

# On Intelligence – Jeff Hawkins

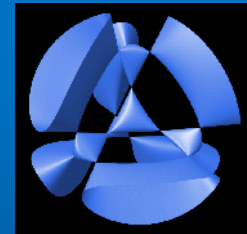
## Chapter 8: The Future of Intelligence

NIH BCIG  
April 27, 2006

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# Building Intelligent Machines (IMs)

- Introduction
- What will IMs be like?
- Technological challenges and timing
- Moral/ethical issues
- Potential applications for IMs
  - Near-term
  - Longer-term
- Conclusion



# IMs can be built – but may not be like what we think

- Appearance and interaction not human-like
- Limited-application robots (smart cars, autonomous mini-submarines, self-guided vacuums/mowers) before androids/robots
  1. Necessity: IMs only require cortex equivalent
  2. Cost: Excessive cost/effort for humanoid robots
- Multiplicity of IM physical embodiments: cars, planes, computer room racks
  - Distributed sensors and memory system



# How to create an IM



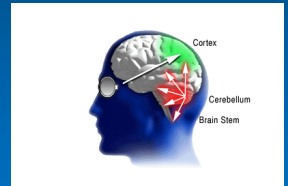
- IM: Sensory input that is connected to a hierarchical memory system that models the world and predicts the future
- Recipe for building IMs
  - Set of senses to extract patterns from the world
  - Attach a cortex-like hierarchical memory system
    - Training period builds a model of its world through its senses
    - Result: With its own model of the world, the IM can analogize to past experiences and make predictions



# Largest IM technical challenges: memory capacity and connectivity

- Capacity

- Cortex's 32 trillion synapses  $\approx$  80 hard-drives
  - An entire cortex is not required
  - IM memory chip error tolerance benefit vs. traditional silicon



- Connectivity

- Speed and sharing substitutes for complexity
  - A cortex cell might connect to 5,000 or 10,000 other cells
  - Electrical pulses are 1 million times faster than neurons
- Cortex dedicated axons can be IM shared connections
- Many approaches to this brain chip connectivity problem underway

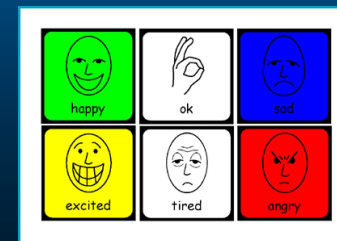
- When? 10-50 years / "within my lifetime"



# Should we create IMs?



- Dark imaginings vs. potential benefits of new technology
- Unlikely for IMs to threaten large portions of the population (Matrix, Terminator)
  - IMs will be defined-capacity human-controlled tools
    - Being intelligent is being intelligent, not being human
  - IMs (based on the neocortical algorithm) will not have emotions
  - Best application: where human intellect has difficulty, tedium
- Concludes
  - IM ethics, easy compared to genetics and nuclear energy
  - IMs are not self-replicating machines
  - No contemplated way for humans to copy minds into machines

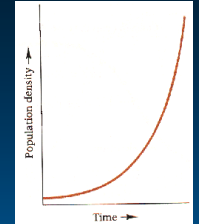


# Why should we build IMs? What will IMs do in the near-term?

- Imagine near-term uses for brainlike memory systems
  - Auditory applications: speech recognition
    - Multi-year training period
  - Visual applications: security camera (crowbar vs. gift)
  - Transportation applications: truly smart car



# Why should we build IMs? What will IMs do in the longer-term?



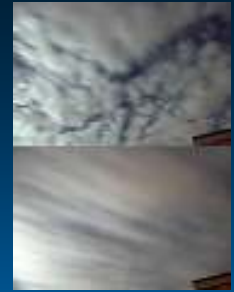
- Technique: Identify scalable aspects (cheaper, faster and smaller)
- Speed: IMs can do in 10 seconds what a human can do in a month
- Capacity: many times human capacity; no biological constraint
- Replicability: easy to copy, reprogram vs. human brains
- Sensory systems: any natural sense plus new senses
- Pattern-recognition: any input with non-random with a richness or statistical structure



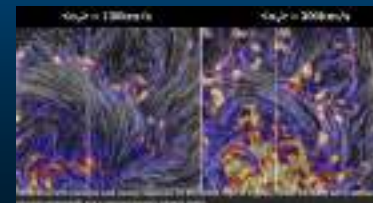
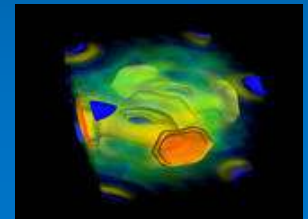


# Why should we build IMs?

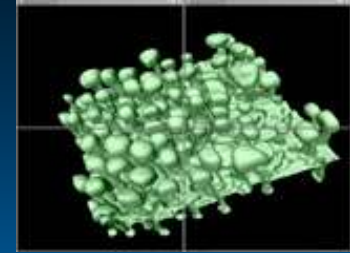
## Specific applications



- Application: any mismatch between human senses and the physical phenomena we want to understand
  - Protein folding
  - Mathematics and physics
- Distributed, globe-spanning sensory systems
  - Weather, animal migration, demographics, energy use
- Understanding and predicting human motivations and behavior
- Minute entity sampling
- Pattern representation in cells or large molecules
- Meta-IM: Collecting several IMs into one whole

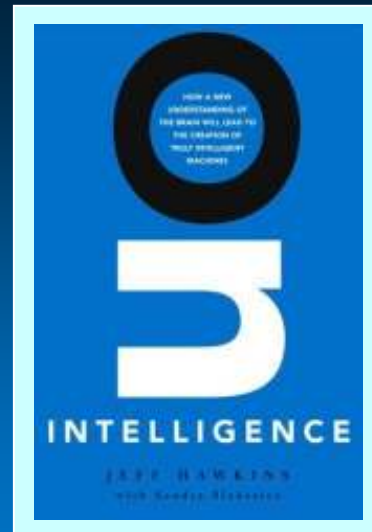


# Conclusion, IMs...

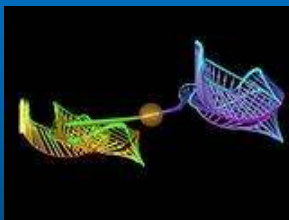


- Think and learn a million times faster than humans
- Remember vast quantities of detailed information
- See incredibly abstract patterns
- Have (distributed) senses more sensitive than our own
- Think in three, four or more dimensions
- Are not limited Turing Test concepts but amazing tools that could dramatically expand our knowledge of the universe





# Thank you!



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