

## Common Sense Inference

# 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?

## 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

### Classic example

Birds can fly.

Tweety is a bird.

Therefore... Tweety can fly.

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**Not-so-classic example**

# Not-so-classic example

Cheap apartments are rare.

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Not-so-classic example

## Not-so-classic example

Cheap apartments are rare.

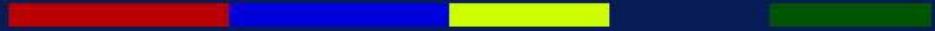
Rare things are expensive.

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Not-so-classic example

## Not-so-classic example



Cheap apartments are rare.

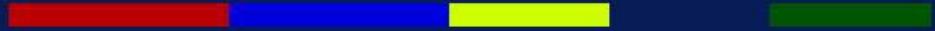
Rare things are expensive.

Therefore... Cheap apartments are expensive.

So, exactly what was wrong with that??

## Common sense inference vs. Mathematical inference

# Common sense inference vs. Mathematical inference



**Mathematical inference =**

- Exact definitions**
- + Universally true statements**
- + Complete reasoning**
- + Depth-first exploration**
- + Batch processing**

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Common sense inference vs. Mathematical inference

## Common sense inference vs. Mathematical inference



Common sense inference =

- Imprecise definitions
  - + Contingent statements
  - + Incomplete reasoning
  - + Breadth-first exploration
  - + Incremental processing
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## Imprecise Definitions

# Imprecise Definitions

Mathematical inference assumes airtight definitions

Common sense contains fluid definitions

Context-dependent

Fuzzy

Dynamic

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## Contingent statements

# 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

# Incomplete reasoning

Traditional logic looks for

Consistency (can't prove a statement and its contradiction)

Completeness

Common sense inference is neither consistent nor complete

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## Incremental processing

# 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

# 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

## 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)

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## Example-based approaches

# Example-based approaches

Go from specific to general rather than general to specific

Programming by Example

Case-Based Reasoning

Reasoning by Analogy

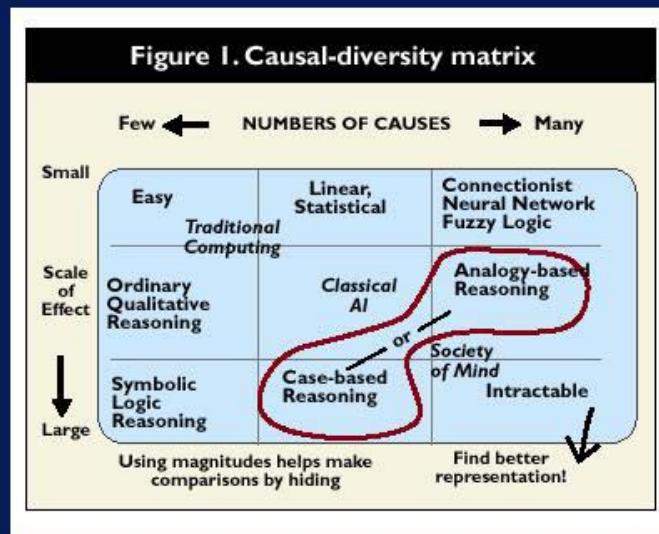
Abduction

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## Causal Diversity

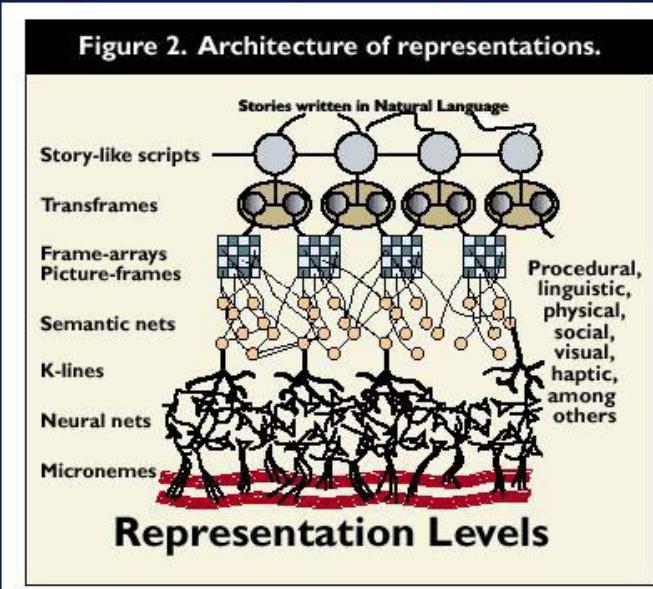
# Causal Diversity



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Maybe combine techniques?

## Maybe combine techniques?



## Common Sense vs. Statistical 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?

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## Implicit Inference

# Implicit Inference

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

Yeah, but maybe not explicitly

Use application context to perform limited inference

## Common Sense and the Semantic Web



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)?

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