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Finger Knuckle Analysis: Gabor Vs DTCWT

Hanna Paulose
M.Tech Student
Department of ECE
SUS College of Engineering and Technology
Tangori, Mohali, India
hannabedi@gmail.com

Er. Harbinder Singh
Assistant Professor
Department of ECE
SUS College of Engineering and Technology
Tangori, Mohali, Punjab
harbindersinghece@sus.edu.in

Abstract— Knuckle biometrics is one of the current trends in biometric human identification which offers a reliable solution for verification. This paper analysis FKP recognition based on the behaviour of two different filtering and classification methods. Firstly, Gabor Filter Banks techniques are applied for finger knuckle print recognition and then the same database is analysed against Dual Tree Complex Wavelet Transform technique. The experiment is evaluated to identify finger knuckle images using PolyU FKP database of 7920 images. Finally, these two different systems are compared for false acceptance rate FAR, true acceptance, false rejection rate FRR and true rejection. Extensive experiments are performed to evaluate both the techniques, and experimental results show the pros and cons of using both the techniques for specific applications.

Keywords— *Finger Knuckle Print (FKP); Gabor Filter; Dual Tree Complex Wavelet Transform;*

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I INTRODUCTION

Use of biometrics dates back over a thousand years, which is defined as the measure of human body characteristics such as fingerprint, voice pattern, Iris and Hand measurement, Gait, Palm Print. It is a potent and unique tool based on the physiological (anatomic) and behavioral characteristics of the human beings as shown in Fig.1.

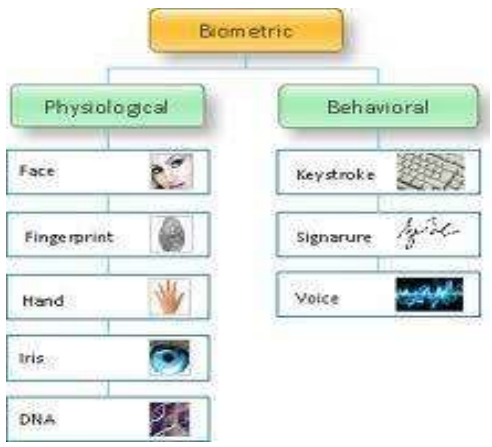


Figure 1: Types of Biometric System

Typically, we can identify the following attributes of a biometric system such as
Uniqueness: It means that an identical feature should not appear in two different people.
Universality: This is the feature which is present/occurs in as many people as possible ie universally.
Permanence: This feature does not change over time, or we can say that it contrast very slowly.
Measurability: **T**he possibility to measure the feature with relatively simple technical instruments
Acceptability: Its is the feature of the measurement in daily lives by all.
Circumvention: It is the toughness of the system to be deceived by fraudulent methods.
This paper discusses about the biometric identifier **finger knuckle print** (FKP), which is the outer or exterior surface of the fingers of a person ie the phalangeal joint. This configuration or pattern of the exterior of knuckle phalangeal joint is unique and dissimilar and can be used for authentication very efficiently and effectively. Pattern of the finger knuckle is highly discriminative and makes the surface a unique biometric identifier. The Finger Knuckle print recognition system typically contains data acquisition, ROI extraction, feature extraction, coding and matching process. For the comparison universally accessible PolyU FKP database of 7920 images were utilized to study the features using different techniques and algorithms. The features of FKP are initially extracted using the Gabor Filter Banks and then the same database images are independently filtered using Dual Tree Complex Wavelet Transform (DT-CWT).

II RELATED STUDIES

The local characteristics or information of FKP was accessed using Scale Invariant Feature Transform SIFT and Speed up Robust Features SURF technique. The SIFT Scale Invariant Feature Transform algorithm is used to get the important ie key points using the scaling and invariant features which were matched to prove the user authentication [1]. Ajay et.al, studied and suggested method of triangulation for authentication using hand vein images of all finger's finger knuckle s [2]. Tao Kong et al.[3] proposed a extraction and classification method based on hierarchical model for finger knuckle print recognition, rooted from an established style fusion method of scores obtained from the images. In the method which is under analysis, firstly Gabor feature has been taken as the basic feature for finger knuckle print recognition and then a new decision rule is defined based on the predefined threshold. G S

Badrinath et al.[1] proposed a system which uses feature extraction with the help of features that are local of improved FKP that are sifted out using the scale invariant feature transform and the speeded up robust features extraction techniques. Nearest neighbour ratio technique is used for matching of features of finger knuckle print and then matching scores of SIFT and SURF are fused using the weighted sum rule. Lin et al. [4] using the outcomes of psycho-physics and neuro-physiology studies that show that image perception is based on both local and global features, suggested, the Local Global Information Combination ie (LGIC) technique. For local feature extraction and classification, the orientation information from the message is extracted using four scales and six orientations Gabor filters and is encoded using the modest coding technique. This process is appropriate for images containing ample line like constructions and has the benefits like great accurateness, sturdiness to brightness disparities, and easy and fast matching. Subsequently the scale of the Gabor filter is amplified to infinity by which the Fourier transform of the finger knuckle print image is obtained. The Fourier constants of the image are taken as the global feature. For matching two good, competitive code maps, normalized Hamming distance obtained from used angular distance is used. BLPOC ie Band Limited Phase Only Correlation is used to measure the correspondence between Fourier transforms ie Global Information of the images. Thus both features ie the local and global features are extracted and the matched separately and two distances obtained, d1 and d2 are then fused according to the rule distance given in Matcher Weighting (MW) algorithm.

III FKP RECOGNITION SYSTEM ARCHITECTURE

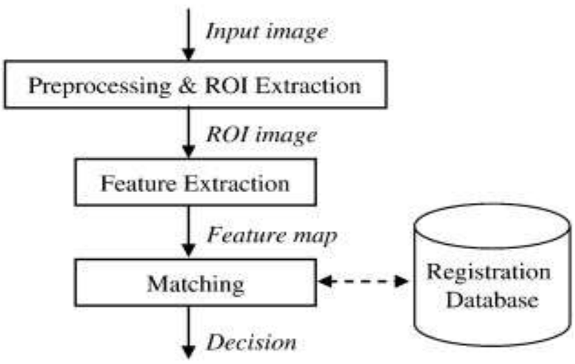


Figure 2: Schematic Diagram for FKP recognition

The system consists of FKP image acquisition assembly followed by data processor which consists of Region of Interest extraction, feature extraction and coding and finally matching is performed to differentiate data into imposter or genuine. The study comprises of comparing two different filtering techniques.

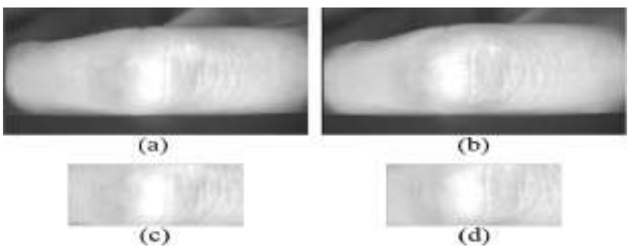


Figure 3: (a,b) finger knuckle print images. (c,d) Region of Interest images.

IV FEATURE EXTRACTION AND MATCHING

This study features study of two different extraction technique and comparison between both of them. The technique of the dual tree complex wavelet transform is initiated by the reason that it provisions in removing the effects of non-uniform brilliance, and the directional features provided by the dissimilar sub bands makes it possible to identify edge information with different directionalities in the equivalent image. The consequential complex-wavelet based feature information are more discriminating and distinguishing compared to the Gabor wavelet-resultant features and at the same time are of lower dimension and time consuming when compared with that of Gabor wavelets. 2-D dual-tree complex wavelet transform is more effective, less time complex and computationally competent. Furthermore, in addition to the reliable and capable classification performances, method 2-D dual-tree complex wavelet transform has a really low computational complexity.

Methodology

The study uses 2D Gabor filters and 2D Dual Tree Complex Wavelet Transform (DT-CWT) to extract the image local orientation information. This information is then employed to extract and represent the finger knuckle print recognition features. While matching of two knuckles, the Euclidian distance or hamming distance is used to measure the similarity.

Feature Extraction

Feature extraction is very important step in pattern recognition because of poor quality and its necessary to capture all options in finger knuckle image for associate economic and competitive and reasonable matching. The effective approaches for matching two coarse textured like biometric pictures is to decide their identical or similarity in spectral domain depiction of mistreatment the section information. Firstly, intra-class differences should be small i.e. features derived from different samples of the same class should be close enough. Secondly, the inter-class separation or differences should be large which means that features derived from samples of different classes must differ significantly to ensure there is no matching between two different knuckles. Also information or feature should be independent of the size, rotation and location of the pattern. 2D Dual tree complex wavelet is independent with regards to translation, rotation and scale, and therefore can be used for pre-processing or extracting features of images.

Gabor Filtering Feature Extraction

The Gabor filtering technique can extract the spatial-frequency and orientation information from the original signal [5]. It has been extensively used as a convolution filter for feature extraction to fulfill the feature extraction job. For years together Gabor Filter technique has been broadly used as an effective tool for feature and information extraction job in face recognition, iris verification, finger print analysis and palm print recognition systems. In [6], Loris and Alessandra described a Gabor feature selection technique which can produce features that are wavelength, phase, magnitude, orientation and bandwidth, which can be used separately or jointly in different combinations in different systems. Kong calculated the three basic three features of Gabor Filter Banks (magnitude, phase, and orientation) produced by the Gabor filter for face recognition system and concludes that the orientation feature is the most robust, discriminative and distinctive feature [7]. T.S. Lee [8] evaluated the situations under which a set of continuous 2D Gabor wavelets will provide a complete illustration of any image, and also determine similar to the self image based wavelet features and parameterizations which allow constant reconstruction of the image from the filtered and superimposed images by summation even though the wavelets formed in an orthonormal basis. In this paper, the 8 filters banks of Gabor filter is proposed by combining the orientation, wavelength, phase and magnitude features using Gabor filter for knuckle print recognition. Experiment and analysis results compare and verify the scheme against Dual Tree Complex Wavelet Transform (DT-CWT) based on performance in FKP recognition. The Gabor filter banks has different methods in the literature and here we adopt the one of the form proposed by Lee [8] as given below:

$$g(x, y; f, \theta) = e^{-\frac{1}{2}\left(\frac{x_\theta{}^2}{\sigma_x} + \frac{y_\theta{}^2}{\sigma_y}\right)} .\cos(2\pi f x_\theta)$$

Where

$$x_\theta = x \sin\theta + y \cos\theta$$
$$y_\theta = x \cos\theta - y \sin\theta$$

and, $g(x, y; f, \theta)$denotes the Gabor filter value in spatial domain x & y denote the x and y coordinates of the Gabor filters, f denotes the frequency of the sinusoidal plane wave in the direction Θ from x-axis. σ_x and σ_y denote the standard deviations of the Gaussian envelope along x & y-axes separately. Four parameters (θ, f, σ_x, σ_y) of Gabor filter must be specified for applying it to an image. The frequency of the filter is completely determined by the local ridge frequency and the orientation is determined by the local ridge orientation. The selection of the values σ_x and σ_y involves trade off. The lager the values of σ_x and σ_y , the more stable and robust the filters are to the discrepancies and noise in the finger print clip/ image, but also are more likely to generate spurious undesired ridges and valleys.

On the other hand, the smaller the values of the filter, the less likely the filters are to introduce spurious ridges and valleys but then they will be less effective in removing and clearing the noise. If σ_x and σ_y are standard deviations of the Gaussian envelope and the values are too large, the filter is more stable and robust to noise, but is probable to smoothens the image to the extent that the ridges and valley details in the finger print are lost. If σ_x and σ_y readings are very small or less, the filter is not operative and effective in removing the noise. Gabor technique is one of the common choice for texture and pattern analysis. There are different kinds of popular sets of Gabor filters. These sets are generally designed based on illustration considerations. The 2D filter represented by extracts the orientation and magnitude information at each pixel in digital knuckle image. At given threshold, the probability of accepting imposter as correct person known as false acceptance rate FAR and likelihood of rejecting genuine user as imposter is known as false rejection rate FRR are calculated. Equal Error Rate EER is an ideal rate or optimal rate where FAR is equal to false rejection rate i.e FRR. Diagrammatically, Equal Error Rate, EER is known or characterized as the crossing point or meeting point between false acceptance rate FAR and false rejection rate FRR. It is commonly used to determine the overall accurateness of the system and serve as comparative measure against the other biometric systems.

Dual tree Complex Wavelet Transform

Complex wavelet filters in two dimensions offer two directional selectivity. So they are able to segregate and differentiate all part of the two dimensional frequency space being implemented separately as two distinct systems. Complex coefficient at each level aligned at angles of ±15º,±45º,±75º are generated from six band pass images. These features and characteristics are useful for pattern recognition of finger knuckle print. In this study we present a new finger knuckle feature extraction method by using 2D DTCWT. The feature extraction scheme is to use the multi-level coefficient of decomposition part of normalized finger image via 2D DT-CWT, which is implemented using dual tree complex wavelet structure. There are many different types of techniques suggested in the literature for extracting unique and invariant feature on rotation, translation and scale. Wavelet techniques are used in the wide range of problems in extraction, classification, data compression, de-noising and reconstruction. Some procedures and techniques used at the output of the wavelet transform to generate a binary feature vector, while other technique consider real value feature vector as output as a real valued featured vector. But the ordinary discrete transform is not shift invariant because of the decimal operation during the transform. Therefore any minor shift in the input signal can cause different output coefficients. DT-CWT has improved directionality and reduced shift sensitivity and it is approximately invariant. It has real and imaginary part in the coefficients. The DT-CWT has two real wavelet transform in parallel where the wavelets of one branch are the other are Hilbert transform of the wavelet. In any high security application, both extremely low false acceptance rate FAR and false rejection rate FRR are desirable at the same time this is also called the double low problem.

The discrete wavelet transform (DWT) which is commonly used in its maximally decimated form. This technique works good for compression of images. Its use for analysis of signal and reconstruction of image tasks has been hindered by two disadvantages of discrete wavelet transform DWT:

- DWT has lack of shift invariance which means that a small shift in the incoming signal can cause a significant variation in the distribution of energy of coefficients of DWT at different scales.
- For the diagonal features it has poor directional and rotational selectivity, as the filters are real and distinguishable.

Shift invariance can be provided by use of the undecimated form of the dyadic filter tree compared to the decimated discrete wavelet transform DWT tree. However, this suffers from increased computation requirements compared to the fully decimated discrete wavelet transform DWT and also exhibits high redundancy in the output characteristics/ features, making successive processing costly also.

Dual-tree complex wavelet transform (DT-CWT) has less time complexity as it is more computationally efficient. When DT-CWT is applied to multi-dimensional signals it has a good directional sensitivity. Summarizing the properties of DT-CWT:

- Approximate shift invariance;
- Good directional selectivity in 2-dimension (2-D) like Gabor filter banks.
- Perfect reconstruction of the image (PR) using short linear phase filters;
- Computational Efficiency.

The complex wavelet methods, analysed here, offer perfect reconstruction, better directional selectivity, and a general multiscale decomposition.

V RESULTS & DISCUSSIONS

The database for FKP images has been provided by Biometrics Research Center, The Hong Kong Polytechnic University. The database consists of 165 FKP images having images of four fingers and 12 images of each finger at different ambient lights. Experiments were carried out to appraise the functioning, evaluate and compare the performance of both methods. Experimental results verify that the DT-CWT method can achieve satisfactory recognition in real time. For two techniques, different feature extraction result in different recognition performances. Finally, these two systems are compared for the features extraction viz the False Rejection Rate, False Accept Rate and Equal Error Rates. Experiments are performed to evaluate both the techniques and capabilities, and experimental results demonstrate that DT-CWT can achieve an encouraging performance.

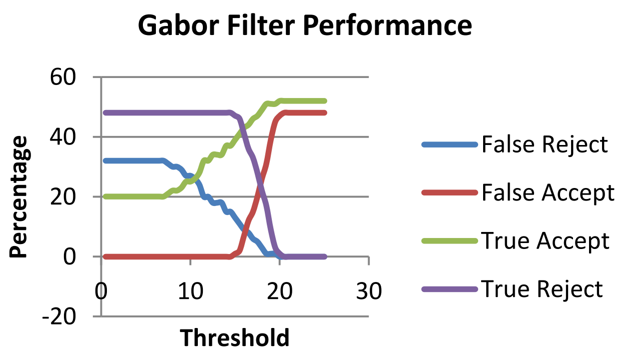


Figure 4: Performance of Gabor extraction technique

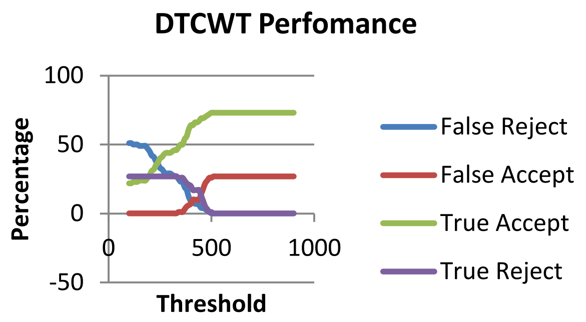


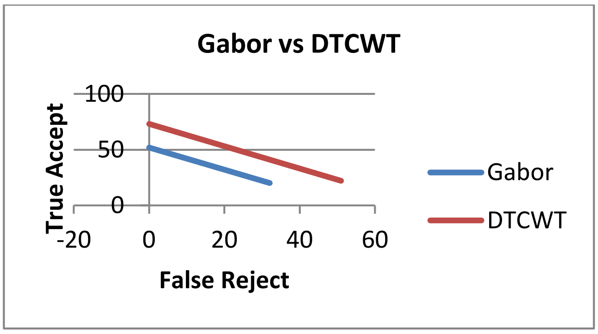
Figure 5: Performance of DTCWT extraction technique

Comparison Gabor Filter vs Dual Tree Complex Wavelet Transform

DT CWT is less time complex and computationally efficient system produced the following outputs and allows the transform to provide approximate shift invariance and directionally selective filters while preserving the properties of perfect reconstruction and computational efficiency with good well-balanced frequency responses. Further the degree of threshold and feature detection capability is more with the Dual tree complex wavelet transform.

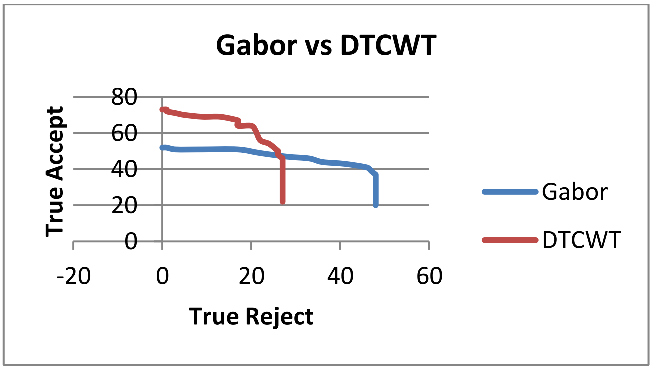
False Reject vs True Accept

The False Reject Vs True Accept graph shows that for a low value of the false reject the standards of true accept is better for DTCWT technique. This means that the DTCWT system performance is better compared to Gabor technique.



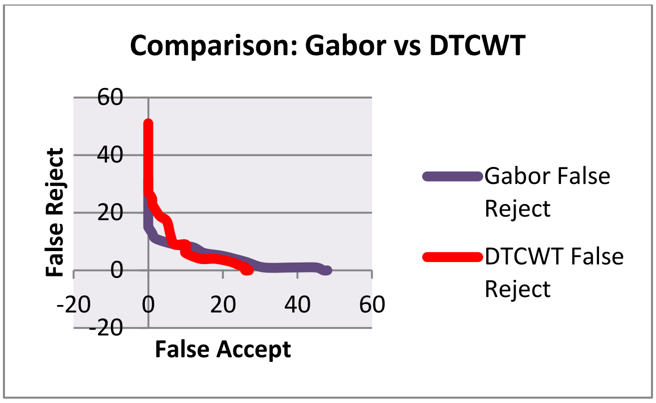
True Reject vs True Accept

The True Reject Vs True Accept graph shows that for a low value of the false reject, the readings of true accept is better for DTCWT technique. This means that the DTCWT system performance is better compared to Gabor technique.



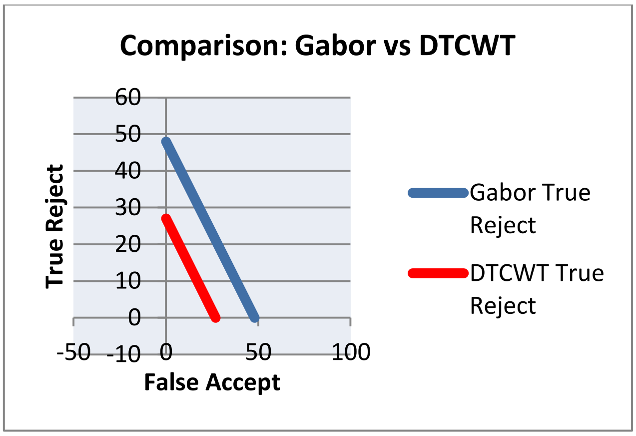
False Accept vs False Reject

The False Accept Vs False Reject graph shows that the false accept of DTCWT is lower than the Gabor System. This analysis depicts that the DTCWT system performance is better compared to Gabor technique.



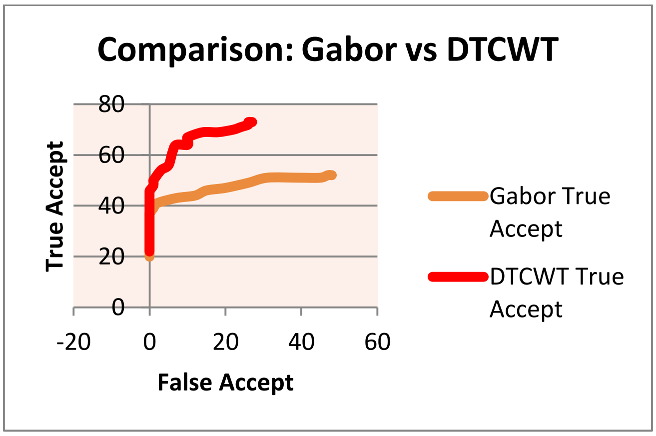
False Accept vs True Reject

The False Accept Vs True Reject graph shows that the false accept of DTCWT is lower than the Gabor System. This illustrates that the DTCWT system performance is better compared to Gabor technique.



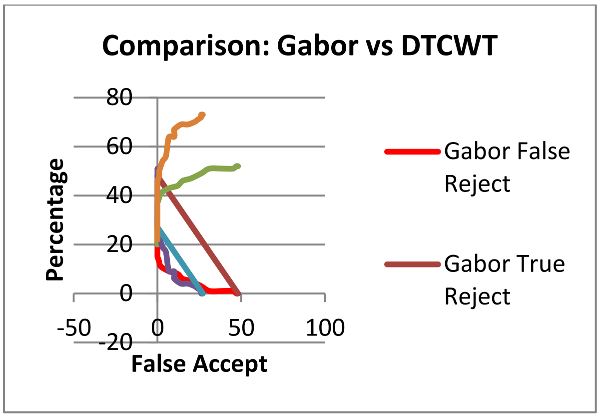
False Accept vs True Accept

The False Accept Vs True Accept graph shows that the false accept of DTCWT is lower than the Gabor System and also better True Accept values are obtained for a low FalseAccept in case of DTCWT technique . This means that the DTCWT system performance is better compared to Gabor technique.



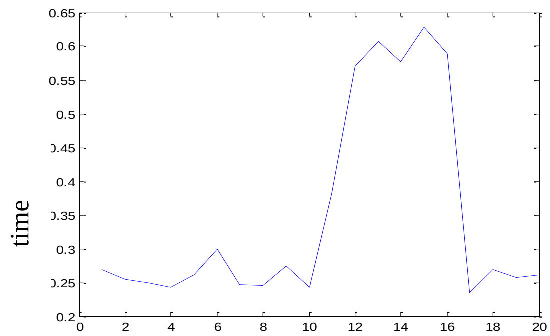
False Accept vs All Values of Gabor and DTCWT

The False Accept Vs other values in the graph shows that the false accept of DTCWT is lower than the Gabor System and also better True Accept values are obtained for a low False Accept in case of DTCWT technique . This means that the DTCWT system performance is better compared to Gabor technique.

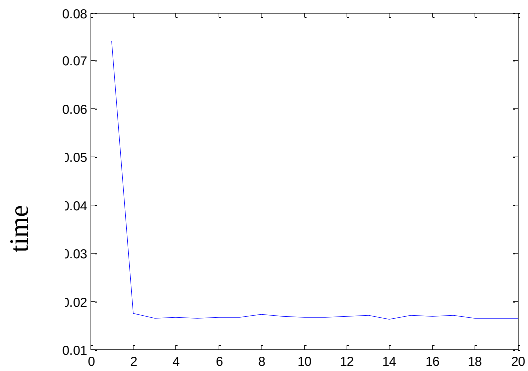


Time Complexity of Gabor and DTCWT

Time Complexity of Gabor and DTCWT in the graph shows that the time required to compute DTCWT features is 10 times lesser than the Gabor System and also time elapsed to compute is for DTCWT technique is stable barring the time taken to compute for initial two subjects. This means that the DTCWT system performance is better compared to Gabor.



Time Complexity: Gabor



Time Complexity: DTCWT

VI CONCLUSION AND FUTURE WORK

This paper presented a comparison of two approaches for personal identification using two dimensional 2D finger knuckle image. Feature based approach 2D Gabor filter method and 2D Dual tree complex wavelet transform is used for identification of knuckle based system. 2D DT-CWT bases systems for feature extraction and classification have been quite effective and efficient in achieving high performance in knuckle recognition and classification. Further, the Dual tree complex wavelet transform Finger Knuckle Identification technique has several advantages such as less time complexity, computational efficiency, user friendliness, reasonable size and cost effectiveness. It has a great potential to be improved and employed in real time applications or utilities in future. This work deliberated single finger knuckle image for identification and classification. In future this can also be extended by considering multiple finger knuckle images along with bending characteristics. Finger geometry and knuckle bending information may also be combined and used for person identification. Variations in the knuckle creases due to some disease or disorder may degrade the performance, which requires further investigation.

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