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FUZZY RULES BASED SYSTEM FOR DECISION MAKING SUPPORT OF PATHOLOGY ANATOMIST

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Abstract

The system is suggested which provides support for a pathology anatomist in decision making about instant nontrauma death occurrence time determination. The system is based on some linguistic expert rules formalized in the form fuzzy knowledge bases.

Introduction

Determination of the death occurrence time, the pathology anatomists should make a decision in, is an important task in legal medicine. Instant and correct diagnosis of the death occurrence time make further investigations and crime disclosure successful.

Determination of the death occurrence time since it took place is a complicated task which requires taking into consideration a set of factors.

Time and change of the ambient, connected with the transportation of the deceased to the specialized stationary diagnostic center worsen informational signatures and decrease the precision of death occurrence time determination. In the ideal case such diagnosis must be performed at the place of crime though the medical expert attending the investigation doesn't often have sufficient experience and qualification to correctly solve his problem of decision making in the particular ambient. In this connection it is necessary to design mobile computer systems providing smart support for pathology anatomists in decision making.

In this paper we suggest an expert system of decision making support in instant nontrauma death occurrence time determination. Expert statements reflecting interconnection between state and diagnoses parameters is formalized using fuzzy knowledge bases.

1. Problem statement

According to the legal medicine examination [1] practice the pathology anatomist should make one of the following decisions while performing diagnosis of death occurrence remoteness:

d_1 - death occurrence time 0…2 hours;

d_2 - death occurrence time 2…6 hours;

d_3 - death occurrence time 6…12 hours;

d_4 - death occurrence time 12…24 hours;

d_5 - death occurrence time 24…36 hours;

d_6 - death occurrence time 36…48 hours;

d_7 - death occurrence time 48…72 hours.

In decision making relative to instant nontrauma death occurrence time it is necessary to take into consideration the following factors (state parameters): x_1 - ambient temperature; x_2 - relative air humidity; x_3 - atmospheric pressure; x_4 - length of deceased; x_5 - the deceased's warm clothes available; x_6 - build; x_7 - possible cause of death; x_8 - degree of the corpse's masticatory muscles stiffness; x_9 - degree of the corpse's lower limbs stiffness; x_{10} - degree of the corpse's upper limbs stiffness; x_{11} - death spots color; x_{12} - death spots saturation; x_{13} - boundaries of death spots; x_{14} - death spots dynamics; x_{15} - blood density.

From the mathematical point of view, simulation of the model for the death occurrence time determination (D) is reduced to finding out the representation of this form:

$$X = \{x_1, x_2, ..., x_{15}\} \rightarrow D \in \{d_1, d_2, ..., d_7\},$$

where X - state parameters vector.

2. Logical evidence tree

Let us represent hierarchical interconnection between state (X) and death occurrence time (D) parameters in the form of the logical evidence tree (Fig. 1). Graph vertices are interpreted in the following way [2]:

tree root - death occurrence time;

terminal vertices – particular state parameters;

nonterminal vertices (double circles) – fuzzy knowledge bases.

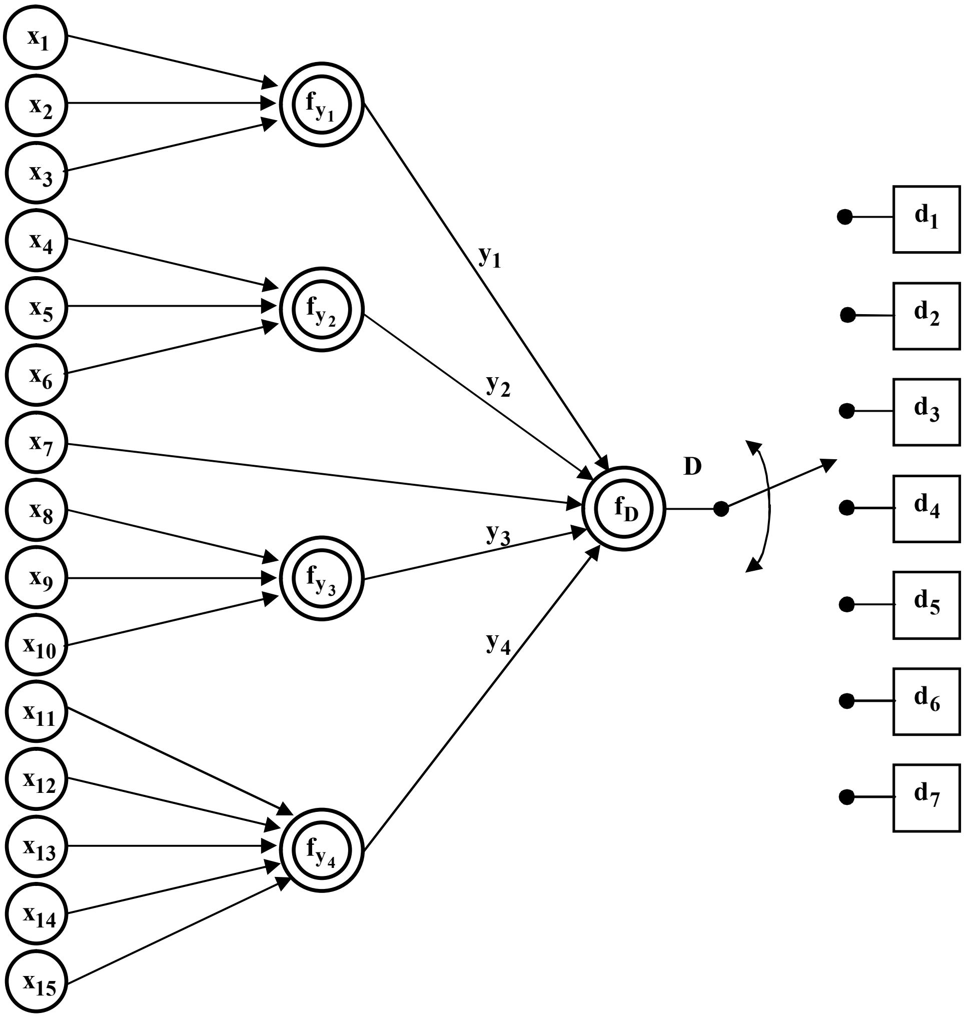

Figure 1. Logical evidence tree

Enlarged state parameters, to which graph edges correspond, as going out of nonterminal vertices, are interpreted in the following way: y_1 - influence of the ambient; y_2 - the type of the object being studied; y_3 - the degree of the corpse's stiffness; y_4 - the type of the death spots. The system of fuzzy logic equations [2] will be brought into correspondence with the evidence tree, using which system we define concrete death occurrence time. To construct the system of fuzzy logic equations it is necessary: 1) to represent state parameters in the form of linguistic variables; 2) to formalize expert statements about cause-consequence connections using fuzzy knowledge bases.

3. Linguistic variables

We'll consider partial and enlarged state parameters as being linguistic variables [4]. To make the linguistic assessment of the state parameters we suggest to use term-sets shown in Table 1.

Table 1

Linguistic assessment of the state parameters

State parameters	Term-set
x_1	**Low (L), Lower then Average (LA), Average (A), High then Average (HA), High (H)**
x_2	**Low (L), Average (A), High (H)**
x_3	**Low (L), High (H)**
x_4	**Low (L), Lower then Average (LA), Average (A), High then Average (HA), High (H)**
x_5	**Available (A), Unavailable (U)**
x_6	**Lean (L), Normal (N), Stout (S)**
x_7	**Mechanical asphyxia (MA), Fumes poisoning (FP), Alcohol poisoning (AP), Instant death (ID)**
x_8	**Unavailable (U), Weak (W), Pronounced (P)**
x_9	**Unavailable (U), Weak (W), Pronounced (P)**
x_{10}	**Unavailable (U), Weak (W), Pronounced (P)**
x_{11}	**Blue (B), Violet (V), Violet-Purple (VP), Purple (P), Red (R), Orange (O), Yellow (Y), Yellow-Green (YG), Green (G)**
x_{12}	**Little Saturated (LS), Saturated (S), Most Saturated (MS)**
x_{13}	**Vivid (Vi), Vague (Va)**
x_{14}	**Death spot completely disappears and appears (DA), Death spot grows pale (GP), Death spot doesn't change color (NCC)**
x_{15}	**No blood secretion (NBS), Thick blood secretion (TBS), Thin blood secretion (TiBS)**
y_1	**Low (L), Lower then Average (LA), Average (A), High then Average (HA), High (H)**
y_2	**I type, II type, III type**
y_3	**Unavailable (U), Weak (W), Pronounced (P)**
y_4	**I type, II type, III type, IV type**

4. Knowledge bases and decision making

Knowledge bases were built on the basis of natural language statements expressed by legal medicine department expert group of Vinnitsa State Medical University (Leader of Group –

Dr. Mocanuk A.). Fragments of fuzzy knowledge bases corresponding to vertices f_D, f_{y_1}, f_{y_2}, f_{y_3}, f_{y_4} are shown in Table 2 – 6.

Table 2

Knowledge about diagnosis

y_1	y_2	y_3	y_4	x_7	D
L	I	U	I	MA	d_1
H	I	W	I	ID	d_2
LA	I	W	I	AP	d_3
A	II	P	II	MA	d_4
H	III	P	III	AP	d_5
HA	III	P	IV	EP	d_6
A	I	P	IV	ID	d_7

Table 3

Knowledge about y_1

x_1	x_2	x_3	y_1
L	L	L	L
L	L	H	L
LA	A	H	LA
A	A	L	A
HA	A	H	HA
H	H	L	H
H	A	L	H

Table 4

Knowledge about y_2

x_4	x_5	x_6	y_2
H	A	N	I
H	U	S	I
HA	A	S	I
LA	A	N	II
HA	U	S	II
A	A	L	II
LA	U	L	III

Table 5

Knowledge about y_3

x_8	x_9	x_{10}	y_3
U	U	U	U
U	W	U	U
W	W	W	W
W	W	U	W
P	P	P	P
P	P	W	P

Table 6

Knowledge about y_4

x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	y_4
V	LS	Vi	DA	TiBS	I
B	LS	Vi	DA	TiBS	I
R	LS	Vi	DA	TiBS	II
VP	S	Va	GP	TBS	II
P	S	Va	NCC	NBS	III
Y	MS	Va	NCC	NBS	IV

Definite death occurrence will be determined by way of solving the system of fuzzy logical equations, which tie up membership function of diagnoses and state parameters [2]. Fuzzy logical equations are derived from the knowledge bases (Table 2- 6) by way of replacing terms for membership function and logic operations AND and OR for operations of minimum and maximum finding, respectively. Fuzzy logical evidence is carried out according to the following algorithm [2]:

1. Fix partial state parameters of the diagnosis object.
2. Find partial state parameters membership degrees to linguistic terms.
3. Weaken found membership degrees in fuzzy logic equations and calculate decision membership degrees to terms $d_1, d_2, \ldots, d_7$.
4. Choose the term from set $\{d_1, d_2, \ldots, d_7\}$ with the maximum membership degree as the diagnosis.

Calculation of the state parameters membership degree to linguistic terms (step 2 of the algorithm) is done in this way:

- when there are quantitative state parameters, weaken numerical value in the analytical expression of membership function [2];
- when there are qualitative state parameters, define membership function maximum of corresponding fuzzy sets intersection [3].

Suggested models and algorithms make the basis of the expert system which provides support in decision making relative to instant nontrauma death occurrence time determination. This expert system is realized on the basis of software shell Fuzzy Expert [2].

Let us have an example of the expert system performance. Let such state parameters correspond to some object: x_1 = +4°C; x_2 = 100%; x_3 = 99.7 kPa; x_4 = 165 cm; x_5 = Available; x_6 = Normal; x_7 = Mechanical asphyxia; x_8 = Pronounced; x_9 =Weak; x_{10} = Pronounced; x_{11} = Red; x_{12} = Saturated; x_{13} = Vague; x_{14} = Group pale; x_{15} = .Thick blood secretion.

As the result of the fuzzy logic evidence we obtain the following degrees of membership:

$\mu^{d_1}(D) = 0.04$; $\mu^{d_2}(D) = 0.17$; $\mu^{d_3}(D) = 0.17$; $\mu^{d_4}(D) = 0.33$;

$\mu^{d_5}(D) = 0.11$; $\mu^{d_6}(D) = 0.11$; $\mu^{d_7}(D) = 0.11$,

what correspond to solution d_4 - death occurrence time 12…24 hours

Conclusion

In this paper we suggest an expert system which provides smart support in decision making about instant nontrauma death occurrence time. This system can be useful also for the students corresponding subject apart from it being employed by practicing pathology anatomist.

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