Methods and Algorithms for Solution of Problem of Diagnostic Information Gathering

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Аннотация—This work is devoted to the analysis of methods and algorithms of the solution of a problem of Diagnostic Information Gathering. The general properties of information being processed by the methods and algorithms are revealed. Structured analysis of the methods is submitted in uniform designations.

Keywords—intelligent activity, knowledge base, problem solver, solving method, algorithm, operations.

I. Introduction

Automatization of an intelligent daily activities means support of the intelligent and other tasks solved by specialists. Analysts aim to reveal in daily activities and domain those intelligent subtasks, for which solving methods are known.

An intelligent activity being automated is often related to the solution of a task of management (of control) in widespread understanding - support of a certain mode of functioning of difficult system. Such the support is often covers interpretation, the forecast, planning, modeling, optimization of decisions, monitoring [1]. So in medicine the problem of management of health of the patient is being solved. It is the complex problem similar to management problem "in general which includes several known tasks: diagnostics, treatment, forecast of change of patient state, observation (monitoring).

During the decades of AI techniques a number of methods and algorithms of solving such problems are suggested - both specific and universal. Their analysis shows existence in algorithms of the solution of similar operations (search and comparison of information, designing of fragments of decisions). There are differences depending on number of types of relations in the used model of knowledge, from used heuristics, from the factors influencing hypothesis (solution).

However the methods of heuristic search are presented and classified in literature at too abstract level (Depth-First Branch-And-Bound, Recursive Best-First Search, etc.), and at the detailed level are presented for specific tasks in concrete subject domains. This makes it impossible to develop and accumulate of software solutions (components) for use in constructing systems for decision intellectual tasks.

Therefore the structured analysis of methods and algorithms for decision of practically useful intelligent tasks and identification inside them a reusable operations is issue of the day. And the purpose of this work is to give structure for describing methods and algorithms for their uniform representation and to demonstrate such representation on the example of one practically useful intellectual task.

II. Problem of Diagnostic Information Gathering

Medicine - a typical example of subject domain with a number of complex and responsible tasks of various types, where many expert systems (research prototypes) were created. After patient's Information Gathering the doctor makes decisions on the diagnosis, its treatment and the forecast of change of the patient's state as a result of medical actions. On the basis of this forecast further monitoring is being planned. If results of such observation don't correspond to the forecast, solutions on correction of the diagnosis and/or the plan of treatment are being accepted which changes the forecast, etc

In medicine there are expert systems both for the solution of separate tasks, and for several. As a rule, ES support a problem of diagnostics, offering additional useful hypotheses that it is very important as doctors often "are fond"of a narrow set of hypotheses. The set of hypotheses being expanded by means of ES more likely (ideally – with guarantee) contains the correct hypothesis. To reveal it, the expanded set of hypotheses has to be reduced further by careful analysis of knowledge and selection of symptoms capable for differentiation of hypotheses with guarantee.

In some publications the need of definition what information isn't enough to decide the problem is mentioned.

This task is considered important, at the same time without separating it from a problem of diagnostics, but devoting to it separate steps in decision algorithms such researchers as: Weiss S. M., Kulikowski C.A., Safir A., 1978; Patil R.S., Szolovits P., Scwartz W.B., 1982; Pople, H. E., 1982; Soltan R.A., Rashad M.Z., El-Desouky B., 2013 [2], [3], [4], [5].

Diagnosis consists of two fundamental activities: the generation of one or more differential diagnoses (each for a separate problem area), and the resolution of individual differential diagnoses) [2].

Thus, search of "way"to reduction of a set of hypotheses – a problem of request of additional information for recognition – a separate task in the offered earlier multilevel classification [1]. Its essence follows. If for any situation represented by some results of observations there are more than one hypothesis of the diagnosis (about a class), then it is required to offer additional observation which will allow to reduce a set of hypotheses.

The major components of task of Diagnostic Information Gathering (request of additional information for recognition of diagnosis) can be summarized as follows:

Givens:

- R (system' case findings and characteristics), such that the cardinality of set of hypotheses (HR) for them not less than two.

Goals:

- to find such request (Q) of additional information for results of R that if R' = R plus the answer to this request (AQ), then a new set of hypotheses of HR' has the smaller cardinality than a set of hypotheses of HR.
- KB - knowledge base meeting a condition of separation of classes.

Constraints:

- all assertions of KB are concordent to findings and characteristics;
- R coordinated with domain ontology.

III. The review of the offered methods

Some approaches and methods of the solution of the Diagnostic Information Gathering problem and realization of these methods are described in science literature. In order to make use of the available experience of creation of solvers of this task for programming of problem-oriented solvers (as intelligent systems' components) or domain-oriented software services solving different tasks, it is important to compare the basic data of a task, required result, structure of knowledge model and the scheme of an algorithm.

In our list of representations of methods the methods and algorithms published during the period "1978 - 2014"are analysed [2], [3], [4], [5].

Example of representation of one of methods from this list follows.

A. The name

Differentiate, Confirm and Explore.

B. The authors

Patil R.S., Szolovits P., Scwartz W.B., 1982.

C. The terms

patient, disorder, useful differentiator.

D. Task inputs

1) s_i - the found violation(s) (i.e. a state or internal process);
2) R_Σ - observation results, known manifestations of found violation;
3) $H_{R,KB,\Sigma}$ - a set of hypotheses h_j, which cardinality not less than two.

E. Required result

Q - signs required for differentiation - one $signName_i$ or several $signName_i$ and

their explanation (model of relations of the signs $signName_i$ and found disorders, violations S_i and differentiable diseases $h_j = disease_i$.

F. Structure of knowledge model

$KB = KB^{cause} + KB^{act} + KB^{cntx} + KB^{terap}$ - multivarious relations between various aspects of the reason (usually internal process of a f_{in}) and effect (an external sign f_{ex} or internal process f_{in}), taking into account of context and assumptions.

G. Scheme of an algorithm

Preliminary stage:

(* Check whether all hypotheses (disease-i)

are related with different plans of treatment *)

Cycle for h_j from set H_R:

find $plan_j(inKB^{terap})$ for h_j;

add $plan_j(fromKB^{terap})$ to set of plans;

end-cycle

check uniqueness of elements of a set of plans.

Main algorithm:

(* for each hypothesis *)

Cycle for $h_j fromset H_R$:

$disease_j = h_j$;

(* to find influences of a disease (hypothesis)

on the found disorders *)

construct (by KB^{cause}) chains of relations

from $disease_j$ to s_i:

$\langle f^{in}_{j-i1} = disease_j, f^{in}_{j-i2}, f^{in}_{j-in}, s_i \rangle$

(* for each element - not - a sign in each of such

chains of communications *)

Cycle for f^{in}_{j-i}

(* to find its influences on un-detected external signs *) find (by KB^{cause}) relations

from f^{in}_{j-i} to f^{ex}_u

$(< f^{ex}name_u, f^{ex}value_u >)$,

not coincident with any $r_u \in R_\Sigma$,

(* among undetected external signs *)

Cycle for all couples of f^{ex}_{u1} and f^{ex}_{u2}

(* to find a differentiator *)

If $(f^{ex}Name_{u1} = f^{ex}Name_{u2}$,

but $f^{ex}Value_{u1} <> f^{ex}Value_{u2})$

then

add $f^{ex}Name_{u1}$ to Q

end-cycle

(* to find influences of a hypothesis-disease

on un-detected disorders *)

find (by KB-cause) relations from

f^{in}_{j-i} to s_u, not coincident with any $s_u \in Si$,

(* for each such disorder *)

Cycle for s_u

(* to find its influences on

un-detected external signs *)

find (by KB^{cause}) relations from s_u to f^{ex}_u

$(< f^{ex}name_u, f^{ex}value_u >)$,not

coincident with any r_u from R_Σ;

(* among un-detected external signs *)

Cycle for all couples of $f^{ex}_u 1$ and $f^{ex}_u 2$

(* to find a differentiator *)

If $f^{ex}Name_{u1} = f^{ex} - Name_{u2}$,

but $f^{ex}Value_{u1} <> f^{ex}Value_{u2}$

Then add $signName_{u1}$ to Q

end-cycle

end-cycle

end-cycle

end-cycle

IV. Basic computing operations

The description of known methods in the specified structure allows to reveal numbers of computing operations presumably sufficient for designing of problem solvers of each type – so problem-oriented (for example, diagnostics), as domain-oriented (for example, medical diagnostics), including domain-and-method-oriented (for example, medical diagnostics by the method of Patil).

On basis of analysis of known algorithms the set of the required computing operations operating with information from input data and the stored model of knowledge are revealed. The examples are follows:

construct chains of relations from this disease to disorder sign

(input:

disease,

sign,

KBcauseName;

результат: set of chains);

find not-found manifestations related with the specified internal processes

(input:

f-in-j-i,

observedResults,

KBcauseName;

result: set of f-ex-u);

find among two static manifestations distinction of its values at similarity of its names

(input:

f-ex-u1,

f-ex-u2;

result: boolean);

etc.

The revealed set of computing operations is designed to facilitate designing of reusable problem solvers, and they, in turn to facilitate design or construct of intellectual systems (from ready solvers, actual knowledge bases and user interface). Domain-oriented solvers of tasks can be created from problem-oriented solvers (for example, by «cloning» problem-oriented solvers and carrying out some modification).

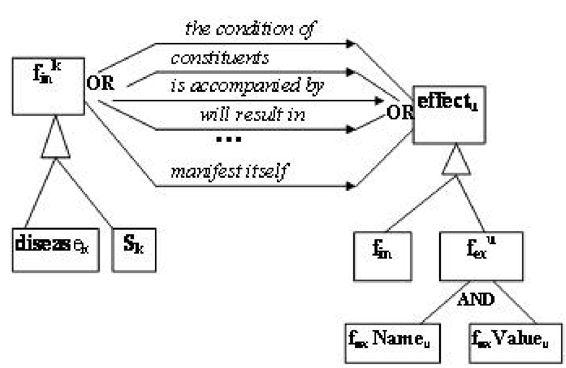

Рис. 1. The semantic network for causal model

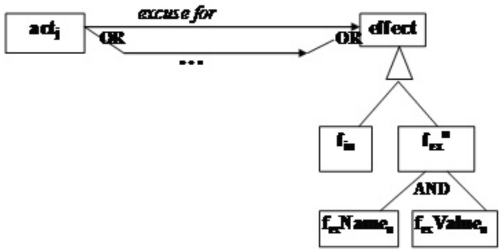

Рис. 2. The model of influence of external impacts on signs or internal processes

Рис. 3. The model of matching of plans of treatment to diseases

V. Discussion

An Using in development of viable intelligent systems of a declarative (not rule-based) KB dictates need of designing reusable components other than inference machine and universal means for explanation. In spite of the fact that long ago distinctions between types of tasks are determined, reusable components for programming solvers at least of some classic tasks aren't offered. The leading collectives have designated as opportune "the researches on development reusable components allowing to perform flexible adjustment on various tasks of one type"[6], meaning "procedural PEAK which are embedded in intelligent application".

Within the conducted research a classification of methods solutions of tasks and their structural description designed to become a basis for development of solvers of tasks of search of hypotheses are proposed: recognitions, a request of the additional information for recognition, forecast, monitoring, linear planning, diagnostics, forecast of result of impacts, planning of management, etc. Such solvers of tasks are problem-oriented and presumably domain-independent (what will be a subject of a further research). The result of such research will mean big or smaller degree of a reusability. An implementations of an operations revealed in the known methods of the tasks solutions become candidates on above-stated "procedural reusable components"

It is expedient to implement the revealed set of computing operations as software agents of IACPaaS platform [7] for reusing during designing cloudy tasks solvers.

VI. Conclusion

The format of representation of results of the analysis of methods and algorithms for the known classes of intellectual tasks is offered. The structure of representation of groups of methods (for one problem task) includes the following parts: problem statements; the uniform designations used for terms; list of representations of methods; the general set of the operations of processing used by different algorithms; a generalized unified model of knowledge necessary for realization of the presented algorithms. The format of representation of methods and algorithms of the solution of tasks includes the following elements: authors (of a method), terms list, an input data of a task, an expected result, a structure of knowledge model; scheme of an algorithm.

In the planned sequence of tasks for which it is necessary to carry out the structured analysis of decision methods (from the point of view of the practical importance) the task of Diagnostic Information Gathering (request of the additional information) became the first. Further tasks will follow: recognitions, diagnostics, monitoring, management planning, forecast of impacts' results.

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