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Expert System for Medical Diagnosis. Fuzzy Logic

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Abstract: Fuzzy systems are considered a special case of expert systems that provides a flexible method for handling uncertainty and imprecise knowledge presentation. This article presents the design steps of an expert system based on fuzzy logic, which would be able to establish a medical diagnosis in electrocardiography domain.
Keywords: expert system, electrocardiographic signal (ECG), database, knowledge base, inference engine, rules.

The main purpose of the Artificial Intelligence is to mimic the human brain whereas in the way he thinks, respond and interact. Thus, different systems are developed for support decision-making calculations, preventive guidance, advice and preliminary indications, but in no case this systems can't replace human thinking, completely [5, 7].

The expert system, as a human expert, tries to solve a problem well defined in a practical activity field. In medical expert systems are introduced, a patient data (various signs and symptoms) and they make a diagnosis or creates an individualized treatment plan for a real case [2, 6].

Fuzzy logic provides the necessary tools for representing the imprecise concepts of intelligent systems as are "high", "hot", "cheap", etc., concepts that are called linguistic variables or fuzzy variables. Their representation used fuzzy sets, in which are captured a quantitative interpretation of the qualitative terms [1, 2].

This project includes a study of Fuzzy logic application in the electrocardiography domain, which will allow for establishing a preventive diagnosis, based on ECG signal analysis (the study of subjects - medical electronics, maintenance, control, diagnosis and design of medical devices).

The Fuzzy Expert system includes a complex of 17 inputs and 10 outputs. As the input variables, that are applied into the system, were assessed the main ECG's standard parameters that could be detected and described from the patient's electrocardiogram composition. These can be: FRC (frequency heart rate), the QRS complex duration, RR interval duration, PR interval duration, QT and PQ interval duration, the U and P waves duration and morphology, the QRS complex properties, the heart's rate form and manifestation, the presence/absence of Adam-Stokes syndrome(SAS)and the Wolff-Parkinson–White syndrome (SWPW)[3, 4].

As the system's outputs, are analyzed the most obvious cardiovascular diseases that could be characterized by a specific set of input parameters that were described above. Among of the investigated diseases are: sinus tachycardia, sinus bradycardia, sinus arrhythmia, atrial fibrillation, first degree AV block, second degree AV block, third degree AV block, paroxysmal Atrial tachycardia, paroxysmal Ventricular tachycardia, the syndrome of preexcitation (WPW) [3, 4].

The Expert system comprises itself, *a database*, into which are included the input parameters assessed from the diagnostic process; *a knowledge base*, which includes the disease's description by a characteristic set of parameters; and an inference engine that performs a mixture data, compares them with the possessed knowledge and, by the rule's set, select one of the system's outputs (the disease).

The MATLAB design tools were used in the expert system's developing. This contains a special Toolbox "Fuzzy Logic Demos" - the package that includes the necessary tools to achieve automatic control, signal processing, system identification, pattern recognition, time series prediction, data mining and financial applications.

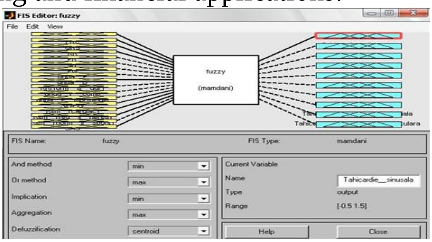

Figure 1. The overview of fuzzy system in MATLAB

The design phase begins with a simple system edition, with an entry and an exit. Here you can model the system that you need (use the standard window - "FIS Editor"). Through the "Edit" menu, you can add some input variables and some output variables, required for the project. Figure 1 shows a fuzzy system with seventeen inputs and ten outputs.

For the each system's inputs (input parameter) were set the universe of discourse, presented in Figure 2. The universe of discourse implies the membership functions. This membership functions define the statements domain and the statements validity of the suggested weight for gradual presentation of the input parameter:

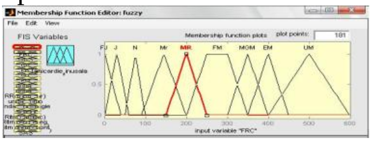

Figure 2. The universe of discourse for the input I – FRC

The statements that are included in Table 1 represent the fuzzification phase that is required for including the digital information. This generally could contain a vast quantity in the process of inference. This step is carried out to define fuzzy sets. The fuzzy sets allow the description of the input information using the language variables. The fuzzification goal is to enable the rules base building, encompassing the owned knowledge, closed to human thinking.

Table 1. The statements for FRC parameter

	Interval	Caracteristica	Bătăi/minut
1.	FJ (FRC)	Foarte joasă	0 – 40
2.	J(FRC)	Joasă	40 – 60
3.	N (FRC)	Normală	50 – 100
4.	r (FRC)	Mărită	90 – 200
5.	R (FRC)	Mare	150 – 250
6.	M (FRC)	Foarte Mare	200 – 350
7.	GM (FRC)	Mega Mare	300 – 400
8.	M (FRC)	Extrem de Mare	350 – 450
9.	M (FRC)	Ultra mare	400 – 600

Those 10 diseases (the system's outputs) are characterized by a set of input parameters specific for each disease, separately. The outputs' universes of discourse, which manifest it under certain statements applied to the input, includes only two functions representation, characterized by the claims of belonging "Yes" or "No" membership functions. This activation provides information about confirmation and validation of disease manifest after performing the necessary analysis.

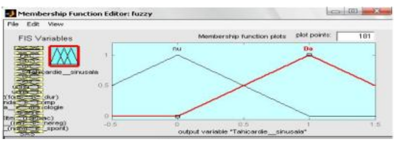

Figure 3. The universe of discourse for output I - sinus tachycardia

Logical inference procedure is the operation that yield valid conclusions based on premises. The rules are created based on input statements by applying logical operators in the process of inference (conjunction ∧, disjunction ∨, implication, equivalence, negation, etc.).

Ex. MR(FRC) & FÎ(RR) & Mr(PR) & N(QRS) & V(RR) & S(Ritm) & R(Ritm) & NS (Ritm) & C(QRS) => Sinus tachycardia.

The defuzzification procedure involves removing the farms data from the system. In this case was investigated and applied the centers of gravity method (COG of the figure, obtained after overlapping and "cutting" the membership functions of interest) that will confirm or validate your diagnosis.

The developed system was tested and simulated on personal computer where the results are presented as the weight of a particular disease manifestation. This expert system will be refined for different situations of exception, and then it will be applied to other physiological parameters and for other disease research.

Conclusion: Novelty and originality of the thesis is to obtain a quick medical decision support which would allow detecting one from 10 researched diseases; development of specialized software with the ability to analyze a considerable amount of input values applied to the system.

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