pedobarography, conclusion making systems,
medical diagnostics

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THE FAULT ANALYSIS MADE BY PSW DATA RECORDER FOR NEUROLOGICAL DISEASE CLASSIFICATION

SHORT NOTE

The paper describes an analysis of measuring errors that are responsible for not satisfactory conclusion quality. The analysis concerns the PSW (Parotec System for Windows) [1] equipment developed for walking abnormality diagnosis. The paper shows the analysis principles that indicate what kind of faults are acceptable, for an adequate disease classification.

1. INTRODUCTION

The PSW is a processing unit used as a measuring device supported by reach computing package producing visual interfaces of the recorded data. Various computer diagnostic devices are provided with Conclusion-Making Units (CMU) supporting processes of disease diagnosis. The PSW data records are registered by set of the patient shoe-sensors. Then the data record is converted into a suitable format and it is visualised on a computer screen.

The diagnostic automation units support a medical treatment relying on precise diagnosis then controlling the recovery and rehabilitation processes. Saving the collection of data-records the user makes an evidence of the disease history.

The quality of the diagnosis depends on several factors that are described bellow.

2. THE DIAGNOSIS DESCRIPTORS

The PSW offers the user full range of interfaces that may be used for the disease analysis. The neural network implemented in an additional unit [3,4] makes possible the CMU usage that simplifies the disease classification for not experienced medical staff [7]. They are able to use the known experts' experience recorded in the knowledge-database.

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The CMU quality depends on its precise teaching, using well-classified data records. Trying to improve measuring quality and the disease classification the disease descriptors (characteristic features) have been selected. These descriptors control the diagnostic process (the disease recognition) within the most representative areas and factors, extracting the disease characteristics to be more readable.

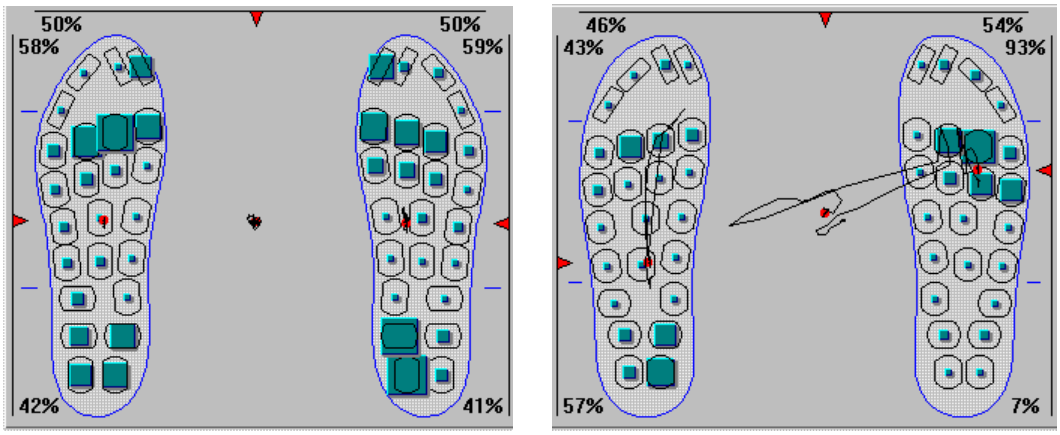

Fig.1. A static data-record with physiological and pathological load movement

The descriptors provide the user with some values that are measures of characteristic features easily interpreted by medical staff.

In our work several descriptors have been distinguished, illustrating:

– a static part of the data record (4 groups using 7 descriptors),
– a dynamic part of the data record (6 groups using 30 descriptors).

One of the most representative factor of diagnosis is a body balance that can be spotted by the descriptor change concerning the length of a load centre movement trajectory, in a static part of data, describing a body balance in standing period of the diagnosis (Fig.1). The trajectory length defines the balance amplitude.

The balance measure descriptor, discussed above can be expressed by the following formula:

$$l_{stat} = \sum_{p=2}^{50} \sqrt{\left(\frac{\sum_{i=1}^{24} (x_i * n_{i,p})}{\sum_{i=1}^{24} n_{i,p}} - \frac{\sum_{i=1}^{24} (x_i * n_{i,p-1})}{\sum_{i=1}^{24} n_{i,p-1}} \right)^2 + \left(\frac{\sum_{i=1}^{24} (y_i * n_{i,p})}{\sum_{i=1}^{24} n_{i,p}} - \frac{\sum_{i=1}^{24} (y_i * n_{i,p-1})}{\sum_{i=1}^{24} n_{i,p-1}} \right)^2} \qquad (1)$$

where:

x, y – define co-ordinates of sensors (Fig.2),

$n_{i,p}$ – is a pressure value in sensor i and sample p of the data-record,

24 – is a number of sensors of a single insole,

50 – is a number of samples in static part of the data-record.

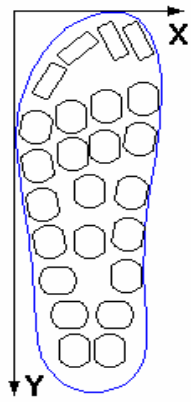

Fig.2. Co-ordinates system on the measurement insole

3. THE FAULT SENSITIVITY

The most expensive part of PSW is an insoles set, therefore the PSW developers decided that every insole-pair is used for two sizes of feet (from 21/22 to 47/48). Moreover, it is enough to consider the insoles fasten that can move in a shoe. That is why the recurrence of data records for the same patient, doing the same measurement, is not available. Although the characteristics of every sensor are unified this relatively high quality set of sensors will generate many different data records for the same patient.

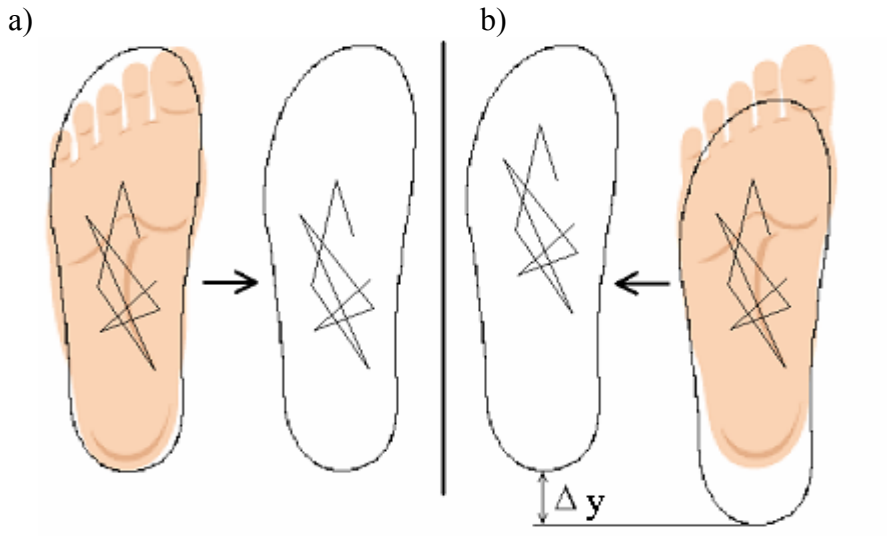

Fig.3. The load distribution trajectories: a) for properly fastened insole,
b) for insole moved backward.

The trajectory length of a load centre movement describes the body balance of the patient. Let us consider the example trajectories presented in Fig.3, where the insole has been drawn by a dotted line.

The example in Fig 3a shows properly fastened insole, while Fig. 3b shows an example where foot is moved towards to a front part of the shoe. This kind of fault makes remarkable problems for foot shape analysis that concerns orthopaedic disease recognition. The trajectory length descriptor will be in that case expressed by a following formula:

$$l_{stat} = \sum_{p=2}^{50} \sqrt{\left(\frac{\sum_{i=1}^{24} \left(x_i * n_{i,p} \right)}{\sum_{i=1}^{24} n_{i,p}} - \frac{\sum_{i=1}^{24} \left(x_i * n_{i,p-1} \right)}{\sum_{i=1}^{24} n_{i,p-1}} \right)^2 + \left(\frac{\sum_{i=1}^{24} \left((y_i + \Delta y) * n_{i,p} \right)}{\sum_{i=1}^{24} n_{i,p}} - \frac{\sum_{i=1}^{24} \left((y_i + \Delta y) * n_{i,p-1} \right)}{\sum_{i=1}^{24} n_{i,p-1}} \right)^2} \qquad (2)$$

It is easy to prove that formula (2) is equivalent to formula (1) – so shifting the insole does not influence the trajectory length, as it is also shown in Fig. 3.

For neurological diseases the diagnosis concerns the pressure centre movement where the insoles fasten stability does not play as crucial role as in orthopaedics. The trajectory length will be the same in both cases – it does not depend on an insole placement within two sizes of a shoe. What is more the analysis has been done with the assumptions that sensors coverage of insoles allows recording the pressure distribution precise enough. Unfortunately some regular faults can be expected, as on the every insole only 24 sensors were installed.

4. CONCLUSIONS

The quality of automatic making conclusion strongly depends on a high quality of data measurement. Anyhow the discussion presented above indicates that the diagnosis areas for measurement quality is not so critical as for another diseases. The CMU developer has to consider all diagnosis factors estimating what kind of data can be accepted for producing the data records used as training sequences.

Using the diagnosis factors, the disease classification methods become easier and faster. Trying to prove this assumptions several experiments have been carried out. Two series of measurements have been made. Analysing of the co-relation factors for series of the source records we obtained not satisfactory result. The coefficient of co-relation was equal to 0,43.

Using the extracted diagnosis factors the adequate co-relation coefficients grown to 0,98. These conclusions indicate high level of redundant and faulty information in the data record that makes the disease recognition difficult or impossible. After this extraction and filtering process of the data record (responsible for the disease) classification procedures become faster and more precise.

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