Representing Space in Region Connection Calculus

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1. Preliminaries

1.1. Space as a multi-level structure
1.2. Space in language *and* space in perception
1.3. Space as absolute (space as independent on physical objects; universal coordinate system) *vs*. space as relative (every concrete place in space is a relation between objects)
1.4. Space as a point set *or* region
1.5. Figure/Ground distinction and its asymmetry
1.6. Scale dependency of space
   a. Large-scale space
   b. Small-scale space
1.7. Spatial processing systems (two (Spelke), a single processing system (Cheng), many (Newcombe))
1.8. Spatial representation as a result of interaction between geometry, spatial experience, and reference frames (subject vs. object centered)
1.9. Places, locations *vs.* directions, motions
1.10. Topology *and* geometry
1.11. Frameworks: An Overview
1.12. Qualitative Spatial Reasoning: relations in space and time

2. Basic spatial ontology:

a. **regions (places)** b. **paths**
c. **objects**
   1. Figures (objects to be located)
   2. Grounds (objects in virtue of which F are located)
   3. Viewers (optional)

d. **Orientation or direction** (determining the relation between figure and ground, left, right, under, above)
e. **Distance**
f. **Additional determining factors**, neither inherently geometric not topological:
   1. Frames of reference (determining (d).)
   2. Manner of movement
   3. Cause of movement

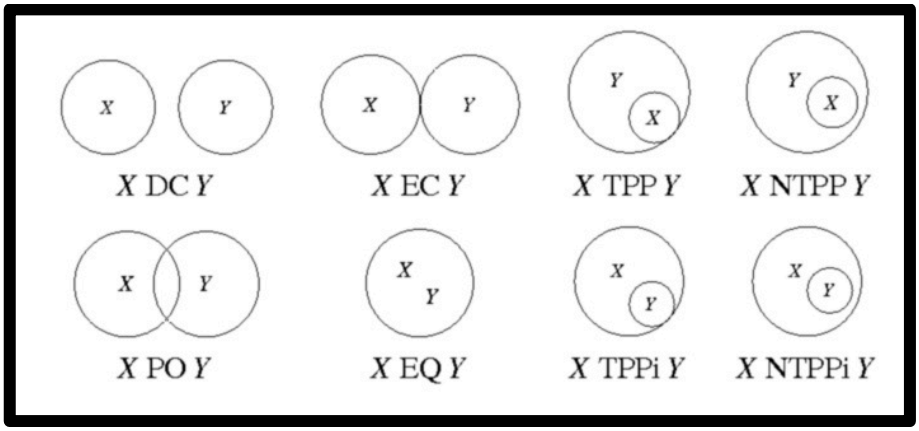
(I) Basic topological and geometric non-functional relations, RCC-8

Randell, Cui, & Cohn, 1992, Mani & Pustejovsky, 2012, Cohn, Bennett, Gooday, & Gotts, 1997, Bennett & Düntsch, 2007, Galton, 2004, Cohn & Renz, 2008, Wolter, & Zakharyaschev, 2000

1. *C(x,y)*: x connects to y $\forall x[C(x,x)]$, $\forall x \forall y[C(x,y) \rightarrow C(y,x)]$
2. Disconectedness (DC): $DC(x,y) \equiv_{def} \neg C(x,y)$
3. Part (P): $P(x,y) \equiv_{def} \forall z[C(z,x) \rightarrow C(z,y)]$
4. Proper part (PP): $PP(x,y) \equiv_{def} P(x,y) \wedge \neg P(y,x)$

5. Overlap (O): $O(x,y) \equiv_{def} \exists z[P(z,x) \wedge P(z,y)]$
6. External connectedness (EC):
$EC(x,y) \equiv_{def} C(x,y) \wedge \neg O(x,y)$
7. Partial overlap (PO): $PO(x,y) \equiv_{def} O(x,y) \wedge \neg P(x,y) \wedge \neg P(y,x)$
8. Equality (EQ): $EQ(x,y) \equiv_{def} P(x,y) \wedge P(y,x)$
9. Discreteness (DR): $DR(x,y) \equiv_{def} \neg O(x,y)$
10. Tangential proper part (TPP):
$TPP(x,y) \equiv_{def} PP(x,y) \wedge \exists z[EC(z,x) \wedge EC(z,y)]$
11. Non-tangential proper part (NTPP):
$NTPP(x,y) \equiv_{def} PP(x,y) \wedge \neg\exists z[EC(z,x) \wedge EC(z,y)]$

Basic RCC relations:



(II) EXTENSIONS of RCC

12**. convex hull** (Cohn, Bennett, Gooday, & Gotts, 1997)
conv(x), i.e., the smallest convex region that includes *x*.
conv(x) ≡def E(x,conv(x))
Conv(x): regions that are entirely/partly inside or outside the convex hull but not overlapping

- topological insideness vs. geometrical insidedness

13. **Orientation**

Main orientational primitives (Mani & Pustejovsky, 2012, 32):
UNDER, OVER, TO_THE_RIGHT_OF (TO_THE_LEFT_OF), IN_FRONT_OF (BEHIND_OF), NEXT_TO

14. **Distance** NEAR, FAR (Mani & Pustejovsky, 2012, Cohn et al., 2014)
15. **Additional geometric features (primitives)** (Forbus et al. 2017.)
15.1.Curvature: STRAIGHT, CURVED
15.2. Axial information: VERTICAL, HORIZONTAL, OBLIQUE, PARALLEL, PERPENDICULAR, COLLINEAR
16. **Functional extensions** (Skilters et al., 2018)
SUPPORT, LOCATIONAL CONTROL (both as EC and DC)

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