Analysis of Semantic Networks By Means of Description Logics

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Abstract

The formalization of heterogeneous semantic networks by means of description logics (DL) is considered in this paper. DL is extended by the addition of some new relations from heterogeneous semantic networks.

1 Introduction

SIMER + MIR [G. S. Osipov, E. P. Kurshev, S. I. Komarov] is a integrated system for knowledge acquisition, knowledge representation and modeling of reasoning, based on heterogeneous semantic networks[Osipov, 1995].

The system decides problems of event recognition and situation analysis in different data domains. SIMER- the part of the system, decides a problem of a construction of knowledge bases, based on acquisitions of knowledges from the expert. MIR- executes simulation of argumentation type reasoning, based on heterogeneous semantic networks.

This technology was applied frequently for creation of applied systems. The logical analysis of this formalism for knowledge representation in SIMER+MIR, therefore is of interest. The present paper describes and studies the above mentioned formalism by means of description logic.

2 Basic concepts of heterogeneous semantic networks.

I am not going to give here much explanation and motivation on the SIMER+MIR system, referring to [G. S. Osipov, E. P. Kurshev, S. I. Komarov]. But to keep this presentation more closed I give brief intuitive description of the kind of the reasoning, modeled by the system and the feature of its semantic network representation. The knowledge representation formalism used by the system SIMER+MIR is heterogeneous semantic networks (HSN) [Osipov, 1995]. HSN, among other things, contains a collection of events, which may hold(accepted) or not at the given state, and binary relations on these. Some events are marked as *facts* , meaning they express empirical (factional) statements. The events of the second kind explicitly marked as *hypotheses* , meaning the possible hypotheses, allowed to be set and discarded during the reasoning process.

The events have a complex structure and can have the properties. The sets of properties are characteristic of an event. A property of an event can be other events or attributes.

For example, to the event "Thunder-storm" we enter the property "Lightning". We can not indicate any dial of values for the property " Lightning " , signifies, this property is the event.

If the event has a property which can vary depending on a situation in certain limits, that have area of defined values, such property is named as attribute. Most of events is characterized by a set of their attributes and ranges of each attribute.

Definitions of relations on the set of events are given in terms of attributes of events. The relations are confirmed by the procedures whose parameters are properties.

To the relations we can compare the following expressions:

R_1 — At observation of an event1 the event2 is always observed. If all attributes of an event2 are attributes of an event1, and all characteristic values of attributes of an event2 are characteristic values of appropriate attributes of an event1.

R_2 — An event2 can be observed or usually observed at observation of an event1. If an event1 and event2 have the common attributes, and these attributes have common for an event1 and event2 characteristic values.

R_3 — An event2 is usually is absent or can be absent at observation of an event1. In other words, the sets of attributes of an event1 and event2 are intersected, but the sets of characteristic values of these attributes are not intersected.

R_4 — At observation of an event1 always there is no event2 In other words, the set of attributes of an event 1 actuates a set of attributes of an event 2, but the sets of characteristic values of these attributes are not intersected.

R_5 — An event1 is a tool of an event2 If one of attributes of an event2 contain the characteristic values with the event1 name.

R_6 — An event1 is in a situation of an event2 If all attributes of an event1 are attributes of an event2, and the sets of characteristic values of attributes of an event1 are subsets of appropriate attributes of an event2.

For example, the events *"Thunder-storm"* and *"Lightning"* are connected by the relation R_1.$("Thunder-storm","Lightning") \in R_1, but$("Lightning","Thunder-storm")$\in R_2$

3 Study of Semantic networks by means of Description Logic

The function of the interpretation, which ensuring one-to-one mapping between DL solution structures and HSN is constructed.

AL –language[Donini F.M., Lenzerini M. Nardi D. Schaerf A.] was used. It is proved, that with the constructed interpretation of simple concepts and roles the individuals interpreted in terms [Osipov, 1995] as events are selected.

Let us set L-concepts as follows:

$$C \doteq \forall P_1.C_1 \sqcap \forall P_2.C_2 \sqcap ... \sqcap \forall P_k.C_k$$

....

$$D \doteq \forall Q_1.D_1 \sqcap \forall Q_2.D_2 \sqcap ... \sqcap \forall Q_n.D_n,$$

where $C_1, C_2, ..., C_k, ...D_1, D_2, ..., D_n...$ — simple concept names. $P_1, P_2, ..., P_n$—rule names.

Then let us define the relations $R_1 - R_6$ over the set of L-concepts as follows:

$(C, D) \in R_1$ if $c \in C^I, d \in D^I \& \forall c(\{D(c)|c \in C^I\} \subseteq D^I)$

$(C, D) \in R_2$ if $c \in C^I, d \in D^I \& \exists c(\{D(c)|c \in C^I\} \subset D^I)$

$(C, D) \in R_3$ if $c \in C^I, d \in D^I \& \exists c \exists d(\{D(c)|c \in C^I\} \subset \{C(d)|d \in D^I\} \& \{C(d)|d \in D^I\} \subset \{D(c)|c \in C^I\})$

$(C, D) \in R_4$ if $c \in C^I, d \in D^I \& \forall c \forall d \exists P_i(c \in \forall P_i.C_i{}^I$
$d \in (\forall Q_j.D_j)^I) \& (P_i = Q_j) \& (C_i \neq D_j)$

$(C, D) \in R_5$ if $c \in C^I, d \in D^I \& \exists d\ (d \in (\forall P^*)^I \& \exists d \in (C^*)^I \& (d = C)$

$(C, D) \in R_6$ if $c \in C^I,\ d \in D^I\ \& \forall c \exists d\ (\{D(c)|c \in$
$\in C^I\} \subseteq D^I) \& (P_i = Q_j) \rightarrow (C_i \neq D_j)$

Interpretation I, mapping by a usual way DL in HSN, is constructed.

Theorem : The interpretation I one-to-one maps DL in HSN.

The relations $R_1 - R_6$ (DL syntactical symbol in this means) supplement connections between concepts. This connections do not depend of the domain (there are the relations of the same level as subsumption is). By this way, the extension of description logics is obtained. Some set of other relations from HSN filled up the base of intensional knowledges. The algorithms for checking whether expressions of a kind $(C, D) \in R_i$ are true in description logics are developed. To make this checking easer concepts C and D are first syntactically compared. For some relations a syntactical comparison of the concepts has proved sufficient.

4 Conclusion

The model obtained is rather complicated and the attempts to simplify it may lead to improving the description logic itself and moreover to improving the reasoning implemented in the system SIMER+MIR. The communication between an algebraic system circumscribing heterogeneous semantic networks and description logics is established. This implies, that heterogeneous semantic networks can play a role of description logic models.

That must be correct and complete model, but this problem completely is investigated yet. There is still a lot to do.

References

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