Common Sense Inference

Let’s distinguish between:

• Mathematical inference about common sense situations
  
  Example: Formalize theory of behavior of liquids

• Inference with common sense knowledge
  
  Not too much about this yet
What is (mathematical) inference?

Set of axioms (true assertions about the world)

Inference engine (set of IF-THEN inference rules) that allows you to

Deduce new assertions from the old (forward chaining)

Determine whether a given assertion is true (backward chaining)
Classic example

Birds can fly.
Tweety is a bird.
Therefore... Tweety can fly.
Not-so-classic example

Cheap apartments are rare.
Not-so-classic example

Cheap apartments are rare.
Rare things are expensive.
Cheap apartments are rare.

Rare things are expensive.

Therefore... Cheap apartments are expensive.

So, exactly what was wrong with that??
Common sense inference vs. Mathematical inference

Mathematical inference =

- Exact definitions
- Universally true statements
- Complete reasoning
- Depth-first exploration
- Batch processing
Common sense inference vs. Mathematical inference

Common sense inference =
  Imprecise definitions
  + Contingent statements
  + Incomplete reasoning
  + Breadth-first exploration
  + Incremental processing
Imprecise Definitions

Mathematical inference assumes airtight definitions
Common sense contains fluid definitions
  Context-dependent
  Fuzzy
  Dynamic

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Contingent statements

All birds can fly, except
Penguins, ostriches, dead birds, injured birds,
fictional birds, caged birds, ...

Circumscription
It’s true, unless you know otherwise

Non-monotonic reasoning
It used to be true that all birds can fly, but not now
Incomplete reasoning

Traditional logic looks for

- Consistency (can’t prove a statement and its contradiction)
- Completeness

Common sense inference is neither consistent nor complete
Incremental processing

Most logical formalisms assume a “batch” process
You present assertions, queries, then system cranks
With common sense apps, you might learn stuff while the system is inferring
The user might give you interactive feedback

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Breadth-first exploration

Most logical inference (e.g., resolution theorem proving) is depth-first
Common sense is broad, not deep
What we want is that, if a simple answer exists, we will find it quickly
Best-first or most-relevant-first limits search
If logic is broken, let’s fix it

Non-monotonic logic and default logics
Circumscription, Situation Calculus
  Formalization of Context
Fuzzy logic and probabilistic logics (e.g. Bayesian)
Multiple-valued logic (yes, no, maybe, dunno)
Modal logic (necessary, possible)
Example-based approaches

Go from specific to general rather than general to specific
Programming by Example
Case-Based Reasoning
Reasoning by Analogy
Abduction

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Causal Diversity

Figure 1. Causal-diversity matrix

- Few ↔ NUMBERS OF CAUSES ↔ Many
- Small → Scale of Effect → Large
- Easy Traditional Computing
- Ordinary Qualitative Reasoning
- Symbolic Logic Reasoning
- Linear, Statistical
- Classical AI
- Case-based Reasoning
- Connectionist, Neural Network, Fuzzy Logic
- Analogy-based Reasoning
- Society of Mind
- Intractable

Using magnitudes helps make comparisons by hiding Find better representation

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Maybe combine techniques?
Common Sense vs. Statistical techniques

Some large-scale, IR, numerical and statistical techniques have achieved success recently

Will statistical techniques “run out”?  

Not necessarily opposed to knowledge-based approaches

Could we use these techniques to “mine” Common Sense knowledge?
Implicit Inference

Do Aria, Empathy Buddy, Goose, etc. do Common Sense Inference?

Yeah, but maybe not explicitly

Use application context to perform limited inference
There’s now a movement to make “The Semantic Web” -- turn the Web into the world’s largest knowledge base.

Could this be a vehicle for capturing or using Common Sense?

We’ve got to untangle the Semantic Web formalisms.

Could this be a way to integrate disparate Common Sense architectures (to solve the software eng. problems of Minsky’s proposals)?