Knowledge extraction for movement analysis data – example in clinical gait analysis.

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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 ergonomic 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 ? ~~In~~ application example, toe-walking (in children?) considered as a major gait deviation in many diseases will be linked with its possible clinical causes come from patient examination? [2] (si on peut en metre 2…)

METHODS

The first step of the method is to extract the different ~~expressions~~ (appearances??) of the considered movement from trials. To do this, a fuzzy space-time windowing of variables permitting to quantify the considered movement that ? could be performed. ~~and~~ A fuzzy c-means algorithm is used then to extract the different expressions of this movement. Each trial can be assign to the different expressions (3^{e} utilisation) with membership values. (un peu difficile à comprendre à mon avis) The second step is to link these expressions (4^{e}) with their possible causes of a movement. Literature and experts could provide the different possible causes. Measures of cause variables - which are interesting in interpretation process - are coded in fuzzy modalities. Fuzzy decision trees are ~~then~~ induced (used?) to create "if-then" rules linking expressions of movement with their possible causes. The (stability?) accuracy of the (trees? not all method?) method could then be evaluated with a stratified ten-fold cross validation.
For? ~~In~~ 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 (children?). Subsequently, toe-walking expressions 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 at the three modalities: {low, average, high}.

RESULTS AND DISCUSSION

In this clinical example of knowledge extraction for movement analysis data; 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… An example of rules, corresponding at the possible causes, is presented Table 1. The accuracy of the method has been evaluated at 81%. Results were in agreement with literature and clinical gait analysis experts. For a new patient, it's now possible to determine possible causes of a given pattern: *abduction approach*. It's also possible to predict the pattern of movement as from clinical measurements: *deduction approach*. Results of this clinical example give a view of possibilities of such method. Compare to classical statistical method, this knowledge extraction method have the advantage to not consider linear relationship between variables, (et multicausal ?) permit to deal with a large amount of data. Fuzzy coding introduces the notion of vagueness and allows manipulation of concept as "high" or "medium" rather than numerical values (difficile de comprendre ce que tu veux dire dans cette dernière phrase).

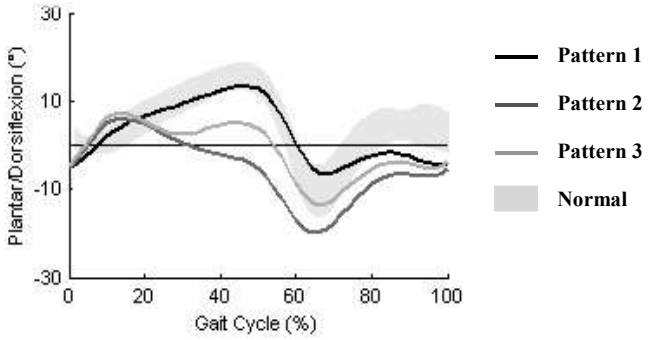

Figure 1: Three ankle gait patterns identified for toe-walkers

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 easy to use explaining movement causes. This intelligence artificial method could 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 want to understand which elements influence movement patterns.

REFERENCES

[1] Chau, T., 2001, Gait Posture, 13, 49-66.
[2] Armand et al 2005, Gait Posture, in press

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** quadriceps

Table 1: Examples of rules explaining a movement pattern for toe-walkers