Single Leaf Image Superresoution using NEDI Technique

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Abstract

The concept of Superresolution is to increase the input image resolution. The paper focuses to study the two different iterative curvature based methods on single diseased leaf image having low resolution. For agricultural countries like India, Crop plays a vital role in country's economic growth. Plants gets viral, bacterial or fungal diseases which have a significant reduction quantity as well as quality of agricultural products. The traditional approach of expert's naked eye observation is time consuming. For this leaf identification system, leaf diseases detection system, plant diseases diagnosis system are developed which demands high resolution leaf images as input for better recognition rate. The cheapest solution is to use superresolution technique which is related in both with the statistical relationship between high resolution output and low resolution input images and with the human perception of image quality. However superresolution algorithms are being affected by artifacts such as over smoothed, jaggies, blurred or over sharped. Fast Curvature Based Interpolation (FCBI) Technique was proposed for this but results are not satisfactory. The paper have described ICBI: Iterative Curvature Based Interpolation combined with NEDI: New Edge Detection Interpolation which gives superresolved image for a single leaf image. Fine edges in SR images are preserved without applying complex mathematical algorithms based on wavelet, fast curvelet, etc. This concept can be useful for agricultural expert to help farmers for exact leaf disease detection and accurate remedial actions. The experimental result shows the best visible SR result of an infected leaf along with Mean Square Root (MSE) and Peak Signal to Noise Ratio (PSNR) statistical results.

Keywords: *Superresolution, Fast Curvature Based Interpolation (FCBI), New Edge Detection Interpolation (NEDI), Mean Square Root (MSE), Peak Signal to Noise Ratio (PSNR).*

I.Introduction

For better performance in image analysis, a common need arises of high resolution. High pixel density is offered by high resolution image and thereby the image has more details then the original image.
The central aim of Super-Resolution (SR) is to generate a higher resolution image from lower resolution images. High resolution image offers a high pixel density and thereby more details about the original scene. The need for high resolution is common in computer vision applications for better performance in pattern recognition and analysis of images. High resolution is of importance in medical imaging for diagnosis. Many applications require zooming of a specific area of interest in the image wherein high resolution becomes essential, e.g. surveillance, forensic and satellite imaging applications.
However, high resolution images are not always available. This is since the setup for high resolution imaging proves expensive and also it may not always be feasible due to the inherent limitations of the sensor, optics manufacturing technology. These problems can be overcome through the use of image processing algorithms, which are relatively inexpensive, giving rise to concept of super-resolution. It provides an advantage as it may cost less and the existing low resolution imaging systems can still be utilized.

Super-resolution is based on the idea that a combination of low resolution (noisy) sequence of images of a scene can be used to generate a high resolution image or image sequence. Thus it attempts to reconstruct the original scene image with high resolution given a set of observed images at lower resolution.
The general approach considers the low resolution images as resulting from resampling of a high resolution image. The goal is then to recover the high resolution image which when resampled based on the input images and the imaging model, will produce the low resolution observed images. Thus the accuracy of imaging model is vital for super-resolution and an incorrect modeling, say of motion, can actually degrade the image further.
The observed images could be taken from one or multiple cameras or could be frames of a video sequence. These images need to be mapped to a common reference frame. This process is registration. The super-

resolution procedure can then be applied to a region of interest in the aligned composite image. The key to successful super-resolution consists of accurate alignment i.e. registration and formulation of an appropriate forward image model. The figure 1 below shows the stages in super-resolution process.

II. Literature Review

Super Resolution Techniques

As per the super resolution imaging analysis is concerned, there are two main domains i.e. Frequency domain and spatial domain approach for image registration. In our case, the results of the spatial domain are very much better in visual quality as well as in analytical parameter also than the frequency domain, which typically failed to adequately register images. By the nature of frequency domain, Fourier transform methods are limited to only global motion models. In the early stages, most of the research work is carried out under frequency domain approach but as more general degradation models were considered; later research has tended to concentrate almost exclusively on spatial domain formulations.

Basically, image super resolution can be obtained in two categories- Non-adaptive SR & Adaptive SR in spatial domain approach.

A. Non-adaptive Image SR

Non-adaptive image SR techniques are based on direct manipulation on pixels instead of considering any feature or content of an image. These techniques follow the same pattern for all pixels and are easy to perform and have less calculation cost. Various non-adaptive techniques are nearest neighbour. bilinear and bicubic. But these techniques having some drawbacks such as problems of blurring of edges or artifacts around edges. It stores only low frequency component of an original leaf image also produces blurry images quality. Mainly it misses the required information from super resolved infected leaf image. To overcome these, we approached for Adaptive Image SR for our agricultural information for more accuracy.

B. Adaptive Image SR.

This technique considers image features like intensity value, edges as well as texture information. It also provides better visual image quality result as it preserves high frequency components from an original infected leaf image, so it is much easier for detection and classification accuracy. Various adaptive SR techniques are NEDI, DDT, FCBI, Learning based approach. Only main drawback is it requires much more computational time. So, here, we have worked over this problem while maintaining the SR quality of an infected leaf image. So, as far as infected leaf image problems are concerned, adaptive image SR approach is much better in practice and advantageous. Machine learning based detection and recognition of plant diseases can provide clues to identify and treat the diseases in its early stages. Comparatively, visually identifying plant diseases is expensive, inefficient, and difficult. Also, it requires the expertise of trained botanist. There are several methods for measuring leaf area, however, in practice, it is used mainly three: the human evaluation, the method of leaf dimensions and the methods which use devices such as plan meter and area integrator. Nevertheless, these methods require extensive work and are time-consuming. Moreover, they have some degree of inaccuracy. And, the measurement techniques are not performed in the most cases by a farmer, but by an expert (agronomist), which delays the diagnosis. With the advances in computing, especially in the graphics processing, it is possible to develop alternative methods for determining the damaged leaf area. Plant diseases have turned into a dilemma as it can cause significant reduction in both quality and quantity of agricultural products.

Fast Curvature Based Interpolation (FCBI)

The method is similar to the Data Dependent Triangulation, but instead of obtaining the new pixel values by averaging the two opposite neighbours with lower difference, we compute second order derivatives in the two diagonal directions and interpolate the two opposite neighbours in the direction where the derivative is lower. In detail, if we consider the first interpolation step, we compute the local approximation of the second order derivative I_{11} and I_{22} along the two diagonal directions using a 12 pixel neighbourhood.
In second technique, the energy term is sum of the curvature continuity, curvature enhancement and isolevels curves .First we compute, for each new pixel, the energy function U(2i+l; 2j+l) and the two modified energies U+(2i+l;2j+l) and U-(2i+l;2j+l), i.e. the energy values obtained by adding or subtracting a fixed value called threshold value to the local pixel value 1(2i+l;2 j+l) [14] and assign this intensity value to pixel. This procedure is iteratively repeated until the sum of the modified pixels at the current iteration is lower than a fixed threshold value.

FCBI Algorithm Steps

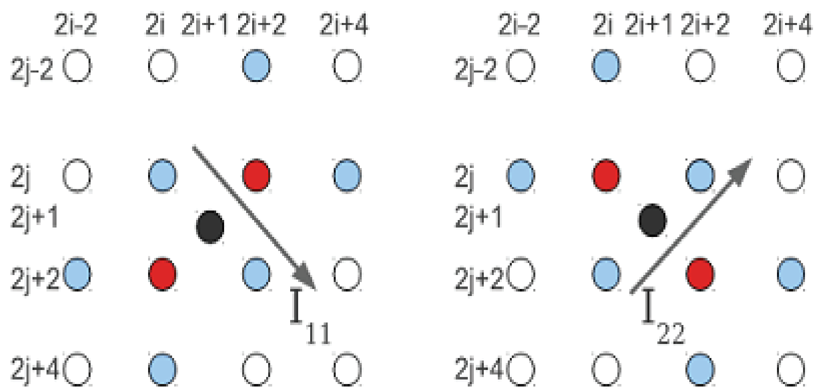

Figure 1: The average of the two neighbors in the direction of lowest second order derivative (I_{11} or I_{22}).

Steps for FCBI technique are as follows:
Step 1: Put original pixels in the enlarged grid at locations 2i,2j.
Step 2: Insert pixels at locations 2i+l,2j+l with the FCB! Method.
Step 3: Apply iterative correction until the image variation is above a given threshold.
Step 4: Insert pixels in the remaining locations with the FCB! Method.
Step 5: Apply iterative correction to the added pixels.
Step 6: Repeat the whole procedure on the new image for further enlargements.

C. Plant diseases analysis and its symptoms

The RGB image feature pixel counting techniques is extensively applied to agricultural science. Image analysis can be applied for the following purposes [3]:

- To detect plant leaf, stem, and fruit diseases.
- To quantify affected area by disease.
- To find the boundaries of the affected area.
- To determine the colour of the affected area
- To determine size & shape of fruits.

C.1. Bacterial disease symptoms

The disease is characterized by tiny pale green spots which soon come into view as water- soaked. The lesions enlarge and then appear as dry dead spots as shown in figure 1(a), e.g. bacterial leaf spot have brown or black water-soaked spots on the foliage, sometimes with a yellow halo, generally identical in size. Under dry conditions the spots have a speckled appearance. Infected plants have brown or black water-soaked spots on the foliage, sometimes with a yellow halo, usually uniform in size. The spots enlarge and will run together under wet conditions. Under dry conditions the spots have a speckled appearance. As spots become more numerous, entire leaves may yellow, wither and drop. Members of the Prunus family (stone fruits, including cherry, plum, almond, apricot and peach) are particularly susceptible to bacterial leaf spot. The fruit may appear spotted or have sunken brown areas.

Figure 2: Leaf disease symptoms. (a) Bacterial disease banyan tree leaf image (b) Fungal disease image (c) Viral disease mug leaf image.

C.2. Viral disease symptoms

Among all plant leaf diseases, those caused by viruses are the most difficult to diagnose. Viruses produce no telltale signs that can be readily observed and often easily confused with nutrient deficiencies and herbicide injury. Aphids, leafhoppers, whiteflies and cucumber beetles insects are common carriers of this disease, e.g. Mosaic Virus, Look for yellow or green stripes or spots on foliage, as shown in figure 1(b). Leaves might be wrinkled, curled and growth may be stunted. Pathogen-caused leaf spot diseases, particularly those of stone fruit trees and such vegetables as tomatoes, peppers, and lettuce are of two types, those caused by bacteria and those caused by fungus. Leaf spotting of either kind is generally similar in appearance and effect. Prevention and treatment of both kinds often involve the same practices.

C.3. Fungal disease symptoms

Among all plant leaf diseases, those caused by fungus some of them are discussed below and shown in figure 2, e.g. Late blight caused by the fungus Phytophthora. It first appears on lower, older leaves like water-soaked, gray-green spots. When fungal disease matures, these spots darken and then white fungal growth forms on the undersides. Early blight is caused by the fungus Alternaria solani. It first appears on the lower, older leaves like small brown spots with concentric rings that form a bull"s eye pattern. When disease matures, it spreads outward on the leaf surface causing it to turn yellow. In downy mildew yellow to white patches on the upper surface. These areas are covered with white to greyish on the undersides as shown in figure 1(c).

III. Proposed System

Existing system was based on ICBI and FCBI, while proposed system is based on ICBI and NEDI pixel expansion. Here pixel is taken and fitted in the grid at a particular location. Neighbors are considered to generate the new pixel. Two diagonal directions are considered and one which is having lower order is chosen. Chosen diagonal is taken to generate new pixel. This procedure is repeated for next pixel until the desired resolution is not obtained.
New Edge-Directed Interpolation
NEDI technique is a combined approach of bilinear interpolation and covariance based adaptive interpolation. In linear interpolation techniques have blurred edges and artifacts. Mainly two purposes to introduce NEDI technique: first is to produce better visual quality then linear interpolation techniques (Bilinear and Bicubic) and second is to reduce the computational complexity of covariance based adaptive interpolation technique.

Algorithm Steps

Step 1: Calculate linear interpolation coefficient.

$$\acute{\alpha} = R\_1\, \acute{r} \quad \ldots\ldots (1)$$

Where R, r are local covariance

Step 2: Calculate HR covariance from LR image.

$$\acute{\alpha} = (CTC)\_1(CT\acute{y}) \quad \ldots\ldots (2)$$

Where y: data vector and C:data matrix

Step 3: Replace value of covariance.

$$\acute{Y}_{2i+1,2j+1} = \sum_{k=0}^{1} j \sum_{l=0}^{1} \alpha_{2k} + lY2(i+k), 2(j+l) \quad \ldots\ldots (3)$$

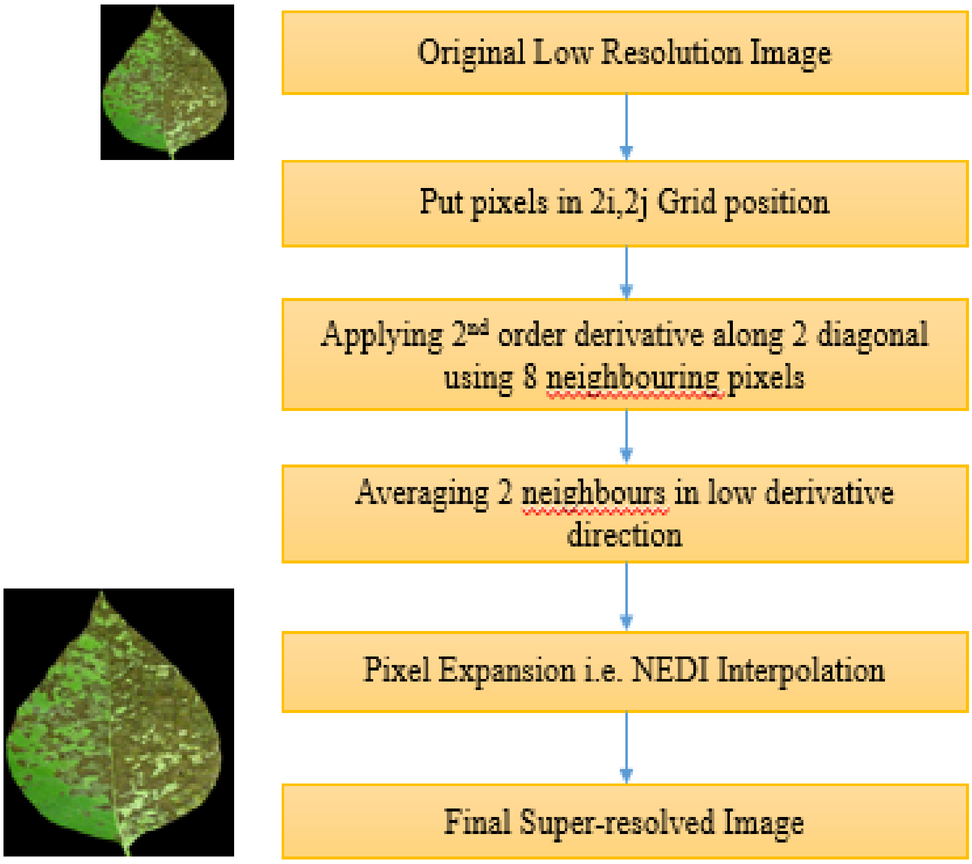

Figure 3: Proposed NEDI Technique Workflow.

IV. Experimental Results

A. Performance Metrics

The analytical parameter such as MSE and PSNR can be calculated as, let, Xi,/ be the original image and X'i,/ be the SR frame whose dimensions are M x N. Then, Mean Square Error can be defined as

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(x_{i,j} - x'_{i,j}\right)^2 \qquad \ldots\ldots\ldots\ldots(4)$$

PSNR avoids many problem of measuring image quality by scaling the MSE according to the image range. It is defined by the equation

$$PSNR = 10\log\frac{255^2}{MSE}dB \qquad \ldots\ldots\ldots\ldots(5)$$

The MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio) shows the better analytical result as that of conventional SR interpolation methods.

B. Result Analysis

I have implemented and tested the proposed NEDI Technique on Intel(R) Core(TM) i5 CPU M 460 @ 2.53 GHz processor having Windows 8.1 with the help of Matlab 2013a. Result of FCBI and NEDI techniques are shown in table 1 and 2 respectively.

Table 1: Fast Curvature Based Interpolation Results

Original Image	FCBI Technique Results	MSE	PSNR
		5.46	40.75
		16.41	35.97
		31.04	33.21
		38.29	32.29

Table 2: Proposed New Edge Detection Interpolation Results

Original Image	Proposed NEDI Results	MSE	PSNR
		5.07	41.08

		**10.96**	**45.73**
		**70.87**	**37.62**
		**92.01**	**36.99**

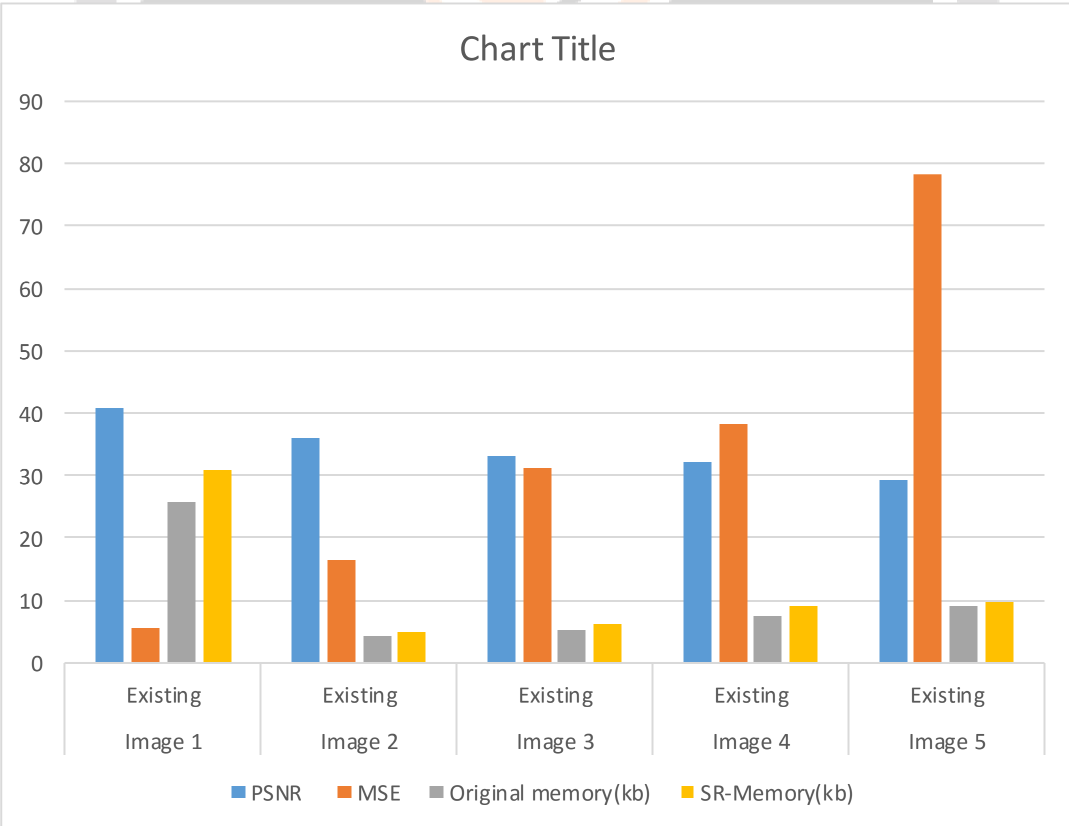

Figure 4: Graphical Analysis of FCBI Technique Results.

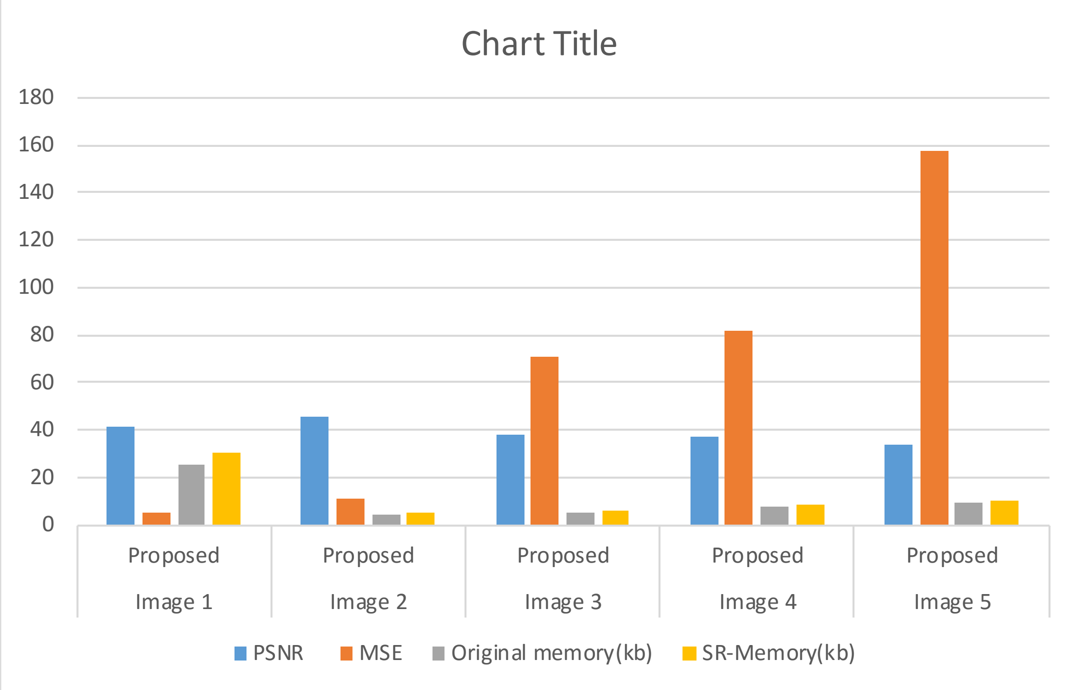

Figure 5: Graphical Analysis of Proposed NEDI Technique Results.

V. Conclusion and Future Work

Plants are economical important for agricultural countries like India which is affected normally by bacterial, viral or fungal diseases that appears on leaf and stem. The agricultural application need HR images for their better functioning of detection and classification. The proposed Image Superresolution method will provide high resolution noise-free image of leaf image for agricultural applications. The experimental results proved that the proposed NEDI Technique is better then the FCBI Technique used previously. Results are also shown graphically. Future scope can be a system where the proposed NEDI system can be embedded to applications such as leaf identification system, leaf diseases detection system and such others.

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