Shape analysis, flatfoot.

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AN AUTOMATIC FOOTSHAPE PLANTOGRAMS ANALYSIS BASED ON A NEW SHAPE-MEASURE

In this note we present a method for recognition of flatfoot abnormality with the help of some new shape-measure describing numerically this abnormality efficient enough. The proposed measure can be easily implemented and used for automatic flatfoot level diagnosis. Experiments carried out on a number of the plantograms, analysed using the computer programme prepared by first of the authors, proved the usefulness of this new approach.

1. INTRODUCTION

Flatfoot is a medical abnormality very often met. It is often caused by wearing not comfortable footwear in an early childhood, in a time of a fast bones growing. According to the definition given in [2], [4] flatfoot is meant as lowering or flattering of elongated and crosswise vaults of a foot causing its functional incapacity. For people who suffer from the flatfoot orthopaedist recommend wearing comfortable orthopaedic insertions or surgical operation. In case this disease is ignored the troubles with walking growth dramatically and during walking strong pain occurs. Although there are known other foot abnormalities, e.g. the first or the fifth finger can be crooked, widely described in the literature [2], [4], we focus in this note only on flatfoot. The standard measure proposed in [2] for describing flatfoot level is visually and intuitive obvious but in a software implementation some difficulties appear. The new proposed measure is easy for implementation and describes flatfoot abnormalities quite well.

2. THE FLATFOOT MEASURES

The very intuitive measure describing flatfoot has been defined in [2]. This measure is denoted by KY and one can calculate it manually according to the formula:

$$KY = \frac{|BC|}{|AC|} \tag{1}$$

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where $|AC|$ and $|BC|$ are the segments illustrated in Fig.1.

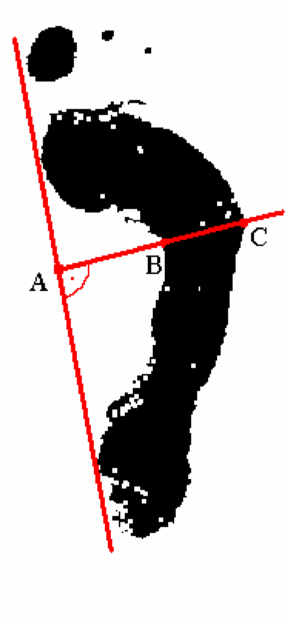

Fig. 1. Illustration of segments $|BC|$ and $|AC|$.

It is obvious that this measure describes the level of irregularity of a foot shape. A normal foot is characterized by the inequality [2]:

$$0{,}26 \leq KY \leq 0{,}45$$

If $KY < 0{,}26$ [2] then we speak about elevation and for $KY > 0{,}45$ [2] about flattering of the foot. In order to determine the measure KY , the precise localization of the point B should be known. This fact causes that KY cannot be calculated precisely, even manually. Therefore automatic determining of KY is also difficult. Hence we suggest using the measure F instead of KY. The F is given by the following formula:

$$F = \frac{A(X)}{A(Conv(X))} \qquad (2)$$

where X denotes a given footprint, $A(X)$ is the area of the footprint, $Conv(X)$ and $A(Conv(X))$ are convex hull of X and its area, respectively. In [1], [5] or [6] this measure is called *convexity* that is deviation of the shape from its convex hull. Figure 2 explains the idea of the convex hull. Measure (2) seems to be more complicated than KY, but its calculation using a computer is easy. That is why that for determining F, only the number of pixels in X and its convex hull $Conv(X)$ must be known. The point B is not needed. These facts cause that F may be calculated more precisely than KY.

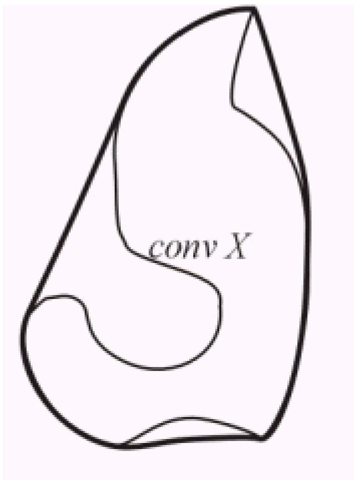

Fig. 2. Convex hull of the shape X.

For a shape equal to its convex hull $F=1$, because appropriate areas are the same. Referring it to the foot case it is equivalent to 100% flatfoot. The larger deviation X from its convex hull is the smaller F is. In this case $0 < F < 1$.

3. FOOTPRINT ANALYSIS

Footprints for analysis with the help of a scanner have been obtained. We scanned feet in a greyscale and with maximal contrast. In this manner feet images presented in Fig. 3 have been obtained.

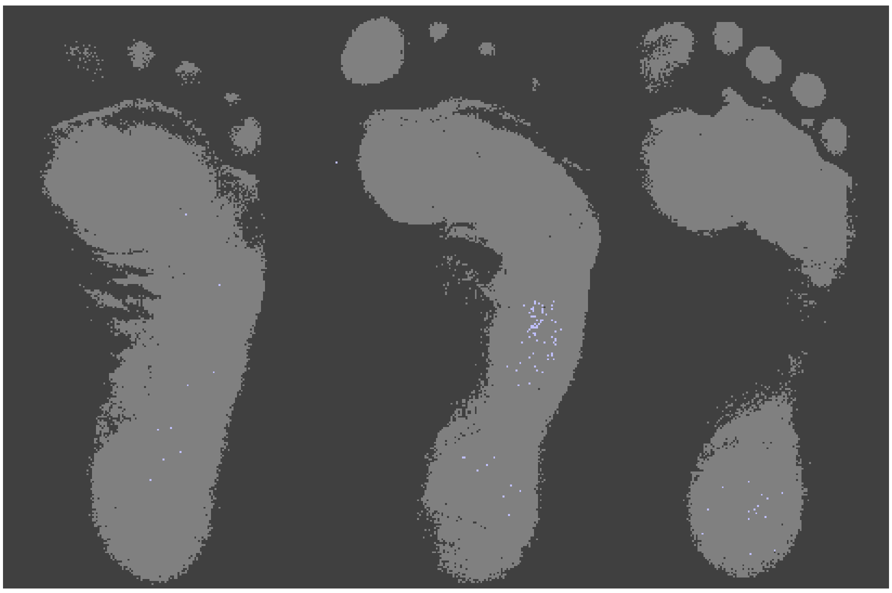

Fig. 3. Examples of scanned feet.

Foot scanning in colours is not recommended because the problem appears with cutting off the area of a foot that directly sticks to a scanner, from the background. This is well illustrated in Fig. 4.

Fig. 4. Greyscale image of the foot.

After binarisation of the images shown in Fig.3 we have obtained the ones presented in Fig. 5.

Fig. 5. Footprints after binarisation.

After binarisation, images were prepared as input data to the program calculating the measure *F*. Calculating of the area of a footprint *A(X)* is very simply. It is enough to count only white pixels. To calculate the area of the convex hull *A(Conv(X))* we must first find its convex hull. For this purpose we used the well-known Graham algorithm described e.g. in [1].

Further experiments show that for analysis of images feet without fingers are more convenient. That is why that fingers cause errors in determining *F*. Therefore we have removed fingers from feet images for further analysis. In Fig. 6 some investigated images are presented.

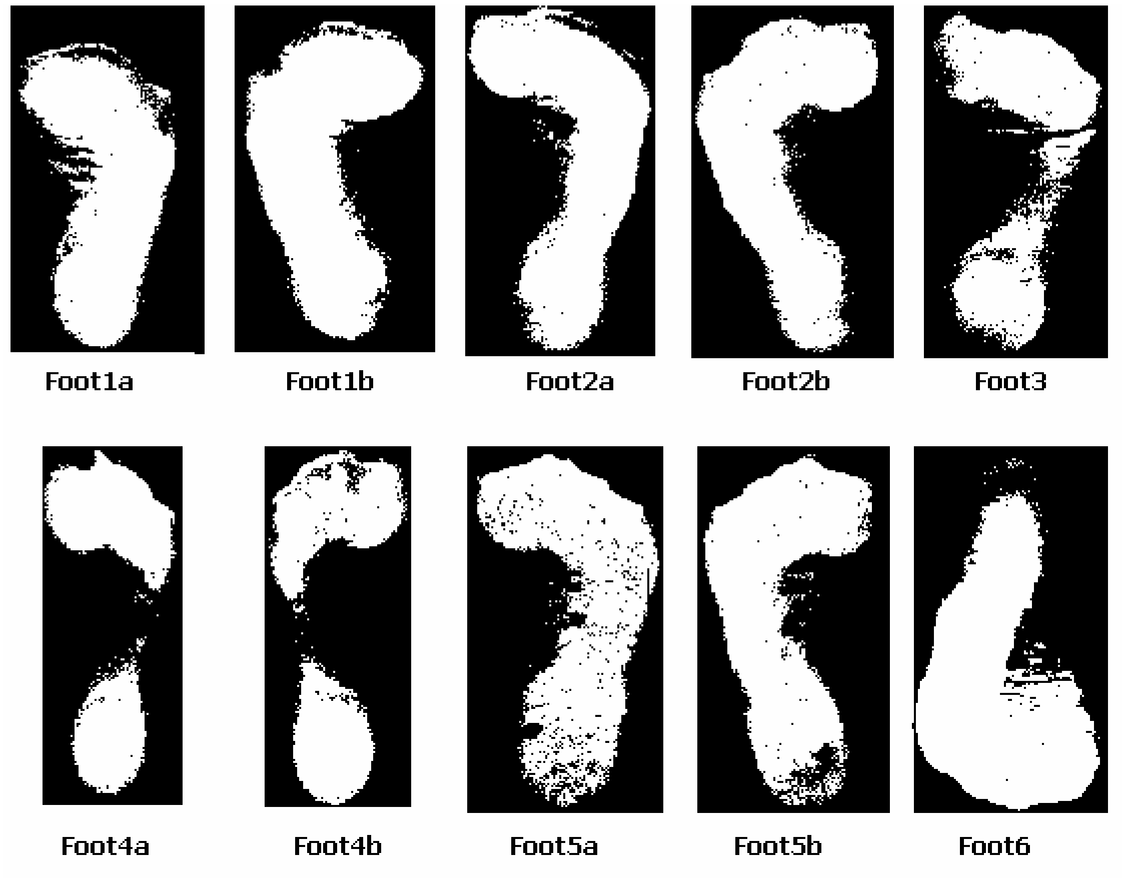

Fig. 6. The footprints examples used for analysis.

For each foot image we have calculated the measure *F*. The obtained results are gathered in Table 1. It is also worth to mention that *F* is invariant to scaling, rotating and translation. This property of *F* is very convenient because calculation of *F* is invariant to localization of a footprint at an image.

Table 1. Results from analysis.

Foot	*F*
Foot1a	0.77
Foot1b	0.77
Foot2a	0.68
Foot2b	0.70
Foot3	0.53
Foot4a	0.53
Foot4b	0.53
Foot5a	0.68
Foot5b	0.69
Foot6	0.74

It is easily seen that the obtained values of *F* agree with visual observations of images. The greatest flatfoot is for Foot1, the smallest for Foot3 and Foot4. Experiments have shown that for normal foot *F* belongs to the interval *[0.5,0.7]* while flatfoot is characterised by *F* greater than 0.7.

4. CONCLUSIONS

Experiments carried out have proven that the proposed new measure *F* can be useful for automatic characterisation of flatfoot abnormality. Taking into account professional advice from orthopaedists it is possible to determine the norms in terms of *F* similarly as it were done for *KY* parameter. The new measure presented in this note may be used for automatic flatfoot diagnose. But this needs further investigations performed for greater number of foot's images to obtain statistical confirmation of experimental results reported in this paper.

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