CS231A Course Project: GPU Accelerated Image Super-Resolution

Fei Yue
Stanford University
450 Serra Mall Stanford, CA
jessyue@stanford.edu

Abstract

This paper proposes a GPU based real-time approach for image super-resolution. This approach is based on the fact that human observers are insensitive to single pixel shifts as long as it is globally coherent. The approach performs dilation or erosion on the pixel level depending on the local context. This approach attempts to eliminate common artifacts produced in traditional super-resolution algorithms, while maintaining a high performance for real-time processing.

1. Introduction

Super-resolution of still images can be broadly applied to many areas of graphics. Specifically, it could be used in mobile devices to enhance image capture quality, or to increase texture and image quality in applications or video games with low resolution. Methods for super-resolution are either example-based [1], multi-image based [2], or a combination of the two [3]. However, none of these yield a good solution for the GPU to be used in a real-time graphical context, as they would have excessive load time. This effort seeks a good approach of super-resolution to be used for real-time video game.

Leveraging the fact that human observers are relatively insensitive to single pixel shifts as long as the adjustment is coherent with the global picture, the general approach here is to dilate (increase contrast on) large bright areas, and erode dark areas to obtain thin and sharp features. Since the GPU is highly parallel, these operations could be accomplished quickly on a per pixel basis.

2. Problem Statement

This effort seeks to find a solution for real-time GPU enlargement of digital photographs to 2x width and 2x height. The solution would be a single-image super resolution of 4x the area, which could be used in video game textures after they are loaded into the video memory. In practice, textures are usually stored in small resolution to save storage space and transfer time for online-games. The enlargement factor of 4x is chosen because anything beyond 4x the area would consume too much video memory in this application.

2.1. Dataset

A large variety of test images are available online from state-of-the-art papers such as [3]. The source images of these are used for testing of the algorithm and doing detail comparison. This allows direct comparison with the results from the state-of-the-art methods.

2.2. Evaluation

Visual inspection is the qualitative metric of evaluation. The objective is not to “correctly” reproduce a source image that is down-sampled and then up-sampled via a super-resolution algorithm. Rather, we want to produce an image that is visually pleasing to the human eye.

The following guidelines are used for evaluation. First, limit hallucination artifacts – any added detail cannot stand out from the detail in the photograph or look out of place to a typical observer. For example, the technique should not introduce waviness on straight edges. Second, match perceptual sharpness of source image. Third, be devoid of linear or cubic up-sampling artifacts. Last, provide similar visual quality as other state-of-the-art methods.

Performance comparison would be an assessment based on estimated number of pixel reads from the source surface for the state-of-the-art methods. Since they are designed for the CPU, it would not be meaningful to directly compare the time of processing with a GPU based algorithm. The suggested method of comparison gives a good estimate of the bandwidth required to implement the algorithm. Given that GPUs are typically bandwidth bound, this is a sound approach for performance evaluation.

3. Technical Approach

To generate the super-resolution image, first generate the gradient of the original image. For each pixel of the original image, sample offset in the direction of the local gradient and perform dilation. In the opposite direction, perform erosion. Next, sample 90 degrees to the gradient

Figure 1: (A) Source image at native resolution. (B) 2x super-resolution of bilinear approach. (C) 2x super-resolution of the approach discussed in this paper. Compared to the bilinear approach, the new method eliminates a lot of the blurriness in the high frequency components and retains details (such as the plant) from the original image much better.

along a line to find other samples which are likely to be a similar surface. Blend the samples on this line to remove typical linear filtering artifacts. Following this, apply a high-pass filter to the source image and perform a similar offset adjustment to the high-passed image. Apply the result back to the image. To make up for the smoothing effect of the above operations, artificial noise is introduced.

4. Preliminary Results

Figure 1 shows the preliminary results from a prototype of the dilation and erosion operations. The initial effort looks promising, as compared to the naïve bilinear approach. However, the resulting image needs more sharpness and details, as well as better adaptation of local contrast.

References

[1] William T. Freeman, Thouis R. Jones, and Egon C. Pasztor. Example-based super-resolution. MERL Technical Report.

[2] M. Irani and S. Peleg. Super Resolution From Image Sequences, ICPR, 2:115—120, June 1990.

[3] Daniel Glasner, Shai Bagon, Michal Irani. Super-Resolution From a Single Image, ICCV 2009.