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Determination of Hand of Origin of Fingerprints by Analysing Fingerprint Characteristics of Whorl Patterns

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Abstract

Fingerprints are unique and permanent to each and every individual. At a crime scene if a single fingerprint is found it could be used to determine the hand from which it originated by analysing the characteristics of the print. The rotation of angle, position of bisector, ridge tracing, ridge counting and the relative position of the delta were used in whorl patterns. The study can help the Investigating Officer to determine the hand of origin of the print. It was help to determine if a fingerprint has been wrongly classified.

Keywords: Fingerprint Direction; Whorls; Archs.

Introduction

Fingerprints are unique patterns that are made by friction ridges (raised) and furrows (recessed), which appear on the pads of the fingers and thumbs. A fingerprint is an impression left by the friction ridges which are the raised portion of the epidermis of a human finger. Impressions of fingerprints are left behind on the surface due to the natural secretion of sweat from eccrine glands that are present on the friction ridge skin. Although many people appear to have similar looking patterns, that is Class Characteristics are the same; the minutiae details owe to the individuality of the pattern amongst individuals.

The patterns formed by the friction ridges on the skin are: (Class Characteristics)

a. Loop (60-65%)

b. Whorl (30-35%)

c. Arch (5-10%)

Loops are the most common pattern of fingerprints found (60-65%). It is described as ridges that enter from one side of the print, recurve and exits from the same side. Loops have one delta, and a core. There are two types of loops;

a. Radial Loop (slope towards the thumb)

b. Ulnar Loop (slope towards the little finger)

Whorl patterns occur 30-35% of the time. Whorls are characterized by a circular type of ridge flow (spiral) pattern. Whorls have two deltas (right and left) and a core. There are four types of whorls;

a. Plain Whorls

b. Central Pocket Whorls

c. Double loop or Twinned loop

d. Accidental

Arches are the least common type of fingerprint occurring about 5-10% of the time. It is characterized by ridges that enters from one side of the print, rises up in the centre and then exits on the opposite side. Arches do not have deltas or a core. It has the following types:

a. Plain Arch

b. Tented Arch

Individual Characteristics or Minutiae

These are the point interests in a fingerprint that are solely responsible for the uniqueness of a fingerprint. These unique characteristics establish the identification of an individual. They may be accidental, or unintentional, characteristics also. This is what the Forensic scientists look for when comparing prints [1].

Some minutiae characteristics include:

a. Bifurcations

b. Trifurcations

c. Ridge Endings

d. Short Ridge

e. Island/Dot

f. Enclosure

g. Eye

h. Spur/Hook

i. Crossover/ Bridge

j. Ridge Crossing

k. Etc.

Materials and Methods

a. Fingerprint Ink Compact

b. Fingerprint recording slip

c. Writing Materials

The study population consisted of 50 females and 50 males belonging to a random student population in Mangaluru city from the age group of 21-26years.Fingerprints were collected from them using a compact, and the total number of prints obtained and their pattern distribution for left and right hand were statistically represented. All samples collected were on voluntary basis. No consent form was issued [2].

The following parameters were considered:

Rotation of Ridge

The central ridge was considered for determining the Rotation of the ridges. If the central ridge is concentric or elliptical then the rotation of ridge is absent.

Position of bisector of the line joining the two deltas:

Arcs were drawn from the top and bottom of the print from both deltas. A line was drawn joining the two points that were formed the meeting of the arc on both sides. The position of bisector was used as a parameter to determine the hand.

Ridge tracing

By tracing the lower type line from the left delta towards right delta, the ending of the segment of the type line is noted as to whether it ends inside or outside the right delta. Then according to the number of ridges in-between between the tracing line and the right delta it is classified as inner, outer, and meeting. 'Inner' means the ridges being traced; starting at the left delta, passes inside of the right delta and three or more ridges intervene between the tracing line and the right delta. 'Outer' means the ridges being traced, after starting at the left delta, passes outside of the right delta, and three or more ridges intervene between the tracing line and right delta. 'Meeting' means the ridges being traced, after starting at the left delta, meets the right delta without intervening ridges or with not more than two such ridges inside or outside the right delta.

Ridge counting

On drawing a straight line simultaneously from the left and right deltas to a core, the number of ridges intersected by it on both sides is counted. 'Left counting' is the count of intervening ridges between the left delta and core is greater. 'Right counting' is the count of intervening ridges between the right delta and core is greater.

Relative position of the delta

The relative position of the deltas to each other was visually examined. Either the right delta was superior to the left delta or the left delta was superior to the right delta [3].

Objectives

1. To determine the hand of origin of a fingerprint based on analyzing the characteristics of fingerprints in whorl patterns.

2. To analyze the statistical pattern distribution of each finger.

Procedure

a. The subject was asked to fill the Personal Information sheet

b. The subject was then asked to apply the fingerprint ink to his/her fingers one by one by using the Fingerprint ink compact.

c. The thumb was roller inwards, that is towards the body on the slab and then the print was deposited in the slot allotted for it on the sheet.

d. The same was repeated for the other four fingers, except the in this case the fingers were rolled outwards, that is away from the body.

Analysis of Fingerprints

a. Fingerprint patterns were tabulated and the patterns were statically represented using a bar graph for each finger on both hands separately and were done for males and females respectively.

b. Only the whorl prints were taken into consideration for further determining the hand of origin.

c. The angle of rotation was traced using a pointed needle to determine if it was clockwise or anticlockwise

d. The two deltas were identified and they were joined together with a light pressured line using a pencil.

e. Using a compass arcs were marked both at the bottom and the top of the print from both deltas.

f. The bisector was then drawn

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g. Ridge tracing and ridge counting was down and the relative position of the deltas to each other was noted down.

Analysis And Results

Parameters for the Right hand

The following parameters were observed when analysis of prints originating from the right hand was taken into consideration. The rotation of the ridge was in anticlockwise direction, the position of the bisector was to the left of the core, the ridge tracing was mostly outer trace, although there were cases of meeting, the left count of ridge counting was more and the relative position of the right delta was superior to the left delta (Figure 1). In cases of meeting, there were instances where the position of the bisector was at the centre of the print and the right delta was relatively slightly superior to the left delta [3].

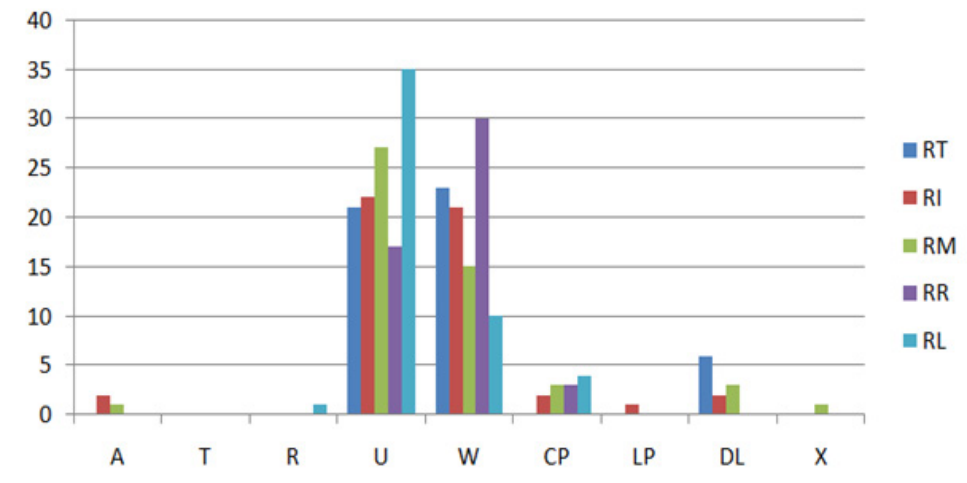

Figure 1: Graphical Representation Of Fingerprint Patterns On The Right Hand Of Female Population.

Parameters for the Left hand

The following parameters were observed when analysis of prints originating from the left hand was taken into consideration. The rotation of the ridge was in clockwise direction, the position of the bisector was to the right of the core, the ridge trace was inner trace, the right count of ridge counting was more and the relative position of the left delta was superior to the right delta [3].Numerical found in the parenthesis are percentage values From the above table it can be observed that the number of whorl patterns found in the Female population (197) exceeds that of those that are found in the Male population (94). The ulnar loops in males, 307, is more than the number of ulnar loops (231) of that found in the female population. The number of plain arches found in male population (23) is more than what is found in female population (6). The number radial loops (26) observed in males is higher than that what is observed in females (Figure 2). The female population has more tented arch formations (2) than that found in the male population (1) (Table 1). The central pocket loops found in the male population (8) is less than what is found in the female population (15).

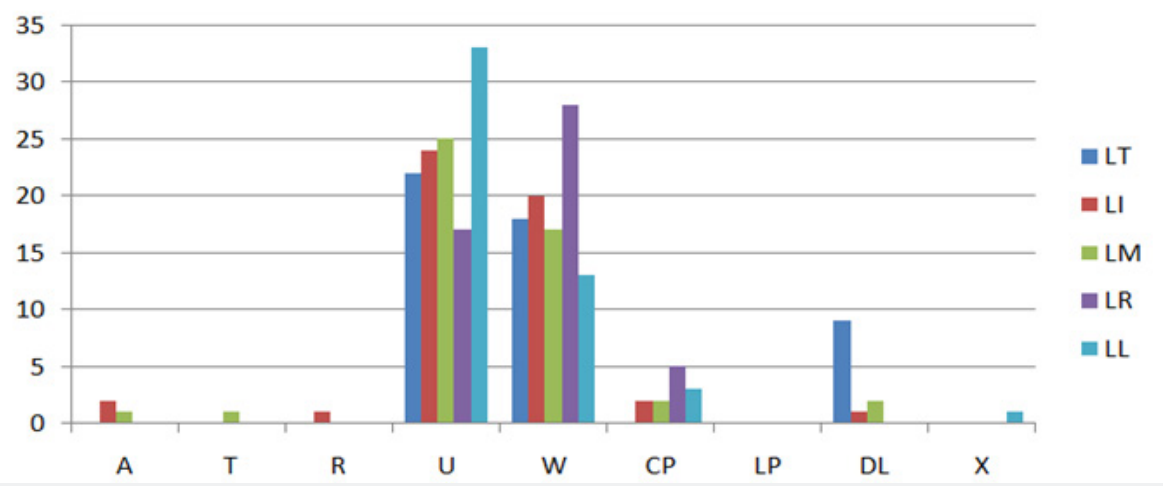

Figure 2: Graphical Representation of Fingerprint Patterns On The Left Hand Of Female Population.

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Table 1: pattern classification between female and male populations.

	Arch	Tented Arch	Radial Loop	Ulnar Loop	Whorl	Central Pocket Loop	Double Loop	Lateral Pocket Loop	Accidental X	Total
Female	6 (1.2)	2(0.4)	3(0.6)	231 -46.2	197 (39.4)	15 -3	21 -4.2	24 -4.8	2 -0.4	500
Male	23 -4.6	1 -0.2	26 -5.2	307 -61.4	94 -18.8	8 -1.6	26 -5.2	9 -1.8	6(1.2)	500

Table 2: Overall Pattern Classification of Right and Left Hand of Males And Females.

Pattern	A	T	R	U	W	CP	DL	LP	X	Total
Finger										
Rhf	3(1.2)	0(0)	1(0.4)	122(48.8)	99(39.6)	12(4.8)	1(0.4)	11(4.4)	1(0.4)	250
Lhf	4(1.6)	1(0.4)	1(0.4)	121(48.4)	96(38.4)	12(4.8)	0(0)	12(4.8)	1(0.4)	250
Rhm	13(5.2)	0(0)	12(4.8)	150(60)	55(22)	5(2.0)	3(1.2)	9(3.6)	3(1.2)	250
Lhm	10(4.0)	1(0.4)	14(5.6)	156(62.4)	41(16.4)	2(0.8)	6(2.4)	17(6.8)	3(1.2)	250
Total	30	2	28	551	291	31	10	49	8	1000

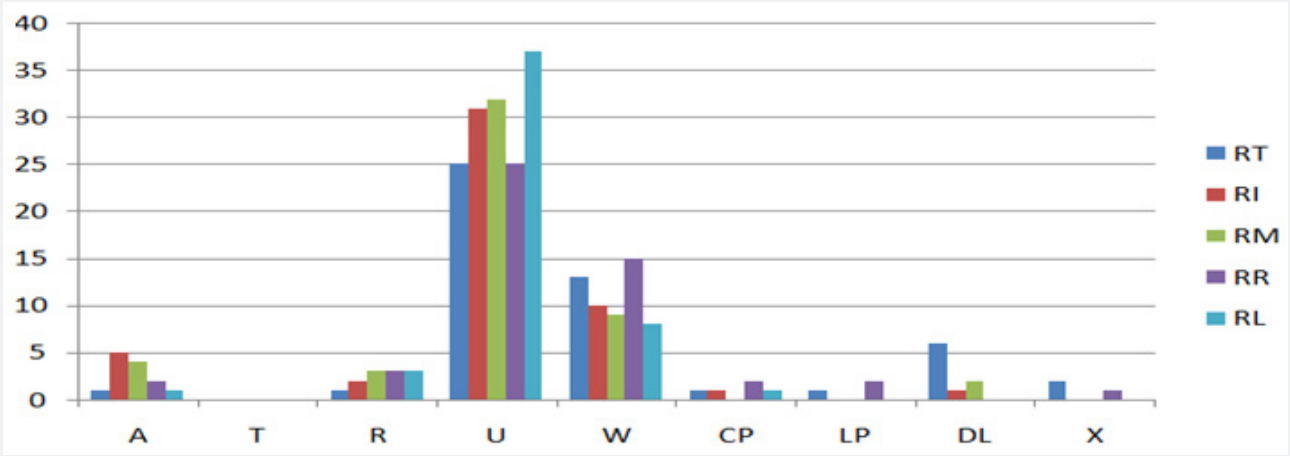

Figure 3: Graphical Representation of Fingerprint Patterns on the Right Hand Of Male Population.

Twenty six double loops were found in male population, whereas 21 double loops were observed in the female population. Around 24 lateral pocket loops were located in the female population, while 9 were noted down in the male population. A total of 8 accidentals were observed, out of which 2 belonged to the female population and 6to the male population. (RHF- Right Hand Female; LHF- Left Hand Female; RHM- Right Hand Male and LHM- Left Hand Male) (Table 2). The above table is a brief representation of the pattern distribution of the various fingerprint patterns found in the left and right hands of male and female population respectively. From a total of 551 ulnar loop patterns, 122 belonged to RHF, 121 to LHF, 150 to RHM and 156 to LHM. About 99 of the total whorl patterns observed belonged to RHF and 96 of them belonged to LHF (Figure 3). The remaining whorl patterns were distributed among RHM, 55, and 41 to LHM. A total of 49 Lateral Pocket loops were observed from which 11 came from RHF, 12 from LHF, 9 from RHM and 17 from LHM.

Thirty One Central Pocket Loops were observed among both Male and Female Population amongst them 12 were seen in RHF, 12 in LHF, 5 to RHM and 2 to LHM. Plain arch patterns were more dominant in the Male population, where a surprising 13 arch patterns were found in RHM and 10 in LHM. A few Plain arches were found in the Female population with 3 in RHF and 4 in LHF. Radial loops were seen mostly in LHM and RHM. One sample each was observed in RHF and LHF. Double loops were found in LHM (6), RHM (3) and in RHF (1). About 8 accidentals were observed in the total sample collection wherein 1 was from RHF, 1 from LHF, 3 from RHM and 3 from LHM. Tented arches were only observed in LHF (1) and LHM (1) (Table 3). Depicts the fingerprint pattern distribution of right hand of female population. Among the total number ulnar loops, 122, a majority belonged to RL (35) and only 17 were observed in RR. There were 99 whorl patterns amongst which most of the patterns were observed in RR (30) and the least were observed in RL (10).

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Table 3: Fingerprint Pattern Distribution Of Right Hand Of Female Population.

Pattern	A	T	R	U	W	CP	LP	DL	X
Finger									
RT	0(0)	0(0)	0(0)	21(17.2)	23(23.2)	0(0)	0(0)	6(54.5)	0(0)
RI	2(67)	0(0)	0(0)	22(18)	21(21.2)	2(17)	1(100)	2(18.1)	0(0)
RM	1(33)	0(0)	0(0)	27(22)	15(15.1)	3(25)	0(0)	3(27.3)	1(100)
RR	0(0)	0(0)	0(0)	17(13.9)	30(30.3)	3(25)	0(0)	0(0)	0(0)
RL	0(0)	0(0)	1(100)	35(28.6)	10(10.1)	4(33)	0(0)	0(0)	0(0)
Total	3	0	1	122	99	12	1	11	1

Table 4: Fingerprint Pattern Distribution Of Left Hand Of Female Population.

Pattern	A	T	R	U	W	CP	LP	DL	X
Finger									
LT	1(25)	0(0)	0(0)	22(18.1)	18(18.7)	0(0)	0(0)	9(75)	0(0)
LI	2(50)	0(0)	1(100)	24(19.8)	20(16.5)	2(16.6)	0(0)	1(8.3)	0(0)
LM	1(25)	1(100)	0(0)	25(20.6)	17(17.7)	2(16.6)	0(0)	2(16.6)	0(0)
LR	0(0)	0(0)	0(0)	17(14)	28(29.1)	5(41.6)	0(0)	0(0)	0(0)
LL	0(0)	0(0)	0(0)	33(27.2)	13(13.5)	3(25)	0(0)	0(0)	1(100)
Total	4	1	1	121	96	12	0	12	1

Arch patterns were only observed in RI (2) and RM (1). One Radial loop was observed in RL, one Lateral Pocket loop in RI and one accidental in RM. There were 12 central pocket loops observed from which 2 were seen in RI and 4 in RL. There were 11 Double loops observed in the right hand of female population, in which a majority of 6 were seen in RT and none were observed in RR and RL. No tented arches were observed in the right hand of the female population. The above graph is a graphical representation of the Table showing the Statistical distribution of the various types of fingerprint patterns found in the Right hand of Female Population (Table 4). Displays the fingerprint pattern distribution of the left hand of female population. Among the total number ulnar loops, 121, a majority belonged to LL (33) and only 17 were observed in LR. There were 96 whorl patterns amongst which most of the patterns were observed in LR (28) and the least were observed in LL (13). Arch patterns were observed in LT (1), LI (2) and LM (1).

One Tented Arch was observed in LM, One Radial loop was observed in LI and one accidental in LL. There were 12 central pocket loops observed from which 5 were seen in LR and 2 each in LI and LM. There were 12 Double loops observed in the left hand of female population, in which a majority of 9 were seen in LT and one was observed in LI. No Lateral pocket loops were observed in the left hand of the female population. The above graph is a graphical representation of the Table showing the Statistical distribution of the various types of fingerprint patterns found in the Left hand of Female Population (Table 5). Depicts the fingerprint pattern distribution of right hand of male population. Among the total number ulnar loops, 150, a majority belonged to RL (37) and 25 were observed both in RT and RR. There were 55 whorl patterns amongst which most of the patterns were observed in RR (15) and the least were observed in RL (8). Arch patterns were only observed in RI (5) and equally in each RT (1) and RL (1). Twelve Radial loops were observed among RM (3), RR (3) and RL (3) with one seen in RT. Three Lateral Pocket loops in RR (2) and RT (1) while two accidentals in RT and one accidental in RR. There were 5 central pocket loops observed from which 2 were seen in RR and 1 each in RT and RI. There were9Double loops observed in the right hand of male population, in which a majority of 6 were seen in RT and one in RI. No tented arches were observed in the right hand of the female population.

Table 5: Fingerprint Pattern Distribution of Right Hand of Male Population.

Pattern	A	T	R	U	W	CP	LP	DL	X
Finger									
RT	1(7.7)	0(0)	1(8.3)	25(16.6)	13(23.6)	1(20)	1(33.3)	6(66.6)	2(66.6)
RI	5(38.4)	0(0)	2(16.6)	31(20.6)	10(18.1)	1(20)	0(0)	1(11.1)	0(0)
RM	4(30.7)	0(0)	3(25)	32(21.3)	9(16.3)	0(0)	0(0)	2(22.2)	0(0)
RR	2(15.4)	0(0)	3(25)	25(16.6)	15(27.2)	2(40)	2(66.6)	0(0)	1(33.3)
RL	1(7.7)	0(0)	3(25)	37(24.6)	8(14.5)	1(20)	0(0)	0(0)	0(0)
Total	13	0	12	150	55	5	3	9	3

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Table 6: Fingerprint Pattern Distribution of Left Hand of Male Population.

Pattern	A	T	R	U	W	CP	LP	DL	X
Finger									
LT	1(10)	0(0)	1(7.1)	28(17.9)	7(17)	0(0)	2(33.3)	10(58.8)	1(33.3)
LI	4(40)	0(0)	4(28.5)	29(18.5)	6(14.6)	1(50)	1(16.6)	4(23.5)	1(33.3)
LM	4(40)	0(0)	3(21.4)	32(20.5)	8(19.5)	0(0)	0(0)	3(17.6)	0 (0)
LR	0(0)	1(100)	2(14.2)	29(18.5)	16(39)	1(50)	1(16.6)	0(0)	0 (0)
LL	1(10)	0(0)	4(28.5)	38(24.3)	4(9.75)	0(0)	2(33.3)	0(0)	1(33.3)
Total	10	1	14	156	41	2	6	17	3

The above graph is a graphical representation of the Table showing the Statistical distribution of the various types of fingerprint patterns found in the Right hand of Male Population (Table 6). Statistically describes the fingerprint pattern distribution of the left hand male of population. Among the total number ulnar loops, 156, a majority belonged to LL (38) and 28 were observed in LT. There were 41 whorl patterns amongst which most of the patterns were observed in LR (16) and the least were observed in LL (4). Arch patterns were observed in equal numbers in LI (4), LM (4) and LT (1) and LL (1). One Tented Arch was observed in LR. From a total of 14 Radial loops, 4 were observed in LI and LL, while one was seen in LT.Three accidentals, one each was observed in LT, LI and LL. There were 2 central pocket loops observed, from which 1 was seen in LR and the other in LI. There were 17 Double loops observed in the left hand of male population, in which a majority of 10 were seen in LT and 3 were observed in LM. A total of 6 Lateral pocket loops were observed 2 each in LT and LL and One each in LI and LR in the left hand of the male population.

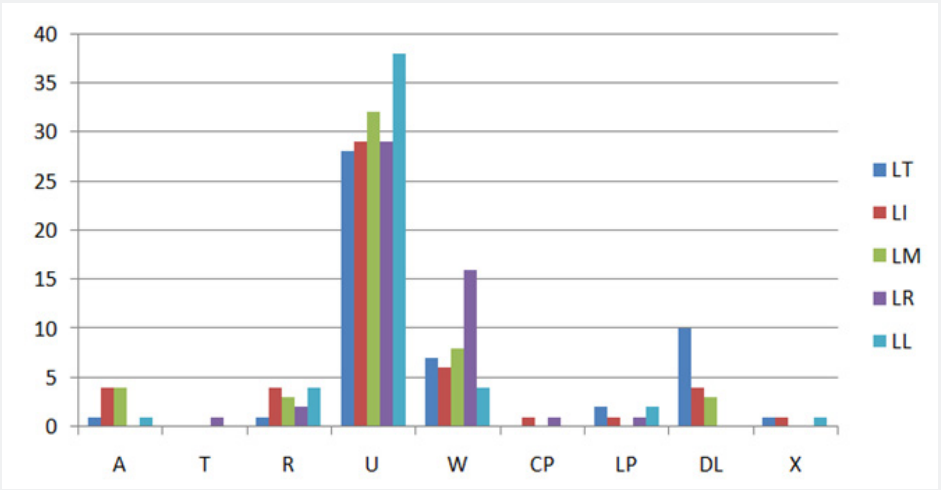

Figure 4: Graphical representation of Fingerprint Patterns on the Left Hand of Male population.

Table 7: Whorl Pattern Analysis of Females Right Hand.

Characteristics		RT	RI	RM	RR	RL	Total(%)
Rotation of ridges	Anticlockwise	22(95.6)	18(85.7)	14(93.3)	28(93.3)	10(100)	92.9
	Clockwise	1(4.3)	3(14.2)	1(6.6)	2(6.6)	0(0)	7
	Total	23	21	15	30	10	
Angle b/w core and delta	Right	15(65.2)	10(47.6)	12(80)	22(73.3)	6(60)	65.6
	Left	4(17.3)	6(28.5)	2(13.3)	4(13.3)	1(10)	17.1
	Equal	4(17.3)	5(23.8)	1(6.6)	4(13.3)	3(30)	17.1
	Total	23	21	15	30	10	
Position of bisector	Right	1(4.3)	4(19)	4(26.6)	4(13.3)	0(0)	13.1
	Left	18(78.2)	8(38)	9(60)	22(73.3)	9(90)	66.6
	Center	4(17.3)	9(42.8)	2(13.3)	4(13.3)	1(10)	20.2
	Total	23	21	15	30	10	

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Ridge tracing	Inner	2(8.6)	10(47.6)	1(6.6)	4(13.3)	0(0)	17.1
	Meeting	3(13)	6(28.5)	0(0)	7(23.3)	4(40)	20.2
	Outer	18(78.2)	5(23.8)	14(93.3)	19(63.3)	6(60)	62.6
	Total	23	21	15	30	10	
Ridgde counting	Right	2(8.6)	7(33.3)	4(26.6)	7(23.3)	1(10)	21.2
	Left	21(91.3)	14(66.6)	11(73.3)	23(76.6)	9(90)	78.7
	Total	23	21	15	30	10	
Relative position of delta	Right	16(69.5)	11(52.3)	11(73.3)	15(50)	4(40)	57.5
	Left	3(13)	6(28.5)	4(26.6)	4(13.3)	3(30)	20.2
	Equal	4(17.3)	4(19)	0(0)	11(36.6)	3(30)	22.2
	Total	23	21	15	30	10	100

The above graph is a graphical representation of the Table showing the Statistical distribution of the various types of fingerprint patterns found in the Left hand of Male Population (Table 7) provides the statistical distribution of whorl pattern analysis female's right hand (Figure 4). There is a total 99 whorl patterns in the right hand of female population. In the present study, for the right hand of female population, the rotation of ridges, anticlockwise was 92.9 percent, clockwise was seven percent. Anticlockwise rotation was the highest in the RL finger (100%) and lowest in the RI finger (85.7%). The clockwise rotation was the maximum in RI (14.2%) and was not present in RL finger (0%). Analysing the angle between core and delta, 65.6 percent of the samples displayed a greater angle towards the right while an equal 17.1percent each displayed a greater left angle or similar/ equal angles. Greater right angle was found in RM (80%) while the least was in RI (47.6%). Greater left angle was found in RI (28.5%) while the least was in RL (10%).

The highest amount of equal angles was found in the RL finger (30%) and the least in RM finger (6.6%). On studying the Position of the Bisector, the position of the bisector was towards the right side of the core in 13.1 percent of the sample, towards the left in 66.6 percent of the cases and centralised in 20.2 percent of the cases. From the Position of the bisectors toward the right, a majority was observed in the RM (26.6%) finger and was absent in RL finger. The maximum number of samples having the bisector towards the left of the core was seen in RL (90%) and was least in RI (38%). The highest value for centralised bisector was observed in RI (42%) and the least was seen in RL (10%). In the study, Ridge tracing displayed outer trace in 62.6 percent of the cases, meeting in 20.2 percent and inner in 17.1 percent of the cases. Among outer trace, the highest value was observed in RM (93.3%) and the lowest was observed in RI (23.8%). Amidst the meeting trace the highest value was obtained by RI (28.5%) and the lowest value was obtained by RM (0%). Amongst the inner trace the maximum value was observed in RI (47.6%) and the minimum in RL (0%).

In the present study, the ridge count between the two deltas and the core, 78.7 percent of the cases showed a higher left count while 21.2 of the cases showed a higher right count. Between the higher right counts, the maximum value was seen in RI (33.3%) and the lowest value was seen in RL (10%). Among the higher left counts the highest value was observed in RT (91.3%) and the lowest value was seen in RI (66.6%). On studying the relative position of the deltas to each other, the right delta was observed to be higher in 57.5 percent of the cases followed by the left delta being higher in 20.2 percent of the case and the deltas being at the same level or indistinguishable level in 22.2 percent of the cases. The RM (73.3%) showed the highest value for a higher right delta, while RL (40%) was the lowest. Among the higher left delta cases, the highest value was observed in RL (30%) while the lowest value was seen in RT (13%). Among the equally levelled deltas, the maximum value was observed in RR (36.6%) while the least was (Table 8). offers the statistical distribution of whorl pattern analysis female's left hand. There is a total 96 whorl patterns in the left hand of female population.

Table 8: Whorl Pattern Analysis Of Left Hand Female Population.

Characteristics		LT	LI	LM	LR	LL	Total (%)
Rotation of ridges	Anticlockwise	2(11.1)	3(15)	1(5.8)	5(17.8)	1 (7.6)	12.5
	Clockwise	16(88.8)	17(85)	16(94.1)	23(82.1)	12(92.3)	87.5
	Total	18	20	17	28	13	
Angle b/w core and delta	Right	2(11.1)	7(35)	2(11.7)	3(10.7)	0(0)	14.5
	Left	9(50)	9(45)	13(76.4)	23(82.1)	11(84.6)	67.7
	Equal	7(38.8)	4(20)	2(11.7)	2(7.1)	2(15.3)	17.7
	Total	18	20	17	28	13	

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Position of bisector	Right	8(44.4)	8(40)	11(64.7)	23(82.1)	11(84.6)	63.5
	Left	6(33.3)	4(20)	1(5.8)	3(10.7)	2(15.3)	16.6
	Center	4(22.2)	8(40)	5(29.4)	2(7.1)	0(0)	19.7
	Total	18	20	17	28	13	
Ridge tracing	Inner	11(61.1)	6(30)	11(64.7)	24(85.7)	12(92.3)	66.6
	Meeting	2(11.1)	5(25)	3(17.6)	3(10.7)	0(0)	13.5
	Outer	5(27.7)	9(45)	3(17.6)	1(3.5)	1(7.6)	19.7
	Total	18	20	17	28	13	
Ridgde counting	Right	14(77.7)	13(65)	14(82.3)	25(89.2)	13(100)	82.2
	Left	4(22.2)	7(36)	3(17.6)	3(10.7)	0(0)	17.7
	Total	18	20	17	28	13	
Relative position of delta	Right	1(5.5)	5(25)	1(5.8)	5(17.8)	1(7.6)	13.5
	Left	12(66.6)	11(55)	12(70.5)	16(57.1)	8(61.5)	61.4
	Equal	5(27.7)	4(20)	4(23.5)	7(25)	4(30.7)	25
	Total	18	20	17	28	13	100

In the present study, for the left hand of female population, the rotation of ridges, anticlockwise was 12.5 percent, clockwise was 87.5 percent. Anticlockwise rotation was the highest in the LR finger (17.8%) and lowest in the LM finger (5.8%). The clockwise rotation was the maximum in LM (94.1%) and was the minimum in LR finger (82.1%). Analysing the angle between core and delta, 14.5 percent of the samples displayed a greater angle towards the right while 67.7 percent displayed greater angle towards the left and 17.7 percent each displayed a similar/equal angles. Greater right angle was found in LI (35%) while the least was in LL (0%). Greater left angle was found in LL (84.6%) while the least was in LI (45%). The highest amount of equal angles was found in the LT finger (38.8%) and the least in LR finger (7.1%). On studying the Position of the Bisector, the position of the bisector was towards the right side of the core in 63.5 percent of the sample, towards the left in 16.6 percent of the cases and centralised in 19.7 percent of the cases.

From the Position of the bisectors toward the right, a majority was observed in the LL (84.6%) finger and was least in LI finger (40%). The maximum number of samples having the bisector towards the left of the core was seen in LT (33.3%) and was least in LM (5.8%). The highest value for centralised bisector was observed in LI (40%) and was absent in LL (10%). In the study, Ridge tracing displayed outer trace in 19.7 percent of the cases, meeting in 13.5 percent and inner in 66.6 percent of the cases. Among outer trace, the highest value was observed in LI (45%) and the lowest was observed in LR (3.5%). Amidst the meeting trace the highest value was obtained by LI (25%) and the lowest value was obtained by LL (0%). Amongst the inner trace the maximum value was observed in LL (92.3%) and the minimum in LI (30%). In the present study, the ridge count between the two deltas and the core, 17.7 percent of the cases showed a higher left count while 82.2 of the cases showed a higher right count. Between the higher right counts, the maximum value was seen in LL (100%) and the lowest value was seen in LI (65%). Among the higher left counts the highest value was observed in LI (36%) and the lowest value was seen in LL (0%). On studying the relative position of the deltas to each other, the right delta was observed to be higher in 13.5 percent of the cases followed by the left delta being higher in 61.4 percent of the case and the deltas being at the same level or indistinguishable level in 25 percent of the cases. The LI (25%) showed the highest value for a higher right delta, while LT (5.5%) was the lowest.

Table 9: Whorl Pattern Analysis of Right Hand Male Population.

Characteristics		RT	RI	RM	RR	RL	Total (%)
rotation of ridges	Anticlockwise	12(92.3)	7(70)	7(77.7)	11(73.3)	6(75)	78.1
	Clockwise	1(7.6)	3(30)	2(22.2)	4(26.6)	2(25)	21.8
	Total	13	10	9	15	8	
angle b/w core and delta	Right	7(53.8)	2(20)	3(33.3)	9(60)	6(75)	49
	Left	3(23)	7(70)	2(22.2)	2(13.3)	1(12.5)	27.2
	Equal	3(23)	1(10)	4(44.4)	4(26.6)	1(12.5)	23.6
	Total	13	10	9	15	8	
position of bisector	Right	1(7.6)	4(40)	2(22.2)	1(6.6)	1(12.5)	16.3
	Left	9(69.2)	2(20)	5(55.5)	10(66.6)	7(87.5)	60
	Center	3(23)	4(40)	2(22.2)	4(26.6)	0(0)	23.6
	Total	13	10	9	15	8	

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ridge tracing	Inner	2(18.8)	7(70)	5(55.5)	3(20)	1(12.5)	32.7
	Meeting	1(7.6)	1(10)	2(22.2)	4(26.6)	0(0)	14.5
	Outer	10(76.9)	2(20)	2(22.2)	8(53.3)	7(87.5)	52.7
	Total	13	10	9	15	8	
ridgde counting	Right	4(30.7)	8(80)	5(55.4)	6(40)	1(12.2)	43.6
	Left	9(69.2)	2(20)	4(44.4)	9(60)	7(87.5)	56.3
	Total	13	10	9	15	8	
relative position of delta	Right	8(61.5)	4(40)	4(44.4)	8(53.3)	6(75)	54.5
	Left	1(7.6)	3(30)	2(22.2)	2(13.3)	1(12.5)	16.3
	Equal	4(30.7)	3(30)	3(33.3)	5(33.3)	1(12.5)	29
	Total	13	10	9	15	8	100

Among the higher left delta cases, the highest value was observed in LM (70.5%) while the lowest value was seen in LI (55%). Among the equally levelled deltas, the maximum value was observed in LL (30.7%) while the least was observed in LI (20%). Numerical found in the parenthesis are percentage values (Table 9) gives the statistical distribution of whorl pattern analysis male's right hand. There is a total 55 whorl patterns in the right hand of male population. In the present study, for the right hand of male population, the rotation of ridges, anticlockwise was 78.1 percent, clockwise was 21.8 percent. Anticlockwise rotation was the highest in the RT finger (92.3%) and lowest in the RI finger (70%). The clockwise rotation was the maximum in RI (30%) and was least in RT finger (7.6%). Analysing the angle between core and delta, 49 percent of the samples displayed a greater angle towards the right while 27.2 percent displayed a greater left angle and 23.6 percent showed similar/ equal angles. Greater right angle was found in RL (75%) while the least was in RI (20%). Greater left angle was found in RI (70%) while the least was in RL (12.5%).

The highest amount of equal angles was found in the RM finger (44.4%) and the least in RI finger (10%). On studying the Position of the Bisector, the position of the bisector was towards the right side of the core in 16.3 percent of the samples, towards the left in 60 percent of the cases and centralised in 23.6 percent of the cases. From the Position of the bisectors toward the right, a majority was observed in the RI (40%) finger and was least in RR finger (6.6%). The maximum number of samples having the bisector towards the left of the core was seen in RL (87.5%) and was least in RI (20%). The highest value for centralised bisector was observed in RI (40%) and the least was absent in RL (0%). In the study, Ridge tracing displayed outer trace in 52.7 percent of the cases, meeting in 14.5 percent and inner in 32.7 percent of the cases. Among outer trace, the highest value was observed in RL (87.5%) and the lowest was observed in RI (20%). Amidst the meeting trace the highest value was obtained by RR (26.6%) and the lowest value was obtained by RL (0%).

Amongst the inner trace the maximum value was observed in RI (70%) and the minimum in RL (12.5%). In the present study, the ridge count between the two deltas and the core, 56.3 percent of the cases showed a higher left count while 43.6 of the cases showed a higher right count. Between the higher right counts, the maximum value was seen in RI (80%) and the lowest value was seen in RL (12.2%). Among the higher left counts the highest value was observed in RL (87.5%) and the lowest value was seen in RI (20%). On studying the relative position of the deltas to each other, the right delta was observed to be higher in 54.5 percent of the cases followed by the left delta being higher in16.3 percent of the case and the deltas being at the same level or indistinguishable level in 29 percent of the cases. The RL (75%) showed the highest value for a higher right delta, while RI (40%) was the lowest. Among the higher left delta cases, the highest value was observed in RI (30%) while the lowest value was seen in RT (7.6%). Among the equally levelled deltas, the maximum value was observed in bothRM (33.3%) and RR (33.3%) while the least was observed in RL (12.5%).

Table 10: Whorl Pattern Analysis of Left Hand Male Population.

Characteristics		LT	LI	LM	LR	LL	Total (%)
Rotation of ridges	Anticlockwise	0(0)	2(33.3)	1(12.5)	1(6.2)	0(0)	9.75
	Clockwise	7(100)	4(66.6)	7(87.5)	15(93.7)	4(100)	90.2
	Total	7	6	8	16	4	
Angle b/w core and delta	Right	3(42.8)	1(16.6)	2(25)	2(12.5)	0(0)	19.5
	Left	2(28.5)	4(66.6)	5(62.5)	12(75)	1(25)	58.5
	Equal	2(28.5)	1(16.6)	1(12.5)	2(12.5)	3(75)	21.9
	Total	7	6	8	16	4	

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Position of bisector	Right	2(28.5)	4(66.6)	4(50)	7(43.7)	1(25)	43.9
	Left	3(42.8)	1(16.6)	3(37.5)	2(12.5)	1(25)	24.3
	Center	2(28.5)	1(16.6)	1(12.5)	7(43.7)	2(50)	31.7
	Total	7	6	8	16	4	
Ridge tracing	Inner	2(28.5)	1(16.6)	4(50)	13(81.2)	4(100)	58.5
	Meeting	3(42.8)	3(50)	3(37.5)	1(6.2)	0(0)	24.3
	Outer	2(28.5)	2(33.3)	1(12.5)	2(12.5)	0(0)	17
	Total	7	6	8	16	4	
Ridgde counting	Right	5(71.4)	4(66.6)	6(75)	13(81.2)	3(75)	75.6
	Left	2(28.5)	2(33.3)	2(25)	3(18.7)	1(25)	24.3
	Total	7	6	8	16	4	
Relative position of delta	Right	2(28.5)	2(33.3)	2(25)	1(6.2)	1(25)	19.5
	Left	1(14.2)	3(50)	4(50)	9(56.2)	1(25)	43.9
	Equal	4(57.1)	1(16.6)	2(25)	6(37.5)	2(50)	36.5
	Total	7	6	8	16	4	100

Table 10 offers the statistical distribution of whorl pattern analysis male's left hand. There is a total 41 whorl patterns in the left hand of male population. In the present study, for the left hand of male population, the rotation of ridges, anticlockwise was 9.75 percent, clockwise was 90.2 percent. Anticlockwise rotation was the highest in the LR finger (6.2%) and lowest in the LT and LL fingers (0%). The clockwise rotation was the maximum in LT and LL (100 %) and was the minimum in LI finger (66.6%). Analysing the angle between core and delta, 19.5 percent of the samples displayed a greater angle towards the right while 58.5 percent displayed greater angle towards the left and 21.9 percent each displayed a similar/ equal angles. Greater right angle was found in LT (42.8%) while the least was in LL (0%). Greater left angle was found in LR (75%) while the least was in LL (25%). The highest amount of equal angles was found in the LL finger (75%) and the least in LM and LR finger (12.5%). On studying the Position of the Bisector, the position of the bisector was towards the right side of the core in 43.9 percent of the sample, towards the left in 24.3 percent of the cases and centralised in 31.7 percent of the cases.

From the Position of the bisectors toward the right, a majority was observed in the LI (66.6%) finger and was least in LL finger (25%). The maximum number of samples having the bisector towards the left of the core was seen in LT (42.8%) and was least in LR (12.5%). The highest value for centralised bisector was observed in LL (50%) and was least in LM (12.5%). In the study, Ridge tracing displayed outer trace in 17 percent of the cases, meeting in 24.3 percent and inner in 58.5 percent of the cases. Among outer trace, the highest value was observed in LI (33.3%) and the lowest was observed in LL (0%). Amidst the meeting trace the highest value was obtained by LI (50%) and the lowest value was obtained by LL (0%). Amongst the inner trace the maximum value was observed in LL (100%) and the minimum in LI (16.6%). In the present study, the ridge count between the two deltas and the core, 24.3 percent of the cases showed a higher left count while 75.6 of the cases showed a higher right count. Between the higher right counts, the maximum value was seen in LR (81.2%) and the lowest value was seen in LI (66.6%).

Among the higher left counts the highest value was observed in LI (33.3%) and the lowest value was seen in both LM and LL (25%). On studying the relative position of the deltas to each other, the right delta was observed to be higher in 19.5 percent of the cases followed by the left delta being higher in 43.9 percent of the case and the deltas being at the same level or indistinguishable level in 36.5 percent of the cases. The LI (33.3%) showed the highest value for a higher right delta, while LR (6.2%) was the lowest. Among the higher left delta cases, the highest value was observed in LR (56.2%) while the lowest value was seen in LT (14.2%). Among the equally levelled deltas, the maximum value was observed in LT (57.1%) while the least was observed in LI (16.6%).

Major Findings and Conclusion

An analysis of 1000 fingerprint patterns was conducted among a random student population of Mangaluru city. The samples included 50 female and 50 male participants. No participant was compelled to give their samples and no consent form was issued.

Analysis of the whorl patterns found in both male and female populations, right and left hand separately the following were the salient features of the study.

a. 1000 fingerprint were collected in the study from which 500 belonged to female and 500 belonged to males. From this total only whorl patterns were selected and were further analyzed.

b. The total number of whorl patterns found in the female population was 197 (39.4%) and those that were found in the male population consisted of 18.8 percent (94) of the total pattern distribution. (with reference to (Table 1)

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c. The number of whorls found in the right hand of female population was 99(39.6) and that of male was 55 (22%). The number of whorl patterns found in the left hand of female population was 96(38.4%) and that of male was 41(16.4%).

Comparison of Male and Female Whorl patterns found on the Right Hand

i. It was observed that among the rotation of ridges parameter, the anticlockwise rotation was more in the female population (92.9%) than that of the male population (78.1%) and was predominantly seen in RL finger in female and RT in males.

ii. The clockwise rotation was seven percent in females and mainly in RI while it was 21.8percent in males and mostly seen also in RI finger

iii. 65.6 percent of the female population displayed a greater angle towards the right while 49 percent of the male population displayed the same, among which majority of the samples were seen in RM and RL in females and males respectively.

iv. Greater value of greater angle towards the left was observed in the male population (27.2%) while the female population consisted of 17.1percent. the parameter under consideration was mostly seen in the RI of both female and male population.

v. Equal angles were observed in highest proportion the male population (23.6%) while the female population consisted of 17.1percent. the majority of the characteristic was observed in the RM in males and RL in females.

vi. The position of the bisector towards the right of the core was detected amongst the male population (16.3%) highest in the RI while only 13.1 percent was found in the female population highest in the RM finger.

vii. Position of the bisector towards the left was majorly seen the female population (66.6%) mainly in RL while 60 percent in the males displayed the same mainly in RL.

viii. Centralized bisector was mainly observed in the male population comprising of 23.6 percent and 20.2 percent in female population, both populations predominantly showing the parameter in RI.

ix. Outer tracing was observed in greater value in the female population (62.6%) while 52.7 percent displayed the same in the male population with the highest values observed in the RM and RL for females and males respectively.

x. Meeting trace was higher in the female population 20.2percent, mainly in RI and the male population showed 14.5 percent, mainly seen in RR.

xi. Among inner tracing, higher value was seen in the male population especially in RI while 17.1 percent in the female population displayed inner tracing mostly in RI.

xii. A higher left ridge count was seen in the female population (78.7%) mainly in RT while among 56.3 percent of the male population displaying the character highest value was seen in RL.

xiii. A higher right count was seen male population (43.6%) and 21.2 percent in the female population. Both populations mainly expressed the character in RI.

xiv. A higher position of the Right delta was seen in 57.5 percent of the female population highest in RM and 54.5 percent of the male population highest in RL.

xv. Left delta was higher in female population 20.2 percent and mostly seen in RL while among the 16.3 percent of the male population RI displayed the highest value.

xvi. Among the equally leveled or indistinguishable positions of the delta, 29 percent of the male population displayed higher value in RM and admits 22.2 percent of the Female population, greatest value was observed in RR.

a. Comparison of Male and Female Whorl patterns found on the Left Hand

xvii. It was observed that among the rotation of ridges parameter, the anticlockwise rotation was more in the female population (12.5%) than that of the male population (9.75%) and was predominantly seen in LR finger in both female and male population.

xviii. The clockwise rotation was 90.2 percent in males and mainly in both LT and LL while it was 87.5 percent in females and mostly seen LM finger.

xix. 14.5 percent of the female population displayed a greater angle towards the right while 19.5 percent of the male population displayed the same, among which majority of the samples were seen in LI and LT in female and male populations respectively.

xx. Greater value of greater angle towards the left was observed in the male population (58.5%) while the female population consisted of 67.7 percent. The parameter under consideration was mostly seen in the LR of male population and LL of female population.

xxi. Equal angles were observed in highest proportion the male population (21.9%) while the female population consisted of 17.1percent. The majority of the characteristic was observed in the LL in males and LT in females.

xxii. The position of the bisector towards the right of the core was detected amongst the male population (43.9%) highest in the LI while 63.5 percent was found in the female population highest in the LL finger.

xxiii. Position of the bisector towards the left was majorly seen the male population (24.3%) mainly in LT while 16.6 percent in the females displayed the same mainly in LT.

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xxiv. Centralized bisector was mainly observed in the male population comprising of 31.7 percent and 19.7 percent in female population, highest value for male population was in LL while it was in LI for female population.

xxv. Outer tracing was observed in greater value in the female population (19.7%) while 17 percent displayed the same in the male population with the highest values observed in RI for both female and male populations.

xxvi. Meeting trace was higher in the male population (24.3%), mainly in LI and the female population showed 13.5 percent, mainly seen in LI.

xxvii.Among inner tracing, higher value was seen in the female population (66.6%) especially in LL while 58.5 percent in the male population displayed inner tracing mostly in LL.

xxviii. A higher left ridge count was seen in the male population (24.3%) mainly in LI while among 17.7 percent of the female population displaying the character highest value was also seen in LI.

xxix. A higher right count was seen female population (82.2%) and 75.6 percent in the female population. Higher count was seen in LL in female population and LR in male populations.

xxx. A higher position of the Right delta was seen in 19.5 percent of the male population highest in LI and 13.5 percent of the female population highest in LI.

xxxi. Left delta was higher in female population 61.4 percent and mostly seen in LM while among the 43.9 percent of the male population LR displayed the highest value.

xxxii.Among the equally leveled or indistinguishable positions of the delta, from 36.5 percent of the male population, most displayed higher value in LT and admits 25 percent of the Female population, greatest value was observed in LL.

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