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Knowledge Structurisation by Multi-agent Approach in a Non-formalizable Subject Area of Health and Medicine

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Abstract - Intellectual agents can be applied to simulate interactions inside system of patients and employees of clinic. Interacting finite automata are chosen to represent intellectual agents. Different roles are simulated by different automata. The central role here is the medic. Model of data and behavior of medic in incomplete and partially doubtful system of treatment standards is presented.

Keywords**:** Non-formalizable domains, structuring and transformation of knowledge, probabilistic autonmata.

1. Introduction

Using intellectual agents is a popular approach in artificial intelligence (AI). It is applied to describe and simulate systems of actors efficiently interacting with the environment. S. Russell & P. Norvig (2003) describe the following types of agents.

- Simple reflexive agent (see Skinner B.F. (1953)). An agent chooses its action using the current perception in accordance with the rules "condition to action". The previous history and acts of perception are not taken into account.
- Reflexive agent, based on the model (see Jonsson A. et al.(2000), Muscettola N. et al. (1998)). It monitors the current state of the environment using properties of a model and then uses the rules "condition-action" without explicit consideration of past history. History can have effects implicitly through behavior of the agent in a model;
- Goal oriented agents (see Fikes R.E. et al.(1971), Nilsson N.J. (1984), Genesereth M.R. and Nilsson N.J. (1987), Newell A. (1990)). They are like previous ones, but the model includes a goal to be achieved. The selected action tries to "approximate" this goal;
- Rating oriented agents (see Horvitz E.J. et al. (1988), Pearl J. (1988)). There is a function allowing the agent to find a compromise if some goals cannot be achieved;
- Trained agents (see Buchanan B.G. et al. (1978), Mitchell T.M. (1997), Samuel A.L. (1959), Samuel A.L. (1967)). It contains training component based on the history of actions, successes and failures. It can acquire new knowledge to change its behavior.

We consider here trained agents, according to the specific of the subject. They are interacting and can form a structured knowledge for such non-formalizable domain as "Health and Medicine". They are changing the behavior during participating in the cooperation.

2. A Brief Overview of Intellectual Agents

Intellectual agents or co-operative agents are usually classified according to problem environment in which the agent is looking for a solution.

Autors accept the classification based of S. Russell and P. Norvig (2003) one. The problem solving environment "Diagnostic" is the multi-agent one. We briefly describe this environment and the list of the agents providing a solution of problems arising in the medical environment (see Table 1).

Table 1. Agents used for medical diagnosis

Agent Type	Performance Metrics	Environment	Executive Mechanisms	IO devices
Diagnostic system of a medical specialist (next DSMS)	Successful treatment of the patient, minimizing costs, legal purity	Patient, a medical organization and specialists	Responces to questions, tests, diagnoses, recommendations, directions, reports	Keyboard input and data from other subsystems from specialists, laboratories and diagnostic equipment
Laboratory system	Rapid results, checking for errors in the results, their transfer to DSMS	Patient, a medical organization specialists	Output test results	Laboratory equipment
Medical diagnostic equipment (e.g., EEG, EKG, MRI, etc.)	Rapid results with no error checking, their transfer into DSMS	Patient, a medical organization specialists	Output test results	Diagnostic equipment

3. A Brief Overview of the Model-Based Data Structuring Synthetic Model Representing the Semantics

It was shown in A. Tsvetkov (2011 and 2013) that this subject area can be represented as a set S_{hi}, containing subsets of entities, relationships, and attributes (E_{hi}, R_{hi}, A_{hi}, respectively), included in a superset S_h. Thus

$$S_{hi} = \{E_{hi}, R_{hi}, A_{hi} | \, E_{hi}, R_{hi}, A_{hi} \subset S_h\} \quad (1)$$

S_{hi} can be used to generate another set S_{hi+1}, also included in S_h.

We reduce the general problem how to generate S_{hi+1} to comparing the knowledge contained in S_{hi}, and S_{hi+1}. If for some S_{hi} and S_{hi+1} their intersection $S_{hi} \cap S_{hi+1}$ is not empty we call it "core" of S_{hi+1}. Then to fill S_{hi+1} reduces to generation of the difference between "core" and S_{hi+1}, as shown in (2).

$$C_{hi+1} \setminus S_{hi+1} = \{E_{hi+1}, R_{hi+1}, A_{hi+1} \mid E_{hi+1}, R_{hi+1}, A_{hi+1} \in C_{hi+1} | E_{hi+1}, R_{hi+1}, A_{hi+1} \notin S_{hi+1}\} \quad (2)$$

However, it should be noted that the above approach is valid not only for the formation of new knowledge about the subject area. Non-formalizable subject areas are such that time when formalization is valid is short, and then there is a transfer back to non-formalized state. Iin other words, the subject area knowledge should be re-formalized often. It is necessary to consider the transition from the set S_{hi} to the next version of this set S'_{hi}.

Let us consider the participants of this process in terms of intellectual agents. An agent "medic" in the interaction with the external environment "patient" uses multiple channels of information: visual (examination of the patient), speech (patient survey), olfactory (maybe that comes from the patient's peculiar smell), tactile (feeling of specific parts of the body), acoustic (listening to the patient), a documentary (the study of documents, conclusions analyzes and examinations, etc.). The resulting information is formalized in Russia in the form of text documents. Forms are prescribed by external bureaucratic environment "health care system." An agent "medic" can also interact with other agents involved in the cooperation, and share information with them (see Table 1). Generally, all the information obtained is formalized in the form of text data: the external environment "patient" description, conclusions about the state of patient inferred by the doctor and received from other agents, the choice of the action (usually treatments). For each external media "patient" process of interaction with the agent may have loops until it reaches the ultimate goal: to cure the patient perfectly. Usually it is cyclic (conditionally infinite , limited only by lifetime of the patient) in order to get the best possible optimum state of the environment.

The state of the environment "Patient" is described as a cortege of parameters:

$$P_{Si} = < S_1, S_2, \dots, S_n > \quad (3)$$

P_{S0} corresponds to the patient's condition, "in good health." Any other state indicates morbid state of the environment "patient". Each parameter represents a set of valid values for this parameter and may be associated with other parameters of a function, i.e., changing the value of one of the parameters may lead to changes of other parameters. In essence the agent "medic" examines the values of the expressions (3) and decides which is the state of the environment, as well as what the parameters should be affected and impact on how these parameters change states of others. I.e. the ultimate purpose of an agent "medic" is to grant transferring from a state P_{Si} to P_{S0}.

$$P_{Si} \xrightarrow{F_A(p_i)} P_{S0} \quad (4)$$

Here F_A is an objective function of the agent "medic", leading the environment "patient" from state P_{Si} to the state P_{S0} with a certain probability p_i. The probability p_i may change in the interaction with the environment and other agents, such as "medic".

4. Model Behavior in Non-formalizable Subject Area in Multi-agent Environment

The central role in medical system is the medic. At the same time model of medic is the most complex automaton in our model. Here we describe this automaton.

To simplify our problem almost without loss of generality is to restrict it to common doctor treating patients according to standards of treatment. To represent a creative specialist is beyond possibilities of our models now. Model is a stochastic automaton. Its states are divided into four classes:

0. Is it necessary to provide treatment? If not, work with the patient at the moment ends;

1. Selecting a standard. It is represented initially as a stochastic solution of the medic originated in a priori probabilities. The decision made by a medic and its probability for this medic is dynamically adjusted according to the history of its decisions. It is a very multi-variant choice.

2. Treatment standard. It is a wood of small depth and small width. In the nodes stay data verification and analysis of the patient next inspection.

3. Identify situations where the standard is inadequate. Then the message from a doctor to a medical environment is generated, and the query whether he wishes to send the message. Then process returns to the fork 1.

The process model is shown in Fig. 1

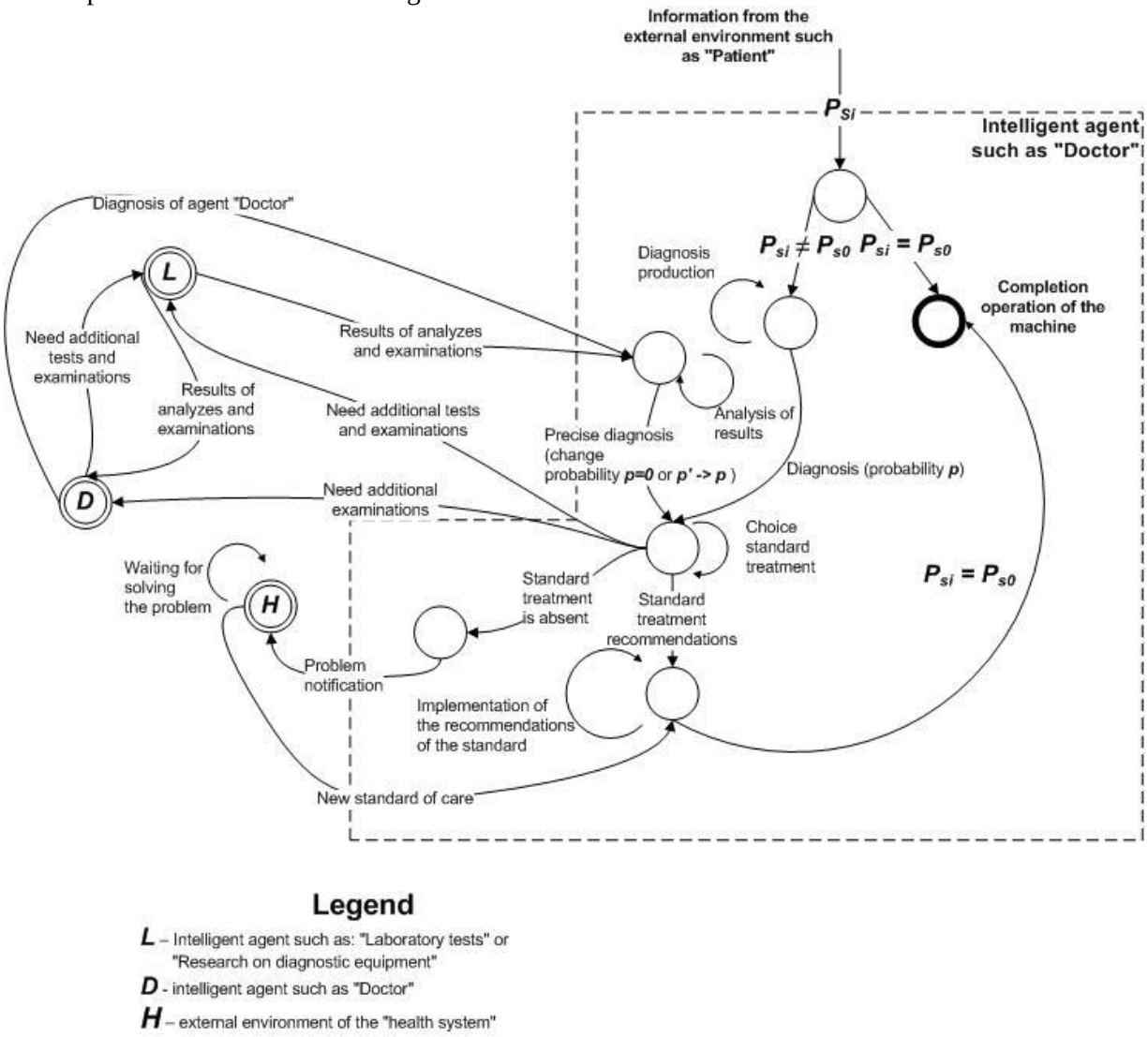

Fig. 1. Stochastic machine simulating the agents "Doctor", "Laboratory tests", "Inspection", as well as interaction with the environment "Patient" and "Public health".

This graph of interactions is used to construct specifications of multi-agent environment as a system of interacting automata and its implementation as a program model.

6. Conclusion

A model of the medic is constructed working in the conditions of notorious incompleteness and of unpredictable change formalizations. Possibility is tested to use this model as a specification in the construction of software interaction model of the patient and the doctor in medical information system .

Our approach is parallel in some aspects and orthogonal in others to say McClimens A., Lewis R. Brewster J. (2012). We simulate patients and doctors not disabled intellectually as person but disabled by necessity to interact with deeply bureaucratized organization of medicine.

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