

# Semantics of Spatial verbs and their role in interoperability

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## The meaning of spatial verbs

Perhaps verbs occur in English sentences as the most important critical component of sentence meaning and completeness. It denotes the notion of process, action or activity and also has a temporal component (tense). There are also verbs which have some intrinsic spatial meaning. These include motion verbs and existence verbs<sup>1</sup> such as {move, fly, drag, pull} and {appear, locate, remain}. For reasons explained in the footnotes we chose to focus on the former category of verbs in our venture of studying spatial verbs.

So what is special about spatial verbs? And are there purely “spatial” verbs? The answer is perhaps no. Spatial verbs are spatio temporal verbs and do not exist in isolation. The tense notion and activity/action distinction exists in a every textual description of spatial behavior. “Cars move on Roads”, “Rivers flow into lakes”. We take into consideration and still for simplicity sake, use only the spatial sense of these verbs for discussion. We also use *to move* as our example since it occurs as a semantic prime as in the current model of the NSM [1] Further if we use the physical sense of move (as it exists in classical physics) we know of the types of moves based on state-of-rest, steady-motion state and accelerating (or decelerating) state<sup>2</sup>. This allows us to relate the verb corresponding to motion definition in reference to spatial entity types in different dimension cases.

The next step is to use spatial verbs that describe these states. It can be considered inappropriate to use diagrams for representing actions and activities and so it is necessary to use alternate representations such as formulae and physical quantities (like displacement, velocity and acceleration) to represent each case and provide verb forms<sup>3</sup> that have meanings which correspond. Such grouping allows highlighting relative semantic similarity of geospatial behavior concepts and also the differences. For example consider the example of *walk*, *swim* and *run*. All though of them relate to the *move* verb, the run has the additional qualification of higher velocity (word-net has in fact links run to the move concept in two steps as compared to *swim* and *walk*)

The next level of categorization would involve the types of spatial entities involved. Thus for a point feature to *move* on a surface feature could correspond *to swimming* while a point *moving* in a container feature can constitute *to sink*. What is essentially important to note is that there are image schematic differences in the way the verbs are described. It is almost clear in most cases which feature types cannot be involved in a certain type of verb.

## “Decomposable units” and “basic spatial verbs”

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<sup>1</sup> The “to be” verb can also be argued as an existence verb but is used in great variety of ways including “is a” or “is a part of” relations. While some of these can be spatial it becomes difficult to dissociate metaphorical extensions of the spatial case.

<sup>2</sup> One can also argue for rate of change of acceleration to account for further states like steady acceleration, Simple harmonic motion and others. Again for simplicity we assume steady acceleration.

<sup>3</sup> WordNet lexicology is used to reference the sense of the verb used.

One natural question would be whether there can be an exhaustive list of basic spatial verbs. Even if the answer is positive it does not provide the purpose of getting atomic concepts of spatial behavior because language is culture and domain dependent. Perhaps the answer lies in cognitive linguistics and embodied lexical development. The work on executing schemas [2] demonstrates an example of what can be constituted behavioral elements and usually expressed as Petri-net diagrams. Our position in regard to composition of behavior using spatial verbs is that the basic verbs should have unique image schematic references. This is not a simple problem because image schemata are extendable. However it is our view that currently available theory is able to provide the basis for most common verbs

The sequels to such questions are related to the existence of semantic primes. Our argument towards the existence of decomposable units of basic verbs is formed on the basis of Jackendoff's proposition on how meanings can be decomposed [3]. It is therefore assumed that there can be many meanings of the same verb when combined with other words (which can be verbs themselves)

### **Semantic Interoperability**

Finally what does this all mean in the context of semantic interoperability? Aren't spatial behaviors expressed sufficiently in ontologies? Is there any major assistance or advancement that this approach offers to the interoperability problems like naming or cognitive heterogeneity?

Maybe there are. This is because of our hypothesis that behaviors of objects actually define the concept of the object rather than their attributes. Concepts expressed in most geospatial ontologies used for semantic interoperability do not fully specify concepts with knowledge about its behavior. This inhibits expression of behavior of geographic feature types which an important part of geospatial domain knowledge and is an important link that can help in translation [4] of concepts or even establishing the fact that a translation is not possible.

### **References:**

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[4] Kuhn, W. (2003). *Semantic Reference Systems*. *International Journal of Geographical Information Science*.