

# Enriching the Notion of Path in ISOSpace

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## Abstract

This paper proposes a modification to the notion of PATH as used in ISOSpace, in order to both simplify the semantics of the MOVELINK tag as well as improve its coherence as a link structure, as defined in Bunt et al. (2016). This follows a suggestion by Lee (2016), where a reformulation of MOVELINK is proposed, in effect restoring an earlier proposal by Pustejovsky et al. (2010), where a motion is a relation between a MOVER and an EVENT\_PATH. This simplifies the specification in ISOSpace, maintains a coherent abstract syntax, and avoids redundancy with the annotation of semantic role labels.

## 1 Elements of ISOSpace

As part of an ISO international standard on semantic annotation, ISOSpace (ISO-24617-7, 2014) provides an abstract syntax, represented in UML diagrams, two concrete syntaxes, and a set of guidelines for the annotation of spatial entities and motions in language. It specifies: (a) how to annotate spatial entities such as places, paths, and spatially involving non-locational objects and motions and other non-motion events in language; and (b) how to annotate and represent their relations in a concrete format, either XML or predicate-logic-like form. The specification for ISOSpace distinguishes between four major types of spatially relevant elements for markup in natural language (Pustejovsky, 2017).

- (1) a. PLACES AND SPATIAL ENTITIES: natural or artificial locations in the world, as well as objects participating in spatial relations.
- b. EVENTS AND MOTION EVENTS: Eventualities involving movement and static situations.
- c. SPATIAL SIGNALS AND SPATIAL MEASURES: linguistic markers that establish relations between places and spatial entities.
- d. SPATIAL RELATIONSHIPS: The specific qualitative configurational, orientational, and metric relations between objects.

In the discussion below, we focus on those elements of ISOSpace that are most relevant for modeling motion events. We begin with the six basic entity types, given below.

- |                                    |                         |
|------------------------------------|-------------------------|
| (2) a. PLACE                       | d. MOTION events        |
| b. PATH                            | e. EVENT (non-motion)   |
| c. SPATIAL_ENTITY (non-locational) | f. SIGNAL (three types) |

The PLACE tag is used for annotating geographic entities like lakes and mountains, as well as administrative entities like towns and counties. (3) shows extents that should be captured with PLACE.

- (3) a. [**Boston**<sub>pl1</sub>] is north of [**New York**<sub>pl2</sub>].
- b. John entered the [**store**<sub>pl3</sub>].
- c. Kiyong flew to [**Montpellier**<sub>pl6</sub>].



id	mv11, mv12, mv13, ...
trigger	identifier of the motion event that triggered the link
source	identifier of the place, path, spatial named entity, or event at the beginning of the path
goal	identifier of the place, path, spatial named entity, or event at the end of the path
midPoint	identifier of the place, path, spatial named entity, or event in the middle of the path
mover	identifier of the entity that moves along the path
ground	identifier of a place, path, spatial named entity or event that the mover's motion is relative to
goal_reached	TRUE, FALSE, UNCERTAIN
pathID	identifier of a path that is equivalent to the one described by the MOVELINK
adjunctID	identifier of the spatial_signal that participates in the link

Table 1: Attributes for MOVELINK

## 2 Problems with MOVELINK

It is perhaps important to understand that the motivation for the MOVELINK tag in ISOSpace comes originally from an interest in tracking objects in motion, as described in texts, and then linking them to maps or other visual geographic displays (Pustejovsky and Moszkowicz, 2008). As such, this results in a conflation of two kinds of information structures: (i) a relation between a motion and the mover in the motion; and (ii) all of the semantic roles that are involved in a motion event. This has the unintended consequence of creating a link structure that overlaps with efforts to annotate semantic roles generally, i.e., SemAF-SR (24617-4, 2014), and specifically within spatial language (Kordjamshidi et al., 2012). Moreover, it is unlike the other relational structures in ISOSpace, in that it identifies no actual relation type, independent of the motion event itself. In this sense, it fails to conform to the definition of a link structure, as proposed in Bunt et al. (2016). For these reasons, following Lee (2016), we propose to simplify the structure of the MOVELINK tag as a relation between a MOVER and the path created by the movement, namely the EVENT\_PATH.

## 3 The Return of EVENT\_PATH

In ISOSpace version 1.3e, Pustejovsky et al. (2010) introduced an additional tag to the elements listed in Section 1 above, namely an EVENT\_PATH. The original intuition behind this type was to have a record of the movement as carried out by the mover: that is, to encode the path created by the traversal of an entity in motion. In order to make this more transparent, following Mani and Pustejovsky (2012), Pustejovsky and Yocum (2013) introduce two axioms of motion into the abstract syntax of ISOSpace, given below.

(7) a. Axiom 1: Mover Participants

Every motion-event involves a mover.

$$\forall e \exists x [\text{motion-event}(e) \rightarrow \text{mover}(x, e)]$$

b. Axiom 2: Event Paths

Every motion-event involves an event-path.

$$\forall e \exists p [\text{motion-event}(e) \rightarrow [\text{event-path}(p) \wedge \text{loc}(e, p)]]$$

These axioms presuppose the following definitions<sup>1</sup>:

(8) MOVER: participant in a motion-event that undergoes a change in its location.<sup>2</sup>

PATH: non-null sequence of locations (places).

<sup>1</sup>See Pustejovsky and Yocum (2013).

<sup>2</sup>Langacker (2008) (p.356) introduces **mover** as one of the six archetypal roles associated with actions and events, while defining it as "anything that moves (i.e. changes position in relation to its external surroundings)". He also treats the mover as a *trajector* in contrast to a *landmark* that provides a ground for the activity or motion of a *trajector*. These two terms, *trajector* and *landmark*, correspond to the terms *figure* and *ground* in our use related to motion-events.

EVENT-PATH:

*Formal:* path which is directed, finite, and bounded with a begin-point, an endpoint, and a sequence of midpoints between them;

*Functional:* path triggered by a motion-event, that traces or represents the locational (physically necessary spatio-temporal) transition or trajectory of the *mover*, of a motion-event.

To illustrate the role of EVENT\_PATH in the context of motion, let us consider some examples.

- (9) a. John<sub>mover</sub> walked from Boston to Cambridge.
- b. An arrow<sub>mover</sub> hit the target.
- c. John pushed a big rock<sub>mover</sub> over the hill.

As shown above, the mover is not necessarily an agent or the cause of a motion. Whatever their semantic roles, however, all these movers above have the characteristics of moving from one location to another. Hence, to understand what is meant by **mover**, some locational change of an object must be implied from a motion.

By the two definitions given above, the **mover** in Axiom 1 is understood to be locationally related to the **event-path** in Axiom 2. By Axiom 1, an object  $x$  is related to a motion-event  $e$  and then by Axiom 2 the motion-event  $e$  to an event-path  $p$  with the relation *loc*. Hence, the mover  $x$  is *locationally* related to the path  $p$ , provided that transitivity is assumed to hold. Following Pustejovsky and Moszkowicz (2011); Lee (2016), to make the relation between the mover and the path more explicit, we introduce the following additional axiom:

- (10) Every motion-event has a path to which it is anchored, and the mover traverses that path.  
 $\forall e \exists \{p, x\} [motion-event(e) \rightarrow [event-path(p, e) \wedge mover(x, e) \wedge traverse(x, p)]]^3$

We assume that traversal can be defined as follows:

- (11) TRAVERSE:
  - a. A binary relation between an object  $x$  and a path  $p$  such that  $traverse(x, p)$  holds if and only if, for any path  $p$ , represented as  $\langle l_0, \dots, l_k \rangle$  with two endpoints  $l_0$  and  $l_k$ , and any object  $x$ , each of the locations of  $x$ , represented as  $l(x)_i$ , in its transition from one location to another, corresponds to each location  $l_i$  in  $p$ .
  - b. For an object  $x$  and a path  $p$  such that  $p$  is a sequence  $\langle l_0, \dots, l_k \rangle$ ,  $\sigma(traverse(x, p))$  implies:  
 $\forall t_i \in N [t_0 \leq t_k \rightarrow [loc(x, t_0), \dots, \forall loc(x, t_k)]]$ .

## 4 Reformulation of MOVELINK

Given these observations, we propose that MOVELINK can be recast as a proper link structure, as a relation between a FIGURE and GROUND, to be defined below. A link structure,  $\langle \eta, E, \rho \rangle$ , within the abstract syntax  $\mathcal{ASyn}_{isoSpace}$  of ISOSpace, has the following properties (Bunt et al., 2016).

- (12) a.  $\eta$  is an entity structure of the **spatial entity** type functioning as the *mover* of a motion-event and as its *figure*,
- b.  $E$  is a singleton containing an entity structure of the **event-path** type functioning as a *ground*;
- c.  $\rho$  is a relation over  $\eta$  and  $E$  triggered by a motion-event.

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<sup>3</sup> *event-path* is here treated as a relation between a path and an event because, unlike a (static) path, an event-path is created by a motion-event.  $loc(e, p)$  holds if and only if  $traverse(x, p)$  holds for each  $l$  in  $p$ .

We assume the mover of a motion to be a *figure*, as suggested by Talmy (1975, 1985). For its interpretation then, each event-path or traversal of the mover of a motion-event requires a reference location, either a place or a path, called *ground*.

The movement link is triggered by a motion-event. In the modified version of ISOSpace, this link is viewed as relating the mover of that motion-event to an event-path traversed by the mover. The MOVER and EVENT-PATH are then treated as the *figure* and *ground* of the movement link, respectively.<sup>4</sup> The revised structure for MOVELINK is shown below.

id	mv11, mv12, mv13, ...
trigger	identifier of the motion event that triggered the link
relType	relation value of motion, defaults to <code>traverse</code>
figure	identifier of the entity that moves along the path
ground	identifier of the event-path of the motion

Table 2: Revised MOVELINK

To illustrate how this plays out, consider the different ways in which a mover can relate to the event-path, as it unfolds in a motion event. We demonstrate this with the distinction that Talmy and others have observed between *internal motion* and *external motion*: below, *se* is SPATIAL\_ENTITY, *m* is MOVE\_EVENT, and *ep* is EVENT\_PATH.

- (13) a. John swam around the lake.  
       John<sub>se1:figure</sub> swam<sub>m1:trigger</sub> around [the lake]<sub>ep1:ground</sub>
- b. John walked around the lake.  
       John<sub>se1:figure</sub> walked<sub>m1:trigger</sub> [around the lake]<sub>ep1:ground</sub>

In (13a), the motion that John is involved in is internal to the region identified as the *figure*, hence the notion of “internal motion”. In (13b), on the other hand, John is engaged in motion external to the PLACE identified by the park, and the *figure* is some path defined functionally as:  $\lambda p[\textit{around}(p, \textit{the\_park})]$ .

The abstract syntax  $\mathcal{ASyn}_{isoSpace}$  of ISOSpace specifies the value of the relation type  $\rho$  to be CDATE, allowing any possible values. In a concrete syntax proposed here, we specify this value to be TRAVERSE, as defined above, a single value for each of the `<moveLink>` instances. If a mover  $x$  traverses a path  $p$ , then  $x$  goes through  $p$  by being located at its begin-point, midpoints, or endpoint, sequentially as time progresses.

## 5 Conclusion

In this paper, we propose a reformulation of the MOVELINK tag in ISOSpace, motivated by two major concerns: it currently fails to satisfy the conditions on link structures in abstract syntax, as defined in Bunt et al. (2016); and it contributes no additional information to the annotation beyond the identification of the semantic roles involved in motion. Since this is information that is already annotated or accounted for by other specifications, it was seen as largely uninformative. The new formulation of MOVELINK structures it as a relation between a MOVER and the EVENT\_PATH created by the traversal in the movement event. This accords with both Talmy’s typological observations regarding how motion is encoded in language, as well as the qualitative spatial interpretation of motion provided in Pustejovsky and Moszkowicz (2011) and Mani and Pustejovsky (2012).

<sup>4</sup>In Mani and Pustejovsky (2012), the *mover* is treated as the figure of a movement link.

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