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REVIEW ON FOURIER DESCRIPTORS AND LAPLACE TRANSFORM WITH WAVELET BASE DIGITAL IMAGE COMPRESSION

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Abstract: Our approach relies on a method which normalizes the Fourier Descriptors (FDs) of image contour with its Laplace transform. Our approach is inspired the observations that the traditional Fourier transform of a 1-D is equivalent to the 2-D of image recognition. We compare between them throughout their efficient recognition. Digital image is basically array of various pixel values.[1] In the digital image Pixels of neighborhood are correlated and so that these pixels contain redundant bits. By using the compression algorithms redundant bits are removed from the image so that size image size is reduced and the image is compressed. Image compression Have two main Components: redundancy reduction and irrelevant data reduction redundancy reduction is achieved by removing extra bits or repeated bits. While in irrelevant reduction the smallest or less important information is omitted, which will not receive by receiver. By applying Fourier Descriptors or Laplace transform before compression algorithm we observe less peak signal to noise ratio (PSNR)

***Index Terms* - Fourier Descriptor; Laplace Transform; image contour; compression algorithms; peak signal to noise ratio (PSNR)**

I. INTRODUCTION

The task of image pattern recognition in real-time is a difficult one. One of the most critical steps is the process of feature extraction. Usually, one has to choose a compromise among certain characteristics such as invariability, discriminating powers, dimensionality and computational complexity of the feature set. Invariant features have the strength of keeping the same value despite geometric transformations (rotation, scaling, and translation). A Fourier transform7 is the most one important transformation function to extract the invariant rotation, scaling, and shift features.

Fourier descriptors (FD) provide one method which can be used to describe the boundaries of no overlapping objects. This method possesses the added advantage of producing a representation that is invariant with respect to rotation, translation, and scale changes.3 We computed the Fourier descriptor and its Laplace transform of the image contour

1.1 Fourier Descriptors and Laplace Transform

Fourier analysis is a fundamental tool in mathematics, signal and image processing. The discovery, popularization, and digital realization of fast algorithms for Fourier analysis (FFT) have had far reaching implications in science and technology in recent decades. The scientific computing community regards the FFT as one of the leading algorithmic achievements of the 20th century.3 In fact, even ordinary consumer-level applications now involve FFT's think of web browser decoding JPEG images so that development of new tools for Fourier analysis of digital data may be of potentially major significance.

Given a close shape in a 2D Cartesian plane, the boundary s of the image can be traced and re-sampled according to, say, the counterclockwise direction, to obtain an uniformly distributed K points. Each point's coordinates can be expressed as (x_0, y_0), (x_1, y_1), (x_2, y_2), (x_{K-1}, y_{K-1}). These coordinates can be expressed in the format of $X(K)= x_K$ and $Y(K)= y_K$. Under this condition, the boundary can be expressed as a sequence of complex numbers:

$$S(K) = X(K) + j\,Y(K),\ \ K = 0,1,2, \dots K - 1 \dots (1)$$

That means the x-axis is treated as the real axis and the y-axis as the imaginary axis. The coefficients of Discrete Fourier Transform (DFT) of this complex sequence z(u) are:

$$Z(u) = \frac{1}{K}\sum_{k=0}^{K-1} s(k)e^{-j2\pi\mu k}, u = 1,2,\ldots,K-1 \quad \ldots (2)$$

The complex coefficients z(u) are called the Fourier descriptors of the boundary. Fourier Descriptors are not directly invariant to image transformations including scaling, translation and rotation, but the changes in the parameters can be related to simple operations on the Fourier descriptors [3]. To get rid of the components caused by scaling, translation, rotation and starting point, we can use equation (3) to keep the Fourier descriptors invariant to scaling, translation, rotation and starting point.

$$c(u-2) = \frac{|z(u)|}{|z(1)|}, u = 1,2,\ldots K-1 \quad \ldots. (3)$$

Algorithm of Fourier Descriptor and its Laplace Transform

Step 1
Convert the grayscale image matrix into black and white.

Step 2
Evaluate the edge detection of black and white image.

Step 3
Given a close shape in a 2D Cartesian plane into the edges of image, the boundary S of the shape can be traced and re-sampled according to the counterclockwise direction xy-plan of point (x,y): S(k)=x(k)+iy(k) , k = 1,2,…,K-1 ; that means the x-axis is treated as the real axis and the y-axis as the imaginary axis.

Step 4
Compute the Fourier Descriptor (FFT) of edge detection S.

$$Z(u) = \frac{1}{K}\sum_{k=0}^{K-1} s(k)e^{-j2\pi\mu k}, u = 1,2,\ldots,K-1$$

Step 5
Compute the Laplace transform of edge detection as:

$$L = 2\pi(x^2 + y^2) \text{ X } FFT(S)$$

Where: FFT(S) is Z (u).

Step 6
We have been made a comparison between Fourier Descriptor and Laplace Transform.

II COMPRESSION ALGORITHM

There are Two types of compression algorithm: Lossless and Lossy. In the loss less compression the compressed image is totally replica of the original input image, there is not any amount of loss present in the image. While in Lossy compression the compressed image is not same as the input image, there is some amount of loss is present in the image.

2.1 A. Lossless compression Techniques

In lossless compression scheme reconstructed image is same to the input image. Lossless image compression techniques first convert the images in to the image pixels. Then processing is done on each single pixel. The First step includes prediction of next image pixel value from the neighborhood pixels. In the second stage the difference between the predicted value and the actual intensity of the next pixel is coded using different encoding methods.

2.2 B. Lossy Compression Techniques

Lossy compression technique provides higher compression ratio compare to lossless compression. In this method, the compressed image is not same as the original image; there is some amount of information loss in the image.

III WAVELET COMPRESSION

Wavelet Image Processing enables computers to store an image in many scales of resolutions, thus decomposing an image into various levels and types of details and approximation with different-valued resolutions. Hence, making it possible to zoom in to obtain more detail of the trees, leaves and even a monkey on top of the tree. Wavelets allow one to compress the image using less storage space with more details of the image. The advantage of decomposing images to approximate and detail parts as in 3.3 is that it enables to isolate and manipulate the data with specific properties. With this, it is possible to determine whether to preserve more specific details. For instance, keeping more vertical detail instead of keeping all the horizontal, diagonal and vertical details of an image that has more vertical aspects. This would allow the image to lose a certain amount of horizontal and diagonal details, but would not affect the image in human perception. As mathematically illustrated in 3.3, an image can be decomposed into approximate, horizontal, vertical and diagonal details. N levels of decomposition is done. After that, quantization is done on the decomposed image where different quantization maybe done on different components thus maximizing the amount of needed details and ignoring 'not-so-wanted' details. This is done by thresholding where some coefficient values for pixels in images are 'thrown out' or set to zero or some 'smoothing' effect is done on the image matrix. This process is used in JPEG2000.

IV PERFROMANCE PARAMETERS

There are two performance parameters are used to measure the performance of the image compression algorithms. One is PSNR (peak signal to noise ratio) and second is Mean square error (MSE). PSNR is the measurement of the peak error between the compressed image and original image.

To compute the PSNR first of all MSE (mean square error) is computed.

Mean Square Error (MSE) is the cumulative difference between the compressed image and original image. Small amount of MSE reduce the error and improves image quality.

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

In the previous equation, M and N are the number of rows and columns in the input images.

The PSNR is computed from following equation

$$PSNR = 10\left(\frac{R^2}{MSE}\right)$$

CONCLUSION

We used Fourier descriptors FD with Laplace transform to extract the invariant features of patterns in our approach, we applied FD of the edges of the images.

Hence basic image compression techniques have been discussed. To conclude the image compression techniques are useful in their related areas and every day new compression technique is developing which gives better compression ratio

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