6.034

Representing Knowledge

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Outline

- What does it mean to *represent knowledge*?
  - Classes
  - Trajectories
  - Transitions
- What does it mean to do it in a way that people understand it?
- Why does that matter?
- The evolution of symbolic thought

Major ideas

★ Regularities in the way *we* think about the world help us represent it to machines

To Date…

- Problem Solving Methods
  - Goals trees, search, constraint propagation
- Learning
  - Nearest neighbors, ID trees, neural nets, SVM, sparse spaces, genetic algorithms
- Knowledge Representations
  - Rules, ID trees, constraints, neural nets

Knowledge Representations

- Rules
  - IF (AND((?y) is a bird, (?y) cannot fly,
    (?y) can swim)
    THEN ((?y) is a penguin))
- ID trees
- Constraints

Knowledge Representations

- Neural nets
  - Wired: *Google's artificial brain learns to find cat videos.* [Aug 2012]

WIRED STAFF SCIENCE 06.26.12 11:15 AM

GOOGLE'S ARTIFICIAL BRAIN LEARNS TO FIND CAT VIDEOS

BY LIAT CLARK, *Wired UK*

When computer scientists at Google's mysterious X lab built a neural network of 16,000 computer processors with one billion connections and let it browse YouTube, it did what many web users might do — it began to look for cats.

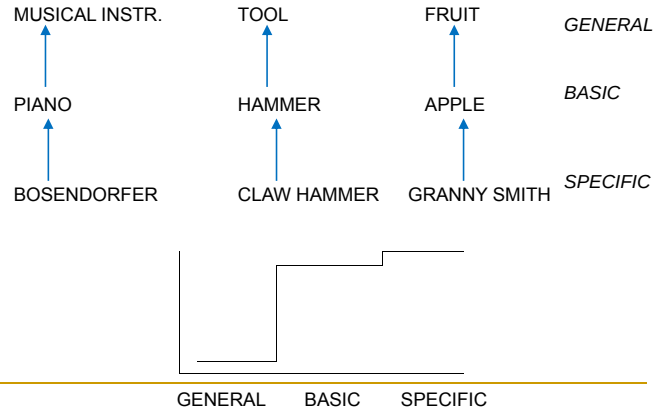
In fact…

- It learned to *recognize* a *still image, full-frontal view of a cat face* when shown one.
- "The same network that hit on our concept of cat also became enthusiastic about a pattern that looked like some sort of furniture-animal compound, like a cross between an foot stool and a goat." *NY Times,* 14 Dec 2016
- What does it *understand*?

Some Motivation

- Classes of objects
- Transitions: change → change
- Common structures
  - Things: games
  - Events: *Makenzie comforted Duncan*.
- Trajectories / actions

Knowledge Representation: Classes



Knowledge Rep'n: Transitions

The car crashed into the wall

	Before	At Crash	After
Speed of car	¬Δ	D	¬A
Dist to wall	↓	D	¬Δ
Car condition	¬Δ	Δ	¬Δ

Vocabulary: Change, Disappear, Appear, Increase, Decrease
Not

Knowledge Rep'n: Transitions

Taking a picture

	Before	At Contact	After
Speed of photon	¬Δ	D	¬A
Dist to sensor	↓	D	¬Δ
Sensor condition	¬Δ	Δ	¬Δ

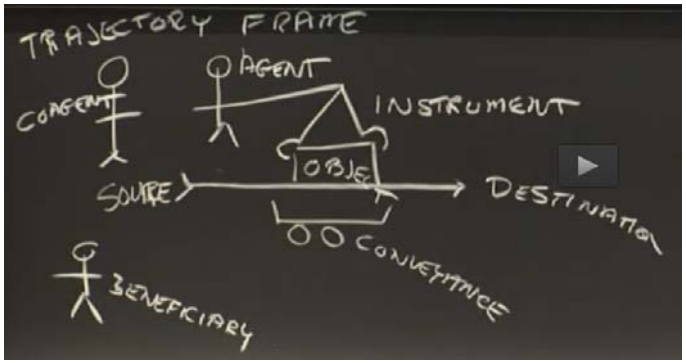
Frames: Common Patterns

Game

Team sports
- Rules:
- Sides:
- # Players:
- Scoring:

Baseball

Knowledge Rep.: Actions



Does it work?

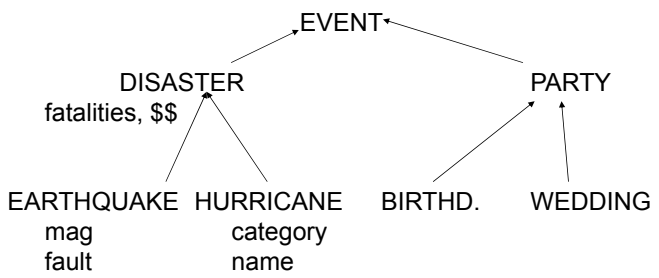
- Empirical test
  - WSJ corpus: 50,000 sentences
  - In 100 of them
    - 25 transitions/trajectories
    - *Prices rose, …*

Putting some pieces together

- *Mackenzie comforted Duncan*

Action frame
Agent:
Action:
Object:
Result
- *Mackenzie terrorized Duncan*
- *Mackenzie kissed Duncan*
- *Mackenzie stabbed Duncan*

Frame Hierarchies



Children's Stories

Robbie and Suzie were going to Marvin's birthday party. One of them wanted to buy a kite. "Be he has one," he said, "he will make you take it back."

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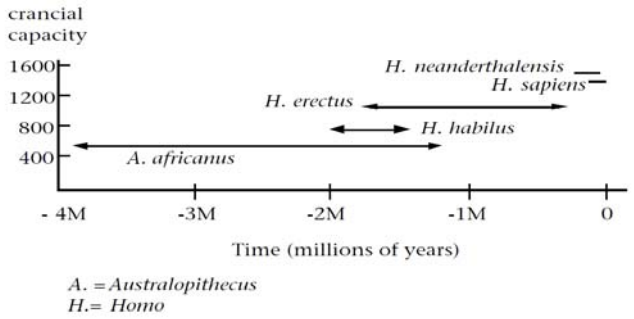
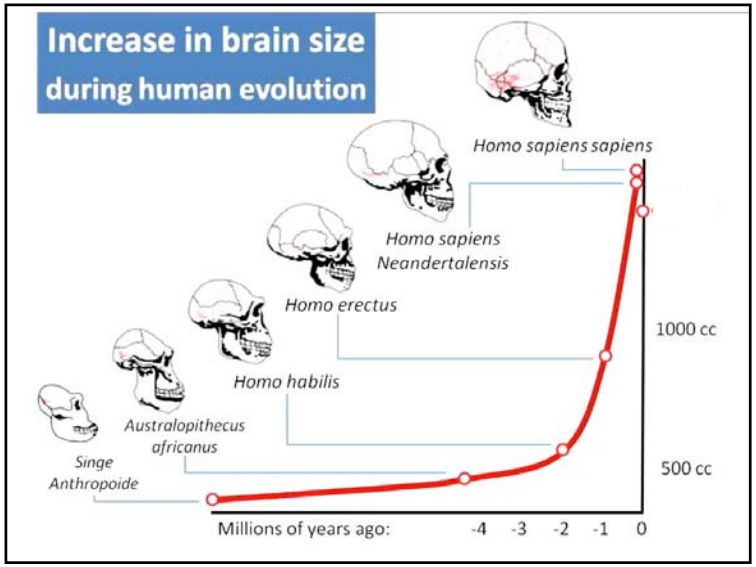
Works the other way around

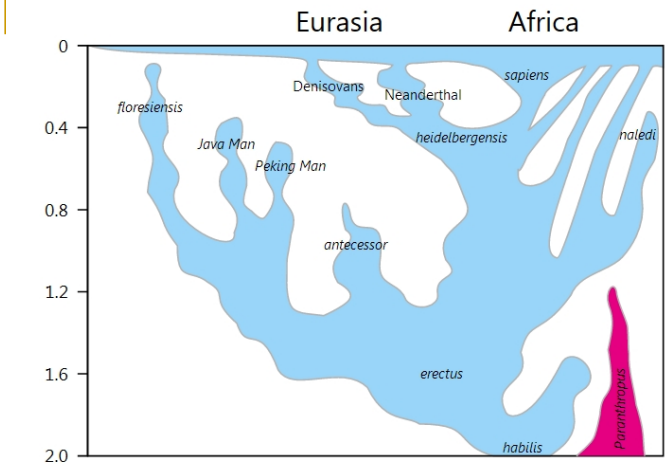
- Frames enable understanding in understanding text
- Frames enable understanding in *producing* text

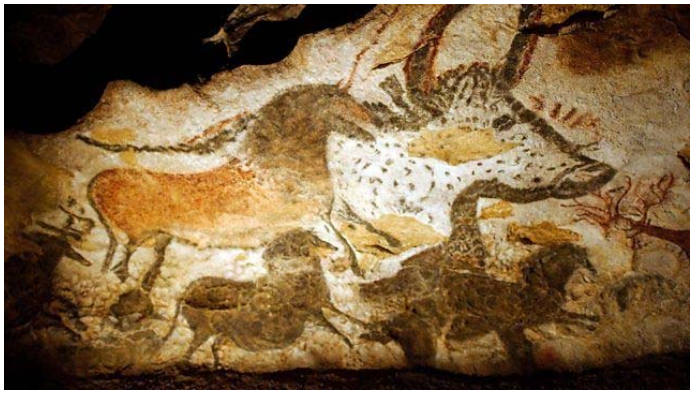
The *Really* Bigger Picture

- What makes *homo sapiens* different from its predecessors in the tree?
- What enabled its remarkable success in spreading around the planet?









REPRESENTATION
RE-PRESENTATION

What good are symbols?

- Communication
- Transmission of knowledge

- Accumulation of knowledge
  - Education
  - Civilization