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A Survey on Single Image Super Resolution Techniques

Shaikh Farhat Ishaque
Department of Computer Engineering, MCOERC, Savitribai Phule Pune University,
Maharashtra, India

Abstract— In medical imaging and astronomical observation, high resolution images are now preferred and requisite. Super resolution is a technique for constructing high quality images .The main idea behind this process is combining a set of low resolution images taken from the same image or scene. Nowadays Super resolution techniques used in many applications including medical imaging, Satellite imaging, digital imaging, Biometric representation etc. This paper presents the principle of super-resolution and makes a survey about various image reconstruction methods. Furthermore paper discusses some issue and challenges faced in this field.

Keywords— Low-Resolution (LR), High-Resolution (HR), Super resolution (SR), multi image Super Resolution: - Obtaining a HR image from one or multiple LR images.

I. INTRODUCTION

Over the past two decades, there is more demand for high resolution and high quality images. In fact the demand is increasing exponentially for their efficient functioning and better quality. The quality of image information determines the efficiency and effectiveness of applications such as medical imaging, remote sensing, HDTV (High Definition Television), Video Surveillance, Video conferencing etc. Hence, high resolution images are required to improve the efficiency of these systems.

For Example, HR medical images are very helpful for a doctor to make a correct diagnosis. It may be easy to distinguish an object from similar ones using HR satellite images, and the performance of pattern recognition in computer vision can be improved if an HR image is provided.

The resolution of an image is dependent on the resolution of the image acquisition device, their cost is very high.

Since 1970s, digital imaging cameras for both still images and movies have been widely developed. These cameras are based on charge coupled devices (CCDs) and CMOS image sensors. Charge-coupled device (CCD) and CMOS image sensors have been widely used to capture digital images. Although these sensors are suitable for most imaging applications, the current resolution level and consumer price will not satisfy the future demand. For example, people want an inexpensive HR digital camera/camcorder or see the price gradually reduce, and scientists often need a very HR level close to that of an analog 35mm film that has no visible artefacts when an image is magnified. Thus, finding a way to increase the current resolution level is needed.

The most direct solution to increase spatial resolution is to reduce the pixel size (i.e., increase the number of pixels per unit area) by sensor manufacturing techniques. As the pixel size decreases, however, the amount of light available also decreases. It generates shot noise that degrades the image quality severely. To reduce the pixel size without suffering the effects of shot noise, therefore, there exists the limitation of the pixel size reduction.

Another approach for enhancing the spatial resolution is to increase the chip size, which leads to an increase in capacitance [1]. Since large capacitance makes it difficult to speed up a charge transfer rate, this approach is not considered effective. The high cost for high precision optics and image sensors is also an important concern in many commercial applications regarding HR imaging. Therefore, a new approach toward increasing spatial resolution is required to overcome these limitations of the sensors and optics manufacturing technology.

One promising approach is to use signal processing techniques. It helps to extract pictorial details along with useful information from the given image of lower quality. Recently, such a resolution enhancement approach has been one of the most active research areas, and it is called super resolution (SR) (or HR) image reconstruction or simply resolution enhancement. HR image processing concentrates on two main topics, image interpolation and image super resolution. Image interpolation is the process by which a single HR image can be obtained from a single degraded LR one, while super-resolution reconstruction of images aims at obtaining a single HR image either from several degraded still images or from several degraded multiframes.

II. SUPER RESOLUTION

If image capture from low resolution camera then occurrence of aliasing, blurring and noise may be possible so Super resolution techniques is preferred for high spatial resolution image. SR Refers to the process of producing a high spatial resolution image from one or more low resolution image, thereby recovering the missing frequency details and remove the degradation that arises during image capturing process extrapolates the high frequency components and minimize aliasing and blurring.

A. Classification

In recent years, many researchers have anticipated a variety of method to get super resolution image. These methods are divided into two categories:

1) Multi Frame Super Resolution: In multi image super-resolution, high resolution image is generated from multiple low resolution images. The basic approach in multi frame SR technique is to combine the no redundant information contained in multiple low resolution images to generate a high resolution image. However this method is unsatisfactory because mostly it takes more computation time than single image super-resolution technique and it degrades when magnification factor is large or number input images available are less.

2) Single Image Super Resolution: Single image super-resolution technique generates HR image from single low resolution image. Single image SR is also called example-based SR because the HR details of LR image can be predicted by learning the relationship between LR patches and their corresponding HR patches from examples. This techniques based on statistics and machine learning approach where the missing high frequency details in low resolution image are learned from a appropriate image database. SR methods under this category are also known as learning based super resolution technique.

III. SUPER RESOLUTION TECHNIQUES

Super Resolution techniques can be classified into mainly two classes of methods the classical multi-image super resolution and Example-Based super-resolution.

Before going to the SR algorithms let us discuss some hardware approaches for increasing pixels per unit area. These are decreasing the pixel size and increasing the sensor size [10], [11].

First specified method is a useful solution but we can't reduce the pixel size beyond a specific threshold and it will decreases the amount of light which reaches the associated cell of the pixel on the sensor .Also increase shot noise in the results .The second solution will increases the capacitance but the charge transfer rate reduced .For large scale imaging this hardware-based solutions will be highly expensive .So we are going to the algorithmic based solutions.

Various methods are proposed in literature to deal with SR Reconstruction Problem.

A. Interpolation Methods

Image interpolation is the process of converting the image from one resolution to other resolution. This process is performed on a one dimension basis row by row and then column by column. Image interpolation estimates the intermediate pixel between the known pixels by using different interpolation kernel.

1. *Nearest Neighbour Interpolation:* Nearest neighbour interpolation is the simplest interpolation from the computational point of view. In this, each output interpolated pixel assign the value of nearest sample point in the input image [2]. This process just displaces the intensity from reference to interpolated one so it does not change the histogram. It preserves the sharpness and dose not produces the blurring effect but produce aliasing.
2. *Bi-linear Interpolation:* In Bi-linear interpolation the intensity at a point is determined from weighted some of intensity at four pixel closet to it. It changes the intensity so histogram is also change. It slightly smoothes the image but does not create an aliasing effect.
3. *Bi-cubic Interpolation:* In cubic interpolation intensity at point is estimated from the intensity of 16 closest to it. The basis function is Bi-cubic gives smooth image but computationally demanding.
4. *B-spline Interpolation:* Spline interpolation is the form of interpolation where interpolate is a special piecewise polynomial called a spline. There is a whole family of the basis function used in interpolation which is given as [2]. Higher order interpolation is much more used when image required many rotation and distortion in separate step. However for single step enhancement is increased processing time.

B. Iterative back projection algorithm

In this algorithm [2]-[4] back projection error is used to construct super resolution image. In this approach the HR image is estimated by back projecting the error between the simulated LR image and captured LR image. This process is repeated several times to minimize the cost function and each step estimate the HR image by back-projecting the error. The main advantage of this method is that this method converges rapidly, less complexity and low-less number of iteration is required. In recently numbers of improvements are used with this approach which is different edge preserving mechanisms.

C. Robust Learning-Based Super-Resolution

This algorithm [5] synthesizes a high-resolution image based on learning patch pairs of low- and high-resolution images. However, since a low-resolution patch is usually mapped to multiple high-resolution patches, unwanted artifacts or blurring can appear in super-resolved images. In this paper, we propose a novel approach to generate a high quality, high-resolution image without introducing noticeable artifacts. Introducing robust statistics to a learning-based super resolution, we efficiently reject outliers which cause artifacts. Global and local constraints are also applied to produce a more reliable high- resolution image. Learning-based super-resolution algorithms are generally known to provide HR images of high quality. However, their practical problem is the one-to- multiple mapping of an LR patch to HR patches, which results in image quality degradation.

D. An Efficient Example-Based Approach for Image Super-Resolution

This algorithm [6], [7] uses learning method to construct super resolution image. The main contributions of these algorithms are:

(1) A class specific predictor is designed for each class in our example-based super-resolution algorithm - this can improve the performance in terms of visual quality and computational cost; and

(2) Different types of training set are investigated so that a more effective training set can be obtained. The classification is performed based on vector quantization (VQ), and then a simple and accurate predictor for each category, i.e. a class-specific predictor, can be trained easily using the example patch-pairs of that particular category. These class specific predictors are used to estimate, and then to reconstruct, the high-frequency components of a HR image. Hence, having classified a LR patch into one of the categories, the high-frequency content can be predicted without searching a large set of LR-HR patch-pairs.

E. Learning Based Super Resolution using Directionlets

In this algorithm [9] example based method using directionlets (skewed anisotropic wavelet transform) are used to generate high resolution image. It does scaling and filtering along a selected pair of direction not necessary horizontal and vertical like wavelet transform. In this approach the training set is generated by subdividing HR images and LR images into the patches of size 8*8 and 4*4 respectably. And then best pair of the direction is assign to each pair from five set of directions [(0,90),(0,45),(0,-45),(90,- 45),(90,45)] and then grouping the patches according to direction which reduce the searching time. Input LR image is contrast normalized and then subdivided into 4*4 patches. Each patch is decomposed into eight bands passing using directionlets. The directional coefficient of six bands HL,HH,VL,VH,DL,DH are learn from training set. Minimum absolute difference MAD criterion is used to select the directionlets coefficient. For AL and AH cubic interpolated LR image is used. These learned coefficients are used to obtain SR image by taking inverse directionlets transform. At the end contrast normalize is undo. Simple wavelet which is isotropic and does not follow the edges results in the artifacts which are removed in this case.

IV. FUTURE RESEARCH DIRECTIONS

In this section, we identify some new directions for future research. From the above survey, spend lots of time in learning knowledge from HR and LR images. In future, will propose single image reconstruction algorithm. This algorithm is divided into two phases: the training phase and the reconstruction phase. In the training phase, the algorithm is operated by training a series of high-resolution images & Construct LR Images then using the K-SVD algorithm to obtain the redundant dictionary. In the reconstruction phase, the algorithm is operated by using the theory of compressive sensing based on redundant dictionary and the l1-Homotopy algorithm to generate the HR image.

Our method is quite simple and effective, and yet produces a robust improvement over bicubic interpolation. Though the proposed algorithm can obtain a satisfying result in image super resolution.

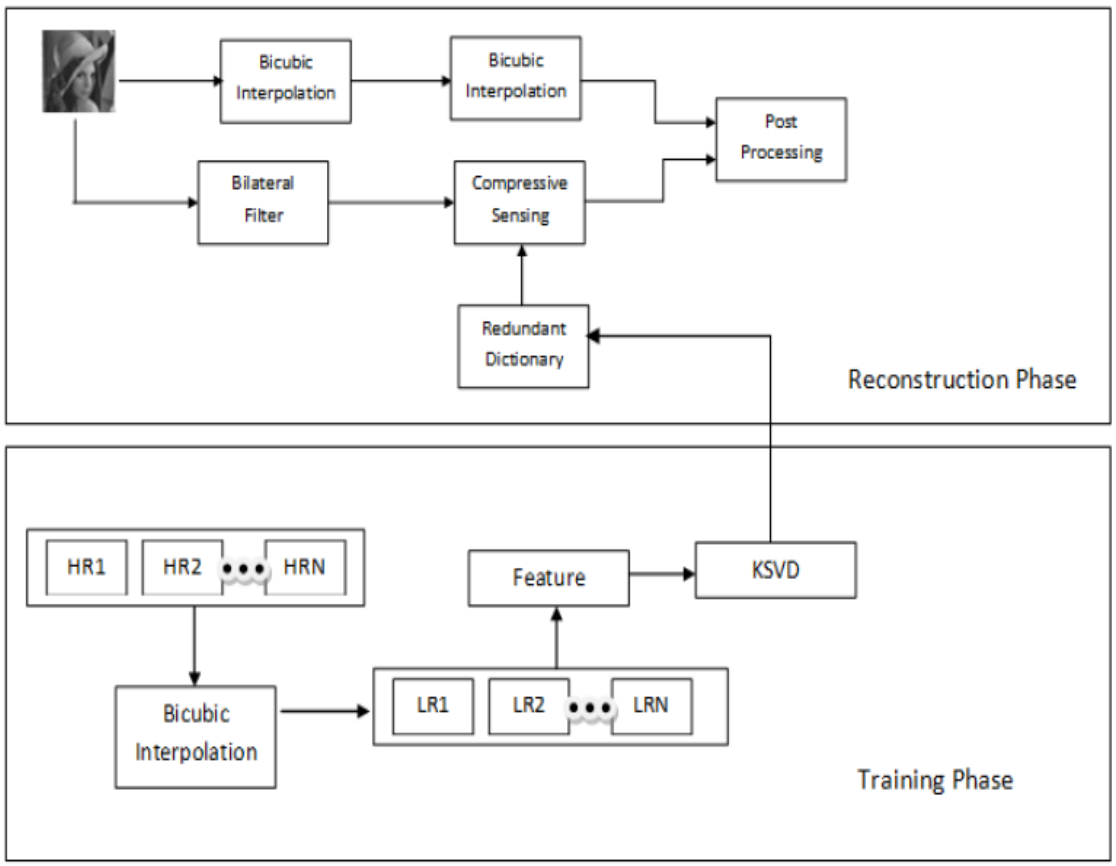

Fig. 1 System Architecture

In addition, the design of image super-resolution and the practical application of the proposed algorithm will face enormous challenges.

V. CONCLUDING REMARKS

This article aims to present the concept of image reconstruction technology by providing an overview of existing algorithms.

From this above literature table, although numerous single image super resolution researches are proposed. Many techniques have been introduced for image super-resolution still there are ongoing researches in this field.

In this survey paper, our goal is to offer new perspectives and out looks of SR imaging research, besides giving an updated overview of existing SR algorithms.

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