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Human Footprint Properties based on Pedobarographic Image Analysis

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Abstract— **The human foot is the primary mechanical interface between our body movement and environment. As increase in relative speed, the foot must transmit increase in propulsive impulsive force to the ground and this mechanics is complex to understand. Depending on the intensity of pressure, the perceived sensation can vary from a sense of touch to discomfort to pain. Thus, knowing the effects of pressure and related sensation can be very helpful for medical diagnosis. In this study, we need to correlate Footprint images with corresponding Body Mass Index of individual using Image processing principles. Pedobarographic images, consist of Red, Green and Blue colours. In this method each colour pixel count correlates with the pressure points of human foot and with relative Body Mass Index. We also find one Footprint Index property which decides type of Foot arch.**

Index Terms— **Body Mass Index, Human Footprint, Foot Disorders, Pedobarography.**

I. INTRODUCTION

Every part of the human body is unique in itself and it is amazing to learn that every part of the body is different in its own way from a similar part in another person's body. Biometrics which is the use of biological or behavioural features of an individual to determine his identity is based on this premise. Personal identification using footprint can be carried out by using any one of the two important features of the foot, namely static and dynamic. Forefoot shape, including toe shape, exhibits significant variation among people. The shape and size features of the foot, defined as the morphology of the foot are extracted and classified based on shape, and minutiae. In this method a foot print verification is implemented using static footprint features. In this method two distinct features such as shape and minutiae are respectively extracted. Matching is done to arrive at a reject or an accept decision. [1] One particular area in the study of human motion is gait analysis. The gait analysis laboratory has become an increasingly common resource in hospitals specializing in orthopaedics and movement disorders. Human walking is a result of a complex process involving the brain, spinal cord, peripheral nerves, muscles, bones and joints. Gait represents the manner or style of walking, and gait analysis refers to a process in which kinematic and kinetic data are measured, calculated, and then analyzed to provide information that describes the events. In 1836, the Weber brothers in Germany accurately measured the timing of gait and of the pendulum-like swinging of the leg of a cadaver. They were also the first to describe the gait cycle. In the 1870s, two pioneers worked on kinematic measurement of human motion. The aim of gait analysis laboratories is to measure and study human gait walking pattern for better understanding and treating of gait abnormalities. It is guidance for therapy, surgery and prosthetics. [2]

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II. LITERATURE SURVEY

The foot pressure distribution also varies according to age of individual. This difference confined to calcaneus and hallux region at medial side of human foot. In adults, during walking weight bearing on lateral side of foot during heel touch and toe off affect stability. [3] Using neural network system as a conclusion making system for diagnosis purpose is beneficial all time. In human walk abnormality diagnosis, the pressure distribution of foot of individual during walking, standing is stored. This tool used for diagnosis of patients and record their data. [4] Human foot pressure distribution indicates Foot arch type. The mid foot area of human foot and pressure ratio are associated with foot arch type. Normally three types of human foot arch, they are High arch, Normal arch and flat foot. The mid foot area and pressure ratio are lower in high arch and higher value in flat foot type. [5]

In many diseases like diabetics, foot condition affects in which sensitivity of exterior part of foot and nervous system is considered. In these patients circulation to feet can be decreased leading to slow healing and risk of infection. Due to nerve damage, it makes feet less sensitive to hot, cold or pain. Study of Pedobarography gives us way to analysis of foot pressure and foot abnormalities. In case of diabetic patients this system is beneficial during foot ulceration and neuropathy causes. High plantar foot pressure associated with peripheral neuropathy involve risk factor of foot ulceration diabetes patients.[6] From diabetes patients, It is observed that there exists relationship among forefoot and rear foot plantar pressure with neuropathy.[7]

The Body Mass Index (BMI) defines individual's mass and height based on body shape. Scientist Belgian Polymath and Adolphe Quetelet studied on this concept between 1830 and 1850. The definition for BMI termed as ratio of person's body mass divided to the square of their height with the units of kg/m2. According to standard rules the individual is underweight if BMI value is less than18.5 which indicates nutrition loss or some health problems. When BMI value is over 25 is considered as overweight and above 30 is obese.

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The high BMI indicates excess body fat which associated with disorders of several organ system such as reproductive system, respiratory system, cardiovascular system and musculoskeletal system. Waist circumference is also a predictor for risk of diabetes and cardiovascular diseases.[8] The study observed that, foot problems in region of West are more than in Africa region. This is because of shoe wearing habits or foot shape of individual. In foot wear science, the key part foot and its loading pattern are still in focus. In this study, by comparison of dynamic plantar pressure distribution between Malawian and Dutch people, can able to conclude whether feet is Flat feet or happy feet. [9] Using Regression analysis body height estimation based on foot length and foot breadth can be possible.[10]

A particular model helps to understand the sensation of pressure threshold and its effect in designing consumer product. In this magnitude of pressure of healthy individual's foot sole and respective perceived sensation were analyzed. [11] The systematic study of human locomotion can be called as Gait analysis. This analysis contains description, measurement and assessment of quantities that gives characteristics of human locomotion. In orthopaedics and rehabilitation for monitoring patients healing progress, gait analysis is used. In these using wearable sensors, motion sensors methods called gait kinetics, gait kinematics and electromyography. As increase in development in sensor technology, this analysis system plays important role in clinical application. [12]

III. Block Diagram

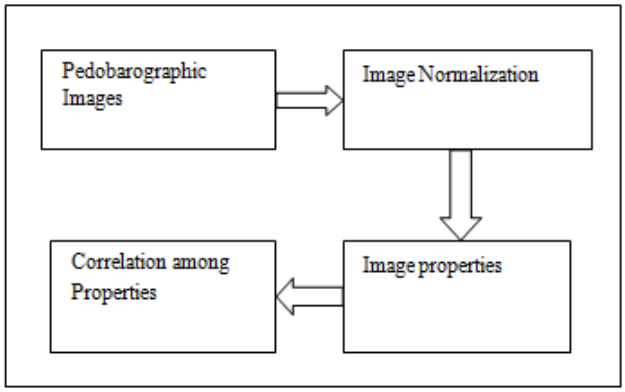

Fig. 1 Block Diagram of system

The block diagram of our system is as shown in Fig. 1 above. Firstly, pedobarographic images used as input images. Then image normalization includes size orientation and angle orientation. We find from these pedobarographic images Red, Green and Blue pixels count and observe correlation among these Pixel count values. We also find another image property called Footprint Index, using Human footprint can be classify in relative foot arch types.

IV. Methodology and Results

In this method total 7 pedobarographic Footprint images are considered. One of sample pedobarographic image is shown in fig.2. They are taken according to different BMI from dataset. Here taken sample Images have BMI range values from 18.6709 to 22.6757. All are in normal BMI range. In this method first all samples of left foot are taken. Then all images area normalized in proper resize 448*164*3. After that from all resize images total pixel count for are Red, Green and Blue color are calculated.

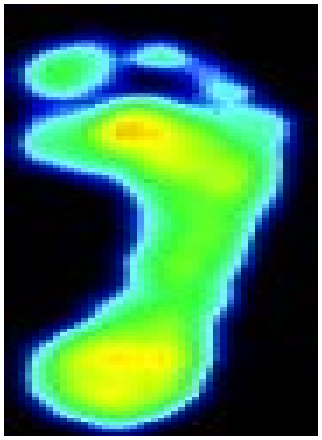

Fig. 2 Pedobarography image.

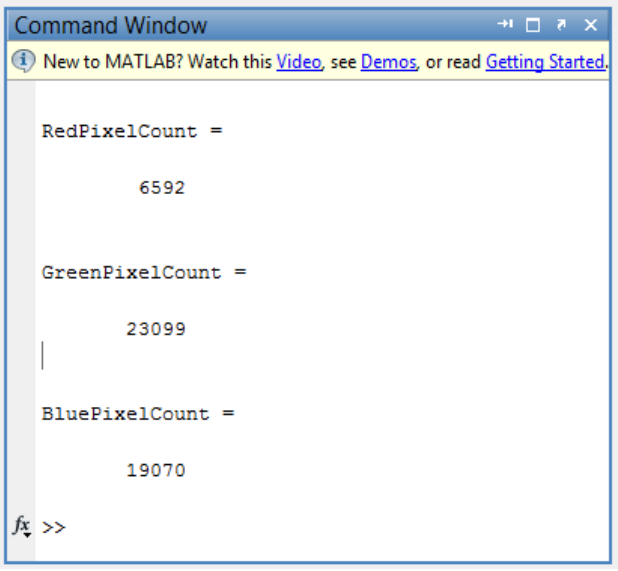

Fig. 3 MATLAB output window for pixel count

We find all color Red, Green and Blue pixel count for each pedobarographic image. As shown in above fig.3 MATLAB output window for this pixel count values. It shows for one of the image pixel count, they are Red pixel count 6592, Green pixel count 23099 and Blue pixel count 19070. Similarly we find out same pixel count for Red, Green and Blue pixel count. Then we observe some relation as shown in fig. 4 indicates graph of all color pixel count with relative BMI values of all 7 pedobarographic images.

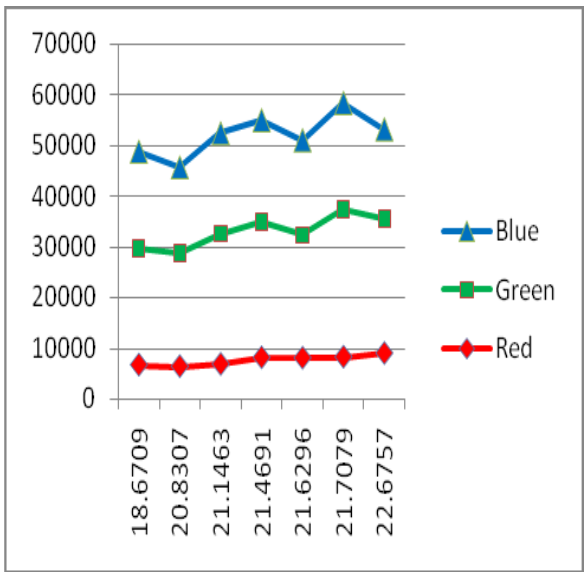

Fig 4. Graph of Red, Green and Blue pixels count.

In this graph X axis indicates BMI range values for all 7 sample Pedobarographic images. Whereas Y axis indicates pixel count values of all colors. There is linear relation among these graphs which is increasing from Red to Blue.

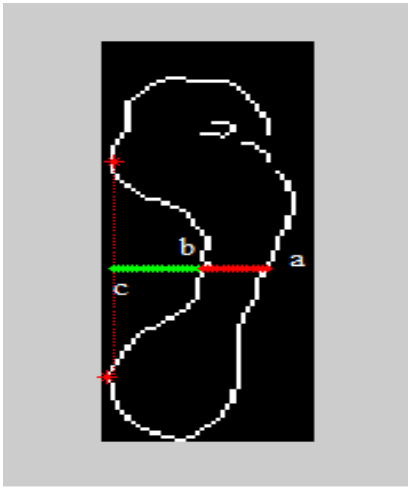

Fig. 5 MATLAB output window for footprint index.

We also fine one image property called Footprint index. Firstly using edge image of human footprint we find out lateral upper minimum distance point from Y axis and same for lower minimum distance point from Y axis. Then we have drawn a tangent line joining these points. As shown in Fig 5, by light dotted line. Then using central line from horizontal part we drawn points from foot width edge, as shown in Fig 5 by thick line (from point a to b) is called A intercept. Again using this point from A intercept we went towards tangent line and got one point and joined by thick line(from point b to c) called B intercept. Ratio of B intercept to A intercept gives us value which we called as Footprint Index (FPI).

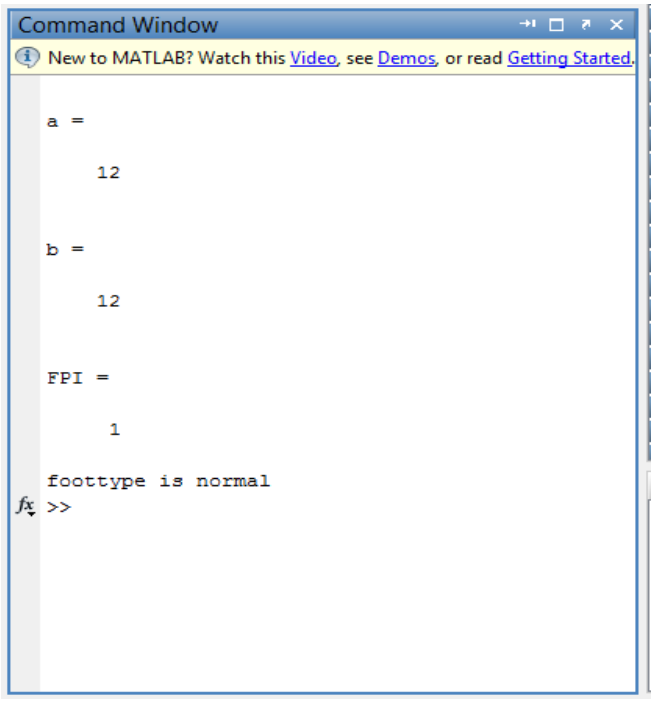

Fig 5. MATLAB output window for Classification of Foot using Footprint Index property

Using this Image property called Footprint Index we can classify Human footprint as Normal, Flat or High arch foot. As shown in above fig. 5 MATLAB output command window for this Footprint Index. Here both A and B intercept are equal, so vales of Footprint Index (FPI) is 1 classifies Human Footprint as Normal. When this Footprint Index Value is above 1 that is 2, 3 or 4 it is called as High arch Foot. Whereas this value Footprint Index is below that is 0.63 or 0.77 etc, it is classifies as Flat footprint.

V. CONCLUSION

From above BMI and Pixels count graph, we can observe that pixel count of each color in a human footprint Image is correlated with Body Mass Index of individual. This color pixel count is directly correlated to intensity levels of image. In Human footprint image higher pressure points indicates high intensity and lower pressure points indicates low intensity level.

From analysis of results we can observe that the classification of human foot can be done in three classes, Normal, Flat and High arch foot. Here we have proposed Foot geometry Index (FGI) which can be effectively used for human foot classification. Further these results can be used for finding out foot abnormalities and this data can be fetched for gait analysis, sports biomechanics and diagnosis of foot diseases.

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