Image schemas and spatial reasoning

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October, 2006
Outline

• Image schemas
• The Image Schema Language (ISL)
  – Static image schemas
  – Dynamic/Action schemas
• Toward a program story
• A conjecture and a bet
Image Schemas

- “An image schema is a condensed redescription of perceptual experience for the purpose of mapping spatial structure onto conceptual structure. . . ”

"[T]hese patterns ‘emerge as meaningful structures for us chiefly at the level of our bodily movements through space, our manipulations of objects, and our perceptual interaction’."
Nonphysical (metaphorical) use of image schemas

• “An image schema is a mental pattern that recurrently provides structured understanding of various experiences, and is available for use in metaphor as a source domain to provide an understanding of yet other experiences.”

"[L]eveses block and reroute the Mississippi's periodic flooding cycles. . ."

"The city becomes a bowl whose levees are holding the water in. . ."

"[T]he only way to regain public confidence after the stumbling early response. . ."

"[T]he path from post-9/11 unity to the rancor and finger-pointing in the aftermath of Katrina's fury. . ."

"Hurricane Katrina has been a low point in Bush's presidency. . ."

"[T]he president's inner circle is working with more than a dozen new task forces. . ."
A catalog of schemas

**Space:**
- Location
- Up-Down
- Front-Back
- Left-Right
- Near-Far
- Center-Periphery
- Contact

**Containment:**
- Container
- In-Out
- Surface
- Full-Empty
- Content

**Locomotion:**
- Momentum
- Path

**Balance:**
- Axis Balance
- Twin-Pan Balance
- Point Balance
- Equilibrium

**Identity:**
- Matching
- Superimposition

**Multiplicity:**
- Merging
- Collection
- Splitting
- Iteration
- Part-Whole
- Count-Mass
- Link

**Existence:**
- Removal
- Bounded space
- Cycle
  - Object
  - Process
  - Agent

Path Schema
Physical Paths

Path as physical object
"Path-to"

Path taken (e.g., trajectory of eclipse)

Path as physical object
"Path-through"

Physical realization of an abstract kind of path – a string construction of a topological shortest path
Path Schemas
Path-as-process

Path-as-process
Neurotransmitter activity in the synapse

Path-as-process
"Career path" according to banking industry
Other metaphorical paths

"Safe Path" safe sex advertisement

Giotto's "Ascension"
Operations on path schemas: Interpretation and Composition

Queudrue tries to block Fabiano's path.

The path towards GM crops in the EU will remain blocked until legislation is in place.
Image Schemas
Representation and Reasoning

• Image schemas are only a tantalizing idea until we formalize their representation and semantics, and invent reasoning and learning methods

• The Image Schema Language is a first step
  – Static schemas
    • Composition and Interpretation
  – Dynamic schemas
    • Prediction and learning
ISL lets you *interpret* elements of schemas as other schemas: Locations as containers.
A procedure for creating a new schema, called container-with-capacity, which has a single slot called capacity (defaulting to 1). This new schema is bound to a source --- which must be a location --- as an interpretation.

Create a new schema called a blockage with one slot called blocker, which is by default filled with the source -- the element that's in the target container-with-capacity. Note that this is an interpretation of the source.
Prediction and Learning in the Image Schema Language
(Chang, Cohen, Beal)
Learning operating regions with ESS

Graph showing MOVE-TO schema's behavior, dependent on the existence of "blockage" (distance(J,obj)=0 && rel-bearing(J,obj) < 90)
Summary of ISL

• Static schemas – couple of dozen moderately well worked-out, composition and interpretation supported, no reasoning system, yet, but axiom-like assertions are there.

• Action schemas – ESS algorithm learns operating regions of controllers, boundaries of operating regions are defined by static image schemas (e.g., object directly in front of you). ESS learns regions to minimize the entropy of predicted transitions between regions given controllers.

• Applied to chess boards, ISIS military sim. and Jean's Room
Toward a program – a challenge problem

COA analysis

Ok, but spatial reasoning includes reasoning about action in space, which would require mental simulation, here.
Toward a program – a challenge problem

COA analysis (or AAR) of richly multivariate traces from a simulated COA
– what happened, who did what to whom, when did it happen, what were the immediate consequences, why did it happen, what's apt to happen next…

Storytelling
In English
A conjecture and a bet

Common sense based on reasoning over abstractions, very abstract image schemas ... the formal operational child

Common sense based on reasoning over image schemas ... the pre-operational and concrete operational child

The bet: Starting at the bottom is the fastest way to the top.

Affordances – the first "action in space" representations, the first spatial commonsense, the first composite image schemas ... develops in the first year

Perceptual invariants, Ecological optics, visual routines, innate image schemas ... available at birth or shortly thereafter