SUPER RESOLUTION

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Abstract- The Super Resolution (SR) reconstruction has become a hot research topic in the field of Image Processing. Super resolution is all about generating high-resolution image from low-resolution image. High resolution image provides a high pixel density therefore provides more information about the original image. High resolution images are very much important for computer vision applications for better performance for pattern recognition and analysis of images. It is useful in medical imaging for diagnosis. It is very much useful for processing of satellite images. Also it is useful for other applications. In this paper we have discussed the techniques used for obtaining super resolutions. We have takenblurred image as an input image and we restored the image using PSF. We have also taken blurred and noisy image and restored the image using ACF, the resultant image got is a good quality image.

Keywords –Resolution, Pixel, Deconvolution, PSF, ACF, Noise spectrum, Autocorrelation

I. INTRODUCTION

In most digital imaging applications, high resolution images and videos are very much required for the purpose of image processing and analysis. It plays a major role for two application areas such as the improvement of pictorial information for human interpretation and also used for representation for automatic machine perception. Image resolution provides the details contained in an image. Higher resolution images provide more image details.

The objective of Super-Resolution (SR) is to generate a high resolution image form low resolution images. High resolution image provides a high pixel density hence it provides more information about the original image [3]. High resolution is very much required for computer vision applications for better performance in pattern recognition and analysis of images. High resolution is very much required for several application areas. Because of the limitations of the sensors, optics manufacturing technology high resolution cannot be obtained. Image processing technology need to be improved to overcome from these problems, rise to the concept of super-resolution [3].

Super-resolution (SR) technique enhances resolution of an image. SR techniques in which the diffraction limit of the system is excelled are called as optical SR. SR techniques in which the resolution of digital imaging sensors is enhanced are called as geometrical SR.There are lot of issues raised up in the area of super-resolution therefore it is very much required to examine the appropriate physical and information theoretical principles. Some of the issues are:

Diffraction limit,information,resolution and localization.

A. *Classification of resolution*

The resolution of a digital image can be classified as follows:
- Pixel resolution
- Spatial resolution
- Spectral resolution
- Temporal resolution
- Radiometric resolution[2]

This paper mainly focused on spatial resolution

B. *Spatial resolution*

In digital image processing the image is made up of small picture element called pixels. Spatial resolution is the pixel density in an image and measures in pixels per unit area. The image spatial resolution is firstly limited by the following [2]:
- The imaging sensors or the imaging acquisition device :

Modern image sensor is typically a charge-coupled device (CCD) or a complementary metal-oxide-semiconductor (CMOS) active-pixel sensor. These sensors are typically arranged in a two-dimensional array to capture two-dimensional image signals. The sensor size or equivalently the number of sensor elements per unit area in the first place determines the spatial resolution of the image to capture. Higher the density of the sensors results higher spatialresolution in the imaging system [2].

An imaging system with inadequate detectors will generate low resolution images with blocky effects, due to the aliasing from low spatial sampling frequency. In order to increase the spatial resolution of an imaging system, one straight forward way is to increase the sensor density by reducing the sensor size. However, as the sensor size decreases, the amount of light incident on each sensor also decreases, causing the so called shot noise. Also, the hardware cost of sensor increases with the increase of sensor density or correspondingly image pixel density. Therefore, the hardware limitation on the size of the sensor restricts the spatial resolution of an image that can be captured [2].

- The optics in the acquisition device:
  While the image sensors limit the spatial resolution of the image, the image details (high frequency bands) are also limited by the optics, due to lens blurs (associated with the sensor point spread function (PSF)), lens aberration effects,aperture diffractions and optical blurring due to motion. Constructing imaging chips and optical components to capture very high-resolution images is prohibitively expensive and not practical in most real applications, e.g., widely used surveillance cameras and cell phone built-in cameras[2].
- Camera speed and hardware storage:
  In some other scenarios such as satellite imagery, it is difficult to use high resolution sensors due to physical constraints. Another way to address this problem is to accept the image degradations and use signal processing to post process the captured images, to trade off computational cost with the hardware cost[2].

C. *Super- Resolution (SR) reconstruction*

Super-resolution (SR) are techniques that construct high-resolution (HR) images from several observed low-resolution (LR) images, thereby increasing the high frequency components and removing the degradations caused by the imaging process of the low resolution camera[2].

The basic idea behind SR is to combine the non-redundant information contained in multiple low-resolution frames to generate a high-resolution image. A closely related technique with SR is the single image interpolation approach, which can be also used to increase the image size. However, since 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 low-resolution observations are available for reconstruction, making the problem better constrained. The non-redundant information contained in these LR images 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., movements of objects, or due to controlled motions, e.g., the satellite imaging system orbits the earth with predefined speed and path. Each low-resolution frame is a decimated, aliased observation of the true scene. SR is possible only if there is a sub pixel motions exits between these low resolution frames1, and thus the ill-posed up sampling problem can be better conditioned.

In the imaging process, the camera captures several LR frames, which are down sampled from the HR scene with sub pixel shifts between each other. SR construction reverses this process by aligning the LR observations to sub pixel accuracy andcombining them into a HR image grid.

The basic idea for super-resolution reconstruction is from multiple low-resolution Frames. Sub pixel motion provides the complementary information among the Low-resolution frames that makes SR reconstruction possible and thereby overcoming the imaging limitation of the camera.

1.4. Super Resolution application areas

1. Surveillance video: frame freeze and zoom region of interest
(ROI) in video for human perception, resolution enhancement for automatic target recognition (e.g. try to recognize a criminal's face)[2].
2. Remote sensing: several images of the same area are provided, and an improved resolution image can be sought [2].
3. Medical imaging (CT, MRI, Ultrasound etc): several images limited in resolution quality can be acquired, and SR technique can be applied to enhance the resolution [2].
4. Video standard conversion, e.g. from NTSC video signal to HDTV signal [2].

II. **TECHNIQUES FOR SUPER RESOLUTION**

Blurs and noise of the image should be removed to give a high resolution image. De-noising techniques can be used for getting good quality image. The de-noising techniques are discussed in the following section.

A. De-noising Techniques

Image de-noising stands as a relatively separate part of image processing.The fundamental task of de-noising is to deconvolve the blurred image with the PSF that exactly describes the distortion. Deconvolution is the process of reversing the effect of convolution. The quality of the de-noising image is mainly determined by knowledge of the PSF. De-noising is an interactive process. You might need to repeat the de-noising process multiple times.For all the iteration the parameters of the de-noising function must be varied. This should be repeated till you achieve an

image that, based on the limits of your information, is the best approximation of the original scene[1].

De-noising or degradation of an image may be caused by the following factors:

Movement during the image captures process by the camera or when long exposure times are used by the subject, Out-of-focus optics, use of a wide-angle lens, atmospheric turbulence, or a short exposure time which reduces the number of photonscaptured and the distortion of scattered light in con-focal microscope.

A blurred or degraded image can be approximately described by this equation:

$$g = Hf + n, \text{ where}$$

gis the blurred image, H is the distortion operator also called the point spread function (PSF)

n is the additive noise introduced during image acquisition that corrupts the image

f is the original image

a. PSF(Point Spread Function)

In the spatial domain, the PSF describes the degree to which an optical system blurs (spreads) a point of light. The distortion operator, which convolved with the image, creates the distortion. Distortion caused by a point spread function is just one type of distortion [1].

b. OFT(Optical transfer function)

The Optical transfer function (OFT) is the transfer function of an optical system like camera, microscope, human eye etc. It describes how the optics project light forms the object or scene onto a photographic film. This function specifies the translation and contrast reduction of a periodic sine wave pattern after passing through the lens system as a function of its periodicity and orientation. The optic transfer function is defined as the Fourier transform of the point spread function, or impulse response of the optics. The optic function provides a comprehensive and well-defined characterization of optical systems [1].

III. EXPERIMENT AND RESULT

Implementation in MATLAB:

The Jackson image is taken for measurement. The following operations are done on the image.

       Simulation of a motion blurs
       Restoration using PSF
       Computation of noise spectrum
       Simulation of a picture with motion blur and noise
       Restoration using ACF(Auto Correlation Function)
       Restoration using NP and 1-Dimensional-ACF

```
I=imread('d:\matlab704\work\jackson.bmp');
figure;imshow(I);
title('I/P:INPUT IMAGE');
 %step 2 : Simulate a Motion blur
LEN=31;
THETA=11;
PSF=fspecial('motion',LEN, THETA);
Blurred=imfilter(I,PSF,'circular','conv');
figure;imshow(Blurred);
title('Blurred');
```

```
 % Step 3 : Restore the Blurred Image
wnr1=deconvwnr(Blurred,PSF);
figure;imshow(wnr1);
title('Restored, True PSF');
 % Step 6:Use Autocorrelation to improve Image Restoration
noise=0.1*randn(size(I));
BlurredNoisy=imadd(Blurred,im2uint8(noise));
figure;imshow(BlurredNoisy);
title('Blurred & Noisy');
 NP=abs(fftn(noise)).^2;
figure;mesh(NP);
title('Noise Sepctrum');
 NPOW=sum(NP(:))/prod(size(noise));   % noise power
NCORR=fftshift(real(ifftn(NP)));  %noise ACF, centered
IP=abs(fftn(im2double(I))).^2;
IPOW=sum(IP(:))/prod(size(I));  % original image power
ICORR=fftshift(real(ifftn(IP)));  % Image ACF, cenered
wnr7=deconvwnr(BlurredNoisy,PSF,NCORR,ICORR);
figure;imshow(wnr7);
title('Restored with ACF');
 ICORR1=ICORR(:,ceil(size(I,1)/2));
wnr8=deconvwnr(BlurredNoisy,PSF,NPOW,ICORR1);
figure;imshow(wnr8);
title('Restored with NP & ID-ACF');
```

Result and screen shots

The following operations are done on the image.
       Simulation of a motion blurs
       Restoration using PSF
       Computation of noise spectrum
       Simulation of a picture with motion blur and noise
       Restoration using ACF
       Restoration using NP and 1-Dimensional-ACF

 The result of the program provides the following:

 The Jackson image is taken as input image.
 Simulate a real-life image that could be blurred (e.g., due to camera motion or lack of focus). The example simulates the blur by convolving a Gaussian filter with the true image (using imfilter). The Gaussian filter then represents a point-spread function, PSF. The image with simulated motion blur is as shown below.

I/P:INPUT IMAGE

Blurred

Figure1: Input Image   Figure 2: Simulated Blurred Image
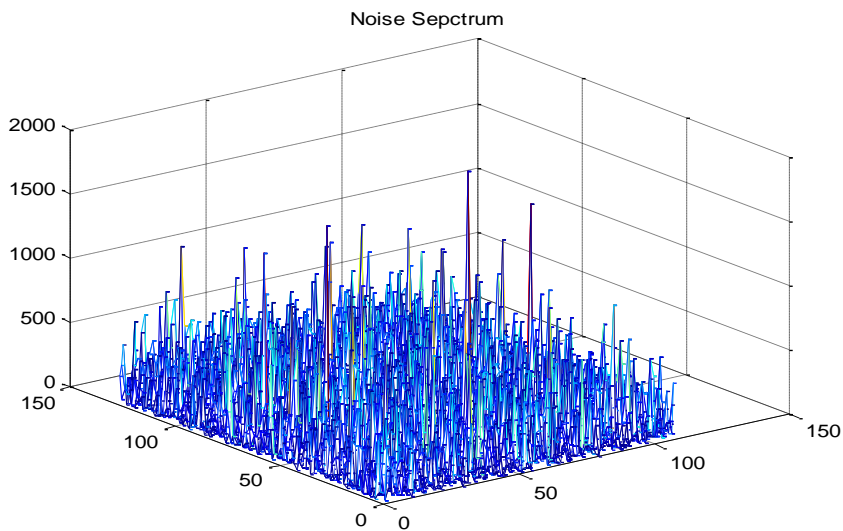
The restored image with the point-spread function (PSF) is as shown below:

Restored, True PSF

Figure3: Restored Image using true PSF

Noise spectrum is computed and the result is shown below:

Noise Sepctrum

:

Figure 4: Noise spectrum

The noise shown above is added to blurred image, the resulting image is as shown below.Autocorrelation is used to improve image restoration; the resultant image is shown below.

Blurred & Noisy   Restored with ACF

Figure 5: Blurred & Noisy Image   Figure 6: Image Restored with ACF

Correlation is done with image; noise power and 1-Dimensional autocorrelation function to improve image restoration, the resultant image is shown below.

Restored with NP & ID-ACF

Figure 6: Image Restored with NP & 1D-ACF

IV.CONCLUSION

This paper presented an effective approach toward single image super-resolution based on spatial domain. Our progressive de-convolution approach can produce very promising results.PSF is used for removing noise, ACF is used for removing blur and noise. Our results show our approach outperforms other state-of-the-art techniques and have wide applications in scientific and daily areas. In Roboticsdeburring is the material removal process, used to take burrs, sharp edges, or fins off metal parts. Burrs are almost always left on parts and tools that have been made;deburring applications can effectively removeburrs. Thus our methods are very practical and effective approach for achieving satisfactory resolution.

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