2D image reconstruction using bicubic interpolation

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Abstract

2D image reconstruction is an important task in many applications of computer vision. The objective of image reconstruction is to recover a degraded image based on mathematical and statistical models. When an image is sent via network, image's size is reduced to fast and low cost. Although the small size images are very useful in the data storage and image transmission, the detail and clear information can't be received from small image. So, small image is enlarged to get visual contents clearly. In enlarged image, some pixel positions are needed to fill Interpolation is the process which generate pixels to fill in the blanks. In this paper, image reconstruction approach is developed based on bicubic interpolation method. This method can produce good image with fine detailed information. This approach can be used to assist in photo editing processes and other computer vision applications.

1. Introduction

Image restoration is an important process in image processing. It is a process to recover image from distorted to its original image. The restoration of degraded images can be applied in many application areas that are needed to repair images. Image interpolation is one part of image restoration. Image interpolation is a process that converts from one resolution to another without losing the visual content in the picture. Image interpolation process is often used in many application areas. The widely used areas are viewing and magnifying satellite images and online images, seeing clearly the face of specific member from the historical group photo, identifying a license plate or a face in law enforcement, analyzing patient's CT scanned image in medical imaging, etc.

Above all the processes need to enlarge image size to see the detailed information. When the small size images are enlarged, it is very important to get sharper or clearer images. Many photo editing software have not developed images with clear information. To see the detailed information in images is an essential for many application areas such as medical imaging, criminal and satellite photo analysis.

This approach can generate clear image with fine detailed information. The rest of the paper is organized as follows. Some previous works of image interpolation are reviewed in section 2. In section 3, image interpolation methods are described. The proposed approach is presented in section 4 and the result is shown in section 5. Finally, in section 6, the conclusion of the paper with possible extension of future work is described.

2. Related work

In literature, most of the image interpolation techniques have been developed by interpolating the pixels based on characteristics of local features such as edge information, nearest neighbor criteria, etc. Todd Wittman [1] proposed a new Mathematical Technique for Image Interpolation. This technique modified existing non-local denoising algorithm to perform upsampling and remove noise simultaneously. It has the issues on controlling parameter h and weighted of average similarity function.

Varsha Patil and Dattatraya [2] presented a wavelet method for medical image enhancement to assist resizing. In multilevel wavelet, the image is decomposed into multiple levels and high frequency components are used to construct high resolution image. This method can eliminate and increase the resolution in low frequency. T. Acharya and P. Tsai [6] also proposed an algorithm for image interpolation in discrete wavelet transform domain. The computation of this technique is non-adaptive but it has adaptive nature due to the edge characteristics of the wavelet sub bands and its contents.

M. Ebrahimi and E. Vrscay proposed a single-frame image zooming technique [5] which is inspired by factal-based image zooming, example-based zooming, and non-local means image denoising and combines these techniques in a consistent and improved framework. This method defined a regularization scheme which exploits the examples taken from the image itself at a different scale in order to achieve image zooming.

An image magnification method is presented by that attempts to produce smooth reconstructions of the image's level curves while still maintaining image fidelity. It is similar to Bayesian restoration but instead of assuming smoothness prior for the underlying intensity function it assumes smoothness of the level curves. Level set reconstruction smoothes contours while preserving edge sharpness, so it is only as sharp as the original approximation used.

3. Interpolation methods

Interpolation works by using known data to estimate values at unknown points. There are two kinds of image interpolation. Interpolation from a higher resolution to a lower resolution is referred as down-scaling or down-sampling. On the other hand, interpolation from a lower resolution to a higher resolution is called up-scaling or up-sampling. Interpolation algorithms can be grouped into two categories: adaptive and non-adaptive. Adaptive methods change depending on what they are interpolating (sharp edges vs. smooth texture), whereas non-adaptive methods treat all pixels equally.

Non adaptive or linear interpolation is a fixed pattern of computation that is applied in every pixel location to recover the missing components. These algorithms are simple to implement and computational requirements are much lower than adaptive methods. These types of algorithms are nearest neighbor, bilinear, bicubic, spline, sinc, lanczos and others. Depending on their complexity, these use anywhere from 0 to 256 (or more) adjacent pixels when interpolating. The more adjacent pixels they include, the more accurate they can become, but this comes at the expense of much longer processing time. These algorithms can be used to both distort and resize a photo.

Adaptive or non-linear interpolation is an intelligent processing that is applied in every pixel location based on the characteristics of image in order to recover the missing components. There are many proprietary algorithms in licensed software such as: Qimage, PhotoZoom Pro, Genuine Fractals and others. Many of these apply a different version of their algorithm (on a pixel-by-pixel basis) when they detect the presence of an edge aiming to minimize unsightly interpolation artifacts in regions where they are most apparent. These algorithms are primarily designed to maximize artifact-free detail in enlarged photos, so some cannot be used to distort or rotate an image.

Nearest neighbor is the most basic and requires the least processing time of all the interpolation algorithms because it only considers one pixel the closest one to the interpolated point. This has the effect of simply making each pixel bigger. Bilinear interpolation considers the closest 2x2 neighborhood of known pixel values surrounding the unknown pixel. It then takes a weighted average of these 4 pixels to arrive at its final interpolated value. This results in much smoother looking images than nearest neighbor.

All non-adaptive interpolators attempt to find an optimal balance between three undesirable artifacts: edge halos, blurring and aliasing. Even the most advanced non-adaptive interpolators always have to increase or decrease one of the above artifacts at the expense of the other two-- therefore at least one will be visible. Also note how the edge halo is similar to the artifact produced by over sharpening with an unsharp mask, and improves the appearance of sharpness by increasing acutance.

Adaptive interpolators may or may not produce the above artifacts; however, they can also induce non-image textures or strange pixels at small-scales. On the other hand, some of these "artifacts" from adaptive interpolators may also be seen as benefits. Since the eye expects to see detail down to the smallest scales in fine-textured areas such as foliage, these patterns have been argued to trick the eye from a distance (for some subject matter).

4. The proposed system architecture

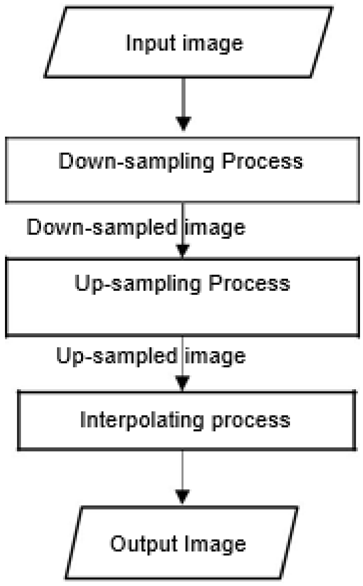

Figure 1. The general architecture of the proposed framework

The proposed system includes three main processes. These are down-sampling, up-sampling and interpolation processes. First, the system accepts input image, it is a clear image. Second the input image is down-sampled by K factor. Next, the down-sampled image is zoomed in the up-sampling phase. The up-sampled image is bur and low image resolution. So, it is passed to the interpolation phase to create sharp and clear image. Finally, the system generates the restored image with fine detailed information as output image. The general architecture of the proposed framework is shown in Figure 1.

4.1 Down-sampling process

In this process, the input image is down-sampled by k=2 factor.

4.2 Up-sampling process

In this process, the image is up-sampled by k factor. Bicubic interpolation technique which is one of the most common interpolation techniques, is used to up-sample image. In this technique, the value of an interpolation pixel is computed with weight average of the nearest sixteen pixels values. The up-sampled image is degraded by losing some information. It cannot define the content clearly. So, it must do interpolation process to recover its important information.

4.3 Interpolation process

This is important process in our framework. The blurred image from the previous process is interpolated by iterative method. It is added the lost information from original image until to reach the desired result.

5. Experimental results

The experiment runs on test images as follow. First, we accept an original image in high resolution 512× 512 in Figure 2. In second phase, we get down-sampled image 256 × 256 and it is shown in Figure 3. In Figure 4, up-sampled image is shown. In this testing, it is up-sampled by k=2 factor. This image is degraded and lost some important information. Finally, the output image is produced in the interpolation process. The interpolation process is iterated 2 times in this paper. This image recovers its lost information and include fine detailed information. This framework uses subjective method to measure the quality of image. Subjective method evaluates based on visual quality of experts (viewers). In all cases, all experts evaluated and proved that the proposed approach can produce good quality image.

Figure 2. The original input image in high resolution (512 x 512)

Figure 3. The down-sampled image (256 x 256)

Figure 4. The up-sampled image (512 x 512)

Figure 5. The output image (512 x 512)

6. Conclusion

Image interpolation process is widely used tool in image processing. Many image applications need to resample the image size to see fine detailed or sharp image. The proposed approach produces a good quality image with fine detailed information. It can also process with gray scale image and assist in image application. For the future work, this approach combines with other nonlinear interpolation.

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