ПРОГРАМНА СИСТЕМА ЗА ВЗЕМАНЕ НА РЕШЕНИЕ В МЕДИЦИНСКАТА ДИАГНОСТИКА

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Предмет на настоящата статия е програмната система *MDPS* , предоставя
ща експериментални средства за вземане на решения в медицинската диагности:

Решава се проблемът какво решение да бъде взето на базата на предполо:
ния, направени с различна степен на сигурност от специалисти, които предст.
лят източници на различна надеждност по отношение на всеки конкретен про
лем.

MDPS е написана на БЕЙСИК и работи на микрокомпютъра ЕЛЕКТРОНИКА 6

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MEDICAL DIAGNOSIS PROGRAM SYSTEM

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In the present paper a program system (MDPS) is described which implements procedures by which some initial steps towards reaching medical diagnosis could be made.

The problem in question is that of deciding what conclusions may be drawn in the presence of evidence provided, on the basis of experts' suppositions which express different degree of certainty and belong to sources of different reliability.

MDPS is written in BASIC and operates on ELECTRONICA 60.

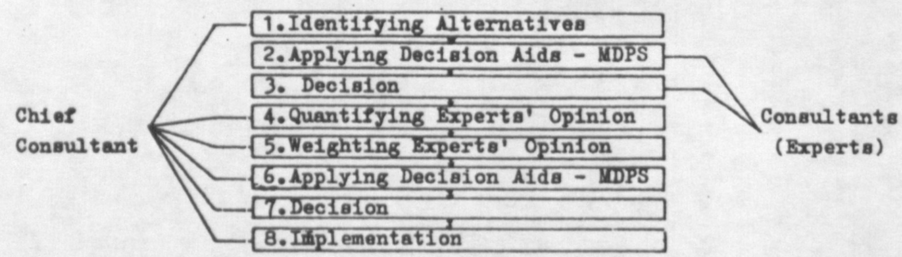
1. INTRODUCTION

Proposals to apply formal approaches to decision making in medical practice are somewhat still new for most of the countries, including our . So, such an attempt could meet a lot of objections, mainly from the physicians, but nevertheless it is worth starting and trying.

Naturally, physicians believe that they must have precise and reliable data before they can use quantitative techniques and that an intuitive process of clinical judgment can by pass the need for precise data. They might have been right up till a few years ago, but recently a lot of techniques[5] , [9], [11] accomplish quantitative analysis on data at any level of accuracy and allow practical reasoning even in case of inconsistency.

In the present paper a program system is described which implements procedures by means of which some initial steps towards reaching medical diagnosis could be made.

The system is designed to take part in the decision making process in question twice (see Fig. 1), first-at stage 2(Fig.1), when every specialist reaches diagnosis by himself, and secondly - at stage 6 when final conclusions about the diagnosis has to be drawn.



The Decision Making Process in Clinical Decision Making

Fig. 1

The first case is a multiobjective decision problem [4] , [7] , [10] , and has been solved by techniques described in [3] .

The second case, which will be the focus of our attention, concerns the problem: what conclusion may be drawn in the presence of evidence provided, on the basis of experts' suppositions which express different degree of certainty and belong to sources of different reliablility.

2. THE PROBLEM

In clinical judgment, the resolution of disagreements (one consultant claiming that surgery should be done, while another consultant claims that nonsurgical therapy is better) is often arbitrary and turns on who yells the loudest, or who has the highest academic rank, or who takes the responsibility for the patient.

For our formal decision analysis we suppose the following situation: there is a doctor who has to diagnose on the basis of his own observations together with evidence submitted by spesialists in different medical disciplines (we may call the former "chief consultant" and the latter - "experts" or "consultants").

Let's point out the main problems which confront a doctor being chief consultant, that is, when he is supposed to review the opinions available and come to a conclusion.

Usually the consultants do not make their assertions with certainty, but ascribe to them degrees of certainty, generally by hedges such as "probably", "almost certainly", "possibly" and so on.

On the other hand, the chief consultant may consider some consultants more reliable than others in the case of a certain problem, or disease, and having in mind their speciality or the reliability of the respective medical tests, he may wish to assign greater weight to their assertions in the process of reaching a final diagnosis.

Suppose: $c_1, c_2, \ldots, c_k$ are the consultants who are asked to express their opinion about a certain medical case; $a_1, a_2, \ldots, a_n$ are the alternatives that seem reasonable (e.g. possible diseases); S_{ij} is the supposition made by c_i , concerning $a_j (i=1,\ldots,k; j=1,\ldots,n)$; w_{ij} - whole number, is the weight attached to c_i , regarding a_j ; $m_{ij} \in [0,1]$ is the degree of certainty with which the supposition S_{ij} is made (it could be numerically expressed by the consultant himself, or by the chief consultant). Obviously, the nearer m_{ij} is to one, the more probable the alternative a_j is considered, according to the expert c_i , and vice versa.

Thus, on the basis of the two matrixes $\| m_{ij} \|_{\substack{i=1,\ldots,k \\ j=1,\ldots,n}}$ with the degrees of certainty and $\| w_{ij} \|_{\substack{i=1,\ldots,k \\ j=1,\ldots,n}}$ with weighting factors, the optimal assertions $S'_{lj}(m'_{lj}, w_{lj})(l=1,\ldots,p/p \le k; j=1,\ldots,n)$ have to be found and, thence, an arrangement between the alternatives $a_1, a_2, \ldots, a_n$, so as to help further process of decision making (reaching diagnosis).

3. SOLUTION

Similarly to some other works [8] we make use of the Elementary Decision Theory [2] , [12] .

We represent every single supposition by its risk function. This is a function f , defined on the interval $[0,1]$, such that $f(x)$ is the value of the risk taken from the decision maker when he accepts the alternative a , proposed by the supposition $S(m,w)$, if he knew that the probability of a to be a right alternative was $1-x$. Thus, for our problem: $f(x) = max\{0, w(x-v)\}$ where $v = 1-m$; m is the given degree of certainty; w is the weighting factor.

If for the alternative $a_j (j=1,\ldots,n)$ there are k suppositions, that is, k risk functions, we denote:

$$y_j(x) = \sum_{i=1}^{k} f_{ij}(x) = \sum_{i=1}^{k} max(0, w_{ij}(x-v_{ij})), \; j=1,\ldots,n. \tag{1}$$

$y_j(x)$ is a function, whose values are net values of the k suppositions. We may call $y_j(x)$ risk function of the alternative a_j .

We wish to know, for what values of certainty m and weight w the alternative a_j may safely be asserted. This amounts to asking for what values of m and w do we have:

$y_j(x) \geqq y(x)$, that is:

$$\sum_{i=1}^{k} max(0, w_{ij}(x-v_{ij})) \geqq \sum_{i=1}^{k} max(0, w(x-(1-m))) \text{ , whenever } \begin{matrix} 0 \le x \le 1 \\ 0 \le j \le n \end{matrix} .$$

Clearly, this problem could easily be converted to a standard one in parametric linear programming and could be solved by the correspondent techniques, but as it is not sufficiently complex, simpler approaches are applicable.

For instance, if we graph the risk function $y_j(x)$ of the alternative a_j , by pointing obviously safe assertions we may see that the lines which correspond to the safe assertions lie below the graph of $y_j(x)$. Several "maximal" ones are among these assertions and it is easy to see that they correspond to the assertions $S'_{lj}(m'_{lj}, w'_{lj})$, with:

$$m'_{lj} = 1 - (v_{lj} - \frac{v_{l+1j} - v_{lj}}{y(v_{l+1j}) - y(v_{lj})} * y(v_{lj}))$$

where $l=1,\ldots,p/p \le k$; $v_{lj} < v_{l+1j}$; $v_{p+1j} = 1$ and

$$w'_{lj} = \frac{y_j(v_{l+1j})}{v_{l+1j} - (1-m'_{lj})} .$$

These maximal assertions may be represented by points $S''_{lj}(m'_{lj}, 1/w'_{lj})(l=1,\ldots,p/p \le k; j=1,\ldots,n)$ and it can be seen that the points, representing the other "safe" assertions exactly fill the region overlying the lines OS''_{1j} , $S''_{1j} S''_{2j}$,..., $S''_{pj} S''_{p+1j}$, $S''_{p+1j} E$.

where :

$$S''_{p+1j} = \begin{cases} S''_{pj} & \text{if} \quad m'_{pj} = 1 \\ (m'_{pj}, 1 & \text{if} \quad m'_{pj} \ne 1 \end{cases} \quad \text{and} \quad O(0,0); E(0,1)$$

(let's call it "safe" region).

Thus, to know all that can be asserted about a given alternative it is enough to know the maximal assertions, and if it is necessary to compare the alternatives - it is enough to calculate the area of the "safe" regions.

The information of both types is provided by MDPS.

4. EXAMPLE

Let's have the following clinical situation: a patient suffers from a certain disease, which is suspected to be among gastritis, gastric ulcer and cancer. The doctor who is supposed to reach the final diagnosis consults three specialists, i.e. gastroenterologist, internist, oncologist. No matter in what way may they present their opinions about the case, it may be medical test results, such as blood tests, X-ray images, cancer screening tests, etc., with the corresponding written interpretation, or interview with the specialists after their personal examining, the chief consultant converts their supposisitions in numerical form, so that they can express degree of certainty about every one of the possible diseases (see Fig. 2a).

After this procedure, the chief expert attaches a weighting factor to each expert, which differs from disease to disease (see Fig. 2b) and depends on his personal consideration for the speciality and qualification of the physician, the reliablility of the corresponding tests, as far as every one of these deseases is concerned.

	gastritis	gastric ulcer	cancer
gastro entero-logist	.6	.2	.4
inter-nist	.4	.1	.4
onco-logist	.6	.6	.8

	gastritis	gastric ulcer	cancer
gastro intero-logist	3	3	1
inter-nist	4	4	2
onco-logist	1	1	3

The risk functions could easily be expressed from the data in Fig.2 :

$$f_{11} = max(0,3(x-0.4)) \quad f_{12} = max(0,3(x-0.8)) \quad f_{13} = max(0,(x-0,6))$$

$$f_{21} = max(0,4(x-0.6)) \quad f_{22} = max(0,4(x-0.9)) \quad f_{23} = max(0,2(x-0.6))$$

$$f_{31} = max(0,(x-0.4)) \quad f_{32} = max(0,(x-0,4)) \quad f_{33} = max(0,3(x-0.2))$$

Hence, using (1) the risk functions for every alternative could be found. The risk functions thus obtained are graphed in Fig. 3: for gastritis - as solid line, for gastric ulcer - as asterik line, for cancer - as dotted line.

Concerning gastritis, each line that lies below the graph $A_1A_2A_3$ of y_1 (and intersects A_1D) represents a safe assertion. As "maximal" assertions easily could be found $S'_{11}(0.6,4)$ and $S'_{21}(0.5,8)$.

Concerning gastric ulcer, the lines that lie below the graph $B_1B_2B_3B_4$ of y_2 (and intersects B_1D) represent safe assertions. The "maximal" asser-

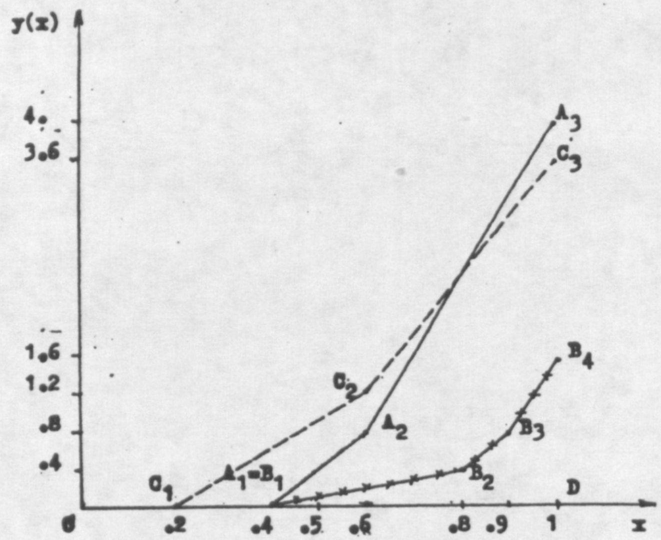


Fig. 3 .

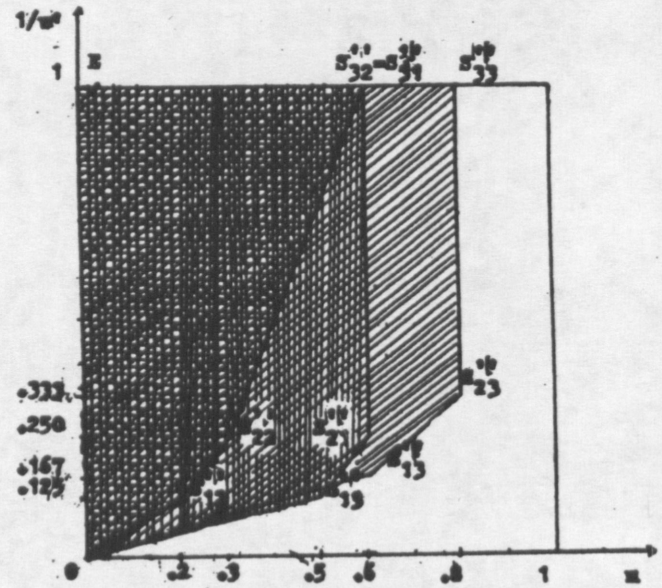


Fig. 4

tions are $S'_{12}(0.6,1)$, $S'_{22}(0.3,4)$, $S'_{32}(0.2,8)$.

Concerning cancer, the safe assertions are those, represented by the lines below the graph $C_1 C_2 C_3$ of y_3 (and intersect $C_1 D$). The "maximal" assertions are $S'_{13}(0.8,3)$, $S'_{23}(0.6,6)$.

The "maximal" assertions are represented by the points S''_{11} , S''_{21} ; S''_{12} , S''_{22} , S''_{32} ; S''_{13} S''_{23} in Fig. 4 and three "safe" regions (different shaded) are obtained: one overlying the line OS''_{11}, $S''_{11} S''_{21}$, $S''_{21} S''_{31}$, $S''_{31} E$; the second - overlying the lines OS''_{12} , $S''_{12} S''_{22}$, $S''_{22} S''_{32}$, $S''_{32} E$, and the third - overlying the lines OS''_{13} , $S''_{13} S''_{23}$, $S''_{23} S''_{33}$, $S''_{33} E$.

The area of the "safe" regions is correspondingly 0,55, 0.38125, 0.7, i.e. the diagnosis cancer is recommended in the presence of the given experts opinion.

5. REALIZATION

MDPS is a computer system which carries out the work involved in the calculations described. To facilitate its use MDPS is written in standard BASIC and can be used in an interactive mode on a microcomputer (it has been operated on ELECTRONICA 60 - a microcomputer compatible with PDP-11/V03, LSI-11, MINC-11, MERA 60). The display for the example given in 4. is included as an appendix 1.

The realization described is just a part of MDPS, which is planned to provide techniques for several different kind decision making operations, with possibilities for coding and extraction of medical information (findings, problems, diagnoses) from medical data base to assist doctors in making medical decisions.

MDPS with some other products of medical informatics, which will run on ELECTRONICA 60 aim at specifying this microcomputer as doctor's office computer [1] , [6] .

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Appendix 1

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RUN

              MEDICAL DIAGNOSIS PROGRAM SYSTEM

NUMBER OF SPECIALISTS ? 3
NUMBER OF DISEASES ? 3

COMPETENCE OF SPECIALIST  1   CONCERNING DISEASE   1 ? 3
COMPETENCE OF SPECIALIST  1   CONCERNING DISEASE   2 ? 3
COMPETENCE OF SPECIALIST  1   CONCERNING DISEASE   3 ? 1
COMPETENCE OF SPECIALIST  2   CONCERNING DISEASE   1 ? 4
COMPETENCE OF SPECIALIST  2   CONCERNING DISEASE   2 ? 4
COMPETENCE OF SPECIALIST  2   CONCERNING DISEASE   3 ? 2
COMPETENCE OF SPECIALIST  3   CONCERNING DISEASE   1 ? 1
COMPETENCE OF SPECIALIST  3   CONCERNING DISEASE   2 ? 1
COMPETENCE OF SPECIALIST  3   CONCERNING DISEASE   3 ? 3

CERTAINTY OF SPECIALIST  1   CONCERNING DISEASE   1 ? .6
CERTAINTY OF SPECIALIST  1   CONCERNING DISEASE   2 ? .2
CERTAINTY OF SPECIALIST  1   CONCERNING DISEASE   3 ? .4
CERTAINTY OF SPECIALIST  2   CONCERNING DISEASE   1 ? .4
CERTAINTY OF SPECIALIST  2   CONCERNING DISEASE   2 ? .1
CERTAINTY OF SPECIALIST  2   CONCERNING DISEASE   3 ? .4
CERTAINTY OF SPECIALIST  3   CONCERNING DISEASE   1 ? .6
CERTAINTY OF SPECIALIST  3   CONCERNING DISEASE   2 ? .6
CERTAINTY OF SPECIALIST  3   CONCERNING DISEASE   3 ? .8


OPTIMAL ASSERTIONS FOR DISEASE   1  :
DEGREES OF CERTAINTY   .6   WEIGHT   4
DEGREES OF CERTAINTY   .5   WEIGHT   8
RECOMMENDATION ON DIAGNOSIS 'DISEASE  1 ' -  .55

OPTIMAL ASSERTIONS FOR DISEASE   2  :
DEGREES OF CERTAINTY   .6   WEIGHT   1
DEGREES OF CERTAINTY   .3   WEIGHT   4
DEGREES OF CERTAINTY   .2   WEIGHT   8
RECOMMENDATION ON DIAGNOSIS 'DISEASE  2 ' -  .38125

OPTIMAL ASSERTIONS FOR DISEASE   3  :
DEGREES OF CERTAINTY   .8   WEIGHT   3
DEGREES OF CERTAINTY   .6   WEIGHT   6
RECOMMENDATION ON DIAGNOSIS 'DISEASE  3 ' -  .7


IN CASE YOU WANT TO CONTINUE, PRINT '1'
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