Computer Science 4150
Artificial Intelligence
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Instructor:
Nick Cercone - CSBldg 105
902-494-2832 - nick@cs.dal.ca

What is a Knowledge Representation [KR]?

Expressive Power versus Notational Efficacy versus Efficiency

Five Distinct Roles for a KR:

1. *a surrogate - a substitute for the thing itself*

The unfortunate dichotomy - reasoning is a process that goes on internally about most things that exist only externally - is a fundamental rationale and role for a representation. It functions as a surrogate inside the reasoner. Operations on and with representations substitute for operations on the real thing. Thus reasoning is a surrogate for action in the world when we cannot or do not (yet) want to take that action.

This discussion leads naturally to two questions: what is the correspondence between the surrogate and its intended identity and how close is the surrogate to the real thing (*fidelity*)? The *semantics* of the representation is the correspondence.

All representations are imperfect and any imperfection can lead to error or be a source of error.

2. *a set of ontological commitments*

The commitments we make, the unavoidable decisions about how and what we see in the world means making a set of ontological commitments. These commitments and their focussing-blurring effect are not an incidental side effect of the representation choice; they are its essence. A judicious selection of commitments provides the opportunity to focus attention on aspects of the world that we believe to be relevant. The focussing part is an essential part of what the representation offers because of the overwhelming complexity of the natural world, cf. the *frame problem*.

3. *a fragmentary theory of intelligent reasoning*

The initial conception of a representation is typically motivated by some insight indicating how people reason intelligently or by some belief about what it means to reason intelligently at all. The theory is fragmentary in two ways: the representation typically incorporates only a part of the insight or belief that motivated it; and this insight or belief is, in turn, only a part of the complex and multifaceted phenomenon of intelligent reasoning. What is intelligent reasoning?

4. *a medium for pragmatically efficient computation*

To use a representation, we must compute with it. As a result, questions about computational efficiency are central to the notion of representation. Along with their specification of set of recommended inferences, representations typically offer a set of ideas about how to organize information in ways that facilitate making those inferences, e.g. semantic networks and their suggestive associative processing nature or frames and their chunking of relevant information. The notion of

triggers and procedural attachment in frames is not so much a statement about what procedures to write (the theory is rather vague here) as it is a description of a useful way to organize information about how to use the frame, for example, attach to each frame information about how to use the frame and what to do if expectations are not confirmed. Similarly, organizing frames into taxonomic hierarchies suggests taxonomic reasoning and facilitates its execution (as in structured inheritance networks).

Math/Logic	Psych.	Biology	Stats.	Econ.
Aristotle				
Descartes				
Boole	James		Laplace	Bentham
				Pareto
Frege			Bernoullii	Friedman
Peano				
	Hebb	Lashley	Bayes	
Goedel	Bruner	Rosenblatt		
Post	Miller	Ashby	Tversky	Von Neumann
Church	Newell	Lettvin	Kahneman	Simon
Turing	Simon	McCulloch, Pitts		Raiffa
Davis		Heubel, Weisel		
Putnam				
Robinson				
Logic **PROLOG**	**SOAR** **KBS, Frames**	**Connectionism**	**Causal Nets**	**Rational Agents**

5. *a medium of human expression*

This role for representations is inevitable as long as we need to tell the machine (or other people) about the world and as long as we do so by creating and communicating representations. [it will presumably continue to be useful even if machines invent their own knowledge representations based on independent experience of the world; if their representations become incomprehensible to us, the machines will be unable to tell us what they know or explain their conclusions]. Various questions are presented as a result of this role: How well does a representation function as a medium of expression? How general is it? How precise? Does it provide expressive adequacy? How well does it function as a medium of communication?

These five roles create multiple, sometimes competing demands, requiring selective and intelligent trade-offs among the desired characteristics.