Processing the Medical Sensors Signals Using Fuzzy Inference System

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***Abstract*—**Sensors possess several properties of physical measures. Whether devices that convert a sensed signal into an electrical signal, chemical sensors and biosensors, thus all these sensors can be considered as an interface between the physical and electrical equipment. The problem is the analysis of the multitudes of saved settings as input variables. However, they do not all have the same level of influence on the outputs. In order to identify the most sensitive parameters, those that can guide users in gathering information on the ground and in the process of model calibration and sensitivity analysis for the effect of each change made. Mathematical models used for processing become very complex.

In this paper a fuzzy rule-based system is proposed as a solution for this problem. The system collects the available signals information from sensors. Moreover, the system allows the study of the influence of the various factors that take part in the decision system. Since its inception fuzzy set theory has been regarded as a formalism suitable to deal with the imprecision intrinsic to many problems. At the same time, fuzzy sets allow to use symbolic models. In this study an example was applied for resolving variety of physiological parameters that define human health state. The application system was done for medical diagnosis help. The inputs are the signals expressed the cardiovascular system parameters, blood pressure, Respiratory system paramsystem was done, it will be able to predict the state of patient according any input values.

***Keywords*—**Sensors, Sensivity, fuzzy logic, analysis, physiological parameters, medical diagnosis.

I. Introduction

To make medical decisions, physicians often rely on conventional wisdom and personal experience to arrive at subjective assessments and judgments. Recently there has been heightened concern over the burden of unwanted variation in clinical practice [1], [2]. Physiological parameters reflect health state. Generally, human health state is defined by variety of physiological parameters. Not all of them are equally informative and important. Besides, not all of those parameters could be easily and precisely controlled.

While designing the overall monitoring system, it is necessary to assess not only importance of measured parameters but also techniques of their measurement and potentiality of implication into practical systems.

Medical investigations have proven that the most important parameters are those that specify the work of heart and respiratory system. They best describe the human heath state. In addition to this, body's temperature is also an important parameter. These physiological parameters evolve in a range of measures. The signal recorded by each sensor varies by weight and therefore its effect on the final diagnosis. To remedy these fluctuations, we propose a fuzzy inference system which is perfectly adequate.

II. Characterization of Physiological Parameters

A. Cardiovascular System Parameters

Since the state of the heart work is associated with physiological functions of vital importance to the human body, it is always advisable to register heart work related parameters when evaluating human health condition.

The prime heart work related physiological parameters are heart work rate (pulse) and blood pressure. Practically they could be obtained in several ways.

Electrocardiogram (ECG) is one of the most representative characteristics of heart work [3]. ECG represents heart's electrical activity recorded from electrodes on the body surface.

In exercise ECG, the signal is distorted because of muscular activity, respiration, and electrode artifacts due to perspiration and electrode movements. This requires additional signal conditioning means.

Another method to measure pulse is the impedance plethysmography. This is a method of determining changing tissue volumes in body, based on the measurement of electrical impedance at the body surface. Pulsing change of blood amount in different parts of body, caused by systemic blood circulation within cardiovascular system, causes proportional changes of electrical impedance.

Blood pressure is the second physiological parameter describing heart's work. Most automatic instruments used for blood pressure measurement, uses oscillometric method. This is more indirect method, and instruments are usually empirically calibrated against the auscultatory method. Automatic instruments work on the principle that when the artery does open during a portion of the pressure cycle, a tiny perturbation, or oscillation, will be superimposed on the pressure inside the cuff. The cuff used there may be wrapped around the wrist (sometimes – finger). The systolic and diastolic blood pressures are defined from varying signal

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amplitude profile, which actually never goes fully to zero that makes practical evaluation of the pressure to be a fuzzy problem.

B. Respiratory System Parameters

Respiratory ensures permeation of the oxygen into the human body. Special medical equipment is required to register respiratory characteristics, so called respiratory system parameters. Those parameters featuring human health state consequently can be divided into three groups:

- Volume parameters; - Respiratory system physical parameters (respiratory rate and other mechanical parameters of respiratory system); - Parameters of gas metathesis within the lungs.

Impedance pneumography and inductive plethysmography are two the most promising noninvasive technologies available now for measuring respiratory function [4], [5].

Several limitations inherent to the impedance pneumography technology can lead to errors in respiratory measurement. First, the electrical resistance of rib cage tissues is less than of air; therefore current passing across the thoracic cavity reflects mainly tissue impedance. Thus, while this method can provide a qualitative indication of chest wall movement, there is no direct relationship to thoracic volume. Further, the electrodes attached to the skin record impedance off all tissue types through which the electrical current travels, including muscles. The method is therefore more prone to motion artifacts. Cardiogenic artifact is another source of recording error inherent in impedance pneumography.

C. Body Temperature

In a healthy individual, body temperature is kept constant in a very small range despite of big differences in temperature of the surroundings and also those in physical activity. This is achieved by systemic nervous regulation. Nervous system maintains the optimal intensity of metabolism and at the same time regulates the amount of heat loss. Overall human body temperature is rather different, especially within inner and outer parts of the body. Temperature measured in anus is about 37.1ºC, in mouth 36.7ºC, in armpit 36.5ºC. For a healthy person this temperature is almost invariable and depending on person may deviate only ±0.4ºC. Body temperature changes are more intensive in young person than in old people. The temperature may slightly or temporarily increase in hot environment. Physical activity may also increase the body temperature. In extreme effort, the increase may be very high.

III. Fuzzy Logic Set Theory

One of the most important areas of application of fuzzy set theory as developed by Zadeh, 1965, is Fuzzy Rule-Based System (FRBS). These fuzzy logic systems constitute an extension of the classical rule-based systems, because they deal with “if-then” rules whose antecedents and consequences are composed of fuzzy logic statements, instead of classical logic ones [6]. Due to this property, fuzzy logic principles have been successfully applied to a wide range of problems in different domains for which uncertainty and vagueness emerge in varying ways. Fuzzy modeling [7], [8] and fuzzy classification [9] are the most common applications.

Fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. The above-mentioned capabilities make fuzzy logic a very powerful tool to solve many ecological problems, where data may be complex or in an insufficient amount.

The fuzzy logic concept provides a natural way of dealing with problems where the source of imprecision is an absence of sharply defined criteria rather than the presence of random variables [10]. The fuzzy approach considers cases where linguistic uncertainties play some role in the control mechanism of the phenomena concerned [11]. Fuzzy inference systems (FIS) are powerful tools for the simulation of nonlinear behaviors with the help of fuzzy logic and linguistic fuzzy rules [12].

A. Principles of Fuzzy Logic

The aim of this section is to provide a summary of its basic concepts. The concept of fuzzy logic was first introduced by Zadeh in 1965 [13]. Fuzzy logic was proposed as an extension of classical logic. A classical logic set is a set with a crisp boundary. In contrast, a fuzzy set is a set without a crisp boundary. The transition from “belonging to a set” to “not belonging to a set” is gradual, and this smooth transition is characterized by membership functions that give fuzzy sets flexibility in modeling linguistic expressions.

The central idea of the fuzzy logic is to model the imprecise aspects of the behavior of the system through fuzzy sets and fuzzy rules. System variables are defined as linguistic variables and their possible values are linguistic terms (expressed as fuzzy sets). Fuzzy sets are used to represent linguistic variables. For example, if the temperature is a linguistic variable, its possible values could be {low, normal, height}. These terms are called linguistic terms and each one is characterized by a fuzzy set. A possible interpretation of the linguistic variable “temperature” and its linguistic terms is shown in Fig. 2. In this example each linguistic term is represented by different fuzzy sets. In general form, each fuzzy rule is written as were A1 and A2 are the fuzzy sets that describe the nature of the inputs, such as low, normal, or height. The linguistic control rules of this system are given by: If X1 IS X1(1) and X2 IS X2(2) and…Xn IS Xn(n) than Y1 is Y1(1).

B. Fuzzification

In order to make fuzzyfication, the linguistic expressions below are used. The proposed fuzzy logic factors impact control system consists of three inputs variables.

- Fuzzy variable “Temperature” has the linguistic values low; normal; height
- Fuzzy variable “heart work and blood pressure” has the linguistic values: lower, normal, higher.
- The variable “Respiratory system parameters” has (under normal, normal, up normal).

The mapping values of input variable through the membership function are the linguistic values Fig. 1. The linguistic values of inputs are shown as a result:

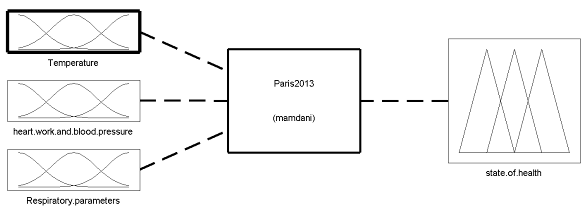

Fig. 1 Plot of inputs-output fuzzy system

C. Fuzzyfication the Input Variable "Temperature"

The entry that represents the temperature is composed of three fuzzy intervals and membership functions defining the low; medium and height temperature Fig. 2.

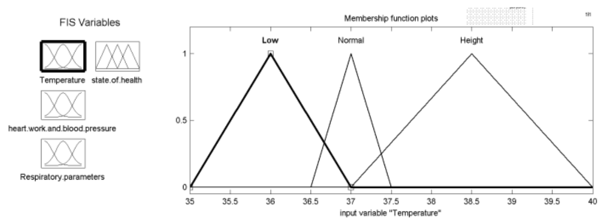

Fig. 2 The discourse universe of input (Temperature) classified in three linguistic categories: "low, normal, height"

D. Fuzzyfication of the Input Variable "Heart Work and Blood Pressure"

The entry that represents the heart work and blood pressure is composed of three intervals and fuzzy membership functions defining the nature of heart work and blood pressure. The degree of heart and blood pressure state is defining by three discourse universe: under normal, normal, up normal Fig. 3.

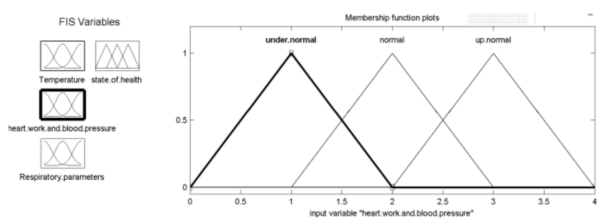

Fig. 3 The discourse universe of input (heart work and blood pressure) classified in three linguistic categories: "Young, Adult, Old"

E. Fuzzyfication of the Input Variable "Respiratory System"

Representing variable parameters of the respiratory system is expressed by three slots and membership functions (under normal, normal, up normal) Fig. 4.

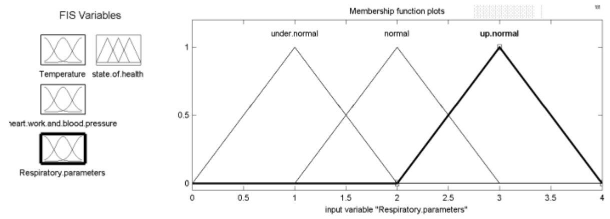

Fig. 4 The discourse universe of input (respiratory system) classified in three linguistic categories: "Young, Adult, Old"

F. Fuzzyfication of the Output Variable

As output variable we define three variables representing the expected state health of patient. We represent each membership function defining the tow states "abnormal" corresponding to a value between 0 and 2 "normal" between 1 and 3 as a "abnormal" number between 2 and 4 Fig. 5.

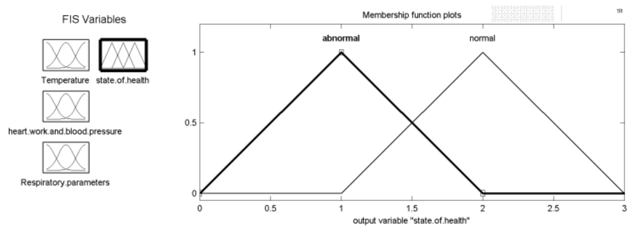

Fig. 5 The discourse universe of output (BMI) is classified in three linguistic categories: "overweight, moderately obese, extremely obese"

G. Defuzzifier

This system has one output that describes the function of human, in fact explains the contribution of each factor on obesity apparition. We can say that it shows the probability of normal function and disease. The crisp value output is given by the defuzzyfication process after estimating its input value. In this system we have center of average (C.O.A) method.

In the defuzzyfication the exact expression is obtained with "centroid" method according to validity degree. The output value according to the inputs values obtained from the designed fuzzy engine system.

Example :

If Temperature 37.5°C, corresponding to linguistic variable height, **AND** heart work and blood pressure have an numerical value 1.52, corresponding to linguistic variable abnormal, **AND** parameters of the respiratory have an numerical value 1.42, corresponding to linguistic variable under normal, **THAN** the output will have a numerical value 1, that corresponding to abnormal state of patient health. Fig. 6.

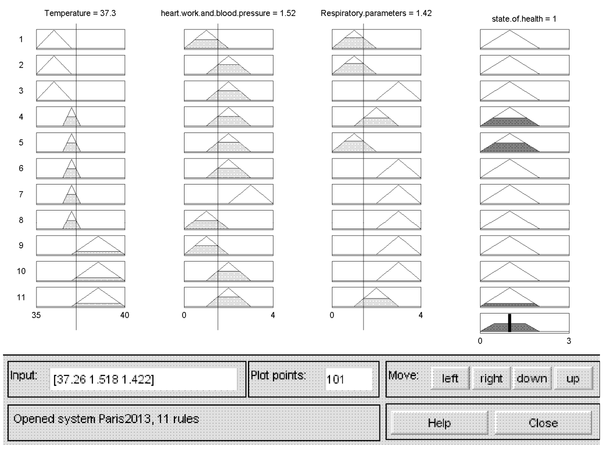

Fig. 6 Application Example: Attribution random variable inputs and direct reading of the output variable

IV. Results and Discussion

In this study, MATLAB-simulation is used by applying rules. We used different parameters. The data were analyzed by the fuzzy logic modeling technique in an attempt to predict state of body health. With the fuzzy modeling, we can represent imprecise data and produce a precise output in the form of fuzzy members. From the results obtained by this study, appear to be a useful tool for medical diagnosis on different parameters recorded by specific sensors identification, quantification and development of early warning systems. The designed system can be extended for any number of inputs. As the three considerate inputs, similarly we can define these system more than three inputs to get more efficient result.

The fuzzy logic inference system shows that the output ‘state health of patient’ corresponding to any input. As all parameters are characterized by their complexity and uncertainty, fuzzy logic as a tool for analyzing such data is perfectly adequate. However, other parameters that are not taken into consideration in this study may be included. The model is extendable for greater precision in the analysis. The proposed system provides an analytical result based on the contribution of each input parameters depending on its degree of membership function. As the basis of rules covers all possibilities, the result reflected faithfully the physical reality of the patient.

V. Conclusion

The artificial intelligent system using fuzzy logic method could extend our understanding of physiological parameters recorded, and the intelligent software created in this study could be used for medical help and as a part of a medical diagnosis and decrease the risk. The goal of this study is to design and perform a pilot investigation which will provide preliminary data. Modern methods of computational intelligence such as fuzzy logic are used to achieve the highest accuracy of pattern recognition. The result of the fuzzy program so far, is a numeric and symbolic terms of state health of patient, using the fuzzy inputs data in the universe of discourse (normal or abnormal). As the inputs parameters are characterized by uncertainty, we believe that this tool is very adequate. We emphasize that our fuzzy system is not meant to replace or substitute for an experienced physicians; on the contrary, we envisage that the fuzzy logic system should be viewed as a decision support in the most accurate.

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