DL based automated consistency checking of spatial relationships

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RÉSUMÉ. Les contraintes d’intégrité spatiales permettent de spécifier les relations autorisées entre des objets spatiaux des bases de données. Dans ce contexte, il est nécessaire de vérifier la cohérence d’un jeu de relations spatiales. Ce contrôle permet de détecter si des relations spatiales spécifiées dans les contraintes d’intégrité par des utilisateurs sont incompatibles. Cet article propose une nouvelle méthode de détection d’incohérences spatiales basée sur des traductions en Logiques de Description (LD) des relations RCC8 entre objets spatiaux. Nous proposons d’utiliser un moteur d’inférence LD traditionnel pour vérifier la cohérence d’un ensemble de relations RCC8. Les traductions LD proposées dans cet article pourront être étendues pour vérifier la cohérence entre des types évolutés d’objets spatiaux (les régions composites, les régions complexes, etc).

ABSTRACT. In using integrity constraints, one can specify the relations allowed between spatial objects of databases. In this context, the control of the consistency of a set of spatial relations is an interesting issue. This control aims at checking if all the spatial relations specified in integrity constraints by users are compatible. In this paper, we propose a new method based on Description Logics (DL) to identify inconsistencies in RCC8 relations. We propose to use traditional DIG reasoners to reach this goal. The DL specifications proposed in this paper can be extended in order to allow checking consistency between different types of spatial objects (composite regions, complex regions, etc.).

MOTS-CLÉS : contrainte d’intégrité, relations spatiales, RCC8, Logiques de Description, moteur d’inférence spatial

KEYWORDS: integrity constraints, spatial relations, RCC8, Description Logics, spatial reasoner
1. Introduction

The formalization of spatial relationships is an active research field. Numerous researchers are interested in the identification of a pertinent set of qualitative spatial relationships. These relations model the possible configurations between spatial objects. For example, the method called RCC8 (Region Connection Calculus) models 8 qualitative spatial relations between two regions [RAN 92]. Let \( X, Y \) be two simple regions i.e., two non-empty regular subsets of some topological spaces. These two regions are represented in Figure 1 by closed connected point set without hole in a 2-dimensional space. The 8 possible relations proposed by RCC8 are defined as follow :

1) DC Disconnected : \( X \) is disconnected from \( Y = DC(X, Y) \)
2) EC Externally Connected : \( X \) is externally connected from \( Y = EC(X, Y) \)
3) EQ Equal : \( X \) is equal to \( Y = EQ(X, Y) \)
4) PO Partially Overlapping : \( X \) is partially overlapping \( Y = PO(X, Y) \)
5) TPP Tangential Proper Part : \( X \) is a tangential proper part of \( Y = TPP(X, Y) \)
6) TPPi Tangential Proper Part Inverse : \( X \) is a tangential proper part inverse of \( Y = TPPi(X, Y) \)
7) NTPP Non-Tangential Proper Part : \( X \) a non-tangential proper part of \( Y = NTPP(X, Y) \)
8) NTPPi Non-Tangential Proper Part inverse : \( X \) is non-tangential proper part inverse of \( Y = NTPPi(X, Y) \)

![Figure 1. A graphical representation of the RCC8 relations](image)

Notice that all these relations are mutually exclusive, that is to say between two regions only one RCC8 relation is applicable.

In parallel of the spatial relationships formalization, an important research field concerns the modelling of spatial integrity constraints in databases ([COC 97] [COC 98] [COC 01] [COC 04] [SER 00]). These constraints are expressed by a set of relations between spatial objects defined by users. These relations are supposed to be satisfied
by the data. If it is not the case, the data are considered as inconsistent and should be detected thanks to data consistency checking mechanisms. At present, some tools allow producing data consistency checking mechanisms from specifications of integrity constraints based on RCC8 relations. For instance, SQL code (queries or triggers) can be produced from a specification of spatial constraints [PIN 07]. This code can be used to check if a database verifies constraints or to forbid inserting data that do not verify them. Figure 2 sums up this approach. Figure 3 shows an example of spatial data that complies with the integrity constraints defined in Figure 2.

**Figure 2. Data consistency checking**

**Figure 3. A spatial configuration that complies with the integrity constraints defined in Figure 2**

In addition to the data consistency checking, the control of the specification consistency of a set of spatial integrity constraints is a complementary issue. This control aims at checking if all the spatial integrity constraints specified by users are compatible and consistent. For instance, suppose that user adds the relation EC(object3, object5) to the list of spatial integrity constraints presented in Figure 2. This new relation
leads to an inconsistency because NTPP(object3, object4) and DC(object4, object5). Thus, if the spatial integrity constraints are inconsistent, none data can fulfill these constraints. Other examples of relations that are incompatible with the set of relations presented in Figure 2 are:

- DC (object2, object4) because EC (object2, object3) and NTPP (object3, object4)
- EC (object1, object3) because NTPP (object1, object2) and EC (object2, object3)

In [STO 98], an operational method is proposed to help users to specify a consistent set of RCC8 relations. This method provides an algorithm that allows deducing all the possible relations from a finite set of relations specified by a user. This can be easily used to control the consistency of the relations. Only the RCC8 relations between 2 simple regions are considered in this method.

In the present paper, we propose an alternative method based on Description Logics (DL) to detect inconsistency in a set of RCC8 relations between simple regions. We introduce DL specifications of RCC8 relations (Figure 1). This method enables using traditional DIG reasoners (e.g., Pellet or Fact++) to check the consistency of relations. The proposed DL specifications could be extended in order to allow checking consistency between different types of spatial objects (composite regions, complex regions, etc.). This constitutes the main advantage of our approach. These extensions could be based on the DL translation techniques presented in this paper. In our opinion, the DL modelling of RCC8 relations opens a new and promising research field.

Representations of RCC8 relations between two spatial regions have been already proposed in Modal Logics [NUT 99] and DL [KAT 05]. Unfortunately, several errors occur in these representations. We highlight these limits in the present paper and we present correct translations of the RCC8 relations in DL.

The paper is organized as follow. Section 2 presents related works. Sections 3 introduces our proposal i.e., our translations of RCC8 relations in DL. Section 4 describes our prototype and a set of experiments.

2. Related works

There exist several logical languages for reasoning over qualitative/symbolic spatial relations. For example, the first workshop on temporal and spatial reasoning at the IJCAI conference was held in France in 1993 [GUE 98]. We do not intend to describe all of them, we just highlight the languages and tools that we thought to be most promising. [HAA 98] present a new Description Logic (DL) called $ALC_{RP}(D)$ to combine thematic reasoning (the usual DL reasoning) and spatial reasoning. This approach is based on concrete domain that will define predicate for representing spatial relations over polygon. At that time, we do not know any reasoner available for free to implement directly this logic. [MIR 07a] [MIR 07b] propose a knowledge representation language based on object called AROM and its extension AROM-ST,
AROM-ONTO. AROM languages are implemented in a tool called ONTOAST. Indeed ONTOAST proposes a quantitative reasoning. The authors argue that AROM languages and associated tools are a complement to a qualitative spatial reasoning. [GRÜ 08] use OWL axioms to simulate RCC5 topological relations. The goal of this work is to approximate possible part-of relations and not to determine exactly which spatial objects are linked with a part-of relation. Thus the result obtains by [GRÜ 08] can not be used to check consistency in integrity constraints.

The authors of [STO 09] propose a new reasoner tool called Spatial Pellet. Spatial Pellet contains a separate RCC8 reasoner in order to provide spatial inference engine. This RCC8 reasoner is based on RCC8 composition table and uses a specific path consistency algorithm. It can be used to check the consistency of a set of spatial relations. Unfortunately, this tool does not provide information about the spatial objects responsible for inconsistencies. The outputs of Spatial Pellet indicate if a spatial configuration is inconsistent or not, but the list of inconsistent spatial relations (or objects) is not provided. Moreover, Spatial Pellet is based on a specific extension of traditional DL. This extension is not supported natively by traditional DIG reasoners and by tools such as Protégé.

The works of [NUT 99] propose a translation of RCC8 relations in Modal Logic. Based on this work, the authors of [KAT 05] propose a translation of the RCC8 relations in OWL-DL axioms (with SHOIN(D)). The RCC8 relations are translated into a list of axioms where a spatial region is represented by a class. This translation contains errors. We notice that the translation of the RCC8 relations do not keep the property to be mutually exclusive. We made an experiment using the translations proposed by [KAT 05] to check that if two RCC8 relations between two regions are defined, then a DL reasoner should find inconsistencies. Over 15 combinations of two RCC8 relations, we found that 6 combinations do not raise inconsistency using the Fact++ reasoner. Our work is based on the correction of the [KAT 05] translations.

Because DL reasoners are no more prototypes but have achieved the state of final products, our goal is to reuse a DL reasoner for reasoning over RCC8 relations. Moreover, this approach enables identifying precisely which subsets of relations constitute a source of inconsistency.

### 3. A new OWL-DL translation of RCC8 topological relations

[KAT 05] propose a first attempt to translate RCC8 relations in OWL-DL based on the Modal Logic (ML) translation proposed by [NUT 99]. We notice several drawbacks in these translations. First of all, the authors of [KAT 05] do not provide any explanation about their translation. They use a role $R$ to express the constraints of RCC8 relations but without giving the semantics of this role. Secondly, the ML and DL translation do not keep the RCC8 relations property to be mutually exclusive.

The main problem comes from the fact that in [NUT 99] each RCC8 relation is expressed by a conjunction of two sets of axioms:
1) \( X \cap Y = \bot \)
2) \( X \cap Y \neq \bot \)

But in DL it is not easy to translate the first set of axioms \( X \cap Y = \bot \). To overcome this problem we propose to define a new formal translation based on a third set of axioms \( X \sqsubseteq Y \). We define our new formal translation using an extension of the well known 9-IM model of RCC8 relations. Thus we organize the description of our proposition as follow : First of all, we present the 9-IM model (section 3.1) and our extension (section 3.2). Thus, we propose in section 3.3 our new formal translation for RCC8 relations. Then we explain our DL translation in section 3.4.

### 3.1. 9-IM translation of RCC8

A well-known method that can be used to model RCC8 relations is the 9-Intersection Model (9-IM) [EGE 92]. In 9-IM, each RCC8 relation is represented by a matrix. This matrix represents the intersections of boundary, interior and exterior of two spatial regions. The result of these 9 intersections might be empty (0) or not (1). Thus each RCC8 relation between two regions \( X \) and \( Y \) is represented by a 3x3 matrix whose coefficients correspond to the results of the intersection between \( X^\circ \) (i.e., the interior of \( X \)), \( \partial X \) (i.e., the boundary of \( X \)), \( X \) (i.e., the exterior of \( X \)) and \( Y^\circ \), \( \partial Y \), \( Y \).

\[
M = \begin{pmatrix}
X^\circ \cap Y^\circ & X^\circ \cap \partial Y & X^\circ \cap Y \\
\partial X \cap Y^\circ & \partial X \cap \partial Y & \partial X \cap Y \\
X \cap Y^\circ & X \cap \partial Y & X \cap Y
\end{pmatrix}
\]

In theory, there are \( 2^9 = 512 \) matrixes. However, some of them are incoherent; they cannot be drawn in a 2-dimensional space. For two simple regions, 8 meaningful configurations have been identified which lead to the following matrixes.

<table>
<thead>
<tr>
<th>DC(X, Y)</th>
<th>EC(X, Y)</th>
<th>EQ(X, Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>\begin{pmatrix} 0 &amp; 0 &amp; 1 \ 0 &amp; 1 &amp; 1 \ 1 &amp; 1 &amp; 1 \end{pmatrix}</td>
<td>\begin{pmatrix} 0 &amp; 0 &amp; 1 \ 0 &amp; 1 &amp; 1 \ 1 &amp; 1 &amp; 1 \end{pmatrix}</td>
<td>\begin{pmatrix} 1 &amp; 0 &amp; 0 \ 0 &amp; 1 &amp; 0 \ 0 &amp; 0 &amp; 1 \end{pmatrix}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PO(X, Y)</th>
<th>TPP(X, Y)</th>
<th>NTPP(X, Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>\begin{pmatrix} 1 &amp; 1 &amp; 1 \ 1 &amp; 1 &amp; 1 \ 1 &amp; 1 &amp; 1 \end{pmatrix}</td>
<td>\begin{pmatrix} 1 &amp; 0 &amp; 0 \ 1 &amp; 1 &amp; 0 \ 1 &amp; 1 &amp; 1 \end{pmatrix}</td>
<td>\begin{pmatrix} 1 &amp; 0 &amp; 0 \ 1 &amp; 0 &amp; 0 \ 1 &amp; 1 &amp; 1 \end{pmatrix}</td>
</tr>
</tbody>
</table>

Tableau 1. Matrixes of 9-IM

#### 3.2. New extension of 9-IM

We will adapt the 9-IM model in order to represent the inclusion relation between regions. Thus the matrix represents the relations between boundaries, interiors and exteriors of two spatial regions.
The relation means that:
- (2) one of the region is included in or equal to the others $X \subseteq Y$ or $Y \subseteq X$,
- (1) there is no inclusion relation between the two regions but the intersection between two regions is not empty $X \cap Y \neq \emptyset$,
- (0) the intersection between two regions is empty $X \cap Y = \emptyset$.

The previous table becomes:

<table>
<thead>
<tr>
<th>DC(X, Y)</th>
<th>EC(X, Y)</th>
<th>EQ(X, Y)</th>
<th>PO(X, Y)</th>
<th>TPP(X, Y)</th>
<th>NTPP(X, Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 2</td>
<td>0 0 2</td>
<td>2 0 0</td>
<td>1 1 1</td>
<td>2 0 0</td>
<td>2 0 0</td>
</tr>
<tr>
<td>0 0 2</td>
<td>0 1 1</td>
<td>0 2 0</td>
<td>1 1 1</td>
<td>1 1 0</td>
<td>2 0 0</td>
</tr>
<tr>
<td>2 2 1</td>
<td>2 1 1</td>
<td>0 0 2</td>
<td>1 1 1</td>
<td>1 1 2</td>
<td>1 2 2</td>
</tr>
</tbody>
</table>

Tableau 2. Matrixes of 9-IM extension

3.3. New formal translation of RCC8

Using our new 9-IM model, we propose a RCC8 translation in a formal language using the following operators: Let $s$ and $t$ be two variables, the formal axioms are build up according to the syntax rules $\top | \bot | s \sqcap t | s \sqcup t | s \sqsubseteq t \sqcap \exists \sqsupseteq s | s \sqsupseteq$. Our goal is to replace all the formula $X \cap Y = \bot$ of the formal translation proposed by [NUT 99] with an inclusion relation $X \sqsubseteq Y$ according to our 9-IM extension model. We will have to check that set of axioms are mutually exclusive. That is to say that one component of axiom (e.g., $\exists X \sqcap \exists Y \neq \bot$ or $X^\circ \sqsubseteq Y^\circ$) is false when combining two formal translation of RCC8 relations.

\[
DC(X, Y) : - \quad X^\circ \sqsubseteq \overline{Y} \quad \land \quad (1)
\]
\[
\exists X \sqsubseteq \overline{Y} \quad \land \quad (2)
\]
\[
Y^\circ \sqsubseteq \overline{X} \quad \land \quad (3)
\]
\[
\exists Y \sqsubseteq \overline{X} \quad (4)
\]
EC(X, Y) : \neg X^o \sqsubseteq Y^o \land \partial X \cap \partial Y \neq \bot \land Y^o \sqsubseteq \overline{X} (5)

EQ(X, Y) : \neg X^o \sqsubseteq Y^o \land Y^o \sqsubseteq X^o \land \partial X \sqsubseteq \partial Y \land \partial Y \sqsubseteq \partial X (8)

PO(X, Y) : \neg X^o \cap Y^o \neq \bot \land X^o \cap \overline{Y} \neq \bot \land \overline{X} \cap \overline{Y} \neq \bot \land X^o \cap \partial Y \neq \bot (12)

TPP(X, Y) : \neg X^o \sqsubseteq Y^o \land \partial X \sqsubseteq \partial Y \land \overline{X} \cap Y^o \neq \bot \land \overline{X} \cap \overline{Y} \neq \bot (17)

NTPP(X, Y) : \neg X^o \sqsubseteq Y^o \land \partial X \sqsubseteq Y^o \land \overline{X} \cap Y^o \neq \bot (20)

3.4. New DL translation of RCC8 and associated explanation

Then we use the following assumptions to translate the formal axioms in DL ones (see Figure 4):

- X and Y are two non empty regions. This assumption is translated in DL as : X and Y are two satisfiable classes.
- p is a point. This assumption is translated in DL as : p is an individual.
- A point \( x_i \) belongs to the region X. This assumption is translated in DL as : an individual \( x_i \) is an instance of the class X.
- \( \overline{X} \) is the exterior of X and is equivalent in DL as the complement of X \( \overline{X} \) : \( \neg \neg X \).
– Two individuals \( x_i \) and \( y_j \) are linked with the role \( R \), if the point \( x_i \) is defined to be close to \( y_j \). In point set topology, we could say that two points \( x_i \) and \( y_j \) are close if for all open set \( O_i \) such as \( x_i \in O_i \) then there exist an \( O_j \) such as \( y_j \in O_j \) and \( O_i \cap O_j \neq \emptyset \). The close relation is linked to touching point definition [NUT 99].

– The interior of \( X \), named \( X^\circ \) in our formal language, is defined in DL as \( iX : \neg X \sqcap \forall R.X \). \( iX \) is the set of points of \( X \) that are close to only points of \( X \).

– The boundary of \( X \), named \( \partial X \) in our formal language, is defined in DL as \( bX : \neg X \sqcap \exists R. \neg X \). \( bX \) is the set of points of \( X \) that are close to at least one point of the complement of \( X \).

**Figure 4. A graphical representation of the role \( R \)**

The translation proceeds in several steps: First, we generate a class for each RCC8 relations, called RCC8 classes. For each RCC8 classes, we generate two child classes that represents spatial regions, called region classes. For each region class, we generate their child classes that represent its components: interior and border following the equations 23 to 26. Depend of RCC8 class, we generate their specific subclasses following their DL translation (presented in equations 27 to 42): like \( bX bY \) for \( EC \) relation. Then if a region is implied in several RCC8 relations, we defined equivalence relations between its region classes, subclasses of different RCC8 classes.

\[
iX \equiv X \sqcap \forall R.X; \quad (23)
\]
\[
iY \equiv Y \sqcap \forall R.Y; \quad (24)
\]
\[
bX \equiv X \sqcap \exists R.(\neg X); \quad (25)
\]
\[
bY \equiv Y \sqcap \exists R.(\neg Y); \quad (26)
\]
\[
DC(X, Y) \quad : \quad \neg X \sqsubseteq \neg Y; \quad (27)
\]
\[
Y \sqsubseteq \neg X; \quad (28)
\]
4. Evaluation

In order to validate our proposition of DL translation of RCC8 relations we have implemented a code generator and made several experiments.
4.1. **Prototype**

We have implemented a tool supporting our approach. This tool allows producing automatically an OWL-DL specification (an ontology) from a set of RCC8 relations defined by a user. The OWL-DL specification corresponds to the DL translations introduced in this paper. This OWL-DL representation can be loaded in Protégé in order to check the coherency and consistency of the ontology with a DIG reasoner.

This code generator is fully adaptable. All transformation rules are defined in configuration files. One can add new topological relations and new transformation rules by modifying these configuration files. The tool has been implemented in Java and is fully compatible with MS Windows and Linux. We will make it possible to download this tool on Internet soon.

Figure 6 presents the main inputs and outputs of the tool.

![Figure 6. Architecture of our approach](image)

In the future, we will continue to enrich the configuration files of the tool when we will propose new qualitative spatial relations and their DL representations.

4.2. **Tests on two RCC8 relations**

The DL axioms representing RCC8 relations should be mutually exclusive. That is to say if an ontology is composed of the set of DL axioms representing two different
RCC8 relations between two regions \( X \) and \( Y \), this ontology should be consistent and incoherent according to [STU 08] definitions. In [STU 08], an ontology \( O \) is said to be consistent if there is an interpretation that is a model for \( O \). An ontology \( O \) is called incoherent if there is at least one class \( C \) of \( O \) and \( C \) is unsatisfiable. A class \( C \) is said to be unsatisfiable if for all models of the ontology \( O \), it has no instance. This type of classes is deduced by a DL reasoner.

The following table presents the results we obtain when testing that DL axioms representing two RCC8 relations are mutually exclusive. We used Protégé and Fact++ reasoner to check the coherency of our OWL representation. The OWL representation was built by our code generator. Each cell represents a combination of two RCC8 relations between two regions \( X \) and \( Y \). The cell contains the unsatisfiable classes found by the Fact++ reasoner. As you can see, each combination of two different RCC8 relations raise unsatisfiability of classes.

For example when combining TPP(\( X,Y \)) and NTPP(\( X,Y \)) set of DL axioms, Fact++ infer that the class \( bXbY \) is unsatisfiable because the \( bXbY \) can not be contained in the interior of \( Y \) (even if the boundary of \( X \) is contained in the interior of \( Y \)) and in the boundary of \( Y \).

<table>
<thead>
<tr>
<th>relations</th>
<th>DC</th>
<th>EC</th>
<th>EQ</th>
<th>PO</th>
<th>TPP</th>
<th>NTPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>bXbY</td>
<td>X,Y</td>
<td>iXiY</td>
<td>bXbY</td>
<td>iX</td>
<td>X</td>
</tr>
<tr>
<td>EC</td>
<td>bXbY</td>
<td>iX,iY</td>
<td>iXiY</td>
<td>iX</td>
<td>iX,bXbY</td>
<td>X,bX</td>
</tr>
<tr>
<td>EQ</td>
<td>X,Y</td>
<td>iX,iY</td>
<td>iXeY</td>
<td>eXiY</td>
<td>eXiY</td>
<td>bX,bY</td>
</tr>
<tr>
<td>PO</td>
<td>iXiY</td>
<td>iXiY</td>
<td>iXeY</td>
<td>eXiY</td>
<td>iXeY</td>
<td>bXeYeX</td>
</tr>
<tr>
<td>TPP</td>
<td>bXbY</td>
<td>iX</td>
<td>eXiY</td>
<td>iXeY</td>
<td>bXbY</td>
<td></td>
</tr>
<tr>
<td>NTPP</td>
<td>X</td>
<td>iX,bXbY</td>
<td>eXiY</td>
<td>iXeY</td>
<td>bXbY</td>
<td></td>
</tr>
</tbody>
</table>

Tableau 3. Results of our DL translations on 2 regions

4.3. Tests on 3 or 4 RCC8 relations

In order to test our DL translations we execute some tests using 3 and 4 regions. These tests are presented in the tables 4 and 5. We used Protégé and Fact++ reasoner to check the coherency of our OWL representation. The OWL representation was built by our code generator. The visual editor of Protégé enables us to locate which regions are involved in spatial inconsistencies. In the tables 4 and 5, the first column contains the set of RCC8 relations between regions. The second column presents the problematic RCC8 relations and third column presents the unsatisfiable classes detected by
Fact++. As you can see in these tables when the set of spatial relations is consistent, the reasoner does not detect unsatisfiable classes.

<table>
<thead>
<tr>
<th>Topological Relations</th>
<th>Incoherent Topological Relations</th>
<th>Detected Incoherences</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTPP(A,B) EC(B,C) EC(A,C)</td>
<td>EC(A,C)</td>
<td>bAbC</td>
</tr>
<tr>
<td>NTPP(A,B) EC(B,C) PO(A,C)</td>
<td>PO(A,C)</td>
<td>iAiC</td>
</tr>
<tr>
<td>NTPP(A,B) EC(B,C) NTPP(A,C)</td>
<td>NTPP(A,C)</td>
<td>A bA iA</td>
</tr>
<tr>
<td>NTPP(A,B) EC(B,C) TPP(A,C)</td>
<td>TPP(A,C)</td>
<td>bAbC iA</td>
</tr>
<tr>
<td>NTPP(A,B) EC(B,C) NTPP(C,A)</td>
<td>NTPP(C,A)</td>
<td>C bC, bBbC iC</td>
</tr>
<tr>
<td>NTPP(A,B) EC(B,C) TPP(C,A)</td>
<td>TPP(C,A)</td>
<td>bChA iC</td>
</tr>
<tr>
<td>TPP(A,B) EC(B,C) EC(A,C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPP(A,B) EC(B,C) DC(A,C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPP(A,B) EC(B,C) NTPP(A,C)</td>
<td>NTPP(A,C)</td>
<td>bAbB iA</td>
</tr>
<tr>
<td>TPP(A,B) EC(B,C) TPP(A,C)</td>
<td>TPP(A,C)</td>
<td>iA</td>
</tr>
<tr>
<td>TPP(A,B) EC(B,C) TPP(A,C)</td>
<td>TPP(A,C)</td>
<td>iA</td>
</tr>
</tbody>
</table>

Tableau 4. Results of our DL translations on 3 regions
Topological Relations | Incoherent Topological Relations | Detected Incoherences
---|---|---
NTPP(A,B) |  | bAbC
NTPP(B,C) |  |  
NTPP(C,D) |  |  
NTPP(A,C) |  |  
NTPP(A,D) |  |  
NTPP(B,D) |  |  
NTPP(A,B) | TPP(A,C) |  
NTPP(B,C) |  |  
NTPP(C,D) |  |  
TPP(A,C) |  |  
NTPP(A,B) | TPP(A,D) | bAbD
NTPP(B,C) |  |  
NTPP(C,D) |  |  
TPP(A,D) |  |  

Tableau 5. *Results of our DL translations on 4 regions*

5. Conclusion

In this paper, we use a method based on Description Logics (DL) to detect inconsistency in a set of qualitative spatial relations between simple regions. We introduce DL specifications of the well-known RCC8 relations. The advantage is that traditional DIG reasoners can be used to check the consistency of relations. Representations of RCC8 relations between two spatial regions have been already proposed in Modal Logics [NUT 99] and DL [KAT 05] but several errors occur in these representations.

We have implemented a tool that produces the DL representation of RCC8 relations and made several experiments that validate our proposition.

In the future, we will extend our DL specifications proposed in order to allow checking consistency between other types of spatial objects (composite regions, complex regions, etc.). In our opinion, the DL modelling of RCC8 relations opens a new and promising research field.

6. Bibliographie


