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DIAGNOSTIC SYSTEMS IN MEDICINE AS PERSONAL INTELLECTUAL TOOLING

Aleksej Voloshin, Maksim Zaporozhets, Pavel Mulesa

Abstract: The standards of diagnostic systems formation in medicine based on modeling expert's "means of action" in form of illegible trees of solution-making taking into consideration the criteria of credibility and usefulness have been suggested. The fragments of "applied" trees at diagnosing infectious and urological diseases have been considered as well. The possibilities of modern tooling theory usage for decision-making during creation of artificial intelligence systems have been discussed

Keywords: Decision making theory; solution trees; credibility; usefulness; diagnostic systems in medicine.

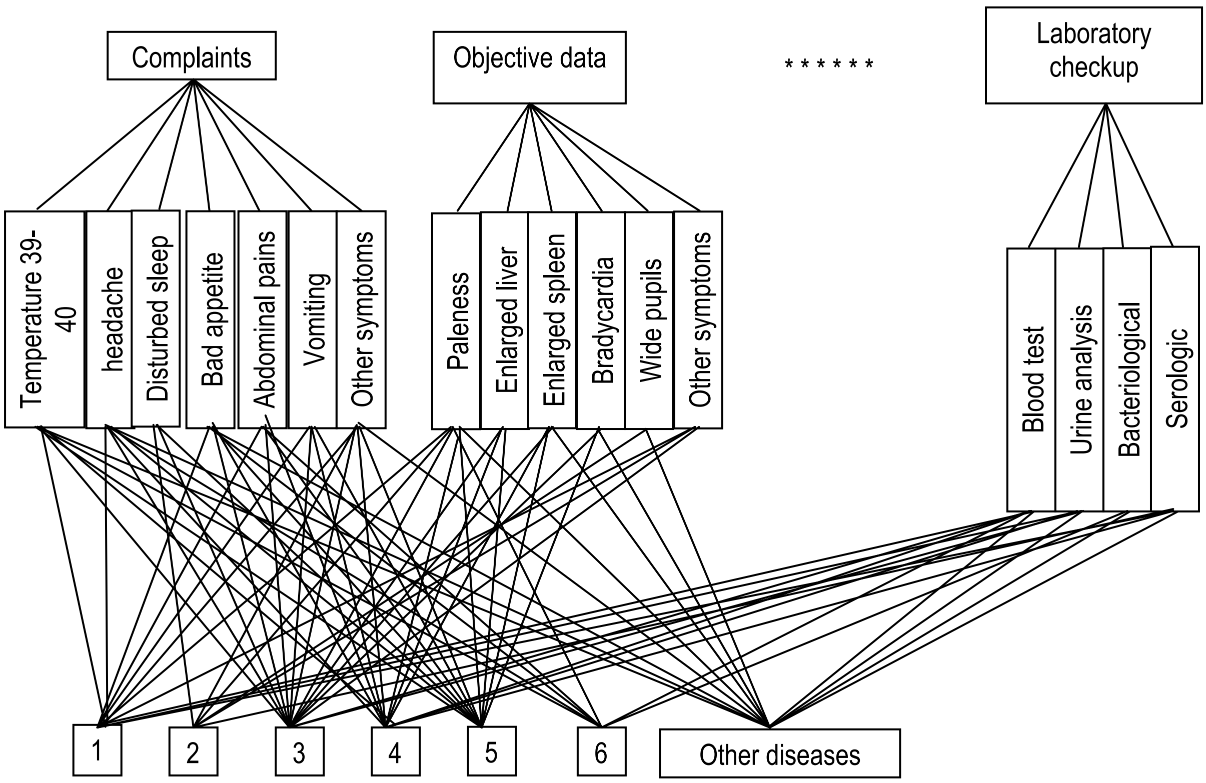
Forewords

One of the first applied areas of artificial intelligence methods usage was medical diagnostics [Lyuher, 2003], [Rassel, 2006]. Elaboration of expert systems in diseases diagnostics is more than 50 years. Though the theory of decision making is a standard means in many problem areas as business, public administration, jurisprudence, military strategy, engineering design and resource management, but in the field of artificial intelligence only several investigators [Rassel, 2006, p.810] added to their arsenal the means of decision making theory in medical diagnostics. One of the main reasons for limited usage of solution trees in medicine is their "exponential size" [Rassel, 2006]. The second criterion, to our consideration (see [Voloshin, 2006]), is the incorrect usage of the "averaged" expertise. In many cases of diseases' diagnostics the "objective" ("common") criteria for assessment of factors interference intensity, that determine a disease, are lacking. The process of decision-making by a doctor-diagnostician up till now at a certain extent is subjective, and in a considerable degree depending on "intuition", "experience" and similar weakly formalized factors. And even now when the canonical program of artificial intelligence became "intellectual agent" designed to help a person [Rassel, 2006, p.1267], and replacement of an individual who is making decision, no talk about this, the role of expert system is added up to medical textbook and reference book [Rassel, 2006, p.1269]. A doctor has to realize the chain of arguments that are the root of any system solution. Otherwise the usage of artificial intelligence systems can bring to the situation when the people become more irresponsible (who will be legally responsible if the diagnosis is wrong?). That is why [Voloshin, 2006] it was suggested to switch from the conception of "expert system elaboration as "assistant" ("intellectual intensifier"), one that is making decision, to the conception of "personal tooling". And for this it is necessary to base the system on such a mode where the decision-making is committed be the user of the system. And the creator of the system has to provide the ways of this method's formalization, and at the same time for the "objectification" of the person's subjective evaluation, who is making the decision, included into the system, it is important to consider psychosomatic peculiarities of the person who is making the decisions (in the systems of economic forecasting [Voloshin, 2005] "the experts-creator's system's subjectivity became objective"). Moreover, it is essential to provide means of subjective peculiarities account of the subject under diagnosis. As it is repeatedly noticed in the history of artificial intelligence, one of the main difficulties of the artificial intelligence system elaboration is the "extraction" of knowledge from the specialist. The task is becoming more complicated if not a "fixed" but a "dynamic" knowledge is needed ("way of thinking").

In this work is reflected the author's experience in intercourse with specialists-diagnosticians at elaboration diagnostic systems as personal intellectual tooling, fulfilling the "means of contributed action" [Lyuher, 2003] in the form of indistinct trees of solution [Voloshin, 2003]. At the same time unlike the majority of diagnostic systems in which the result of diagnostic is based on the criteria of "credibility" [Rassel, 2006], simultaneously with the evaluation of the tree arcs (factors interference), are set by impose (usefulness) of the very factors. The latter, to a certain degree, permits to avoid one of the most spread "traps" in diagnostics – confusion of credibility and significance [Rassel, 2006, p.804].

Solution Trees Formation

The tree solution method is based on the formation hierarchical structure of factors, which have direct and indirect influence on the diagnosis. In the top part of the solution tree are concentrated the main, the major factors. Further for this factors are determined sub-problems, which are influencing them. In the same way are processed the distinguished problems and etc. In the lives of this tree are included factors for which the sub-problems are not determined. For better visibility a fragment of solution tree for infectious diseases of intestinal group forecasting is shown in figure 1.



1 – salmonellosis, 2 – botulism, 3 – hepatite A, 4 – leptospirosis, 5 – typhoid fever, 6 – dysentery.

Figure 1.

Solution tree formation is led to the selection by experts the problems and sub-problems (tops of the tree) and the links between them (tree arcs). Further, the specialists define the importance (probabilities) of transitions between the tops. Indistinct evaluation of the specialists with the help of logical variables is allowed, which are described by the functions of belongings (vectors of actual numbers from 0 to 1). Each expert is giving three assessments –

optimistic, realistic and pessimistic scalarisation of which occurs while taking into account the psychological type of expert.

The tree is constructed on the basis of experts' collective evaluations with the usage of paired comparisons method. Algebraic methods of experts' information processing are used for the formation of an "effective" tree.

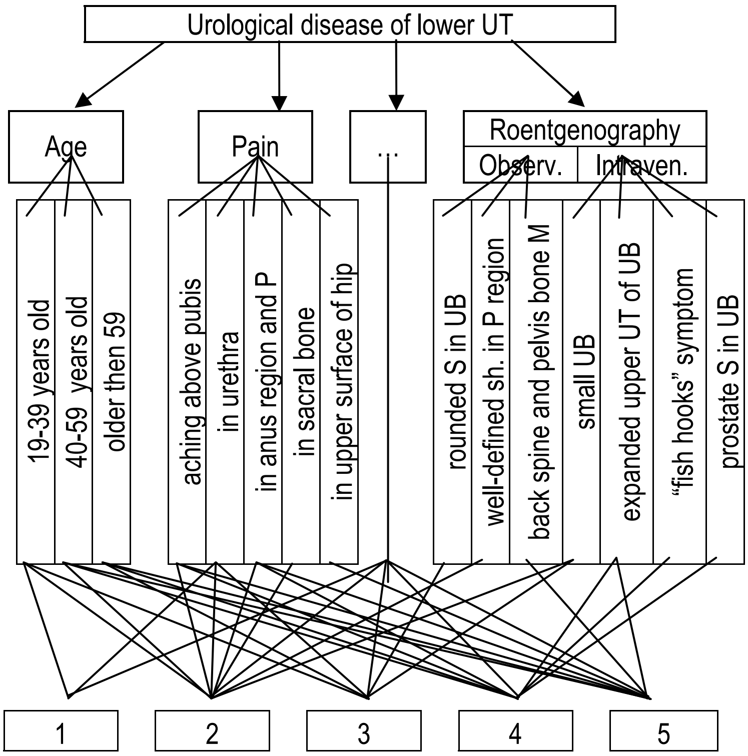
The algorithm of consecutive analysis of variants is used for the determination of optimal ways in solution trees that allows elaborating trees with thousands of peaks [Voloshin, Panchenko, 2001].

The tree of solutions is set by tables. Each table – is a separate level of the tree, each line of the table - is a separate peak\top on this level. Each element of the line is the probability of the transition from the given peak to the top of the upper level. These probabilities are set by the functions of attribute. The tables are filled in by experts questioning.

In expert way are set the matrixes – the result of tops variants' comparison, which can be inserted in the tree. On the basis of matrixes analysis are defined the tops which are included into the tree, and probabilities from which is possible the transfer into them from the peaks of the upper level.

On figure 2 is depicted a diagnostic tree of lower urinary tracts (UT) urological disease.

Note: UT – urinary tracts; P – perineum; UB – urinary bladder; M – metastases; S - shadows



1 – urethritis, 2 – prostatitis, 3 – UB stones, 4 – prostate adenoma, 5 – prostate cancer.

Figure 2.

The solution tree is examined as a graph (fig.3), a matrix of graph's tops incidence is formed, which contain the information about the weight of each top of the solution tree.

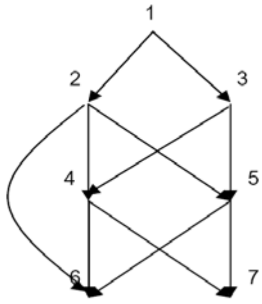


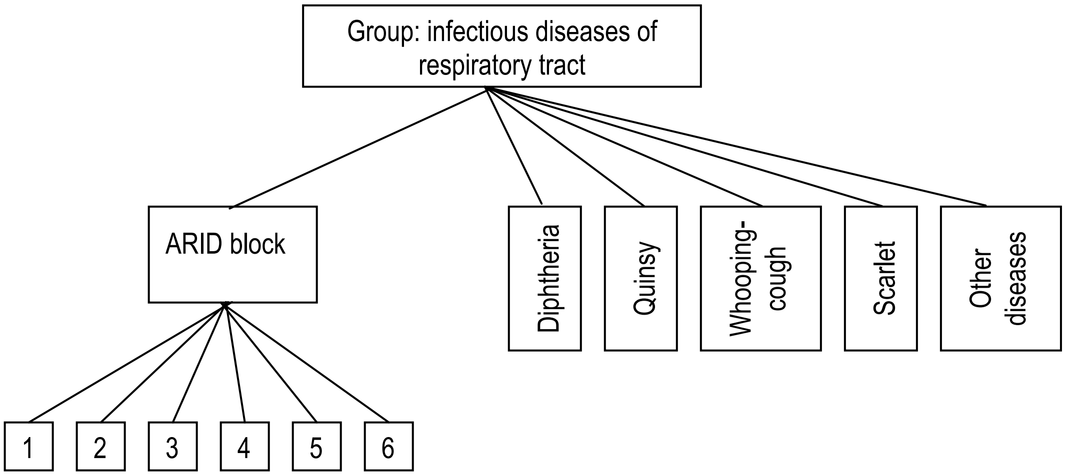
Figure 3.

System Description

At the time of decision making (diagnosing) doctor's task is to elaborate huge amount of data in a short term what is one of the components of successful diagnosing and as a result, successful medical treatment.

The solution tree in diagnosing of infectious diseases, unlike the cases observed earlier [Voloshin, Holovnya, 2005], has a multilevel structure. It is connected with the fact that the infectious diseases are divided into groups, the groups contain diseases, but some diseases make up units.

Infectious diseases are divided into five groups: intestinal infectious diseases, infectious diseases of respiratory tract, blood (transmissible) infectious diseases, infectious diseases of external tegument and infectious diseases with the parental mechanism of transmission (injection). The groups contain diagnoses, but some of the diagnoses are joined in units on the bases of symptoms similarity, extension methods and similarity of clinical presentations. For example, the unit of ARID (acute respiratory infectious diseases) contains such diseases as: influenza, parainfluenza, adenovirus disease, rhinovirus disease, respiratory syncytial disease, rheovirus disease (fig.4). For each group is formed a corresponding solution tree, the main solution tree consists of several sub-trees.



1 - influenza, 2 - parainfluenza, 3 - adenovirus disease, 4 - rhinovirus disease, 5 - respiratory syncytial disease, 6 - rheovirus disease.

Figure 4.

As it is known, a doctor in the process of diagnosis at 90% and sometimes at 100% is depending on the results of laboratory research.

Modern technological progress and scientific achievements permit with the help of laboratory research to define the photogene and the disease itself at 100%. But the doctor meets the problem - to prescribe a corresponding laboratory research. For this he needs to analyze the symptoms, which were found during the examination, and the patient's complaints concerning his or her health. That is why in a solution tree of is given a sub-tree where are defined the prescriptions of needed laboratory research.

A doctor has to be as well a psychologist in order to get more exact information, which is received, from the patient in the form of complaints. He has to define the patient's psychological type, for example, the truthfulness and the volume of complaints on his or her health.

System's Working Algorithm

First of all a doctor has to determine the method of laboratory research, the results of which are brought into the system, is defined the significance of each symptom. The program is analyzing the tree of decisions, which was created to define the methods of laboratory research and withdraw the results. After the analyses of the obtained results, into the system is put the data with new sign of significance and selection criterion. The selection criterion in this case is the pathogen itself which determines the group of infectious diseases and which is peculiar if not one, then several diseases of the same group and block. The given criterion insures the decrease in waste of time by reducing the scale of search. The system is analyzing the solution tree of the given group, which is indicated in the criterion of selection, and withdraw the results. If the result is a block (see fig.4), then the system continues its work while analyzing only this block from the very beginning. But other choices are possible as well, when the data belongs to different groups then the system is analyzing the corresponding tree on the bases of one group's data, after this – the data that belongs to another group. The main algorithm of the system's work is shown on figure 5.

Variants Elimination Method

Whether in this case a great number of possible choices are comparatively not big, then the required result the system may achieve by means of direct surplus. But with the increase of variants' number this possibility is practically disappearing even if the PC is used.

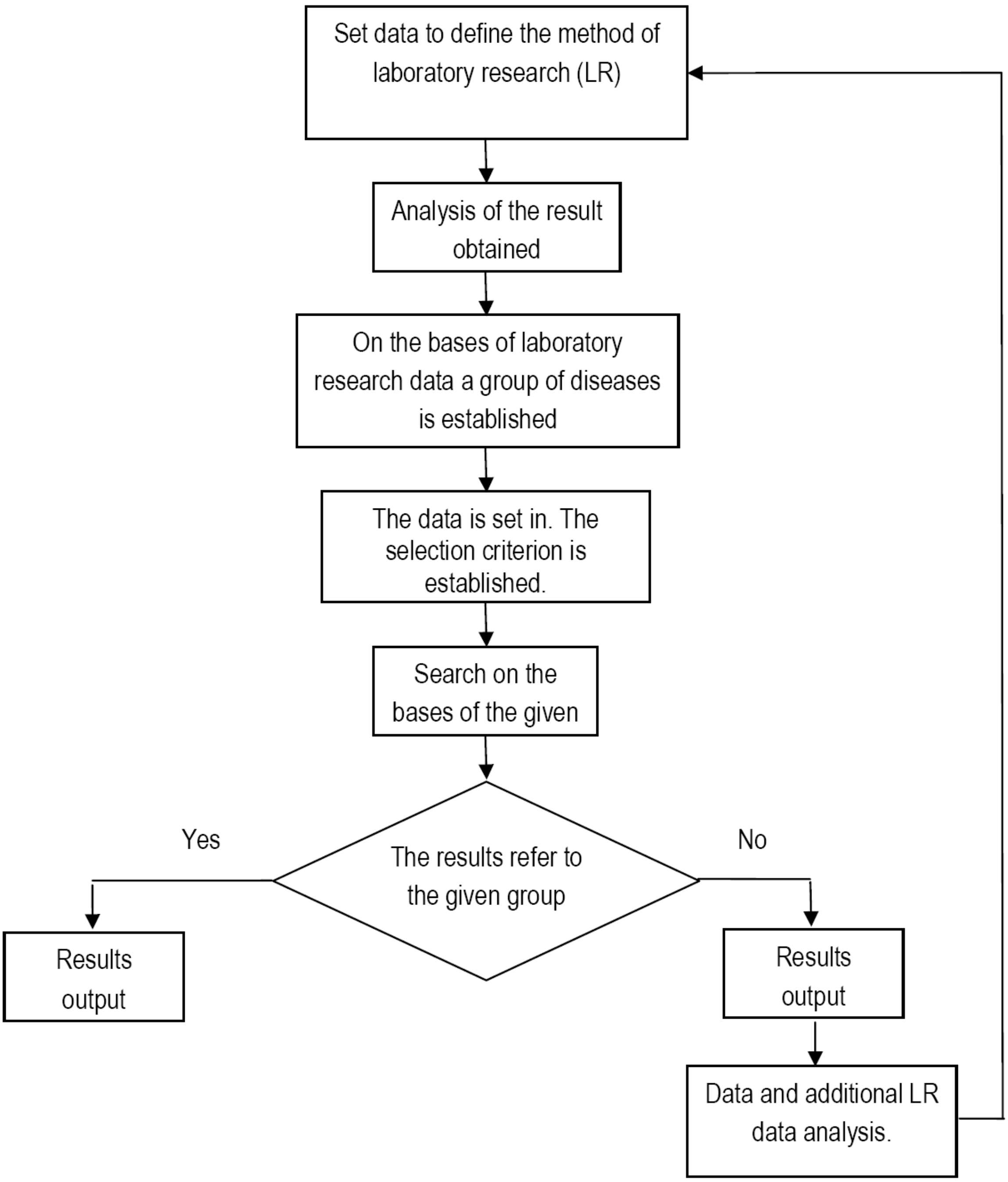


Figure 5.

Thus, arises the necessity of general methods of purposeful excess usage, which allow generating the required data during acceptable time. One of the approaches is the method of sequential variants analyses. At the heart of this method is placed the idea of the decision process presentation as a multistage structure. Each stage is connected with the examination of this or that characteristics variants subset (or separate variants) presence and leads either to the immediate shortening of the choices initial quantity, or prepare the possibility of such shortening in future. On the bases of theoretical and practical analysis of the given problem is necessary to formalize the distinctive features which are to be possessed by the required variant. Then is important to discover as far as possible more indicators which allow to determine that the given choice is not the looked for. Among these indicators are chosen the easiest tested ones and peculiar to the biggest number of variants simultaneously. After this the selection of the numerical scheme of decision lies in assignment of efficient procedure of signs examination that allows to sift out the noncompetitive variants and to find the optimum one.

From the point of view of formal logic the scheme of variants sequential analysis is reduced to the review of the following operations sequence:

- fragmentation of a quantity task solution variants on family of sub-quantities each of which possesses additional specific characteristics;
- usage of these specific characteristics for the search of logical antagonisms at description of single subsets;
- exclusion of the further variants subsets examination, in the description of which are given logical antagonisms.

At the same time the system of sequential analysis of construction and elimination of variants lies in such variants formation and operators of their analysis selection which allow to eliminate the unpromising parts of the variants without their complete construction – in proportion as this lack of any prospect is possible to detect. Since by elimination of unpromising parts of the variants simultaneously is eliminated a great number of its continuations, a considerable economy in computational procedure is taking place which is more important the more specific features of the task are used for the creation of operators of analysis and elimination [Pospelov, 1980], [Moiseev,1971].

At the beginning, the main rule of elimination of the unpromising variants was the principle of monotonous recursiveness, which is cognate to the criterion of optimal dynamic programming [Bellman, 1960]. On the basis of this principle algorithms of step-type variants construction were created for different tasks solution of discrete optimization [Mikhalevich, Shkurba, 1966].

Along with the known values the algorithms of step-type solutions construction possesses as well certain disadvantages. Thus, they, as a rule, make great demands from the on-line storage of PC and determine, with the number growth of task limitation, the drastic increase of calculating work volume for optimizing. These facts are confirmed by computing experiments as well by theoretical estimate.

At the same time the very procedure of sequential variants analysis allows to create common schemes of discrete optimization tasks solution, which differs from the dynamic ones (i.e. based on step-type decisions construction). The refusal from the idea of step-type decisions construction at tasks solution with the method of sequential analysis and variants elimination leads to the necessity of organizing the sub-variants analysis procedure. Thereby disappears the necessity to choose the “principles” of partial decisions development and is eliminated the “dissymmetry” in analysis of decision component. As well is eliminated the need to remember all the time a quantity of “not dominating” partial decisions that are developed at the next step [Volkovich, Voloshin,1984].

At the heart of sub-trees analysis methods into the system is placed the described above decomposition method of alternative variants retrieval [Voloshin, 1987].

Conclusion

The authors do not know the usage facts of the current achievements in the theory of decision-making in medicine, though for their usages in other fields, first of all in economics, over the last years were given two Nobel Prizes.

While implementing the idea of “object – action manner – subject” interaction [Voloshin,2006] is advisable to consider the diagnosis establishment task as a task of collective decision making [Voloshin, Vaschenko, 2006] in whish the “efficient” agents are - “patient – expert diagnostic system – doctor”. It is advisable in some cases, obviously, to enlarge the number of agents, e.g. of “pharmacist” (purposes his or her aims, frequently antagonistic for the patient). And here are possible completely other “optimizing principles”, that differ from “utility maximization taking into consideration the probabilities” [Rassel, 2006].

It is not excluded that the compromise in “life” is achieved as realization of “Nash’s optimization principles” [Voloshin, Maschenko, 2006] – a solution is chosen (consciously or unconsciously), from which it is disadvantageous to deviate both for all agents together, as well as for each separately.

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