Use of computer science in medicine, automatic conclusion, expert systems, pedobarography, metrology.

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A ROUGH DECISION TO GAIT DISTURBANCES CLASSIFICATION

The paper concerns the use of diagnostic measures for detection of gait disturbances for neurological pathologies identification. Project of using the PSW (Parotec System for Windows) system for detection of gait's characteristics described by the expert doctor and collected in knowledge base stored using modified Horn's rules with fuzzy linguistic notions was based on several years of experience in implementation and use of the PSW system. Linguistic notions are computed dynamically with use of diagnostic measure distribution of examined population. It makes system more friendly (isolates expert from questions which values of measures describe physiological gait), on the other hand it provides self-tuning of system during acquisition of still growing amount of measurements collected. Condition of correct pathology classification is to obtain proper description of disturbance from an expert and collection of explorations among pathological and physiological population. The best way of tuning the system is to use it for sift research. An implementation of system is currently at the final stage.

1. INTRODUCTION

The PSW (Parotec System for Windows) measuring device [1], [2], allows collecting data of load distribution on the foot while a patient is standing or walking. It provides diagnosis and supervision of the rehabilitation process by orthopaedic doctors [3]. For these goals programming tools were made, they make an automatic conclusion of pathologies [4] possible and provide more friendly usage. There are two fields of research – usage of neural networks during the process of pathology recognition [5] and usage of fuzzy logic for building rules taken from expert doctor [6].

Neurology can also be considered for using PSW [7]. A direct usage of PSW measure values especially in neurology seems to be too complicated. After consultations with neurology specialists the set of diagnostic measures was made. They describe characteristic elements of gait and patient's posture, such as: times of contact and rise of foot during walk, phase-time relation registered during dynamic measure, load of characteristic foot zones, trajectory of patient's body gravity centre, differences between loads of feet and others [8].

The description determines connection of using diagnostic measures and conclusion making based on fuzzy conclusion rules. The task of the currently implemented system is to filter out from the whole population of examined patients these with pathological features described by the neurology expert, and to verbally specify an intensity of the pathology

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2. GAIT DISTURBANCES CLASSIFICATION SYSTEM STRUCTURE

The general system structure diagram is shown on Fig.1. Population explorations set made using PSW system, currently proceeded or analyzed measure and the expert's knowledge are input for the system. The result of processing is a lingual description of gait disturbances which occurred in analyzed measure.

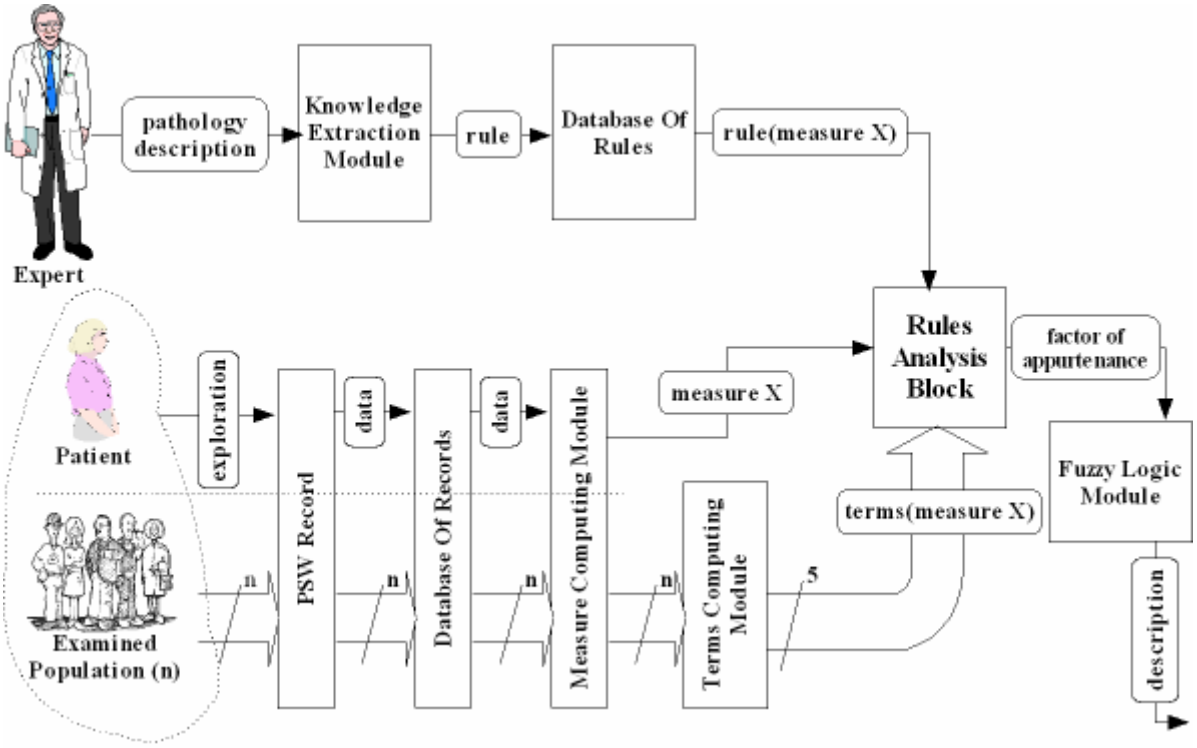

Fig. 1. Components of conclusion making system.

The identified pathologies (gait disturbances) are given to the system by an expert using a knowledge extraction module (Fig.2). The knowledge base has been made using the set of rules. The rule contains primary conditions and conclusions. Entering a new inferring rule to the knowledge base begins with setting its name. Next it is needed to define primary conditions by following steps below:

- selection of diagnostic measure [8],
- selection of relation operator,
- qualification (selection of linguistic notion)

A *primary condition* stored in base is written as:
Primary condition = DM relation_operator linguistic_notion
where:
DM $\in$ { defined diagnostic measures }
Relation_operator $\in$ { <,> },
Linguistic_notion $\in$ {very small, small, average, big, very big}.

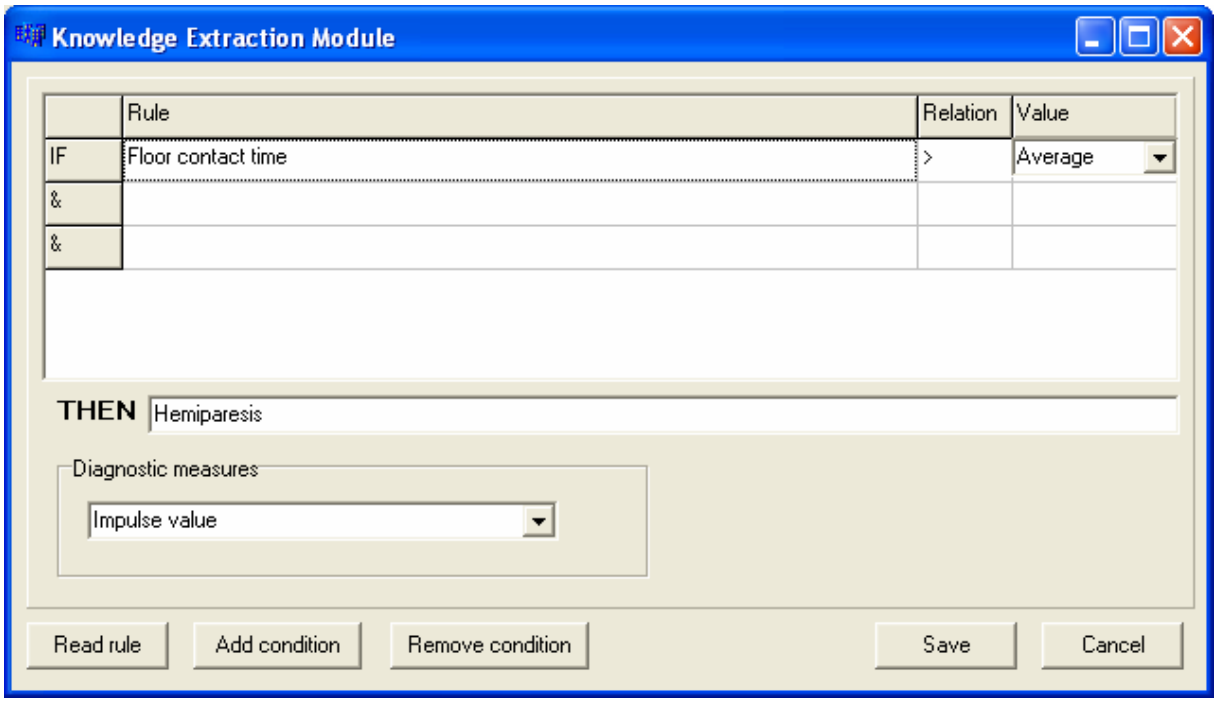

Fig. 2. Interface of knowledge extraction module.

A rule can consist of a few primary conditions joined by the '&' operator. With this notion it is possible to make a conjunction of conditions for pathology description.

The alternative of conditions can be reached by entering to database rules which point out the same conclusion i.e. rules with the same name.

While making a description of disturbance, the expert has to understand the physical interpretation of proposed measures in the system. If the requirement is fulfilled – it is enough to use this measure to define its relation and intensity in proportion to the average of population – the physiology. It is assumed that after proper learning and tuning of system, average of examined population belongs to physiological range. The system during the stage of computing will change linguistic notions to bands of measured values.

Rules analysis block can compute the set of rules in two ways.

– check appurtenance factor chosen from list of rules,
– generate list of the rules which have the factor of appurtenance above zero. It means that there exists at least 'very small' factor which fulfils conditions that belong to analyzed rule.

A conclusion process begins with a decomposition of the rule to single primary conditions using the rule syntax interpreter, afterwards conditions are analyzed and a sharp factor of appurtenance consequent on condition computing is saved.

Analyses of the condition consist of the next stages:

– define the identifier of the diagnostic measure DM, based on which the condition is built,
– check of flag that informs if minimal and maximal value of measure exists in population and when it is needed, compute and save these values,
– compute the DM value for analyzed measure (see Fig.3. marked 0,6 value),
– if it is necessary, set up maximal or minimal value in population using computed value,
– build linguistic notions (triangles with equal bases) for universe which is defined between minimal and maximal DM value (see Fig.3. values 0,05 and 0,6),
– compute and save factor of appurtenance for analyzed condition.

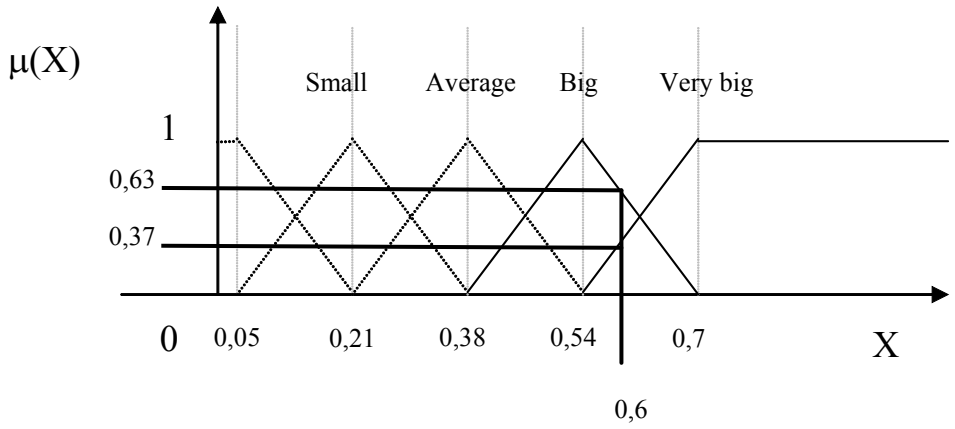

Fig. 3. Principle of the membership factor declaration $\mu(x)$ for linguistic notions [6].

In table 1 factors of appurtenance 'Fac' for analyzed condition with measure and DMx identifier based on the situation shown on Fig.3 have been presented.

Table 1. Listing of the appurtenance factors.

Condition	Fac	Comment
DMx > „Small"	1	
DMx > „Average"	1	FAC(„Big")=0,63+FAC(„Very big")=0,37
DMx > „Big"	0,37	
DMx < „Small"	0	
DMx < „Average"	0	
DMx < „Big"	0	
DMx < „Very big"	0,63	

Factors of appurtenance derived from primary conditions are composed according to rule below:

- composition of conditions joined by '&' operator in single rule has been made using geometrical average of appurtenance factors,
- composition of rules with the same identifier has been made using sum with limitation of 'one' compositional factors of appurtenance from particular rules.

Finally appurtenance factor's value of the rule $\in$ <0, 1> is being projected on linguistic notions domain and computed this way is used for description of gait disturbance.

3. CONCLUSIONS

The presented system is friendly enough to be used by medical personnel without the specialist (neurology) and informatics preparation. The only person who should have wider knowledge about the system is expert who enters the rules.

The implemented solution provides use of the system with a measure base definitely smaller (about few hundreds of measures) than with using expensive teaching of neural network. Besides, measures do not have to be described and classified by specialists.

It seems advisable to build a central base of measures filtrating according to the age category. Obtaining a huge amount of measure data causes use of the system for the sift research among youth.

Initially the system will be tested by neurology doctors, but it can be used in all fields of implementation where gait disturbances can point out the precise pathology. It needs to be emphasized that the PSW exploration is non-invasion and cheap.

BIBLIOGRAPHY

[1] PIECHA J., ZYGUŁA J.: PC Visual interface for Orthopaedic Expertise, Proc. of Int. Conference, pp. 162–167. Zakopane May 1995.

[2] ZYGUŁA J., PIECHA J., ŁYCZAK J., GAŹDZIK T., PROKSA J.: Zaawansowany system pomiarowy obciążeń statycznych i dynamicznych dla diagnostyki schorzeń ortopedycznych, Chirurgia narządów ruchu i ortopedia polska t. LXI 1996, suplement 3B, s. 119–124.

[3] SHEREFF M.J., BREGMAN A.M., KUMMER F.J.: The effect of immobilization devices on the load distribution under the foot. Clin Orthop 192, 1985, pp. 260-267.

[4] ZYGUŁA J.: Przetwarzanie danych pomiarowych dla systemu wnioskowania o patologiach w obszarze stopy, Rozprawa doktorska (promotor J. PIECHA), Politechnika Śląska, Gliwice 1997.

[5] KOPICERA K., PIECHA J., ZYGUŁA J.: The neural network characteristics-selection for orthopaedics diagnosis, Proc.of Int. Conference ASIS'99 Krnov sept. 1999.pp.113-118.

[6] ZYGUŁA J.: System wnioskowania rozmytego dla patologii narządu ruchu, Journal of Medical Informatics and Technologies. MIT2000. Ustroń-Jaszowiec 2000, pp.CS57-CS64, ISBN 83-909518-2-7

[7] ZYGUŁA J., PIECHA J., ZBROJKIEWICZ J.: Ocena zaburzeń równowagi na podstawie danych rejestrowanych w obrębie stopy, Materiały III Krajowej Konferencji Naukowej "Techniki Informatyczne w Medycynie" (ISBN 83-909518-0-0) TIM'98, Ustroń - Jaszowiec 15 - 17 X. 98r., str.BP105 - BP116.

[8] CHANDZLIK S., PIECHA J.: The body balance measures for neurological disease estimation and classification. Journal of Medical Informatics & Technologies, Vol. 6, pp: IT-87 – IT-94, 2003.