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FUZZY THEORY APPROACHES TO THE MEDICAL DIAGNOSIS PROBLEMS

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Two methods are described which present some kind of simulation techniques in respect to the clinical diagnostic process and could supplement a real diagnostic process or traditional teaching methods in medicine. The methods apply fuzzy theory techniques and are part of a more complex Medical Diagnosis Program System (MDPS). They are exemplified by application to ophthalmology. The programs are written in FORTRAN-IV and run on the "BK" microcomputers.

1. INTRODUCTION. A computer system which diagnoses human diseases is something at least as attractive as the impressive devices wielded by magicians in the middle ages. But it still remains undoubtedly true that in the sphere of clinical diagnosis the computer has not made an impact comparable to that in many other parts of life. One of the explanations which strikes the nonspecialist in the medical science is the fact that the clinical diagnostic process (viewed as a monolithic structure) does not exist.

In an attempt to assess the problem further we felt that it might be interesting to reach again some aspects of computers and medical diagnosis by fuzzy theory approaches [2] .

In addition to the decision making method in the case of experts consultation, developed as a part of the Medical Diagnosis Program System (MDPS) described in [4] we present two methods intended to take part at the stage of personal reaching diagnosis by clinicians in the decision making process. These methods present another part of the MDPS, described as "Clinician's helper" part.

2. DIAGNOSIS PROBLEMS AND FUZZY METHODS. A medical diagnosis is usually based on information obtained by the examination of a large number of variables (symptoms). These variables have heterogeneous character. Some of them are quantitative. They are results of medical tests. Some of the variables are semi-quantitative having several states, for example, the variable "sex" (male, female, pregnant female). And finally there are qualitative variables: presence or absence of a symptom. The values of such variables could often be met in the form of expressions like: "severe pain, getting better" in medical reports. Thus, every method dealing with such variables confronts at least two problems: heterogeneity of the variables (even the test results are in different metric systems) and manipulation of qualitative data. These difficulties are the main challenges for using the fuzzy set theory in the field

(3)
$$\mu_B(y) = \frac{1}{n} \sum_{i=1}^{n} | \mu(x_i) - \mu(x_i, y) | .$$

The value of $\mu_B(y)$ gives an arrangement between the diseases.

If it is known that some symptoms are more significant for the final diagnosis weighting factors w_i ($0 \leq w \leq 1$; $i = 1, \ldots, n$) for every diagnostic parameter could be introduced.

The second method includes the following stages:

step 1: As in the first method.

step 2: Constructing the weighted normalized relation $R'/X \times Y$ from the relation $R/X \times Y$ and weighting factors of the diagnostic parameters.

step 3: Calculation of the membership function values of B/Y with the help of (3) considering $R'/X \times Y$ instead of $R/X \times Y$.

step 4: Ranking the diseases according to the descending order of B/Y.

The determination of $R/X \times Y$ in both methods models the acquisition of knowledge from real-case studies, the determination of A/X in them models the search of a fuzzy cause.

Both methods complement one another concerning their applicability. The first method is a screening method, the second - a preference ordering. The first method could imply the difference between the significance of the diagnostic parameters, while the second one could take it into account.

5. AN EXAMPLE FOR APPLICATION IN MEDICINE. The methods described in the previous section depend on accumulated medical experience. That is why these techniques could be applied if information concerning the correspondent area of medical studies is available.

The example developed as an illustration of the proposed ideas concerns various classes of eye diseases (ophthalmology) and uses accumulated real-life medical data, which we borrow from [1] .

Let us suppose that from profound studies the following choice of ophthalmology disorders and symptoms have been made:

$X = \{$ pain, ulcer, palpable nodes, age > thirty, vision change, on lower lid, redness $\}$

$Y = \{$ chalazion, hordeolum, basal cell, squamous, other $\}$

and from a large-scale series of real-life medical cases - the following table of values for R has been introduced:

Y \ X	pain	ulcer	palpable nodes	age > 30	vision change	on lower lid	redness
chalazion	0.10	0.10	0.10	0.50	0.50	0.50	0.50
hordeolum	0.95	0.80	0.80	0.50	0.50	0.50	0.10
basal cell	0.05	0.05	0.10	0.70	0.70	0.90	0.20
squamous	0.05	0.05	0.07	0.07	0.90	0.10	0.20
other	0.70	0.70	0.20	0.05	0.50	0.50	0.30

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APPENDIX 1

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     MEDICAL DIAGNOSIS PROGRAM SYSTEM

1.CLINICIAN'S HELPER REGIME
2.CHIEF CONSULTANT'S HELPER REGIME
 TYPE THE NUMBER OF THE REGIME
1
     MDPS:CLINICIAN'S HELPER REGIME
1.DATA ACQUISITION SUBREGIME
2.DIAGNOSTIC PREDICTION  SUBREGIME
3.TEACHING SUBREGIME
4.DISPLAYING SUBREGIME
 TYPE THE NUMBER OF THE SUBREGIME
1
     DATA ACQUISITION SUBREGIME
 ENTER THE MEDICAL DISCIPLINE NAME
OPHTHALMOLOGY
 ENTER THE NUMBER OF DIAGN PARAM
7
 ENTER THE NAMES OF DIAGN PARAM
1.PAIN
2.ULCER
3.PALPABLE NODES
4.AGE>30
5.VISION CHANGE
6.ON LOWER LID
7.REDNESS
 ENTER THE NUMBER OF THE DISEASES
5
 ENTER THE NAMES OF THE DISEASES
1.CHALAZION
2.HORDEOLUM
3.BASAL CELL
4.SQUAMOUS
5.OTHER
 FILL IN THE INFORMATION  IN THE FOLLOWING TABLE:
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DISEASE	SYMPTOMS	NUMBER CASES	FREQUENCY
CHALAZION	PAIN	450,	0.10
	ULCER	450,	0.10
	PALPABLE NODES	450,	0.10
	AGE>30	450,	0.50
	VISION CHANGE	450,	0.50
	ON LOWER LID	450,	0.50
	REDNESS	450,	0.50

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 HORDEOLUM               0.351
 BASAL CELL              0.364
 OTHER                   0.364
 CHALAZION               0.403
 SQUAMOUS                0.510
 IF YOU WANT TO CONTINUE, PRESS 'G'
G
      MEDICAL DIAGNOSIS PROGRAM SYSTEM

1.CLINICIAN'S HELPER REGIME
2.CHIEF CONSULTANT'S HELPER REGIME
 TYPE THE NUMBER OF THE REGIME
1
     MDPS:CLINICIAN'S HELPER REGIME
1.DATA ACQUISITION SUBREGIME
2.DIAGNOSTIC PREDICTION  SUBREGIME
3.TEACHING SUBREGIME
4.DISPLAYING SUBREGIME
 TYPE THE NUMBER OF THE SUBREGIME
2
     DIAGNOSTIC PREDICTION SUBREGIME
 ENTER THE  MEDICAL DISCIPLINE NAME
OPHTHALMOLOGY
 ENTER THE VALUES OF THE DIAGN PARAM
 EXPRESSED AS DEGREES
 PAIN                    0.9
 ULCER                   0.4
 PALPABLE NODES          0
 AGE>30                  0.8
 VISION CHANGE           0.1
 ON LOWER LID            1
 REDNESS                 0
 WEIGHTINGS FACTORS, YES OR NO
NO
 DIAGNOSTIC SUGGESTIONS:

 HORDEOLUM               0.9
 BASAL CELL              0.9
 OTHER                   0.7
 CHALAZION               0.5
 SQUAMOUS                0.1
 IF YOU WANT TO CONTINUE, PRESS 'G'
G
      MEDICAL DIAGNOSIS PROGRAM SYSTEM

1.CLINICIAN'S HELPER REGIME
2.CHIEF CONSULTANT'S HELPER REGIME
 TYPE THE NUMBER OF THE REGIME
1
     MDPS:CLINICIAN'S HELPER REGIME
1.DATA ACQUISITION SUBREGIME
2.DIAGNOSTIC PREDICTION  SUBREGIME
3.TEACHING SUBREGIME
4.DISPLAYING SUBREGIME
 TYPE THE NUMBER OF THE SUBREGIME
3
     TEACHING SUBREGIME
 ENTER THE MEDICAL DISCIPLINE NAME
OPHTHALMOLOGY
 ENTER THE NAME OF A CONFIRMED DIAGNOSIS
HORDEOLUM
 ENTER THE VALUES OF THE DIAGN PARAM
 EXPRESSED AS DEGREES
 PAIN                    0.9
 ULCER                   0.4
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