Personality Identification System based on Human Foot Anatomy

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Abstract: *The research work presents a personality identification system for the identification of human behavior/personality using the anatomical structure of human foot. The human foot basically belongs to the physiological constituent of biometric trait with unique characteristics suitable to identify human behavior, genealogy and personality. Notable application areas of the trait include forensic investigation, affection determinant, security checks at religious places, airports and more uniquely, its application is very useful in the maternity wards of hospitals for identification of infants to prevent baby swap. Key identification attributes of human foot are the geometric patterns and the minutiae features. For the purpose of this work, the geometric pattern is considered, specifically the toe shape and length of human foot was used. Foot images from 65 adults were captured using a digital image scanner. The data captured were labelled with their corresponding feature descriptors. Automatic identification algorithm based on classification rule learning was deployed to match the foot feature descriptors with their personality/behavior template in the knowledge base. The results from the system implementation and percentage behavior match showed that the system is quite suitable for identifying personality/behavior of an individual with performance accuracy of 89%.*

Keywords: Personality, genealogy, foot anatomy**,** biometric**,** knowledge base, toe shape

1. Introduction

The increasing need for intelligent and security systems in our society has generated considerable interest in the use and acceptability of biometric traits in identifying an individual based on his or her physiological or behavioral characteristics. Typical examples of biometric traits include: face, iris, fingerprint, palm print, footprint, voice, signature and so on. For the purpose of this work, the footprint is considered, specifically the toe shape pattern and length of human foot was used. According to [1; 2], the human foot is the lowermost part of the human leg. Its shape, along with the body's natural balance-keeping systems makes humans capable of not only walking, but also running, climbing, and countless other activities. The foot is an intricate part of the body, consisting of flexible structures of bones, joints, muscles, and soft tissues [3]. Figure 1 and Figure 2 depicts the images of human feet and its internal structure respectively.

Figure1: Image of human feet
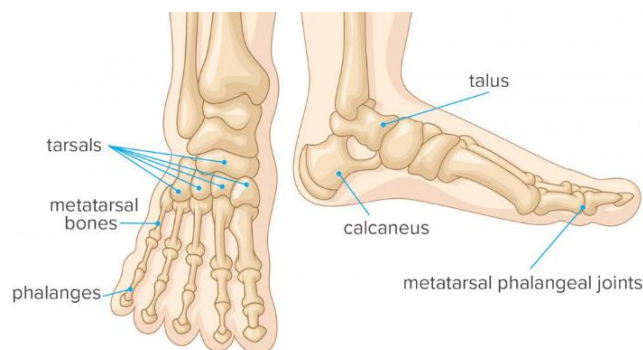
Figure 2: Internal Structure of Human foot

2. Literature Review

2.1 Human Footprint

According to [4], footprints are the impressions or images left behind by a person walking or running on a surface as depicted in Figure 3. Generally, the human footprint possessed the following characteristics: the toes, ball of foot, anterior transverse arch, medial longitudinal arch, lateral longitudinal arch and a heel. Figure 4 showed the overall shape of human foot and its characteristics.

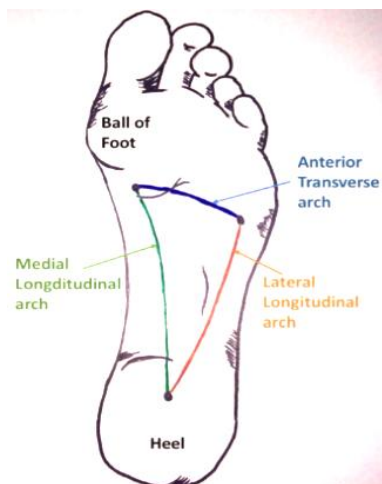**Figure 3:** Images of human footprint on a surface

Figure 4: Characteristics of Human foot

3. Geometric features of the Human foot

According to [5], some of the commonly used geometric features of human foot are presented in sections 3.1, 3.2, 3.3 and 3.4.

3.1 The Foot Width

The foot width is measured by the distance between the left and right-side point of the foot. There are three common widths in the foot, the first width is from the center point, the second width is found in the upper part above the center point and the third width is found at the bottom under the center point of the foot.
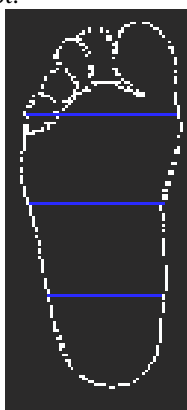

Figure 5: The three segment of the human foot width

3.2 The Foot length

The foot length of a human being varies in size from the fetal stage to a fully-grown adult. Usually, women tend to have smaller feet than men. The foot length is defined as the distance between the top point and he bottom of the foot. Hence, the length of human foot can be calculated by taking the distance between the top and bottom points of each foot.

Figure 6: Foot length measurement

Foot length and width measurement as described in [6] is depicted in figure 7, while figure 8 depicts the toe length measurement
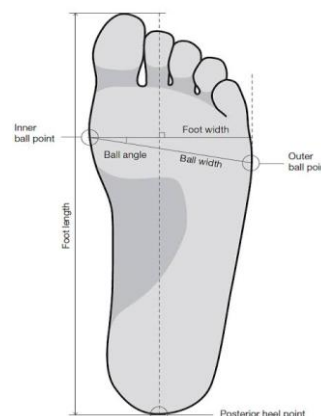

Figure 7: Foot length and width measurement
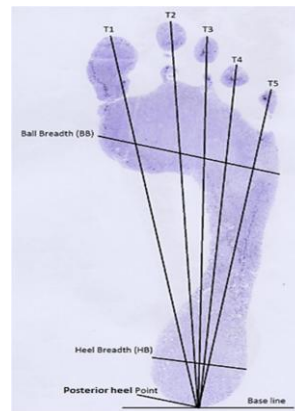

Figure 8: Toe length measurement

3.3 The Foot Center Point

The center point of human foot is one of the special characteristics that can be used to determine the stability of a person when standing. It depends on the center of gravity, calculatable by measuring the distance between the center and outer point by different angles.
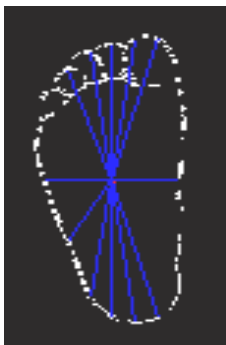
Figure 9: Foot Center Point

3.4 The Toe Shape

The Toe Shape is another geometric feature that can be used to identify the genealogy and personality of a person. It's very important in forensic investigation and good for spying criminals [5; 6]**:** Typical examples of the toe shapes are described below:

Egyptian Toe shape: The Egyptian foot shape is a type of foot distinguished by a long big toe, followed by the other toes tapering at a 45-degree angle. The entire foot is at an incline, and usually longer and narrower than other shapes. People with this type of foot, love extra pampering and are generally very friendly people.

Figure 10: Egyptian toe shape

Greek Toe shape: The Greek toe pattern is often referred to as the flame foot or fire foot. This toe type is characterized by a protruding second toe longer than the big toe. People who have this type of toe are touted and extremely sporty and creative, enthusiastic about new ideas. They are energetic and they have the trait of natural leaders, but can be impulsive and a bit stress head. They love causing chaos just to grab eye-balls of other people [7].

Figure 11: Greek toe shape

Roman Toe shape: This toe shape is characterized by the first three toes being of the same height, with the other two in descending order. The people who possess this toe type are known to have a balanced body shape, as well as personality with inherently outgoing, energetic and love adventures.

Figure 12: Roman toe shape

Celtic Foot: The Celtic foot is believed to be a variation of the Greek foot with big toes a bit shorter. It has different toe lengths that don't follow a strict descending order. A Celtic foot may have third or fourth toes that are about the same length as the big toe or the third, fourth, and fifth toes have a grouping of the same size. People that falls into this category are dynamic and can do many things at the same time. They are impulsive and may face uproar in marriage.

Figure 13: Celtic toe shape

Peasant Toe shape: The Peasant Foot has all toes practically the same length; it appears square in shape, though the big toe may be a tad bit longer. Personalities that possess this type of feet are patient, honest and thoughtful person. They love weighing up options before making decision, pondering for ages over their decisions. They analyze their decision carefully. They are peace maker who is excellent at resolving conflicts.
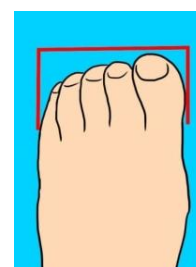

Figure 14: Peasant/European toe shape

Extra Small Toe shape: The shape of the extra small little toe pattern is quite similar to the Egyptian toe. This foot type has an extra tiny pinky toe as a distinguishing feature. The rest of the toes are tapering in descending order, just like the Egyptian toe. People who fall into this category are very secretive and they avoid discussing with others, if they have a choice. If the tiny toe faces sideways, such person may be rather free spirit and rebellious.

Figure 15: Extra small toe shape

Wide-set Toes shape: The wide-set toe pattern which is also referred to as the traveler's foot has in between the toes a lot of gap. The toes are stretched quite far apart. Individuals with this toe shape are naturally hard workers, who hate waiting around. They are constantly on the move, love travelling and exciting adventures. They are happiest when they go out of their environment.

Figure 16: Wide-set toe shape

Stretched Big Toe shape: This type of toe shape has the big toe strays far away from the other four toes, which are packed tightly together. Individuals with this type of foot shape are tends to be secretive and love keeping their personal spaces. They are fiercely independent by nature and love arguments. They may tend to play devil's advocate in certain circumstances.

Figure 17: Stretched toe shape

Warrior Toes: People with the warrior toes have a long big toe and four other toes of relatively similar length. People that fall into this category may be socially butterfly and love partying. They love confrontation and tend to get into heated arguments over topics they are passionate about.

Figure 18: Warrior toe shape

4. Foot Pathologies

The foot arch pattern (pathology) in human is also very unique [8]. It can also be used to determine the personality behavior and feet conditions of an individual. The foot arch is divided into three types; the normal arch, flat arch and high arch as shown in Figures 19a and Figure 19b respectively. The height of each person's arches varies normally and it could be hereditary. People with high arches are usually more sufficient independent in nature, those with flat or low arches are more sociable and enjoy being around others while people with normal arch are averagely dependent [9]. If the middle part of an individual foot arch is about half filled, this means such an individual have a normal arch.

Naturally, the arch supports the body weight and pronates (rolls in) under a normal load. If the footprint looks like a complete foot, then the individual has a flat arch. If the foot probably rolls in (pronates) when such individual walk or run, this may contribute to muscle stress and joint problems. A person with little of his or her footprint seen is likely to have high arch and high arches may contribute to excessive strain on joints and muscles.

(a)
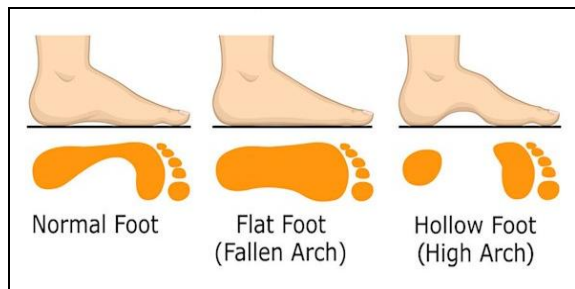
(b)
Figure 19 (a & b): Type of Foot Arches

5. Materials and Method

Figure 20 presents the architecture of the Personality Identification System (PIS) developed for the work. The PIS consist of five components, the first component is the foot image scanner and enrolment component, this component handles the image capturing and enrolment of individual that want to use the system, the second component is the foot image template generation, this component model the distinctive individual foot feature descriptor called the template, the third component is the personality behavior knowledge base (KB), this component serves as the repository where the inference of the personality behavior are drawn for matching. The fourth component is the foot image test component linked with the KB; this component is responsible for the matching of the foot image with the template in the KB. The last component is responsible for the display of the predicted personality behavior of prospective user of the system.
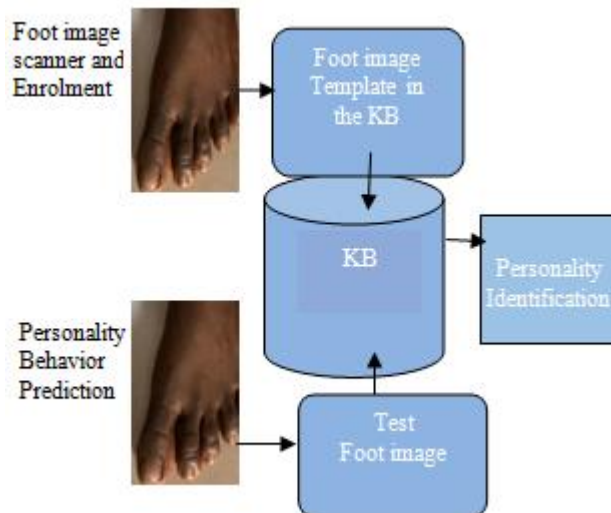

Figure 20: Architecture of PBIS

6. Data Collection and Analysis

Foot images from 65 persons were captured using a digital scanner called easy foot scan machine. The toe length was specifically measured, modeled with its shape pattern, and labelled with their corresponding feature descriptors. Samples of data collected are shown in Table 1. The result analysis of the feature descriptor, reported personality/behavior and percentage of behavior match were presented in Table 2.

Table 1: Analysis of sample data captured and representations

Identity	Foot images	T1 cm	T2 cm	T3 cm	T4 cm	T5 cm	LBA	PBT	SBT	WST	TTS	PTS
P1		20	19	18	17	16	1	0	0	0	0	0
P2		22	23	21	20	18	0	1	0	0	0	0
P3		18	19	17	16	15	0	0	1	0	0	0

P4		26	28	27	22	20	0	0	0	1	0	0
P5		25	26	25	20	18	0	0	0	0	1	0
P6		18	18	18	18	18	0	0	0	0	0	1

T1 = Toe1, T2 = Toe 2, T3 = Toe3, T4 = Toe 4, T5= Toe 5, LBA = Long Big Toe Ascending Order, PST = Protruding Big Toe, SBT = Stretched Big Toe, WST = Wide Stretched Toe, TTS = Three-two Toe shape, PTS = Peasant Toe Shape.

7. Discussion and Experimental Results

The automatic identification model based on classification rule learning was deployed in the work to match the feature descriptor of an individual foot considered with their corresponding personality/behavior template in the knowledge base. For one specific identification, the following classification rule is devised:

If LBA = 1 (feature descriptor template in the KB) then Identity is P1. ……………………………………….. (1)
The system recognizes an individual by searching the templates corresponding to users' label in the knowledge base for a match. The system conducts a *one to many* comparisons to establish an individual identity/personality. The identification problem is stated as follows: given an input query feature set X, determine the identity I_k, $k \in$ (1,2…….N, N+1), where $I_1, I_2, ……...I_N$ are the N identifiers enrolled in the system, and I_{N+1} indicating the reject case. To determine the individual's identity, the decision rule is expressed as,

$$X \in \begin{cases} I_M & If\ M = max_k\ \{S(X,Y_{Ik})\ and\ S(X,Y_{IM})\ \} >= PI \\ I_{M+1} & Otherwise \end{cases} \quad (2)$$

Where S represents the function that measures the similarity between X and Y_{Ik}. Y_{Ik} is the biometric template corresponding to identity I_k, and PI is the predefined personality identification. The value $S(X,Y_{Ik})$ is a match descriptor between the feature label of the query and the stored template corresponding to identity I of the person being identified. The above described identification as the open-set identification. Results from these processes are presented in Table 2.

Table 2: Analysis of samples of foot images captured with their personality behavior and percentages of match

Identity	Label/Feature Descriptor	Personality/Behavior	% of behavior match
P1	LBA - Long big toe, followed by the other toes tapering at a 45-degree angle.	Love extra pampering and are generally very friendly.	92%
P2	PBT - Foot toe has protruding second toe longer than the big toe.	• Touted, extremely sporty and creative, with leadership qualities to boast of. • Evidently careless. • Love causing chaos just to grab eye-balls of other people.	91%
P3	BT - Big toe strays far away from the rest of the toes	• Fiercely independent by nature and love arguments.	88%
P4	WST- Foot shape has a lot of gap between all the toes. - The toes are stretched quite far apart.	• Love travelling and exciting adventures Happiest when they go out of their environment	87%
P5	TTS - First three toes being of the same height, with the other two in descending order.	• Balanced body shape • Energetic and love adventures	86%
P6	PTS- Toes practically has the same length; appears like square in shape.	• Reeks of patience, and are probably the most thoughtful. • Ponder for ages over their decisions, and have the ideal choice of people for resolving issues and conflicts	90%

| | | • Rational and honest by nature. | |

8. Conclusion

An approach to personality behavior identification of an individual using the anatomical structure of human foot was considered in this work. The foot images from 65 persons were captured using digital scanning machine called easy foot scan machine. The images captured were labelled with their corresponding feature descriptor in the system knowledge base. Automatic identification algorithm deployed for matching process incorporates classification rule learning, and the results of the comparison and percentage of personality behavior matches were reported appropriately. The overall result showed that the approach can be suitably used to predict/identify the personality behavior of an individual with performance accuracy of 89 %.

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