Comparison of Fingerprint Classification using KFCG Algorithm with Various Window Sizes and Codebook Sizes

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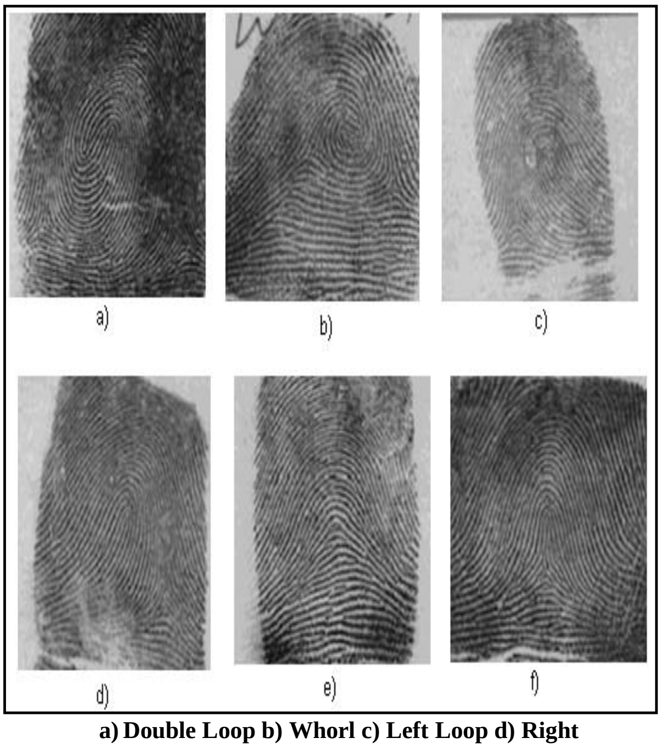
ABSTRACT
In biometric identification, fingerprints are most widely used. Fingerprint identification has become time consuming because of growing size of fingerprint databases. Fingerprint classification can be one of the significant preprocessing steps to improve the speed of fingerprint identification systems. Fingerprint Classification is done to put a given fingerprint to one of the existing classes. Classifying fingerprint images is a very difficult pattern recognition problem, due to the small interclass variability. In this paper a comparative analysis based on vector quantization for fingerprint classification using Kekre's Fast Codebook Generation (KFCG) is presented using various codebook sizes and window sizes. KFCG is one of the better and faster vector quantization codebook generation methods. Here, Fingerprint Classification is done using KFCG codebook of sizes 4, 8 and window sizes 2x2, 4x4, 6x6, 7x7, 8x8, 9x9, 10x10 and 16x16. The proposed approach is computationally lighter. It is observed that the method effectively improves the computation speed and provides accuracy of 84% for window size 7x7 and codebook of size 4 and for codebook of size 8 accuracy is 74% for window size 8x8.

Keywords
Vector Quantization, Kekre's Fast Codebook Generation (KFCG), Fingerprint Classes.

1. INTRODUCTION
Preprocessing of fingerprint images greatly influences the performance of fingerprint identification systems. Poor-quality and noisy fingerprint images mostly result in false singular points(SPs) and missing singular points which generally results in lack of overall performance of the identification systems [17]. The major problem in designing fingerprint classification system is to determine what features should be obtained and how these features can categorize the fingerprint into their classes [13]. Fingerprint classification not only reduces comparisons of fingerprints, but also improves the overall effectiveness of fingerprint identification system [18].

The fingerprint classification scheme devoid of preprocessing of images and fetching of singular points, have been proposed in [1]. Here the rigorous comparative analysis of fingerprint classification using KFCG algorithm is done with the help of two codebook sizes (4 & 8) and 8 window sizes. Classification is done using vector quantization (VQ). KFCG[1,2,3] is one of the VQ codebook generation techniques which forms clusters by taking mean squared error difference. The paper is organized as follows: Section II describes considered classes of fingerprints, Section III explains about KFCG algorithm. Section IV presents proposed novel approach of fingerprint classification and Section V consists of results and discussions.

2. FINGERPRINT CLASSES
In the Henry system of classification, there are three essential fingerprint patterns: loop, whorl and arch, which constitute 60–65%, 30–35% and 5% of all fingerprints respectively [12,14,15]. There are also more complex classification systems [20] that break down patterns even further, into plain arches or tented arches, plain whorl or double loop and into loops that may be right or left [19]. These patterns may be further divided into sub-groups [16] by means of the smaller differences existing between the patterns in the identical broad collection as shown in Fig. 1.



a) Double Loop b) Whorl c) Left Loop d) Right Loop e)Plain Arch f) Tented Arch

Fig. 1: Fingerprint Classes

2.1 Loop
A loop is a fingerprint pattern in which one or more of the ridges enter on either side of the impression, recurve, and terminate or tend to terminate on or toward the same side of the impression from whence such ridge or ridges entered.

Ridges flowing in the direction of the thumb are termed as Right Loop and that flowing in the direction of little finger are termed as Left Loop, considering Left hand.

2.2. Arches

In Plain Arch, most of the ridges enter upon one side of the impression and flow or tend to flow out upon the other side; on the other hand, in Tented Arch the ridge or ridges at the center form an upthrust.

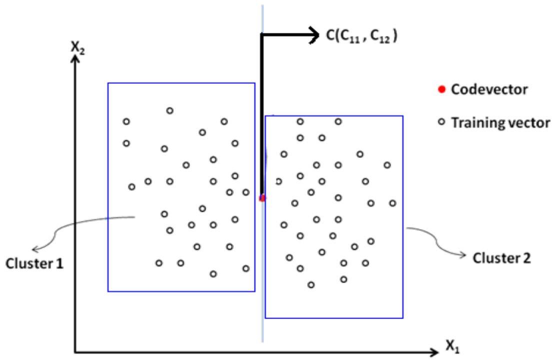
2.3 Whorl

The plain whorl has two deltas and at least one ridge making a complete circuit, which may be spiral, oval, circular, or any variant of a circle. The double loop consists of two separate loop formations, with two separate and distinct sets of shoulders, and two deltas.

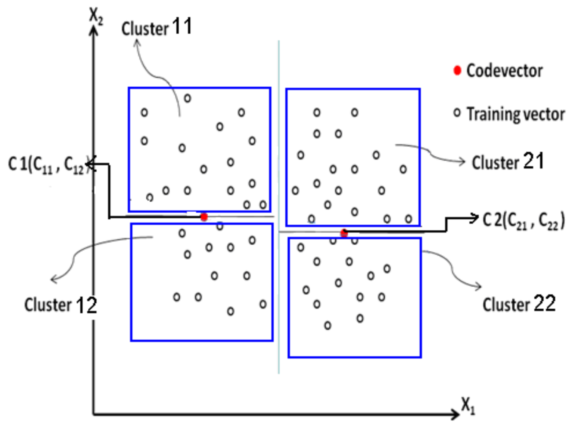
3. KFCG

Kekre's Fast Codebook Generation algorithm [4, 5 and 6] is used for image data compression and content based image retrieval. This algorithm reduces the time for generating codebook [1, 7, 8, 9,10]. It is explained as follows: Initially the set of all training vectors with centroid c1 is considered as a group/cluster.

In the first iteration of the algorithm, the clusters are formed by comparing first element of training vector with first element of codevector C1. The vector Xi is grouped into cluster 1 if $x_{i1} < c_{11}$ else vector Xi is grouped into cluster 2 as shown in Fig. 2.a. where codevector dimension space is 2.
In the second iteration, cluster 1 is split into two by comparing second element xi2 of vector Xi belonging to cluster 1 with that of the second element of the code vector. Cluster 2 is split into two by comparing the second element xi2 of vector Xi belonging to cluster 2 with that of the second element of the code vector as shown in Fig. 2.b. This procedure is repeated till the codebook size is reached as specified by the user. It is observed that this algorithm requires a lesser amount of time to generate codebook as it does not require any computation of Euclidean distance.



2.a : First Iteration of KFCG algorithm



2.b : Second Iteration of KFCG algorithm

Fig 2. KFCG Algorithm

4. PROPOSED FINGERPRINT CLASSIFICATION USING KFCG

In the training phase, KFCG is applied on fingerprint images and generated codebooks are considered as Feature Vectors. Based on these codebooks the pattern classifier are developed and used for classification. In testing phase the query images can be compared with pattern classifier for fingerprint classification. Here, all the 50 images from the database are used in training as well as testing phase. The percentage of classification accuracy is used to compare the performance of the variation of proposed fingerprint classification method.

$$Percentage\ Accuracy\ of\ Classification$$

$$= \frac{No.of\ images\ successfully\ classified}{No.of\ classification\ attempt} \times 100$$

5. RESULTS AND DISCUSSIONS

KFCG has been tested on a database of 50 fingerprint images each of size 256x256. The images selected correspond to classes like arch, tented arch, left loop, right loop and whorl. Codebook of size 4 and 8 are used for classification for various window sizes alias 2x2, 4x4, 6x6, 7x7, 8x8, 9x9, 10x10 and 16x16. In all 2 codebook sizes and 8 window sizes have resulted into 16 variations of proposed method. It is observed that KFCG-8 provides the best results. KFCG-16 results in void clusters hence it is not included in the result and discussion. Fig. 3., gives the comparative analysis of % classification accuracies for the respective pixel window sizes. The comparison of various codebook sizes used in KFCG for fingerprint classification is represented as Fig. 4. in form of % classification accuracy for the respective pixel window sizes.

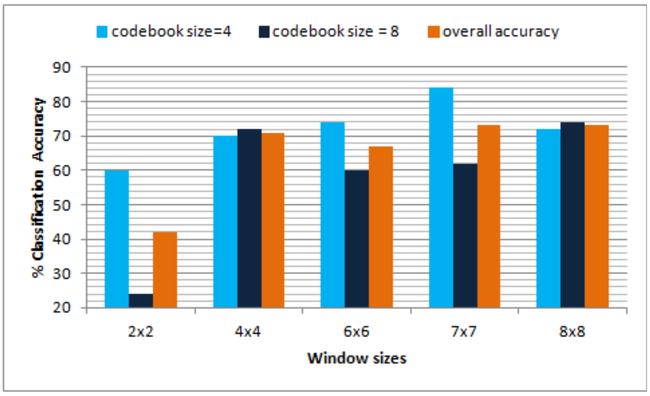


Fig. 3: Percentage classification accuracy for respective pixel window sizes

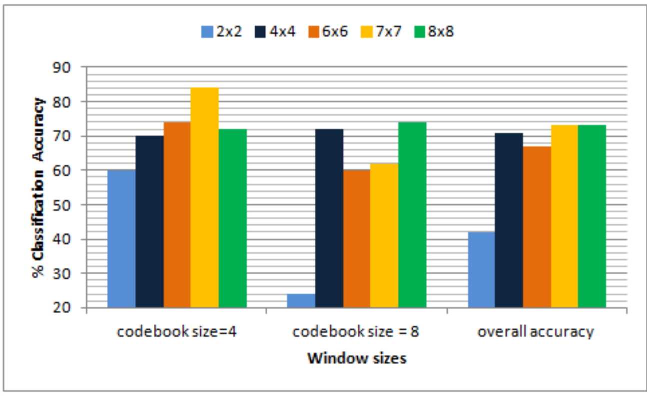


Fig. 4: Percentage classification accuracy for considered codebook sizes

Table 1 shows percentage accuracy of classification obtained during experimentation of proposed variants of fingerprint classification methods using KFCG. Here for codebook size 8 the null clusters are formed for KFCG in window sizes 9x9, 10x10 and 16x16.

Table 1. Percentage accuracy of Classification for proposed variants of Fingerprint Classification using KFCG

	codebook size =4						codebook size = 8					
Window sizes	**LL**	**RL**	**A**	**TA**	**W**	**Average**	**LL**	**RL**	**A**	**TA**	**W**	Average
2	70	80	10	83.33	90	60	100	0	0	33.33	0	24
4	100	70	50	83.33	80	70	100	70	60	83.33	80	72
6	80	90	60	83.33	90	74	50	70	50	100	70	60
7	100	100	70	100	90	84	30	100	50	100	70	62
8	90	80	40	100	90	72	90	100	40	83.33	90	74
9	80	100	50	100	80	74	null clusters					
10	90	100	40	100	90	76	null clusters					
16	100	70	70	83.33	70	72	null clusters					

6. CONCLUSION

Classification is an important task for the success of any fingerprint identification system. The performance comparison of variations of VQ based fingerprint classification technique using KFCG is discussed in the paper. In all 8 pixel window sizes are used in KFCG codebook generation for codebook sizes 4 and 8, resulting into 16 variations of proposed method. The experimental results have shown that codebook size 8 gives better performance with higher pixel window sizes. Whereas for lower window sizes the best performance is given by KFCG codebook of size 4 generated using pixel window of size 7x7. A novel technique based on vector quantization for fingerprint classification using Kekre's Fast Codebook Generation (KFCG) provides accuracy of 84% for codebook size 7. It is computationally fast as it does not include calculation of any distances. Future work consists of testing the proposed approach on a large database.

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