Data mining in analyzing pressure on plantar surface in children gait

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Introduction

Data mining is the set of methods which enables to manage a huge and multidimensional set of measured data. Data mining provides for fast and efficient analyzing of the data and finding new, sometimes unexpected, connections between various parameters [3]. One of the important problems is an automatic instrumented human gait analysis. Gait is very complex human activity which could be described by enormous number of parameters. The measurement of some of those parameters is necessary to perform the quantitative human gait assessment. Nowadays, the methods of automatic human gait analysis are very popular, because they break the limitations of manual evaluation of the data concerning gait [1], [2]. The good example of such problem could be handling with children with pes planovalgus (PP). Pes planovalgus is one of the most frequently appearing foot diseases. In this case the foot has a small, longitudal arch while loading. It is a result of the muscular-ligament system failure. Moreover in pes planovalgus the heel bone is in the pronation position while results from the foot being more flattened. The results of pes planovalgus are foot deformation and pain. It shows that the children should be correctly diagnosed and they should start therapy as soon as possible. The data mining methods could be very helpful in constructing the support decision making system.

One of the most promising techniques of data mining is decision tree. Decision trees enable to extract the knowledge hidden in the data and presenting it in a very vivid way. They provide very simple conditions in the tree nodes and lead to conclusion (class) on the lowest level of the tree. It is very important that the results are easy for interpretation and could be used by the staff with neither mathematical nor engineering background. Decision trees have already been successfully used in the human gait analysis in clinical applications [2].

This paper describes the application of decision tree to the analysis of biomechanical signals. The main aim of the analysis of those signals is to demonstrate the possibility of the diagnosis, which utilizes recorded signals describing the gait of the investigated subject by means of decision tree.

Materials and Method

The foot pressure measuring system is one of the most common devices for human gait analysis. The devices of this type are often used in foot pathologies. During the investigation the barometric insole of an appropriate size is put into the subject's shoes. The insoles consist of capacitive sensors (max 240 sensors per insole), which allow to record with frequency of 300 Hz the distribution of pressure of the human plantar onto the contact surface while walking. We made measurements based on a group of 20 children (10 children with PP and 10 children as a reference group with typical foot). The subjects walk along a pathway in a comfortable self-determined way. Thus, for the single subject many strides of human gait have been recorded (260 strides: 140 strides for control group and 120 strides for children with PP). The subjects who took part in the investigations were at age 14.3 ± 5.93 (PP group) and 15.0 ± 1.69 (control group), body weight:

44.4 ± 11.46 kg (PP) and 53.25 ± 9.15 kg (control). We grouped insole sensors seven anatomic zones (Z) (Fig. 1). Zone 1 is equivalent to toes, 2 metatarsal heads (from 2nd to 5th), 3 head of 1st metatarsal, 4 cuboid bone, 5 navicular bone, 6 lateral heel and 7 is an internal heel.

We divide the recorded time series into parts. The parts are the phases which are present in normal support phase of gait. They were: loading response (0–10% of gait cycle), Mid Stance (10%–30%), Terminal Stance (30%–50%), PreSwing (50%–60%). We have calculated the following parameters for the every zone end every gait phase: the average value of absolute pressure; the average value of pressure normalized to body weight; the time of i^{th} zone contact and the percent of participation the i^{th} zone in whole foot loading. Moreover recorded strides has been divided into two sets: learning set (185 strides) – which was used for building decision tree and testing set (75) – which was used to check the quality of the system. In this paper we build decision tree based on the CART algorithm and Gini's index. A 10-fold cross validation was used to prevent from over fitting of the decision tree.

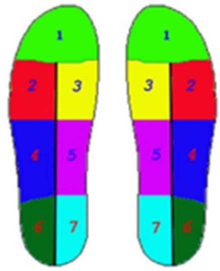

Fig. 1. The sensors insole divided into anatomic zones

Results

The result of using the CART algorithm was a decision tree with 11 nodes (6 conslusion nodes) (Fig. 2). The rate of correct classification is quite good: 95% for reference group and 93% for PP one in case of training set and 95% for reference group and 83% for PP group. It is easily to notice that the most important for decision making are two gait phases: Mid Stance (and Pre Swing. It should be underline that during MidStance phase of gait a foot is in full load and in fact the pathological position of foot should be the most noticeableat that time. Very important in distinguishing those two group are zones connected to internal side of the foot (zone 5 and zone 7). It is connected with pronation of foot in case of the pes planovalgus subtects.

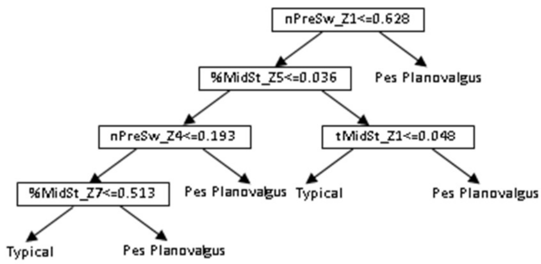

Fig. 2. The obtained decision tree

Conclusions

The results demonstrate that decision trees are a powerful technique which could be successful applied in analyzing pressures on plantar surface in children gait. The advantage of employing decision trees is the easiness of results interpretation. Constructing a decision tree could help in finding the associations between measured data and undertaken decision. Decision trees could improve the understanding of human gait phenomenon.

References

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