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# Proximal Interpolation in Image Zooming Using Advanced Neighborhood Algorithm

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***Abstract:- Image zooming, the process of enlarging the image is a direct application of image interpolation procedures. Image interpolation is the process of determining the unknown values of an image at positions lying between some known values. The existing system used the PDE-based curvature interpolation method for image zooming by edge-detection. The proposed work also includes the neighborhood regions. The basic interpolation technique i.e. Proximal or nearest-neighbor interpolation is applied. In this technique, the output pixel is assigned the value of the pixel that the point falls within and no other pixels are considered. This is achieved using the advanced neighborhood algorithm for image zooming. Here the input image can be a grayscale, RGB, or binary image. This algorithm computes each output pixel by taking the value of each input pixel and distributes it to the corresponding output pixel's 3-by-3 neighborhood. The proposed algorithm performs median filtering for the image matrix using the 3-by-3 neighborhood as a smoothing procedure to reduce the artifacts like blurring, jagging and ghosting. The proposed zooming algorithm works with different image types.***

***Keywords:- Curvature interpolation method, Edge-detection, Image zooming, Median filtering, Proximal interpolation.***

## I. INTRODUCTION

Digital zoom is a method of decreasing (narrowing) the apparent angle of view of a digital photographic or video image. Digital zoom is accomplished by cropping an image down to a centered area with the same aspect ratio as the original, and usually also interpolating the result back up to the pixel dimensions of the original. It is accomplished electronically, with no adjustment of the camera's optics, and no optical resolution is gained in the process.

In computer graphics, image scaling is the process of resizing a digital image. Apart from fitting a smaller display area, image size is most commonly decreased in order to produce thumbnails. Enlarging an image (up-sampling or interpolating) is generally common for making smaller imagery fit a bigger screen in full screen mode, for example.

In "zooming" an image, it is not possible to discover any more information in the image than already exists, and image quality inevitably suffers. However, there are several methods of increasing the number of pixels that an image contains, which evens out the appearance of the original pixels. When comparing the image quality achieved by digital zoom with image quality achieved by resizing the image in post-processing, there's a difference between cameras that perform potentially lossy image compression like JPEG, and those that save images in an always lossless Raw image format. In the former case, digital zoom tends to be superior to enlargement in post-processing, because the camera may apply its interpolation before the detail is lost to compression. Some digital cameras rely entirely on digital zoom, lacking a real zoom lens, as on most camera phones. Other cameras do have a real zoom lens, but apply digital zoom automatically once its longest focal length has been reached. Professional cameras generally do not feature digital zoom. Image interpolation techniques are required in various tasks in image processing and computer vision such as image generation, compression, and zooming. Thus, image interpolation methods have occupied a special position in image processing and computer graphics.

There can be many reasons for interpolation. In digital image processing one of the reasons may be increasing or zooming the picture. Interpolation techniques can be characterized into three methods: linear, nonlinear, and variational ones. For linear methods, various interpolation kernels of finite size have been introduced, in the literature, as approximations of the ideal interpolation kernel (sinc function) which is spatially unlimited; various nonlinear interpolation methods have been studied to overcome the artifacts of linear methods. The major step in the nonlinear methods is to either fit the edges with some templates or predict edge information for the high resolution (HR) image from the low-resolution (LR) one. Recently, variational methods have been suggested to form reliable edges by integrating partial differential equation (PDE) models; see and for a total variation (TV)-based interpolation method and for edge-forming anisotropic diffusion models.

A PDE-based interpolation method which is able to produce zoomed images having the same curvature profile as in the LR one, either in color or grayscaled is the curvature-incorporating method (CIM) for image zooming. This method utilizes the gradient-weighted curvature measured from the LR image, as a driving force, in order to construct an HR image having an accurate curvature profile. The provided work is a mathematical framework of CIM which can appropriately quantify the curvature profile for the HR image domain and minimize interpolation artifacts like blurring, jagging and ghosting, for image zooming of arbitrary magnification factors.

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## II. VARIOUS INTERPOLATION METHODS

### A. *Linear Interpolation Methods*

Image interpolation is to construct a 2-D continuous function $u(x,y)$ from its discrete image data $u(k,l)$, where $x$ and $y$ are real numbers and $k$ and $l$ are integers. It is traditional that the continuous function is expressed as the convolution of the discrete samples with a continuous 2-D filter $H_{2D}$ according to

$$u(x,y)=\sum_{k}\sum_{l}u(k,l)H_{2D}(x-k,y-l)$$

For linear interpolation methods, the interpolation kernel $H_{2D}$ has been selected to be separable for convenience and to reduce the computational complexity

$$H_{2D}=H(x).H(y)$$

where $H$ is symmetric (or even), i.e. $H(-x)=H(x)$. It is often required for the kernel H to satisfy the zero crossing condition and the partition of unity condition.

$$H(0)=1, H(x)=0, x|=1,2,....(1a)$$

$$\sum_{k=-\infty}^{\infty}H(d+k)=1,\ forall\, 0\le d<1.......(1b)$$

The condition in (1a) guarantees that the image is not modified if it is resampled on the same grid, and therefore the kernel can avoid image smoothing to preserve high frequency components. Kernels that fulfill (1a) are called interpolators, while others are called approximators. The condition (1b) implies that the energy of their sampled image remains unchanged. That is, the interpolation does not change them and brightness of the image. Kernels that satisfy or fail (1b) are named, respectively, dc-constant or dc-inconstant. It is known that superior kernels are interpolators and dc-constant, but the converse is not always true.

### B. *Curvature Interpolation method*

In CIM for image zooming. Let $\Omega$ and $\tilde{\Omega}$ be the original LR image domain and its $\alpha$ -times magnified in HR image domain, respectively. For a function $f$ defined on $\Omega$, its true/ideal zooming and numerical interpolation on $\tilde{\Omega}$ will be, respectively, denoted by $\tilde{f}$ and $\hat{f}$ .

*1) Edge Detection-GW Curvature:*

Denoising is done as a first step in image zooming. The PDE-based models that employ the curvature itself as the smoothing operator (e.g., the TV model) are known to have a tendency to converge to a piece wise constant image. Such a phenomenon is called the staircasing. Thus, the curvature would better be replaced by a curvature-related diffusion operator $\kappa$ which is more effective and easier to handle. In this paper we will employ the following gradient-weighted (GW) curvature:

$$\kappa(u)=-\nabla u\nabla.\left(\frac{\nabla u}{|\nabla u|}\right)$$

in order to measure the degree of curving of the image surface. The scaling factor between the GW curvatures on $\Omega$ and $\tilde{\Omega}$ is $\alpha^2$, due to the multiplication by the gradient magnitude.

In the algorithm, the GW curvature measured from the original LR image is interpolated and incorporated as an explicit driving force for the same GW curvature model on $\Omega$. The driving force would help the model construct the HR image more effectively, enforcing the resulting image to satisfy the given curvature profile. Such a curvature interpolation method turns out to produce HR images of little interpolation artifact. It also should be noticed that the GW curvature can be interpolated more reliably than the image itself.

*2) CIM for Image Zooming:*

The CIM consists of three parts: 1) the evaluation of the curvature on the given image domain; 2) its interpolation to the HR image domain; and 3) the construction of a zoomed image, carrying an appropriate curvature profile, by solving the constrained curvature. The following presents the details of the new zooming method.

*Step1:* Evaluation of $\kappa(v^0)$ on $\Omega$ :

For the LR image $v^0$, rewrite $\kappa(v^0)$ by

$$\kappa(v^0)=-|\nabla v^0|_1\left(\frac{v_x^0}{\nabla v^0|}\right)_x-\nabla v^0|_2\left(\frac{v_y^0}{|\nabla v^0}\right)_y$$

where both $|\nabla v^0|_1$ and $\nabla v^0|_2$ are same as $\nabla v^0$.

The following numerical schemes are of second-order accuracy; however, they are specifically designed in order for the resulting algebraic system to have the same positive element on its main diagonal and to become a weighted averaging in its Jacobi iteration.

Thus, the GW curvature can be expressed algebraically as

$$\kappa=Av^0$$

where $v^0$ represents the given image, $\kappa$ denotes the second-order finite difference approximation of the GW curvature, and $A$ is the coefficient matrix, of which the non-zero elements corresponding to the five-point stencil centered at $x_{ij}$ .

*Step2:* Interpolation of $\kappa$ to $\tilde{\Omega}$ :

This step can be fulfilled by simply applying a linear interpolation method. As one can see, the curvature is much less oscillatory than the image, and therefore it can be interpolated with fewer artifacts. We will simply apply the bilinear method for the interpolation.

*Step3:* Construction of a Zoomed Image $u$ on $\tilde{\Omega}$ :

In order to solve the curvature efficiently and conveniently, we will deal with the problem algebraically.

Let $\tilde{u}$ be the true/ideal HR image on for which we are looking. Then, it follows that $\tilde{u}$ must satisfy an algebraic equation of the form


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$$\tilde{A}\tilde{u} = \tilde{K}, \quad \tilde{u}_{\tilde{\Omega}_0} = v^0$$

where $\tilde{K}$ is the true curvature on $\tilde{\Omega}$ and $\tilde{A}$ denotes the true coefficient matrix.

Thus the CIM for image zooming can be summarized as follows:

i) On $\Omega$, evaluate the coefficient matrix $A$ an d the curvature $K$ for given image $v^0$:

$$\begin{cases} Av^0 \approx \kappa(v^0) \\ K = Av^0 \end{cases}$$

ii) Apply a linear method to zoom $A$ and $K$:

$$\begin{cases} A \rightarrow \hat{A} \\ K \rightarrow \hat{K} \end{cases}$$

iii) On the HR image domain $\tilde{\Omega}$ solve for $u$:

$$\hat{A}u = \frac{1}{\alpha^2}\hat{K}, \qquad u\,|_{\tilde{\Omega}^0} = v^0$$

Thus, the image interpolation can be carried out with a higher reliability and efficiency by incorporating appropriate curvature information. The CIM construct clear and reliable zoomed images which are already denoised.

## III. ADVANCED NEIGHBORHOOD ALGORITHM

The CIM is applicable for image zooming either in color or grayscale, of arbitrary magnification factors. It has been numerically verified that the CIM results in clear images of sharp edges that are already denoised. The proposed work includes the neighborhood regions along with edges. This is achieved by applying proximal interpolation with advanced neighborhood algorithm for image zooming.

This algorithm changes the magnification of the image and displays the new view in a new figure. It determines the pixel's 3-by-3 neighborhood at the output image, distributes the value of the center pixel in the input matrix to the entire pixel's neighborhood corresponding to it, and filtering the enlarged image by median. Here the input image can be a grayscale, RGB, or binary image. This algorithm computes each output pixel by taking the value of each input pixel and distributes it to the corresponding output pixel's 3-by-3 neighborhood. The proposed algorithm performs median filtering for the image matrix using the 3-by-3 neighborhood as a smoothing procedure to reduce the artifacts like blurring, jagging and ghosting.

## IV. RESULTS AND COMPARISON

The image interpolation methods have occupied a special position in image processing and are specially used in image zooming. The input image to be zoomed is a noisy image which needs to be denoised first.

Fig 1. Input image

The noisy image has the PSNR value 14.155 dB and the denoised image has the PSNR value 29.884 dB. Edges are detected sharply by the GW curvature.

Fig 2. Denoising and Edge Detection

Initially the linear interpolation method was used in image zooming.

Fig 3. Interpolation results

The curvature interpolation method performs image zooming based on the edges detected by the GW curvature. The original image and the zoomed image out are obtained as follows.

Fig 4. Original Image


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Fig 5. Image Zooming by CIM

This method was based only on the edges. So for a better zooming performance additional neighborhood regions were considered. Hence, Advanced Neighborhood algorithm was used for zooming.

Fig 6. Image Zooming by Neighborhood Algorithm

The variation in the PSNR values of the various intermediate images to the output zoomed image is shown as a plot.

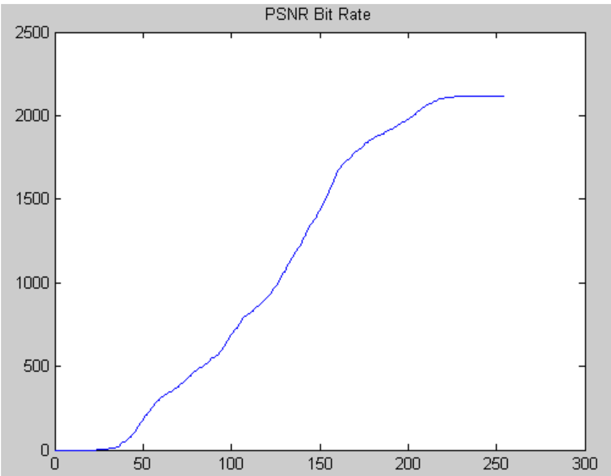


Fig 7. Variation of PSNR Bit Rates

## V. CONCLUSION

The existing work used an interpolation algorithm, called the curvature interpolation method (CIM), which was effective in image zooming and easy to implement. The proposed paper uses proximal interpolation which includes neighborhood regions too. In order to reduce interpolation artifacts, the resulting image is constructed incorporating the interpolated curvature as a driving force, instead of directly interpolating the image itself. Here the input image can be a grayscale, RGB, or binary image. This algorithm computes each output pixel by taking the value of each input pixel and distributes it to the corresponding output pixel's 3-by-3 neighborhood. The proposed zooming algorithm works with different image types effectively.

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