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RESEARCH ARTICLE

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Projection of a Fuzzy Relation Using Symmetric Formula by Three Generation Fingerprints

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Abstract
Fingerprint plays a main role in different fields and applications. It makes comfort feel to identify a person and also secure to save about its details. In forensic science, they used fingerprint analysis to identify criminals within more than hundred years. In this paper, we analyze the difference between three generations fingerprint from a family by using projection of a fuzzy relation.

INTRODUCTION

In 1965, Fuzzy Logic was initiated by "L. A. Zadeh". Fuzzy logic makes comfortable way to analyze human valuable problems. It accepts only the membership values [0, 1] for finalize on mathematical way. They use the mathematical tools to make a solution on confusing stage. [1, 5, 6]. Fingerprint is intricate to link and identify mutual person. So, we choose fuzzy logic to match the fingerprint and find the approximate result. Fingerprint have eight common patterns such that ulnar loops, radial loops, plain arches, tented arches, plain whorls, double loop whorls, peacock eye whorls (central pocket whorls) and accidental whorls. [3, 11].

Over and above thousands of researchers are research in different fields by using fuzzy logic. More than 25 research journals based on applications and theory of fuzzy logic. Fuzzy logic is more applicable in human real life such as Engineers (mechatronics, consumer electronics, electrical, agricultural, control systems engineering, mechanical, aerospace, image processing, civil,

computer, robotics, environmental, power engineering, industrial, and optimization); Field of Research and development (biology, chemistry, biomedical, geological, earth science, physics, political science, economics, management, business analysis, social scientists, public plan analysis, Law); Medical applications (psychology, clinical decision, heart pain management, medical diagnosis, treatment plans, sugar and brain tumor treatment, DNA fingerprinting, heart problem, etc.); Numerous applications (pattern recognition (eye, facial, fingerprint, DNA, etc.), Transportation (problem, investment and planning), Statistical method, neural network, knowledge based methods, fuzzy logic rule-based, traffic signal control, trip distribution, air conditioners (room air cooler, dehumidifying coil, Air-heating coil, Humidifier), Thermodynamics for Air Conditioning, atm, banks, vacuum cleaners, washing machines, aadhar, transmission systems, new product pricing, subway control systems, helicopters, stock trading, knowledge-based systems, Biometric,

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cryptography, attendance and mark statement, etc.). [7, 10, 12]

PRELIMINARIES

Definition 1: A fuzzy subset $\tilde{L}$ of a set X is defined as a function $\mu_{\tilde{L}}$ = X → [0, 1]. This function is called as membership function. Then,

$$\mu_{\tilde{L}}(x) = \begin{cases} 0 & , \quad 0 < x \\ \frac{x}{(b-a)\times 5} & , \quad 0.2 < x < 0.4 \\ \frac{x}{(d-c)\times 5} & , \quad 0.7 < x < 0.9 \\ 1 & , \quad \text{Otherwise} \end{cases}$$

is known as $\tilde{L}$ membership function. Where a = 0.2, b = 0.4, c = 0.7 and d = 0.9, [0, 1] is an interval.

Definition 2: Consider $\tilde{A}$: X x Y → [0, 1] of classical relations X = x_i and Y = y_j where i = 1, 2, 3, ……, n; j = 1, 2, 3, ……, m.

$$\tilde{A} = \int_{X_1, X_2, X_3, \ldots, X_n} \frac{\mu_{\tilde{A}}(x_1, x_2, x_3, \ldots, x_n)}{x_1, x_2, x_3, \ldots, x_n}$$

is known as fuzzy relation. [1, 5, 6]

Definition 3: The union of two relations $\tilde{A}$ and $\tilde{B}$ (i.e.) $\tilde{A} \cup \tilde{B}$ is defined by

$\mu_{\tilde{A} \cup \tilde{B}}$ (x, y) = max {$\mu_{\tilde{A}}$ (x, y), $\mu_{\tilde{B}}$ (x, y)}

(or)

= $\mu_{\tilde{A}}$ (x, y) ∨ $\mu_{\tilde{B}}$ (x, y)}.

is also called as max-relation (or) maximum of relation. [1, 5, 6].

Definition 4: The projection of a fuzzy relation is a combination of first and second projection. First projection will be found maximum for each row and second projection find maximum for each column. Hereafter again find a maximum value from first projection column and second projection row values. If the values are same then it called as global projection or total Projection.

First projection

$$\tilde{A}^{(1)} = \{x, \max_{y} \mu_{\tilde{A}}(x, y) \,/\, (x, y) \in X \times Y\}$$

Second projection

$$\tilde{A}^{(2)} = \{x, \max_{x} \mu_{\tilde{A}}(x, y) \,/\, (x, y) \in X \times Y\}$$

Global Projection

$$\tilde{A}^{(G)} = \{x, \max_{x} \max_{y} \mu_{\tilde{A}}(x, y) \,/\, (x, y) \in X \times Y\}$$

Suppose $\tilde{A}^{(G)} = 1$, then relation is normal and $\tilde{A}^{(G)} < 1$, then relation is sub-normal. [1]

Types of Fingerprints in Forensic Science

- Exemplar fingerprint
- Latent fingerprint
- Patent fingerprint
- Plastic fingerprint
- Electronic fingerprint
- Foot print

A1. Exemplar Fingerprint [2, 4, 9]

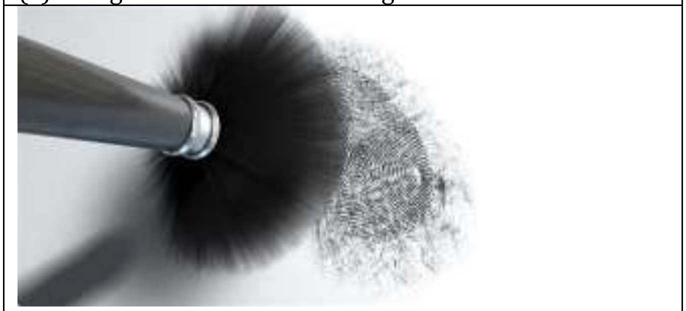
After criminal arrests, the police officer collects the impression from criminal finger for future use. This impression was taken from one edge of the nail to other. It can be collected for all fingers by using ink on paper or live scanner.

Fig. 1. Exemplar Fingerprint.

A2. Latent Fingerprint [2, 4, 9]

It created by sweat and oil on the finger surface. This impression will not be visible in naked eye. So, they required some additional processing like brush and chemical powder to see the impression. After use of chemical powder, it shows n-number of finger images on same place. The chemical and brushes are differing based on surface or colour.


(a) Things used for invisible image


(b) Invisible image by using chemical powder


(c) Rarely visible latent prints on a knife

Fig. 2. Latent Fingerprint.

A3. Patent Fingerprint [2, 4, 9]

It is easily visible on human eyes. We don't need any chemical powder to see the impression left by the person's finger on a surface. This print created by oil, blood, ink, dirt or grease.


(a) Olive oil


(b) Blood


(c) Ink

Fig. 3. Patent Fingerprint

A4. Plastic Fingerprint [2, 4, 9]

It can be created by pressing finger on cello tape / gel, tar, wax, fresh paint, soap or clay. This print also called 3-D impression. These fingerprints are easily visible on human eye without any additional product.

(a)Tape / gel

(b) Fresh paint

(c) Soap

(d) Wax

(e) Clay

Fig. 4. Plastic Fingerprint

A5. Electronic fingerprint [2, 3, 4, 9]

These prints need a scanner to scan the clear impression. It can be used in many fields like smart phones, laptops, schools, colleges, industries, aadhar card, banks, etc. The scanner has four types. They are:

- Optical scanners
- Capacitive or CMOS scanners
- Ultrasound fingerprint scanners
- Thermal scanners

Electronic fingerprint is also called as live scan or live capture fingerprint or ink less.


(a) Laptop


(b) Scanner


(c) Biometric


(d) Record fingerprints using scanner.

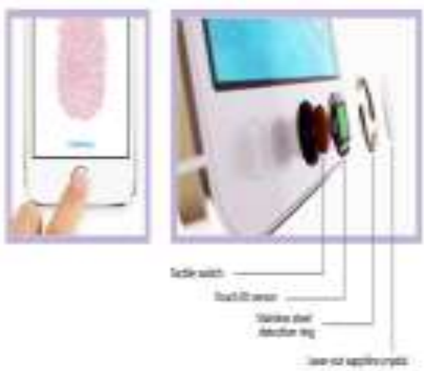

(e) The new iPhone fingerprint lock features

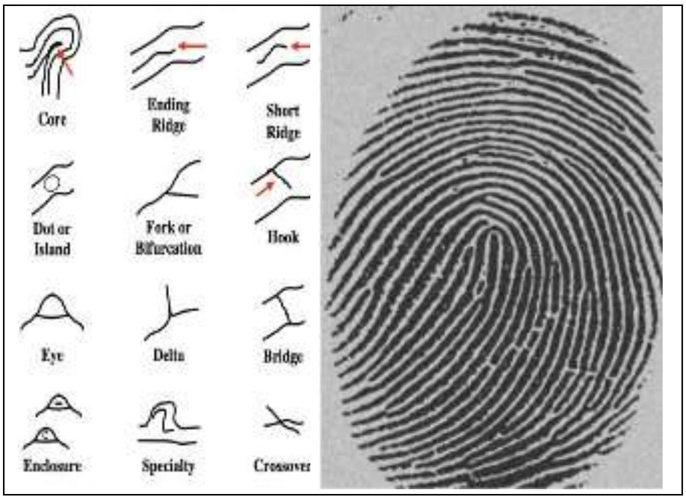
Fig. 5. Electronic Fingerprint

A6. Foot Prints [2, 4, 9]

Every human has a unique foot prints. This print also helps to find a person. Now-a-days many hospitals can collected a baby foot print and record it on a birth certificate.

Fig. 6. Foot Print

B. Minutiae



Fig, 7. Minutiae

EXPERIMENTAL AND RESULTS

Our aim is to compare the three generations fingerprint from a family. We collect sample of 60 family's fingerprint. Here, construct some variables for each generation like L, M and N.

First generation (Grandparent) - L
Second generation (Parent) - M
Third generation (Child) - N

First, we select two generation in a family (L and M). Similarly, we did for other two pairs. Here after drawn a gridline and fix a fingerprint. Then we consider 3 rows and 3 columns to compare each cell on both sides.

For the ridge comparison of cells are valued by different ways with help of definition 1 to construct a matrix table. If cells not match, then we consider a value 0; it matches If cells not match, then we consider a value 0; it matches minimum, then consider a value 0.3; suppose it matches maximum, then we fix 0.7 and it matches perfectly, then we give a value 1.

Invalid = 0
Match low = 0.3
Match high = 0.7
Perfect = 1

From these values we create matrix table. First table is a comparative table. The second table, we rotated upto 360^0 (rotation start from first row third column). The third table, we change cells by using symmetric formula a_{ij} to a_{ji} where i = j = 1, 2, 3 and done in same way. The fourth table, we rotated symmetric table upto 360^0 (rotation start from first row third column). After create these tables, we use definition 4 to get a satisfied result. Similarly, we compared upto 52 family to get a result.

For example,

Devi (49) - First generation
Kasturi (31) - Second generation
Mohammed Shafi (5) - Third generation

TABLE I. Comparing L and M.

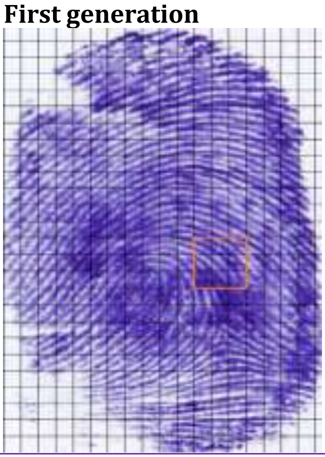
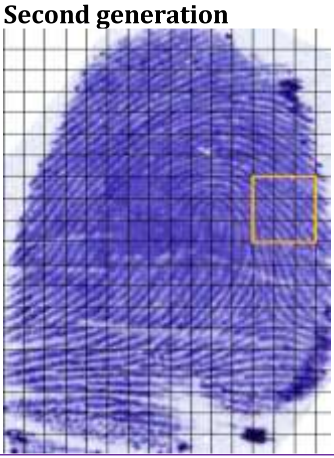
First generation	Second generation
	

TABLE II. Comparative marked cells are valued by using definition 1.

0.8	0	0
0.8	1	0.8
0	1	1

Now we using definition 4 for different way of tables.

TABLE III. Using table II.

				1st Projection	
	0.8	0	0	0.8	
	0.8	1	0.8	1	
	0	1	1	1	
2nd Projection	0.8	1	1	1	Global Projection

TABLE IV. Convert table II to 360°.

(start from 1st row last cell and rotate to 360 degree).

				1st Projection	
	0	0.8	1	1	
	0	1	1	1	
	0.8	0.8	0	0.8	
2nd Projection	0.8	1	1	1	Global Projection

TABLE V. Convert table II to symmetric method. (a_{ij} to a_{ji}).

				1st Projection	
	0.8	0.8	0	0.8	
	0	1	1	1	
	0	0.8	1	1	
2nd Projection	0.8	1	1	1	Global Projection

TABLE VI. Convert table V to 360°.

(start from1st row last cell and rotate to 360 degree).

				1st Projection	
	0	1	1	1	
	0.8	1	0.8	1	
	0.8	0	0	0.8	
2nd Projection	0.8	1	1	1	Global Projection

At last, the above four table values are equal.

L~M = 1.∴ By the definition 4, L~M is normal.

TABLE VII. Comparing M and N.

Second generation	Third generation

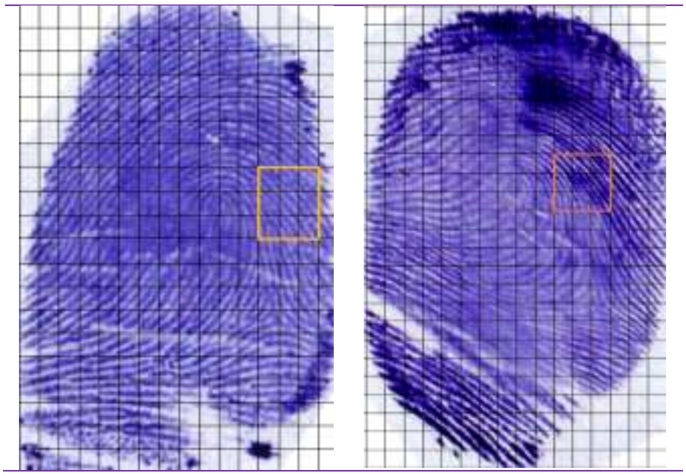


TABLE VIII. Comparative marked cells are valued by using definition 1.

1	0	1
1	0.3	1
0	0.3	1

Now we using definition 4 for different way of table.

TABLE IX. Using table VIII.

				1st Projection	
	1	0	1	1	
	1	0.3	1	1	
	0	0.3	1	1	
2nd Projection	1	0.3	1	1	Global Projection

TABLE X. Convert table VIII to 360°.
(start from 1st row last cell and rotate to 360 degree).

				1st Projection	
	1	1	1	1	
	0	0.3	0.3	0.3	
	1	1	0	1	
2nd Projection	1	1	1	1	Global Projection

TABLE XI. Convert table VIII to symmetric method. (a_{ij} to a_{ji}).

				1st Projection	
	1	1	1	1	
	0	0.3	0.3	0.3	
	1	1	0	1	
2nd Projection	1	1	1	1	Global Projection

TABLE XII. Convert table XI to 360°.
(start from1st row last cell and rotate to 360 degree).

				1st Projection	
	1	0.3	0	1	
	1	0.3	1	1	
	1	0	1	1	
2nd Projection	1	0.3	1	1	Global Projection

At last, the above four table values are equal.
M~N = 1.
∴ By the definition 4, M~N is normal.

TABLE XIII. Comparing N and L.

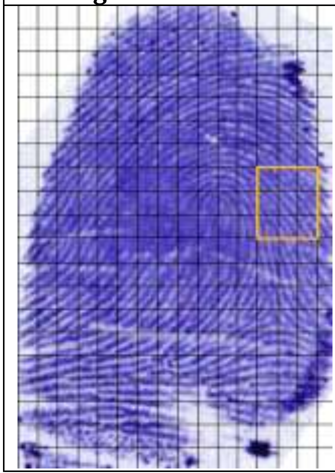
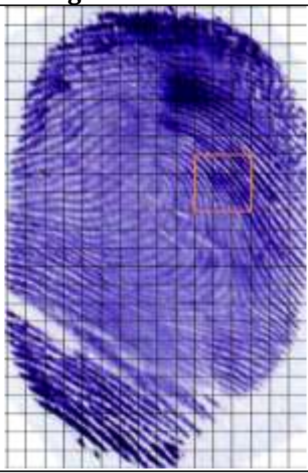
Third generation	First generation
	

TABLE XIV. Comparative marked cells are valued by using definition 1.

0.8	0.3	0
0.3	0	0.8
0.3	0.3	0.8

Now we using definition 4 for different way of table.

TABLE XV. Using comparative marked table.

				1st Projection	
	0.8	0.3	0	0.8	
	0.3	0	0.8	0.8	
	0.3	0.3	0.8	0.8	
2nd Projection	0.8	0.3	0.8	0.8	Global Projection

TABLE XVI. Convert table XIV to 360°.
(start from 1st row last cell and rotate to 360 degree).

				1st Projection	
	0	0.8	0.8	0.8	
	0.3	0	0.3	0.3	
	0.8	0.3	0.3	0.8	
2nd Projection	0.8	0.8	0.8	0.8	Global Projection

TABLE XVII. Convert table XIV to symmetric method. (a_{ij} to a_{ji}).

				1st Projection	
	0.8	0.3	0.3	0.8	
	0.3	0	0.3	0.3	
	0.8	0.8	0.8	0.8	
2nd Projection	0.8	0.8	0.8	0.8	Global Projection

TABLE XVIII. Convert table XVII to 360°.
(start from1st row last cell and rotate to 360 degree).

				1st Projection	
	0.3	0.3	0.8	0.8	
	0.3	0	0.3	0.3	
	0.8	0.3	0	0.8	
2nd Projection	0.8	0.3	0.8	0.8	Global Projection

At last, the above four table values are equal.
N~L = 0.8.
∴ By the definition 4, N~L is sub-normal.
The above comparison of three fingerprint table mutual results are
I = L~M = 1.
II = M~N = 1.
III = N~L = 0.8.
Note: Suppose the result is less than 0.5 then it's not similar.

CONCLUSION

Analysis of three generation of a family fingerprints have been compared by using projection of a fuzzy relation. Finally, the result for the analysis of three generation fingerprints are maximum similar.

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