Extraction of knowledge for movement analysis data – example in clinical gait analysis.

[1]Stéphane Armand, [1]Eric Watelain, [2]Emmanuel Roux, [1]François Xavier Lepoutre
[1]LAMIH – UMR CNRS 8530, UHVC, Valenciennes, France, stephane.armand@univ-valenciennes
[2]LTSI - INSERM U642, Université de Rennes 1, Rennes, France.

INTRODUCTION

A major challenge in the field of human movement analysis is the interpretation of data acquired. For example, this interpretation could lead to optimization of performances in sport, to better space organization in ergonomics or to define therapeutic planes in medicine. The large amount of data provided by motion capture devices makes interpretation a difficult task for human reasoning [1]. Techniques of artificial intelligence could decrease the subjectivity and give a helpful tool for interpretation. The aim of this study is to provide a method to link a movement with the elements of interpretation of this movement. For application example, toe-walking - considered as a major gait deviation in many diseases - will be linked with its possible clinical causes provided by physical examination.

METHODS

The first step of the method is to extract (from trials) the different patterns or expressions of a considered movement. In order to reach this aim, a fuzzy space-time windowing of variables permitting to quantify the considered movement can be performed. And then a fuzzy c-means algorithm can be used to extract the different expressions of this movement. Each trial is assigned to these different patterns with membership values. Next, each pattern is characterized by the weighted mean of motion analysis data.

The second step is to link these expressions with their possible causes. Literature and experts could provide the different possible causes. Measurements of cause variables - which are interesting in interpretation process - are coded in fuzzy modalities. Fuzzy decision trees are then induced to create "if-then" rules linking expressions of movement with their possible causes. The accuracy of these rules can be evaluated with a stratified ten-fold cross validation.

For application example, toe-walking was explored with this method. A database of 2511 clinical gait analysis containing 11950 trials is used in input to extract the different expressions of toe-walking. Subsequently, toe-walking patterns are linked with their clinical causes. Possible clinical causes are extracted from clinical examination measurements including range of movement, muscular tone and strength which are coded in membership values according to the three modalities: {low, medium, high}.

RESULTS AND DISCUSSION

In this clinical example of extraction of knowledge; the first step of the method has permitted to extract three different patterns of toe-walking (figure 1). The second step of the method has highlighted clinical possible causes of these three patterns represented by 12 main rules. A rule is a combination of clinical elements leading to one of the three groups. An example of rules, corresponding to the possible causes, is presented on Table 1. The classification accuracy of the rules has been evaluated at 81%. Results were in agreement with literature and clinical gait analysis experts. For a given pattern of a new patient, it is now possible to determine possible causes of this pattern: *abduction approach*. It is also possible to predict the pattern of movement as from clinical measurements: *deduction approach*. Results of this clinical example provide an overview of possibilities of such method. Compared to classical statistical method, this method of extraction of knowledge has the advantage of not considering linear relationship between variables and permits to deal with a large amount of data. Fuzzy coding introduces the notion of vagueness and allows manipulation of language terms as "high" or "medium" rather than numerical values.

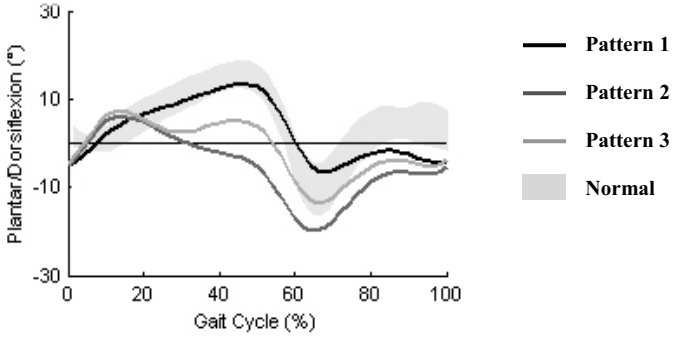

Figure 1: Three ankle gait patterns identified for toe-walkers

CONCLUSIONS

This two steps method using fuzzy c-means and fuzzy decision trees is an original method to extract knowledge from motion analysis data. It provides intelligible rules permitting identification of possible movement causes. This artificial intelligence method can be a helpful tool for all the people who have to deal with a large amount of data in the field of human motion analysis and who want to understand which elements influence movement patterns.

REFERENCES

[1] Chau T. *Gait Posture* **13**, 49-66, 2001.

Table 1: Examples of rules explaining movement patterns of toe-walkers.

Rules	Rules conditions		
	Condition 1	**Condition 2**	**Condition 3**
Rule 1 – Pattern 1	Low **tone** triceps surae	Medium **strength** quadriceps	
Rule 2 – Pattern 1	Low **tone** triceps surae	Medium **strength** tibialis anterior	
Rule 3 – Pattern 2	High **tone** triceps surae	Low **range of motion** dorsiflexion	High **tone** quatriceps