EXPERT KNOWLEDGE ACQUISITION SYSTEM

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One of the main element of expert systems and decision support systems is the system's knowledge base (KB). In the process formation it is necessary to obtain a large volume of expert information. Usually this information contains the expert's estimation of a number of different situations (states) in the problem field under consideration [1]. The process of expert's knowledge elicitation is labour intensive as far as knowledge engineers and experts are concerned. That is why the development of effective methods for KB construction allowing to decrease the number of situations estimated by experts on the base of certain assumptions about the structure of a problem field is an urgent task.

The task of diagnostic system KB construction can be presented as follows. Let there be an object which can be in different states. Object's state can be described by M attributes. For each attribute m ($m=\overline{1,M}$) a set Q_m of its possible values is given: $Q_m=\{q_{m1},q_{m2},\dots,q_{mn_m}\}$, where q_{mi} is the i-th value of attribute m. $A=Q_1xQ_2x\dots xQ_M$ defines the set of all hypothetically possible object's states: $a_i \in A$ is the i-th object's state, $a_i=(a_{i1}, a_{i2},\dots,a_{iM})$, where $a_{im} \in Q_m$, $m=\overline{1,M}$. Let us mark a set of properties which an object is able to possess as $P=\{P_1,P_2,\dots,P_L\}$. It is necessary on the base of expert's knowledge to build a classification of all possible object's states $A=\bigcup_{l=0}^{L} K_l$ in such a way: state $a_i \in A$ belongs to the class K_l if an object in this state according to the expert's opinion possesses the property P_l. Object's states in which the object does not possess any of the properties under consideration belong to the class K_0.

The hypothesis about different degree of inherence of attribute values to each property is in the basis of the proposed approach [2]. It is supposed that an expert is able to order values of each attribute scale according to the decreasing of values' inherence for each property and that this order does not depend on the values upon other attributes. This hypothesis allows to introduce antireflexive and transitive binary relations of inherence r_l^m for each property l on the set of possible values for attribute m ($l=\overline{1,L}$, $m=\overline{1,M}$): $(q_{ms},q_{mt})\in r_m^l$, if the value q_{ms} is not less inherent for the l-th property than the value q_{mt}. Let us form an antireflexive and transitive binary relation of dominance upon inherence for the l-th property

$$R^l=\left\{(a_s,a_t)\in A\times A \mid \forall m=\overline{1,M} \quad (a_{tm},a_{sm})\bar{\in} r_m^l \quad \text{and} \quad \exists m_0 \quad 1\le m_0\le m \right.$$
$$\left. \text{so that} \quad (a_{sm_0},a_{tm_0})\in r_m^l\right\} ; \qquad l=\overline{1,L} .$$

It is natural to suppose that if an expert marks the presence of some property in some object's state, than the state being described by a set of attributes' values not less inherent for the same property also possesses this property. That is may be put down formally in the following way:

$$\text{if} \quad a_s\in K_l \quad \text{and} \quad (a_t,a_s)\in R^l \quad \text{than} \quad a_t\in K_l \qquad (1)$$

That is why if some object's state is not inherent for some property, then the state less inherent for this property can not possess this property, that is:

$$\text{if} \quad a_s\bar{\in} K_l \quad \text{and} \quad (a_s,a_t)\in R^l \quad \text{than} \quad a_t\bar{\in} K_l \qquad (2)$$

This assumption about possibility to make a conclusion for a number of states without their direct estimation by an expert allows to construct a rational procedure of expert's interview to classify all possible object's states.

In dependence with peculiarities of the task under consideration the requirements to the type of reflexion of a set of object's states into a set of classes may be formulated differently. In accordance with this requirements there may be different presentations of the expert classification task. At first let us consider the task of nominal classification, assuming that on the set of properties there is no any relation. It is nesessary to build up a covering of the initial set of states when in each state an object can possess several properties.

In the process of expert's interview the expert is presented with some object's state and the expert gives a conclusion about classes of inherence for this state (properties which an object possesses in this state). This way the expert classifying the state a_i marks two sets of classes: those of inherence for this state K_i^+ (corresponding to the properties it possesses) and those that this state does not possess K_i^- (corresponding to the properties that the object does not possess).

This information allows to decrease the uncertainty about classes of inherence for object's states in the process of the following two-stage procedure. At the first step for each class of the first set all states dominating the state a_i upon the relation of inherence are determined. For each of them this class is considered to be defined (that is for $K_j \in K_i^+$ if $a_s R^j a_i$ then $a_s \in K_j$). At the second stage for each class of the second set it is possible to determine less inherent states than the estimated one. For these states it is possible to exclude this class from acceptable ones for them (that is for each $K_j \in K_i^-$ if $a_i R^j a_s$ then $a_s \bar{\in} K_j$).

This way classification by an expert of one state allows in an indirect way to define classes of inherence for some other states on the base of introduced binary relations.

Let us consider the task of ordinal classification of object's states. In this task there are antireflexive and transitive binary relations on the set of classes which define order on classes (from the best K^n to the worst K^s). for each attribute it is defined only one binary relation of inherence R_1 and it is assumed that object's state a_i, dominating upon inherence the state a_j can not be put into a less inherent class:

$$\text{if} \quad a_i R_1 a_j \quad \text{and} \quad a_j \in K^s, \quad \text{then} \quad a_j \bar{\in} K^n, \quad n<s \qquad (3)$$

The interpretation of this task presentation may be the following. An object in different state defined by a set of attributes' values is able to possess some property. The degree of its inherence to this property is able to be different in differing object's states. For each attribute values are ordered upon the degree of inherence for the property under consideration. In the desired classification an object in a less inherent for this property state than the other one must not possess this property in a more inherent degree. The use of binary relations allows and in this task of expert classification to decrease uncertainty about other states on the base of the classification of one state [2].

It is possible to formulate a more general task of nominal and ordinal classification. Within such task an object in each of its states is able to possess some of L properties in different degree of inherence. It is necessary on the base of expert's knowledge to build up such a classification of object's states that passes the requirements of nominal classification task and requirements of an ordinal classification task.

The solution of nominal and ordinal classification task can be obtained by consequent implementation of methods for solution of nominal classification task and ordinal classification task. At first the nominal classification task is being solved. Within this stage an expert while classifying the state a_i points out not only corresponding properties but also their degree of inherence in this state. These stages is over when all object's states are classified and so it is known L set of states possessing one and the same property. At the second stage L tasks of ordinal classification are being solved. Within each of them for all states belonging to the l-th class the degree of inherence for the l-th property is defined $(l=\overline{1,L})$. For object's states being classified directly by an expert in the cause of nominal classification task solution degrees of inherence are known. For all other states these degrees are to be determined in the cause of ordinal classification task solution.

In any procedure of expert's interview it is necessary to take into account the possibility of erroneous answers [3,4]. There can be random errors and errors connected with nonconsistency of answers. Errors in an expert classification conclude in violence of conditions (1) and (2) and in violence (3) for ordinal classification task.

The proposed procedure for processing of expert information allows to detect errors in an expert's answers. In fact if an expert puts some object's state into class which has been excluded for it from possible ones on the base of an expert's prevous answers this means that the last answer contradicts with some from the previous ones. To eliminate this contradiction both corresponding answers are presented to the expert for reclassification of corresponding states.

The approach to knowledge base construction described has been used in development of a medical diagnostic system for cardia and some other diseases. Knowledge base was constructed on the base of the described procedure of expert's interview carried out as computerized interactive complex. Interface with an expert is user-friendly: a situation displayed for an expert is analogous to some patient's history. Answers expected from an expert are formulated in a traditional form of diagnostic conclusions. Besides this an expert evaluates the degree of suspision on the disease (in terms "high", "middle", "low"). Also it is possible to answer "situation is contradictory" in the case when the data of attributes under consideration are not able to be presented in one situation.

The developed interactive system for expert knowledge elicitation allows to construct a complete knowledge base for structured problem field. The implementation of binary relation of inherence makes it possible to decrease essentially the duration of expert's interrogatory and also to detect and eliminate errors in expert's answers. According to our opinion the described system for expert knowledge elicitation is sufficiently universal and may be used while constructing knowledge base in different tasks (management, financial, technical) of expert classification.

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