CS112, Fall 2013
Brandeis University

Problem Set #5: Spatial Logic in Natural Language
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1. Region Connection Calculus 8 (RCC8)
The composition table for RCC8 is given in Figure 1 below.

o	DC	EC	PO	TPP	NTPP	TPPi	NTPPi	EQ
DC	*	DC,EC,PO,TPP,NTPP	DC,EC,PO,TPP,NTPP	DC,EC,PO,TPP,NTPP	DC,EC,PO,TPP,NTPP	DC	DC	DC
EC	DC,EC,PO,TPPi,NTPPi	DC,EC,PO,TPP,TPPi,EQ	DC,EC,PO,TPP,NTPP	EC,PO,TPP,NTPP	PO,TPP,NTPP	DC,EC	DC	EC
PO	DC,EC,PO,TPPi,NTPPi	DC,EC,PO,TPPi,NTPPi	*	PO,TPP,NTPP	PO,TPP,NTPP	DC,EC,PO,TPPi,NTPPi	DC,EC,PO,TPPi,NTPPi	PO
TPP	DC	DC,EC	DC,EC,PO,TPP,NTPP	TPP,NTPP	NTPP	DC,EC,PO,TPP,TPPi,EQ	DC,EC,PO,TPPi,NTPPi	TPP
NTPP	DC	DC	DC,EC,PO,TPP,NTPP	NTPP	NTPP	DC,EC,PO,TPP,NTPP	*	NTPP
TPPi	DC,EC,PO,TPPi,NTPPi	EC,PO,TPPi,NTPPi	PO,TPPi,NTPPi	PO,TPP,TPPi,EQ	PO,TPP,NTPP	TPPi,NTPPi	NTPPi	TPPi
NTPPi	DC,EC,PO,TPPi,NTPPi	PO,TPPi,NTPPi	PO,TPPi,NTPPi	PO,TPPi,NTPPi	PO,TPP,NTPP,TPPi,NTPPi,EQ	NTPPi	NTPPi	NTPPi
EQ	DC	EC	PO	TPP	NTPP	TPPi	NTPPi	EQ

Figure 1: RCC8 Composition Table

Using the somewhat formal strategy of proof that I've used in class, show the derivations for the values given above, for the following compositions:

(1) a. NTPP ∘ DC
b. TPP ∘ PO
c. EC ∘ NTPP

2. Using RCC8 in Language (*This is a speculative problem!*)
The expressions in RCC8 can be used to express mereotopological relations in 2D space. When expressing spatial configurations in language, however, there is often a painful mismatch or inadequacy of RCC8 relations for capturing linguistic meaning. You are to:

(2) a. Give a first-order representation of a sentence. You can refer to definite descriptions as Skolem constants (e.g., *the dog* $\mapsto D_1$).
b. Give as many of the RCC8 relations as possible. The resulting "interpretation" will be underspecified semantically in many cases.

Here is an example worked out.

Relation	Description
DC	Disconnected
EC	External Connection
PO	Partial Overlap
EQ	Equal
TPP	Tangential Proper Part
TPP_i	Inverse of TTP
NTTP	Non-Tangential Proper Part
NTTP_i	Inverse of NTTP

Table 1: RCC8 Relations.

(3) a. The shirt has a stain on it.
b. $\exists x[shirt(D_1) \wedge stain(x) \wedge have(D_1, x)]$
c. $TPP(x, D_1) \vee NTPP(x, D_1)$

A. Now do this for the sentences below in (4):

(4) (a) The car is in the street.
(b) A table is in a room and an apple is on top of it.
(c) The nail is nailed into the wall.
(d) The milk is in a glass with a label on it.

B. What is missiing in your interpretation will be many aspects of the semantics, including *orientation*, the expression of the regions as inhabiting *3D space*, as well as other subtle features. For each sentence above, state what is needed in order to better distinguish the meaning, and characterize the spatial configuration in the sentence. For example, what if we put a Girl Scout patch on the above shirt.

(5) The shirt has a Girl Scout patch on it.

You are to think about issues that are completely outside the scope of RCC8; e.g., where's the patch? On the inside or the outside? What does that even mean? Is it EC or NTPP? And so forth.

Note: Containment in 3D space is similar to TPP or NTPP in 2D. Orientation requires new machinery. What is it? We'll be covering this in class Tuesday, but speculate!!