Project report

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A comparative study of the toe print and fingerprint distribution in indo Mongolian race

Submitted in Partial Fulfilments of the Requirement for the Degree of
M.Sc. Forensic Science

Submitted by

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GALGOTIAS UNIVERSITY
(Established under Galgotias University Uttar Pradesh Act No. 14 of 2011)

May 2020

CERTIFICATE

This is to Certify that Mr.**Himjyoti Sarma** has carried out his project work entitled "**A comparative study of the toe print and fingerprint distribution in indo Mongolian race**" under my supervision. This work is fit for submission for the award of Master Degree in Forensic Science.

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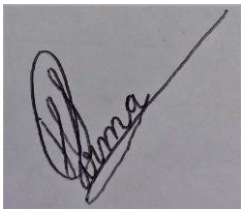
CANDIDATE DECLARATION

I hereby declare that the dissertation entitled "**A comparative study of the toe print and fingerprint distribution in indo Mongolian race**" submitted by me in partial fulfillment for the degree of M.Sc. in Forensic Science to the Division of Forensic Science, School of Basic and Applied Science, Galgotias University, Greater Noida, Uttar Pradesh, India is my original work. It has not been submitted in part or full to this University of any other Universities for the award of diploma or degree.



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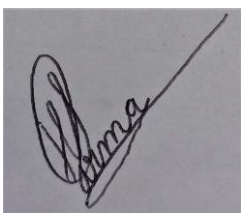

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LIST OF ABBREVIATIONS

Radial loop	-	RL
Ulnar loop	-	UL
Fibular Loop	-	FL
Tibial Loop	-	TL
Single Spiral Whorl	-	SSW
Double Spiral Whorl	-	DSW
Concentric Whorl	-	CCW
Central pocket loop whorl	-	CP
Twinned loop	-	TwL
Accidental	-	ACC
Tented arch	-	TA
Plain arch	-	PA
Exceptional arch	-	EA
Left little finger	-	LLF
Right little finger	-	RLF
Left ring finger	-	LRF
Right ring finger	-	RRF
Left middle finger	-	LMF
Right middle finger	-	RMF
Left index finger	-	LIF

Right index finger	**- RIF**
Left thumb	**- LTh**
Right thumb	**- RTh**

PROJECT SUMMARY-

The project was done with the objective of finding important characteristic features of Fingerprint and Toe print which would give us the basic idea of distinctiveness among them. The following points were being noted-

- Fingerprint patterns are present within the anterior portion of distal phalanx(toward the palm) whereas the visible features of toes is present within the posterior portion of lower distal phalanx.
- Distribution order for hand is loop, whorl, composite, arch whereas distribution order for foot is loop, arch, composite, whorl.
- In the right hand the distribution pattern shows loops with 59.5%, whorl with 25%, composite with 10.5% and the least with arches having 4.1%. In the left hand the prints also are arranged in the same way as the right hand. The arrangement follows as loops with 60.8%, whorl with 23.2%, composite with 10% and the least with arches having 5.8%.
- Distribution pattern of right foot shows that loop constitute 60.2%, arch constitute 28.3%, composite constitute 7.5% and whorls constitute 4%.and the pattern composition of left foot follows- loops with 50.6%, arches with 34.6%, composite with 10% and whorls with 4.8%
- While determining the pattern distribution among males and females, the loop patterns are considered to be the predominant type of pattern. In males, the composite and arch are the second last and least common type of patterns
- There appears to be an inverse relationship between the occurrences of whorl and arches in toes and fingers. As generally in fingers, the indices of arches decreases with elevation of whorl frequency
- True whorls and central pocket is less abundant in toes.
- The distribution of maximum and minimum pattern type frequencies differs significantly at some points existing in toes and fingers.
    a) The maximum frequencies of whorls in finger is mostly concerned on digit iv while in toes the patterns are more concerned on digit III

b) The maximum frequencies of ulnar(fibular) are in finger v and in toe II
c) Arches are concentrated in finger v and in toe II
d) The maximum frequency of composites in finger occurs in digit I and digit IV.While in toes it occurs mostly in iv and digit II

- The average ridge count of all fingers is 14.5 ± 0.56 and for all toes 11.4 ± 0.63.
- The sequential of ridge count, for all configuration including the arches are- fingers: I>IV>V>III>II ;toes: III>I>II>IV>V.

CHAPTER I
INTRODUCTION & OBJECTIVE

OBJECTIVE-

- The necessity of devising means of identifying criminals, notwithstanding any precautions they may take to conceal their identity, has led to the introduction of Finger Print System and Toe Print System. This system is based on two special features viz. persistency of papillary ridges on the palmer surface of the hands and Distal-phalangial surface of the feet of the human beings and individuality of enormous variety of ridge peculiarities in their relative positions in different individuals.

- With a view to check the recurrence of crime by the same person, law provides enhanced punishment. Criminals frequently use different names to avoid identification when arrested for repeating crime. To have a sound check against such persons and to establish identity of criminals, Finger Print System and Toe-print collecting system has been adopted.

- Creation of Toe print collection format for the symbrachydactyly or leprosy victims that do not have good fingerprints to identify them with. Therefore, it is vital to expand the study beyond the data collection alone and so classification and distribution are important

INTRODUCTION-

Dactylography deals with the scientific interest and sensible value in regard to the lineation among the skin on the finger and toes rather than the hands and feet. The Greeks used the term δάχτυλοτων ποδιών (dáchtylo tou podio', finger of the foot) for a toe; and the toes are almost of the same importance to dactylography and present similar patterns for study.[1]The identification of a person can be done using toe print in the same way as that with fingerprint. A dactylographer uses the upper skin layer folding for their studies. The study of toe and finger usually involve reading the ridge pattern present in the tip of the phalanges. The patterns can never be altered throughout life except by destruction of the true skin. The ridges emerge on the fingers first, then on the palms or soles. Fingerprints and toe prints are genotypically determined. Ridge pattern is made by constant regulation and physical attachment of cells by proliferation and differentiation. But the distinctiveness of the ridge is established due to developmental noise. Friction ridges begin to form at about 10.5 weeks of estimated gestational age (EGA). Volar pads start to relapse and friction ridges grow until about 16 weeks of EGA, when the minutiae become set. Sweat glands mature and conjointly the epidermal–dermal ridge system continue to mature and grow in size. By the end of the 2ndtrimester, sweat ducts and pores form along the dermal ridges and conjointly the foetus begins to endure even a lot of rise.[2] These ridges and furrows by their arrangement form different patterns that are constant and persist throughout life and the patterns are arch, loop, whorl and composites. The print patterns of the skin of the toes are as particular, individualistic and changeless as those of fingers.Like finger prints, skin pattern of toes are distinctive and permanent and may provide identity as well. Although, like fingerprints the toe prints are also specific for every individual, only a few correlation of the pattern with each other is yet established. Due to its constancy and specific individuality the patterns that are

left at the scene of crime gives an immense effective clue about the suspects of the crime. [3][4] The FBI (USA) has White fingerprint distribution databases on the net. The distribution shows the data by percentage of the three main classes of fingerprints consistent with the categories. This can afford an indebt fingerprint analysis and can also increase the speed of the storage/retrieval process for the bulky fingerprint database. [5] the percentage was found to be constant for any random selection of the fingerprint betting on anyplace or position within the USA. In that way, this experiment was designed to administer us a similar way of statistical data for indo-Mongoloid race which might be constant among similar population. [6][7]

CHAPTER 2- Literature Review

2.1 HISTORY OF DERMATOGLYPHICS

Joannes Evangelista Purkinje, a physiologist and scientist in 1823 was appreciated for his Scientific breakthrough for the discovery of papillary ridges of the hands and feet .(8) Fingerprints had pulled in Grew,(9) Bidloo,(10) Malpighius(11) as some time in the past as 1680's. Cummins and Midlo notice Hintze, Albinus, Mayer, Schröter, and Bell.(12) But the main endeavor of systematic categorization of fingerprint patterns is mentioned by Purkinje. He utilized a nine pattern classification.Until 1880,little was comprehended.Then two papers by Henry Faulds and W. J. Herschel showed up which suggested the utilization of fingerprints for individual identification.(13) Herschel detailed utilizing this strategy for individualization in India. Faulds reported his enthusiasm for fingerprints dated from discovering impressions of them on old Japanese ceramics.In the year 1892, Sir Francis Galton published his exemplary settlements on fingerprints.(14) While a lot of Galton's work was coordinated towards identification of unique fingerprint impression, he additionally sought after the subject as a scholar keen on expanding Purkinje's nine finger designs in his own classification of the fingerprints and the hand. He begat various new terms in the field.(15) He additionally investigated the heriditary details of fingerprints, examining correlations of kins, twins and hereditarily irrelevant people and was the first to report concordance of papillary ridge designs among family members. This opened the field as a helpful instrument in human anthropology. Dermal palmer and plantar edges are profoundly helpful in natural investigations. Their remarkably factor attributes are not copied in others, even in monozygotic twins or even in a similar individual. Since dermal ridges are found on various creatures, it will be fascinating to see whether dermal ridge are duplicated in cloning.

The subtleties of these dermal details are perpetual. However while the individual attributes are variable, that assorted variety falls within pattern limit that allowed methodical classification.(16) In the mid twentieth century an American, Harris Hawthorne Wilder, spearheaded far reaching investigations of the system, inheritance and racial variation of palmer and grower papillary edge designs just as fingerprints. He started to distribute a progression of papers regarding these matters in 1902 and proceeded with distribution through 1916. These spoke to the principal investigation of palmer and plantar dermatoglyphics.(17) His significant other, Inez Whipple-Wilder distributed the investigation of non-human epidermal ridges in 1904.(18) Further significant hereditary investigations of fingerprints in the primary quarter of the twentieth century were made by the Norwegian Kristine Bonnevie distributing in 1924.(19)

The second quarter of the twentieth century, the field was overwhelmed by Harold Cummins, at some point educator of Microscopic Anatomy at Tulane University. In 1926(20)he begat the word dermatoglyphics and utilized it at the yearly gathering of the American Association of Anatomists. It shows up around the same time in a paper composed with his partner Charles Midlo(21) That term, dermatoglyphics, is utilized to this date in portraying the scientific fields of investigation of the palmer and plantar edges of the hands and feet. In 1929, he along with others, including Midlo and the Wilders, distributed one of the most generally referenced papers on dermatoglyphic strategy to date.(22) Over the years, only he and with partners, distributed various investigations in the field just as his now acclaimed 1943 book, Finger Prints, Palms and Soles, a book of scriptures in the field of dermatoglyphics,(23) which he committed to the pioneer Harris Hawthorne Wilder. Cummins was keen on psycology reflected by the hand. When of his 1943 distribution he knew the tasks by dactologists. Dactylomancy was the act of foreseeing the human condition and the future as per the quantity of whorls and loops on the fingers of the subject. Either Cummins or Midlo had this done in 1935. It is intriguing to note for our future investigations that the dactologist who read one of those writers related whorls to 'constancy, endurance and perseverance.'(24) The writers inferred that character and personality likely could be connected to dermatoglyphic perceptions. They quote both Takashima and Kojima concerning character qualities found in relationship to fingerprints.(25)

After Cummins and Midlo, established researchers appears to have neglected the contribution of the fingerprint readers. Palmistry fortune teller, otherwise called cheirologists, were excused in 1973 by L. S. Penrose, a goliath in the field in the second from last quarter of the twentieth century, since he accepted that they utilized the fine dermal ridges which shaped the premise of the study of dermatoglyphics.(26) Penrose was in mistake, however his blunder might be the

reason we see little effect from the investigations of 'cheirologists' on work of the researches of dermatoglyphics. The understudies of hand prescience have since quite a while ago examined the essentialness of dermatoglyphic designs. Mavalwala(27) depicts a two volume Japanese original copy by Ashizuka-Sai Shofou dating from 1820 that rundowns thirty-two distinct kinds of whorls and their occurrence in different mixes on the five fingers. There is a long history in India and China of the utilization of fingerprints as signs or characteristics or character qualities. Old stories from the two India and China have customs of perusing certain properties or capacities from fingerprints. Before we become interested at the propensity to discover importance in the checked number of prints, we note that such a methodology is frequently utilized in logical investigations of the fingerprint for significant connections of fingerprints as hereditary and additionally constant wellbeing markers. So while the ends attracted Chinese and Hindu people ways might be interesting, their techniques for investigation despite everything endure.As a matter of fact, present day examiners of Palmistry had been showing an interest for the dermal edges since the turn of the twentieth century. Comte de Saint-Germain distributed perceptions on the relationship of palmer apices (triradii) and distal mounts in 1897-98.(28) (See figure 3) William G. Benham, the prominent American palmist, wrote in his treatise regarding the matter distributed in 1900 that the dermal ridges that shaped a zenith under each finger could be utilized to locate the specific focal point of each mount under the fingers and in the event that it was dislodged under the finger, that displacement could be utilized to show impacts regarding the individual's character.(29) Apparently as he described that he hadn't understood that occasionally there may be two apices under fingers and at different occasions no apices would be found. A peak is referred to in dermatoglyphics as a triradius. The FBI calls the triradius the delta, as have various unique mark.(30)

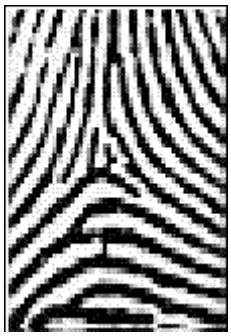


Figure 2.1.1-Triradius

By the 1930's the English palmist Noel Jaquin, originator of the Society for the Study of Physiological Patterns, (SSPP)(31) was reading character characteristics for five distinctive unique finger impression designs, the loop, whorl, arch, tented arch and composite.(32)(33) Vera

Compton proceeded with these investigations and distributed her perspectives in 1951.(34) Yusuke Miyamoto proposed character quality acknowledgment dependent on his comprehension of some eastern methods of reasoning and different sorts of fingerprints in 1963.(35) Byrle B. Hutchinson announced in 1967 that the SSPP had gathered a library of prints in its endeavors to help the translation of these markings.(36) She further deciphered dermatoglyphic markings dependent on these records and her own broad observations.(37) Dr. Eugene Scheimann, M.D. referenced them in his work of clinical palmistry in 1969.(38) Seven years after Hutchinson's work, the initial two works of the American, Beverly C. Jaegers, showed up in 1974 talking about her own discoveries on mental attributes demonstrated by dermatoglyphic markings of the hand.(39) Fred Gettings(40) likewise examined the subject in 1965.

2.1.1 DERMATOGLYPHIC DEVELOPMENT

Prior scientific discoveries related dermatological stamping improvements to the initial four months of incubation, as indicated by Dr. Eugene Scheimann, M.D.(41). or on the other hand in the subsequent trimester as indicated by Dr. Theodore J. Berry, M.D., F.A.C.P.(42) Schaumann and Alter(43) depict the procedure all the more precisely and in detail as occurring from the get-go in fetal turn of events and being hereditarily decided while being changed by natural powers as exemplified by presentation to Rubella(44) and Thalidomide(45). As indicated by Schaumann and Alter, the procedure of dermal edge development starts with the arrangement of fetal volar pads. These are hill molded arrangements of mesenchymal tissue raised over distal metacarpal bone on each finger, in the interdigital territories just beneath the fingers, and on the hypothenar and thenar regions of the palms and soles. Secondary cushions are found in different zones, for example, in the medial region of the palm and on the proximal phalanges. The fingertip arrangements of volar pads are first noticeable in the 6th to seventh week stretch of advancement. William J. Babler shows the epidermal edges initially show up as restricted cell multiplications around the tenth to eleventh week stretch of incubation. These expansions structure shallow layerings that venture into the epidermal layer of the dermis. The quantity of ridges keep on expanding, being shaped either between or as contiguous existing ridge. It is during this time of essential edge arrangement that the characteristic designs are formed.(46) At around 14 weeks the essential edge arrangement stops and optional edges start to shape as sweat organ anlagen develop along the apices of the essential edges at uniform interims. Right now the epidermal edges initially start to show up on the volar surfaces. The dermal papillae are accounted for to create in the valleys between the ridges on the profound surface of the epidermis around the 24th week. Up to that point the morphology of essential and auxiliary edges shows up

as a smooth edge of tissue and from that point peg like structures, the dermal papillae, normal for the authoritative dermal ridges are continuously formed.(47)

Babler reported that there is a connection between the volar pad shape and the epidermal ridge design, explicitly limited volar pad identified with whorl designs. There was likewise a recommendation of relationship between the state of the distal phalanx and the example type and noteworthy connections between's the hard skeleton of the hand and the epidermal edge measurements. On the off chance that is likewise proposed that the fundamental hard skeleton connects with the edge setup. Additionally, time of solidification might be a key factor in ridge patterning.(48) It had been accepted that the basic time of improvement of ridge development started in the embryo of around 70-mm crown-back end length, or around 12 weeks of age.(49) However, we accept this must be set at an impressively before time. The volar pad become obvious around the sixth to seventh seven day stretch of gestation.(50) Also, clinical proof backings the finding of curve designs with abbreviated distal phalanges or short fingers due to the shortening of their hard parts (brachytactyly).(51) Brachymesophalangia-5 (short-center phalange) has been recognized as ahead of schedule as 41 mm Crown Rump Length development of the baby (preceding the tenth week) and before the arrangement of the epidermal ridges.(52) More as of late Babler showed that solidification of the distal phalanges seems to assume a key job in epidermal edge setup and that any relationship of example type with the length of phalanges might be identified with the hardening procedure of the distal phalanges as opposed to their size.(53) As ahead of schedule as 1929 K. Bonnevie had theorized that unique mark designs were reliant upon the basic course of action of fringe nerves.(54) W. Hirsch and J. U. Schweichel summed up feeling up to 1973 and called attention to the course of action of veins and nerve combines under the smooth epidermis that exists in the blink of an eye before glandular folds. They estimated that the folds were actuated by the vein nerve pairs.(55) They portray an alternate and longer advancement of the dermal edges some of which might be post natally concluded.(56) They presume that example of papillary edges is set after the improvement of the glandular folds, and along these lines following four months, in spite of the fact that the development example of the glandular folds are one of the three powers hypothesized to control the last exceptionally orchestrated surface example. the glandular folds

become detectable in the fourth month. So we have an example of advancement of edges from perhaps as ahead of schedule as the tenth or eleventh seven day stretch of growth and not being set until after the forward month of development and not obvious on the outside of the skin until after the 6th month of incubation with some conceivable minor post natal changes as crease folds.

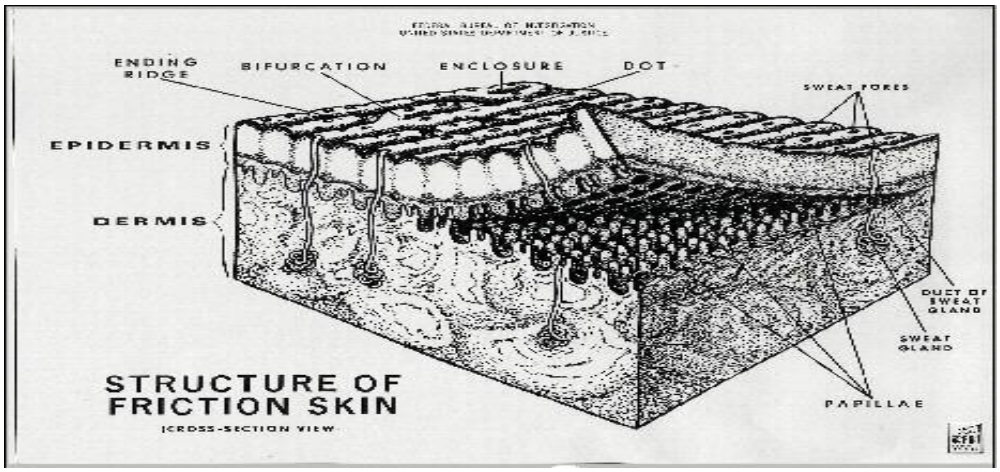


Figure-2.2.1

Hirsch and Schweichel, supra., emphasize that the neuro epithelium plays an important part in the development of the dermatoglyphic patterns. Numerous aberrations of these patterns are recorded as developed in cases where the nervous tissue has been damaged during embryological development. At that time it was still impossible to posit a casual for the occurrence of any particular pattern alteration in association with either chromosomal anomalies or other clinical syndromes. But even then the authors offered these explanations:

1) failure of nerves to grow into the epithelium may be expressed through dermatoglyphic aplasia (failure to develop);

2) Both qualitative and quantitative deviations of sub epithelial nerve branches to form may be evidenced by dermatoglyphic dysplasia (abnormal development); and

3) Where dermatoglyphics are distorted, there may be a disturbance of the spatial arrangement.(57)

By comparison, the neural tube that will develop into the central nervous system and neural crest from which the peripheral nervous system will develop, appears during the third week of gestation. By the fifth week, three main subdivisions of the central nervous system, the forebrain, midbrain and hindbrain are evident.(58) We have speculated on a number of factors that correlate the palmer patterns with the development of the nervous system and account for those patterns being reflective of behavioral reactions. Skin cells and the entire vertebrate nervous system develop from the outer most layer of the early embryo, the ectoderm. The nervous system

first appears as a thickened column of epithelial cells known as the neural plate. Shortly after it forms it begins to differentiate along its anterior-posterior axis and folds into the neural tube. During this process the primitive forebrain and midbrain begin to form in the anterior section of the tube while the hindbrain and spinal cord begin to develop to the posterior portion of the tube. What controls this regional identification of the neural plate? Apparently this is controlled by adjacent mesoderm,(59) the precursor of bone, connective tissue, muscle, blood, vascular and lymphatic tissue as well as the pleurae of the pericardium and peritoneum. This has given rise to the theory that normal development of the nervous system is induced by cells of a special region that has been called the organizer. Recently, in confirming this theory in frogs, two proteins, noggin and follistatin, have been identified with inducing the neural development process. After the induction of the neural plate by signals from the organizer region those cells can then differentiate into neurons and glial cells. After the regional identification of the neural plate, the mesodermal tissues continue to impose organization on the sensory and motor axons in the spinal cord, but segmentation of the hindbrain, and perhaps the midbrain and forebrain are presently believed to result from intrinsic cell reactions within the neural tube.(60) A number of congenital problems have left their marks on both the brain and the hand. Examples of such associations are the significant increases in palmer single flexion creases ("simian line") and Sydney creases (distal or proximal transverse crease that completely crosses the palm) and mental retardation in a Down syndrom, missing interphalangeal flexion creases in mentally retarded individuals, and "sandal" plantar creases on the soles of those with Down syndrome and Rubinstein-Taybi syndrome.(61) Elevated incidence of Sidney creases have also been observed in children with delayed development, learning difficulties, or minor behavioral problems.(62) Elevated incidence of Sidney lines have also been observed in leukemia,(63) and in environmental congenital rubella and possibly cytomegalovirus.(64) Other environmental effects were noted to the hand and the palmer creases caused by or related to chemical agents thalidomide, methadone and alcohol.(65) The latter is also related to mental retardation. Any changes to the normal incidence of transverse creases (Sidney, simian lines and interrupted transverse creases), will occur very early in pregnancy. By about the eighth week of gestation the thenar crease becomes visible starting on the radial side of the hand between the thumb and index finger. Around the ninth week of gestation, the metacarpophalangeal creases (between the palm and the fingers) are visible and the distal interphalangeal crease barely is visible. The thenar crease continues to be visible. As we progress into the tenth week the proximal interphalangeal creases start to become visible. The 12th week brings signs of the distal transverse crease across the palm starting under the area between the index and middle fingers to later extend to the ulnar margin of the palm. By

the thirteenth week both the distal and proximal transverse creases are becoming visible and after the 14th week of gestation at the 15th week all palmer creases can be clearly seen. The onset for spontaneous movement of the hand has not been reported until about the middle of the 11th week of pregnancy and fetuses are reported to begin to tightly grasp at 16 to 20 weeks.(66) It would therefore appear that the palmer creases are genetically rather than mechanically induced. It is also interesting to note that Hale observed that dermal ridge differentiation also advances "progressively from the apical pads proximally and in the radio-ulnar (or tibio-fibular) direction."(67) We find in interesting to note that the progress of the development of these creases is from the radial to the ulnar side of the hand. We would suspect that Hales observations of similar development of fingerprints accurate, though we would believe that the development of the print on number 4 finger (the ring finger) may, at least at times, precede that of the print on finger three (the middle finger) because of the higher incidence of whorls on the ring finger as compared with the middle finger. However, this may be related to the size of the volar pads and the fact that the ring and index finger are often the same size. Still, one often finds whorls on the ring finger and not on the index finger. Ulnar loops are the most common finger print. And whorls are least common on the little finger and next on the middle finger. They are much more common on the thumbs, index fingers and ring fingers. Certain elevated frequency of patterns of the epidermal ridges have also been observed in relation to rubella, cytomegalovirus, and liquior embryopathy.(68) If this were to hold true in cases coupled with higher elevation of unusual early palmer creases, this could support a hypothesis of an earlier onset of any genetic factors involved in the formation of epidermal ridge patterns. The relationship of genotypes to phenotypes appears as one of the most promising current area of study to understand the correspondence of hand markings to neurophysiological development. Breakthroughs in the 1990's in the study of genetic conservation of sequence, equivalence of expression and functional homology not only cross species but also from cell to cell(69) are promising to furnish us with the actual shared messengers or triggers that are responsible for patterning of the neurological structures as well as the skin on the palm.We accept that both line and epidermal edge designing in the embryo might be firmly dependent upon the profoundly rationed qualities that have a place with the formative pathways which work in an assortment of various cells at various formative stages are not just acceptable contender for atomic imperfections hidden some multi-organ syndromes,(70) but at the same time are acceptable possibility for being associated with designing of the lines and edges. So we may look to homebox containing Pax qualities that may likewise be identified with determination of neural cell separation, or maybe the Sonic hedgehog (shh) and hepatocyte atomic factor-3 (HNF-3) which are both communicated in the notochord

and later in the floor plate.(71) The Hox qualities, or possibly their combinational articulation, that assume a job in the improvement of the spinal line and hindbrain advancement, may likewise play a role in the midbrain and forebrain.(72) The sonic hedgehog (shh), retinoic corrosive and its receptors and the homeobox qualities are additionally involved in the foundation of skin handle, that are additionally identified with very much characterized projects of example development in the CNS as well as in the hub skeleton, and the appendage buds.(73) The idea of formative field is additionally under current examination regarding both ordinary and irregular skin development.(74) Observations tolerating the presence of such fields interrelate anatomically unmistakable structures through co-ordinate improvement and, as a result of the massive substance of quality connection inside the field, a lot of tissues shaped in the beginning periods of early stage advancement can respond indistinguishably from various dysmorphogenetic causes. This might be the reason a few perceptions of line developments and dermatoglyphic examples can be identified with a few mental and states of being. This may assist us with bettering get when, in the formative procedure, real ordinary and unusual characteristics are set up in the subject.

2.2 FINGERPRINT

Essentially Skin of human fingertips comprises of ridges and valleys and they combinely forms the individual characteristics. At the hour of pregnancy these unmistakable patterns are completely evolved and are lasting all through the entire life expectancy. Those patterns are called fingerprints. From various looks into it has been seen that no two people have similar fingerprints, so they are novel for every person .in view of the mentioned characteristics, fingerprints are famous for biometrics applications. Unique mark coordinating recognition is an unpredictable acknowledgment issue so, Manual finger impression matching isn't just time taking yet specialists likewise sets aside long effort for instruction and preparing. Fingerprints have wonderful permanency and uniqueness for the duration of the time. From perceptions we reason that the fingerprints offer more secure and solid individual distinguishing proof than passwords, id-cards or key can give. Models, for example, PCs and cell phones outfitted with unique mark detecting gadgets for fingerprint based password protection are being implemented to replace ordinary password protection methods.A fingerprints are the most significant piece of human finger. It is experienced from the exploration that all have their distinctive fingerprints and these fingerprints are changeless for entire life. So fingerprints have been utilized for the scientific application and recognizable proof for quite a while. A unique finger impression is the sythesis of numerous ridges and creases. Fingerprints can't recognized by their edges and

wrinkles. It very well may be recognized by Minutia, which are some unusual focuses on the edges. Minutia is separated in to two sections, termination and bifurcation. Termination is likewise called ending and bifurcation is additionally called branch. Again minutia comprises of ridges and furrows. valley is additionally alluded as furrow.

Figure 2.2.1 Finger print image acquired by a Sensor

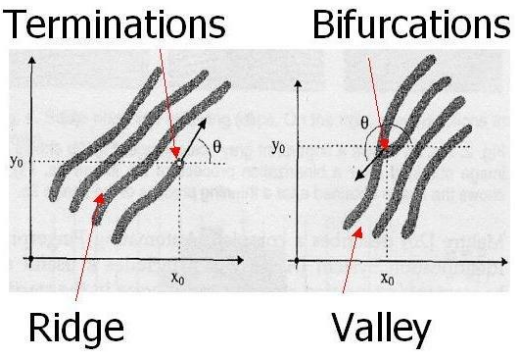


Figure 2.2.2 (Diagram of minutia)

2.2.1 Finger print recognition:-

The fingerprint recognition problem can be grouped into two sub-domains such as:-

i) fingerprint verification ii) fingerprint identification (Figure2.2.3).

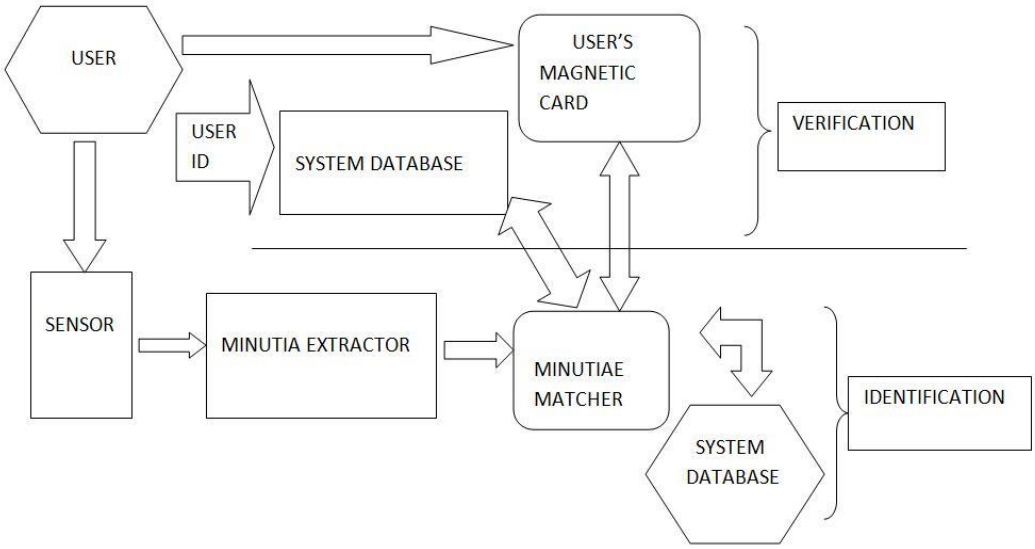


Figure 2.2.3

Fingerprint verification is the method where we compare a claimant fingerprint with an enrollee fingerprint, where our aim is to match both the fingerprints. This method is mainly used to verify a person's authenticity. For verification a person needs to put his or her fingerprint in to the fingerprint verification system. Then its representation is saved in some compress format with the person's identity and his or her name. Then it is applied to the fingerprint verification system so that the person's identity can be easily verified. Fingerprint verification is also called, one-to-one matching. Fingerprint identification is mainly used to specify any person's identity by his fingerprint. Identification has been used for criminal fingerprint matching. Here the system matches the fingerprint of unknown ownership against the other fingerprints present in the database to associate a crime with identity. This process is also called, one-to many matching. Identification is traditionally used for solve crime and catch thieves.

2.2.2 TYPES AND CODES OF FINGERPRINT PATTERN

The fingerprints of an individual are expressed by a 40-digit code, comprising of a 4-digit code for each of the 10 fingers of the individual, recorded in the conventional sequence from the right thumb to the left little finger of the 4-digit for each finger, the first two represent the pattern as listed below and the last two digits represent the ridge count of the print.

ARCH	-	Plain	..	01
	-	Approximating Radial Loop	..	02
	-	Approximating Ulnar Loop	..	03
TENTED ARCH			..	04
RADIAL LOOP	-	Plain	..	05
	-	Converging	..	06
	-	Nutant	..	07

ULNAR LOOP	-	Plain	..	08
	-	Converging	..	09
	-	Nutant	..	10
CENTRAL POCKET	-	Inner Tracing	..	11
LOOP	-	Outer Tracing	..	12
WHORL	-		..	15
TWINNED LOOP	-	Ascending Loop Radial	..	16
	-	Ascending Loop Ulnar	..	17
LATERAL POCKET	-	Ascending Loop Radial	..	18
	-	Ascending Loop Ulnar	..	19
ACCIDENTAL	-		..	20
SCARRED	-		..	21
AMPUTATED/MISSING	-		..	22

PATTERN **CODE**

2.2.3 PATTERN DEFINITIONS [75]

PLAIN ARCH CODE-01

In a plain arch pattern, the ridges extended from one side of the finger to the other without turning back, rising slightly at the centre, where the curvature looks like an arch.

Figure- 2.2.4

RADIAL AND ULNAR ARCHES - CODES 02 & 3

In some arch patterns, there is a delta or the appearance of a delta. When this happens no ridge must intervene between the `Inner' and `Outer' terminal. When the slope of the ridges is that of a radial loop, pattern is coded `02'. When the slope of ridges is that of Ulnar loop, the pattern is coded `03'.

TENTED ARCH - CODE 04

In some patterns of the arch type, the ridges near the middle may have an upward thrust, arranging the selves on both sides of a vertical spine (or axis) towards which adjoining ridges converge not necessary in equal proportions, and appearing as a tent in outline.

Figure- 2.2.5

PLAIN LOOPS - CODES 05 & 08

In a loop pattern one or more ridges recurve i.e. run back on their previous course, having a delta and at least one ridge intervening between the `Inner' and `Outer' terminals. There are two kinds of loops - Ulnar and Radial. A radial loop is so called because the ridges terminate in the direct of the radial bone of the forearm i.e. the ridges slant towards left in case of right hand finger and to the right in case of left hand fingers. An ulnar loop is so called, because the ridges terminate in the direction of Ulnar bone of the forearm in other words the ridges slant right towards right in case of right hand fingers, and left in case of left hand fingers. A plain loop is one which does not conform to the definite of a Nutant loop or converging loop.

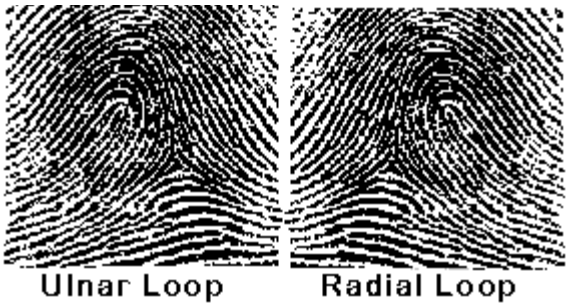


Figure- 2.2.6

CONVERGING LOOPS - CODES 06 & 09

A converging loop is one in which there is a visible convergence within the pattern area.

NUTANT LOOPS - CODES 07 & 10

In Nutant loops, the ridges about the summit of the core bend and drop in the direction of the delta.

CENTRAL POCKET LOOPS - CODES 11 & 12

This pattern can be described as in incipient whorl because a few ridges about the core possess features of the whorl type and the remaining ridges conform to the loop type. There must be no more than four recurving ridges intervening between the core and inner delta. Central pocket loops are classified as `Inner' or `Outer' tracing.

The count is obtained by counting between the core and the outer delta.

Figure 2.2.7

WHORL - CODES 13

In whorls, some of the ridges make a turn through at least one complete circuit. There are two deltas. It is grouped into 3 types- Concentric , Single Spiral and Double spiral Whorl.

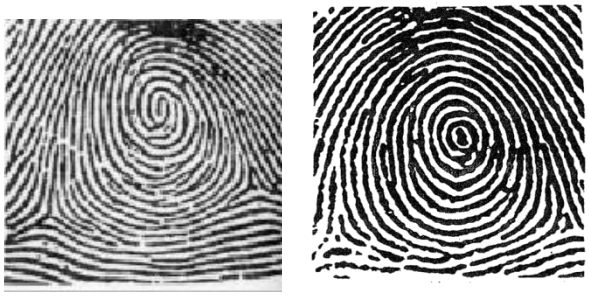


Figure- 2.2.8- Concentric Whorl and Spiral Whorl

TWINNED LOOP - CODE 16 & 17

Twinned loops possess two well defined loops which more or less embrace each other. A ridge must appear in the core of at least one of the loops when both loops are formed by a continuous unbroken ridge. There are two deltas on either side of the pattern. Twinned loops are sub-divided on Radial or Ulnar, taking into consideration the ascending loop.

When the ascending loop is of radial formation it is `twinned loop ascending loop radial' (Code 16) and when the ascending loop is of Ulnar formation it is `Twinned' lop ascending loop `Ulnar' (Code 17). When the loop-system is horizontal, the lower loop is considered as ascending loop and the classification is done accordingly.

Ridge counts are recorded between the core of the ascending-loop and its delta :

Figure 2.2.9- Twinned Loop

LATERAL POCKET LOOPS : CODE 18 & 19

In this type of pattern, the ridges constituting of the two loops bend sharply downward on one side before recurving thus forming a `Pocket'. This pocket is filled by the ridges of the other loop. Both deltas are on the same side of the ascending loop. Lateral pocket loops are

sub-divided `Ulnar' or `Radial' slope according to loop formation. The ridge counts are recorded between the core and delta of the ascending loop.

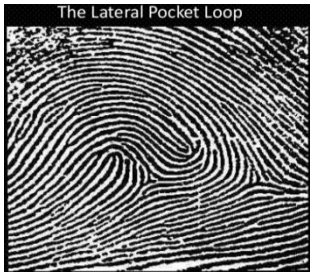


Figure- 2.2.10

ACCIDENTAL - CODE 20

This is a comparatively uncommon type of pattern being one of the more complicated, combinations of patterns, such as loop by loop whorl resting on loop, loop resting on whorl, whorl resting on whorl, arch with pocket etc.

UNUSUAL PATTERNS

The vast majority of patterns fall into the various pattern categories without any difficulty. Occasional patterns similar to those illustrated at the end of the chart have to be classified. It will be seen that the major part of such pattern conforms to a well defined pattern and it is only the periphery ridges that are out of order. To overcome this, the periphery ridges are ignored, and the pattern is classified accordingly.

SCARRED PRINTS - CODE 21

Common sense point of view must be adopted in the case of an impression revealing a scar. It may be of a temporary nature or permanent. It may or may not obscure the pattern and/or count. If the scarring is slight and does not prevent a realistic classification of the pattern and count, it should be ignored.Fingers with pattern wholly obliterated will be coded 21 with a zero count. If a finger is bandaged or otherwise not able to be printed its pattern must be coded as 21 with a count zero.

AMPUTATED FINGERS - CODE 22

Amputated fingers will be coded 22 with zero count.

2.2.4 Automated Fingerprint Identification System (AFIS) [76]

The Henry classification and its sub arrangements have demonstrated to be an unwieldy framework for putting away, recovering and looking for fingerprints especially as unique finger impression assortment extends. The manual methodology was the main practical way to deal with the support of unique finger impression assortment till the rise of finger impression innovation. Since 1970, innovative advances have made conceivable the arrangement and recovery of the fingerprints by PCs. The core of AFIS innovation is the capacity of a PC to filter and carefully encode fingerprints with the goal that they can be exposed to a rapid PC handling. The AFIS utilizes programmed filtering gadgets that can change over the picture of a unique mark into advanced details that contains information demonstrating edges (bifurcations).The relative position and direction of the particulars are additionally decided permitting the PC to store each unique finger impression as a carefully recorded geometric example. The PC search decides the level of connection between's the area and relationship of the particulars for both the inquiry and record prints. As such PC can make a huge number of unique mark examinations in a second.

During this quest for the match, the PC utilizes an examining framework that doles out prints to every one of the standards set by an administrator. At the point when the hunt is finished, the PC at that point creates a rundown of document prints that have the nearest relationship to look through prints. The last check is made via trained expert who will analyze all the prints. Before the AFIS police were normally limited to looking through wrong doing scene fingerprints against those of known suspects. Presently with the speed and exactness of ten fingerprints handling by AFIS it is conceivable to look through inert wrongdoing scene fingerprints against a whole record's print assortment database. AFIS has gotten a central change the manner in which criminal examiners work, permitting them to invest less energy and creating suspect records and additional time in researching the suspects produced by the computer.77

2.2.5 Methods of detecting fingerprints: [78]

Fingerprints are the most definitive types of physical evidence. All the objects at the scene of crime should be considered as possible evidence of fingerprints. Fingerprints left by the culprit at the scene of crime are known as "chance prints". These prints are left by the criminal unconsciously, and are rightly called as "burglar's visiting cards". There are three main classes of chance prints as described below:

Visible prints: These are the prints formed when fingers are smeared with some colored material such as paint, ink, dirt, blood or other visible material. Prints of this type are less often found, because the person who leaves them can easily see and take care to remove them. If by chance they are still found then they could be there as a result of haste or inattention. Prints of this nature do not need any development.They can be easily recorded by taking photographs with or without use of filters.

Plastic prints: These are generally found on pliable surface and are called plastic prints. Plastic prints are generally found on objects such as soap, mud, pitch, candles, thick dried blood, melted wax or paraffin, adhesives and so on. Prints of this nature can be photographed by angular illumination. Fingerprints on candle can also be intensified by rolling over them a thick layer of printer's ink by means of rubber roller and then taking a photograph.

Latent prints: The most important of the chance prints are the latent or invisible prints. The prints have very poor visibility and can be made clearly visible after suitable development. Latent prints are formed by the deposition of the colorless greasy substance from the palmar surface of the fingers. This greasy substance is formed out of perspiration, dirt, and oily matter from the face, hair, skin, tools etc which is carried by the fingers.

Locating latent print is obviously a much more difficult task and does require the utilization of technique that will visualize the print. The method of choice will depend on the type of surface that is being examined. Print found on hard and non absorbable surfaces e.g. glass, mirror etc are preferably developed by the application of the powder, whereas prints on the soft and porous surface like paper, cardboard, cloth needs to be treated with chemical.

Development of latent prints: There are two general methods for developing latent fingerprints, physical and chemical. Physical methods are based on the fact that perspiration and greasy matter retain certain substances without fusion e.g. powder dusting and iodine fuming. Chemical techniques alter the components of perspiration directly, causing a reaction giving rise to certain colouration e.g.: Ninhydrin and silver nitrate. Since a number of methods exist for the development, it is important to determine which method will give the best results.

Powder Development Techniques: [78]

A fingerprint developing is usually provided with black, grey and anthracene fingerprint powders. Some kits also provide silver, red and gold colour fingerprint powders.

Black powder: The basic ingredients of black powder are lamp black, graphite and charcoal.

Grey/ white powder: This give excellent result consists of mercury and chalk.Various other formulations like white powder consisting of titanium dioxide, zinc oxide and acacia are also available.

Red powder: Also known as Dragon's Blood is a finely powdered resin from the fruit of a palm that is used in the manufacture of zinc engravings. When a latent print is developed with dragon's blood and heat is applied to it, a fine print will appear.

Silver powder: The main ingredient of this powder is fine aluminium dust. In trace is used on hard surfaces, which are polished or varnished and on objects like feather, cellophane etc.

Fluorescence powder: When fingerprints have to be developed on a multicolored surfaces such as multicolored cartoons, magazine covers, calendars, tins etc, these powders are used. The developed prints are then removed to the dark room and exposed to ultraviolet light. The latent impressions fluoresce and can be photographed without any interference from the colored background.

How to apply the powder: [79]

A variety of techniques are used for the purpose of developing latent prints, the most popular being a camel or squirrel hairbrush. Ostrich feather brush is also quite popular. For successful development, powder is applied into a powder container and tapping powder on the developing surface. As powder is brushed over an area containing a latent print, particles adhere to greasy deposits. Only ridge patterns stand out from the contrasting background. Good results are obtained only when powder is applied sparingly. Brush strokes must be gentle. Once the outline of a pattern is seen, the brush movements are made along the flow of ridges. This helps in removing excess powder adhering between the ridges without damaging the ridges.

Magna brush development

This is a special type of brush powder technique. The powder used is essentially magnetic in character. The bristle less brush when brought near the powder attracts the dust to its tip. Later the brush is brought near the latent print. On releasing the magnetic contact the powder drops on the surface showing off the print. The method is quite inexpensive and it allows the development of latent prints on porous surfaces such as raw wood, leather, paper etc. it however cannot be used on metallic objects.

Chemical methods:

- Iodine fuming development
- Silver nitrate development
- Ninhydrin development

Iodine fuming development: This method for visualizing the latent prints is the oldest. This method is useful in porous surfaces such as paper, cardboard and plaster wall, where the fats oils of greasy prints get absorbed on the surface. When vapours of iodine are forced on the surface, fatty and oily deposits physically absorb the iodine fumes and the print gets developed to yellow-brown colour. The developed prints

should be photographed immediately as otherwise the prints fade due to the release of iodine from the prints. Iodine developed prints can be fixed with 1% starch solution. The print will turn blue and can be expected to last for several weeks to several months.[78]

Silver nitrate development: In a chance fingerprint, the grease and moisture will dissipate with the passage of time, but the salt from the perspiration persists indefinitely. If an aqueous solution of silver nitrate, about 3% is allowed to act on a latent print, a chemical reaction occurs between sodium chloride and silver nitrate producing a photosensitive silver chloride. The dried object when exposed to light source shows a dark developed print. The developed print can remain for many years. This method is particularly useful for paper, cardboard and even unpainted wood.[78]

Ninhydrin development: This method is fairly recent, very old prints, where the powders are not likely to adhere to the prints and the iodine fuming or silver nitrate development also are not likely to succeed, can be developed by this process. Ninhydrin reacts with amino acids present in human perspiration giving rise to absent pink or purple coloured print. The development of prints is hastened by application of heat. This has been used almost exclusively for prints on paper. This method should be used after the iodine method but before the silver nitrate process.[78]

Other methods of fingerprint development [79]

Laser method: Laser light has revolutionized the fingerprint technology. Laser method developed by Ontario provincial police and Xerox research centre in Canada. Laser takes the advantage of the fact that perspiration contains a variety of component that fluoresces when illuminated by laser light. It has been found that latent fingerprint residue contains a variety of organic substances like oils, paint and inks, which have inherent luminescence property.Using a continuous argon ion laser and observing through suitable filters, latent fingerprints show luminescence. These prints can be photographed using special filters. If inherent luminescence fails to detect latent fingerprint through lasers, the same can be treated with fluorescent material like coumarin-6 to give induced luminescence to latent fingerprint. Very old

prints even as old as ten years can be developed using laser method on surfaces like plastic, rubber, painted walls, paper, wood, leather etc.

The main advantage of laser beam over the conventional fingerprint development methods is its capability to develop latent prints that cannot be developed by any other method. It is highly sensitive method, and does not suffer from any time limitation. The developed prints show off markedly under laser source. This method is highly evolved and can become the method of choice to be followed by other conventional methods.

Photographic method: The prints obtained by this method are very clear, but because only areas in direct contact can be photographed the method has only limited value in dermatoglyphic analysis and is expensive.[80]Fingerprint matching has been used in Forensics and Criminalistics for over a century, and the last decade has seen an exponential increase in use of automated fingerprint recognition. Fingerprint recognition is an example of Biometrics. Biometrics is defined as the automated recognition of individuals based on physiological or behavioral characteristics. Fingerprint recognition is among the most widely used biometric systems.[81]

Fingerprint recognition is an important biometric technology and its use is increasing day by day. Fingerprint recognition is affected by several physiological factors like age, wear and tear of skin and technological factors like sensor technologies.[48]

Today, the use of computers for fingerprint matching and identification is highly desirable in many applications. Examples include building security systems and police work. In fact, despite the fingerprints representing unique patterns they possess some similarities in their structures, making the identification of complicated patterns difficult. A complete fingerprints identification system consisting of edge line detection, edge lines thinning, core point detection feature extraction and fingerprint image recognition and identification was introduced.[82]Ali, Al-Zewary proposed a new fast edge to trace ridge lines of the fingerprint images. Edge line skeleton method, based on edge point categorization, is also introduced. Fingerprint image core point was detected by adaptive technique; core is based in slicing the edge lines into four groups representing the four possible directions (i.e. vertical, horizontal, and two diagonals). A set of 34-measure features are proposed for recognizing and identifying fingerprint images.[83]

2.3 Toe Print[84]

Popular techniques toe printing is the process of obtaining, for identification purposes, an impression of the papillary ridge of the toes. Scant material relating to toe prints is available in the literature, but it is sufficient for comparison with the data on fingers. The most extensive analysis of toe prints is that of Takeya His material consists of 1000 Chinese. Another important contribution is the study by Newman It is based upon a much smaller number of subjects, 100 European American males but its value is enhanced by the conjoint analyses of toes and fingers of the same individual. Steffens investigates toe prints and finger prints in 100 pairs of twins (German), 50 pairs each of monozygotic and same sexed dizygotics, the sexes being in equal numbers in either group. She presents data not only embracing the total material but also for a series composed of one member from each pair, selected to eliminate possible vitiation of the statistics by the inclusion of twin partners. Hasebe(286) presents the frequencies of configuration types in toes of 100 Japanese males. The configurations of toes conform to the topography described for fingerprints, they present, moreover, the same basic types and the same manifestations of transition from one type to another and are subject to identical method of analysis. Only passing comment has been made with regard to pattern form and pattern size, and there is no information at all in reference to the middle and proximal phalanges

The frequencies of the basic types of patterns, in the four available collections, are listed as Whorls and tibial (radial) loops are less abundant than in fingers while arches are more frequent Comparisons of fingers and toes in the same racial populations demonstrate consistent direction of this intermembral difference. In Newman's collection of 100 European Americans whorls are 67% more frequent in fingers than in toes, and arches are nearly six times more abundant in toes than in fingers. Steffens' German series presents a whorl frequency in fingers which is 40% greater than that in toes, arches are 4 1/2 times more frequent in toes. Hasebe's Japanese series displays an even more striking difference in the same direction whorls being 2 1/2 times more abundant in fingers, and arches nearly 8 times more abundant in toes. The fingers of Japanese have a much greater abundance of whorls than do the fingers of European Americans or Germans, yet the toes of Japanese as compared with European peoples show a lesser number of whorls. Thus there appears to be an inverse relationship between the occurrences of whorls and arches in toes and fingers As is generally true in mass statistics of fingers, the incidence of arches decreases with elevation of whorl frequency.

2.3.1 Toe Print Recognition

Toe print-based identification is a new and prominent candidate that can be used in biometric authentication. In biometric authentication toe can be used to distinguish a person from his/her toe. Toe prints are well accepted as a biometric measure. Human toe print is used for personal identification in various applications [85]. Toe print-based identification is popular for the uniqueness and permanence of toe print. Toe prints are unique across toes of same individual. Even the identical twins having similar DNA have different toe prints [86].The biometric use of toe print uses ridge patterns for identification. Likewise in many respects to fingerprints and palm print identification. The unique pattern of lines can either be whorl, loop, or arch pattern. Valleys are the spaces or gaps that are on either side of a ridge. Minutiae are the important features of toe print, which are usually defined as the ridge endings and the ridge bifurcations [87, 88]. A ridge ending refers to the point, where a ridge ends abruptly. A ridge bifurcation refers to the point, where a ridge forks into a branch ridge. The toe print recognition and identification problem can be divided into two groups i.e. toe identification and verification [89 -92]. Toe print verification is use to prove the legitimacy of an individual by his toe print. In toe verification, the user provides toe print along with claim identity information. While toe identification refers to the recognition of a person from his/her toe with no prior knowledge about the person's identity and tries to match his toe print acquired image with those in the whole toe print database. Both verification and identification problem required well defined representation of toe images. For extracting geometrically features from the toe print and using those for toe print matching with available templates.Spectral features are extracted from the input toe image. These features are used to model toe of different users. In testing phase the toe is recognize using SVM classifier by using MFCC spectral features.

2. Experimental Setup

Since no standard corpus of toe images is available online, so the database is created by the authors using Futronic FS88 scanner.

A.Acquisition of Toe Images

The acquisition of toe images is a vital task in the development of database. Clear and noise free images will train the classifier properly and improve the recognition rate. For the acquisition of toe images Futronic FS88 scanner was used. The method proposed in

this paper is to find unique features from a toe image by using MFCC. The process has two phases.

a) Training Phase

b)Testing Phase

In training phase an image taken through scanner is lexicographically ordered into a 1D signal. Then features are extracted using MFCC and obtained features are used to train the SVM classifier. In testing phase the same procedure is repeated and the extracted features are fed to SVM for classification.

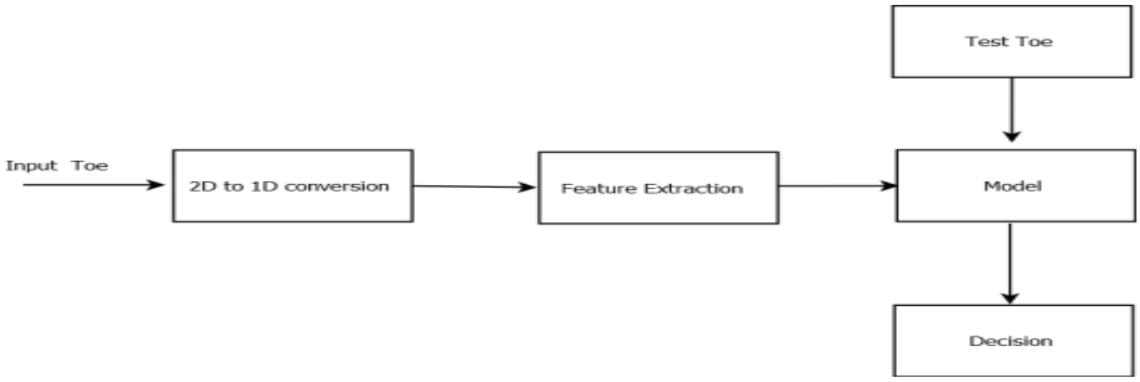


Figure 2.3.1 -Block diagram of proposed Model

All the steps of MFCC that is used in toe recognition are same that of used in speech recognition except the conversion of 2D image into 1D signal. After converting the image from 2D to 1D then MFCC is applied to extract the features. All the steps of MFCC are shown in Fig 2.3.2

B. Conversion to 1D- The first step is the conversion of 2D toe image to 1D signal using lexicographically ordered because MFCC work on 1D signal.

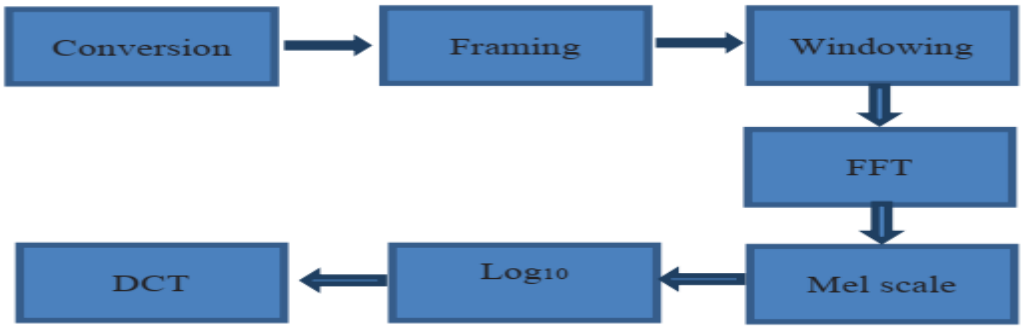


Figure 2.3.2- Block diagram of MFCC

C. Framing

In this step, the 1D signal is break down into small frames. The framing is done in order to get short time Fourier transform after applying Fourier transform on each frame. The frame size should not be large enough because the sudden changes in the frame will not be detected and it should not be small enough that no information is grasped. The frame size is kept 20ms to 30ms with overlapping of 50%. The sample per frame can be calculated as

$$N = F_S * T$$

Where N is number of frames, F_S is sampling frequency and T is time per frame.

D. Windowing

In time domain, windowing is the technique of multiplying a frame and window function. This technique is helpful to make the irregular edges at the start and end of frame smoothen. This helps in the reduction of high frequencies components. The output of a windowing signal is:

$$Y(m) = X(m) * W_n(m) \qquad 0 \leq m \leq N-1$$

Where Y(m) is the input signal, N_m is the samples in each frame and $W_n(m)$ is the hamming window. The hamming window is represented as:

$$W_n(m) = 0.54 - 0.46\cos(2\pi m/N-1) \quad 0 \leq m \leq N-1$$

The reason of using the hamming window is that it provide narrow main lobe and on the same time the side lobes are very low.

E. Fast Fourier Transform

In this step the Fast Fourier Transform (FFT) of each frame is taken in order to get short time Fourier transform (STFT). FFT transform the signal from time to frequency domain. Here DFT and FFT both can be used but since FFT is fast and easy to compute, so FFT is used in this method.

F. Mel Scale

STFT of a signal is passed through the Mel filter bank. Passing the signal through filter bank is equivalent to the approximation of energies present in the spectrum. To calculate this energy a triangular filter bank is used at each point. Triangular band pass filters are

used for this purpose and their spacing is given by Mel Scale. It is a scale between pitch and frequency and it shows that their relation is linear below 1 kHz and logarithmic above 1 kHz. The purpose of Mel Scale is designing the filters. It specifies the width of filters and spacing between them. The frequency can be converted to Mel using following formula:

$$Mf = 2594 \log_{10}(f/700 + 1)$$

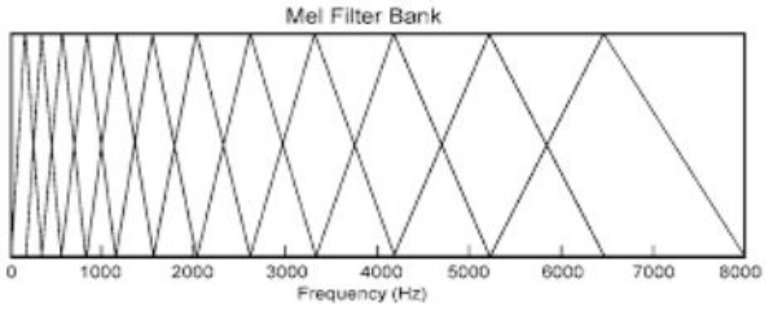


Figure 2.3.4- Mel Filter Bank

Filters in beginning are narrow to find the energy near 0 kHz and get wider with increase in frequency as shown in Fig 2.3.4 Properly spaced filters give the energy of signal at each point.

G. Logarithm

In this step, logarithm is applied on the output of Mel filter bank.

H. Discrete Cosine Transform (DCT)

In this final step, the signal is converted back to time domain from frequency domain. Also the log Mel spectrum coefficients are determined and compressed in this step. IFFT can also be used for this conversion but DCT is preferred due to its efficiency.

2.3.2 Toe print types

	**Plain Arch**
	**Tented Arch**
	**Fibular Loop**
	**Tibial Loop**
	**Twin Loop**
	**Whorl**

CHAPTER 3-METHODS AND METHODOLOGY

The present study was conducted in the Hengrabari locality of Guwahati City, Kamrup Metro District from 3rd of February to 20th of March.

Type of study**:** Prospective cross sectional study

A) Inclusion criteria:

Total subjects included were 78 Males and 28 Females of Indo-Mongolian race. Residents from Hengrabari locality were selected. Students and Staff members from Gauhati Medical College and population from in and around Kamrup Metro district were also included in the study. Subjects who were healthy and having normal hands and feet were included in the study.

B) Exclusion criteria**:**

Subjects where there was any evidence of injury of fingertips and Toe tips that leads to change in the fingerprint pattern (Leprosy, scars of the fingertips, lacerations); Evidence of Worn finger or toe prints; and Extra webbed fingers or bandaged finger are excluded from the study. Peoples who are not of Indo-Mongolian race were excluded from the study. Informed written consent was obtained prior to taking the fingerprints with proper procedure explained to the subjects.

Materials: The materials which were used for this study are as follows:

1) Violet Ink Stamp pad.
2) Hard board (23x36 cms).
3) Hand Lens.
4) Pencil.
5) Measuring scale.
6) Pro forma.

(NOTE -Prior to sample collection the subjects were required to wash their hand and feet thoroughly. The washed hands and feet should then be cleaned using a clean towel.)

Sampling Pro forma

Fingerprint Template-

Finger print collection was accomplished with the conventional card slip method that is normally used in forensic science laboratory. It consists of 10 equally sized square units. With each unit sizing around 3.3 x 3.3 cms. Each of this unit was used to take rolled print from the subjects chosen for study. This template has both characteristic of taking rolled print and plain print together which is to ensure that no mismatching should take place in any way. Although the presence of both type of print is necessary I have confined my work on taking only rolled print of people. For proper individualization and characterization of those prints I have also done naked eye confirmation along with basic recording procedure. This process is done so that it would save time and ink simultaneously.

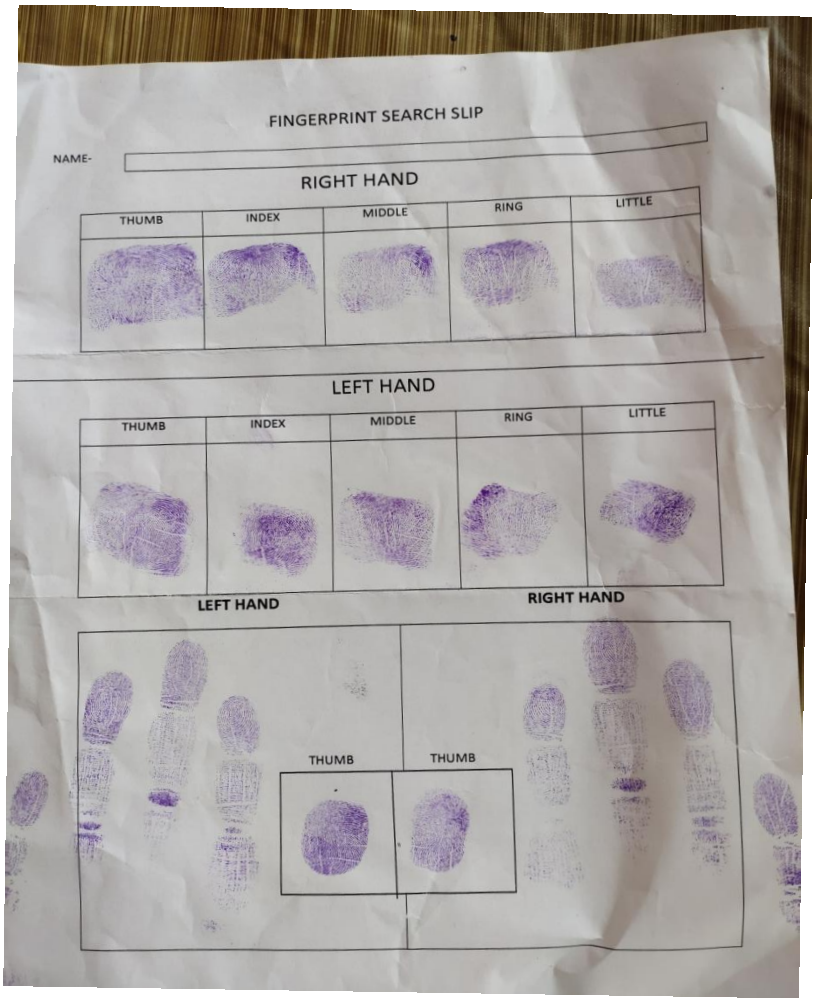


Figure-3.1- Fingerprint Sample

Toe Print Template-

Toe print collection was done on a self designed paper format. The template has 10 spaces where each of those spaces is allotted for toe print collection. In this print template I have limited my print collection only to rolled prints. The rolling of the prints is taken longitudinally from lower end to the upper end of the toe. This is exactly opposite the way the fingerprints are collected. Toe prints have their characteristic feature in the lower end of the phalanges. So taking the prints from lower end is very crucial if we were to see any visible feature.

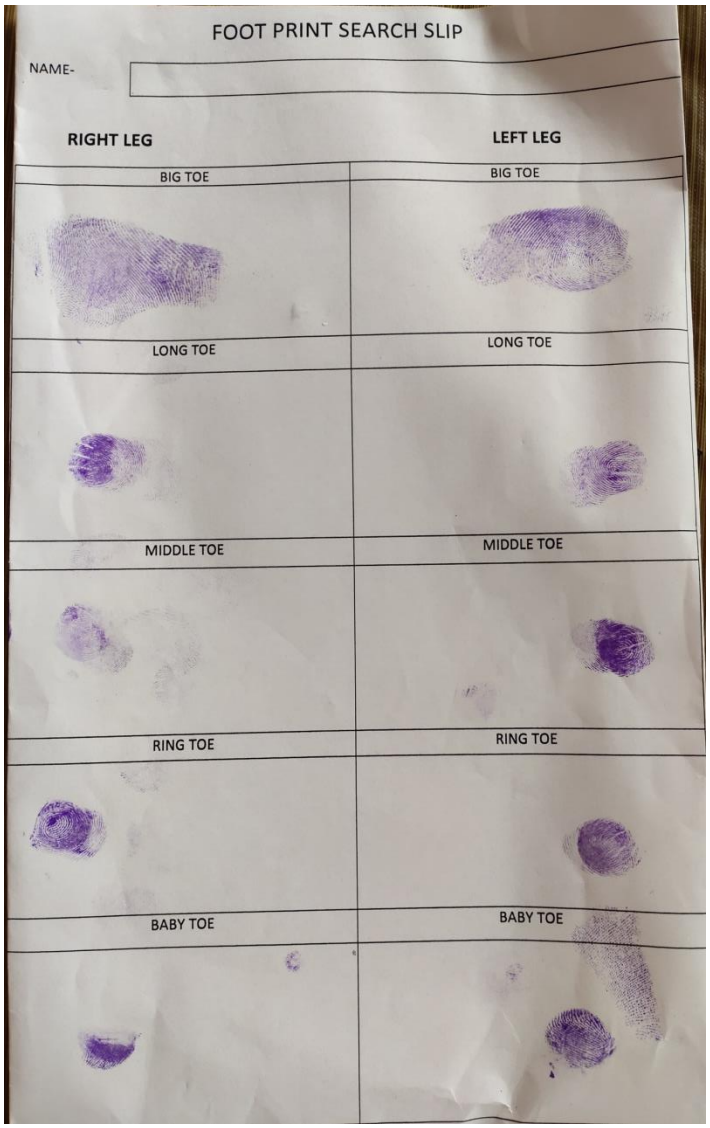


Figure-3.2

Fingerprint Recording Procedure-

For recording, forearm of an average adult should be parallel with the floor. The subjects were asked to relax. After that the individual's hand is grasped at the base of the thumb with my hand. The hand was then cupped over the individual's fingers, and then tucked those fingers which were not to be printed. When taking the rolled impression, the side of the finger bulb is placed upon the card. The finger is then rolled to the other side until it faces the opposite direction. Care is being exercised so the bulb of each finger, from tip to below the first joint, is rolled evenly. Generally, the weight of the finger is the maximum pressure needed to clearly record a fingerprint. In order to take advantage of the natural movement of the forearm, the hand should be rotated from the more difficult position to the easiest position. This requires the thumbs be rolled toward and the fingers away from the center of the individual's body. Each finger was rolled from nail to nail in the appropriate space, taking care to lift each finger up after rolling to avoid smudging. Then all required textual information was completed.

Figure 3.3- Fingerprint Collection

Examination of fingerprints-The pattern of fingerprints was studied by using magnifying lens and was established as: Loop, Whorls and Arch that were studied on the basis of appearance of re curving ridges according to the Henry's system of classification. This system of Henry appoints a number to each finger according to the sequence in which it is positioned in the hand that begins with the right thumb (RT) as number 1 and ending at the little finger of left hand (LL) as number 10.The sequential distribution of fingerprint patterns in both hands of individuals and its linkage was evaluated and analyzed statistically. The data was prepared in a tabular form as the table contains different sections of Right Thumb, Right Index , Right Middle , Right Ring ,Right Little ,Left Thumb, Left Index, Left Middle , Left Ring ,Left Little fingers and the assign each section a pattern that a particular finger have.

Toe Print Recording Procedure-

Method used in Toe print collection is the same used in fingerprint acquisition, which is ink dabbing method. In this technique Toes were dabbed in the ink pad by rolling the toes from inter-phalangial joint to the tip of distal phalanx. Care is being exercised so the bulb of each toe, from tip to below the first joint, is rolled evenly. The ink should also cover evenly from edge of the first joint to the tip of the Toes. So using the correct amount of ink is vital. Then those stained toes are re-dabbed by the same rolling method in the space prescribed in its respective card templates .The toe print is better taken with the individual seated on the chair, while the "personnel" should be squatting in front of him and the ink slab placed in front of him. A towel must be used to wash the sole before the staining is finished. Figure 3.4 is the pictures taken during one of my toe capturing sessions.1000 successful toe prints were obtained for the study from 100 individuals in Guwahati City.

Figure 3.4- Toe Print Collection

Examination of Toe prints-

The pattern of Toe prints were studied by using magnifying lens and were established as: Loop, Whorls, Arch ,Composite that were studied on the basis of appearance of re curving ridges according to the Harold Cummins & Charles Midlo's Classification on Toe print. According to Cummins and Charles the Loops were classified as Fibular loop(Ulnar) and Tibial Loop(Radial).Whorls may classified also according to the presence of one core or two Monocentric(True Whorl and Central Pocket) , Bicentric(Lateral Pocket Loop, Twin Loop, Accidental).

CHAPTER 4- RESULTS AND DATA ANALYSIS

4. Result-

It is a data driven approach. In this approach I have collected the prints using door to door sampling. A total of 1000 fingerprint and 1000 toe print were collected from 100 indo-Mongolian race of people. The collected data were tabulated according to print characteristic for each individual digit. Later an analysis was being constructed considering all whole print collected and a comparative study of the collected print from both hands and Feet were constructed.

4.1 Primary fingerprint Analysis-

A total of 1000 fingerprint were collected during the study in the respective card template. Study of composition of Distribution pattern in each finger has concluded that 11 types of fingerprint classes are present .With Ulnar Loop having the maximum percentage, constituting 55.6% of 1000 prints and Concentric Whorl constituting 16.3% of total studied pattern making it the 2nd most prevalent pattern in finger. Concentric Whorls are most abundantly found in Ring finger. Considering both the hands, the probability of founding Ulnar loop is more in Little Finger followed by Middle finger and Thumb. While considering pattern composition of Ring finger it can be formulated that Ring finger has both Ulnar loop and Concentric Whorl in almost equal proportion. The study was tabulated accordingly for better grasping of facts.

TABLE 1-Fingerprint pattern Composition

	Ulnar Loop	*Radial Loop*	*Concentric Whorl*	*Single Spiral Whorl*	*Double Spiral Whorl*	*Plain Arch*	*Tented Arch*	*Twin Loop*	*Lateral Pocket*	*Central Pocket Loop*	*Accidental*
Right Thumb	*56*	*4*	*9*	*11*	*1*	*4*	*0*	*8*	*0*	*4*	*2*
Right index	*44*	*11*	*17*	*8*	*4*	*3*	*4*	*4*	*3*	*0*	*2*
Right Middle	*63*	*2*	*12*	*5*	*0*	*0*	*3*	*8*	*0*	*2*	*5*
Right Ring	*39*	*2*	*39*	*7*	*0*	*2*	*0*	*2*	*0*	*5*	*4*
Right Little	*75*	*3*	*10*	*3*	*0*	*3*	*2*	*1*	*0*	*2*	*1*
Left Thumb	*60*	*5*	*5*	*9*	*3*	*5*	*0*	*9*	*1*	*1*	*2*
Left Index	*47*	*8*	*15*	*6*	*2*	*4*	*6*	*1*	*1*	*3*	*5*
Left Middle	*60*	*4*	*11*	*8*	*1*	*2*	*4*	*6*	*0*	*2*	*2*

Left Ring	*44*	*3*	*33*	*7*	*1*		*3*	*1*	*0*	*6*	*2*
Left Little	*68*	*4*	*12*	*3*	*0*	*4*	*1*	*2*	*0*	*1*	*5*

Table 2 and 3

RIGHT HAND PATTERN DATA	
ULNAR LOOP	*277*
RADIAL LOOP	*22*
PLAIN ARCH	*12*
TENTED ARCH	*9*
SINGLE SPIRAL WHORL	*34*
DOUBLE SPIRAL WHORL	*5*
CONCENTRIC WHORL	*87*
TWIN LOOP	*23*
CENTRAL POCKET	*13*
LATERAL POCKET	*3*
ACCIDENTAL	*14*

LEFT HAND PATTERN DATA	
ULNAR LOOP	*279*
RADIAL LOOP	*24*
PLAIN ARCH	*15*
TENTED ARCH	*14*
SINGLE SPIRAL WHORL	*33*
DOUBLE SPIRAL WHORL	*7*
CONCENTRIC WHORL	*76*
TWIN LOOP	*19*
CENTRAL POCKET	*13*
LATERAL POCKET	*2*
ACCIDENTAL	*16*

Table 4 - PERCENT FREQUENCIES* OF FINGERPRINT TYPES IN 100 INDIVIDUAL

GALTON TYPES		***LOOPS***		***WHORLS***			***ARCHES***		***COMPOSITE***			
DIGIT	***SIDE***	***ULNAR LOOP***	***RADIAL LOOP***	***CONCENTRIC WHORL***	***SINGLE SPIRAL***	***DOUBLE SPIRAL***	***PLAIN ARCH***	***TENTED ARCH***	***TWIN LOOP***	***LATERAL POCKET***	***CENTRAL POCKET***	***ACCIDENTAL***
I	***R***	*56.5*	*4.04*	*9.09*	*11.1*	*1.01*	*4.04*	*0*	*8.08*	*0*	*4.04*	*2.02*
	L	*60*	*5*	*5*	*9*	*3*	*5*	*0*	*9*	*1*	*1*	*2*
	R+L	*58.25*	*4.52*	*7.04*	*10.05*	*2*	*4.52*	*0*	*8.54*	*0.5*	*2.52*	*2*
II	***R***	*44*	*11*	*17*	*8*	*4*	*3*	*4*	*4*	*3*	*0*	*2*
	L	*47.95*	*8.16*	*15.3*	*6.12*	*2.04*	*4.08*	*6.12*	*1.02*	*1.02*	*3.06*	*5.1*
	R+L	*45.98*	*9.58*	*16.15*	*6.06*	*3.02*	*3.54*	*5.06*	*2.51*	*2.01*	*1.53*	*3.55*
III	***R***	*63*	*2*	*12*	*5*	*0*	*0*	*3*	*8*	*0*	*2*	*5*
	L	*60*	*4*	*11*	*8*	*1*	*2*	*4*	*6*	*0*	*2*	*2*
	R+L	*61.5*	*3*	*11.5*	*6.5*	*0.5*	*1*	*3.5*	*7*	*0*	*2*	*3.5*
IV	***R***	*39*	*2*	*39*	*7*	*0*	*2*	*0*	*2*	*0*	*5*	*4*
	L	*44*	*3*	*33*	*7*	*1*	*0*	*3*	*1*	*0*	*6*	*2*
	R+L	*41.5*	*2.5*	*36*	*7*	*0.5*	*1*	*1.5*	*1.5*	*0*	*5.5*	*3*
V	***R***	*75*	*3*	*10*	*3*	*0*	*3*	*2*	*1*	*0*	*2*	*1*
	L	*68*	*4*	*12*	*3*	*0*	*4*	*1*	*2*	*0*	*1*	*5*
	R+L	*71.5*	*3.5*	*11*	*3*	*0*	*3.5*	*1.5*	*1.5*	*0*	*1.5*	*3*

****Calculated on available totals***

Table 2 and 3 is showing an evident image that it is impossible for an examiner to predict the discovered print to the side of limb from which it might have originated. In the right hand the prints were arranged from higher to lower composition. The arrangement follows loops with 59.5% ,whorl with 25%,composite with 10.5% and the least with arches having 4.1%.Similarly in the left hand the prints are arranged in the same way as the right hand. The arrangement follows as loops with 60.8%, whorl with 23.2%, composite with 10% and the least with arches having 5.8%.

Table 4 is a compilation of data from 100 individuals(Indo-Mongolian).A collection of this size gives reasonably stable indication, for its particular racial composition of frequencies of pattern types and their differential distribution on digits. In the table loops are on an average 60% of all patterns, Whorl 24%, Arches 5% and Composite 10%.With subdivision of major classes, differences of frequencies are disclosed also among the subtypes. Of the 3 classes of whorls True whorls are nearly two times as frequent as Twin Loop, Lateral Pocket, Central Pocket and Accidental Combined. In the series Whorls have a frequency of 24% of all patterns while Twin Loop 4.2%, Central Pocket 2.6%, Lateral Pocket 0.5% and Accidental 3%.The frequency of Ulnar Loop, 60% is about 12 times of Radial Loop (4.6%).

DISTRIBUTION OF PATTERN TYPES ON SINGLE DIGIT-In considering the distribution of pattern types, corresponding digits of left hand and Right hand are combined. On every digits Ulnar loops are the most abundant pattern, the frequency ranging downward from 71.5% in Digit V, 61.5% in Digit III, 58.25% in Digit I and 45.98% and 41.5% in Digit II and IV respectively. Whorls next in total frequency are most numerous on Digit IV and II ,43.5% and 25.23% respectively. Followed by Digit I 19.09% and Digit III 18.5%.While,Digit V present a sharp reduction of 13%.Of all pattern types Concentric Whorl have the greatest relative range of frequency among the digits. They occur in 36% in Ring finger.16.15% in Digit II.11.5% AND 11% in Digit III and V respectively. And Digit I with 7.04%.Arches likewise has a wide range of frequencies among Digits, but a lesser range than that of Loops, Whorl and Composite. Their frequencies for II,V,I,III and IV are 8.6%,5%,4.52%,4.5% and 2.5% respectively.

To summarize the data on distribution following observation is being made-

1) Digit I(Thumb Finger) presents the highest incidence of Single spiral whorl and Twin loops. There is furthermore a bimanual difference in Composite frequency, the Right thumb bearing the larger number then the Left Thumb. The frequency of Concentric Whorl is least observed in this digit.
2) Digit II(Index Finger) bears more Radial Loop, Double Spiral Whorl, Tented Arch and Lateral Pocket than any other digits. Of all Lateral Pocket 80 % occur here. And this digit bears 50%, 43.4% and 23.3% of the total number of Double Spiral Whorl, Tented Arches and Accidental respectively.

3) Digit III(Middle Finger) has next to the greatest frequency of lunar loop, tented arch and twin loop. and bears the least frequency of plain arch and double spiral whorl.

4) Digit IV(Ring Finger) bears next to the highest frequency of Single Spiral Whorl. It also bears the highest Frequency of Concentric Whorl and Central Pocket.

5) Digit V(Little Finger) presents the highest frequency of Ulnar loop and minimum values of Whorl and Composite types.

4.2 Primary Toe print Analysis

Toe print study was concluded based on the collection of 1000 prints. Similarly like fingerprint 11 toe print pattern were classified accordingly. The overall study of toe prints were arranged in an ascending order that is from higher findings to the lower findings .in the analysis of those prints it was found that loops constituted the maximum of all prints , that is 55.4%.followed by arches with 31.4%, then composites with 8.8% and then finally with whorls having 4.4%. From the study we can formulate that if fibular loop is found in a crime scene then the print has a higher probability of coming from any 4 toes considered altogether from big toe to ring toe, excluding the baby toe. Children have more chances of developing arches then loops. Chances of finding whorls, tibial loop, central pocket and lateral pocket are almost nil. The visible features of toes are present in the posterior portion of lower distal phalanx. In case of baby toes the findings are more toward tented arch rather than fibular loop. There isn't any distinction in pattern composition among male and female.

TABLE 5-Toe Print pattern distribution

	Fibular Loop	***Tibial Loop***	***Concentric Whorl***	***Single Spiral Whorl***	***Double Spiral Whorl***	***Plain Arch***	***Tented Arch***	***Twin Loop***	***Lateral Pocket***	***Central Pocket Loop***	***Accidental***
Right Big toe	***71***	***2***	***1***	***0***	***0***	***21***	***2***	***2***	***0***	***0***	***1***
Right Long toe	***72***	***0***	***1***	***7***	***0***	***12***	***3***	***3***	***1***	***0***	***1***
Right Middle Toe	***57***	***0***	***4***	***5***	***0***	***5***	***2***	***19***	***2***	***1***	***5***
Right Ring Toe	***62***	***1***	***1***	***1***	***0***	***17***	***15***	***0***	***0***	***0***	***3***
Right Baby Toe	***36***	***0***	***0***	***0***	***0***	***23***	***41***	***0***	***0***	***0***	***0***
Left Big Toe	***67***	***4***	***0***	***3***	***1***	***19***	***3***	***0***	***0***	***0***	***3***
Left Long Toe	***65***	***0***	***0***	***2***	***2***	***16***	***3***	***4***	***5***	***1***	***3***
Left Middle Toe	***52***	***0***	***9***	***6***	***0***	***7***	***3***	***22***	***0***	***0***	***1***
Left Ring Toe	***40***	***0***	***0***	***1***	***0***	***24***	***23***	***6***	***1***	***0***	***4***
Left Baby Toe	***25***	***0***	***0***	***0***	***0***	***32***	***43***	***0***	***0***	***0***	***0***

Table 6 and 7

RIGHT FOOT PATTERN DATA	
FIBULAR LOOP	298
TIBIAL LOOP	3
PLAIN ARCH	78
TENTED ARCH	63
SINGLE SPIRAL WHORL	13
DOUBLE SPIRAL WHORL	0
CONCENTRIC WHORL	7
TWIN LOOP	24
CENTRAL POCKET	1
LATERAL POCKET	3
ACCIDENTAL	10

LEFT FOOT PATTERN DATA	
FIBULAR LOOP	249
TIBIAL LOOP	4
PLAIN ARCH	98
TENTED ARCH	75
SINGLE SPIRAL WHORL	12
DOUBLE SPIRAL WHORL	3
CONCENTRIC WHORL	9
TWIN LOOP	32
CENTRAL POCKET	1
LATERAL POCKET	6
ACCIDENTAL	11

Table 8- PERCENT FREQUENCIES* OF TOEPRINT TYPES IN 100 INDIVIDUAL

GALTON TYPES		LOOPS		WHORLS			ARCHES		COMPOSITE			
DIGIT	SIDE	FIBULAR LOOP	TIBIAL LOOP	CONCENTRIC WHORL	SINGLE SPIRAL	DOUBLE SPIRAL	PLAIN ARCH	TENTED ARCH	TWIN LOOP	LATERAL POCKET	CENTRAL POCKET	ACCIDENTAL
I	R	71	2	1	0	0	21	2	2	0	0	1
	L	67	4	0	3	1	19	3	0	0	0	3
	R+L	69	3	0.5	1.5	0.5	20	2.5	1	0	0	2
II	R	72	0	1	7	0	12	3	3	1	0	1
	L	64.35	0	0	1.98	1.98	15.84	2.9	3.96	4.9	1	2.9
	R+L	68.17	0	0.5	4.5	1	13.9	3	3.5	3	0.5	2
III	R	57	0	4	5	0	5	2	19	2	1	5
	L	52	0	9	6	0	7	3	22	0	0	1
	R+L	54.5	0	6.5	5.5	0	6	2.5	20.5	1	0.5	3
IV	R	62	1	1	1	0	17	15	0	0	0	3
	L	40.4	0	0	1.01	0	24.24	23.5	6.06	1.01	0	4.04
	R+L	51.2	0.5	0.5	1	0	20.62	19.25	3.03	1	0	3.52
V	R	36	0	0	0	0	23	41	0	0	0	0
	L	25	0	0	0	0	32	43	0	0	0	0
	R+L	30.5	0	0	0	0	27.5	42	0	0	0	0

Calculated on available totals

Table 6 and 7 is the representation of pattern constitution in Right and Left toes consecutively. The result shows that there isn't any distinguishing factor associated when same types of limbs are selected simultaneously. Distribution pattern of Right Foot shows that Loop constitute 60.2%, Arch constitute 28.3%, Composite constitute 7.5% and Whorls constitute 4%.Similarly the pattern composition of left foot follows- Loops with 50.6%,Arches with 34.6%,Composite with 10% and Whorls with 4.8%

DISTRIBUTION OF PATTERN TYPES ON SINGLE DIGIT-

To summarize the data on distribution following observation is being made-

Digit I (Big Toe) bears a large number of Fibular Loop and Tibial Loop than any other toe.

Digit II (Long Toe) bears next to the Highest Frequency of Fibular Loop and is the site of lower frequency of Tibial loop and higher frequency of Lateral Pocket.

Digit III (Middle Toe) carries by far the highest frequency of Whorl, Twin Loop and Concentric Whorl and the Least Frequency of Arches.

Digit IV (Ring Toe) bears next to the Highest Frequency of Tented Arch and highest Frequency of Accidental.

Digit V (Baby Toe) is the site of Highest Frequency of Arches (Plain and Tented) and Least Frequency of Fibular Loop, Twin Loop. It is also the site where chances of founding Whorl pattern are minimal.

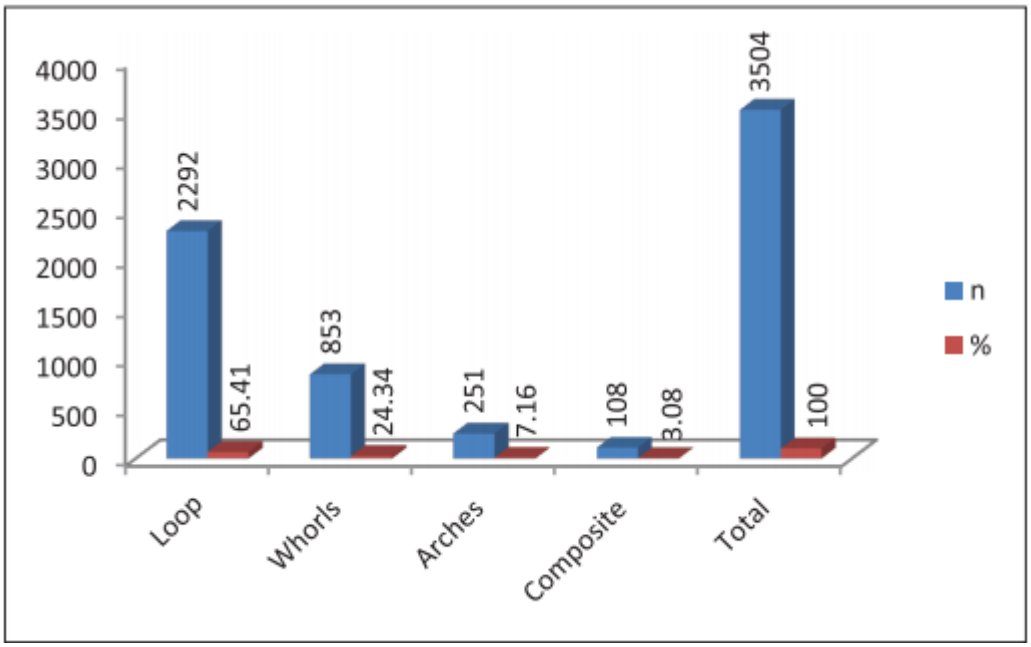
4.3 SECONDARY DATA ANALYSIS -

In-depth analysis of fingerprint and toe print analysis is best done with the background knowledge of both fields. Therefore inclusion of different information from various sources is crucial for the purpose of constructing a higher value analysis. This project introduces the rationale and concept of the secondary analysis of existing data, describes several sources of publicly available datasets, and provides general guidelines for conducting secondary analyses of existing data.

Fingerprint Related Findings-

For better analysis of the fingerprint data a proper introduction to its related field is necessary. Therefore similar type of fingerprint related projects is being chosen for a better correlation. The correlative study is based on the following research -

A) Sandeep V. Binorkar and Anand B. Kulkarni on "Study on the fingerprint pattern and gender distribution in and around Nanded district of Maharashtra state" concluded that among 3504 individuals, principal pattern among male and female was loop, followed by Whorl arches and Composite. The observation were formulated in the given graph-



B) Hanshi Bansal and Ashish Bdiye on "Distribution of Fingerprint Patterns in an Indian Population" formulated the analysis that the ulnar loop (51.3%) was found to be the most

predominant pattern. Ulnar loops were observed in 53.28% females as against in 49.21% males followed by whorl patterns in 24% females next to 29.06% in males. It was observed that whorl pattern was significantly higher in ring finger in both the sexes, females contributing about 42.14% of whorls against 36.42% of ulnar loops and in males 56.25% of whorls against 25% of ulnar loops

C) Neha Baryah and Kewal Krishan on "Exploration of digital dermatoglyphics of two ethnicities of North India- forensic and anthropological aspects" has stated that in the study that loops were the most predominant pattern type followed by whorls, then composites and finally the arches. Moreover, the subtypes of pattern types in a sample were mostly dominated by ulnar loop followed by single spiral whorl and double spiral for Rajput males, Brahmin males and Brahmin females except in Rajput females where concentric whorl was the third most predominated pattern sub-type. Tented arch and arch with diminutive loop were the least occurring pattern subtype in Rajput males and females, on the contrary, plain arch and twinned loop were least reported in Brahmin males and females respectively.

D) Tanuj Kanchan and Saurabh Chattopadhyay on "Distribution of Fingerprint pattern among Medical student" has made conclusion from the study among 1100 fingerprint patterns from 110 individuals. Here Loops were the most common pattern followed by whorls and arches in both hands among males and 'females. While loops were the predominant patterns on the index, middle and little fingers, predominance of whorls was evident on thumb and ring fingers. Loops were most often found on little finger (77.7%) followed by middle finger (73.7%) and index finger (49.1 %). Frequency of whorls was maximum on the ring finger (55%) followed by thumb (53.6%) and index finger (38.2%). 56% of the total arches (n= 50) were present on the index finger. For clear understanding of the facts the reports were arranged in the following table-

Patterns	Males (Both Hands)					Females (Both Hands)				
	Little Finger	Ring Finger	Middle Finger	Index Finger	Thumb	Little Finger	Ring Finger	Middle Finger	Index Finger	Thumb
Ulnar loop	67.19	25	66.4	39.84	47.67	72.14	36.43	70	42.14	46.43
Plain whorl	13.28	56.25	21.09	29.69	25	10.71	42.15	15.72	24.29	27.14
Central Pocket	10.16	10.94	0.78	4.69	0	8.57	13.57	1.43	6.43	0.71
Tented Arch	0	0	0	3.12	0.78	1.43	2.86	0.71	5.71	0
Plain Arch	0	0	0.78	1.56	1.56	0.71	0	2.14	6.43	1.43
Radial Loop	4.69	2.34	4.7	4.69	2.34	2.86	0.71	1.43	3.57	0.71
Twinned Loop	3.12	4.69	3.13	10.16	20.31	0	3.57	6.43	5.71	14.23
Lateral pocket Loop	0	0	1.56	0.78	2.34	1.43	0	1.43	1.43	5
Accidental	1.56	0.78	1.56	5.47	0	2.15	0.71	4.3	4.3	4.3
Total	100	100	100	100	100	100	100	100	100	100

Other studies determined by Nithin et. al. in South Indians of Mysore who reported the most common occurrence of ulnar loops (52.3%) followed by whorl pattern (28.74%).

Gangadhar et al.in Adikarnataka population of Mysore city of Karnataka State who reported predominance of loop patterns (57.11%) followed by whorls (27.89%) and arches (15.00%).

By Jaga and Igbigbi in Ijaw subjects of Southern Nigerians [16], Igbigbi and Msamati in Kenyan and Tanzanian subjects and by Eboh in Anioma and Urhobo population of Southern Nigeria where ulnar loop followed by whorls and arches patterns were reported

Another study by Kaneeka Joshi on **"**The distribution of fingerprint patterns with gender in Delhi, India Population" has stated that among the 2000 fingerprint samples, 1130 were loops, 625 were whorl, 125 were Composites and 120 are arch pattern.

Sidhart Timsinha et.al. on "Comparative sex wise study of fingerprints in relation to toe prints "revealed that in Fingerprint The loops were found to be maximum in number i.e.57.14% in left hand and 58.08% in the right hand of both the sexes combined. The next highest pattern observed was whorl comprising of 24.14% and 24.32% in left and right hand respectively. Arches were the third highest in frequency in both genders i.e. 17.14% and 15.57% in left and right hand respectively.

Toe print Related Findings-

There are very scant materials available for toe prints. However based on those few guidelines available I have developed this research with an objective of formulating a more refined analysis. The major outbreak on toe print study was done by Takeya, Hasebe, Newman and Steffen's study on Chinese, Japanese, European- American and Germans

respectively. In Newman's collection of 100 European Americans whorls are 67% more frequent in fingers than in toes, and arches are nearly six times more abundant in toes than in fingers. Steffens' German series presents a whorl frequency in fingers which is 40% greater than that in toes; arches are 4 1/2 times more frequent in toes. Hasebe's Japanese series displays an even more striking difference in the same direction whorls being 2 1/2 times more abundant in fingers, and arches nearly 8 times more abundant in toes. The fingers of Japanese have a much greater abundance of whorls than do the fingers of European Americans or Germans, yet the toes of Japanese as compared with European peoples show a lesser number of whorls. Thus there appears to be an inverse relationship between the occurrences of whorls and arches in toes and fingers as is generally true in mass statistics of fingers, the incidence of arches decreases with elevation of whorl frequency.

2. Sidhart Timsinha et.al. on "Comparative sex wise study of fingerprints in relation to toe prints "have stated that loops consisted of highest percentage in both the hands and feet of both the sexes i.e. 60.58% in male and 54.26% in female and whorls were the second highest in occurrence, the composite pattern were the least to contribute in finger pulp pattern .However toe prints shows loops to be highest, followed by arch and composite being minimum in both the sexes.

C) Obaje Samuel Enemakwu on "Experimental Analysis of Toe Print Class Distribution in Caucasian and Lepers "have revealed that The Lepers toe print loop population is 63.5%, and is the highest in population, followed by whorls with population of 21.3%, the lepers arch was 10.8% and the tented arch is 4.4%, arch's group is the least.

CHAPTER 5-DISCUSSION AND CONCLUSION

5.1 . Discussion-

The present study was aimed to evaluate whether any correlation exist between toe print and fingerprint. The analysis shows that fingerprint patterns are present within the anterior portion of distal phalanx (toward the palm) whereas the visible features of toes are present within the posterior portion of lower distal phalanx. Study of distribution pattern in each finger and toes has concluded that 11 forms of classes are present. In the right hand the distribution pattern shows as loops with 59.5%, whorl with 25%, composite with 10.5% and the least with arches having 4.1%. In the left hand the prints also are arranged in the same way as the right hand. The arrangement follows as loops with 60.8%, whorl with 23.2%, composite with 10% and the least with arches having 5.8%. Distribution pattern of right foot shows that loop constitute 60.2%, arch constitute 28.3%, composite constitute 7.5% and whorls constitute 4%.and the pattern composition of left foot follows- loops with 50.6%, arches with 34.6%, composite with 10% and whorls with 4.8% .The result shows distribution order for hand is Loop, Whorl, Composite, Arch whereas distribution order for foot is Loop, Arch, Composite, Whorl.

Considering the findings from primary and Secondary Evaluation, a comparative study was established accordingly. This study include comparison of Primary Fingerprint data to Secondary Fingerprint data considering the different studies related to that field. And another study includes the comparison of Primary Toe print data to Secondary Toe print data simultaneously.

Fingerprint Analysis-

From the primary data it is clear that the pattern distribution order for hand is Loop, Whorl, Composite and Arch which is directly in accordance with the studies by Neha Baryah and Kewal Krishan on "Exploration of digital dermatoglyphics of two ethnicities of North India- forensic and anthropological aspects" and Kaneeka Joshi on **"**The distribution of fingerprint patterns with gender in Delhi, India Population". According to the study the more common type of pattern was found to be loop and the least common pattern was arch. Other studies were also published which deals with the prevalence of fingerprints and were compared with the present study. After comparing the previous data with the present database it was found that loop patterns are the most common patterns. But if we were to chose the two most prevalent pattern that is Loops and Whorl then my primary study goes in accordance with all the all the mentioned studies. While determining the pattern distribution among males and females, the loop patterns are considered to be the predominant type of pattern. In males, the composite and arch are the second last and least common type of patterns. According to Ching Cho in New Zealand, who

observed that whorl pattern in the population predominates (60.6%) followed by Ulnar loops (38.65%) which disagrees with this present study as this study reports that loop patterns (60.2%)are present in most of the population followed by whorls (24.2%)

Toe Print Analysis-

Sameway,From the primary data it is clear that the pattern distribution order for foot is Loop, Arch, Composite, Whorl. From the studies of Takeya, Hasebe,Newman and Steffen's it is clear the most frequent patterns are Loops and Arch which is in accord to my study. There appears to be an inverse relationship between the occurrences of whorl and Arches in toes and Fingers. As generally in fingers, the indices of arches decrease with elevation of Whorl frequency. The proportionate representation differs widely in toes and Fingers. True whorls and Central Pocket is less abundant in toes.

The distribution of Maximum and Minimum pattern type freque

ncies differs significantly at some points existing in Toes and Fingers.

a) The Maximum frequencies of Whorls in Finger is mostly concerned on Digit IV while in toes the patterns are more concerned on Digit III

b) The Maximum Frequencies of Ulnar (Fibular) are in finger V and in toe II

c) Arches are concentrated in Finger V and in Toe II

d) The maximum frequency of Composites in finger occurs in Digit I and Digit IV.While in toes it occurs mostly in IV and Digit II

e) The Maximum frequency of Radial (Tibial loop) in Finger is mostly concerned on Digit II while in toes the patterns are concerned in Digit I

The coefficient of correlation of arch frequencies of finger and toes for same digit is -0.16 and the coefficient of determination is 0.028

The coefficient of correlation of Whorl frequencies of finger and toes for same digit is -0.2 and the coefficient of determination is 0.04

The coefficient of correlation of Loop frequencies of finger and toes for same digit is -0.44 and the coefficient of determination are 0.19.

The coefficient of correlation of arch frequencies of finger and toes for same digit is 0.48 and the coefficient of determination is 0.23. Although technically a positive correlation, the relationship between the variables is still weak (*nb.* the nearer the value is to zero, the weaker the relationship).

The correlation coefficient is a statistical measure of the strength of the relationship between the relative movements of two variables. A correlation of -1.0 shows a perfect negative correlation, while a correlation of 1.0 shows a perfect positive correlation. A correlation of 0.0 shows no linear relationship between the movements of the two variables.

Whereas, the coefficient of determination, R^2, is used to analyze how differences in one variable can be explained by a difference in a second variable. The higher the coefficient, the higher percentage of points the line passes through when the data points and line are plotted

	Arches		Loops		Whorls	
	R	L	R	L	R	L
European American(Newman)	10%	6	67.8	61	22.2	23
German(Steffens)	17.2	20.8	62.6	56	20.2	23.2
Japanese(Takeya)	17.6	26	62	57.7	20.4	2.0
Japanese(Hasebe)	9.4	24.2	63.4	58.6	17.2	17.2
Indian(Indo-Mongolian)	28.2	34.6	60.2	50.6	4	4.8

In Newman, Steffens, Takeya, Hasebe, in each of the toes except III whorls are most abundant on the left side then on the right. Whereas in Indo-Mongoloids in each toes except II Whorls are most abundant on the left side then on the right.

In Newman, Steffens, Takeya, Hasebe, Tibial loops likewise are more frequent on left toes Indicating a reversal of trend noted in Radial loops of finger. Whereas in Indo Mongoloids the tibial loops in toes and Radial loops in finger shows a same trend of more frequency on left side.

Arches are more frequent on the left toes but this trend also agrees with that observed in fingers.

5.2 .CONCLUSION

This analysis conjointly rejected this study's initial hypothesis that if the fingerprints of a group of people are similar, then there should be a similarity between their toe prints. Rather, the information displayed no sturdy correlation between an individual's fingerprints and toe prints. This analysis proves that one cannot predict a fingerprint from a toe print. On the opposite hand, detectives can conclude that a discovered Plain arches have a higher chance of returning from an individual's toes then the finger. Likewise, if a Forensic examiner discovers a Radial Loop (or Fibular Loop for Toes), then it is likely to be from an individual's Thumb finger (or Big Toe as in Toes). There appears to be an inverse relationship between the occurrences of whorl and Arches in toes and Fingers. Generally in fingers, the indices of arches decrease with elevation of Whorl frequency. The proportionate representation differs widely in toes and Fingers. True whorls and Central Pocket is less abundant in toes. Inspection alone indicates that toe print patterns tend to be smaller than the finger patterns. This is borne out in the ridge count reported by myself. The average ridge count of all fingers is 14.5 ± 0.56 and for all toes 11.4 ± 0.63.In as much as arches are very frequent in toes and the zero ridge count of the configuration lowers the average value. It is important to note that difference persist when arches are excluded from determination. Excluding arches the figures are: average count in fingers,15.3± 0.42 ;average in toes, 12.9±0.21.The sequential order of ridge count, for all configuration including the arches are- Fingers: I>IV>V>III>II ;Toes: III>I>II>IV>V.When both hands and feet are considered the coefficient of correlation has more positive inclination towards Arches and least toward loops. Though that correlation is week it still shows that there is higher favourability of Arch outcome from both hand and feet.

FUTURE SCOPE -

The toe print has very little or no info obtainable on-line for researchers to correlate with. The present biometric mode, like fingerprint includes a large on-line database offered for analysis and study of the functions. Such systems are distinguished by population distribution, class, identification etc. After we do toe print coverage, it is vital to expand the study beyond the data collection alone and so classification and distribution are important. Toe print could also suffice for the fingerprint for the symbrachydactyly or leprosy victims that do not have good fingerprints to identify them or vote with.There are some cases where the culprit consciously leaves toe print in a crime scene with the motive that he would be removed from the list of suspect during the investigation and to make the case even more complicated.Thus formulating a distribution data of toe print and fingerprint might help us in distinguishing a person's finger from its toe.

REFERENCES-

1. Harold Cummins and Charles Midlo.Fingerprint, Palm and Soles, An introduction to Dermatoglyphics; Newyork, Dover Publication, Inc.1961: 135-42

2. Cummins, H. The Topographic History of the Volar Pads (Walking Pads; Tastballen) in the Human Embryo. Contributions to Embryology. 1929, 20, 105–126.

3. Mukherjee JB. Forensic Medicine and Toxicology, 3rd ed. Kolkata: Academic publisher; 2007: 166-74.

4. Rao NG. Textbook of Forensic Medicine and Toxicology, 2ndedn New Delhi: Jaypee Brothers Medical Publishers
(P) Ltd, 2010:97-99.

5. Obaje SE. Lepers personal identification using the soleprint in place of fingerprint. Proceedings of the 3rd International Conference on Electronics and Computer Technology. Kanyakumari. India. 2011; 3: 471-474. http://bit.ly/2rOH5Ao

6. Obaje Samuel Enemakwu,Experimental Analysis of Toe Print Class Distribution in Caucasian and Lepers, American Journal of Biometrics & Biostatistics,2019

7.Muralidhar, R.S, et al. Fingerprint pattern in different blood groups; JIAFM 0ct-Dec 2011; 33(4):343-345

8. Joannes Evangelista Purkinge, "Physiological Examination of the Visual Organ and of the Cutaneous System" (***Commentatio de Examine Physiologico Organi Visus et Systematis Cutanei)*** Breslau: Vratisaviae Typis Universitatis, 1823. (Translated into English by Cummins, H, and R.W. Kennedy, Am.J.Crim.Law.Criminology. vol 31, pp. 343-356, 1940)
9. Grew's presentation to the Royal Society in 1684 cited by Harold Cummins and Charles Midlo, ***Finger Prints, Palms and Soles An Introduction To Dermatoglyphics***, ©1943 The Blakiston Company, Philadelphia, p. 11
10. G. Bidloo, ***Anatomy Humani Corporis***, Amsterdam, 1685
11. M. Malpighius, ***De externo tactus organo***, London, 1686.
12. Cummins and Midlo, ***Finger Prints, Palms and Soles An Introduction To Dermatoglyphics***, supra., pp. 11-15. The works of Hintze 1747 and Albinus 1764 were briefly mentioned. J. C. A. Mayer's work ***Anatomische Kupfertafeln nebst dazu gehörigen Erklörungen,*** 1783-1788, last section on fingerprints, 1788 is cited for the observation that the skin ridge patterns are never duplicated in two persons though they have certain likenesses. J. F. Schröeter is cited for his illustrations of the organization of ridges and

pours and the morphology of the skin of the palm in his work of 1814 published in Leipzig: ***Das menschliche Gefühl oder Organ des Gestastes***. Bell is cited for his contribution, ***The Hand***, to the Bridgewater Treatise on ***The Power, Wisdome, and Goodness of God, as Manifest in the Creation*** 1833 wherein he observed clearly two functional advantages of epidermal ridges, increased friction aiding firmer grasp and the aid to the sense of touch.

13. H. Faulds, ***On the Skin furrows of the hand*** Nature 22:605 (October 28, 1880) and W. J. Herschel ***Skin furrows of the hand*** Nature 23:76 (November 25, 1880).

14. Sir Francis Galton, ***Fingerprints***. London: MacMillan & Co.

15. Norris M. Durham and Chris C. Plato, editors, ***Trends in Dermatoglyphic Research***, © 1990 Kluwer Academic Publishers: Dordrecht/Boston/London, p. 4.

16. Harold Cummins and Charles Midlo, ***Finger Prints, Palms and Soles An Introduction To Dermatoglyphics***, ©1943 The Blakiston Company, Philadelphia, p. 19.

17. Harris Hawthorne Wilder, ***Palms and soles***. A,. J. Anat 1902, 1:423-441; ***Racial differences in palm and sole configuration***, Am. Anthropologist 1904 6:244-293; ***Duplicate Twins and double monsters (part only)***, Am J. Anat. 1904, 3:426-472; ***Palm and sole studies***, 1916, Biol Bull 30:135-172, 211-252.

18. Inez L. Whipple-Wilder, ***The Ventral Surface of the Mammalian Chiridium*** J. Morph Anthropol 1904, 49:153-221.

19. Kristine Bonnevie, ***Studies on palillary patterns of human fingers***, J Genet 1924 15:1-111.

20. Norris M. Durham and Chris C. Plato, editors, ***Trends in Dermatoglyphic Research***, © 1990 Kluwer Academic Publishers: Dordrecht/Boston/London, p. 6.

21. Harold Cummins and Charles Midlo, ***Palmar and Plantar Epidermal Configurations (Dermatoglyphics) in Eurpoean Americans***, Am J Phys Anthropol, 1926 9:471-502.

22. Harold Cummins, H. H. Keith, Charles Midlo, R. G. Montgomery, Harris Hawthorne Wilder, Inez Whipple-Wilder, ***Revised methods of interpreting and formulating palmar dermatoglyphics***, Am J. Phys Anthropol 1929, 12:415-473.

23. Harold Cummins and Charles Midlo, ***Finger Prints, Palms and Soles An Introduction To Dermatoglyphics***, ©1943 The Blakiston Company, Philadelphia.

24. Ibid, p. 9-10.

25. Ibid, p. 280-281. Quotes from T. Kubo ***Beiträge zur Daktyloskopie der Koreaner***, Mitt. Med. Fachschule Keijo, pp. 117-223, 1918; pp. 1-63, 1919; pp. 1-150, 1921.

26. L. S. Penrose, ***Fingerprints and Palmistry***, The Lancet, June 2, 1973, p. 1241. Penrose displays an arrogant ignorance in his 1973 remarks that "in the whole range of the cheiromantic cult, no use of the fine dermal ridges by which the science of dermatoglyphics is concerned..." is mentioned "except sometimes cursorily in the literature." He ignores the works of his contemporaries Jaquin, Compton, Scheimann and Hutchinson who all wrote for those interested in the cheiromantic cult. Yet Beyrl B. Hutchinson was familiar with Penrose's work while he was at the Galton Laboratory, ***Your Life in Your Hands*** Neville Spearman, Ltd., London, 1967, p. 96.

27. ***Dermatoglyphics, An International Perspective***, Jamshed Mavalwala, Editor, 1978, Moulton Publishers, The Hague - Paris, Aldine, Chicago, USA distributors, p. 19.

28. Harold Cummins and Charles Midlo, ***Finger Prints, Palms and Soles An Introduction To Dermatoglyphics***, ©1943 The Blakiston Company, Philadelphia, p. 9.

29. Samudrik Tilak M. Katakkar, ***Encyclopedia of Palm and Palm Reading***, ©1992 UBS Publishers' Distributors, Ltd., New Delhi, pp. 114 - 116.
30. Saint-Germain, Comte C. de, (Valcourt-Vermont, Edgar de), ***The Practice of Palmistry for Professional Purposes***, Chicago, 1897 Newcastle Publishing, London, reprint 1973.
31. Benham, William G., ***The Laws of Scientific Hand Reading***, ©1900, Knickerbocker Press, New York Health Research, Mokelumne Hill, CA reprint of the January, 1912 printing. p 194-195.
32. United States Department of Justice, Federal Bureau of Investigation, ***The Science of Fingerprints, Classifications and Uses,***(Rev. 12-84) U.S.G.P.O., pp. 11-18 especially, see also for example: Frederick Kuhne, ***The Fingerprint Instructor***, 1917, Munn & Company, Inc, New York, especially page 34; and Harry Battley, ***Single Finger Prints***, 1930 New Scotland Yard (H. M. Stationary Office), especially 33-37.
33. 39 Larchwood House, Baywood Square, Chigwell Essex, 1G7 4AY U.K., phone 0181 500 8315, Hon. Harry G. Gullefer, Secretary.
34. Noel Jaquin, ***The Hand of Man***, Faber & Faber Ltd, London, 1934 pp. 44-46.
35. Noel Jaquin, ***The Signature of Time***, 1940, Faber & Faber, Ltd., London, pp. 87-96. See also Noel Jaquin, ***The Hand Speaks, Your Health, Your Sex, Your Life***, 1942, Lindoe & Fisher, London. My copy Sagar Publications, New Delhi, India, 1973, pp. 15, 19. Noel Jaquin, ***Practical Palmistry***, Originally published as "***The Human Hand***" D. B. Taraporevala Sons & Co. Private Ltd, Bombay, India, 1958, 1964 pp. 157-162.
36. Vera Compton, ***Palmistry for Everyman***, Associated Booksellers, Westport, Conn., 1951, 1956, pp. 40-43.
37. Yusuke Miyamoto, ***Fingerprints***, © 1963, translated by Saki Mochizuki and Michael Whitington, Japan Publications Trading Company, Tokyo, Japan and Rutland, Vt., U.S.A.
38. Hutchinson, B. Beryl, **Your Life in Your Hands,** Sphere Books, Ltd., London, 1967., p. 89.
39. Ibid pp. 89-125.
40. Eugene Scheimann, M.D., ***The Doctors's Guide to Better Health Through Palmistry,*** Parker Publishing, 1969. pp. 59-76.
41. Beverly C. Jaegers, ***You and Your Hand*** ©1974 Aries Productions Creve Coeur, Mo. and ***Hand Analysis, Fingerprints and Skin Patterns-dermatoglyphics*** ©1974 Aries Productions St. Louis, Mo. Ms. Jaegers has assured me that she came to her interpretations based upon the many palms and fingerprints she examined and did not depend upon the work of others, including Ms. Hutchinson.
42. Fred Gettings, ***The Book of The Hand***, © 1965, reprint 1968, Paul Hamlyn, Ltd., pp. 115-119.

43. Eugene Scheimann, M.D., ***The Doctors's Guide to Better Health Through Palmistry***, supr., p. 59.

44. ***The Hand As A Mirror Of Systemic Disease***, Theodore J. Berry, M.D., F.A.C.P., F. A. Davis Company, Publishers, Philadelphia, 1963, for early development of dermatoglyphic patterns see also ***Dermatoglyphics in Medical Disorders***, by B. Schaumann and M. Alter (1976) New York: Springer-Verlag, pp. 187 - 189.
45. ***Dermatoglyphics in Medical Disorders***, Blanka Schaumann, Milton Alter, Springer-Verlag, 1976, pp. 1 - 7.

46. Schaumann and Alter, supra., pp. 209-211, 250-251.
47. Schaumann and Alter, supra., pp. 132-133.
48. William J. Babler, ***Prenatal Communalities in Epidermal Ridge Development***, pp. 54-68 in ***Trends in Dermatoglyphic Research***, edited by Norris M. Durham and Chris C. Plato, Kluwer Academic Publishers, Dordrecht/London/Boston © 1990. (Vol 1, Studies in Human Biology)
49. A. R. Hale, ***Morphogenesis of volar skin in the human fetus***. 1951, Am. J. Anat 91:147-173.
118. ibid, n. 64, pp. 64-68.
50. Schaumann and Alter, supra., pp. 2-3.
51. Schaumann and Alter, supra., p. 1.
52. Schaumann and Alter, supra., pp. 137-142.
53. William J. Babler, ***Prenatal Communalities in Epidermal Ridge Development***, supra n. 64, p. 67 referring to S. M. Garn, W. J. Babler & A. R. Burdi, ***Prenatal origins of brachymesophalangia-5***. Am. J. Phys. Anthrop. (1976) 91: 147-173
54. Ibid. p. 67.
55. K. Bonnevie, ***Zur Mechanik der Papillarmusterbuldung. I. Die Epidermis als fromativer faktor in der entwicklung der fingerbeeren und der Papillarmuster***. Arch. Entwickl. Organ., (1929) 117:384.
56. W. Hirsch and J. U. Schweichel, ***Morphological evidence concerning the problem of skin ridge formation.***. Ment. Defic. Res., 17:58, 1973.
57. Ibid. They confirm that the volar pads on the index and middle fingers are visible in the second month. They relate the symmetry or asymmetry of the pads and their development to whether whorls, loops or arches may be expected, with symmetrical = whorls, asymmetrical = loops and weak pad development = arches. They indicate that the pad shape is genetically set though environmentally modified. When crown rump length reaches about 90 mm (4^{th} month) the first distinct, sharply delineated fold like proliferations appear in the epidermis and these are later perceived as glandular folds. These glandular folds bear a close special relationship with the distribution of capillary-neurite pairs. On the basis of the pattern of these glandular folds, they predicted that the forces of the growth pressure of these folds, the trajectory of the system of the epidermis and the glandular ducts would determine the highly arranged surface pattern of the papillary ridges. The final expression of genetic information in the form of surface patterns would be modified by environmental influences. Glandular folds , proliferations of cells from the epidermis that make their way into the mesenchyme (dermis) and form from the lateral distal borders of the distal phalanx to the medial proximal part of that phalanx and forming a Horshoe-shaped border on the fingertip. Folds continue to be formed at the periphery until the pad surface is entirely covered. This process occurs on the proximal phalanges beginning in the fifth month. During the fifth month the sweat glands set and the glandular ducts reach the surface in the sixth month. During the later course of development of the glandular folds, the volar pads become increasingly less prominent while the connective tissue becomes richer in collagen and denser. Secondary furrow fold formation is seen in the sixth and seventh month but it has either slight or no effect on the formation of the papillary ridge pattern. The papillary ridges on the surface skin molded by the glandular fold cell proliferation after the formation of glandular folds, sweat gland secretion and keratinisation has begun, after the sixth month.

The authors speculate that three factors may possibly accomplish the transfer of the deep patterns to the skin surface: 1) proliferation pressure from the increased mitotic rate of the basal cell layer; 2) stabilization of the sweat gland secretion ducts at regular intervals on the surface; and, 3) by some counteracting force as a result of the first two forces, exerted by the tonofilament system, the system of fine filaments in the cytoplasm of each cell that function as supportive elements within the cytoskeleton and form the main precursors of keratin in the epithelium. They conclude that the pattern of the papillary ridges is set after the development of the glandular folds, after the forth month.

58. Ibid. P. 69.

59. Richard E. Behrman, M.D., Robert M. Kleigman, M.D. and Ann . Arvin, M.D., ***Nelson Textbook of Pediatrics***, 15th Edition © 1996, p. 34, W. B. Saunders Company, division of Harcourt Braced & Company, Philadelphia/London/Toronto/ Montreal/ Sidney/Tokyo.

60. Eric R. Kandel, James H. Schwartz and Thomas M. Jessel, ***Essentials of Neural Science and Behavior***, © 1995, Appelton & Lange, Norwalk, Connecticut, pp. 94-95.

61. Eric R. Kandel, James H. Schwartz and Thomas M. Jessel, ***Essentials of Neural Science and Behavior***, *supra.*, pp. 94-95.

62. Sumiko Kimura, Blanka A. Schaumann, Chris C. Plato and Tadashi Kitagawa, ***Developmental Aspects of Human Palmar, Plantar, and Digital Flexion Creases***, in ***Trends in Dermatoglyphic Research***, edited by Norris M. Durham and Chris C. Plato, Kluwer Academic Publishers, Dordrecht/London/Boston © 1990. (Vol 1, Studies in Human Biology), p. 84.

63. Schaumann and Alter, supra., p. 109.

64. Schaumann and Alter, supra., p. 109.

65. Yog R. Ahuja, Chris C. Plato, ***Effect of Environmental Pollutants on Dermatoglyphics*** in ***Trends in Dermatoglyphic Research***, supra., pp. 125-128.

66. Ibid pp. 129-132.

67. Sumiko Kimura, et. al., supra, pp. 84-98

68. A. R. Hale, ***Morphogenesis of volar skin in the human fetus***. 1951, Am. J. Anat 91:147-157.

69. Yog R. Ahuja and Chris C. Plato, supra.

70. Peter Thorogood, ***The Relationship Between Genotype and Phenotype: Some Basic Concepts***, in ***Embryos, Genes and Birth Defects,*** supra., pp. 1-16.

71. Anne Reeves Haake and Lowell A. Goldsmith, ***The Skin*** in ***Embryos, Genes and Birth Defects,*** supra., pp. 251-280 (275).

72. Andrew J. Copp, ***The Neural Tube,*** in ***Embryos, Genes and Birth Defects,*** supra., pp. 133-152 (145-146)

73. Peter Thorogood, ***The Head and Face***, in ***Embryos, Genes and Birth Defects,*** ©1997, John Wiley & Sons, Chichester, Weinheim, New York, Brisbane, Singapore, Toronto, pp. 197-229 (209-219)

74. Anne Reeves Haake and Lowell A. Goldsmith, ***The Skin*** in ***Embryos, Genes and Birth Defects,*** supra., pp. 251-280 (269-70).

75. Anne Reeves Haake and Lowell A. Goldsmith, ***The Skin*** in ***Embryos, Genes and Birth Defects,*** supra., pp. 251-280 (263).

76.Noel Jaquin, ***The Signature of Time,*** 1940, Faber & Faber, Ltd., London. pp. 85-95; Jaquin, Noel, ***The Hand Speaks, Your Health, Your Sex, Your Life***, 1942, Lindoe & Fisher, London. My copy Sagar Publications, New Delhi, India, 1973.. pp. 15, 19.

77.Saferstein R. Criminalistics an Introduction to Forensic Science.4th Ed. New Jersey:Prentice Hall, Englewood Cliffs;1990:363-364.
78.Nadar D.S. Forensic Science in Crime Investigation 3rd Ed. Hyderabad: Asia Law House; 2002:48-49.

79.Cunliff F., Piazza BP. Criminalistics and Scientific Investigation.1st Ed, New Jersey: Prentice Hall, Englewood Cliffs; 1990:278.
80.Bridges BC.,Vollmer A.,Monir M. Criminal investigations, Practical fingerprinting, Thumb impression, Hand writing, Expert testimony, opinion evidence.1st Ed. Allahabad: The University Book Agency; 1995: 54-58.
81.IBG; Biometrics Market and Industry Report. 2007, IBG NY. P- 224.

82.Al-Zewary MS: Computer Processing Techniques for Fingerprints image identification. MSc Thesis College of science, University of Baghdad, 1996.
83.Al-Zewary: A New Fast Automatic Technique for Fingerprints Recognition and Identification. Journal of Islamic Academy of Sciences.1997:10(2); 55-60.
84. Shibli Nisar and Muhammad Wasim Ashraf; A New Approach for Toe Recognition Using Mel Frequency Cepstral Coefficients

85.J. Wayman, A. Jain, D. Maltoni, and D. Maio. An introduction to biometric authentication systems. Springer, 2005.

86.D. Bhattacharyya, R. Ranjan, F. Alisherov, and M. Choi. Biometric authentication: A review. International Journal of u-and e-Service, Science and Technology, 2(3):13-28, 2009.
87. A.K. Jain, Y. Chen, and M. Demirkus. Pores and ridges: Highresolution finngerprint matching using level 3 features. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 29(1):15- 27, 2007.
88.F.G. Hashad, T.M. Halim, S.M. Diab, B.M. Sallam and F.E. Abd EISami . Fingerprint Recognition uing Mel-Frequency Cepstral Coefficient: Pattern recognition and Image Analysis, 20(3):360-369, 2007.
89.V. Awasthi, V. Awasthi, and K. K. Tiwari. Fingerprint analysis using termination and bifurcation minutiae. International Journal of Emerging Technology and Advanced Engineering, 2:124-30, 2012.

90.Zhen, X. Wu, Z. Liu, and H. Chi. On the importance of components of the mfcc in speech and speaker recognition. ACTA SCIENTIARUM NATURALIUM-UNIVERSITATIS PEKINENSIS, 37(3):371-378, 2001.
91.A. Jaimes and N. Sebe, "Multimodal humancomputer interaction: A survey", Computer Vision and Image Understanding, 108(1): 116-134, 2007
92.B.J. Shannon., K.K. Paliwal., “A comparative study of filter bank spacing for speech recognition”,Proc. of Microelectronic engineering research conference, Brisbane, Australia, Nov. 2003.