2D-Discrete Fractional Fourier Transform for Facial Image Compression

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ABSTRACT

Face Recognition (FR) has gained significance over the past few decades in validating the true identity of an individual. However, in practice a crucial but often ignored portion of the FR system is the compression of acquired FR images. Besides installing standard compression techniques in recognition, significant compression techniques are being developed in recent years. Thus, in this paper an effective approach for compressing facial images have been proposed. Here, a 2D-Discrete Fractional Fourier Transform (2D-DFFT) has been employed that compresses the frontal facial images in a fair manner. The performance of the proposed approach is compared with existing algorithm to analyze its performance.

KEYWORDS: Face recognition, compression techniques, 2D-Discrete Fractional Fourier Transform (2D-DFFT).

I. INTRODUCTION

Face recognition has gained a significant acceptance in recent years. It has prominence in the field of pattern recognition, image analysis and more specifically biometrics [1, 2]. The Automatic Face Recognition System (AFRS) identifies the face images with varying facial expressions, facial accessories and illuminations. The image size and the resolutions play an important role in the facial recognition approach. Conversely, the influence of image compression on FRS is not considered, but it requires greater significance in recent years.

The face images are recognized from a database comprising of several hundred facial images. But now a day, as we are moving towards more secure, efficient and robust network in several places it is imperative to reduce the size of the image as low as possible. For this purpose images are initially compressed and stored in the database. The compression techniques are crucial as the compressed image occupies less memory space or can be transmitted faster because of its small size [3]. Thus the application of compression techniques on FR has gained importance.

Various image compression techniques have been developed in recent years, however, there is still a need for a compression approach that provides high compression with quality reconstruction [4]. Images comprise of the huge volume of information that needs large
storage space, huge transmission time and large transmission bandwidth, hence it is beneficial to compress the image by storing only the vital data required to reconstruct the image. A general characteristic of several images is that neighboring pixels are interrelated and thus comprises redundant information and thus harder to compress. Thus, in this paper a 2D-Discrete Fractional Fourier Transform (2D-DFFT) has been utilized to compress the image and stored in the database.

II. RELATED WORK

[5] Proposed a spherical wavelet parameterization for 3D face recognition and compression. Initially preprocessing and registration of face information is done in 3D space. Then spherical wavelet features are extracted from that provides a compressed descriptive biometric feature. The spherical representation of the face allows dimensionality reduction. This step maintains the geometry information that leads to high performance matching in the compressed space.

In [6] the face recognition by the PCA is verified for different sizes of the compressed image and its aptness to the store the image in smaller sizes is assessed. It is shown that if the images are compressed up to 10% of the original image size the face recognition is successful and compressing images below 10% in unsuccessful in several cases.

Four types of PCA algorithms such as 2D-PCA, 3D-PCA, 2D-kernel PCA (2D-KPCA) and 3D-KPCA has been employed for compressing the image [7]. These PCA algorithms are compared to analyze their performance based on their PSNR value. The results show that the 3D-KPCA performs better than the other three algorithms.

A 3D face recognition system has been proposed with compression technique and the impact of the compressed images on the identification rate is examined [8]. Here, set partitioning in hierarchical trees coding approach has been utilized for compression. The set partitioning in hierarchical trees is an enhancement to the embedded zerotree wavelet. The results indicate that including compression to a 3D face recognition system is reasonable.

[9] Uses a sparse representation based approach that encodes the information of the image based on the other image information and uses the sparsity as the measure of the compressibility. If the sparse representation is more, the image can be compressed better.

A K-SVD [10] algorithm has been proposed for compressing the facial images. The K-SVD dictionaries are trained for predefined image areas and each image is compressed according to the dictionaries. The encoding is performed according to the sparse coding of every image area with relevant trained dictionary and the decoding is the simple reconstruction of the image areas using linear combination of atoms.
III. DISCRETE FRACTIONAL FOURIER TRANSFORM (DFFT) COMPUTATION

The FFT is a member of a more common class of transformations that are referred to as quadratic phase transforms or linear canonical transformations. The transformation members are divided into basic operations such as scaling, average Fourier transforms, chip convolution and chip multiplication. The FFT of a signal \( s(t) \) can be calculated using the following steps.

(i) Initially, the function \( s(t) \) is multiplied by the chirp function \( c(t) \) which is expressed as

\[
g(x) = c(t) \cdot s(t) = e^{(-i\pi x^2 \tan(\delta/2))} s(t) \tag{1}
\]

The time-bandwidth and bandwidth product of \( g(x) \) might be twice than that of \( s(t) \). Thus the samples of \( g(x) \) are required at \( \frac{1}{2} \Delta x \) intervals. If the samples \( s(t) \) set at an interval of \( 1/\Delta x \) then it can be interpolated and multiplied by the samples of the chirp function to get the intended samples of \( g(x) \).

(ii) Next convolute \( g(x) \) with a chirp function as shown below

\[
g'(x) = C_\delta \int_{-\infty}^{\infty} e^{(i\pi \beta (x-x')^2)} g(x') dx' \tag{2}
\]

Here, \( C \) is given as

\[
C_\delta \equiv e^{\left(-i\frac{\pi \sin((\sin \delta)/4)}{\sin \delta} \right)} , \delta \equiv \frac{\alpha \pi}{2} \tag{3}
\]

As \( g(x) \) is bandlimited the chirp function is replaced with the bandlimited version to perform convolution

\[
g'(x) = C_\delta \int_{-\infty}^{\infty} e^{(i\pi \beta (x-x')^2)} g(x') dx' = C_\delta \int_{-\infty}^{\infty} h(x-x')g(x') dx' \tag{4}
\]

\[
h(x) = \int_{-\infty}^{\infty} H(v)e^{(i2\pi vx)} dv \tag{5}
\]

\[
H(v) = \frac{1}{\sqrt{\beta}} e^{i\frac{\pi}{4}} e^{(-iy)^2 \beta} \tag{6}
\]

Eq (4) can be sampled with

\[
g'(\frac{n}{2\Delta x}) = \sum_{n=1}^{N} h(\frac{n-m}{2\Delta x}) g(\frac{n}{2\Delta x}) \tag{7}
\]

(iii) Finally, the function is again multiplied with the chirp function
2D Discrete Fractional Fourier Transform (DFFT) computation

For a $A \times B$ matrix, the 2D DFFT is obtained in a simple way: the one dimensional DFFET is applied to every row of the matrix and then to the results column. For a 2D DFFT, two angle of rotations ($\theta_1$ and $\theta_2$) are considered. Here $\theta_1 = \frac{\alpha \pi}{2}$ and $\theta_2 = \frac{\beta \pi}{2}$. The generalization of DFFT to 2D is given as

$$Y_{\theta_1, \theta_2}(u, s) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} k_{\theta_1, \theta_2}(u, s; t, r) x(t, r) dt dr$$

$$k_{\theta_1, \theta_2}(u, s; t, r) = k_{\theta_1}(u, t) k_{\theta_2}(s, r)$$

IV. DFFT Compression Model

In image compression using DFFT, the compression model performs three operations such as subimage decomposition, transformation, and quantization as shown in fig 1. The decoder performs the reverse sequence of steps of the encoder. As the quantization produces irreversible loss of information, the inverse quantizer block is not considered in the decoder as illustrated in fig 2.
An image is initially divided into non-overlapping m x m (8 X 8) sub images. A 2D-DFFT is then applied to each and every block that converts the gray level pixels of the spatial domain into frequency domain coefficients. Then the transformation coefficients are quantized according a threshold selected and the variation of ‘a’. By regulating the transform co-efficient threshold a compromise is made with the compression factor and the image quality. The quantized co-efficient are organized in a zig-zag fashion to form the compressed image.

At the decoder the reverse process of encoder is performed using the inverse 2D-DFFT. Then the non-overlapped images are combined to obtain the decomposed image.

V. RESULTS

The performance of the proposed approach is evaluated in terms of PSNR (Peak-Signal-to-Noise Ratio). A set of 5 images was utilized in our experiment. The results of two of them are presented. The PSNR is given as

\[
PSNR = 10 \log_{10}\left(\frac{255^2}{||x - x'||^2}\right)
\]  

(11)

![Fig 3 PSNR Value of Image 1](image-url)
Fig 3 and 4 shows the PSNR Value of the compressed image for two image sets. The results show that the PSNR value increases with the number of bytes compressed is more. The results are compared with the existing JPEG-2000 compression algorithm and it is shown that the performance of the proposed approach is more than the JPEG-2000 approach.

VI. CONCLUSION

Face Recognition (FR) has gained significance over the past few decades in validating the true identity of an individual. However, in practice, a crucial but often ignored portion of the FR system is the compression of acquired FR images. Besides installing standard compression techniques in recognition, significant compression techniques are being developed in recent years. Thus in this paper a 2D-Discrete Fractional Fourier Transform (2D-DFFT) has been employed that compresses the frontal facial images in a fair manner. The performance of the proposed approach is compared with existing JPEG-2000 algorithm and the results show that the proposed approach performs better than the existing approach.

REFERENCES


