Spatial Relations in Motion Predicates

- **Topological Path Expressions**
  - arrive, leave, exit, land, take off
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- **Orientation Path Expressions**
  - climb, descend
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- **Topo-metric Path Expressions**
  approach, near, distance oneself
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  arrive, leave, exit, land, take off

- **Orientation Path Expressions**
  climb, descend

- **Topo-metric Path Expressions**
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- **Topo-metric orientation Expressions**
  just below, just above
Manner construction languages
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Language Data

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  English, German, Russian, Swedish, Chinese

- **Path construction languages**
  Path information is encoded in matrix verb, while adjuncts specify manner of motion
  Modern Greek, Spanish, Japanese, Turkish, Hindi
(55) a. The event or situation involved in the change of location;
Defining Motion (Talmy 1985)

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b. The object (construed as a point or region) that is undergoing movement (the figure);
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(57) a. The *event* or situation involved in the change of location;
b. The object (construed as a point or region) that is undergoing movement (the *figure*);
c. The region (or *path*) traversed through the motion;
Defining Motion (Talmy 1985)

(58) a. The event or situation involved in the change of location;
b. The object (construed as a point or region) that is undergoing movement (the figure);
c. The region (or path) traversed through the motion;
d. A distinguished point or region of the path (the ground);
(59) a. The event or situation involved in the change of location;  
b. The object (construed as a point or region) that is undergoing movement (the figure);  
c. The region (or path) traversed through the motion;  
d. A distinguished point or region of the path (the ground);  
e. The manner in which the change of location is carried out;
Defining Motion (Talmy 1985)

(60) a. The *event* or situation involved in the change of location;
b. The object (construed as a point or region) that is undergoing movement (the *figure*);
c. The region (or *path*) traversed through the motion;
d. A distinguished point or region of the path (the *ground*);
e. The *manner* in which the change of location is carried out;
f. The *medium* through which the motion takes place.
Path Predicates

[Diagram]

John \( \xrightarrow{figure} \) VP \( \xrightarrow{ground} \) NP

\( \xrightarrow{trans} \) departed  \( \xrightarrow{} \)  Boston
Manner with Path Adjunction

John biked to the store

S
 NP \_ figure \\
 VP \_ ground \\
 V \_ act \_ biked \\
 PP \_ trans \_ to the store
Path with Manner Adjunction

John translocated by car from Boston.
(61) a. Isabel climbed for 15 minutes.
(63) a. Isabel climbed for 15 minutes.
   b. Nicholas fell 100 meters.
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   b. Nicholas fell 100 meters.

(66) a. There is an action (e) bringing about an iterated non-distinguished change of location;
(67) a. Isabel climbed for 15 minutes.
    b. Nicholas fell 100 meters.

(68) a. There is an action (e) bringing about an iterated non-distinguished change of location;
    b. The figure undergoes this non-distinguished change of location;
(69) a. Isabel climbed for 15 minutes.
    b. Nicholas fell 100 meters.

(70) a. There is an action (e) bringing about an iterated non-distinguished change of location;
    b. The figure undergoes this non-distinguished change of location;
    c. The figure creates (leaves) a path by virtue of the motion.
(71) a. Isabel climbed for 15 minutes.
   b. Nicholas fell 100 meters.

(72) a. There is an action (e) bringing about an iterated non-distinguished change of location;
   b. The figure undergoes this non-distinguished change of location;
   c. The figure creates (leaves) a path by virtue of the motion.
   d. The action (e) is performed in a certain manner.
(73) a. Isabel climbed for 15 minutes.
    b. Nicholas fell 100 meters.

(74) a. There is an action (e) bringing about an iterated
    non-distinguished change of location;
    b. The figure undergoes this non-distinguished change of
    location;
    c. The figure creates (leaves) a path by virtue of the motion.
    d. The action (e) is performed in a certain manner.
    e. The path is oriented in an identified or distinguished way.
Unlike pure manner verbs, this class of predicates admits of two compositional constructions with adjuncts.
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(77) **Manner of motion verb with path adjunct;**
    John climbed to the summit.
Unlike pure manner verbs, this class of predicates admits of two compositional constructions with adjuncts.

(79) **Manner of motion verb with path adjunct;**
    John climbed to the summit.

(80) **Manner of motion verb with path argument;**
    John climbed the mountain.
With Path Adjunct

NP: John

VP: act

V: climbed

PP: to the summit

S: figure

ground

trans
With Path Argument

John trans climbed the mountain
Dynamic Interval Temporal Logic
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- **Path** verbs designate a distinguished value in the change of location, from one state to another.
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- **Manner of motion** verbs iterate a change in location from state to state.
Capturing Motion as Change in Spatial Relations

Dynamic Interval Temporal Logic

- **Path** verbs designate a distinguished value in the change of location, from one state to another. The change in value is tested.

- **Manner of motion** verbs iterate a change in location from state to state. The value is assigned and reassigned.
Directed Motion

(81) \[ \text{loc}(z) = x_{e_1} \xrightarrow{\nu} \text{loc}(z) = y_{e_2} \]

When this test references the ordinal values on a scale, this becomes a directed \( \xrightarrow{\nu} \)-transition (\( \xrightarrow{\nu} \)), e.g., \( x \neq y \), \( x \neq y \).
When this test references the ordinal values on a scale, $\mathcal{C}$, this becomes a *directed $\nu$-transition* ($\nu$), e.g., $x \preceq y$, $x \succeq y$. 
Directed Motion

\[(85) \quad \text{loc}(z) = x_{1} \xrightarrow{\nu} \text{loc}(z) = y_{2}\]

When this test references the ordinal values on a scale, \( C \), this becomes a directed \( \nu \)-transition (\( \vec{\nu} \)), e.g., \( x \leq y, \ x \geq y \).

\[(86) \quad \vec{\nu} = df \quad \varepsilon_{i} \xrightarrow{\nu} \varepsilon_{i+1}\]
Directed Motion

(87)

\[ e_{[i,i+1]} \]

\[ x \leq y? \]

\[ e_i \]

\[ x := y \]

\[ e_{i+1} \]

\[ A(z) = x \]

\[ A(z) = y \]
Manner-of-motion verbs introduce an assignment of a location value:

\[ \text{loc}(x) := y; y := z \]
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Directed motion introduces a dimension that is measured against:

\[ d(b, y) < d(b, z) \]
Manner-of-motion verbs introduce an assignment of a location value:

$$\text{loc}(x) := y; y := z$$

Directed motion introduces a dimension that is measured against:

$$d(b, y) < d(b, z)$$

Path verbs introduce a pair of tests:

$$\neg \phi? \ldots \phi?$$
The execution of a change in the value to an attribute $A$ for an object $x$ leaves a trail, $\tau$. For motion, this trail is the created object of the path $p$ which the mover travels on; for creation predicates, this trail is the created object brought about by order-preserving transformations as executed in the directed process above.
The execution of a change in the value to an attribute $A$ for an object $x$ leaves a trail, $\tau$. 
Change and the Trail it Leaves

- The execution of a change in the value to an attribute $A$ for an object $x$ leaves a trail, $\tau$.
- For motion, this trail is the created object of the path $p$ which the mover travels on;
The execution of a change in the value to an attribute $\mathcal{A}$ for an object $x$ leaves a trail, $\tau$.

For motion, this trail is the created object of the path $p$ which the mover travels on;

For creation predicates, this trail is the created object brought about by order-preserving transformations as executed in the directed process above.
Motion leaving a Trail

(88) **Motion leaving a trail:**
   a. Assign a value, \( y \), to the location of the moving object, \( x \).
      \( \text{loc}(x) := y \)
Motion Leaving a Trail

(89) Motion leaving a trail:
   a. Assign a value, $y$, to the location of the moving object, $x$.
      \[ \text{loc}(x) := y \]
   b. Name this value $b$ (this will be the beginning of the movement);
      \[ b := y \]
(90) **Motion leaving a trail:**

a. Assign a value, \( y \), to the location of the moving object, \( x \).

\[
loc(x) := y
\]

b. Name this value \( b \) (this will be the beginning of the movement);

\[
b := y
\]

c. Initiate a path \( p \) that is a list, starting at \( b \);

\[
p := (b)
\]
(91) Motion leaving a trail:
   a. Assign a value, $y$, to the location of the moving object, $x$.
      \[ \text{loc}(x) := y \]
   b. Name this value $b$ (this will be the beginning of the movement);
      \[ b := y \]
   c. Initiate a path $p$ that is a list, starting at $b$;
      \[ p := (b) \]
   d. Then, reassign the value of $y$ to $z$, where $y \neq z$
      \[ y := z, y \neq z \]
Motion Leaving a Trail

(92) **Motion leaving a trail:**

a. Assign a value, $y$, to the location of the moving object, $x$.
   $$\text{loc}(x) := y$$

b. Name this value $b$ (this will be the beginning of the movement);
   $$b := y$$

c. Initiate a path $p$ that is a list, starting at $b$;
   $$p := (b)$$

d. Then, reassign the value of $y$ to $z$, where $y \neq z$
   $$y := z, y \neq z$$

e. Add the reassigned value of $y$ to path $p$;
(93) **Motion leaving a trail:**

a. Assign a value, \( y \), to the location of the moving object, \( x \).

\[
\text{loc}(x) := y
\]

b. Name this value \( b \) (this will be the beginning of the movement);

\[
b := y
\]

c. Initiate a path \( p \) that is a list, starting at \( b \);

\[
p := (b)
\]

d. Then, reassign the value of \( y \) to \( z \), where \( y \neq z \)

\[
y := z, y \neq z
\]

e. Add the reassigned value of \( y \) to path \( p \);

\[
p := (p, z)
\]

f. Kleene iterate steps (d) and (e).
Quantifying the Resulting Trail

Figure: Directed Motion leaving a Trail
(95) a. The ball rolled 20 feet.
   \[ \exists p \exists x \left[ \text{roll}(x, p) \land \text{ball}(x) \land \text{length}(p) = [20, \text{foot}] \right] \]
Quantifying the Resulting Trail

Figure: Directed Motion leaving a Trail

(96) a. The ball rolled 20 feet.
\[ \exists p \exists x [ [ \text{roll}(x, p) \land \text{ball}(x) \land \text{length}(p) = [20, \text{foot}]] \]
b. John biked for 5 miles.
\[ \exists p [ [ \text{bike}(j, p) \land \text{length}(p) = [5, \text{mile}]] \]