DECISION MAKING IN CONTRADICTORY KNOWLEDGE BASE

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The problem of inference making in contradictory knowledge base is considered. A method is outlined which provides synthesis of a behaviour of the system combining virtual teacher and a disciple.

I. Introduction

Decision making may be performed within a contradictory or incomplete knowledge base.This issue has a practical sense because a total verification of an expert system may be unreachable in the real conditions and may require a lot of computation resources. Meanwhile, making sound inferences in contradictory knowledge systems is often possible which is in the focus of the scientific research [1,2]. The problem has relation to interactive distant learning systems with virtual coach [3]. The role of a virtual coach is realized by an expert system with the knowledge represented by the two types of rules. The first set **R**1 of rules connect the states of the coach with the signals coming from the disciple. The second set **R**2 of formulas represents the scripts which outline possible behaviour of the system as a whole. Our nearest task is to give some necessary details to the matter.The states of the coach include those representing initiation of the learning, active supervising, interruption, prompting, expectation of the answer, verifying the answer, performing test control and data registration in the system journal. The states of the disciple include work with the material, expectation of the help, attempt to find the required information without addressing the coach, performing test or making some kind of a job not connected to the learning process. Because the states of the disciple are unknown to the coach the latter makes and adopts hypotheses about these states stemming from the logic of the educational process encoded in the knowledge base. The coach is simulated by some kind of an automaton which gets the signals from the disciple. The signals are provided by the hidden system procedures integrated into the virtual learning system. For example, some signal may come from the timer controlling the time duration the disciple spends on reading the material. The other signal may come from the sensoring module verifying if the disciple reads the material in the required order or peruses through the text haotically.Also the other signalling subsystem provides notification of the correctness of the disciple's answers to the questions the coach may ask to control how the disciple understands the material.

Essential specificity of the virtual learning system is that there are possible the states of the automaton simulating the coach in which no reasonable continuation is possible. The situation may be explained by the fact that some previously made hypotheses was incorrect and the coach follows in the wrong direction. One of the reasons of this situation is possible contradictoriness or incompleteness of the knowledge base. Contradictoriness of the knowledge base means that it addmits two mutually incompatible facts like those where one means that a disciple performs a chaotic perusing the material and the second means that disiciple performs control test. In this case the behavior of the coach should be corrected. The possible way to correct the bevaviour is to return to some previous state and reconsider possible continuations if there are available ones. This basic idea lies in the background of the current paper. However, it is not sufficient to return to the previously made decisions. It is also required to exclude possibility to repeat erroneous solution. This is quite an interesting question from the theoretical view point. It directs us to the question how to provide correct inferences in the incorrect or contradictory knowledge. There are some possible solutions. The current paper suggests one of them.

II. Problem formulation and its solution

The rules of **R**1 have the form of S_i & $q_j \to S_k$ where S_i and S_k denote the states of the system and q_j means a signal providing transition from state S_i to S_k. For instance, the states are identified as the states of the coach and a signal is identified as one of the possible disciple reactions. The second type of formulas **R**2 is represented by the formulas identified with the scripts of the system behaviour as a whole, e.g. by the formulas like that one $S_i(t)$ & $S_j(t) \to S_m(t{+}1) \vee S_k(t{+}1)$ This formula expresses a fact that if a system consequently passes the states $S_i(t)$ and $S_j(t)$ then it must proceeds from either $S_k(t{+}2)$ or $S_m(t{+}2)$. The script formulas represent possible trajectories of a system behaviour. Finally, one needs in a sequence **L**1 of signals received from disciple and a sequence **L**2 consisting of the states which the coach consequently moved through. It is necessary to note that the signal from the disciple may be partly undefined, incorrect or, as they say, have a fuzzy character. So, the coach should take decisions in the uncertain conditions. With respect to the data items we have input above, the problem is stated as following: given **R**1,**R**2,**L**1,**L**2 and a current signal q. It is required to define a new state of the coach.

In general case, it is supposed that a knowledge system {**R**1,**R**2} may be contradictory or even incomplete. Now let us address to a solution method. Put the values from **L**1 into the system of formulas {**R**1,**R**2} for the corresponding time moments (time changes within the discrete interval [0, 1, 2, ..., i,..., T]). By this one obtains some system $W(\tau)$ of propositional boolean formulas with a time argument. For example, let consider the formula $S_i(t)$ & $q_j(t) \to S_k(t+1)$ Let then there is a signal $q_j(2)$ in **L**1. By putting $q_j(2)$ into the formula one gets $S_i(2) \to S_k(3)$. The example elucidates how a substitution provides formulas transformation. Clearly, $W(\tau)$ connects the formulas from {**R**1,**R**2} for the different time moments (accordingly to the signals $q_{i_1}(0), q_{i_2}(1), q_{i_3}(2), \ldots$ from **L**2). Now it is necessary to find a solution of the system $W(\tau+1)$. Let us try to use the system trajectory, represented in **L**2). This trajectory may be correct or not because the solutions were made at the previous moments 0, 1, 2, ..., τ without guarantee of their correctness. Add the formulas of the state passed from **L**2 into $W(\tau)$. Now we obtained a working system $W'(\tau)$ and we are interested in any valid solution of $W'(\tau)$. We proceed from the fact that $W'(\tau)$ may be inconsistent or incomplete. This fact will be established if it exists by means of the method described in [3]. For the sake of clarity, let $W'(\tau)$ be represented by a set of disjuncts $d_1, d_2, \ldots, d_z$. For each disjunct d_i introduce a boolean variable α_i and replace d_i by $\alpha_i \to d_i$. Let us add one more formula $\alpha_1 \vee \alpha_2 \vee \ldots \vee \alpha_z$. Now let us find a solution of the system obtained. It should be clear that if all the values α_i in solution are units then (1) $W'(\tau)$ is not contradictory and (2) a new state of the coach is obtained in accordance with the "logic"of the system behaviour represented in **L**2. If there are at the least one or more zero values of α_i in the solution obtained then it is still unclear if this is due to the system inconsistency or its incompleteness. According to the method [4] one should add $W'(\tau)$ a new disjunct $A_m = \alpha_{m_1} \vee \alpha_{m_2} \vee \ldots \vee \alpha_{m_k}$, where index m_i corresponds to every $\alpha_{m_i} = 0$ in the current solution. This addition cuts the current solution of $W'(\tau)$ so the new iteration of the method gives another solution (if exists) different from the current one. Now suppose that a contradiction was obtained when solving $W'(\tau)$ at some iteration i. Return to the iteration i-1 with some zero $\alpha_{m_i} = 0$. The solution process reaches by this the final point. First, one can conclude now that the system $W'(\tau)$ is contradictory and secondly,no posterior extension of the system cannot abolish its inconsistency. However, our goal is somewhat different, namely – to discover (if it exists) some maximum-size compatible part of the system which makes it possible to prolong the trajectory represented in **L**2). Denote the disjuncts added to the system by **A**. Find a solution of the system $\{W'(\tau),\mathbf{A}\}$. If it exists it gives some reasonable continuation of the trajectory presented in **L**2. If the solution does not exist then it is necessary to make one more step backward to reconsider the continuation made at the more earlier step and so on. The process may end in the beginning state signalizing that the system knowledge base is bad and provides no possible valid behavior.

The method outlined above gives the possibility to reveal the parts of the knowledge base wich are suspected to be incorrect and should be revised by the experts.

III. Conclusion

The outlined approach may be used in the interactive distant learning systems; in the intelligent interacting distributed agents; in man-machine problem solving systems e.t.c. The first realization of the system has been worked out in [2]. The first version of the system should appear soon. The realization consists of the client and server parts. The client is written as a HTML-document to provide the disciple to open the distant e-handbook. The e-handbook is realized on the basis of the c and javascript languages The system integrates the modules for selecting the subject, content representation and navigation facilities alongside with the intelligent help and supervising modules providing information for decision making. The system provides possibility for a real tutor to interfere the learning process in order to control the process by himself (herself). It is unclear though will the system be self-sufficient or not. The question of this kind was actively discussed in the 70th years of the former century. The answer is still unclear. It is quite difficult to replace a man with some kind of a computer program. However, we see that the distatnt learning moves in this direction, so the necessity in developing man-cimputer educational systems is evident.

IV. References

1. Герман, О.В. Получение выводов в противоречивых системах / О.В. Герман // Кибернетика и системный анализ. – 2005. №5. - С. 29-41.
2. Розоноэр, Л.И. О выявлении противоречий в формальных теориях / Л.И. Розоноэр // Автоматика и телемеханика. – 1980. - №№6,7. – С. 27-33.
3. Гурин, Н.И. Организация структуры электронной обучающей системы с активным контролем приобретаемых знаний./ Н.И. Гурин, О.В. Герман// Труды БГТУ, Серия VI, вып. XVII (физмат. Науки и информатика), Мн., 2009, с.с.107-110.
4. Герман, Ю.О. Машина вывода для противоречивых логических систем: дисс. на соискание степени магистра технических наук. – Минск, БГУИР, 2009 – С.70.