Knowledge-Based Systems 23 (2010) 491–495

Contents lists available at ScienceDirect

Knowledge-Based Systems

journal homepage: www.elsevier.com/locate/knosys

Short communication

Answering queries that may have results in the future: A case study in food science

Rallou Thomopoulos [a,d,*], Jean-Rémi Bourguet [a,d], Bernard Cuq [b], Amadou Ndiaye [c]

[a] INRA, UMR1208 IATE, INRA-SupAgro-UM2-CIRAD, F34060 Montpellier, France
[b] SupAgro, UMR1208 IATE, INRA-SupAgro-UM2-CIRAD, F34060 Montpellier, France
[c] INRA, UMR927 USBB, CNRS-INRA-Univ. Bordeaux I, F33405 Talence, France
[d] LIRMM, CNRS-Univ. Montpellier II, F34095 Montpellier, France

ARTICLE INFO

Article history:
Received 27 July 2008
Received in revised form 16 December 2009
Accepted 6 February 2010
Available online 16 February 2010

Keywords:
Knowledge representation
Query answering
Conceptual graphs

ABSTRACT

This paper presents a method to represent the evolution of objects during their life cycle, using a logic- and graph-based knowledge representation model. An extension is proposed in order to answer "*prospective queries*," concerning the achievement, in the future, of the searched piece of knowledge. A case study in the field of cereal transformation illustrates the proposed approach.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

An essential feature that is expected from a knowledge based system is to answer queries, i.e. to be able to determine if a piece of information (the query) can be deduced from the knowledge base. We focus on the two following issues: (i) taking into account the "life cycle" of objects in query answering, by considering queries such as e.g. "can one expect – in the future – a food product that is rich in vitamins ?" (ii) providing an intuitive and easily readable formalism to the end users, who are not computer science specialists. However mostly used knowledge representation formalisms are expressed in first-order logic formulas and difficult to handle for non-specialists. Therefore we are interested in the conceptual graph model, which is currently, in artificial intelligence, the only logic-based model that has an equivalent interpretation in graph theory, i.e. graph representations have interpretations in first-order logic, and graph operations have equivalent logical deductions [1].

The question is thus to introduce, in the conceptual graph model, a way of representing – and reasoning with – information about objects life cycle, that is, to take into account their evolution. This work is the first one to introduce this dimension in the conceptual graph model with respect to the graph/logic equivalence of the model. Existing studies have already shown the interest of this model compared to other available formalisms, in particular in terms of interpretability [2,3], but also concerning soundness and completeness. We thus rely on these works for the comparison with other methods.

Section 2 presents related work and briefly exposes the conceptual graph model. Section 3 gives our contributions concerning the "evolves into" relation and prospective queries. A case study concerning food quality prediction is presented in Section 4. Section 5 proposes some future directions.

2. Background

2.1. Related work

Several studies have dealt with the representation of time, in particular Prior's fundamental work in first-order and hybrid logic [4]. Prior proposes four grades of representation, the first two grades being in first-order logic. The first grade defines tenses entirely in terms of objective instants and an earlier–later relation. The second grade distinguishes a particular instant, the 'Now', as a primitive notion treated as a constant. A proposition p with no explicit temporal reference is not considered as incomplete, but interpreted as $T(Now,p)$ ("p is true now"). Fp, "it will be the case that p", is defined as a short-hand for $T(Now,Fp)$, "there exists some instant t which is later than now, and p is true at t" (and similarly for the past tense, Pp). This second grade is of particular interest here, since it corresponds to the assumption made in a classic knowledge representation model without time dimension (as in the classic conceptual graph model), where a proposition is interpreted as present.

* Corresponding author. Address: IATE Joint Research Unit, INRA-Supagro-UM2-CIRAD, 34060 Montpellier, France.

E-mail addresses: rallou@supagro.inra.fr (R. Thomopoulos), bourgujr@supagro.inra.fr (J.-R. Bourguet), cuq@supagro.inra.fr (B. Cuq), ndiaye@bordeaux.inra.fr (A. Ndiaye).

0950-7051/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.knosys.2010.02.001

In the conceptual graph model, previous work has considered the introduction of temporal features. Delugach [5] extends the conceptual graphs with "demons" that take concepts as inputs, and assert or retract concepts as an output. Mineau [6] extends these proposals by allowing conceptual graphs as inputs and outputs, which is applied in [7]. However our concern here is different since it consists in extending query answering. In ontology research, some studies have dealt with causal and time concept modeling, such as [8]. However the question considered in [8] concerns the temporal granularity of temporal relations, i.e. how long the time intervals in causal relations. These are modeled by time concepts called causal time scales. In this paper, we do not consider time granularity, nor a deep modeling of a time axis, since we describe evolution of an object in terms of simple anteriority/posteriority relations, for query–answering purposes.

2.2. The classic conceptual graph model

The Conceptual Graph (or CG) model [9] is a knowledge representation formalism based on labelled graphs. We use the formalization presented in [1]. The *support* provides the ground vocabulary (the "ontology") used to build the knowledge base: types of concepts, instances, and types of relations linking the concepts. The set of concept types (resp. of relation types) is partially ordered by the "kind of" relation. The *conceptual graphs*, built upon the support, are composed of two kinds of vertices, concept vertices (in rectangles) linked by relation vertices (in ovals). The set of CGs is partially pre-ordered by the *specialization relation* (denoted $\leqslant$), which can be computed by the projection operation (a graph morphism allowing a restriction of the vertex labels). The projection is a ground operation in the CG model since it allows the search for answers, which can be viewed as specializations of a query. The support, the conceptual graphs, and the specialization relation, have a logical interpretation in first-order logic. For instance, the logical interpretation of the conceptual graph represented in Fig. 1, is the following: $\exists x,y,z,w$ (*Durum wheat*$(x) \wedge$ *Processing*$(y) \wedge$ *Protein*$(z) \wedge$ *High content*$(w) \wedge$ *undergoes*$(x,y) \wedge$ *contains*$(x,z) \wedge$ *characterized*(z,w)).

3. Main focus

In this section, we consider the hypothesis that an object may become, during its life cycle, a different object but conserves its properties, which is a first approximation. We propose a query answering method adapted to this assumption, which makes sense in the application case, as a qualitative approach: the properties of the end food products (for instance, nutritional properties such as vitamin content, glycemic index, etc.) depend on the raw material used and on processing conditions. It is thus sensible to consider that, for a given property, a high-quality raw material is more likely to provide a high-quality end product.

3.1. Enrichment of the support with the "evolves into" relation

In addition to the "kind of" relation, we introduce the "evolves into" relation (denoted $\xrightarrow{e}$) ordering the concept type set of the support. Its logical interpretation is based on Prior's second grade.

3.1.1. Logical interpretation

For two concept types C and C' linked by the "evolves into" relation, the associated logical semantics we propose, $\phi(C \xrightarrow{e} C')$, can be formulated as follows (I is the set of individual marker):

$$\phi(C \xrightarrow{e} C') \quad \forall x \in I, C(x) \rightarrow \mathbf{F}C'(x)$$
$$\text{that is :} \quad \forall x \in I, T(t, C(x)) \rightarrow \exists t_1 : t \leqslant t_1 \wedge T(t_1, \mathbf{C}'(x)).$$

E.g. let "Durum wheat" and "Semolina" be two concept types linked by the "evolves into" relation. The associated logical interpretation is the formula:

$$\phi(\text{Durum wheat} \xrightarrow{e} \text{Semolina}) \quad \forall x \in I, \text{Durum wheat}(x) \rightarrow \mathbf{F}\text{Semolina}(x)$$
$$\text{that is :} \quad \forall x \in I, T(t, \text{Durum wheat}(x)) \rightarrow \exists t_1 : t \leqslant t_1 \wedge T(t_1, \text{Semolina}(x)).$$

3.1.2. Properties

3.1.2.1. *Reflexivity*. Given a concept type C, $\phi(C \xrightarrow{e} C)$ is the following:

$$\phi(C \xrightarrow{e} C) \quad \forall x \in I, C(x) \rightarrow \mathbf{F}C(x)$$
$$\text{that is :} \quad \forall x \in I, T(t, C(x)) \rightarrow \exists t_1 : t \leqslant t_1 \wedge T(t_1, C(x)).$$

The reflexivity property is obtained for $t = t_1$.

3.1.2.2. *Transitivity*. Given three concept types C, C′ and C'' such that C evolves into C′ and C′ evolves into C″, we have:

$$\phi(C \xrightarrow{e} C') \quad \forall x \in I, C(x) \rightarrow \mathbf{F}C'(x)$$
$$\text{that is :} \quad \forall x \in I, T(t, C(x)) \rightarrow \exists t_1 : t \leqslant t_1 \wedge T(t_1, C'(x)) \text{ and}$$
$$\phi(C' \xrightarrow{e} C'') \quad \forall x \in I, C'(x) \rightarrow \mathbf{F}C''(x)$$
$$\text{that is :} \quad \forall x \in I, T(t_1, C'(x)) \rightarrow \exists t_2 : t_1 \leqslant t_2 \wedge T(t_2, C''(x))$$

Hence by transitivity of the "$\leqslant$" relation we obtain:

$$\forall x \in I, T(t, C(x)) \rightarrow \exists t_2 : t \leqslant t_2 \wedge T(t_2, C''(x))$$
$$\text{that is :} \quad \forall x \in I, C(x) \rightarrow \mathbf{F}C''(x) \quad \text{i.e.} \quad \phi(C \xrightarrow{e} C'')$$

The transitivity property is thus obtained. The "evolves into" relation being reflexive and transitive, it is a partial preorder on the set of concept types.

3.2. Prospective queries

3.2.1. Scope

A query in the CG model is expressed in the same formalism as a fact, by a conceptual graph. For example, Fig. 2 represents the query: "is there a semolina containing a high content in protein?". It is a classical query, whose answer consists in deciding whether this information can be deduced from the knowledge base. It is evaluated using the projection operation. We are now interested in queries about the possible future occurrence of a given piece of knowledge: can this information be obtained from the knowledge base extended to the "evolves into" relation? We call such queries *prospective queries*. E.g. the conceptual graph of Fig. 2 is then interpreted as the prospective query: "can one expect to obtain a semolina containing a high content in protein?".

Fig. 1. Example of conceptual graph.

Download English Version:

https://daneshyari.com/en/article/402643

Download Persian Version:

https://daneshyari.com/article/402643

Daneshyari.com