IMAGE PROJECTION OVER THE EDGE

NUR AZMAN ABU
WONG SIAW LANG
SHAHRIN SAHIB

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Image Projection over the Edge

Nur Azman Abu
Faculty of Information and Communication Technology
Universiti Teknikal Malaysia Melaka (UTeM)
Melaka, Malaysia
E-mail: wong.siawlang@gmail.com

Wong Siaw Lang
Faculty of Information and Communication Technology
Universiti Teknikal Malaysia Melaka (UTeM)
Melaka, Malaysia
E-mail: wong.siawlang@gmail.com

Shahrin Sahib
Faculty of Information and Communication Technology
Universiti Teknikal Malaysia Melaka (UTeM)
Melaka, Malaysia
E-mail: wong.siawlang@gmail.com

Abstract— **Image projection is usually associated with image enlargement projected on screen or large display devices. The objective of this paper is to achieve sharper image projection and thinner transition over the edge. Tchebichef moment has been chosen here since it performs better than the popular Discrete Cosine Transform. This transform integrates a simplified mathematical framework technique using matrices, as well as a block-wise reconstruction technique. The result shows Tchebichef moment gives better image projection over the edge on graphical and real images.**

Keywords- **Image Projection, Tchebichef Moment Transform**

I. INTRODUCTION

Digital image has been an importance element in daily life. Users can easily capture images using small computing devices such as PDA, digital camera, mobile phone and so on. However, the displaying devices have been improved in a wide range from a small screen for mobile phone or PDA to a large LCD monitor with high definition. This leads to the importance of image resolution translation technique that can enlarge image size for suitable display on different devices.

Image enlargement is a method to convert from a lower resolution image into a higher resolution image. Some image enlargement applications are medical imaging[1], videoconferencing[2], and digital photographs[3]. Besides for displaying purposes, image enlargement can be used in zooming application as well. So far, various researches have been done in image enlargement. The most popular methods are interpolation by convolution, which includes nearest neighbor method[4] and bi-cubic interpolation[5].

In image super-resolution[6], using Tchebichef Moment Transform (TMT) instead of Discrete Cosine Transform (DCT)[7] gives better projection. Although DCT for image enlargement has been proposed by Stephen A. Martucci[8], it has not been practically explored after a quarter century. Earlier, orthogonal moment functions are used in several computer vision and related image processing applications, such as image compression[9], pattern recognition, object

identification, template matching, and pose estimation[10]. This paper will not only inspect the image quality visually, but also analyze the reconstruction difference on re-enlargement images.

The organization of the paper is as follows. The next section will have brief description on the Tchebichef Moment Transform. Section 3 presents the experimental methods and results of Tchebichef Moment Transform on image projection over the edges. Lastly Section 4 will conclude this paper.

II. TCHEBICHEF MOMENT TRANSFORM

Let T_{mn} be TMT based on a discrete orthogonal polynomial set $\{t_n(x)\}$ defined directly on the image space $[0, S-1]$, thus satisfying all the required analytical properties without any numerical approximation errors:

$$T_{mn} = \frac{1}{\rho(m,S)\rho(n,S)} \sum_{i=0}^{S-1}\sum_{j=0}^{S-1} t_m(i)t_n(j)f(i,j) \qquad (1)$$

for $m, n = 0, 1, 2, \ldots, S-1$

For a description of the properties of Tchebichef polynomials and the definitions of related terms such as the squared-norm $\rho()$, please refer to [10]. The Tchebichef orthogonal polynomials set $\{t_n(x)\}$ can be generated iteratively as follows,

$$t_0(x) = 1,$$
$$t_1(x) = \frac{2x+1-S}{S},$$

978-0-7695-4042-9/10 $26.00 © 2010 IEEE
DOI 10.1109/ICCNT.2010.54

$$t_n(x) = \frac{(2n-1)\cdot t_1(x)\cdot t_{n-1}(x) - (n-1)\left(\frac{S^2-(n-1)^2}{S^2}\right)\cdot t_{n-2}(x)}{n} \qquad (2)$$

for $n = 2, 3, \ldots, S-1$

The first few discrete orthogonal Tchebichef polynomials are shown in Figure 1a. The equivalent discrete orthogonal cosine functions are shown in Figure 1b. The above definition uses the following scale factor[11] for the polynomial of degree

$$\beta(n, S) = S^n \qquad (3)$$

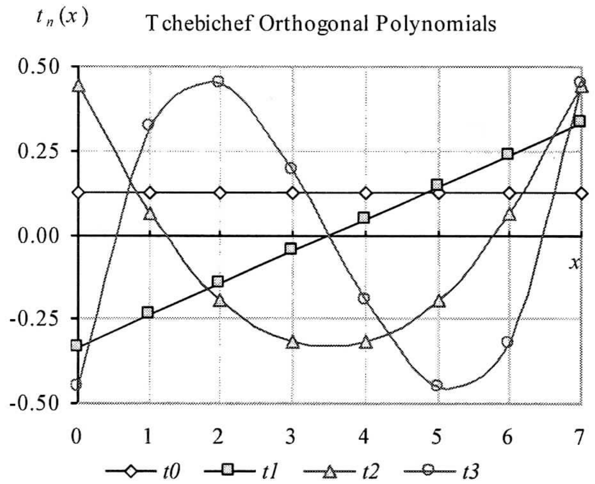

Figure 1a. The discrete orthogonal Tchebichef Polynomial $t_n(x)$ for n = 0, 1, 2 and 3.

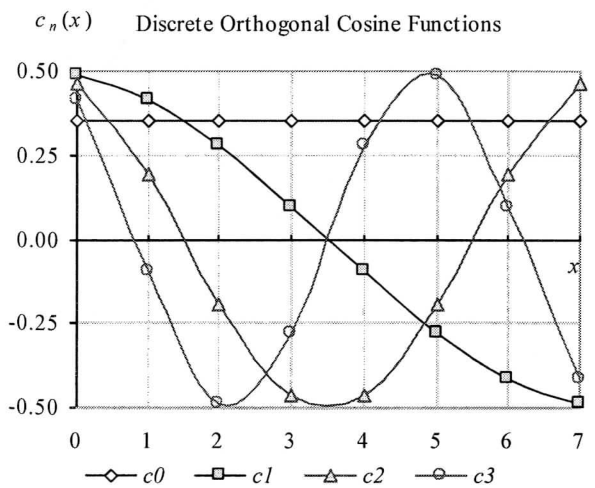

Figure 1b. The discrete cosine functions $c_n(x)$ for n = 0, 1, 2 and 3.

The set $\{t_n(x)\}$, has a squared-norm given by

$$\rho(n,S) = \sum_{i=0}^{S-1} \{t_i(x)\}^2$$

$$= \frac{S\cdot\left(1-\frac{1^2}{S^2}\right)\cdot\left(1-\frac{2^2}{S^2}\right)\cdot\left(1-\frac{3^2}{S^2}\right)\cdots\left(1-\frac{n^2}{S^2}\right)}{2n+1} \qquad (4)$$

Discrete orthogonal Tchebichef moment has its own advantage in image processing which has not been fully explored. Since computer image data operates on integers, discrete orthogonal Tchebichef moment is suitable for computer image processing. As shown in Figure 1a, the polynomial domain is discrete over natural numbers. Unlike the continuous orthogonal transform, discrete orthogonal Tchebichef moment is capable of performing image reconstruction exactly without any numerical errors[12].

III. Projection Error Over the Edge

There are eighty images that chosen to be examined and analyzed. These images are classified into forty real images and forty graphical images respectively. For displaying purposes, image of Lena is taken as the example. Originally, all the images (24-bit RGB with 512x512 pixels) are downsized to half of their original dimension (24-bit RGB with 256x256 pixels) using the popular image resizing technique, which is bi-cubic interpolation method, as shown in Figure 2 below.

Figure 2. 24-bit RGB of Lena image with 256x256 pixels (scaled to 50%)

The downsized images are then upsized using Tchebichef Moment Transform method to their original dimension. During the image enlargement, the image is divided into 4x4 blocks of pixels and processed from left-to-right and from top-to-bottom. These 4x4 blocks of moment coefficients shall be used to reconstruct a larger 8x8 block of pixels as shown in Figure 3.

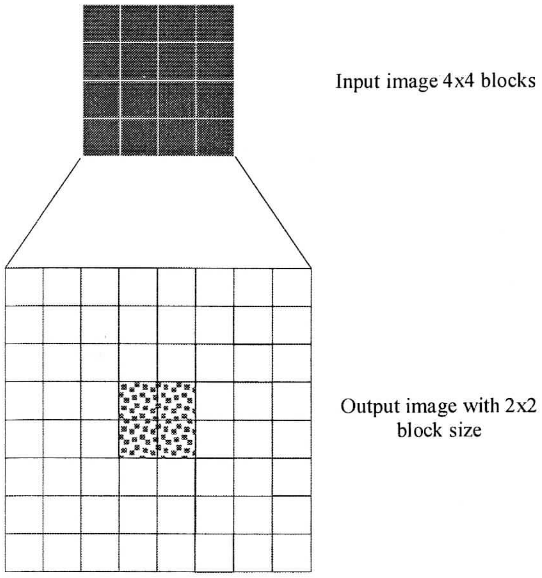

Figure 3. The Visual Representation of Pixel Block

For each layer of the images, the 4x4 block is shifted one pixel at a time, hence out of 8x8 block of pixels, only 2x2 blocks shall be taken as the output image. The output Lena image with one pixel shift is shown in Figure 4. Subsequently, the error images shall be calculated by obtaining the difference between the original images and re-enlargement images. The error images may reveal many differences in detail, such as color variations and shifts in the surrounding of edges, which would seriously impact quantitative measurement.

Figure 4. Enlarged Image of Lena with one pixel shift (scaled to 50%)

Refer to Figure 5, it is clearly shown that most of the errors around the edges are higher compared to the other regions. This is because in the original image, there are sharp 'jumps' or 'dives' of pixel values near the edges, whereas in the enlarged image, those pixels around the edges have been filtered and rounded.

In order to improve those errors, a combination of edge detection and projection over the edge techniques shall be applied on projected image. Edge detection is identifying points in an image at which the image brightness changes sharply or has discontinuities. The result of applying the edge detector may produce a set of connected curves that indicate the boundaries of objects, the boundaries of surface markings as well as curves that correspond to discontinuities in surface orientation as shown in Figure 6.

Figure 5. Error Image of Lena after Image Projection (scaled to 50%)

Figure 6. Original Image of Lena with Canny Edge Detector (scaled to 50%)

In this case, 'Canny' edge-finding method is used whereby the edges are detected by looking for local maxima of the gradient of an image. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges [13].

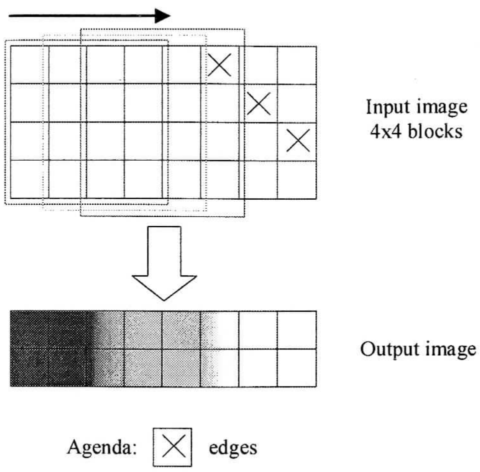

Figure 7. Visual Representation of Projection over the Edges Techniques

IV. Experimental Methods and Results

An experiment has been done to validate the error is significantly higher around edges. Refer to Figure 7 above, during the image enlargement, the original image is divided into 4x4 blocks of pixels and processed from left-to-right first. When the 4x4 block is shifted one pixel at a time, out of 8x8 blocks of pixels, the 2x4 block of pixels is taken as the output image. As we move along the original image, if there is no edges detected based on 'Canny' edge detector, the new 2x4 block of pixels is taken and replaced the previous pixels by 2x2 blocks. Otherwise, the previous block is remained and the process from left-to-right is stop. Then, we will use the same strategy above and perform the process from right-to-left.

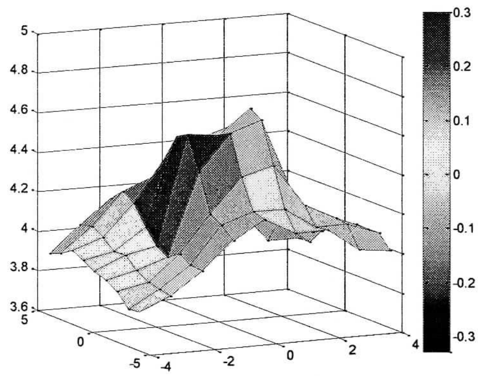

Figure 8a. Volcano-shape of the error surrounding the edges for Lena image.

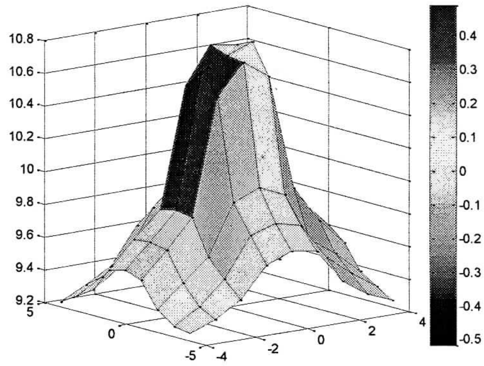

Figure 8b. Volcano-shape of the error surrounding the edges for 40 real images.

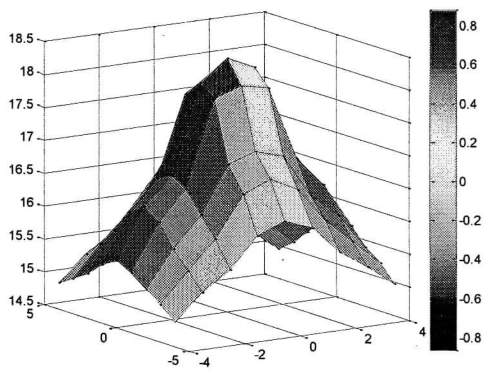

Figure 8c. Volcano-shape of the error surrounding the edges for 40 graphical images.

The error surrounding the edges has been observed as a significant contribution to the image sharpness. This is a common location where a watermark is preferably inserted. Figure 8a shows a typical error projection over the edge for Lena image. Figure 8b shows ideal error distribution for real images. Figure 8c shows higher error in the image projection for graphical images.

V. Conclusion

In this paper, a novel approach based on discrete orthogonal Tchebichef Moment Transform for image projection over the edge is proposed. The objective of this paper is to achieve sharper image projection and thinner transition over the edge. The Tchebichef Moment Transform integrates a simplified mathematical framework technique using matrices, as well as a block-wise reconstruction technique to eliminate possible occurrences of numerical instabilities at higher moment orders. The preliminary experimental results show that the Tchebichef Moment provides better sharper image projection with less error over the edge.

REFERENCES

[1] T.M. Lehmann, C. Gonner and k. Spitzer, "Survey: Interpolation Methods in Medical Image Processing", *IEEE Trans. On Medical Imaging*, Vol. 18, No. 11, pp. 1049–1075, Nov 1999.

[2] Mei-Juan Chen, Chin-Hui Huang and Wen-Li Lee, "A Fast Edge-Oriented Algorithm for Image Interpolation", *Image and Vision Computing*, Vol. 23, No.9 pp.791–798, Sep 2005.

[3] M. Unser, "Splines: A Perfect Fit for Signal and Image Processing", *IEEE Signal Processing*, No.11, pp. 22–38, Nov 1999.

[4] P.Thevenaz, T. Blu and M. Unser, "Interpolation Revisited", *IEEE Transaction On Medical Imaging*, Vol. 19, No.7, pp. 739–758, Jul 2000.

[5] H.S. Hou and H.C. Andrews, "Cubic Spline for Image Interpolation and Digital Filtering, *IEEE Transaction on Speech and Signal Processing*, Vol. 26, No. 9, pp. 508–517, Dec 1978.

[6] Nur Azman Abu, Wong Siaw Lang And Shahrin Sahib, "Image Super-Resolution Via Discrete Tchebichef Moment", *International Conference On Graphic And Image Processing ICGIP 2009*, Kota Kinabalu, Malaysia, 13–15 November, 2009, Proceedings International Conference On Computer Technology And Development ICCTD 2009, Volume 2, pp. 315–319.

[7] N. Ahmed, T. Neterajan and K. R. Rao, "Discrete cosine transform", *IEEE Trans. on Computers*, Vol. 23, pp. 90–93, Jan 1974.

[8] Stephen A. Martucci, "Image Resizing in the Discrete Cosine Transform Domain", *Proceedings International Conference Image Processing*, Vol. 2, pp. 244–247, 1995.

[9] Wong Siaw Lang, Nur Azman Abu and Hidayah Rahmalan, "Fast 4x4 Tchebichef Moment Image Compression", *International Conference of Soft Computing and Pattern Recognition SoCPaR 2009*, pp. 295–300, 4–7 December 2009, Melaka, Malaysia.

[10] R. Mukundan, "Some Computational Aspects of Discrete Orthonormal Moments", *IEEE Transactions on Image Processing*, Vol. 13, No. 8, pp. 1055–1059, Aug 2004.

[11] R. Mukundan, S. H. Ong and P. A. Lee, "Image Analysis by Tchebichef Moments", *IEEE Trans. on Image Processing*, Vol. 10, No 9, pp. 1357–1364, Sep. 2001.

[12] Nur Azman Abu, Nanna Suryana and R. Mukundan, "Perfect Image Reconstruction Using Discrete Orthogonal Moments", *Proceedings of The 4th IASTED International Conference on Visualization, Imaging, and Image Processing VIIP2004*, Marbella, SPAIN, pp. 903–907, 6–8 Sep. 2004.

[13] John Canny, "A Computational Approach to Edge Detection," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. PAMI-8, No. 6, 1986, pp. 679–698.