A Review of Approaches for Representing RCC8 in OWL

Erasmus University Rotterdam

Introduction

Nowadays, it is increasingly important to be able to represent data in a proper, meaningful way. The Semantic Web enables one to find, share, and combine information more easily. Even though one could represent and reason with many types of information, tasks related to **spatial knowledge** remain non-trivial. Despite the fact that spatial features can be stored in ontologies, these representations cannot capture the **semantics** of spatial relations in a reasonable manner, as relations are more complex than features. The need for spatial information modeling on the Web is stressed by the large amount of available unstructured spatial data, which is a promising resource for decision making related to various topics.

The Region Connection Calculus (RCC), and in particular **RCC8**, is a popular method for qualitative spatial or topological representation and reasoning. The RCC spatial relations operate on regions, i.e., subsets that contain the closure of their interior and are based on a single primitive relation: the Connected (**C**) relation. RCC8 relations are Externally Connected (**EC**), Disconnected (**DC**), Partially Overlapping (**PO**), Equal (**EQ**), Tangential Proper Part (**TPP**), Inversed Tangential Proper Part (**TPPi**), Non-Tangential Proper Part (**NTPP**), and Inversed Non-Tangential Proper Part (**NTPPi**). These relations are depicted in Figure 1.

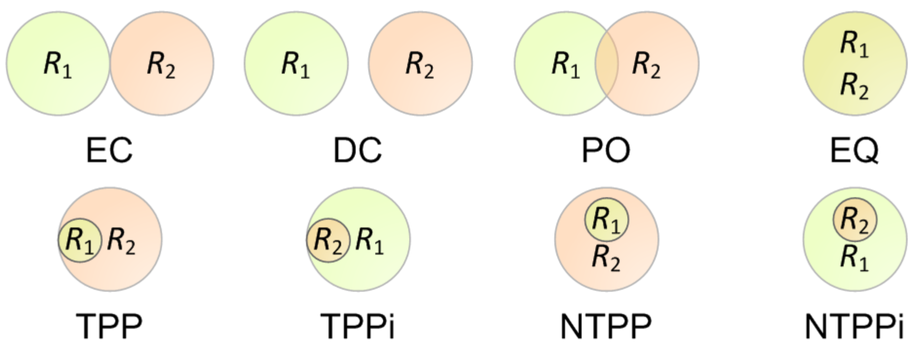

Figure 1: RCC8 Relations

RCC8 is likely to be of use on the Semantic Web. However, several **issues** arise when trying to enable topological spatial reasoning on the Semantic Web using **RCC8** in conjunction with Web Ontology Language (**OWL**).

OWL DL

Representing RCC8 relations between regions R_1 and R_2 in **OWL DL** (based on $\mathcal{SHOIN}$) results in the relations presented in Table 1.

RCC8	OWL
EC(R_1,R_2)	$\forall C.R_1 \sqsubseteq \exists C.\neg R_2$; $R_3 \equiv R_1 \sqcap R_2$
DC(R_1,R_2)	$R_1 \sqsubseteq \neg R_2$
PO(R_1,R_2)	$R_4 \equiv \forall C.R_1 \sqcap \forall C.R_2$; $R_5 \equiv R_1 \sqcap \neg R_2$; $R_6 \equiv \neg R_1 \sqcap R_2$
EQ(R_1,R_2)	$R_1 \equiv R_2$
TPP(R_1,R_2)	$R_1 \sqsubseteq R_2$; $R_7 \equiv R_1 \sqcap \exists C.\neg R_2$
TPPi(R_1,R_2)	$R_2 \sqsubseteq R_1$; $R_8 \equiv R_2 \sqcap \exists C.\neg R_1$
NTPP(R_1,R_2)	$R_1 \sqsubseteq \forall C.R_2$
NTPPi(R_1,R_2)	$R_2 \sqsubseteq \forall C.R_1$

Table 1: Representing RCC8 in OWL

There are several **problems** related to this representation. For instance, RCC8 relations need to be used at **ABox** (data) and not at **TBox** (abstract) level (regions are best viewed as instances, not classes). Furthermore, OWL DL offers no support for the **role reflexivity** that is required for the implementation of relation C.

OWL 2

The previously mentioned issues are accounted for in **OWL 2** (based on $\mathcal{SROIQ}$). Here, **reflexivity** is supported. To circumvent definition problems at ABox and TBox level, an **RCCBox** (similar to the role box in $\mathcal{SROIQ}$), in which the RCC relations and composition tables are specified, is proposed in literature.

However, there still are **problems** related to composition tables in OWL. The equivalents given by the composition tables or RCC8 relation definitions are in fact double inclusions between the left hand side and the right hand side. For instance, **complex role inclusion axioms** (in the form of $S \circ T \sqsubseteq R_1 \sqcup ... \sqcup R_n$, e.g., EC $\circ$ NTPP $\sqsubseteq$ PO $\sqcup$ TPP $\sqcup$ NTPP) are required in order to be able to construct the composition table of RCC8. These axioms are currently not supported in OWL 2. Also, there is still a need for **composition** on the right hand side of the role inclusion axioms (in the form of $R_1 \sqcup ... \sqcup R_n \sqsupseteq S \circ T$, e.g., PO $\sqcup$ TPP $\sqcup$ NTPP $\sqsupseteq$ EC $\circ$ NTPP).

Conclusions

Several issues arise when representing RCC8 relations in OWL, while maintaining decidability. OWL DL lacks required features such as role reflexivity and role inclusion axioms. OWL 2 includes some of these features, but still lacks complex role inclusion axioms.

Frederik Hogenboom
fhogenboom@ese.eur.nl
Flavius Frasincar
frasincar@ese.eur.nl
Uzay Kaymak
u.kaymak@ieee.org

Econometric Institute
Erasmus School of Economics
Erasmus University Rotterdam
PO Box 1738, NL-3000 DR
Rotterdam, the Netherlands
http://www.eur.nl/english/

ERASMUS UNIVERSITEIT ROTTERDAM