Signal-symbol Interface

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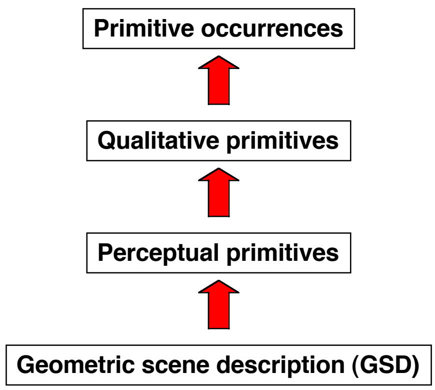
Computing Primitive Occurrences



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Geometric Scene Description (GSD)

The GSD is a quantitative object-level scene interpretation in terms of
- **recognised objects and**
- **their (possibly time-varying) locations in the scene**

- **useful definition of input for high-level scene interpretation**
- **objects may only be roughly classified (e.g. "moving-object")**
- **high-level processes must be able to correct mistakes and fill in missing evidence**

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Perceptual Primitives

Perceptual primitives are geometrical and photometrical attributes which can be immediately determined from a GSD.

For object configurations:
- **objects provide reference features in terms of**
  - **locations (center of gravity, corners, surface markings, etc.)**
  - **lines (edges, surface markings, axes of minimal inertia, etc.)**
  - **orientations (inate, motion, viewer)**
- **perceptual primitives are measurements between reference features:**
  - **distance**
  - **angle**
  - **temporal derivatives thereof**

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Qualitative Primitives

Qualitative primitives are predicates over perceptual primitives constant over some time interval.

- **qualitatively constant values**
  e.g. constant orientation, constant distance
- **values within a certain range**
  e.g. topological relations, degrees of nearness, typical speeds
- **values smaller or larger than a threshold**
  e.g. increase of distance, slowing down

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Qualitative Predicates for Occurrences in Traffic Scenes

Used in NAOS: "Natural-language description of object motions in traffic scenes"

exist
move
decelerate, accelerate
turn_left, turn_right
increasing_distance, reducing_distance
along, across
in_front_of, behind, beside
on, above, under, below
at, near_to
between
(and others)

Note that qualitative predicates are often (but must not be) part of natural language.

For technical applications one may use technical (artificial) qualitative predicates, e.g.

v50 (= $45 \leq v \leq 55$ km/h)

shape_x (= shape_index ≤ 4.174)

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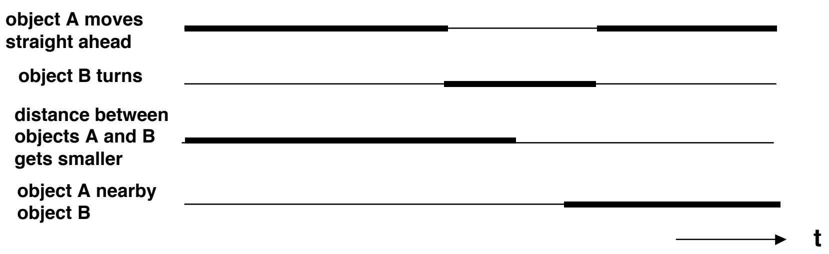
Primitive Occurrences

A primitive occurrence is a conceptual entity with one or more objects for which a qualitative predicate is true over a time interval.

Primitive occurrences provide the raw material for high-level scene interpretations.



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Temporal Decomposition of Scenes

Temporal decomposition

- **by temporal segmentation:**
  constancies of time-dependent properties of an image sequence
- **by model matching:**
  occurrences which obey a model

Compare with spatial decomposition

- **by spatial segmentation:**
  image regions with spatially constant (uniform) properties
- **by model matching:**
  image regions which obey a model

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Occurrence Models

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Structure of Occurrence Models

Basic ingredients:	
	• relational structure
	• taxonomy
	• partonomy
	• spatial relational language
	• temporal relational language
	• object appearance models

- An occurrence model describes a class of occurrences by
  - properties
  - sub-occurrences (= components of the occurrence)
  - relations between sub-occurrences

- A primitive occurrence model consists of
  - properties
  - a qualitative predicate

- Each occurrence has a begin and end time point

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Occurrence Model for Placing a Cover

name:	place-cover
parents:	:is-a agent-activity
parts:	pc-pl :is-a plate
	pc-sc :is-a saucer
	pc-cp :is-a cup
	pc-tt :is-a table-top
	pc-tp1 :is-a (transport with (tp-obj :is-a plate))
	pc-tp2:is-a (transport with (tp-obj :is-a saucer))
	pc-tp3 :is-a (transport with (tp-obj :is-a cup))
	pc-cv :is-a cover
time marks:	pc-tb, pc-te :is-a timepoint
constraints:	pc-tp1.tp-ob = pc-cv.cv-pl = pc-pl
	pc-tp2.tp-ob = pc-cv.cv-sc = pc-sc
	pc-tp3.tp-ob = pc-cv.cv-cp = pc-cp
	pc-cv.cv-tb ≥ pc-tp1.tp-te
	pc-cv.cv-tb ≥ pc-tp2.tp-te
	pc-cv.cv-tb ≥ pc-tp3.tp-te
	pc-tp3.tp-te ≥ pc-tp2.tp-te
	pc-tb ≤ pc-tp1.tb
	pc-tb ≤ pc-tp2.tb
	pc-tb ≤ pc-tp3.tb
	pc-te ≥ pc-cv.cv-tb
	pc-te ≥ pc-tb + 80Δt

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Occurrence Model for Overtaking in Street Traffic

Variant of aggregate representation language developed by Kockskämper 1996 for model-based diagnosis

Predicate:	overtake
	:is-a occurrence-model
	:local-name ov
Arguments:	(?veh1 :is-a vehicle)
	(?veh2 :is-a vehicle)
Time marks:	(ue.B ue.E)
Component events:	(mv1 :is-a (move ?veh1 mv1.B mv1.E))
	(mv2 :is-a (move ?veh2 mv2.B mv2.E))
	(bh :is-a (behind ?veh1 ?veh2 bh.B bh.E))
	(bs :is-a (beside ?veh1 ?veh2 bs.B bs.E))
	(bf :is-a (before ?veh1 ?veh2 bf.B bf.E))
	(ap :is-a (approach ?veh1 ?veh2 ap.B ap.E))
	(rc :is-a (recede ?veh1 ?veh2 rc.B rc.E))
Temporal relations:	(ov.B = bh.B)
	(ov.E = bf.E)
	(ap :during mv1)
	(ap :during mv2)
	(rc :during mv1)
	(rc :during mv2)
	(bh :overlaps bs)
	(bs :overlaps bf)
	(bh :during ap)
	(bf :during rc)

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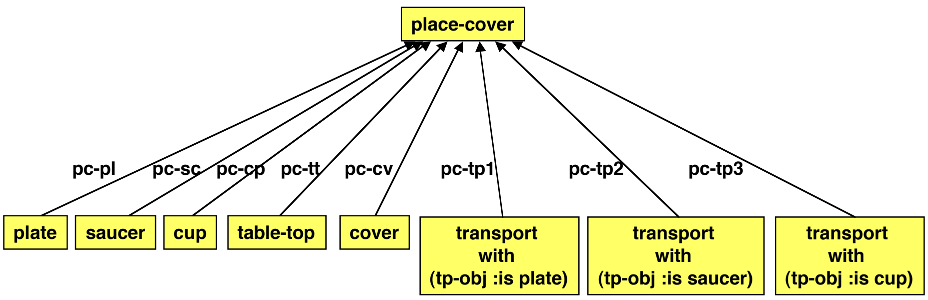
Parts Structure

- associational structure between aggregats and their parts
- probabilistic information may be added



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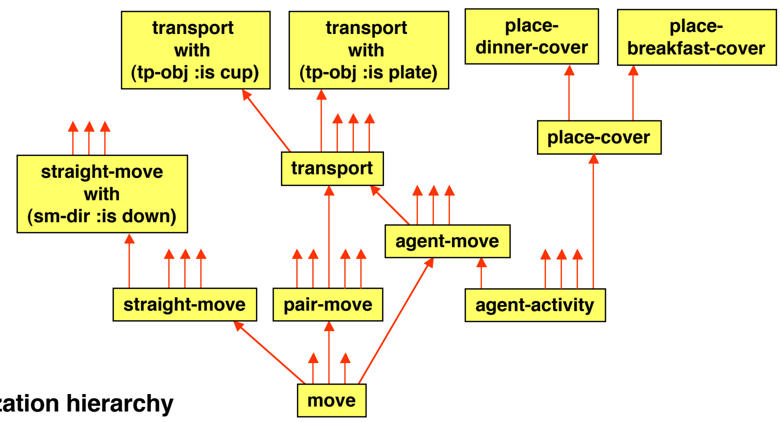
Concept Hierarchy



- specialization hierarchy
- nodes are concept expressions
- multiple inheritance

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Reified Relations

An instance of the frame "transport" can be viewed as a reified relation:

(transport move1 move2 tb1 te1) ➡ (instance trans1 transport)
(tp--hand-move trans1 move1)
(tp-obj-move trans1 move2)
(tp-tb trans1 tb1)
(tp-te trans1 te1)

name:	transport
parents:	:is-a agent-activity
parts:	tp-hand-move :is-a move with mv.obj is-a hand
	tp-obj-move :is-a move
	tp-touch :is-a touch
time marks:	tp-tb, tp-te :is-a timepoint
constraints:	tp-hand-move.mv-tb ≥ tp-touch.to-tb
	tp-hand-move.mv-te ≥ tp-touch.to-te
	tp-obj-move.mv-tb = tp-hand-move.mv-tb
	tp-obj-move.mv-te = tp-hand-move.mv-te
	tp-tb = tp-hand-move.mv-tb
	tp-te = tp-hand-move.mv-te

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Reified Relations vs. Situated Objects

A single relation permits several conceptualizations in an object-oriented framework depending on what is considered on "object"

Example: (behind obj1 obj2 tb te)

1. behind :is-a spatial-relation "behind occurrence" (reified relation)
2. behind-obj1 :is-a phys-object "a specially situated physical object"
3. behind-obj2 :is-a phys-object "a specially situated physical object"
4. behind-begin :is-a timepoint "a special timepoint"
5. behind-end :is-a timepoint "a special timepoint"

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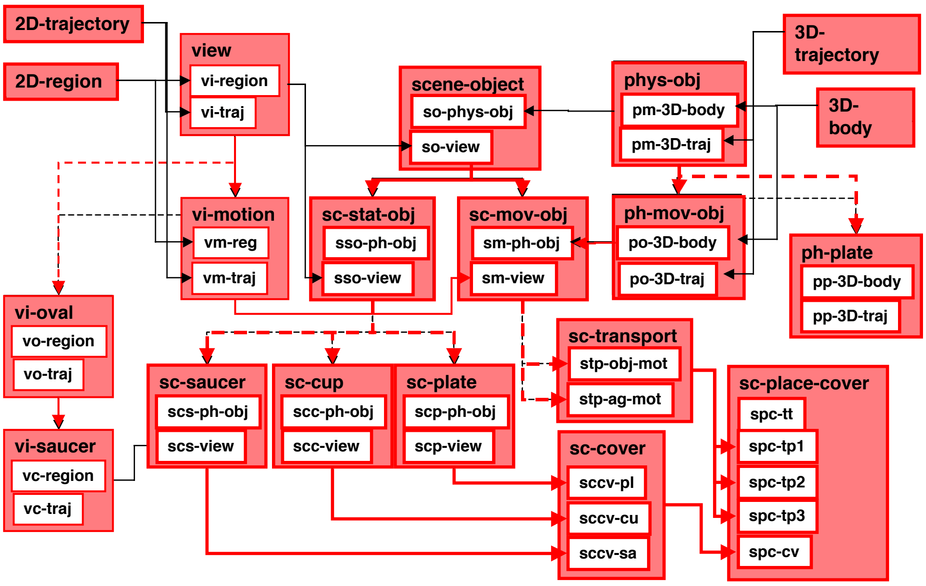
Aggregates in Taxonomical Hierarchies



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