TECHNIQUE TO EVALUATE A COMPREHENSION-BASED INTERFACE FOR MULTIPLE EXPERTS

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Abstract

This paper deals with an interface between expert knowledge and group of experts from whom this knowledge has been acquired and who are going to be users of it. Method is based on deriving the most supported opinion of the group of experts acting as knowledge sources with further applying of it as an interface to each of experts acting as user. Knowledge is acquired using three-valued voting-type knowledge representation (agree, disagree, no-op) of interactions between objects of the domain and the concepts used by experts to describe these objects. During the co-operative knowledge base is being built, the voting-type technique is used to derive peculiarities of each expert to use concepts to describe the domain objects. This paper presents the method of evaluation the similarity between experts which is used later when experts become users of co-operative knowledge. When user is apply to a co-operative knowledge base the evaluation is used to select knowledge acquired from group of the most similar experts to that user. This can be implemented as a system to be used to navigate access of a user to such knowledge which he can interpret in the most accurate way.

1. INTRODUCTION

In practice, one of the following three strategies may be used composing user interface: only opinion of one user is utilized, opinions of multiple users are collected, but only one of them is used one at a time, or opinions are integrated. Research described in [5] deals with the strategy of integrating opinions. They assumed that the acquired knowledge has more validity if it is obtained from the consensus (if existing) across users.

The interesting view to the role of intelligent interface in human society is presented in [2]. They discuss three-level structure of information distribution inside society. They assumed that there is only one knowledge source (brain using the terminology of the paper) in some specific area of knowledge. In their model they assumed that there exists a gatekeeper between users and knowledge source. The gatekeeper does not have any specific area of knowledge only general information. The gatekeeper knows to whom to address each question.

One possible application of the three-level information structure is discussed in [6], that includes telephone operators acting as gatekeepers in [2]. Operators serve as experts in a variety of domains of relevance to their customers' lives, helping them to navigate through the dynamic changes in their customers' worlds. Operators have detailed domain-specific knowledge that includes the computer systems that they use, the business and geographical domains of their customers, and skills in conducting brief but effective conversations. Authors postpone formal, quantitative work, beginning their analyses with qualitative, collaborative approaches. The results of these analyses were conceptually compelling, and guided next steps. Such hybrid model assumed to be an effective bridge between the human-process-oriented world of the operators, and the formal-product-oriented world of the engineers.

In [4], an approach to user adaptation realized in a multiagent interface system for interaction with a virtual environment. Single agents of the interface system adapt to users' individual preferences by learning from direct feedback. The core idea is that agents that were successful in meeting the user's expectations are given credit while unsuccessful agents are "discredited".

The necessity to include user's context in the multiple domain and co-operation among users and experts was discussed in [1, 3]. Too often the work in developing expert systems focuses on the knowledge needed for problem solving, not on the wishes of end users. However, users generally have a high level of in their own domain area.

This paper deals with an interface between expert knowledge and group of experts from whom this knowledge has been acquired and who are going to be users of it. Method is based on deriving the most supported opinion of the group of experts acting as knowledge sources with further applying of it as an interface to each of experts acting as user. Knowledge is acquired using three-valued voting-type knowledge representation (agree, disagree, no-op) of interactions between objects of the domain and the concepts used by experts to describe these objects. During the co-operative knowledge base is being built, the voting-type technique is used to derive peculiarities of each expert to use concepts to describe the domain objects. This paper presents the method of evaluation the similarity between experts which is used later when experts become users of co-operative knowledge. When user is apply to a knowledge base the evaluation is used to select knowledge acquired from group of the most similar experts to that user. This can be implemented as a system to be used to navigate access of a user to such knowledge which he can interpret in the most accurate way.

In the next chapter we present the basic notation used throughout the paper. The next chapter deals with finding the most supported relations among the experts that describes the common comprehension of a future user group. In the next chapter we discuss evaluating similarity between individual experts (we call them "brains") and those ones of them who act as user. Evaluation is made with respect to the common comprehension and interpreted as "brain-user" interface. We end up with conclusions in the last chapter.

2. NOTATIONS

We describe knowledge of a domain as a quadruple $< D, C, S, P >$, where D is the set of domain objects $D_1, D_2, \dots, D_n$; C is the set of concepts $C_1, C_2, \dots, C_m$, used to describe domain attributes, S is the set of users (knowledge sources) $S_1, S_2, \dots, S_r$, who describe domain objects, and P is the semantic predicate that defines relationship between sets D, C, S by the following way:

$$P(D_i, C_j, S_k) = \begin{cases} 1, if\ \ user\ S_k\ \ uses\ concept\ C_j\ to\ describe\ D_i; \\ -1, if\ \ user\ S_k\ \ refuces\ to\ use\ concept\ C_j\ to\ describe\ D_i; \\ 0, if\ \ user\ S_k\ \ does\ not\ \mathrm{exp}ress\ his\ opinion\ \ about\ \ this. \end{cases}$$

3. MOST SUPPORTED RELATIONS

The six binary relations DC, CD, DS, SD, CS, SC are formed using the following formulas:

$$DC_{i,j} = CD_{j,i} = \sum_{k}^{r} P(D_i, C_j, S_k), \forall D_i (D_i \in D) \forall C_j (C_j \in C);$$
$$SC_{k,j} = CS_{j,k} = \sum_{i}^{n} (DC_{i,j} \cdot P(D_i, C_j, S_k)), \forall S_k (S_k \in S) \forall C_j (C_j \in C);$$
$$SD_{k,i} = DS_{i,k} = \sum_{j}^{m} (DC_{i,j} \cdot P(D_i, C_j, S_k)), \forall S_k (S_k \in S) \forall D_i (D_i \in D).$$

The above definition of the value of the relations *DC* sums up the total support to use (or refuse to use) each concept to describe each domain object among all the experts. If, for example, $DC_{i,j} = 5$ then it means that there are 5 similar opinions to use (or refuse to use) the concept C_j to describe object D_i among all the experts. The value of the relation *SC* represents the total support that each expert gets using (or refusing to use) certain concept to describe all the domain objects. If, for example, $SC_{k,j} = 3$ then it means that the expert S_k has used the concept C_j three times in a similar way with some other experts. The value of the relation *SD* represents the total support that each expert gets using (or refusing to use) all the concepts to describe certain domain object. If, for example, $SD_{k,i} = 4$, then it means that the expert S_k has described the object D_i four times in a similar way with some other experts.

3.1. Standardizing Relations

From the definitions presented above it follows that the minimum and maximum values of total support in each relation are:

$$\max_{i,j} DC_{i,j} = \max_{j,i} CD_{j,i} = r; \qquad \min_{i,j} DC_{i,j} = \min_{j,i} CD_{j,i} = -r;$$
$$\max_{k,j} SC_{k,j} = \max_{j,k} CS_{j,k} = n \cdot r; \qquad \min_{k,j} SC_{k,j} = \min_{j,k} CS_{j,k} = n \cdot (2 - r);$$
$$\max_{k,i} SD_{k,i} = \max_{i,k} DS_{i,k} = m \cdot r; \qquad \min_{k,i} SD_{k,i} = \min_{i,k} DS_{i,k} = m \cdot (2 - r).$$

In many situations it is easier to interpret values of total support when they are replaced by the values standardized to the closed interval $[0,1]$. This transformation can be made using the following formulas (notice that we use brackets around the name of the standardized support array to distinguish it from the array with the basic support values):

$$[DC]_{i,j} = [CD]_{j,i} = \frac{DC_{i,j} + r}{2 \cdot r}; \qquad [SC]_{k,j} = [CS]_{j,k} = \frac{SC_{k,j} + n \cdot (r-2)}{2 \cdot n \cdot (r-1)};$$
$$[SD]_{k,i} = [DS]_{i,k} = \frac{SD_{k,i} + m \cdot (r-2)}{2 \cdot m \cdot (r-1)}.$$

3.2. Quality Evaluation

The quality of each knowledge source from the support point of view is calculated using the standardized total support values derived above. For each source S_k, we define quality evaluation value $Q^D(S_k)$ that reflect the quality of the knowledge source to describe the domain objects, and quality evaluation value $Q^C(S_k)$ that describes the quality of the knowledge source to use concepts in description:

$$Q^D(S_k) = \frac{1}{n} \cdot \sum_{i}^{n} [SD]_{k,i}; \qquad Q^C(S_k) = \frac{1}{m} \cdot \sum_{j}^{m} [SC]_{k,j}.$$

It can be easily proofed that: $Q^D(S_k) \equiv Q^C(S_k)$.

4. EVALUATING EXPERTS SIMILARITY

Experts ("brains") and users similarity, concerning concepts and their use to describe domain objects, is evaluated against the most supported comprehension. This evaluation can be done via domain objects or via concepts or via both of them as presented in Figure 1 and can be interpreted as evaluation of "brain-user" interface.

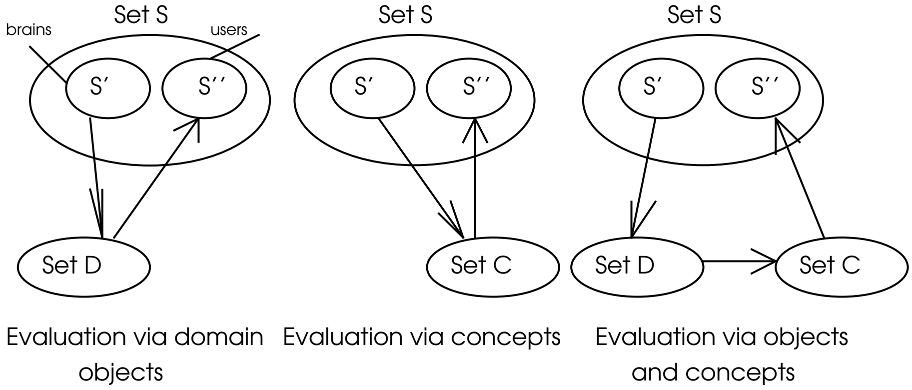

Figure 1. Three types of evaluation

4.1. Evaluation via domain objects

We derive a matrix SS^D as a matrix product of *SD* and *DS* matrices:

$$SS^D = SD \times DS.$$

The values of this matrix in a way measure the support each expert receives from others concerning his description of the domain objects. The user, who has highest sum value of row, is the one whose way to describe domain objects, is most similar to the others. If, for example, $SS^D_{k,q} = 2$ then experts S_k and S_q have two similar opinions in their description of domain objects.

The highest value in each column shows to whom each expert gives the highest support. Thus the expert who corresponds to the line with this highest value is the best one to be used as a reference during interface. Usually with large experts' group it is necessary to use a subgroup of the most similar experts as a reference during interface.

4.2. Evaluation via concepts

We derive a matrix SS^C as a matrix product of *SC* and *CS* matrices:

$$SS^C = SC \times CS.$$

The values of this matrix in a way measure the support each expert receives from all others concerning use of concepts. The expert, who has highest sum value of row, is the one whose way to use concepts is most supported by the others. If, for example, $SS^C_{k,q} = 7$ then experts S_k and S_q have seven similar opinions in their way of using concepts.

4.3. Evaluation via objects and concepts

We derive a matrix SS^{DC} as a matrix product of *SD, DC* and *CS:*

$$SS^{DC} = SD \times DC \times CS.$$

The values of this matrix in a way measure the support each expert receives from all others concerning both domain objects and concepts. The expert, who has highest sum value of matrix row, is the one whose way to use both objects and concepts is most supported by the others. If, for example, $SS^{DC}_{k,q} = 6$ then experts S_k and S_q have six similar opinions in their selection of concepts to describe domain objects.

We suppose three possible types of questions addressed from experts-brains to experts-users:

1) find out domain objects that can be described by certain concept;

2) find out concepts that describe certain domain object;

3) find out value of correspondence between certain domain object and certain concept.

We use SS^D interface to select brain to whom it will be better to address question of the first type from certain user. We use SS^C interface to select brain to whom it will be better to address second type question from a user. We use SS^{DC} interface to select brain to whom it will be better to address question of the third type from certain user.

5. CONCLUSION

The goal of this paper was to present how to evaluate degree of similarity between collaborative knowledge acquired from a group of experts and knowledge taken separately from one expert of this group. The valuation can be used in interfaces connecting multiple expert knowledge base with each of experts. This paper uses an assumption that knowledge about experts similarity is acquired using three-valued voting-type knowledge representation. All experts express their comprehension concerning the use of each concept to describe each domain object. Results of voting are collected in three-dimensional array that is then used to derive the most supported comprehension among the experts. Using this information we evaluated the comprehension of experts against each other with respect to domain objects, concepts, or both. The best match between comprehension of each pair of experts shows who should understand each other in the best way talking about certain domain object or concept. Usually a user can take from a knowledge base only generalized knowledge of multiple experts. However this user has its own comprehension of knowledge he can obtain. The interface is needed to reorganize an answer to user into the most suitable form for his comprehension. The interface selects which expert (or group of experts) knowledge can be used to satisfy users comprehension. The proposed valuation technique is planned to be used to support such interfaces.

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