

What Is A Knowledge Representation?

6.871 - Lecture 13

Outline

- What Is A Representation?
 - Five Roles
- What Should A Representation Be?
- What Consequences Does This View Have For Research And Practice?
 - One answer to a foundational question
 - The “spirit” of a representation
 - The spirit should be *indulged*□
 - In analysis
 - In system construction
 - The central task of knowledge representation

Terminology and Perspective

- Inference = getting new expressions from old
Not limited to deductive (sound) inference.
- “Knowledge Representation Technologies”:
rules, frames, logic, semantic nets, etc.

What Is a KR?

- 1) It's a surrogate.
A substitute for the thing itself.
- 2) It's a set of ontological commitments.
In what terms should I think about the world?
- 3) It's a fragment of a theory of intelligent reasoning.
 - What is intelligence?
 - What can I infer from what I know?
(i.e., which inferences are sanctioned?)
 - What should I infer from what I know?
(i.e., which inferences are recommended?)

What Is a KR?

4) It's a medium for pragmatically efficient computation.

The computational medium in which thinking is accomplished.

How should I organize information to facilitate that thinking?

5) It's a medium of expression and communication.
A language we use to talk to the machine.

[1] It's A Surrogate

- A stand-in for the object in the real world.
- Operations on the KR substitute for actions in the world.
- Reasoning is itself a substitute for action.
- (Conversely, actions can substitute for reasoning).

[1] It's A Surrogate

- Questions:
 - A surrogate for what?
 - How accurate a surrogate?

[1] It's A Surrogate

- Questions:
 - A surrogate for what? → semantics
 - How accurate a surrogate?

[1] It's A Surrogate

- Questions:
 - A surrogate for what? → semantics
 - How accurate a surrogate? → fidelity

[1] It's A Surrogate

- Questions:
 - A surrogate for what? → semantics
 - How accurate a surrogate? → fidelity
 - More fidelity is not automatically better
 - Perfect fidelity is impossible.

[1] It's A Surrogate

Perfect fidelity is impossible

→ We inevitably lie.

→ Incorrect inferences are inevitable.

Sound reasoning can't save us.

A better representation can't save us.

→ We have already sinned.

→ We may as well be pragmatic about it.

[2] Set of Ontological Commitments

- Surrogates are inevitably imperfect
 - KR selection unavoidably makes an OC.
- Commitment occurs even at the level of the KRT's
 - Diagnosis as rules vs. frames.

[2] Set of Ontological Commitments

- The commitment accumulates in layers
 - EG: medical diagnosis
 - frames → prototypes, defaults, taxonomy
 - prototypes of what?
 - what diseases?

[2] Set of Ontological Commitments

Alcoholism as disease: View comes into question

Saying that standard treatments have not helped many drugs and alcohol abusers, some people on the front lines of treatment are challenging the view of addiction as a disease controlled by biological factors.

The idea that alcoholism is a disease that can be treated like other chronic medical conditions has been doctrine since the 1960s. By the '80s, the biomedical model had become so dominant that many researchers believed it was only a matter of time before a gene for alcoholism would be found.

Now, however, some specialists are backing off from that stand. While biology certainly plays a role in addiction, they say, it isn't the whole or even most of the story. The social and environmental factors behind why people drink or take drugs, as well as their beliefs about how their drug of choice helps them, are just as crucial in understanding and treating addictions, they argue.

“The negative effects of stressful life events, socioeconomic status and unemployment are key factors,” says Emil Chiauzzi, clinical director of addiction services for the Deaconess-Waltham Hospital. “And people do not become addicted only to a drug, but to the drug experience, the rituals involved.”

Adapted from
Boston Globe
4/9/06 p.1

[2] Set of Ontological Commitments

- The commitment accumulates in layers
 - EG: medical diagnosis
 - frames → prototypes, defaults, taxonomy
 - prototypes of what?
 - what diseases?
- Commitment is inevitable
- Commitment is crucial

[3] Fragment of a Theory of Intelligent Reasoning

- What are all the inferences am I permitted to make?
 - Example: classical formal logic; sound inference
 - Other answers
 - Logic: circumscription
 - Rules: plausible inference
 - Frames: good matches, expectations, defaults.

[3] Fragment of a Theory of Intelligent Reasoning

- What are all the inferences am I permitted to make?
 - Logic: sound inference
- Which inferences am I encouraged to make?
 - Example: Frames
 - What reasoning to do: anticipatory matching
 - Other examples
 - SN: propagation; links.
 - Rules: chaining; associations.
 - Logic: lemmas; connection graphs.
 - Combinatorial explosions
 - the need for guidance on what we *should* do, not only what we *can* do.

[4] Medium for pragmatically efficient computation

- Reasoning with KR means computing with it.
- The pendulum swing
 - Heuristic adequacy (1969)
 - The logicist view (circa 1974)
 - The computational imperative view (circa 1984)

[4] Medium for pragmatically efficient computation

- The pragmatics of it: How can I organize information to facilitate reasoning?
 - Example:
Frames — triggers, procedural attachment, taxonomic hierarchies

[5] Medium of Expression and Communication

- It's how we say things about the world.
- It's how we communicate with the reasoner.
- In principle, as a medium of expression:
 - How general, how precise?
 - Does it provide expressive adequacy?
- In practice, as a medium of communication:
 - How transparent is it?
Can we understand what's been said?
Can we generate the right expression?

What *Should* A Representation Be?

1) Surrogate: imperfect fidelity

→ incorrect inference is inevitable

→ take a pragmatic view of soundness/efficiency

2) Ontological commitment

Unavoidable

One of the most important things a KR can supply

A source of power

Insufficiently explored (but this is changing)

Important at the tool level

What *Should* A Representation Be?

3) Theory of intelligent reasoning

Representations should inform the reasoner about what inferences should be encouraged

What *Should* A Representation Be?

- 4) Medium of pragmatically efficient computation
 - In real use: average time complexity matters.
 - Doing well most of the time on problems actually encountered
 - In real use: worst cases need not be fatal.
 - Coroutine-style resource-limited comp'n is interruptible
 - freedom from requiring guarantees
 - Representation should inform the reasoner about how to organize information to make the encouraged inferences inexpensive, on average.
 - data structures
 - Ex: a-k-o assertions vs a-k-o links

What *Should* A Representation Be?

5. Medium of expression and communication

- “Possible” vs. reasonably obvious and natural.

What *Should* A Representation Be?

- All five roles matter.
- The five roles characterize the “spirit” of a representation.
- The spirit should be indulged, not overcome.
 - “Programming the representation”
 - If it doesn't fit naturally, design a new one.

What *Should* A Representation Be?

Every representation is only one of several possible approximations to reality.

→ there is no one right one

→ one or another may be better suited to a specific task

→ need to connect representation to the reasoning to the task

→ Let the domain tell you:

a good set of abstractions (ontology)

which inferences are needed/recommended

→ Build those abstractions into the language

→ Make the recommended inferences easy

What *Should* A Representation Be?

- There's significant power in attending to the domain.
- Domain independent languages are overlooking an important source of power.

Summary

- What Is A Representation
 1. It's a surrogate, one of several approximations.
 2. It's a set of ontological commitments.
 3. It's a fragment of a theory of intelligent reasoning.
 4. It's a medium for pragmatically efficient computation.
 5. It's a medium of expression and communication.

Summary

- What Should A Representation Be?
 - Pragmatic in its view soundness and efficiency.
 - Strong in ontological commitment.
 - Pluralistic in defining sanctioned inferences.
 - Effective in recommending inferences and organizing information.
 - Efficient in the average case (pragmatic efficiency)
 - Effective as a medium of communication.
 - Supported by guarantees but not limited by them.
 - Focused on the world.
 - Rich in abstractions matched to the task.
 - Indulged.

Summary

- Fundamental task of KR:
Capturing the richness of the natural world.