Spatial Relations for Positioning Objects in a Cabinet

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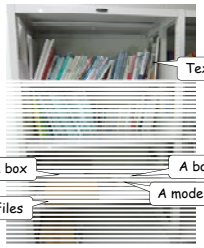
Research Goal

To propose a set of qualitative spatial relations designed for supporting man-machine communication about object locations in a *cabinet*

'Planar' storage where we can ignore the front-back arrangement of two different objects

For example:



In smart home environment, machines have to communicate such '*positioning expressions*' with ordinary people.

But why do we consider a new set of relations, instead of using a existing sets of topological relations and directional relations?

Reason 1

Existing direction models distinguish huge number of relations:

- Papadias & Sellis [1] → 69 relations
- Cicerone & Felice [2] → 218 relations
- Kurata & Shi [3] → 222 relations

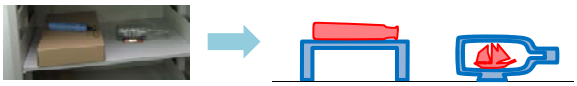
Reason 2

Topological relations [4-5] are based on *partonomy* and *connectivity*, but partonomy does not hold between physical objects

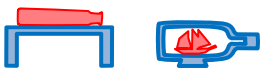
- Porland is *in* Oregon (partnomy)
- An model ship *in* a bottle (not partonomy)

Our Model

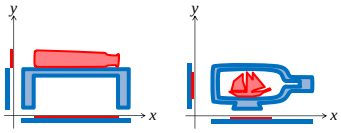
First, we consider the cross-section of objects.

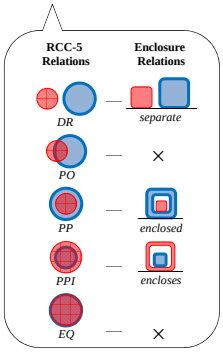


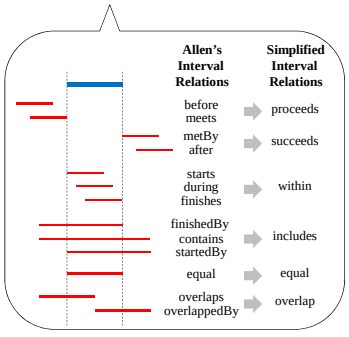
To capture topological characteristics, we consider *enclosure relations*, which correspond to RCC-5 relations [5].



To capture directional characteristics, we consider simplified version of Allen's interval relations [6] on x- and y-axes.







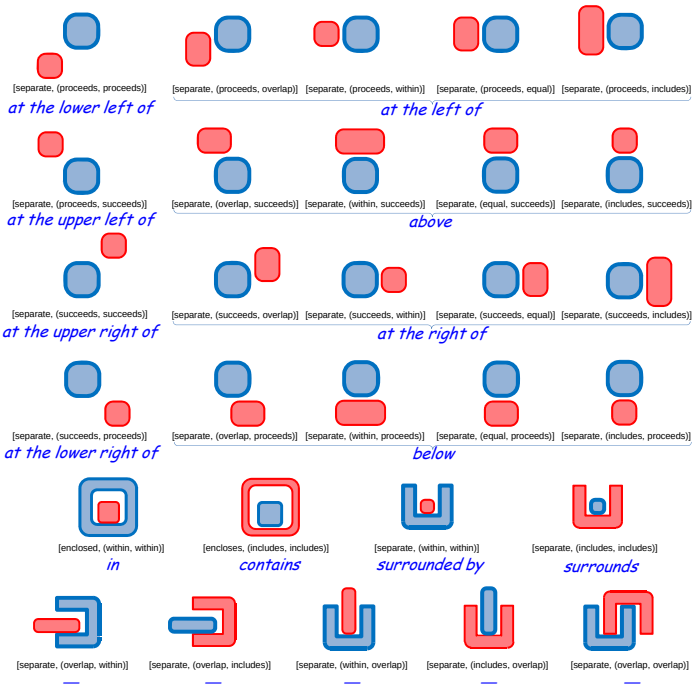
Finally, we combine the enclosure relation and the pair of interval relations.

[separate, (within, succeeds)] [encloses, (within, within)]

These relations are called *cabinet relations.*

Possible Relations and Expressions

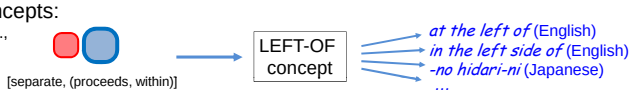
Even though we can consider $3 \times 6 \times 6 = 108$ cabinet relations, **only 29 relations** are possible in the real world:



As shown above, most of the 29 cabinet relations can be mapped to simple positioning expressions in English.

For generality, we can consider an intermediate use of ontological concepts:

e.g.,



Reasoning on Cabinet Relations

Converse of a cabinet relation can be derived by combining the converse of each element.

e.g., $r(A, B)$ = [separate, (proceeds, within)] → $r(B, A)$ = [separate, (succeeds, includes)]

Similarly, compositions of two cabinet relations can be derived by combining the composition of each element pair.

e.g., $r(A, B)$ = [separate, (proceeds, within)]
$r(B, C)$ = [encloses, (includes, includes)] → $r(A,C)$ = [separate, (proceeds, *)]

Composition table of the enclosure relations

	separate	enclosed	encloses
separate enclosed encloses	* separate separate,encloses	separate,enclosed enclosed enclosed,encloses	separate * encloses

Composition table of the simplified interval relations

	proceeds	succeeds	within	includes	equal	overlaps
proceeds	proceeds	*	proceeds, within, overlaps	proceeds	proceeds	proceeds, within, overlaps
succeeds	*	succeeds	proceeds, succeeds, within, overlaps	proceeds, succeeds	proceeds, succeeds	proceeds, succeeds, within, overlaps
within	proceeds	proceeds, succeeds	within	*	within	proceeds, succeeds, within, overlaps
includes	proceeds, within, includes, overlaps	proceeds, succeeds, within, includes, overlaps	equal, within, includes, overlaps	within, includes	within, includes	within, includes, overlaps
equal	proceeds	proceeds, succeeds	within	within, includes	equal	overlaps
overlaps	proceeds, within, includes, overlaps	proceeds, succeeds, within, includes, overlaps	within, overlaps	proceeds, succeeds, within, includes, overlaps	overlaps	*

Future Work

- To find justification for the proposed mapping between cabinet relations and positioning expressions
- To implement the above idea and test its applicability in a smart home environment

References

[1] Papadias, D., Sellis, T.: Spatial Reasoning Using Symbolic Arrays. In: International Conference GIS (1992)
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[3] Kurata, Y., Shi, H.: Toward Heterogeneous Cardinal Direction Calculus: . In: KI 2009, LNCS 5803, pp. 452-459. (2009)
[4] Egenhofer, M., Herring, J.: Categorizing Binary Topological Relationships between Regions, Lines and Points in Geographic Databases. In: NCGIA Technical Reports 91-7 (1991)
[5] Randell, D., Cui, Z., Cohn, A.: A Spatial Logic Based on Regions and Connection. In: Knowledge Representation and Reasoning, 165-176(1992)
[6] Allen, J.: Maintaining Knowledge About Temporal Intervals. Communications of the ACM 26, 832-843 (1983)