Interpolation for Super Resolution Imaging

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Abstract-High Resolution (HR) means pixel density within image is high. Along with pleasing picture, the high resolution image offers additional information that may be vital in analyzing image precisely in applications like, military, medical imaging, consumer electronics and so forth. Super resolution image reconstruction is used to restore a high resolution image from several low resolution images. Super resolution image reconstruction is three stage process: Registration, Interpolation and Restoration. In this paper we suggest a wavelet based interpolation that decomposes image into correlation based subspaces and then interpolate each one of them independently. Finally combine these subspaces back to get the high resolution image. We propose it for super resolution imaging along with results to put forth that it produces best results qualitatively analyzed using subjective quality measure. The concepts related to super resolution imaging; interpolation and wavelet are covered as background theory.

Keywords: *Image Interpolation, Super-Resolution and Wavelet.*

I. INTRODUCTION

In most electronic imaging applications, images with high resolution are desired and often required. Pixel density within high resolution image is high, and therefore high resolution image can tender supplementary details that may be critical in various applications. High resolution medical images are very helpful for a doctor to make correct diagnosis. In case of satellite images, it may be easy to distinguish an object for similar ones using high resolution image. Also the performance of pattern recognition in computer vision can be improved if an HR image is provided. In most of these applications, zooming of image is achieved by using interpolation of region of interest. Also to correct the aspect ratio, interpolation is used to increase the resolution of image. As interpolation itself has limitations, discovery of approach to boost the current resolution level is needed. Super Resolution (SR) image reconstruction is currently providing the solution to this problem and is one of the most spotlighted research areas. It can overcome the natural resolution constraint of the imaging system and perk up the performance of most digital image processing applications.

A. Super Resolution Image Reconstruction

Resolution of image is dependent on the resolution of image acquisition device. Since 1970s, CCD and CMOS sensors have been widely used to capture digital images. The current resolution level and consumer price are not satisfying current and future demands of imaging applications. The most direct solution is to reduce pixel size, that is, increase number of pixels per unit area by sensor manufacturing technique. But as pixel size reduces the amount of light available also decreases and it generates shot noise that in turn degrades the image quality. Another approach for increasing spatial resolution is to increase the chip size, which leads to increase in capacitance. Since large capacitance would make it difficult to speed up the charge transfer rate, this approach is not feasible. For these hardware based solutions, the limitations of manufacturing technology of high precision optics and image sensors are important concerns from commercial point of view. Hence a software approach towards increasing the spatial resolution is required to overcome these limitations. Software approach based on signal processing approach is referred as super resolution imaging. The most important advantage is that it may cost less and existing low resolution imaging systems can still be used.

Super-resolution (SR) restoration aims to solve the problem: given a set of observed images, estimate an image at a higher resolution than is present in any of the individual images. Researchers have developed variety of super resolution approaches in last decade. The basic premise for increasing the spatial resolution in super resolution technique is availability of multiple low resolution images captured from the same scene. These multiple low resolution images represent different looks of the same scene. The super resolution image reconstruction is three stage process: Registration, Interpolation and Restoration. Registration refers to motion compensation that is used to map the motion from all available low resolution frames to a common reference frame. The motion field can be modeled in terms of motion vectors or as affined transformations. The assumption is that all pixels from available low resolution frames can be mapped back onto the reference frame. Next, in order to obtain a uniformly spaced up-sampled image, interpolation onto a uniform sampling grid is done. This is to map the motion compensated pixels onto a super resolution grid. The third stage restoration is used to remove the sensor and optical blurring in resultant up-sampled image. There are methods developed for pixel registration based on pixel shift, motion blur, phase correlation or photometric cue, training images etc. [28-32]

In this paper, we present a wavelet based interpolation scheme for super resolution process, which can even be used to zoom the image. This section has covered concepts related to super resolution imaging. In section II, we present a brief literature review of interpolation and its techniques. In section III, the problem domain is formulated. In section IV we present the solution guidelines on which the proposed technique is based along with supporting wavelet features. We pick a few applications such as medical imaging and natural images and show results of proposed technique in section V. Conclusions are presented in section VI.

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II. INTERPOLATION

Interpolation also known as re-sampling is an imaging method to increase (or decrease) the number of pixels in a digital image. Interpolation transforms a discrete matrix into a continuous image. It is process of fitting the data with a continuous function and re-samples the function at finer intervals as per need. Hence interpolation is the process by which we estimate an image value at a location in between image pixels. For example, if you resize an image so it contains more pixels than it did originally, it calculates values for the additional pixels through interpolation.

A. Existing Interpolation Techniques

Image interpolation has been a key branch of Image Processing and is used for zooming or for increasing the resolution of the image. Much work has been done in this regard. Various techniques have been developed. Some digital cameras use interpolation to produce a larger image than the sensor captured or to create digital zoom. Virtually all image editing software support one or more methods of interpolation. There are many interpolation methods: Nearest neighbor interpolation, Simple Replication, Bilinear interpolation, Bicubic interpolation, Quadratic, Lagrange, B-spline, sinc, Gaussian among others. The interpolation methods all work in a fundamentally similar way. The difference among various approaches lies in the interpolation model chosen [1,2]. In each case, to determine the value for an interpolated pixel, the point in the input image is located that the output pixel corresponds to. Then a value to the output pixel is assigned by computing a weighted average of some set of pixels in the vicinity of the point. The weightings are based on the distance each pixel is from the point. The methods also differ in the set of pixels that are considered. For nearest neighbor interpolation, the output pixel is assigned the value of the pixel that the point falls within. No other pixels are considered. For bilinear interpolation, the output pixel value is a weighted average of pixels in the nearest 2-by-2 neighborhood. For bicubic interpolation, the output pixel value is a weighted average of pixels in the nearest 4-by-4 neighborhood. The number of pixels considered affects the complexity of the computation. Therefore the bilinear method takes longer time than nearest neighbor interpolation, and the bicubic method takes longer than bilinear. However, the greater the number of pixels considered, the more accurate the effect is, so there is a trade-off between processing time and quality. Let us see details of few basic techniques of interpolation.

Nearest Neighbor Interpolation

Nearest neighbor interpolation is the simplest method and basically makes the pixels bigger. The color of a pixel in the new image is the color of the nearest pixel of the original image. If you enlarge 200%, one pixel will be enlarged to a 2 x 2 area of 4 pixels with the same color as the original pixel. Most image viewing and editing software use this type of interpolation to enlarge a digital image for the purpose of closer examination because it does not change the color information of the image and does not introduce any anti-aliasing. For the same reason, it is not suitable to enlarge photographic images because it increases the visibility of blocking artifacts.

Bilinear Interpolation

Bilinear Interpolation determines the value of a new pixel based on a weighted average of the 4 pixels in the nearest 2 x - 2 neighborhood of the pixel in the original image. The averaging has an anti-aliasing effect and therefore produces relatively smooth edges with hardly any artifacts.

Bicubic interpolation

Bicubic interpolation is more sophisticated and produces smoother edges than bilinear interpolation. Here, a new pixel is a bicubic function using 16 pixels in the nearest 4 x 4 neighborhood of the pixel in the original image. This is the method most commonly used by image editing software, printer drivers and many digital cameras for re-sampling images. Adobe Photoshop CS offers two variants of the bicubic interpolation method: bicubic smoother and bicubic sharper.

Fractal interpolation

Fractal interpolation is mainly useful for extreme enlargements (for large prints) as it retains the shape of things more accurately with cleaner, sharper edges and less halos and blurring around the edges than bicubic interpolation would do. Genuine Fractals Pro from The Altamira Group includes it.

An interpolation is resizing the image; both increase and reduce the resolution. When the size of an image is reduced, some of the original pixels are loosed because there are fewer pixels in the output image. Aliasing that occurs as a result of size reduction normally appears as "stair-step" patterns (especially in high-contrast images, or as moiré (ripple effect) patterns in the output image. When either bilinear or bicubic as the interpolation method is used the tool using it automatically applies a lowpass filter to the image before interpolation to limit the impact of aliasing on the output image.

B. Interpolation for Super Resolution

The zooming algorithm is the process to enlarge a picture preserving the details. If we have two or more frame of the same scene, it possible to obtain a sharpen image, using the super resolution techniques. Usually, some Digital Cameras allow choosing the best frame between the numerous frames acquired simultaneously. With the super resolution it is possible to merge such Low-Resolution (LR) frames to obtain a new enhanced picture, where the relative misalignment between successive frames of the same scene allows recovering more high frequency details. In this way the physical limits of the acquisition system are substantially bypassed by properly using more than one frame.

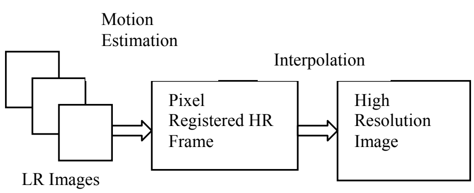

Figure 1. Stages of Super resolution Image Reconstruction