Journal of Theoretical and Applied Information Technology
15th March 2017. Vol.95. No 5

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

FINGERPRINT BIOMETRIC IDENTIFICATION WITH GEOMETRIC MOMENT FEATURES

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ABSTRACT

The use of biometric in recognizing individuals is now a phenomenon in today's world. As there is security need within wide array of applications including transactions security across computer networks, PIN (personal identification number) replacement in retail business and banking, high-security wireless access, televoting as well as restricted areas' admission, biometric is more and more a subject of interest. The traditional mode of personal identification verification is grounded on possession (ID card) or knowledge (secret code) but ID cards could be stolen or lost while codes could be forgotten. These problems could allow opportunity to criminals to steal someone's identity. As such, using features that are uniquely belonging to a person would decrease fraud possibility. Also, in many situations, the use of biometry is convenience. This is because biometry can take over the use of codes, keys and cards. Also, fingerprint is regarded as biometric that is most practical. With regard to performance, applications of pattern recognition mostly rely on extraction of feature and classification or learning scheme, the extraction and selection of meaningful features. This generates major problem in identification of fingerprint; how to attain features in numerous fingerprint styles so that the right individual could be reflected. Geometric Moments is proposed by this paper for feature extraction with identification of fingerprints and analyze its performance.

Keywords: *Biometric, Global Feature, Fingerprint, Identification, Individuality, Geometric Moment Invariant, Uniqueness Presentation*

1. INTRODUCTION

It is projected that biometric-based identification and systems of verification will be a primary technology equipped with applications such as control of access to computers and buildings, decrease in deceitful transactions in electronic commerce, and determent of illegal immigration (1).

The traditional personal identification systems are mostly either token-based or knowledge–based. A token-based identification system is characterized by the reliance on personal identification number (ID cards), smart cards or magnetic strip when representing the identity of a user. However, problem occurs when tokens are stolen, lost or shared, or obtained by criminals who can conceal their real identity via the presentation of bogus or duplicate identification; this causes the whole security of the systems to be jeopardized. As such, it is possible for an imposter to employ software of social engineering (2) or dictionary attacks (3) and tool to crack password when employing this system. Thus, the use of token-and knowledge-based system on its own, is not enough to guarantee identity determination that is more secure and dependable. In relation to this, adding another level of biometric procedure on the already available systems prior to the system decision would increase the system's effectiveness. Thus, two or three layers of identification process are included at the starting or at the ending level of a system in which, each layer puts emphasis on each other. Such system is termed the Biometric-based identification.

Technology of biometric comprises technique that consistently employs measurable physiological or behavioral characteristics when differentiating one individual from another. In fact, biometrics have been actively researched for instance, DNA, keystrokes pattern on keyboard, geometry of hand, shape of fingerprints, face, ear, irises, handwriting, speech and signature (1 , 5, 4).

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Biometric system is also deemed as system of security covering the pattern recognition domain. This system measures and analyses human body's biological data, extracts a set of feature from the data obtained, and has the set compared with the template sets from the database. In relation to this, Unimodal biometric system (7) represents the Biometric systems that could identify a user with a single biometric trait only; either behavioral or a physical trait. Such systems of biometric have been successful in certain real life applications. An individual's fingerprints, face, ear and irisesareinherently image based and necessitate the techniques of image processing, pattern recognition, and computer vision in order to enable implementation. On the other hand,an individual's speech, keystrokes, signature and hand geometry are used in the signal processing and pattern recognition. There have been some attempts to combine multiple biometrics (10, 6) (audio-video, faces- fingerprints, etc.).

Fingerprints are one of the indicators ofbiometricwith the highest levels of reliability (19,20). In fact, within the domain of forensics, fingerprints have been comprehensively used in investigating crimes (21). At current time, systems of fingerprint are more and more being included in a comprehensive range of applications for civilian and commercial to authenticate user. On other hand, numerous previous works have concentrated on local features. Local minute features (7, 22,23) are among the examples. However, these features entail rigid characteristics which cause miss-classification. As such, fingerprint biometrics will be employed in this study. The method can take place in biometric-based identification with Geometric Moment Invariant. The process recommended will generate a distinct representation of individual features for fingerprint identification Individuality within the field of biometric identification.

2. PROPOSED GLOBAL FEATURES ON FINGERPRINT-BIOMETRIC IMAGES

This study proposes global features to manage fingerprint-biometric images to perform the identification process. This method is an adaptive method; it is used in feature extraction. It separately improves the class by way of bringing the feature points to superior locations. This could efficiently denote individual characteristics of fingerprint-biometric in an individual class prior to their usage in the process of matching.

Searching between individuals employing shapes of fingerprint images has become the interest of numerous scholars in the domain of pattern recognition. Shape is among the rudimentary features employed in describing the content of image and it is a crucial visual feature (30). Nonetheless, it is not easy to perform extraction on features that exactly denote and describe the individual's shape. Thus, the proposal of a new mechanism for unimodal biometric identification that employsfingerprintbecomes this study's first Objective.

Meanwhile, Geometric Moment Invariant (GMI) algorithm has the capacity to extract a useful set of global features which denote the fingerprint from the region representation of fingerprint shape. These extracted features are then tested for fingerprint individuality in the field of identification. As such, the use of GMI algorithm will become the second objective of this study.

Analyzing the features of Geometric Moment Invariant in terms of efficiency becomes the third objective of this study. The purpose of the analysis is to minimize variation for intra-class while maximizing the variation for inter-class for fingerprint Individuality in biometric Identification. This objective comprises a method equipped with a procedure which is crucial owing to the fact that techniques that fulfil the 'individuality' of the concept of unimodal biometric concept will become useful for the application of fingerprint identification.

3. UNIQUENESS REPRESENTATION IN FINGERPRINT BIOMETRIC

The biometric of fingerprint is regarded as individualistic. Meanwhile, fingerprint in terms of individuality is tied to the theory that each person possesses stable fingerprint (7). The fingerprint of the same person is shown in Figure 1 while that of different persons is presented in Figure 2. For the same person, the general shape of fingerprint in part differs for but it rather varies for other persons. Such is termed 'fingerprint individuality.' The intra-class measurement and estimation is demonstrated for features of the exact person's fingerprint. On the other hand, the inter-class measurement and estimation is demonstrated for different person's fingerprint. The best unique features must have the capacity to create the lowest amount of similarity error for intra-class. As for inter-class, highest similarity error should be obtained. In other words, attaining unique features

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

from a fingerprint is crucial as this will make efficient fingerprint recognition in the area of biometric identification.

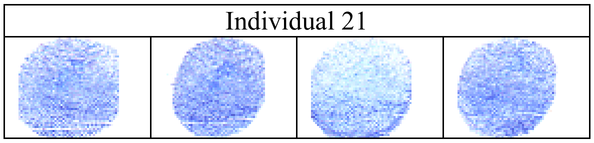


Fig 1: Fingerprint with same Individual

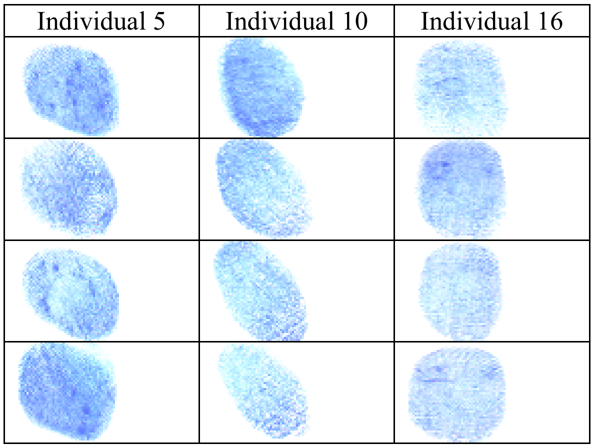


Fig. 2 fingerprint with different Individuals

The past work has mostly obtained the local features from fingerprint. However, the global features in fingerprint from the whole shape have not been sufficiently obtained. It should be noted that shape appears to be effective in the domain of identification (7,19,20,24).

4. FEATURE EXTRACTION

Feature extraction entails a process whereby an input object is converted into feature vectors of numerical feature sets to create a representation of an object. In the task of feature extraction, the information that is extracted from an image or object is termed features. Local features represent objects' constituent parts and their relationships. As for the global features, they illustrate the properties of the entire object (8). It is highly crucial to have a good technique in the selecting and extracting features and for a long time, this has been the focal point of attention of research (9, 11, 10, 12, 13). Features that fulfill the two requirements of having small intra-class invariance and large interclass invariance are regarded as good features (13). Also, a good set of features typically exemplifies certain crucial characteristics of discrimination, reliability, independence as well as small space of feature where the amount should be small enough to allow simplification and expedition of the classification process (14).

Within the domain of fingerprint identification, numerous techniques of feature extraction have been delved into. Meanwhile, numerous researchers have employed fingerprint matching process according to methods that are based on minutiae. These methods comprise locating the distance values between the input and referenced minutiae point sets. Closer minutiae points are characterized by a match between two minutiae point sets. This however, leads to miss-identification.

4.1 Fingerprint Shape Representations

Numerous techniques of shape representations and description are available today, which are usable in extracting features from an image in pattern recognition. Two distinct approaches in handling fingerprint shape are: the analytic (local / structural approach) and holistic (global approach). There are two methods to each approach: region-based (entire region shape) method and contour-based (contour only) method. Holistic approach characterizes the image's shape in its entirety. On the other hand, analytic approach denotes image in sections. This study has selected the holistic approach owing to the fingerprint shape requirement that necessitates extraction as one single entity that cannot be divided. Owing to this, global method is examined to ascertain the most appropriate technique for the concept of fingerprint individuality in the field of biometric identification.

4.2 Geometric Moment Invariant (GMI)

When the first GMI was formulated by (15), it was to be employed in the application of 2D pattern recognition. The information originated from the boundary regions invariant under translation, rotation as well as scaling.GMI was tested by (12) on a simple shape and the technique appeared to be effective for similarity-transformed on rotated shape. Further, GMI less impacted by noise (16). However, for a scaled shape, GMI demonstrated poor performance. As such, there have been numerous studies conducted to enhance the scale transformation, as far as this method is concerned. Also, as indicated by the outcomes, GMI is appropriate in the description of simple images.

Geometric Moment is used in the objects recognition and the application of pattern recognition. It is important that an assemblage of unique features computed for a particular object could ascertain the similar object that has differing size and orientation (24).For geometric moments, the steps of calculation entail (24,28):

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

1) Reading an input image data from left to right and from top to bottom, 2)Thresholding the image data for the extraction of the area of the target process and 3) Computing the image moment value, m_{pq} until third order with formula:

$$m'_{pq} = \int\int_{\delta} (x')^p (y')^q f'(x',y')dx'dy' \quad ; \quad p,q = 0,1,2,.... \quad (1)$$

2) Compute the intensity moment, (x_0, y_0) of image with formula:

$$x_0 = m_{10}/m_{00}; \quad y_0 = \frac{m_{01}}{m_{00}} \quad (2)$$

3) Compute the central moments, μ_{pq} with formula :

$$\mu_{pq} = \iint_{\delta} (x - x_0)^p (y - y_0)^q f(x,y)dxdy \; ; \quad p,q = 0,1,2 ... \quad (3)$$

4) Compute normalized central moment, η_{pq} to be used in image scaling until third order with formula:

$$\gamma = \frac{(p+q+2)}{2}, \quad \eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\frac{\gamma}{2}}} \quad , \quad p+q \leq 3 \quad (4)$$

5) Compute geometric moments, Φ_1 0 to 0Φ_4 with respect to translation, scale and rotation (geometric moment invariants) invariants with formula below:

$$\Phi 1 = \mu_{20} + \mu_{02} \quad (5)$$

$$\Phi 2 = (\mu_{20} - \mu_{02})^2 + 4\mu^2 11 \quad (6)$$

$$\Phi 3 = (\mu_{30} - \mu_{12})^2 + (3\mu_{21} - \mu_{03})^2 \quad (7)$$

$$\Phi 4 = (\mu_{30} - \mu_{12})^2 + (\mu_{21} - \mu_{03})^2 \quad (8)$$

$$\Phi 5 = (\mu_{30} - 3\mu_{12})(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})^2] + (3\mu_{21} - \mu_{03})(\mu_{21} + \mu_{03})[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] \quad (9)$$

$$\Phi 6 = (\mu_{20} - \mu_{02})[\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2] + 4\mu_{11}(\mu_{30} + \mu_{12})(\mu_{21} + \mu_{03}) \quad (10)$$

$$\Phi 7 = (3\mu_{21} - \mu_{03}(\mu_{30} + \mu_{12})[(\mu_{30} + \mu_{12})^2 - 3(\mu_{21} + \mu_{03})^2] - (\mu_{30} - 3\mu_{12})(\mu_{21} + \mu_{03})[3(\mu_{30} + \mu_{12})^2 - (\mu_{21} + \mu_{03})^2 \quad (11)$$

5. ANALYSIS OF BIOMETRIC FINGERPRINT WITH GLOBAL EXTRACTED FEATURE (GEF)

The sample of extracted images of individual fingerprint shape is presented in Table 1 and 2. These features entail the original extracted features following global feature: Minutiae feature extraction (MFE) and Geometric Moment Invariant (GMI).

Table 1: Invariant features of individual 7 by Geometrical Minute algorithm

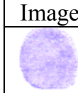
Image	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
	178	162	184	190	183	168	167	159	192	209
	211	189	213	189	216	168	165	188	182	188
	213	209	174	208	210	147	153	200	209	206
	193	190	202	210	189	215	171	153	168	185

Table 2: Invariant features of individual 7 by GMI algorithm

Image	F1	F2	F3	F4	F5	F6	F7
	20.06	363.59	2.59	2.57	6.62	5.88	3.88
	20.43	415.26	2.68	2.67	7.18	5.14	1.10
	21.84	486.67	4.45	3.53	1.25	7.71	4.77
	29.37	938.17	1.86	9.05	8.20	2.61	6.33

6. SIMILARITY MEASUREMENT

The measurement of uniqueness is via the employment of the Mean Absolute Error (MAE) function. Tables 3 and 4 present the example of the computation of MAE. There are 4 images for every individual. Meanwhile, Feature 1 to Feature 7 entails an extracted feature denoting individual with GMI whereas Feature 1 to Feature 10 comprises an extracted feature denoting individual with Geometrical Minute. The value of MAE provides the invarianceness of fingerprint and reference image (first image) [8]. If there are small errors, it means that the image is near to the reference image. From the overall results' value, an average of MAE is calculated.

Where:

$$MAE = \frac{1}{n}\sum_{i=1}^{f} |(x_i - r_i)| \quad (12)$$

n Denotes the number of images.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

x_i Denotes the current image.

r_i Denotes the reference image or location measure.

F Denotes the number of features.

i Denotes is the feature column of image.

The function of MAE is employed in the study due to the fact that it matches up with the individual fingerprint measurement's individuality in the domain of biometric identification. Every individual carries with him or her specific features or characteristic in fingerprint. The MAE function allows the measurement of the variance between fingerprints with similarity error of two fingerprints from detail characteristics in the column of feature. As such, to calculate the variance between two fingerprint images for the each column's features from extracted invariant feature vector of image in this study. Mean value of MAE that is the smallest is regarded as the most identical to that of the original image (the reference image or the first image) to be compared. Meanwhile, mean value of MAE that is the largest is regarded as the most different/dissimilar from that of the original image. In addition, MAE function is grouped under robustness theory of statistical procedure and the simplest practical solution (29).Tables 3 and 4 presents example for computing the MAE value for individual fingerprint shape extracted by the technique of GMI.

Table 3: Example of fingerprint shape for individual number 8

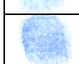
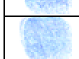
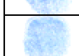
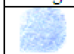
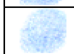
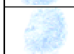
Image	F1	F2	F3	F4	F5	F6	F7	MAE
	2.00	4.35	3.80	3.68	1.35	7.98	1.80	--
	2.65	8.25	9.06	7.48	5.60	2.21	1.92	5.94
	2.72	8.66	7.84	7.82	6.12	5.50	3.55	5.55
	2.87	4.42	3.67	3.55	1.26	7.66	1.62	0.44
Mean Absolute Error								2.98

Table 4: Example of fingerprint shape for individual number 9

Image	F1	F2	F3	F4	F5	F6	F7	MAE
	1.53	3.77	2.60	2.42	5.87	4.51	1.18	--
	1.82	2.53	2.72	1.56	2.44	2.23	1.57	2.15
	1.33	2.02	3.32	1.52	2.34	2.05	1.89	2.56
	1.72	2.51	1.68	1.29	1.67	1.84	6.82	4.00
Mean Absolute Error								2.18

The computation of variance between images of fingerprint with the reference image is conducted with the column of every feature. Therefore, comparison will be made between the first column feature of image and the first column feature of the reference image. The first row is where reference image is located. Comparison is made between every feature's column of an image and the feature's columns of the reference image. Thus, variance between these two images in its entirety can be obtained. It is important that positive value of variance is obtained. This is because this process has the objective of computing the difference between two images rather than the value of invariant feature vector itself. As such, the computation employs the absolute function. Mean of variance for that image is obtained by computing the summation of all variance of all features of the columns. This is done before the computation of the mean of all mean variance of each image is performed. In this process, the obtained final mean value is termed the value of MAE for this data set. Figure 3 presents the pseudo code for this process.

```
r = reference image;
c = current image;
for c = 1 to no_of_writer {
for i = 1 to no_of_features
sum_feature = abs(ci - ri);
mean_feature_c
sum_feature/no_of_features;
sum_mean = sum_mean + mean_feature_c;
```

Fig. 3 MAE algorithm

6.1 Intra-class and Inter-class Analysis

This section will perform analysis (intra-class and inter-class analysis) on the MAE value obtained from the earlier process. Intra-class entails to a group of features extracted from a same individual. On the other hand, inter-class entails group of features extracted from different individuals. For

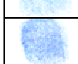
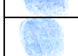
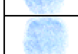
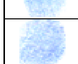
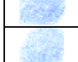
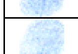
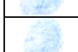
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

intra-class, MAE value should be smaller in comparison to that of inter-class, irrespective of the shape of fingerprint of a person. This would verify the individuality of fingerprint in this study.

In making comparison between fingerprints, there are two variability's of concern (26, 24) the fingerprint variability of the exact individual and the fingerprint variability from one person to another. The variation of within-person (the variation within a person's fingerprint samples) is less than that of the between person (the variation between the fingerprint samples of different person) (17,24, 18). Thus, it is not a concern with regard to the range between MAE value of intra-class and that of interclass. What matters is that it demonstrates the characteristic of individual fingerprint in terms of its individuality in which, the value of intra-class must be less than that of inter-class value, in order to fulfill the individuality of fingerprint requirement.

The differences between intra-class (one individual) are presented in Table 3 and Table 4, while the differences between inter-class (different person) measurements are presented in Table 5 employing the MAE function for the shape. Tables 3, 4 and 5 are employing fingerprint biometric. However, MAE value for intra-class shown in Table 3 and 4 are lower than MAE value in Table 5. The MAE value presented in Tables 3, 4and 5 can be analyzed in order to verify the individual fingerprinting terms of individuality. Tables 3 and 4 present lower MAE value. This indicates that feature between fingerprints from the same individuals has close feature value, in comparison to the fingerprint from different individuals are shown in Table 5.

Table 5: Example of fingerprint shape for individual's number 8 and 9

Image	F1	F2	F3	F4	F5	F6	F7	MAE
	2.72	8.66	7.84	7.82	6.12	5.50	3.55	--
	2.87	4.42	3.67	3.55	1.26	7.66	1.62	2.72
	1.53	3.77	2.60	2.42	5.87	4.51	1.18	2.53
	1.82	2.53	2.72	1.56	2.44	2.23	1.57	3.41
	1.33	2.02	3.32	1.52	2.34	2.05	1.89	3.46
	1.72	2.51	1.68	1.29	1.67	1.84	6.82	3.90
	2.00	4.35	3.80	3.68	1.35	7.98	1.80	2.77
	2.65	8.25	9.06	7.48	5.60	2.21	1.92	9.83
Mean Absolute Error								3.58

7. UNIQUENESS PRESENTATION: RESULT, ANALYSIS AND INTERPRETATION

The GMI result with the geometrical minute method is presented in this section. This is to demonstrate its applicability into the domain of fingerprint-biometric identification. Additionally, it also compares and analyzes the GMI with the technique of geometrical minute. The purpose is to verify the hypothesis of the worthiness of GMI exploration in the domain of fingerprint identification.

7.1 Uniqueness presentation to Proof Individuality of fingerprint-biometric

As shown by the MAE value results in Table 6, the GMI algorithm should be explored further with regard to the domain of fingerprint biometric identification. The similarity error results demonstrate that the Uniqueness of authorship for intra-class (same individual) is smaller in comparison to that of inter-class (different individual). This fulfils the requirement of individuality of the notion of individual fingerprint within the field of biometric identification; here, for intra-class (same individual) the MAE value is smaller in comparison to that of inter-class (different individual) with respect to fingerprint. The reason is the ability of moment function as image representation. Therefore, this analysis of Uniqueness presentation affirms the applicability of GMI as a technique of feature extraction for biometric identification domain. In addition, the extracted feature has been affirmed to bring the unique features of a person in individual fingerprint.

Table 6: Uniqueness presentation with GMI fingerprint-biometric identification

Individual	Intra-class (fingerprint)		Inter-class (fingerprint)
Two person	0.50	0.75	0.80
10 person	0.15	0.74	1.42
20 person	0.82	0.31	1.45
30 person	0.54	0.20	1.69
40 person	0.29	0.78	1.98

Table 7: Inter-class for individual number 1and number 2

Technique	Intra-class (fingerprint)		Inter-class (fingerprint)
GMI	0.5061	0.7529	0.8003
Geometrical minute	0.5625	0.625	0.4531

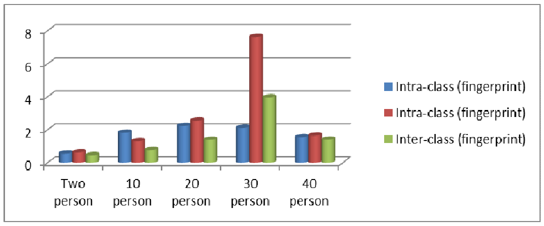


Figure 4: Graph of Uniqueness presentation for GMI

The result shown in the table above demonstrates the unique characteristic or individual feature for individual fingerprint. It is important that similarity error for inter-class is greater than that of intra-class in individuality of fingerprint concept (see Figure 4). As shown, features extracted by the GMI algorithm are closer for the same individual in comparison to those of different individual. This generates lower MAE value for intra-class in comparison to that of the inter-class.

Thus, the technique proposed has the capacity to extract features in the domain of biometric identification. Nonetheless, the results in this section will not be compared and analyzed in searching for the best technique. Section 7.2 discusses the comparison of the technique. It also validates the algorithm of GMI complimented to the fingerprint-biometric concept in terms of individuality, within the domain of biometric identification. The technique is applicable for the condition of the same and also the different individual. Results of other technique are also proven for discuses of fingerprint-biometric concept.

7.2 Intra-class and Inter-class Result

The intra-class and inter-class analysis result is discussed in this section. Table 7 through Table 11 presents the intra-class result representing 40 individuals.

Table 8: Inter-class for 10 individuals

Technique	Intra-class (fingerprint)		Inter-class (fingerprint)
GMI	0.15978	0.7482	1.42792
Geometrical minute	1.825	1.325	0.775

Table 9: Inter-class for 20 individuals

Technique	Intra-class (fingerprint)		Inter-class (fingerprint)
GMI	0.82932	0.31317	1.45094
Geometrical minute	2.22863	2.55857	1.39877

Table 10: Inter-class for 30 individuals

Technique	Intra-class (fingerprint)		Inter-class (fingerprint)
GMI	0.544347	0.207867	1.690447
Geometrical minute	2.125	7.625	3.9688

Table 11: Inter-class for 40 individuals

Technique	Intra-class (fingerprint)		Inter-class (fingerprint)
GMI	0.292855	0.780635	1.989795
Geometrical minute	1.55494	1.64804	1.40768

As demonstrated by the tables above, both techniques for lowest MAE value are inconsistent with the exception of the GMI technique; the GMI technique presents the lowest MAE value in almost all tables. The Geometrical minute analysis with intra-class and inter-classis presented in Figure 5.

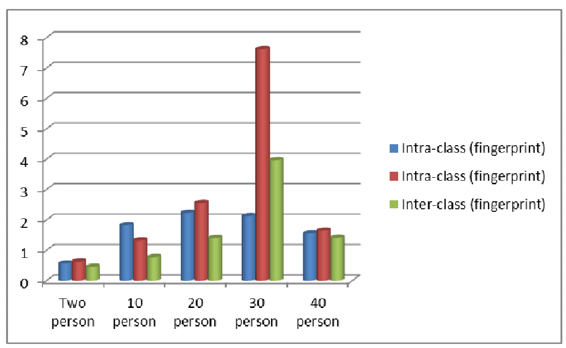


Figure 5: graphical the Geometrical minute analysis with intra-class and inter-class.

8. CONCLUSION

This study attempts to demonstrate the effect of GMI technique for the method of Uniqueness representation method for proving the individuality of fingerprint-biometric in Identification domain. The introduction of Uniqueness representation is for proving the individuality of fingerprint-biometric with GMI in the task of feature extraction. Additionally, this study introduces the best technique, which is measured through the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

computation of the mean between the lowest and highest MAE value. This owes to the two techniques for attaining different scale value in extracted features. The technique's ability to extract individual features is crucial. This owes to the fact that individual features are the key in the identification of the individual. Technique that generates the highest level of individuality in extracted features is important; it contributes to a successful process of identification in the field of identification. As shown by the experimental outcomes, the proposed GMI generates the highest degree of individuality in comparison to Geometrical minute technique in the domain of fingerprint identification.

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