AN ALGORITHM ON A RELATIONAL KNOWLEDGE MODEL AND ITS APPLICATION

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ABSTRACT : In this paper a knowledge model about relations will be proposed. This model can be used to organize a knowledge base consisting of concepts, relations, and related rules. Some problems on the model are considered. An algorithm for solving the above problems will be improving and be using in a program for solving problems in analytic geometry.

I. RELATIONAL KNOWLEDGE MODEL.

In many fields an important part of knowledge consists of concepts, their relations and rules for reasoning on the concepts. In this part we suggest a model that can be used to represent knowledge about binary relations on some concepts. Each concept is a kind of objects. Between objects there are binary relations. An object can be determined by certain facts representing relationships with another objects, and their determination. For example, in analytic geometry a plane P is determined if there exist a determined nonzero vector n and a determined point M so that M belongs in P and n is perpendicular to P.

A relational knowledge model consists of the following parts:

1. A finite set of concepts $C = \{X_1, X_2, \ldots\}$. Each concept X_i is a kind of objects. The notation X_i is also denoted as the domain of the concept X_i such as the concept "plane" in analytic geometry.

2. A finite set of relations $R = \{ R_1, R_2, \ldots \}$, where each R_m is a kind of relation between two concepts X_i and X_j or is a kind of relation on one concept. For example, the perpendicular relation between a vector and a plane, the parallel relation between a vector and a plane. Relations may have certain properties.

3. A finite set of object-determining rules $D = \{ D_1, D_2, \ldots \}$, where each D_i is a rule can be used to determine an object. Each rule has the form as follows: from facts that u_i is determined and $u_i\ R_i\ u$ $(1 \le i \le k)$, and some certain conditions on objects u_i we can determine the object u. These are an object-determining rules in analytic geometry:

   v: vectors, M:point, d:line;

   $u\ //\ d,\ M \in d \Rightarrow v \perp w$.

4. A finite set of inference rules $I = \{ I_1, I_2, \ldots \}$, where each I_i is a rule that can be used in process of reasoning to solve problems on the knowledge model. There are two kinds of inference rules: (1) rules for deducing a new relation between some objects and (2) rules for deducing a new determined-object that has relationships with a certain object.

Our relational knowledge model can be illustrated in figure 1:

Inference rules
Object-determining rules
Relations
Concepts

Figure 1.

An example of the relational knowledge model is 3-dimensonal analytic geometry. In this field we have main concepts: point, vector, line, plane, etc. Between those concepts there are binary relations: perpendicular relation, parallel relation, etc... For each concept we have some object-determining rules. In knowledge there are also inference rules that can be used to solve problems.

II. SOME PROBLEMS ON RELATIONAL KNOWLEDGE MODEL.

1. Model of general problem.

We consider a general problem consisting of the following sets:

$O = \{O_1, O_2, \ldots, O_n\}$, the set of objects in the problem.

$F = \{r_1, r_2, \ldots, r_n\}$, the set of facts representing some relationships between objects.

$A \subseteq O$, the set consisting of objects that are determined.

G = the goal of the problem, an object or a relationship between objects.

The problem will be denoted as $(O,F,A) \rightarrow G$.

2. Problems from the general problems.

We consider two problems:

(1) Finding out some general algorithms to solve the problem.

(2) Constructing a readable solution for solving naturally the problem.

In the next parts, we propose some methods for solving these problems.

III. RESULTS.

In this part some algorithms theorems will be proposed. These theorems can be used to solve the above problems.

1. The algorithm to determine an object.

step 1. Recording the objects in the problem and the goal of the problem.

step 2. Initializing the solution be empty.

step 3. Recording the facts given (hypothesis):

- Determination of objects.
- Relations between objects.

step 4. Testing the goal. If the goal obtained then goto the reducing step (step 8).

step 5. For each object that is not yet determined, search the object determining rules to test the determination of the object. Objects will be considered by the order: goal object, objects that have relationships with the goal object, and another objects.

If (there exists an object can be determined) then

recording the information about the rule found into the solution, and the new facts or new objects produced by applying the rule. Then goto step 2.

step 6. Searching the inference rules of second type to deduce new determined object that has a relationship with an object which is not determined yet. Objects are considered in a suitable order: goal object first, and second objects that have relationships with the goal object, and another objects.

If (success in finding out the rule) then

recording the information about the rule found into the solution, and the new facts or new objects produced by applying the rule. Then goto step 2.

step 7. Searching the inference rules of first type to deduce new relationship.

If (success in finding out the rule) then

recording the information about the rule found into the solution, and the new facts or new objects produced by applying the rule. Then goto step 2.

step 8. Reducing the solution found.

2. Some theorems.

The following theorems are some results that are related to the above algorithm.

Theorem 1:

(i)The number of new objects that were deduced in the algorithm for determining object is finite.

(ii)The number of new relationships that were deduced in the algorithm for determining object is finite.

The theorem shows that the algorithm is convergent after finite steps.

Theorem 2:

(i) The complexity of searching for object determining rules in step 5 is $O(m^{k.nD}.n_1^k)$.

Where,

k = max(number of relationship-facts in the left-hand side of a rule),

nD = number of object determining rules,

n_1 = number of objects that are determined.

(ii)The complexity of searching for inference rules of second type in step 6 is $O(m^{k.n2}.n_1^k)$.

Where,

n2 = number of objects that are not determined.

(iii)The complexity of searching for inference rules of first type in step 7 is $O(m^{k.n2})$.

The complexity of the algorithm that was estimated by these theorems is $O((m.n)^{k.t})$, where t depends on the number of objects that are not yet determined. This number t is usually small.

3. RELATIONSHIPS BETWEEN OBJECTS.

To determine a relationship between objects, we also have an algorithm. This algorithm and the algorithm to determine an object are similar. Some related theorems are also proved.

4. Improving the algorithms.

The algorithms can be improved by using some methods in artificial intelligence:

- Using heuristics.
- Using patterns.

In program for solving problems in analytic geometry, we propose heuristics rules for improving solution searching process .

IV. APPLICATION EXAMPLE.

Based on the relational knowledge model, we constructed a program for solving problems in analytic geometry. The following are problems that are solved by our algorithms.

Example 1.

Given the points E and F, and the line (d). Suppose E, F, and (d) are determined. (P) is the plane satisfying the relations: E ∈ (P), F ∈ (P), and (d) // (P). Find the general equation of (P).

Solution:

Based on these algorithms, we have a solution consisting of the following steps:

1. E ∈ (P), F ∈ (P) produce a vector u // (P).
2. (d) // (P) produce a vector v // (P).
3. (P) is determined.
4. we have the equation of (P) from the object (P).

Example 2.

Given planes (Q1) and (Q2), and the line (d). Suppose (Q1), (Q2), and (d) are determined. (P) is the plane satisfying the relations: (d) // (P), and (P) passes the intersection of (Q1) and (Q2). Find the general equation of (P).

Solution:

Based on these algorithms, we have a solution consisting of the following steps:

1. (d) // (P) produce a vector v // (P).
2. Produce a line (d') such that: (d') ⊆ (P), (d') ⊆ (Q1), (d') ⊆ (Q2).
3. (d') is determined.
4. produce a point M determined in (P) and a vector v // (P).

5. (P) is determined.
6. we have the equation of (P) from the object (P).

V. CONCLUSIONS.

Relational knowledge model proposed in this paper give us a tool for representing knowledge that can be used to construct a knowledge base for reasoning. A program that is designed and implemented successfully based on the above model. There are many problems are needed to research to develop the relational knowledge model. But we hope that the model will be researched and developed to become a useful tool for designing the knowledge base in knowledgeable systems.

MỘT THUẬT TOÁN TRONG MÔ HÌNH TRI THỨC QUAN HỆ VÀ ỨNG DỤNG

Đỗ Văn Nhơn – Lê Hoài Bắc

TÓM TẮT :Trong bài báo này chúng tôi giới thiệu một mô hình toán học cho tri thức về các quan hệ. Mô hình nầy có thể được sử dụng trong việc tổ chức một cơ sở tri thức bao gồm các khái niệm, các quan hệ, và các luật liên quan. Một vài vấn đề trên mô hình được xem xét cùng với các thuật toán và các định lý để giải quyết vấn đề. Chúng tôi cũng nêu lên áp dụng của mô hình trên trong thiết kế hệ giải toán.

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