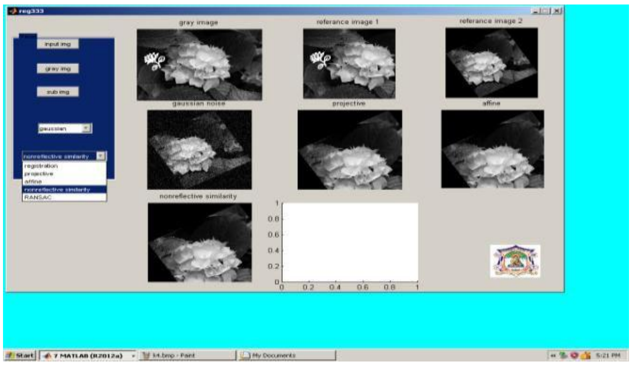

Fig5.3: Conventional registration using different transformation.

Case II: Automatic Image Registration

In case of automatic image registration control points selected automatically using RANSAC method which gives inliers and outliers, they are shown in Fig5.4.

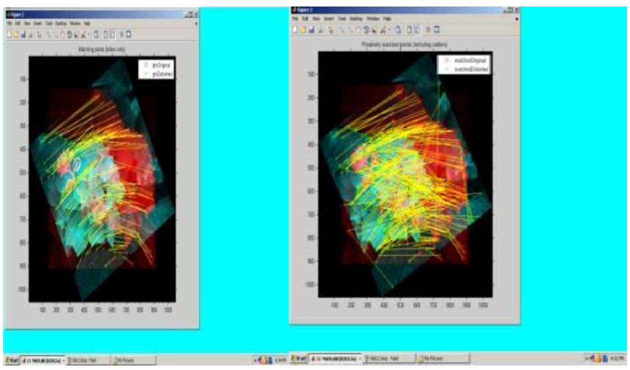

Fig5.4: Putatively matched points (inliers only& outliers).

Fig5.5. gives outputs of conventional techniques compared with automatic image registration technique using RANSAC shown below.

Fig5.5: Output conventional technique compared with automatic image registration technique using RANSAC.

Case III: Image Fusion

Fig5.6, Fig5.7 are the input images after applying fusion process we get output which is have more significant information than two input images, which is shown in below Fig5.8.

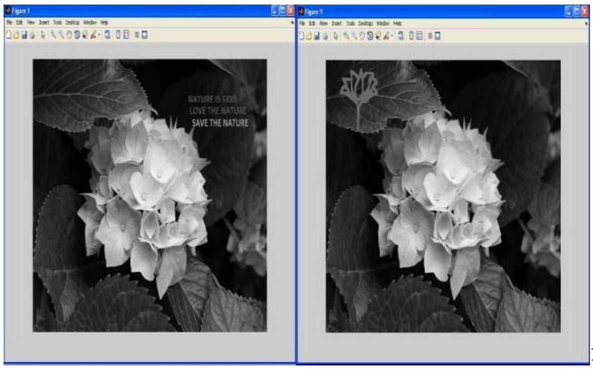

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Fig 5.6: Input image 1. Fig 5.7: Input image 2.

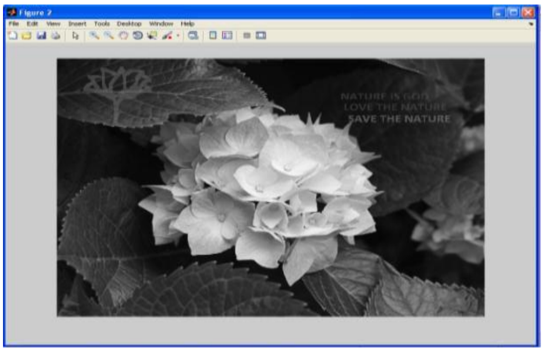

Fig 5.8: Fused output image.

Case IV: Image Interpolation:

Different interpolation techniques shown in below Fig5.9, Fig5.10, and Fig5.11 are gives the interpolated images, with different techniques called nearest, bilinear, and bicubic to get high resolution image from low resolution images.

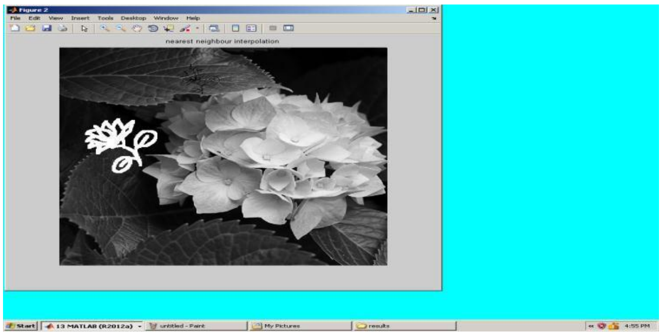

Fig5.9: Nearest Interpolation.

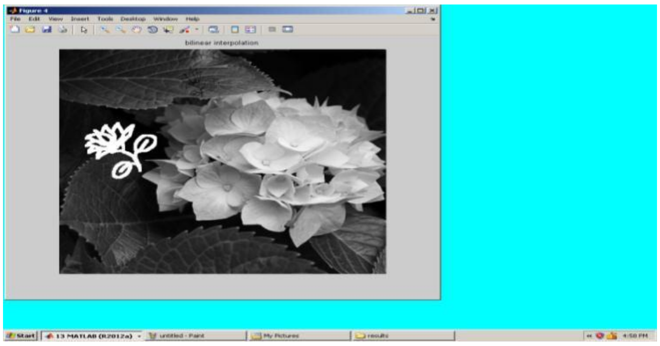

Fig5.10: Bilinear Interpolation.

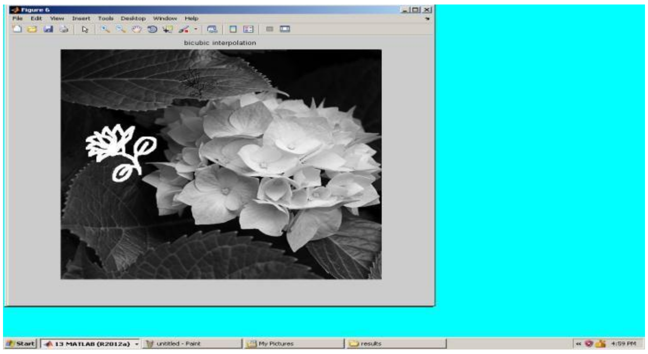

Fig5.11: Bicubic Interpolation.

Table 1 : Comparison of different interpolation techniques.

Interpolation Algorithms	Computation Time	Complexity of Algorithm	Visual Quality
Nearest	Low	Low	Poor
Bilinear	Low	Low	Average
Bicubic	Average	Average	Good

Table 1 shows the comparison of nearest, bilinear and bicubic interpolation techniques based on complexity and visual quality.

VI. CONCLUSION

In this paper, the different registration methods are designed and implemented which can be used to align the images. This is a very helpful and basic step for super resolution. Image fusion gives significant information from several images into single image hence it produce necessary information to further process. Interpolation is done to enhance the resolution of low quality or resolution images based on different methods and analyzes done by comparison. In future work, an efficient and advanced super resolution algorithm will be implemented and tested.

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