*automatic conclusions, medical expert systems,
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AUTOMATIC CONCLUSIONS MAKING ON NEUROLOGICAL DISEASES BY MEANS OF DISTRIBUTED DATA ACQUISITION

The paper concerns the implementation of some diagnostic measures describing gait disturbances produced by neurological diseases. The discussed contribution explains various experiments provided by the authors' works on Parotec System for Windows development [1]. The subject of the investigations was defined by many experiments carried-out at clinics, with gait's characteristic features analysis, involving the fuzzy logic paradigms. The linguistic notations of diagnostic classes are computed dynamically in accordance with disease statistics, provided by the characteristics of the patient under investigation. The comprehensive system was recognised as a friendly user package, which insulates the user from the complex analysis of measures describing the physiological gait characteristic features. What is more, the application has the ability to be tuned more precisely after the data record size has grown. The software-units implementation provided the user with a self-tuned system that enriches the application knowledge, during the data acquisition, while the set of the data records is still growing.

1. INTRODUCTION

Pedobarography provides the operator with specific data that can be used for gait disturbances description, with various characteristic features, adequate to neurological diseases and patient's actions.

The Parotec System for Windows (PSW) is an example measuring device [1, 2] that allows collecting data, describing a body load distribution on a patient's footprint during the time of the '*standing and walking*' cycle.

The developed functions provide the diagnostic investigations with new factors of the above diseases classifications and supervision formulas definitions. They allow the user support various rehabilitation processes, where gait characteristics give measurable factors of the recovery processes [3] observations. In order to reach these goals, several software extensions to the PSW were made (Fig. 1). The processing machines and their software units support the available recovery factors.

The computing units provided by the data-analysis algorithms make automatic conclusions, for several pathologies [4] possible.

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The completed work concern the exploration of two fields of research problems. First, the neural networks implementation, with well matched training processes used for several pathological states recognition [5]. The second problem concerns a fuzzy logic theory implementation for the interpretation of conclusion rules defined by highly experienced neurologists [6],[7].

Although the standard PSW options usage, for neurological diseases classification is possible, the data interpretation of various data formats brings the user with many difficulties.

The carried out clinic-experiments provided us with readable diagnostic measures and data records. They described several characteristics of gait and patients' posture, with time relations into a foot floor-contact in the gait cycle. There are several trajectories of body balance, observed in time of the patient's standing or walking [2, 7].

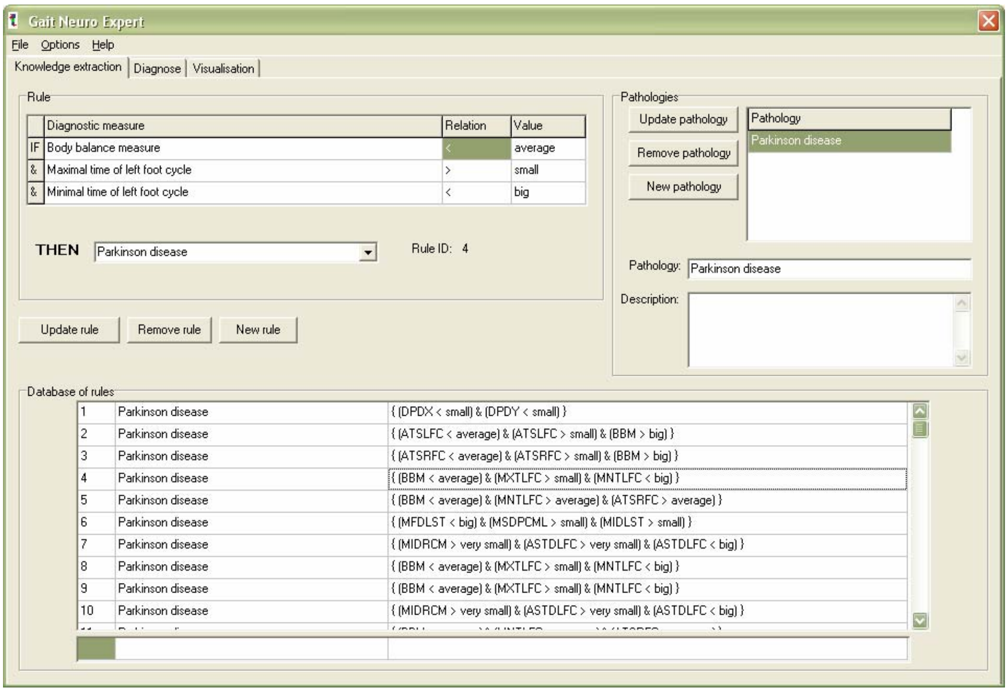

Fig. 1. The knowledge formulas definition interface

2. THE KNOWLEDGE FORMULAS DEFINITION

The knowledge processing algorithm of the diseases extraction, with the acquired interfaces (Fig.1), was described in this unit. The user has to fulfill some formulas for pathologies description.

The rules definition was supported by three primary conditions, describing the gait characteristics using simple linguistic expressions, with their relations to the characteristic values of the variables. In case the rules are not properly defined the unit refuses entering the data into the decisions set. After the decisions are set satisfactory the rules definition are matched with the adequate pathology, being under consideration.

The formulas with the conclusions description have been presented bellow.

Rule ID, pathology name, list of primary conditions

The decision table contains following factors:

$$T=<X, A, V, \delta>$$

where:

T – the decisions table,
X – set of objects,
A – C∨D – set of attributes,
C – set of conditional attributes
D – set of the decision attributes
V – set of attributes values,
$\delta : X \times C \rightarrow Vd$

For the decision rules:
The X defines a set of the decisions rules; D is set of pathologies;
then:

δ: X × C → (D, V_i) – it is a function that points out the pathology and its level.

The implemented modifications were caused by several factors, as type of the defined knowledge, language of the rules description and how the pathology level is determined by fuzzy logic paradigms.

The rules description formal language, concerning the knowledge database was determined, on a context-free grammar *G*:

$$G =<N, \Sigma, P, S>$$

where:

G – assigns a context-free grammar,
N – is a set of terminal symbols (final alphabet),
Σ – assigns a set of non-terminal symbols (a supplementary alphabet),
P – the production list
S – a head of grammar

finally:

N = $\{V_m, V_r, V_i, \&\}$
Σ = {R, W}
P: <W>::= $V_{m_i}\ V_{r_i}\ V_{i_i}$
<R>::= <W> | <W>&<W> | <W>&<W>&<W>
S=W
V_m = {names of measures abbreviations}
V_r = {„<”, „>”}
V_i = {„very small”, „small”, „average”, „big”, „very big”}

The products of the defined grammar components are used for the rules creation, composed of one to three primary conditions, joined together by a conjunction operator. In the conclusion making process the rules, pointing out the same pathology, are joined together by an OR (disjunction) operator.

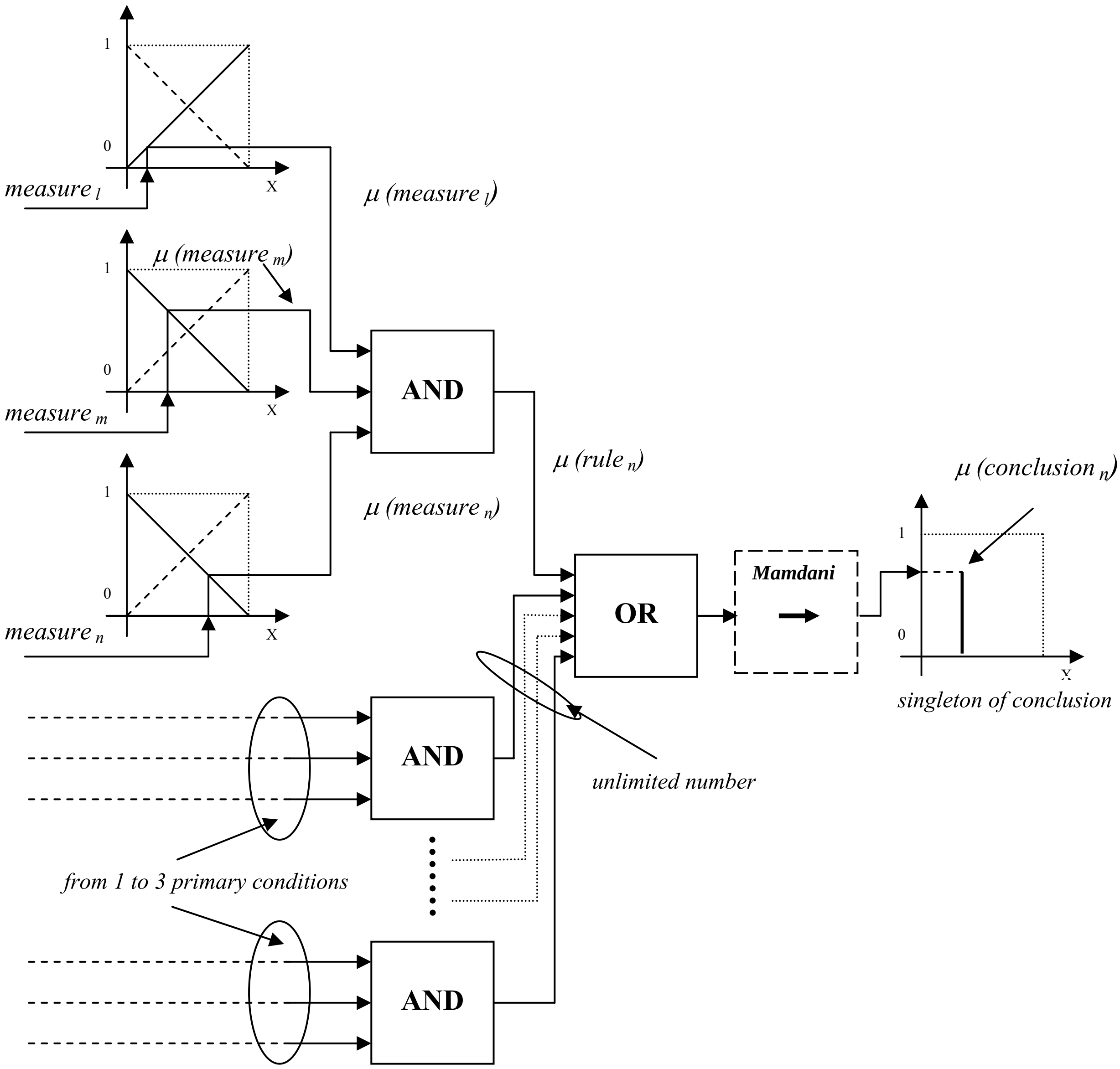

Fig.2. The fuzzy inferring flowchart

In Fig. 2 the computing formulas, for the conclusion making unit were presented; with fuzzy disjunctions for all rules of the defined pathologies.

The conclusions are given in linguistic formats, like: *"Probability of pathology is equal to 99%"*

For a final conclusion, a fuzzy composition of the diagnosis, on all rules combined with the discussed disease (within the data base content) is calculated. The system combines the probability of pathologies, related to the diseases group, in the knowledge base of the system. The user obtains a list of pathologies, with their probabilities level above zero.

The diagnosis extraction interface-window in Fig.3 is divided into four parts that define the conclusion conditions. They are used for computing process of primary conditions coefficients for the rules and group of rules selection. They imply the pathology classes, selected and judged by the computer.

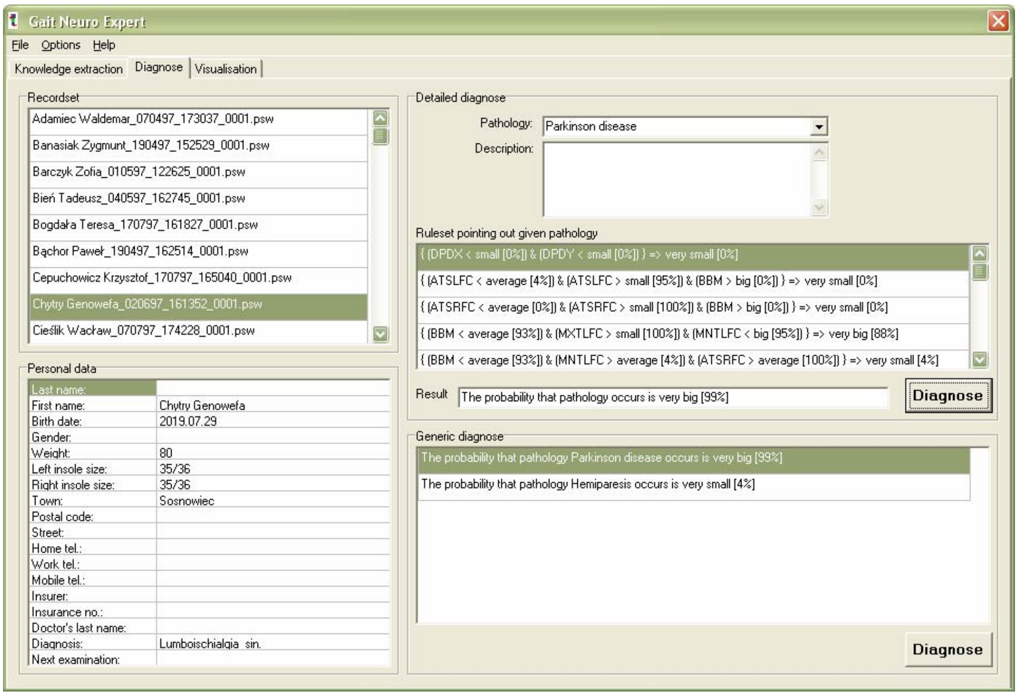

Fig.3. The diagnosis interface window

This interface allows the user choosing all functions of the diagnosis with some abilities of the rules tuning and selecting the most reliable records from the knowledge data base components.

3. THE DATA VISUALISATION

Several additional functions for the programme services simplification of the system have been implemented as well. The user can follow crucial goals of the conclusions; with their quality tuning. The tuning process concerns the sensitivity of the conclusion making, based on the data values analysis. They are related to the empirically established threshold measures; looking at the results observed in “Visualisation” window (Fig. 4). The above functions allow analysing any specific values engagement, of the chosen (by the operator) records.

On the right side of the figure, the list of the data-records is presented. Choosing whichever of them, the processing unit will compute the data, showing the results for the entered values. The data selection chart, for the above operations was presented in Fig.5. The list of the considered data records belonging to the defined range can be obtained clicking on the adequate bar.

In the selection chart the values ranges are presented; in percentage and number of available records, for every abnormality range. The list of records, qualified to the range, can be chosen by clicking the bar related to the range.

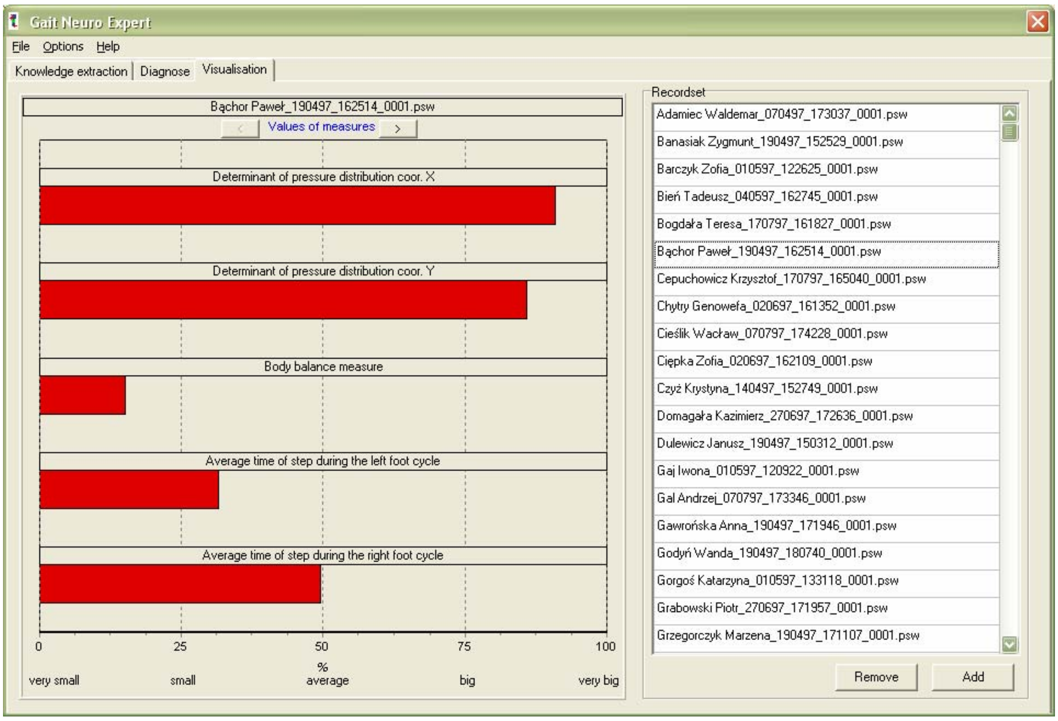

Fig.4. The data records' values visualisation sheet

Thanks to these simple and friendly graphical forms, the processes of the conclusion making factors can be traced simpler.

Fig.5. The available data of the examined records

4. SYSTEM TUNING AND SYNCHRONISATION

The user interface allows a clinician to combine many different databases and records, choosing the "Record-set" from an option "File" (Fig. 1). The user can choose, for the comparison, any object which is in accordance with (at least one) classification item. Working with many databases is also possible; finding relations between the knowledge databases and selected files. Then, the chosen rules are used for the specified group of records analysis.

The application was also provided with **a** templates generator in menu "File". The application allows copying the file *emptydb.emp* from the program folder using filename *reguly.mdb*. The new database will be provided with all information items except the decision table (set of rules and set of pathologies).

The conclusions can be undertaken on the basis of 69 diagnostic measures [8] that are used for the conclusion rules definition. The large number of rules, with various combinations, makes many problems for in-experienced users. For simplification of this choice some subsets of rules were defined, making the rules extraction easier and faster.

In the same way diagnostic measures presented in "Visualisation" are focused on a content that concerns subjects with their specific features. The subset of the chosen measures is included in the time of the rule creation process.

The system was also provided with fuzzy conjunction and disjunction operators, with possibilities of choosing the most adequate types of operators for the conclusion (Fig. 6). These classifications have to be done by experts within the system tuning process.

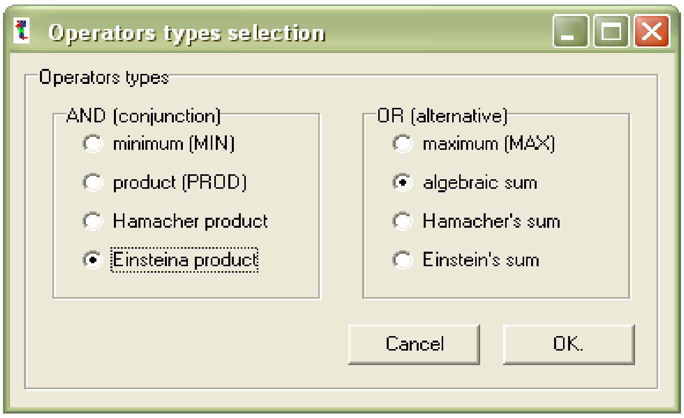

Fig.6. Fuzzy-operators selection board

The conclusion making interface allows the user to check the file in accordance with a given set of values or the diagnosis classes. The user can isolate these files that disturb the diagnosis quality. These features are very useful for excluding records that were classified faulty or incidentally.

Usually, the operator is working self dependably, on his personal workstation. The discussed programme was provided with network interfaces allowing the user to check any pattern records or diseases classes, at any remote host. Both stations have to be synchronised for finding compatible interfaces of these data units. The database possessor works as a server-side of the system. The station asking for the data base approach works as a client. Anyhow every station can execute both services.

At the flowchart in Fig.7 the stations co-operation scheme has been presented; they work after connection, established between client and server units.

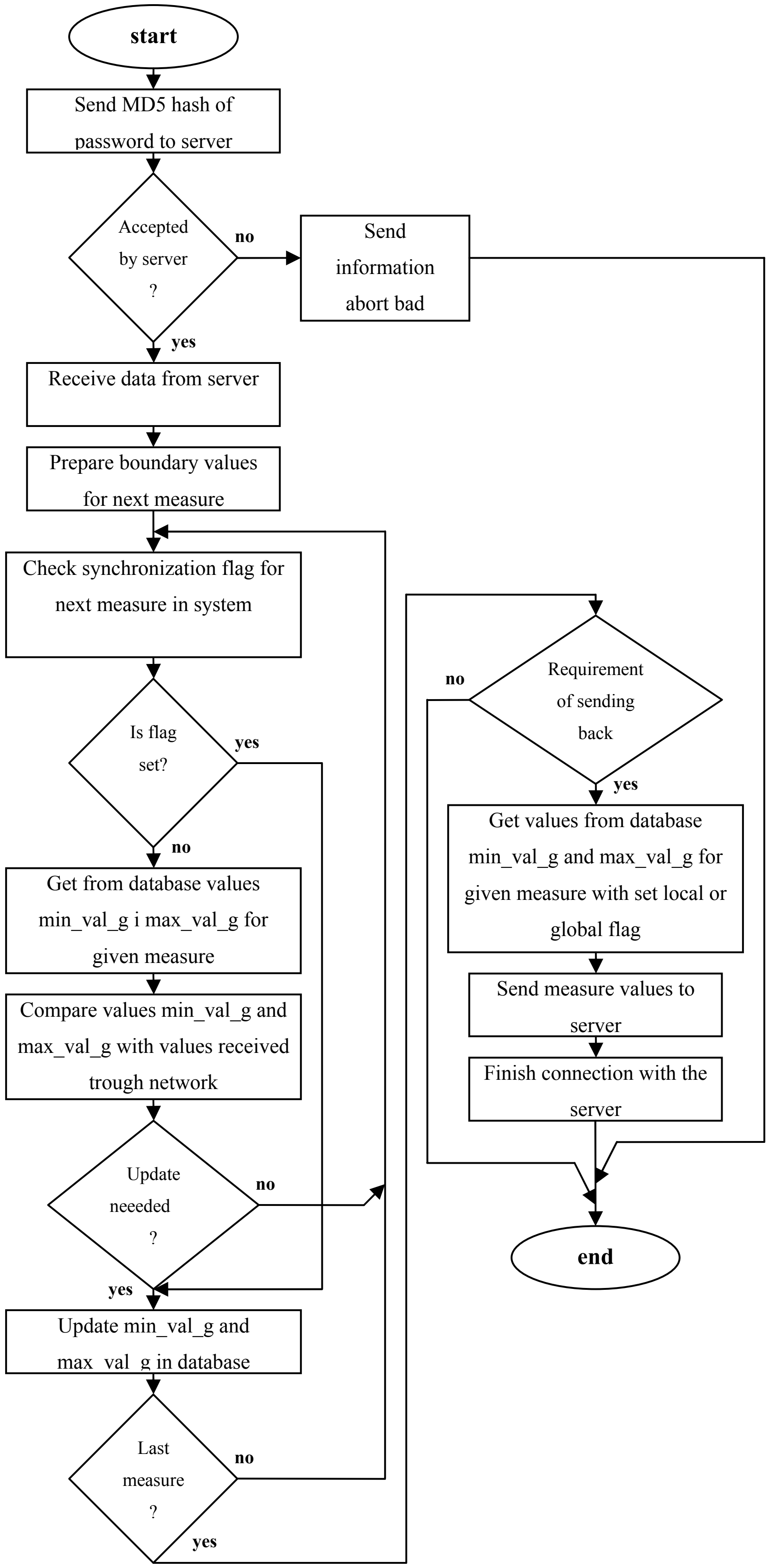

Fig.7. Synchronisation processes flowchart of pattern data finding

The transmission synchronisation between partner workstations has been presented in Fig.8. For this goal a special protocol with log file (containing history) was also provided.

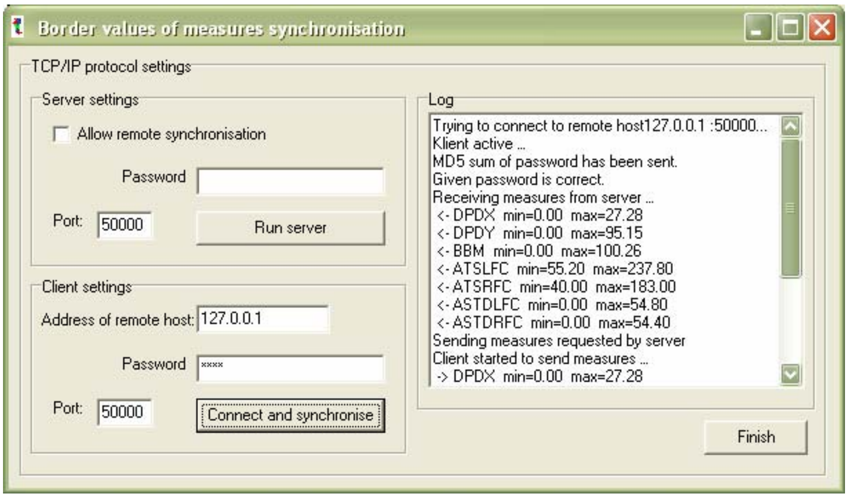

Fig.8. Partner units synchronization interface

5. CONCLUSIONS

The system has been designed as an open platform for further investigations and development. The introductory experiments proved that many complex data can be combined into one final conclusion. Nevertheless it was impossible to finish the examination full check–up for a quality diagnosis.

The quality of diagnosis depends on number of data records that the developer has for his disposal, at the beginning of his examination. The field testing of the system will come soon, in clinical experiments with the involvement of experts, namely computer research workers and expert neurologists. They have to collect all needed records for establishing the decision rules and for tuning the conclusion making unit.

After this examination of the quality of the conclusions, the system will be released for further examination at clinics of neurology practices.

The work described in this paper concerned the development of non-invasive diagnostics equipment, for the precise definition of neurological diseases and for controlling the rehabilitation process.

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