

# FUBON CENTER

## AI IN BUSINESS SPEAKER SERIES

*Demystifying AI and Machine Learning:  
What You Need to Know*

*Dr. Pedro Domingos in conversation with Prof. Foster Provost*

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# Demystifying AI and Machine Learning

## What You Need to Know

**Pedro Domingos**  
University of Washington / D. E. Shaw

# What Is Artificial Intelligence?

**AI** = Getting computers to perform tasks that previously required human intelligence

- Reasoning and problem-solving
- Common-sense knowledge
- Planning
- Learning
- Speech and language
- Vision
- Navigation and manipulation
- Etc.

# The Two Eras of AI

- 1960s-1980s: Knowledge-based systems
  - Manually enter all the necessary knowledge
  - Failed because of the knowledge acquisition bottleneck
- 1990s-present: Machine learning
  - Extract the knowledge from data
  - Big data → More intelligence

# So How Do Computers Discover New Knowledge?

1. Fill in gaps in existing knowledge
2. Emulate the brain
3. Simulate evolution
4. Systematically reduce uncertainty
5. Notice similarities between old and new

# The Five Tribes of Machine Learning

Tribe	Origins	Master Algorithm
Symbolists	Logic, philosophy	Inverse deduction
Connectionists	Neuroscience	Backpropagation
Evolutionaries	Evolutionary biology	Genetic programming
Bayesians	Statistics	Probabilistic inference
Analogizers	Psychology	Kernel machines

# Symbolists



Tom Mitchell



Steve Muggleton



Ross Quinlan

# Inverse Deduction

Addition

$$\begin{array}{r} 2 \\ + 2 \\ \hline = ? \end{array}$$

Subtraction

$$\begin{array}{r} 2 \\ + ? \\ \hline = 4 \end{array}$$

# Inverse Deduction

## Deduction

Socrates is human  
+ Humans are mortal .

---

= ?

## Induction

Socrates is human  
+ ?

---

= Socrates is mortal

# Spot the Biologist in this Picture



# Connectionists



Yann LeCun

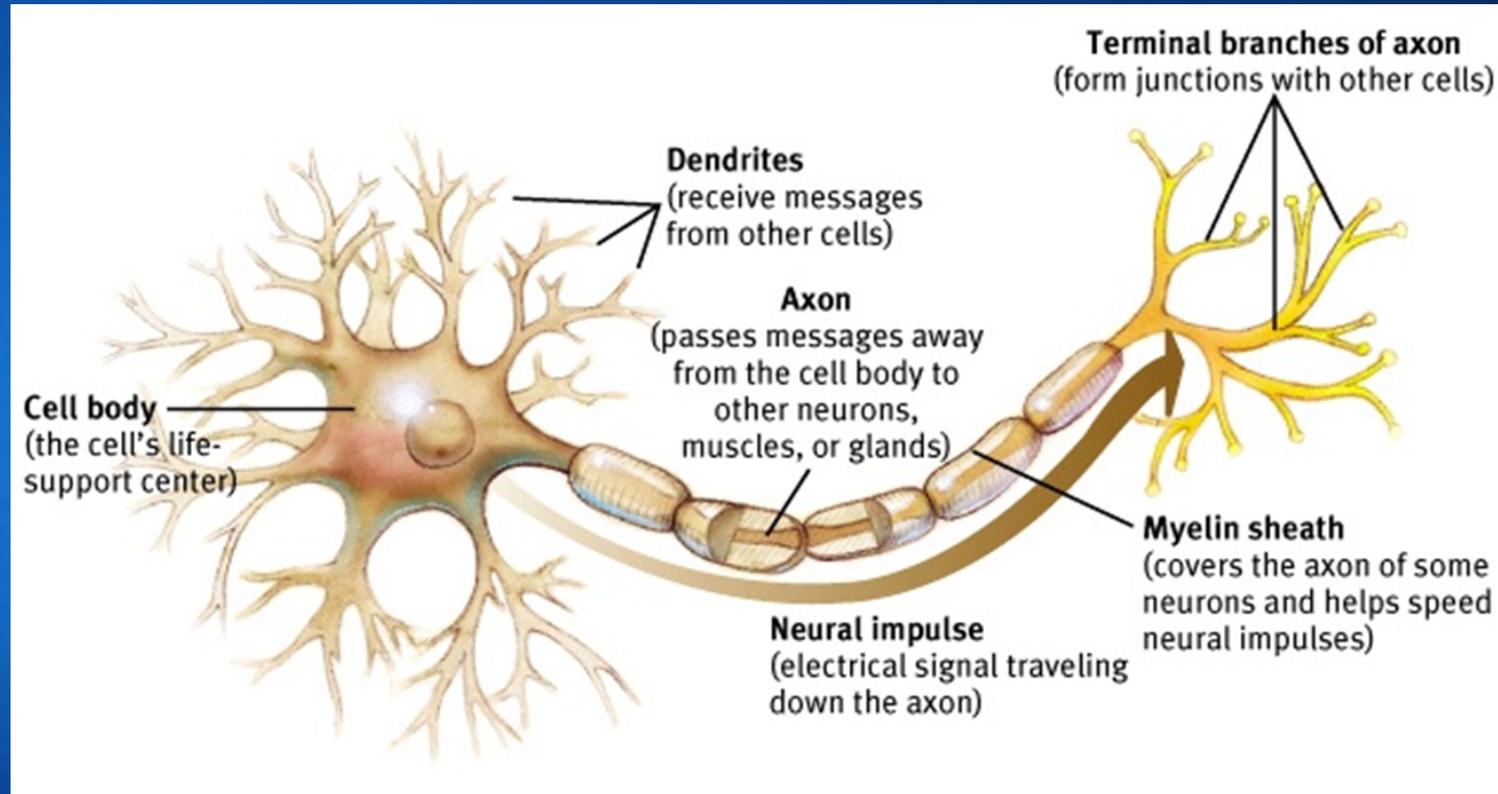


Geoff Hinton

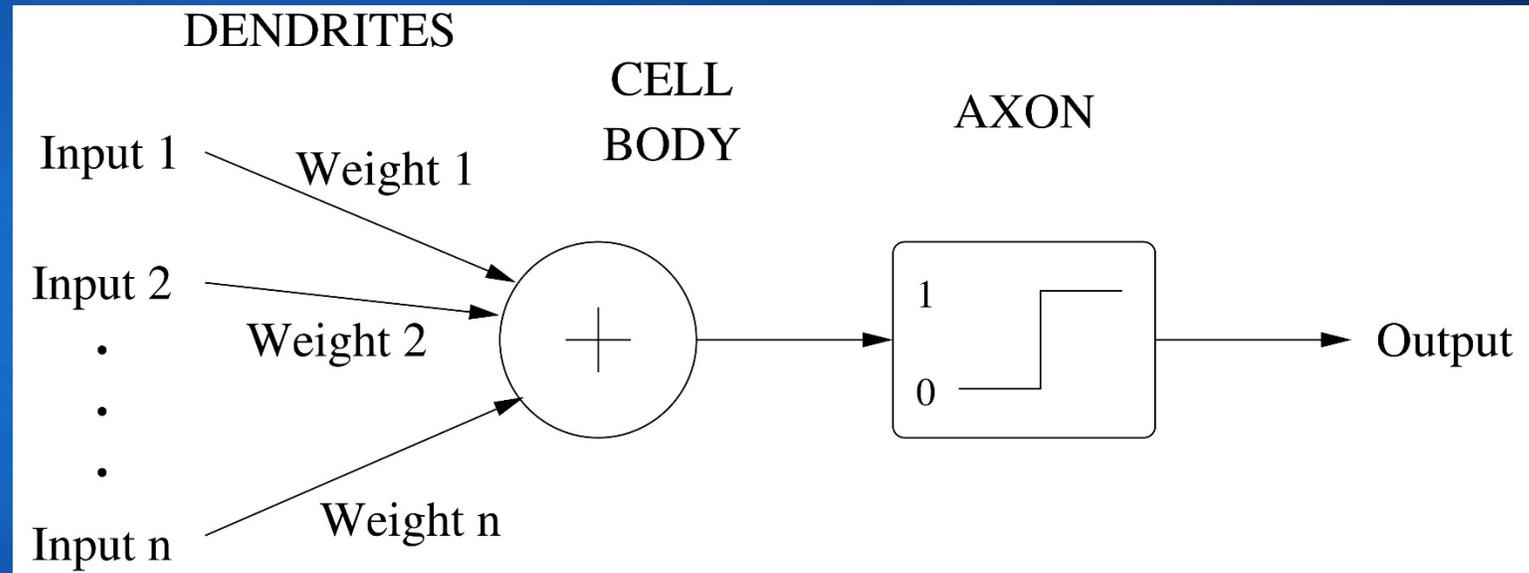


Yoshua Bengio

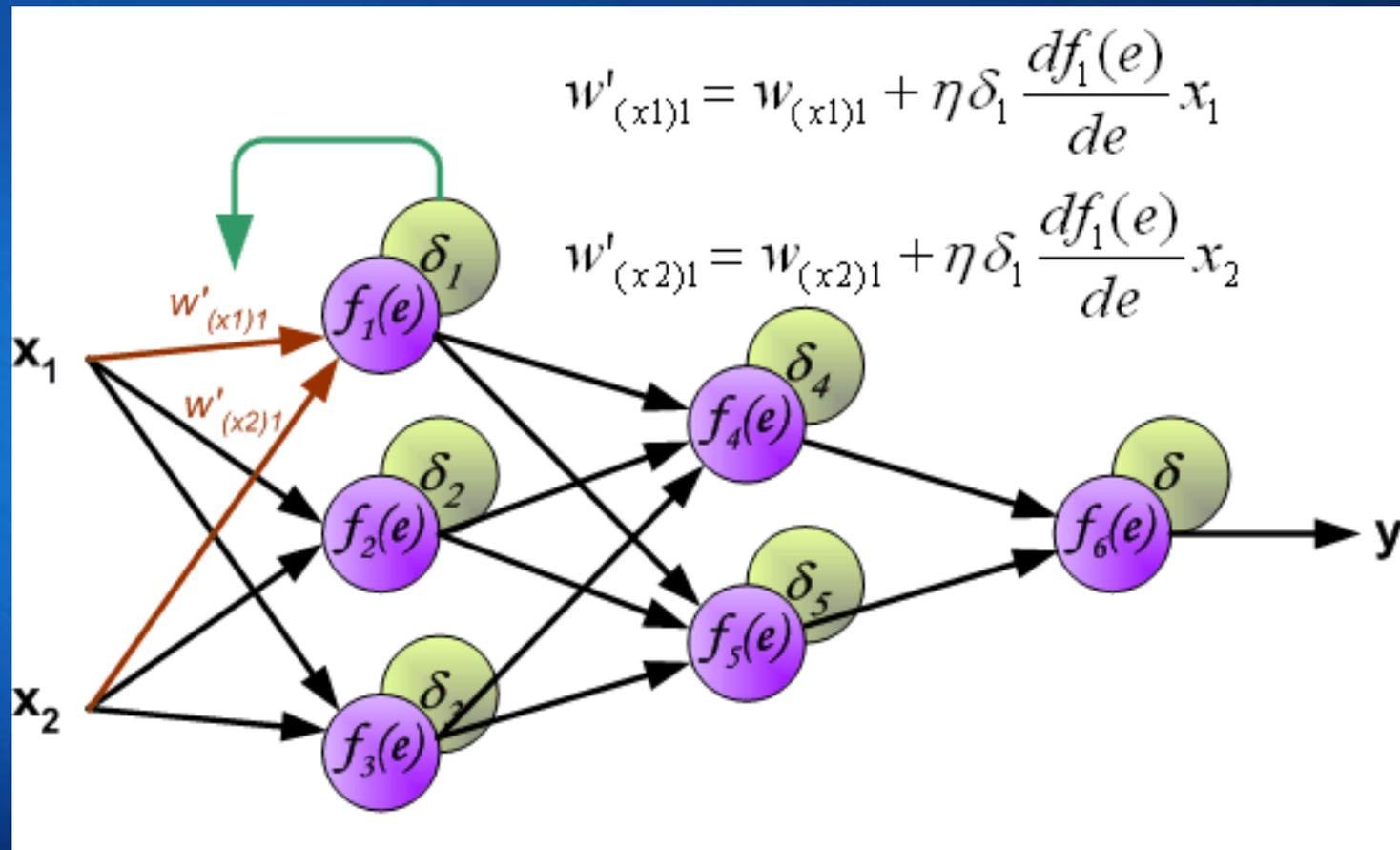
# A Neuron



# An Artificial Neuron



# Backpropagation



# The Google Cat Network

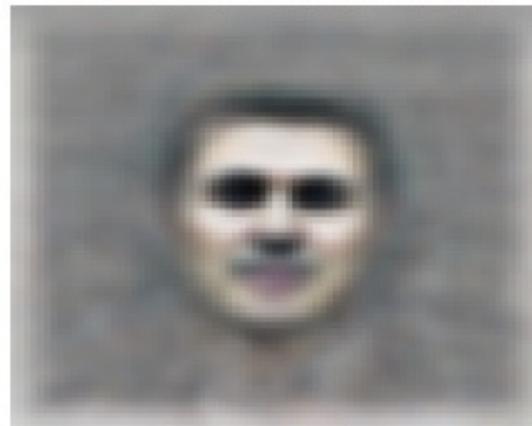
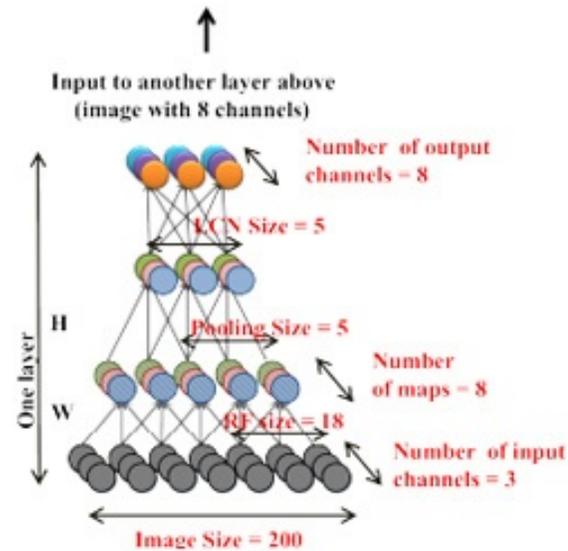


Figure 6. Visualization of the cat face neuron (left) and human body neuron (right).

# Evolutionaries



John Koza

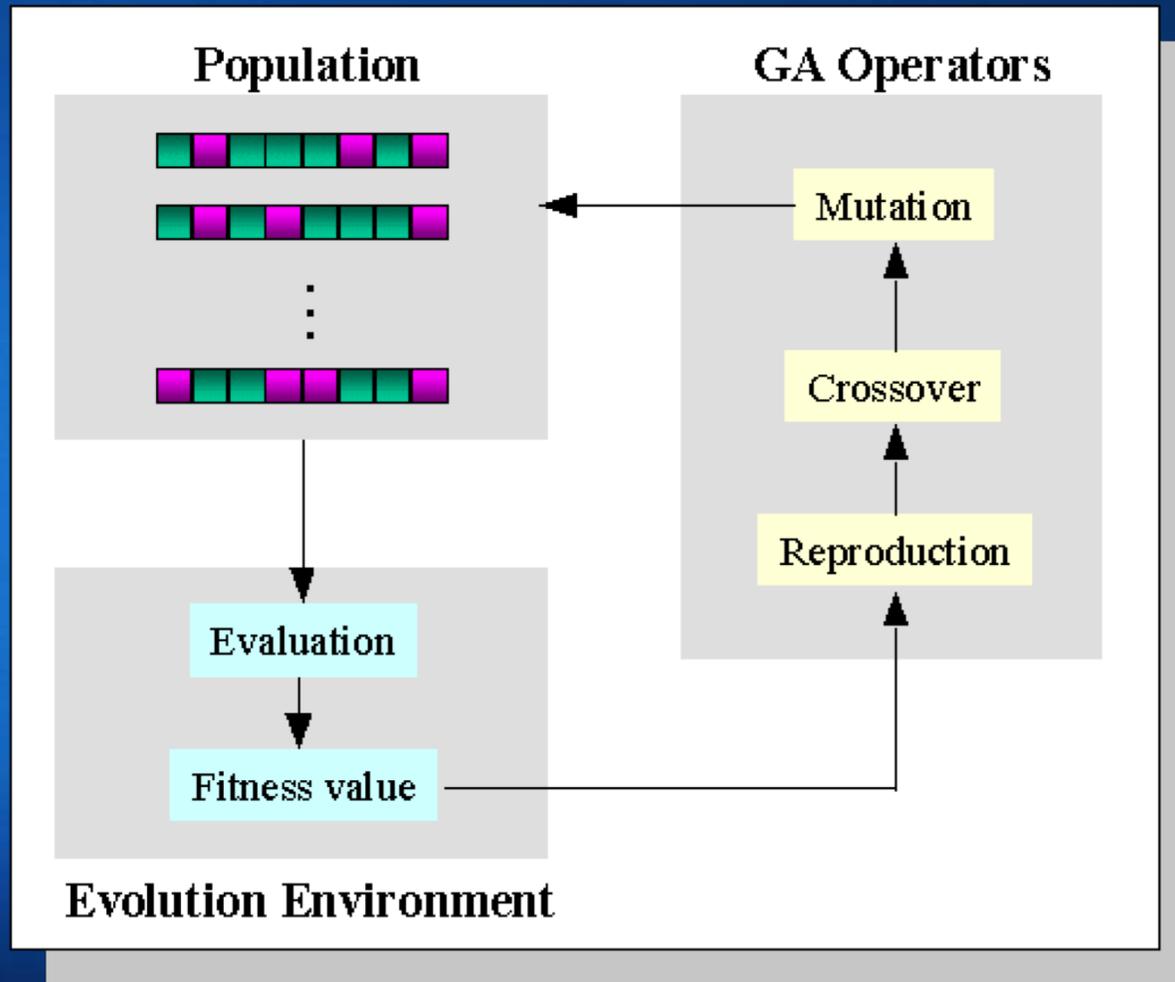


John Holland

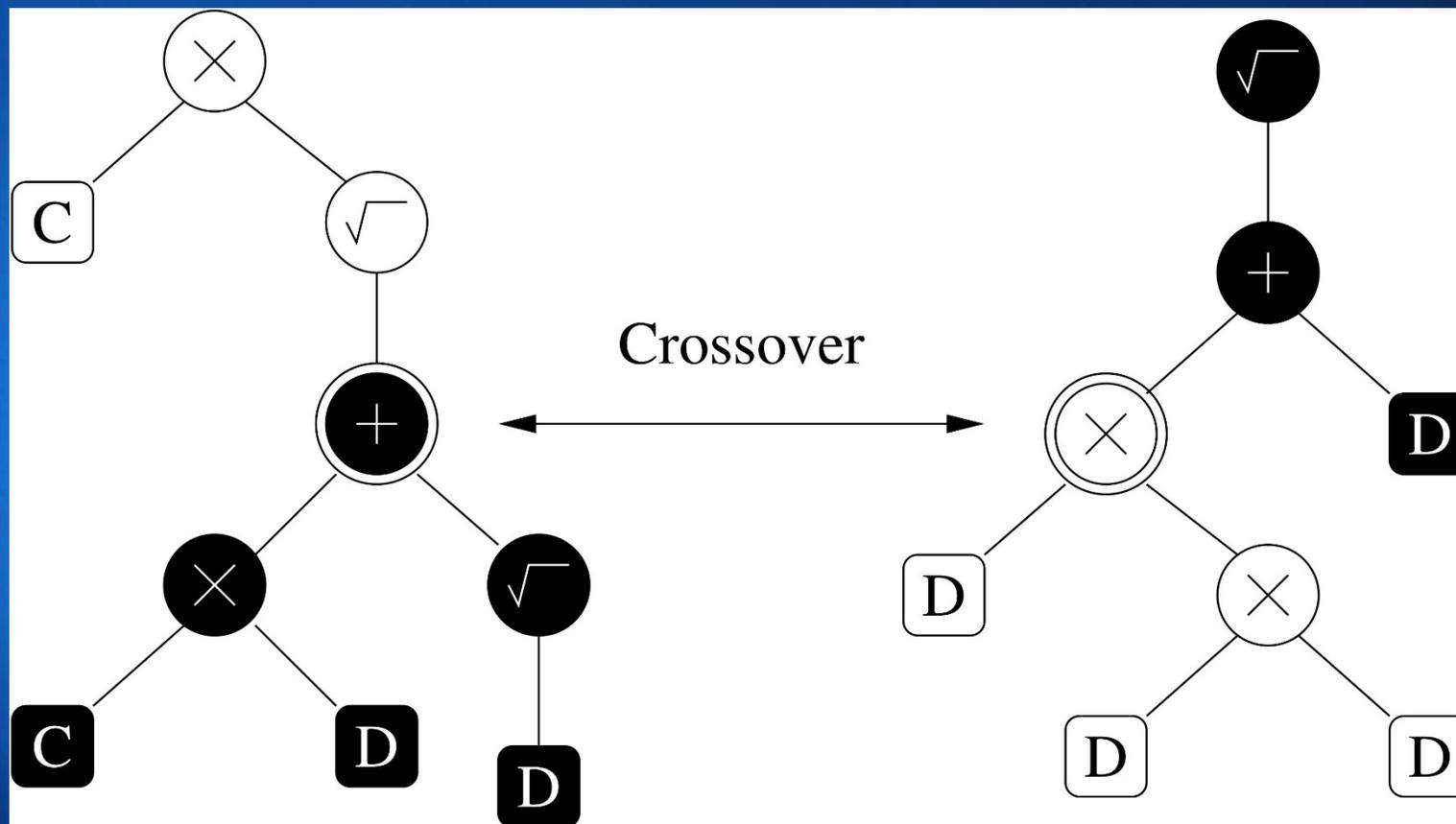


Hod Lipson

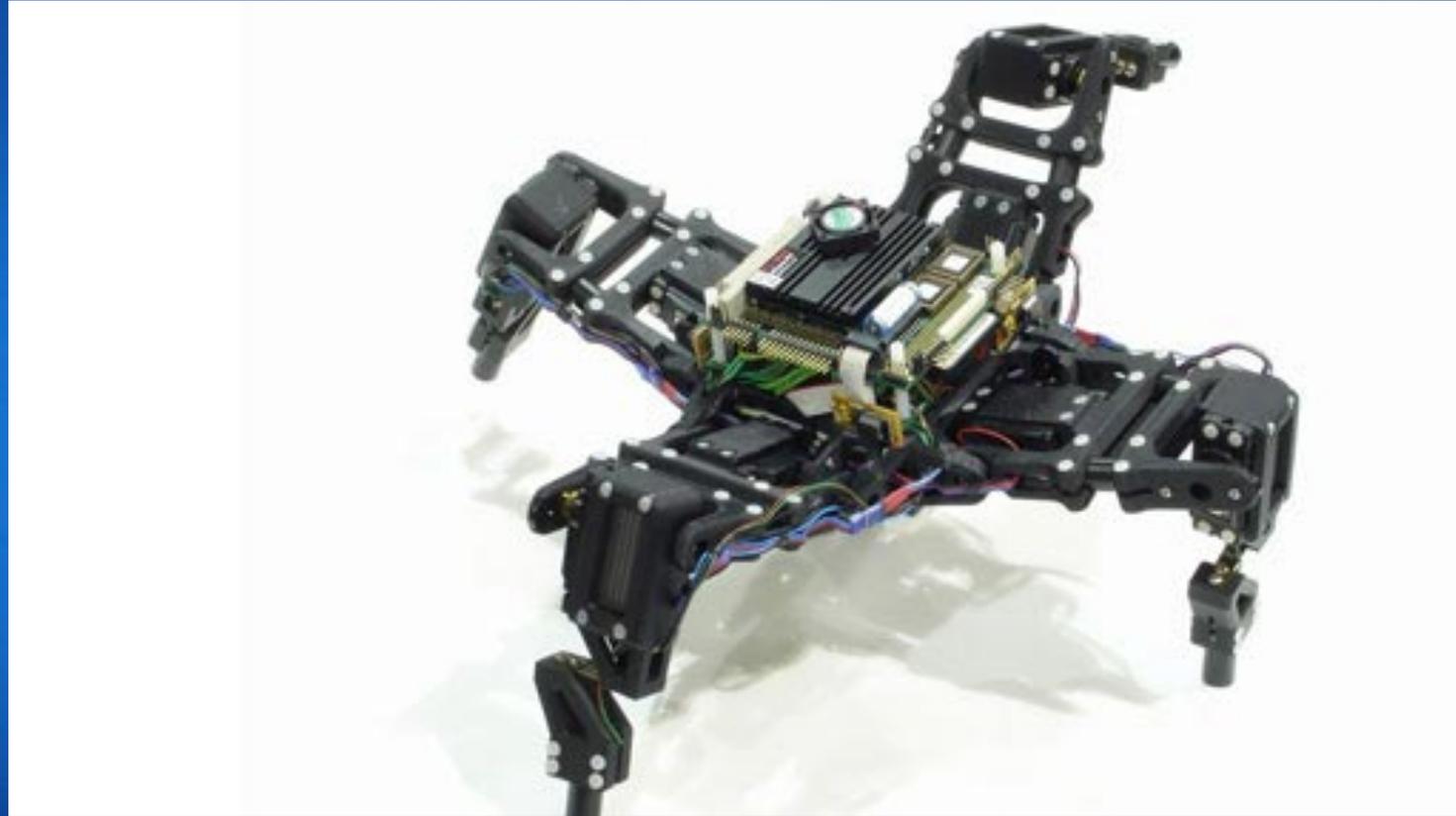
# Genetic Algorithms



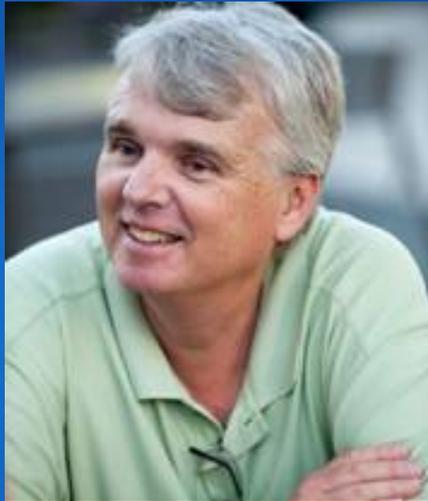
# Genetic Programming



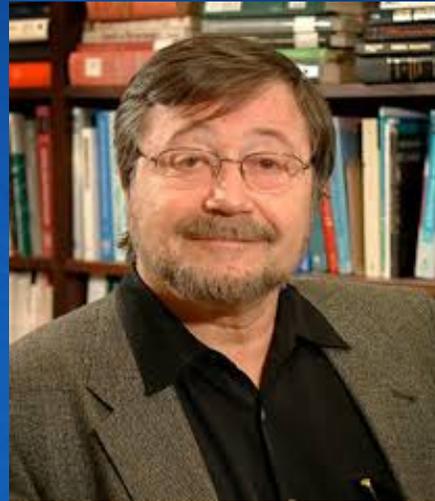
# Evolving Robots



# Bayesians



David Heckerman

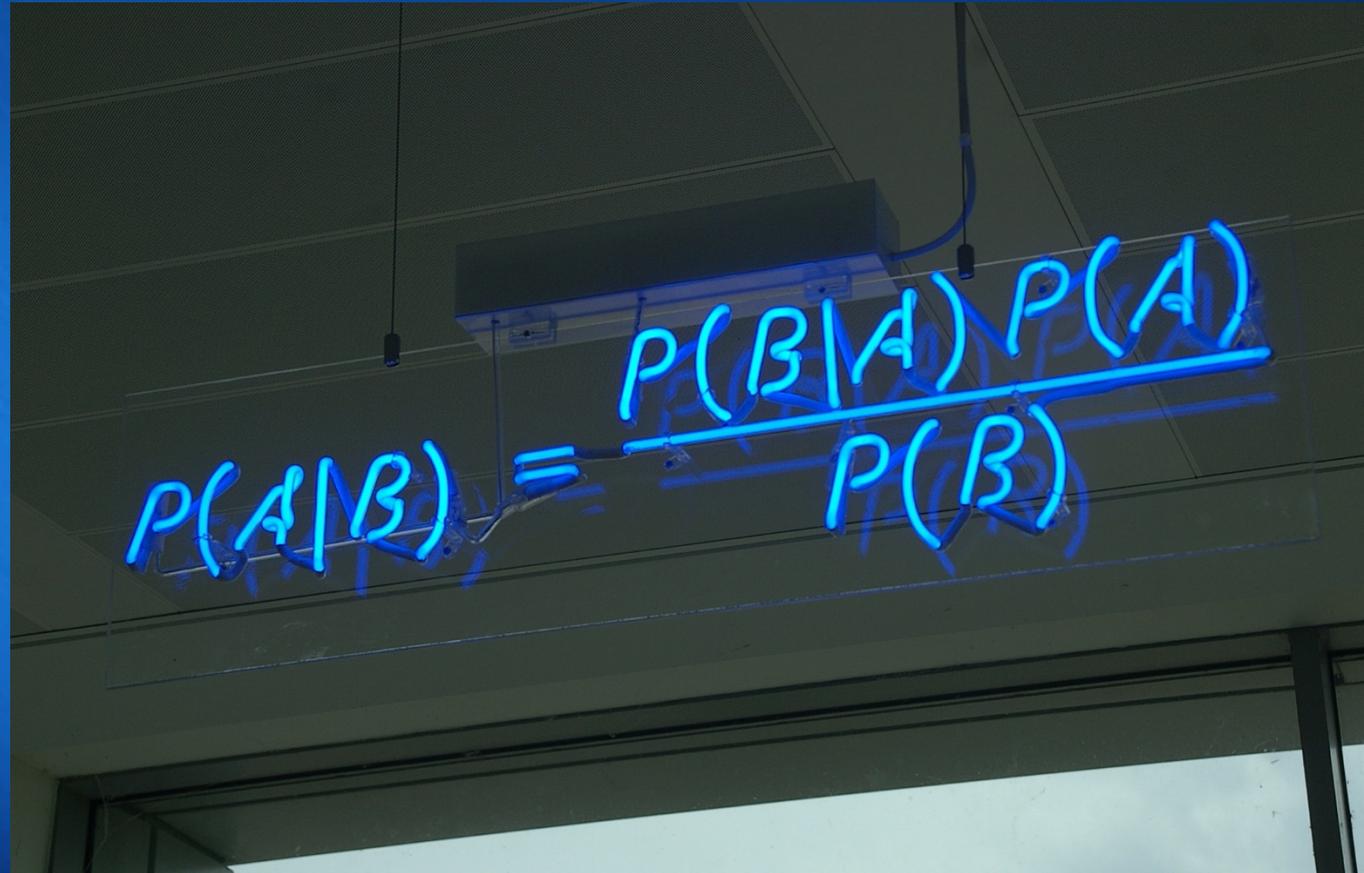


Judea Pearl



Michael Jordan

# Probabilistic Inference

A photograph of a whiteboard with a blue projection of a probability formula. The formula is  $P(A|B) = \frac{P(B|A)P(A)}{P(B)}$ . The whiteboard is mounted on a ceiling, and the projection is from a device above it. The background is a dark blue gradient.
$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

# Probabilistic Inference

## Likelihood

How probable is the evidence given that our hypothesis is true?

## Prior

How probable was our hypothesis before observing the evidence?

$$P(H | e) = \frac{P(e | H) P(H)}{P(e)}$$

## Posterior

How probable is our hypothesis given the observed evidence?  
(Not directly computable)

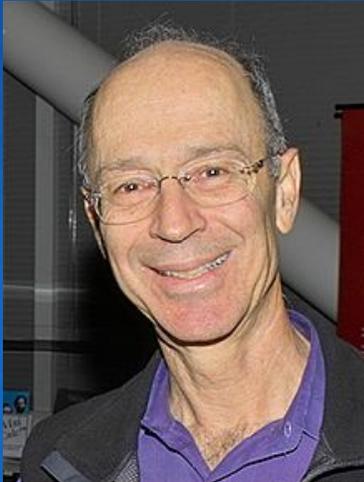
## Marginal

How probable is the new evidence under all possible hypotheses?  
 $P(e) = \sum P(e | H_i) P(H_i)$

# Spam Filters



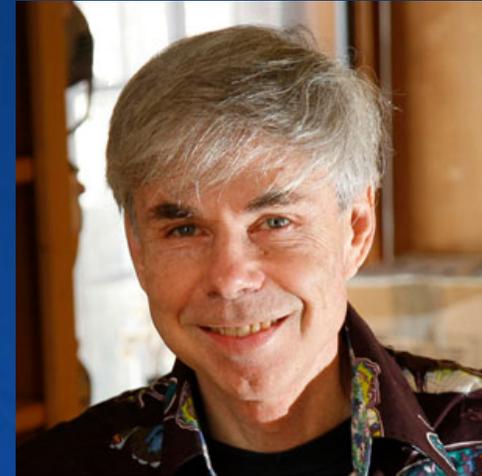
# Analogizers



Peter Hart

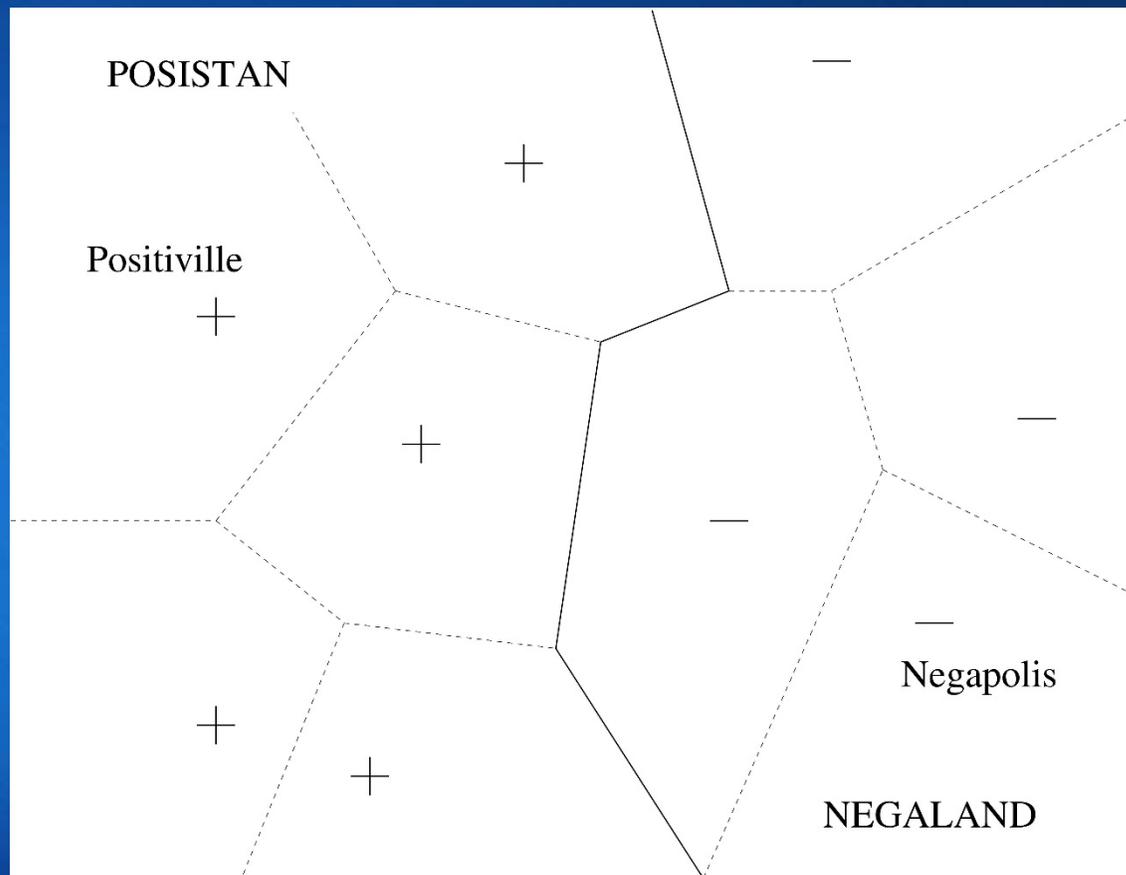


Vladimir Vapnik

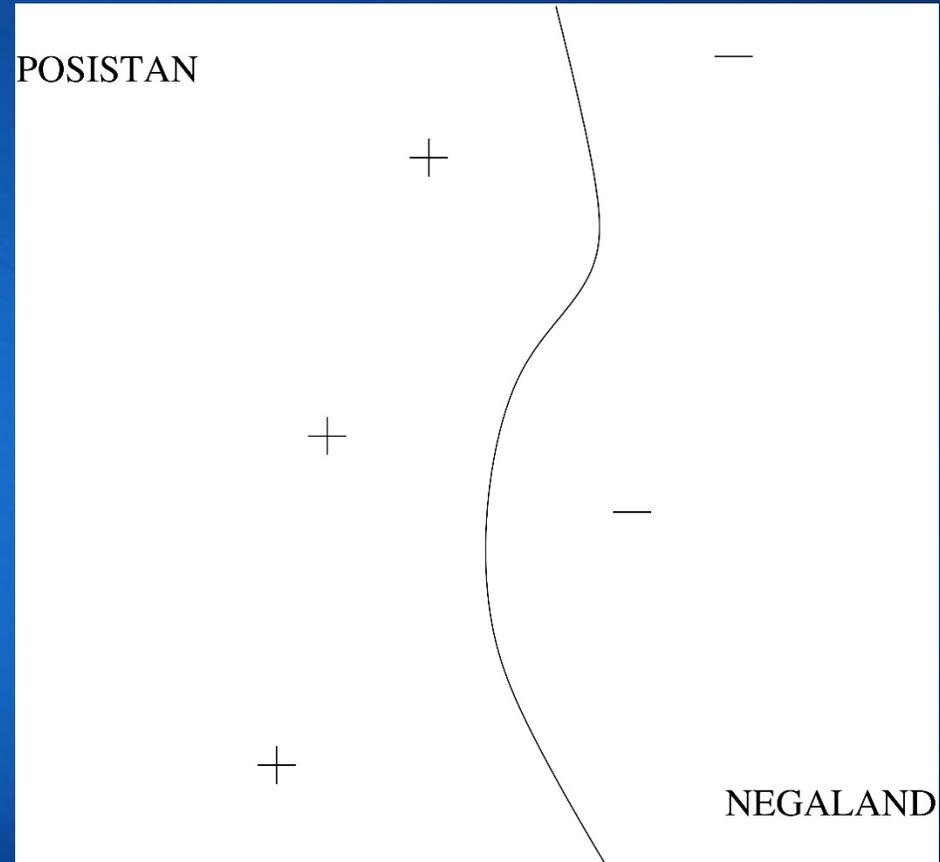


Douglas Hofstadter

# Nearest Neighbor



# Kernel Machines



# Recommender Systems

The screenshot shows the Netflix interface with a red header. The Netflix logo is on the left, and a search bar with the text 'Movies, TV shows, actors, directors, genres' is on the right. Below the header are navigation tabs: 'Watch Instantly', 'Browse DVDs', 'Your Queue', and 'Movies You'll Like' (which is highlighted with a heart icon). The main content area features a heading 'Congratulations! Movies we think You will ❤️' and a sub-heading 'Add movies to your Queue, or Rate ones you've seen for even better suggestions.' Below this are eight movie and TV show recommendations arranged in two rows of four. Each recommendation includes a title, a poster image, an 'Add' button, a star rating (5 stars), and a 'Not Interested' button.

**NETFLIX** | Your Account & Help

Movies, TV shows, actors, directors, genres

Watch Instantly | Browse DVDs | Your Queue | **Movies You'll ❤️**

**Congratulations!** Movies we think **You** will ❤️

Add movies to your Queue, or **Rate** ones you've seen for even better suggestions.

- Spider-Man 3**  
Add  
★★★★★  
Not Interested
- 300**  
Add  
★★★★★  
Not Interested
- The Rundown**  
Add  
★★★★★  
Not Interested
- Bad Boys II**  
Add  
★★★★★  
Not Interested
- Las Vegas: Season 2 (6-Disc Series)**
- The Last Samurai**
- Star Wars: Episode III**
- Robot Chicken: Season 3 (2-Disc Series)**

# The Big Picture

Tribe	Problem	Solution
Symbolists	Knowledge composition	Inverse deduction
Connectionists	Credit assignment	Backpropagation
Evolutionaries	Structure discovery	Genetic programming
Bayesians	Uncertainty	Probabilistic inference
Analogizers	Similarity	Kernel machines

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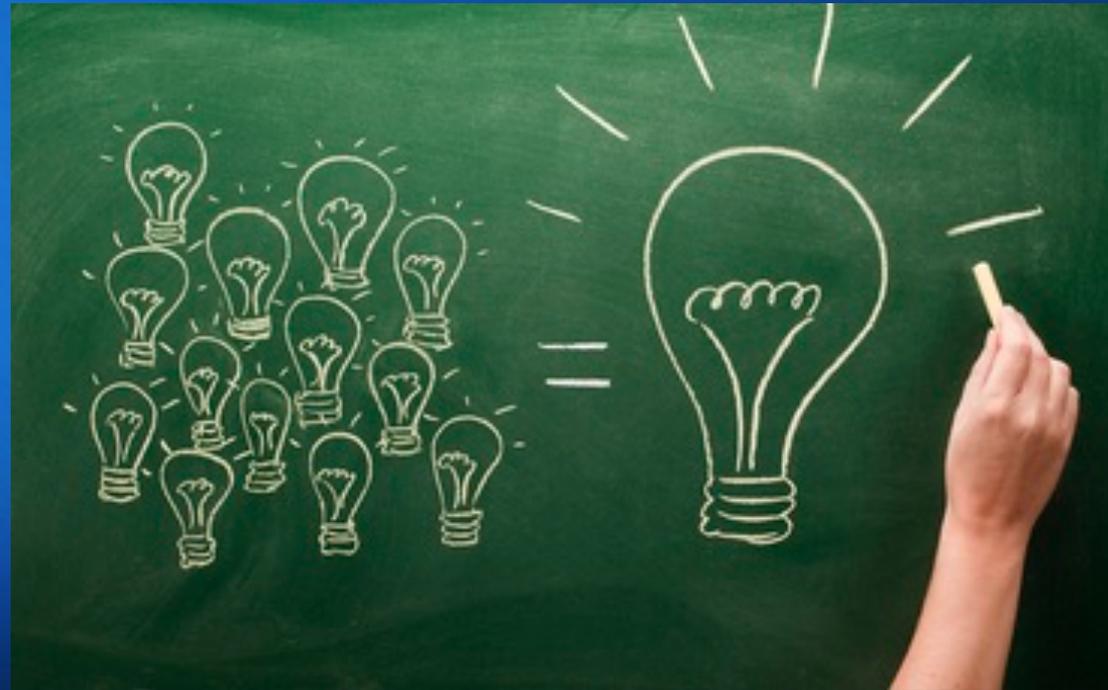
But what we really need is  
a single algorithm that solves all five!

# Putting the Pieces Together

- Representation
  - Probabilistic logic (e.g., Markov logic networks)
  - Weighted formulas → Distribution over states
- Evaluation
  - Posterior probability
  - User-defined objective function
- Optimization
  - Formula discovery: Genetic programming
  - Weight learning: Backpropagation

# Toward a Universal Learner

- Much remains to be done . . .
- We need your ideas

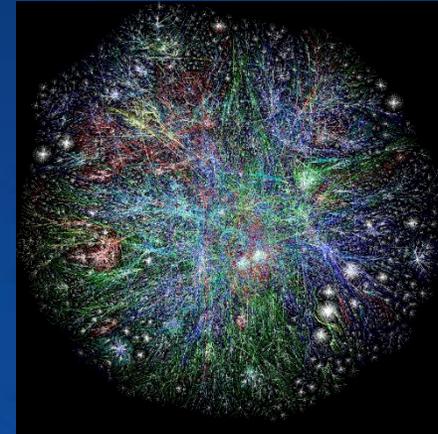


# What a Universal Learner Will Enable

Home Robots



World Wide Brains



Cancer Cures



360° Recommenders



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