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Searching image databases, flatfoot
Shape-measure.

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AUTOMATIC PLANTOGRAPHY FOOTPRINT DATABASE SEARCHING METHOD

In this note we present a very simple database searching method for footprints of the desired flatfoot abnormality. The method is based on the new shape-measure introduced in [7]. The used measure describes flatfoot abnormalities very well, do not use reference points determined manually, so is it easily implemented for fully automatic footprints comparison task. Experiments carried out on a number of plantograms, with the help of the software prepared by the first author, approved good searching results of the described method.

1. INTRODUCTION

Flatfoot is a medical abnormality very often met. By definition [2], [4] flatfoot is a lowering or flattering of elongated and crosswise vaults of a foot causing its functional incapacity. It is often caused by wearing not comfortable footwear in an early childhood, in a time of a fast bones growing. Flatfoot problems are not often treated as serious ones. If they are ignored, the troubles with walking growth dramatically and during walking strong pain occur. In such situation flatfoot orthopaedist recommend wearing comfortable orthopaedic insertions or in extreme cases - surgical operation. Flatfoot is not only the one known abnormality related to foot. There many others described in details e.g. in [2],[4]. But our interest in this note is concentrated only on flatfoot.

Knowing what flatfoot is we can now formulate our task. Assume that we have footprints database and we want to find quickly and effectively the all database footprints of the desired characteristic. It means that we are looking for all footprints similar to the given one. The search should be performed automatically. The last condition excludes the use of the measure, popular among orthopaedists, denoted usually by *KY* [2] because it requires manually determining of some reference points. That is why we chose the shape-measure introduced in [7]. That measure do not need any reference point, characterizes flatfoot abnormality very well, is easily implemented and therefore it can be used in fully automatic footprints comparison tasks.

A footprint database searching system might be of interest for orthopaedist during posing and verification diagnosis process. Also it could be useful for medical teaching purposes.

The paper is organized as follows. In Section 2 we recall the definition of the shape-measure that can be used as the main tool in automatic database searching. Next, in Section 3 the process of preparation of database footprints is described. Further, in Section 4 searching database algorithm and experimental results are presented. The last Section is the Conclusions Section.

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2. FLATFOOT MEASURE

For shape description we use the measure *F* that is based on convex hull [6] of the given shape. This measure gives quite good characterization of flatfoot abnormality what has been approved experimentally in [7]. The measure *F* is defined as follows:

$$F = \frac{A(X)}{A(Conv(X))} \tag{1}$$

where *X* denotes a given footprint, *A(X)* is the area of the foot, *Conv(X*) and *A(Conv(X))* are convex hull of *X* and its area, respectively. In the literature [1], [5] or [6] this parameter is called convexity, which is deviation of the shape from its convex hull. This is clear why this parameter is good for flatfoot problems description. Parameter *F* for computer calculations is very easy. One can calculate it by determining the number of pixels *A(X*) of the shape and the number of pixels of the convex hull *A(Conv(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. FOOTPRINTS DATABASE PREPARATION

Footprints for analysis have been obtained with the help of a scanner. We scanned feet in a greyscale and with maximal contrast. In this manner we have obtained foot images presented in Fig. 1. Next, they have been binarised.

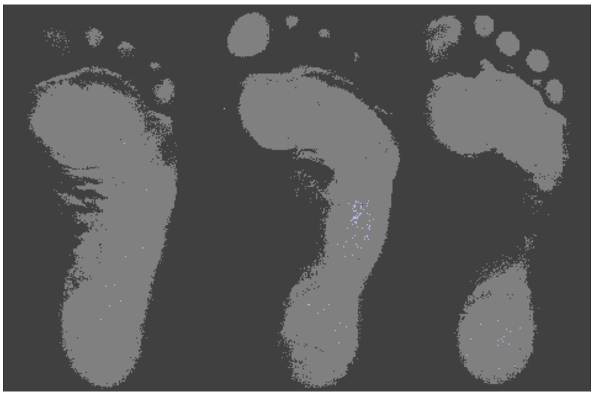

Fig. 1. Examples of scanned feet.

After binarisation of the images shown in Fig. 1 we have obtained the ones presented in Fig. 2.

Fig. 2. Feet after binarisation.

The binarised images are well prepared to input to the program calculating the parameter *F*. Calculating of the area of a foot *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 showed that for image analysis feet with removed 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.

4. ALGORITHM AND EXPERIMENTS

The way we prepared footprint database was described above. Now we present the comparison process. Denote the database by *D* and a query image by *q* . The aim is to find those footprints in the database *D* that are similar to the query image *q*. For all database footprints the measure *F*, that characterises flatfoot well, is calculated. Similarity condition is defined by the following expression:

$$(F(d) - F(q)) \leq T \tag{2}$$

where *F(d)* and *F(q)* denotes the measure of the database footprint and the query one, respectively. *T* is the chosen threshold, which is used for taking decision concerning similarity between images *d* and *q*. When this parameter is very small, only very similar footprints are founded. As the result of the use of inequality (2) we obtain the all footprints that are similar to the query flatfoot. Namely, we obtain the following set of all database footprints similar to the query footprint, that is:

$$\{d_i : (F(d_i) - F(q)) \leq T, \quad i = 0,1,...n\} \tag{3}$$

where *n* denotes the number of footprints in the database.

In our experiments we used several footprints presented in Figure 3. All calculations have been performed first with *T=0,05* and next with *T=0,01*.

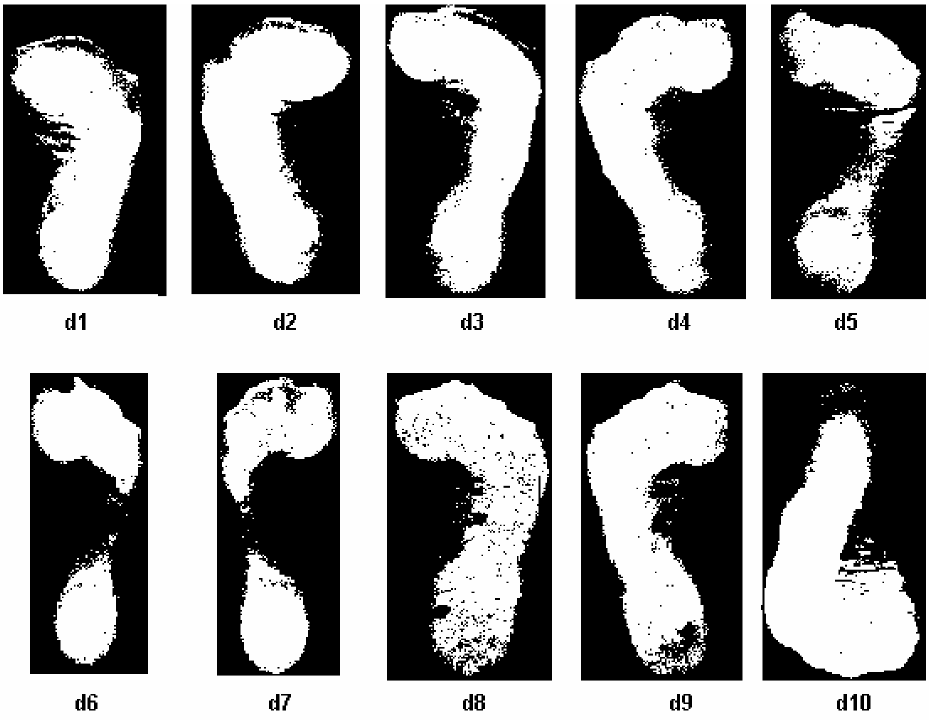

Fig. 3. Feet chosen to analysis.

We have carried out the analysis by taking one footprint and use it as the query one. In Table 1 the results of experiments have been gathered. From this table it is clearly seen that we have obtained all footprints with flatfoot very similar to the query footprint with respect to the given *T*.

Table 1. Results of analysis.

Footprint	**Set (T=0,05)**	**Set (T=0,01)**
d1	{d2,d10}	{d2}
d2	{d1,d10}	{d1}
d3	{d4,d8,d9}	{d8,d9}
d4	{d3,d8,d9,d10}	{d9}
d5	{d6,d7}	{d6,d7}
d6	{d5,d7}	{d5,d7}
d7	{d5,d6}	{d5,d6}
d8	{d3,d4,d9}	{d3,d9}
d9	{d3,d4,d8,d10}	{d3,d4,d8}
d10	{d1,d2,d4,d9}	{}

5. CONCLUSIONS

The carried out experiments approved that the described footprint database search method is very effective and finds footprints with the desired flatfoot abnormality quite well. The shape-measure coefficient used in searching process appeared to be useful. It properly characterises flatfoot abnormalities. Also it seems that the shape-measure *F* could be useful for classification purposes of the flatfoot abnormalities. But to check if it is really so, we need to perform more experiments. More experiments are also needed for statistical approvement of the formulated above conclusions.

The described method is very simple. It would be interesting to compare it with the group of methods based on Fourier analysis of shape boundary with respect to complexity of the algorithm and efficiency during database searching or classification. It will be searched in our future works.

BIBLIOGRAPHY

[1] JANKOWSKI M.: Elements of computer graphics, Wydawnictwo Naukowo-Techniczne, Warszawa 1990, pp. 65-67, (in Polish).
[2] KASPERCZYK T.: Defects of a posture – diagnostics and treatment, Kasper Sp. z.o.o. , Kraków 1994 (in Polish).
[3] KINDRATENKO V.: Development and application of image analysis techniques for identification and classification of microscopic particles, Universiteit Antwerpen, Ph.D. Thesis, Antwerpen 1997, (http://cgi.ncsa.uiuc.edu/People/kindr/phd/index.html).
[4] KRÄMER J.: Orthopaedics, Springer PWN, Warszawa 1997 (in Polish).
[5] KOCJAN K., KOTARSKI W., WIDUCH S.: Blood cells analysis based on simple geometrical shape descriptors, Journal of Medical Informatics & Technologies, Vol. 2, pp. 177-182, 2001.
[6] KOCJAN K.: Geometrical coefficients in shape analysis, Systemy Wspomagania Decyzji, Zakopane 2002, (in Polish).
[7] KOCJAN K., KOTARSKI: An automatic plantography footprint analysis based on a new shape measure, Journal of Medical Informatics & Technologies, Vol. 8, pp. 15-20, 2004.
[8] KOCJAN K.: Analiza kształtu obiektów 2D z wykorzystaniem współczynników Fouriera, Systemy Wspomagania Decyzji, Grudzień 2003, (in Polish).