DERMATOGLYPHIC: Finger Pattern Types
(Henry Classification), Total Ridge Count

Introduction

In common parlance, the study of the skin patterning on the finger palms, soles, and toes, are termed as Dermatoglyphics. It is derived from an ancient Greek term \( \text{derma} = \text{skin}; \ \text{glyphe} = \text{a carving} \) (Nath, 1984). In Human as well as in many other organism the palmer and planter surfaces are covered by skin different from others parts of the body. The surface is continuously corrugated with narrow minute (friction ridges) ridges and there are neither hairs nor sebaceous (oil) gland. However, sweat glands are abundant and relatively large in size. Similarly palms and soles of all primates’ bear ridges. The tails of certain monkeys and paws in some mammals other than primates also possess such kind of ridges.

In human it starts appearing for the first time from the twelfth to sixteenth week of embryonic development. Their formation get completed by the twenty fourth week i.e. about six foetal months. Thus once formed becomes permanent and do not change or alter throughout the course of life until intentionally destroyed or decomposed after death.
Brief historical development

The study of finger print started since long back showing an archaeological evidence of ancient Chinese and Babylonian civilizations to sign legal documents in 1000 BC. In AD 650, nearly 600 years before Marco Polo visited “Cathay”, Chinese historian Kia Kung-Yen wrote of fingerprints used in an older method of preparing contracts. The law book of Yung-Hwui of the same period listed that the husband in a divorce decree had to sign the document with his fingerprint.

In the late 1700’s, a German doctor, J.C.A. Mayer, A very astute observation were made. He reported that fingerprints are never duplicated by nature. However he did not continue to work.

Most historians credit Sir William Herschel with being the first person to categorically use fingerprints for identification purposes. In 1858, when he began the practice, the idea was probably based on superstition; but Herschel quickly saw the value of fingerprints as a positive form of identification.

The first person given credit for using fingerprints to solve a crime is Henry Faulds. He wrote in Nature magazine that when bloody finger marks or impressions on clay, glass, etc. exist, they may lead to the scientific identification of criminals. However the only scientific method of study started recently at the end of the 19th century.
Today due to the advances in the state-of-the-art have led to computerization of fingerprint record files. Automated Fingerprint Identification Systems (A.F.I.S.) is in operation in many parts of the country.

For example A. F. I. S. not only stores record cards in computer memory, it will match latent fingerprints from crime scenes to its data bank. A well-known example of the speed of an A.F.I.S. at work was in California. A latent fingerprint was entered into the system, and in less than four minutes later the print was matched, and a killer who had eluded police for six years was identified and apprehended.

**Working principles of Dermatoglyphics**

Importance of Dermatoglyphics lies due to the following distinct characters

1. It is not modified by environmental factors
2. It is Non-adaptive in characters
3. Not subjected to high rate of mutation
4. It can be identifiable without any subjective biasness etc.

In the case of particular fingerprint it has three important principles:

1. **First Principle:** A fingerprint is an individual characteristic. No two fingers have identical ridge characteristics (we have no specific proof of this, so we go on the scientific principle of inductive reasoning: it helps to explain why the term "fingerprint have been shown to be identical, therefore no fingerprints are identical. This is used throughout science, and will hold up until one contradictory example is found. As it is impossible to test every fingerprint on every person living, not to mention those in the past & those yet to be born, in the absence of contradictory evidence this will continue to be accepted as a fundamental principle.)
2. **Second Principle:** A fingerprint will remain unchanged during an individual’s lifetime.

3. **Third Principle:** Fingerprints have general ridge patterns which make it possible to systematically classify.

**Importance**

Because of all this important traits, in the present society it becomes one of the tremendous tools for human biologist. It is used for the personal identification as pointed out by Henry Fauld (1880) and Francis Galton (1892). It becomes one of the greatest contributions to the law enforcing departments on the principle that ‘anything can lie but not finger print’. It becomes one of the cheapest means to prove the identity of the criminals. It is also very much applicable in the prevention of impersonation and applied in the biometrics based electronic gadgets. Its value increases in clinical investigations with the rapid growth in human genetics and along with the discovery of chromosomal aberration in man. Because of its unchangeable characteristics, it has got very importance place in criminal investigation by storage, search, retrieval and matching of prints using computers with different methods (automated fingerprint identification systems; AFIS) etc. The anthropologists are very much concerned not only in the context of twin diagnosis (monozygotic and dizygotic), disputed paternity diagnosis, primatology and biological variation among different populations etc. but it try to understand in all the perspectives considering even the cultural and social background of the populations.
Main classes of fingerprints: (Loops, Whorls, and Arches)

Loops: 60-65% of the population has loops. It is characterized by having one or more ridges entering from one side of the print, curving and exiting from the same side. It has classified mainly two types:

1. Loop opening toward little finger: Ulnar loop (As the ulna is the *medial* bone).
2. Loop opening toward thumb: Radial loop (As the radius is the *lateral* bone). All loops must have one delta and type lines. The core is the center of the loop.

Whorls: 30-35% of the population has whorls. All whorl patterns must have type lines and two deltas. It has four major types:

1. Plain,
2. Central pocket,
3. Double loop and
4. Accidental

Plain whorls must have at least one ridge that makes a complete circuit and an imaginary line from one delta to the other must touch a whorl ridge. Central pocket whorls must have at least one ridge that makes a complete circuit and an imaginary line from one delta to the other cannot touch a whorl ridge. Double loop is two loops combined to make one whorl. Any other types not in the three categories are called accidentals (generally, they have a whorl type pattern).
Arches: Only 5 percent of the population has arches. Arch ridges tend to enter from one side of the print and leave out on the other side. It has two distinct types:

1. Plain arches and
2. Tented arches.

Plain arches tend to show a wave like pattern. Tented arches show a sharp spike at the center of the arch. Arches do not have type line, deltas or cores. The pictures of the following main classes of the fingerprint are shown in the figure given below:

**Finger Pattern types (Henry’s Classification)**

There are more than fifty finger pattern types of classification systems which are used in different countries and in different organization developed by many thinkers and scholars. So far the most acceptable classification applied in finding out of the criminals from the crime scene is produced by Galton, Henry and Vucetich system of classification. This type of classification is also known as Ten Digit classification system mainly developed by Edward Henry. In developing this classification he experimented with Herschel’s finger print system. He then visited Galton and later developed his own classification system. It is based on the recognition of certain fundamental structures like Arch, Loops, Whorl and Composite which are variants of the fundamental structure along with their distribution pattern of occurrence on the finger. Beside some of the secondary factors which are of importance in this classification include the direction of slope of the ridge, the distance between the right and the left delta and the core etc.
Sir Edward Henry (1850-1931)

Sir Edward Richard Henry was a high-ranking official (IGP) in Bengal in India during the nineteenth century. He was responsible for the government payroll, paying the natives who worked on the roads and railways. When Henry took over the position, there was a high rate of fraud cases. Some individuals would claim two or more paychecks under different names. If a worker died, his family would often hide the body and continue to claim his paycheck for years.

Sir Edward Henry solved the fingerprint-indexing problem with an ingenious solution in 1897. Scotland Yard adopted the Henry-System in 1901. Since then, the system has been adopted by virtually every country in the world (with minor regional variations).

In this type of classification all the ten digit fingerprint are analyzed under the following seven headings.

1. Primary classification system
2. Major divisions system
3. Secondary classification system
4. Sub-secondary classification system
5. Second sub-secondary classification system
6. Final classification system and
7. Key classification system
The Primary Classification (of all Ten Fingers)

This is a version of the Sir Henry’s system of classification, and is the first classification used by the FBI to "whittle down" the possible suspects in a crime scene. In this classification the ten fingers of the two hands are grouped in five pairs in the following manner.

Pair 1 includes Right Thumb and Right Index (RT&RI)  
Pair 2 includes Right Middle and Right Ring (RM&RR)  
Pair 3 includes Right Little and Left Thumb (RL&LT)  
Pair 4 includes Left Index and Left Middle (LI&LM)  
Pair 5 includes Left Ring and Left Little (LR&LL)

The fingers are paired, placing one finger in the numerator of a fraction and the other in the denominator. This way all ten fingers can be paired.

<table>
<thead>
<tr>
<th>R. Index</th>
<th>R. Ring</th>
<th>L. Thumb</th>
<th>L. Middle</th>
<th>L. Little</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------</td>
<td>-----</td>
<td>--------</td>
<td>----------</td>
<td>----------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R. Thumb</th>
<th>R. Middle</th>
<th>R. Little</th>
<th>L. Index</th>
<th>L. Ring</th>
</tr>
</thead>
</table>

Right thumb and right Index combination pattern could be either Loops or a Whorl. Therefore the possible combination of pattern on this first pair would be L/L, L/W, W/L, W/W. similar pattern follow in all the remaining pair. When the four possible combinations of the pair are combined with that of the four possible combinations of the second pair, the resultant number of possible combination would be 4x4= 16. When
third pair is associated with the combination of first and second it becomes \(4 \times 4 \times 4 = 64\) or \(16 \times 4 = 64\) when fourth and fifth pair is associated than it finally become \(4 \times 4 \times 4 \times 4 \times 4 = 1024\). This could be represented in the chart having 32x32 cabinsates arranged horizontally and vertically which would provide location for all combination of loops and whorl of the ten digits taken in five pair.

In practical understanding different numerical values have been assigned. If a whorl pattern is found on the first pair of the fingers (R. Index/R. Thumb), it is given a value of 16. A whorl on the next pair would be given a value of 8. The next pair, 4, then 2, then one for the last pair. Arches and loops are valued at 0. So that the fractions don't end up with 0 in the numerator or denominator, 1 will be added in both numerator and denominator.

Ex: If a whorl was found on the R. Index finger and the R. Middle finger, the following fractions would result:

\[
\begin{align*}
16 &+ 0 + 0 + 0 + 0 + 0 \\
0 &+ 8 + 0 + 0 + 0 + 0
\end{align*}
\]

If we add 1 to the top and bottom, we end up with a fraction of \(17/9\).

\[
\begin{align*}
16 &+ 0 + 0 + 0 + 0 + 0 + 1 \\
0 &+ 8 + 0 + 0 + 0 + 0 + 1
\end{align*}
\]

Therefore, we can eliminate all suspects that do not have this fraction. It is simply a way of quickly classifying fingerprints of a large group of subjects.

1. **Major Divisions System**

This system is created by counting the ridges in loop patterns and by tracing the whorl patterns on the thumbs only for both the right and the left hands. The loop
patterns on the thumb have been subdivided into three categories according to the
number of ridges counted between the delta and the core of a loop. The categorization
of loops on the thumb is made in the following manner:

1. All loops on thumb with ridge count between 1-12 are identified as ‘I’ type
2. All loops on thumb with ridge count between 13 -19 are identified as ‘M’ type.
3. All loops on thumb with ridge count 20- and above are identified as ‘O’ type

For major division the type of pattern on right thumb is taken as numerator and
left thumb for denominator. Thus with three types we obtain in the following nine
combinations.

<table>
<thead>
<tr>
<th>RT/LT</th>
<th>RT/LT</th>
<th>RT/LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I/I</td>
<td>M/I</td>
<td>O/I</td>
</tr>
<tr>
<td>I/M</td>
<td>M/M</td>
<td>O/M</td>
</tr>
<tr>
<td>I/O</td>
<td>M/O</td>
<td>O/O</td>
</tr>
</tbody>
</table>

So the value of this classification fluctuate between I/I to O/O

2. **Secondary classification system**

For secondary system the patterns appearing on Index Fingers of the Right and
the Left hand are considered. They are in the nine pattern types--- PLAIN ARCH, TENTED ARCH, RADIAL LOOP, ULNAR LOOP, WHORL, CENTRAL PECKET, LOOP, LATERAL PECKET LOOP (DOUBLE LOOP), TWINED LOOP (DOUBLE LOOP) and ACCIDENTALS which are represented by the following eight symbols: A, T, R, U, W, C, S and X. For arriving at secondary classification the patterns occurring on Right Index Finger are taken as numerator and the Left Index Finger for denominator. These eight types of pattern symbols would provide 64 possible combinations of Right Index / Left Index.
Thus the secondary formula for any individual would fluctuate between A/A type to X/X.

3. **Sub-Secondary classification system:**

   This classification system can be made under the following three heads based on the occurrence of patterns on the Index, Middle, and Ring finger of the Right and the Left hands.

   a. **Lettered Group Method**

   b. **Henry’s Method of Ridge Counting and Tracing**

   c. **New Method of Ridge Counting and Ridge Tracing.**

   a. **Lettered Group Method**

   b.

   Whenever plain arches, tented arches and radial loops occur in any finger other than the index finger the prints are classified under Lettered Groups. This type of pattern is recorded by employing small alphabetic symbols in the sequence of their appearance.
<table>
<thead>
<tr>
<th>Thumb</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
<th>Little</th>
<th>Main number</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(I)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>a</td>
<td>-</td>
<td>-</td>
<td>(II)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>a</td>
<td>a</td>
<td>-</td>
<td>(III)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>a</td>
<td>-</td>
<td>a</td>
<td>(IV)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>(V)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>-</td>
<td>a</td>
<td>-</td>
<td>(VI)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>-</td>
<td>a</td>
<td>a</td>
<td>(VII)</td>
</tr>
<tr>
<td>a</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>a</td>
<td>(VIII)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(IX)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>a</td>
<td>-</td>
<td>-</td>
<td>(X)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>a</td>
<td>a</td>
<td>-</td>
<td>(XI)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>(XII)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>-</td>
<td>a</td>
<td>-</td>
<td>(XIII)</td>
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<td>-</td>
<td>A</td>
<td>-</td>
<td>a</td>
<td>a</td>
<td>(XIV)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>a</td>
<td>(XV)</td>
</tr>
<tr>
<td>-</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>a</td>
<td>(XVI)</td>
</tr>
</tbody>
</table>

The roman numbers are noted in addition to the lettered formula to avoid any kind of confusion in recording and for quick searching. When both the numerator and denominator fall in the sub class (IX), the impressions are classified according to the second or third system of the sub secondary system. The number of the groups for the other hand shall be similar i.e. 16 in all. Thus taking 16 groups each for the right and the left hand the total number of possible combinations would be 16x16 = 256, when the pattern on the index finger (as fulcrum) is identified as A. thus on taking T and R patterns on the index finger as fulcrum, we would get 256 possible combinations for each T and R respectively. For arriving at the lettered formula the patterns on the right hand fingers are taken as numerator and left hand for denominator.
c.  Henry’s Method of Ridge Counting and Ridge Tracing

Henry’s methods is followed for classifying the fingerprints when under the sub-secondary system, the lettered group formula indicates the category IX, that is the plain arches, tented arches and radial loops are present only on the index finger and not on any other finger or in other words when classification is not possible according to the lettered groups method then the Henry’s method of ridge counting and ridge tracing is employed. Under this system the loop patterns are subdivided into two groups on the basis of the number of ridges counted between the core and the delta for the three fingers separately.

Index finger
1. All loops showing a ridge count between 1-9 are taken as ‘I’ types
2. All loops showing a ridge count as 10 and above are taken as ‘O’ types

Middle finger
1. All loops showing a ridge count between 1-10 are taken as ‘I’ types
2. All loops showing a ridge count as 11 and above are taken as ‘O’ types

Ring finger
1. All loops showing a ridge count between 1-11 are taken as ‘I’ types
2. All loops showing a ridge count as 12 and above are taken as ‘O’ types

All whorl patterns, including the composite one are subdivided into three groups i.e. I, M, O types, as explained earlier. Plain arches and tented arches present on the index finger are taken as ‘I’ types loop for the purpose of classification.

This will provide the following eight combinations of loops and whorls on these three fingers i.e Index, Middle and Ring.
<table>
<thead>
<tr>
<th>Groups</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2.</td>
<td>L</td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>3.</td>
<td>L</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>4.</td>
<td>L</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>5.</td>
<td>W</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>6.</td>
<td>W</td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>7.</td>
<td>W</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>8.</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
</tbody>
</table>

Each of these groups would have the following combinations according to the type of pattern i.e. I and O type for loops and I, M and O types for whorls.

Groups 1: LLL
III, IIIO, IOI, IOO, OOI, OIO, OII, OOO

Groups 2: LLW
III, IIM, IOI, IOM, IOO
OII, OIM, OIO, OOI, OOM, OOO

Groups 3: LWL
III, IIIO, IMI, IMO, IOI, IOO
OII, OIO, OMI, OMO, OOI, OOO

Groups 4: LWW
III, IIM, IIIO, IMI, IMM, IMO, IOI, IOM, IOO
OII, OMI, OIO, OMI, OMM, OMO, OOI, OOM, OOO

Group 5: WLW
III  IIM  IIO  IOI  IOM  IOO  MII  MIM  MIO  
MOI  MOM  MOO  OII  OIM  OIO  OOI  OOM  OOO

Group 6: WLL
III  IIO  IOI  IOO  MII  MIO  
MOI  MOO  OII  OIO  OOI  OOO

Group 7: WWL
III  IIO  IMI  IMO  IOI  IOO  MII  MIO  MMI  
MMO  MOI  MOO  OII  OIO  OMI  OMO  OOI  OOO

Group 8: WWW
III  IIM  IIO  IMI  IMM  IMO  IOI  IOM  IOO  
MII  MIM  MIO  MMI  MMM  MMO  MOI  MOM  MOO  
OII  OIM  OIO  OMI  OMM  OMO  OOI  OOM  OOO

For arriving at the sub secondary formula according to this method, the right hand fingers are taken as numerator and the left hand fingers for denominator.

d. New Method of Ridge Counting and Ridge Tracing.

Index finger

1. All loops with ridge count between 1-5 are taken as ‘I’ type
2. All loops with ridge count between 6-12 are taken as ‘M’ type
3. All loops with ridge count between 13 or above are taken as ‘O’ type

Middle finger

1. All loops with ridge count between 1-6 are taken as ‘I’ type
2. All loops with ridge count between 7-13 are taken as ‘M’ type
3. All loops with ridge count between 14 and above are taken as ‘O’ type

Ring finger

1. All loops with ridge count between 1-7 are taken as ‘I’ type
2. All loops with ridge count between 8-14 are taken as ‘M’ type
3. All loops with ridge count between 15 and above are taken as ‘O’ type

The whorls are grouped into I, M, O types according to their tracing. Plain arches, tented arches and radial loops existing on index finger are taken as ‘I’ type loops for the purpose of classification in a similar manner as that followed in the Henry’s method of sub-secondary system.

The world and loop patterns existing on the index, middle and ring fingers would provide the following eight combination groups:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>10.</td>
<td>L</td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>11.</td>
<td>L</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>12.</td>
<td>L</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>13.</td>
<td>W</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>14.</td>
<td>W</td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>15.</td>
<td>W</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>16.</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
</tbody>
</table>

As both the pattern type i.e. loops and whorls are subdivided into I, M, O types, each of the eight groups would provide following twenty seven possible combination.
Groups I: LLL
III, IIM, IIO, IMI, IMM, IMO, IOI, IOM, IOO
MII MIM MIO MMI MMM MMO MOI MOM MOO
OII OIM OIO OMI OMM OMO OOI OOM OOO

Because of the three fold division of loop patterns, the remaining seven groups -- LLW, LWL, LWW, WLL, WLW, WWL and WWW could show the same twenty seven combination as shown for Group 1. The only advantage of this system over the Henry's one is that we get as many as 216 possible combinations while in Henry's method we get only 125 combinations.

For the purpose of recording the right hand index, middle and ring fingers are taken for numerator and the left hand finger for denominator.

4. Second Sub-Secondary classification system:

In case of huge collection of finger prints under a specific sub-secondary system, it is essential to incorporate the use of Second Sub-Secondary system to split them into smaller groups so as to save time in searching a particular fingerprint slip. Sub secondary system in lettered form is to be used by identifying the patterns on the middle and the ring fingers only by representing them through symbolic small alphabets (letters) in the following manner.
<table>
<thead>
<tr>
<th>Pattern type</th>
<th>Alphabetic Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Invaded or Crested Ulnar Loop</td>
<td>k</td>
</tr>
<tr>
<td>2. Nutan Ulnar Loop</td>
<td>n</td>
</tr>
<tr>
<td>3. Plain Ulnar Loop</td>
<td>u</td>
</tr>
<tr>
<td>4. Whorl</td>
<td>w</td>
</tr>
<tr>
<td>5. Central Pocket Loop</td>
<td>c</td>
</tr>
<tr>
<td>6. Double Loops (lateral pocket and twined)</td>
<td>s</td>
</tr>
<tr>
<td>7. Accidentals</td>
<td>x</td>
</tr>
</tbody>
</table>

In case plain arches, tented arches and radial loops occur on the middle and the ring fingers than the second sub-secondary system is not used. In such situation the prints are classified according to the lettered method of sub-secondary system.

The patterns on the middle and the ring fingers would show the following four combinations:

<table>
<thead>
<tr>
<th>Group</th>
<th>Middle</th>
<th>Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2.</td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>3.</td>
<td>W</td>
<td>L</td>
</tr>
<tr>
<td>4.</td>
<td>W</td>
<td>W</td>
</tr>
</tbody>
</table>

The loops are subdivided into three types i.e. k, n, and u, while the whorls have four types i.e. w, c, s, and x. on the basis of the type of patterns occurring on the middle and the ring fingers, the following combinations would be possible under each groups:
Group 1: LL

kk, kn, ku, nk, nn, nu, uk, un, uu.

Group 2: LW

kw, kc, ks, kx, nw, nc, ns, nx, uw, uc, us, ux.

Group 3: WL

wk, wn, wu, ck, cn, cu, sk, sn, su, xk, xn, xu

Group 4: WW

ww, wc, ws, wx, cw, cc, cs, cx, sw, sc, ss, sx, xw, xc, xs, xx

For arriving at Second Sub - secondary formula the pattern types occurring on the right hand middle and ring fingers are taken for numerator and the left ones for denominators.

The invaded loops, the crested loop and the nutant loop patterns which are utilized in the second sub secondary system may be identified as follows:

**An Invaded Ulnar Loop** is a pattern which represents an appearance though a series of ridge were swarming (passing) over the pattern coming from the direction of delta and trying to engulf the loop (for second sub - secondary system it is represented by symbol ‘k’).

**A Crested Ulnar Loop** is a pattern in which the ridges swarms over the pattern and merge to form a sort or crest over the pattern area (for second sub - secondary system the crested loop is also represented by symbol ‘k’).
**A Nutant Loop (Indented Loop)** is a pattern in which a loop assumes the appearance of a sickle, or the core line exhibits a bent near the point of core. Such loops are identified as nutant loop. (for second sub – secondary system a nutant loop is represented by symbol 'n').

5. **Final classification system:**

   The final system of the Ten Digit classification is made by recording the ridge count of loop and whorl patterns on the little finger exclusively.

   The ridges of a whorl are to be counted from left delta to the core in case of right little finger and from right delta to the core in case of left little finger.

   In case of double loop patterns the ridges are to be counted between the left delta and the core of the ascending loop for right little finger and between right delta and the core of the ascending loop for left little finger.

   In case of loop patterns the ridges are counted in the usual manner i.e. between the core and the delta. For arriving at the final formula the ridge count of the right little finger is taken for numerator and the left for denominator.

6. **Key classification system:**

   Key classification system involves the ridge counting of loop or whorl patterns appearing on the right thumb only. For the purpose of recording the ridge count is specified followed by the pattern type representing through small alphabetic symbols which were used under the second sub secondary system i.e. k, n, u, w, c, s, and x.
The value of the key system is placed at the extreme left of the completed classification formula in line with the numerator. The various positions in the classification line for these divisions when completely applied are as follows:

<table>
<thead>
<tr>
<th>Key</th>
<th>Major</th>
<th>Primary</th>
<th>Secondary</th>
<th>Sub-Secondary</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>L</td>
<td>1</td>
<td>U</td>
<td>IOI</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td>1</td>
<td>U</td>
<td>IOO</td>
<td>10</td>
</tr>
</tbody>
</table>

The system of ridge count in case of whorl and double loop patterns is the same as that followed in the final system i.e. for whorls between left delta and core, and for double loops between left delta and the core of the ascending loops.

In some cases, this meant that an investigator had to go through all of the known fingerprint for the comparison work. Second Sub-secondary classification is only used when a group of fingerprints becomes too cumbersome and unwieldy.

**Total Ridge Count**

Fingerprint ridge patterns result from environmental influences on the expression of a number of interacting genes. At least seven genes are thought to be involved in finger ridge formation (Penrose, 1969).

The polygenic inheritance model describes the nature of fingerprint ridge patterns well. There are three major groups of dermal ridge patterns: (1) Arches, (2) Loops, and (3) Whorls. The arch is the least frequent pattern, subdivided into two groups, plain (the ridges rise slightly over the middle of the finger) and tented (the ridges rise to a point in the center). The loop pattern is more complicated. It consists of a core and a tri-radius (a point where three ridge groups meet at angles of about 120 degrees). Loops are classified as radial or ulnar depending on the orientation of the core ridge. Radial loops have a triradius that is on the side of the little finger, with the loop opening towards the
The ulnar loop has a triradius that is on the side of the thumb, with the loop opening towards the little finger. The whorl pattern on the other hand, has two tri-radii with the ridges inside the whorl consisting of a number of different patterns.

The sum of ridge counts on all the fingers of both hands which is a quantitative trait having inheritance in nature is called the TOTAL RIDGE COUNT (TRC). In a study by Rolt (1968), the average TRC for males was found to be 145 and for females it was found to be 126. The ridge count on a finger with a loop is determined by counting the number of ridges between the triradius and the center or core of the pattern. For arch the ridge count is 0, for whorl ridge count is made from each triradius to the center of the fingerprint but only the higher of the two possible counts is used.

Procedure and Results:

To prepare a set of your fingerprints, to determine TRC, and record the data, first prepare a chart of your ten fingerprints. Use a #2 pencils and shade in a 3cm square area on a piece of plain paper to make an 'ink' pad. Rub one of the fingers gently on the graphite square; making certain that it covered all of the tri-radii of the fingerprint. Now carefully place a piece of clear tape on the blackened finger so that the tape comes in contact with entire print. Make certain that it include any tri-radii on the outer edges of the finger by rolling the finger over the tape in one continuous motion. Peel away the tape and affix it to the appropriate place on the chart (unlined paper). Repeat this process, preparing a print for each of the ten fingers. Examine each print carefully; if a print is incomplete or smeared, prepare a new one. If necessary, use a magnifying glass to classify the pattern (arch, loop, or whorl) and to determine the ridge count for each print.

Draw a line between the delta and core. As long as you touch or cross a ridge, you have a ridge count.
1. One ridge must be a looping ridge.

2. The delta and core are not counted.

3. Fragments and dots are counted as ridges only if they appear as thick as the surrounding ridges.

4. If you cross a bifurcation, count both of its arms.

5. If the delta is on the only loop, there is no ridge count. "0" count

6. White space must intervene between the delta and the first ridge count.

7. If the delta is above the shoulder of a single looping ridge and the core is on the shoulder, there is no ridge count unless the imaginary line cuts the recurve.

8. For natural and unnatural breaks in the ridges, the distinction is left to the judgment of the individual classifier.

9. When the core is placed on a spike that touches the inside of the inner most sufficient recurve, the recurve is included in the ridge count only when the delta is located below a line drawn at right angles to the spike. (If the delta is located in area “A”, the recurring ridge is counted.)

   To determine TRC add together each of your individual ridge counts. Arches have a ridge count of zero. For loops, count the number of ridges between the tri-radius and the center or core of the pattern. For whorls, a ridge count is made from each tri-radius to the center of the fingerprint and the higher of the two possible counts is recorded.
Figure given below is an example of some fingerprint patterns and the TRC. A: arch with no tri-radius and ridge count of 0; B: loop with one tri-radius and a ridge count of 12; C: whorl with two tri-radii and a ridge count of 15 (the higher of the two possible counts.

After recording the fingerprint pattern data, total ridge count, and sex in the excel spreadsheet different type of analysis can be perform as per the need of investigation. We can check the difference between males and females in their ridge counts or patterns. By knowing the Total Ridges Count comparison work with the necessary population or individual can be easily drawn.

Conclusion

Dermatoglyphics become one of the very important topics to be understood by all the human society. Day by day its importance is felt in solving the problems of human crimes. It has unlimited application in our problematic society especially in the law enforcing department. In spite of numerous research work in improving the study of its application like complicated finger pattern type classification (Henry’s classification), Total Ridge Count etc. still in-depth and extensive research to know the Dermatoglyphics in details are always necessitate.