What is a knowledge representation?*

1. Surrogate (a substitute for the thing itself)
2. Set of ontological commitments (in what terms should I think about the world?)
3. Fragmentary theory of intelligent reasoning
4. Medium for pragmatically efficient computation
5. Medium of human expression

*Thanks to Ana Maguitman

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Role 1: A K. R. Is a Surrogate

- A representation functions as a surrogate inside the reasoner, a stand-in for the thing that exists in the world.
- There must be some correspondence specified between the surrogate and its intended referent in the world
- Fidelity
  - How close, what's kept, what's omitted

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Role 2: A K.R. Is a Set of Ontological Commitments

- Commitment to a representation technology
- Commitment to a content
- A K.R. is not only a data structure:

  In AI, a representation of knowledge is a combination of data structures and interpretative procedures that, if used in the right way in a program, will lead to "knowledgeable" behavior. [Handbook of Artificial Intelligence Vol. 1, ed. Barr, Avron and Feigenbaum]

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Role 3:A K.R. Is a Fragmentary Theory of Intelligent Reasoning

- The theory (partially) answers:
  - What does it mean to reason intelligently?
  - What can we infer from what we know?
  - What *ought* we infer from what we know?

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Role 3:A K.R. Is a Fragmentary Theory of Intelligent Reasoning

Mathematical Logic	Psychology	Biology	Statistics	Economics
Aristotle				
Descartes				
Boole	James		Laplace	Bentham Pareto
Frege Peano			Bernoullii	Friedman
Goedel Post Church Turing Davis Putnam Robinson	Hebb Bruner Miller Newell, Simon	Lashley Rosenblatt Ashby Lettvin McCulloch, Pitts Heubel, Weisel	Bayes Tversky, Kahneman	Von Neumann Simon Raiffa
Logic PROLOG	SOAR KBS, Frames	Connectionism	Causal Networks	Rational Agents

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Role 4: A K.R. Is a Medium for Efficient Computation

- Need structures that facilitate search (indexed data, frames, graphs, trees, etc.)
- Also need procedures that allow efficient manipulation of these data structures (resolution, heuristic search, etc.)

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Role 5: A K.R. Is a Medium of Human Expression

- How well does the representation function as a medium of expression?
- How general is it?
- How precise?
- Does it provide expressive adequacy?

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Simple KR Example: Story (Nursery Rhyme) Understanding

(thanks to Maguitman et al.)

- Early AI work on understanding focused on children's stories
- Motivation: Simplicity
- Realization: Not so simple
- Talking dogs: fine
- Flying dogs: Not so fine

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Little Miss Muffet

Little Miss Muffet
Sat on her tuffet
Eating her curds and whey;
Along came a spider
Who sat down beside her
And frightened Miss Muffet away

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Little Jack Horner

Little Jack Horner
Sat in the corner
Eating a Christmas pie,
He put in his thumb
And pulled out a plum
And said “what a good boy am I”.

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Breakout Groups (10 min)

- Come up with a first definition of what it means to “understand” a story
- In the remaining time, write background facts and inference rules needed to understand Little Miss Muffet
- The Miss Muffet story is available on canvas via a link on the syllabus

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What does it Mean to Understand a Story?

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Illustration of One Approach

- Working definition: Understanding = making causal connections
- Note:
  - The example focuses on types of knowledge and connections---*not* the selection or naming of primitives
  - We'll examine those with conceptual dependency theory, coming next).

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What background knowledge is needed? How did you represent it?

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Some basic facts:

food(curds-and-whey).
insect(spider).
food(christmas-pie).
food(plum).
is-in(plum,christmas-pie).

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What are Some Rules?

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Basic domain "rules"

hungry(X) => desire-to-eat(X).
desire-to-eat(X) => eat(X).
eating(X,Y) -> eat(X).
eating(X,Y) -> food(Y).
scared(X) => run-away(X).
scary(X) & close-to(X,Y) -> scared(Y).
insect(X) -> scary(X).
tired(X) => desire-to-sit(X).
desire-to-sit(X) => sit(X).
desire-to-eat(X) => desire-to-sit(X).

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Basic domain "rules" (cont.)

sit-in(X,Y) -> sit(X).
sit-on(X,Y) -> sit(X).
close-to(X,Y) <-> close-to(Y,X).
in(X,Y) & food(Y) -> food(X).
eating(X,Y) & is-in(Z,Y) -> eating(X,Z).
says(X,Y, good-boy) -> good-boy(Y).
extracted(X,Y,Z) => posses(X,Y).
possess(X,Y) & food(Y) & desire-to-eat(X) =>
eating(X,Y).
want(X,Y) => extracted(X,Y,Z).
extracted(X,Y,Z) -> want(X,Y).
possess(X,Y) & want(X,Y) -> good-boy(X).

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Story Specific Knowledge for *Little Miss Muffet*

sit-on(muffet, tuffet).
eating(muffet, curds-and-whey).
move-towards(muffet, spider).
close-to(muffet, spider).
sit(spider).
scared(muffet).
run-away(muffet).

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Story Specific Knowledge for *Little Jack Horner*

sit-in(horner, corner).
eating(horner, christmas-pie).
inserted(horner, horners-thumb, christmas-pie).
extracted(horner, plum, christmas-pie).
possess(horner, plum).
says(horner, horner, good-boy).

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?- why(run-away(muffet)).

insect(spider) is a fact.
insect(spider) implies scary(spider)
close - to(spider,muffet) is a tentative fact.
scary(spider) and close - to(spider,muffet) implies scared(muffet)
scared(muffet) causes run - away(muffet)

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?- why(eat(horner)).

possess(horner,plum) is a fact.
food(plum) is a fact.
hungry(horner) is a tentative fact.
hungry(horner) causes desire - to - eat(horner)
possess(horner,plum) and food(plum) and desire - to - eat(horner) causes eating(horner,plum)
eating(horner,plum) implies eat(horner)

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