A Thousand Brains

A New Theory of Intelligence

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Self Introduction

- Hui Zheng
- Working on:
  - the Neural Circuit Mechanisms of Cognition.
  - Computational Neuroscience.
- Co-advised by:

Dr. Jingfeng Zhou

Dr. Yunzhe Liu

About the Author

- Jeff Hawkins
- Computer Scientist and Neuroscientist.
- At the 2021 BAAI Conference, he delivered a speech entitled「The Thousand Brains Theory - A roadmap for creating machine intelligence」.

Two Paths to AGI

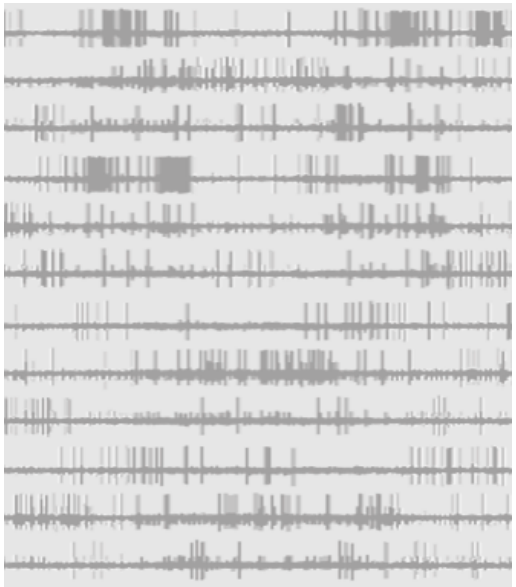
- Focus on specificity: get computers to outperform humans on specific tasks.
- Focus on flexibility: create machines that can do many things and apply what they learn from one task to another.

How to go from brain science to artificial intelligence?

- Brain Science.
- Computational Neuroscience.
- Brain-Inspired Computing.

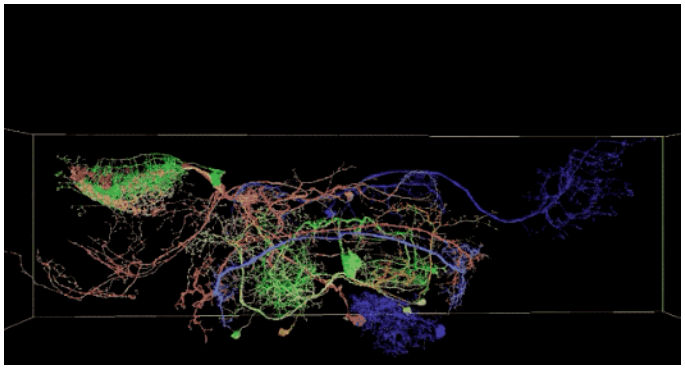
Brain Science

- Electrophysiological recording.



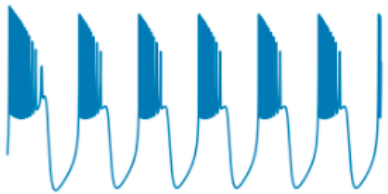
Brain Science

- Electrophysiological recording.
- Using cryo-electron microscopy images to reconstruct brain structure.

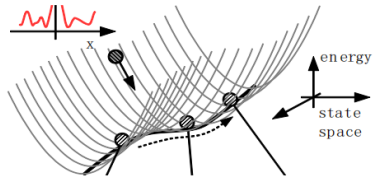


Computational Neuroscience

- Neuronal Dynamics.



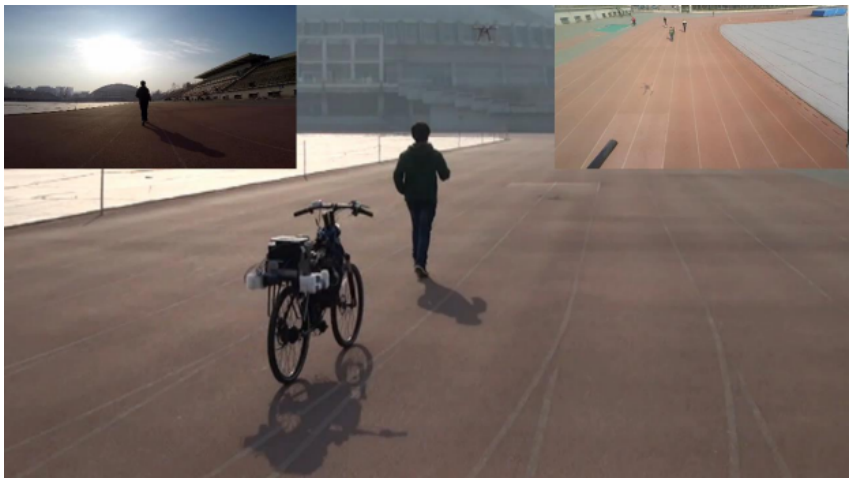
Microscopic Phenomenon Modeling



Macroscopic Phenomenon Modeling

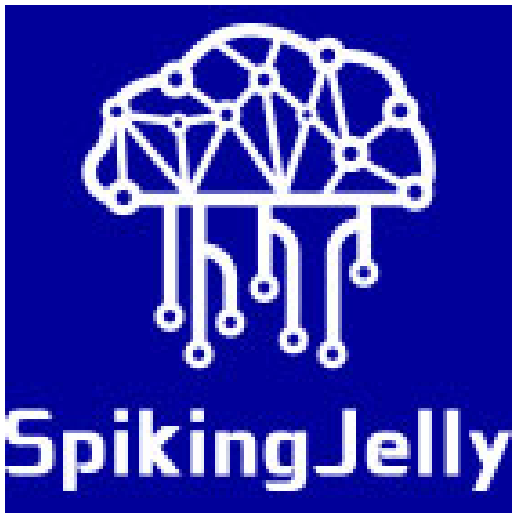
Brain-Inspired Computing

- "Tianji" Chip.



Brain-Inspired Computing

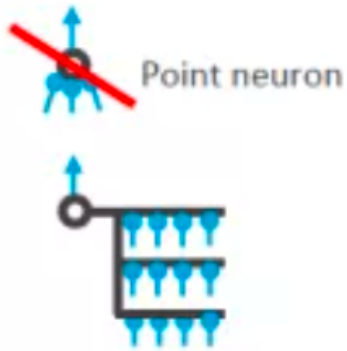
- "Tianji" Chip.
- SNN.



BrainPy

Brain-Inspired Computing

- "Tianji" Chip.
- SNN.
- Dendritic Computing.



The Composition of the Brain

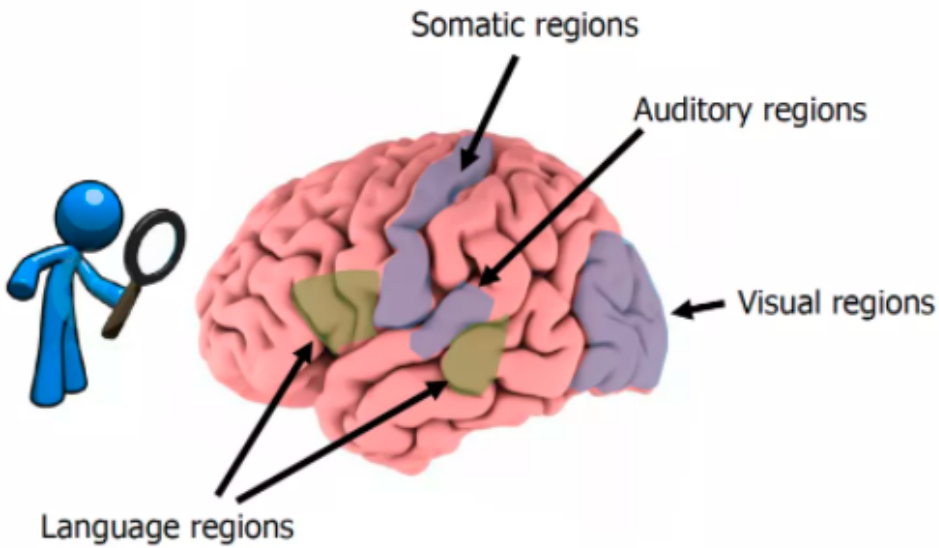
- **Neucortex**: One continuous sheet of neural tissue 70% of brain by volume.
  - Perception.
  - Language.
  - Cognition, thought, planning(engr., math, science, literature...)
- **"Older" brain areas**: Dozens of specialized brain regions 30% of brain by volume.
  - Breathing, digestion, reflex behaviors.
  - Walking, running, chewing.
  - Emotions.

The Neucortex Learns a Model of the World

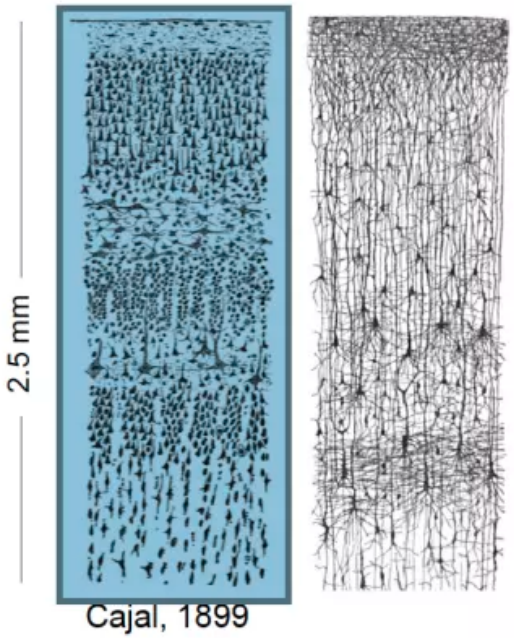
- Everything you know is stored in this model.
  - How things look, feel, and sound.
  - Where things are located.
  - How things change when we interact with them.
  - Includes tens of thousands of objects, words, and concepts.
- The brain's model allows us to:
  - Recognize objects and where we are.
  - Predict the consequences of our actions.
  - Plan and achieve goals.

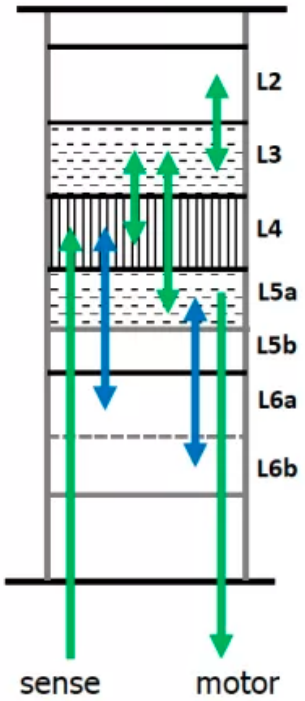
The Composition of the Neucortex

- The Neurotex looks uniform.
- But it is divided into dozens of functional regions.



The Circuits of the Neucortex Look Similar Everywhere



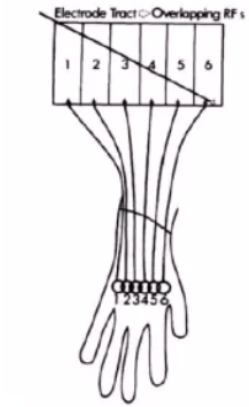


Common Circuitry

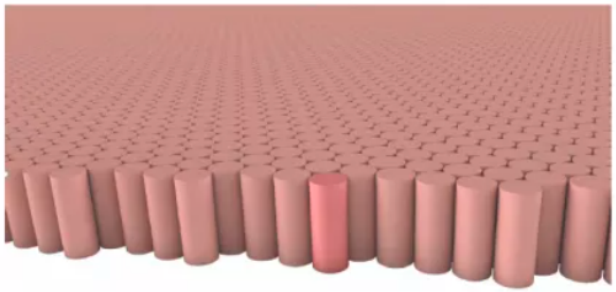
- Types of Neurons.
- Organized in layers.
- Connections between layers.
- Sensory input.
- Motor output.

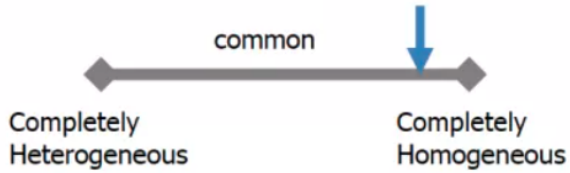
Vernon Mountcastle's Big Idea

- All areas of the neucortex look the same because they perform the same intrinsic function. What makes one region visual and another auditory is what it is connected to.
- The human neucortex got large by copying a functional unit, the "cortical column".



Mountcastle 1997

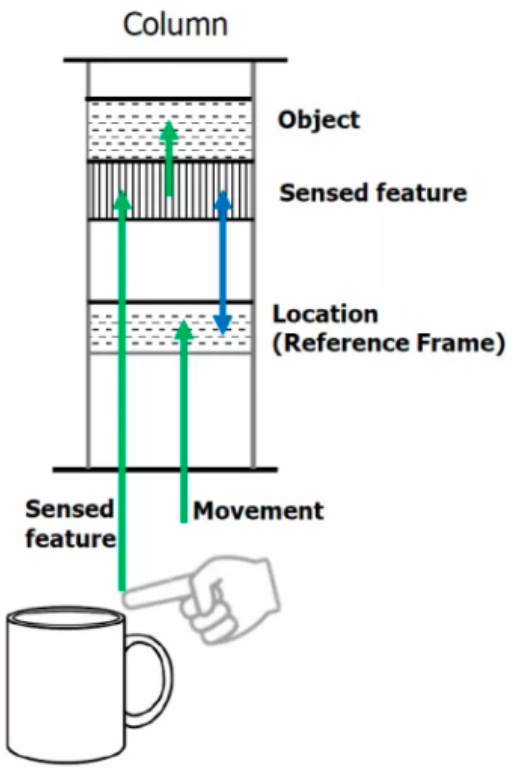




What does a cortical column do?

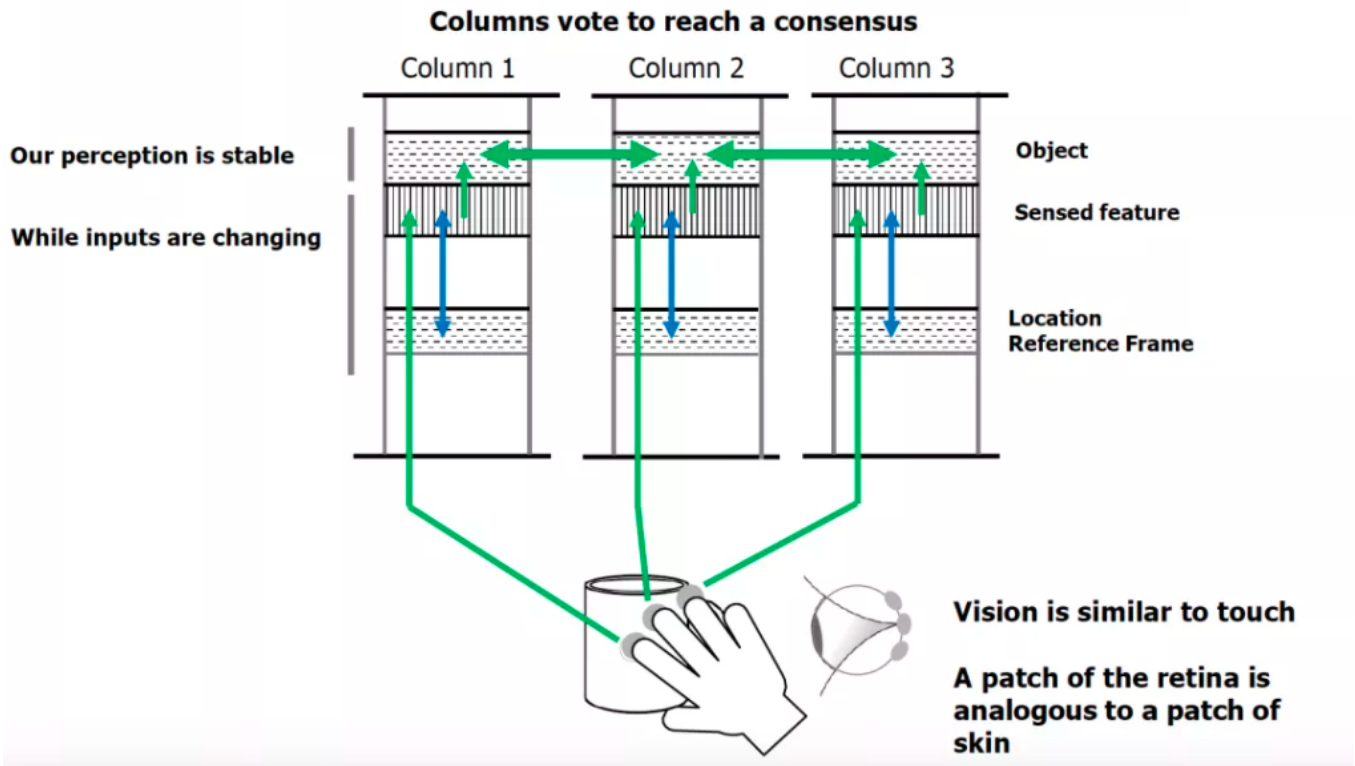
The Thousand Brains Theory

- Columns learn models by integrating sensory input and movement over time.



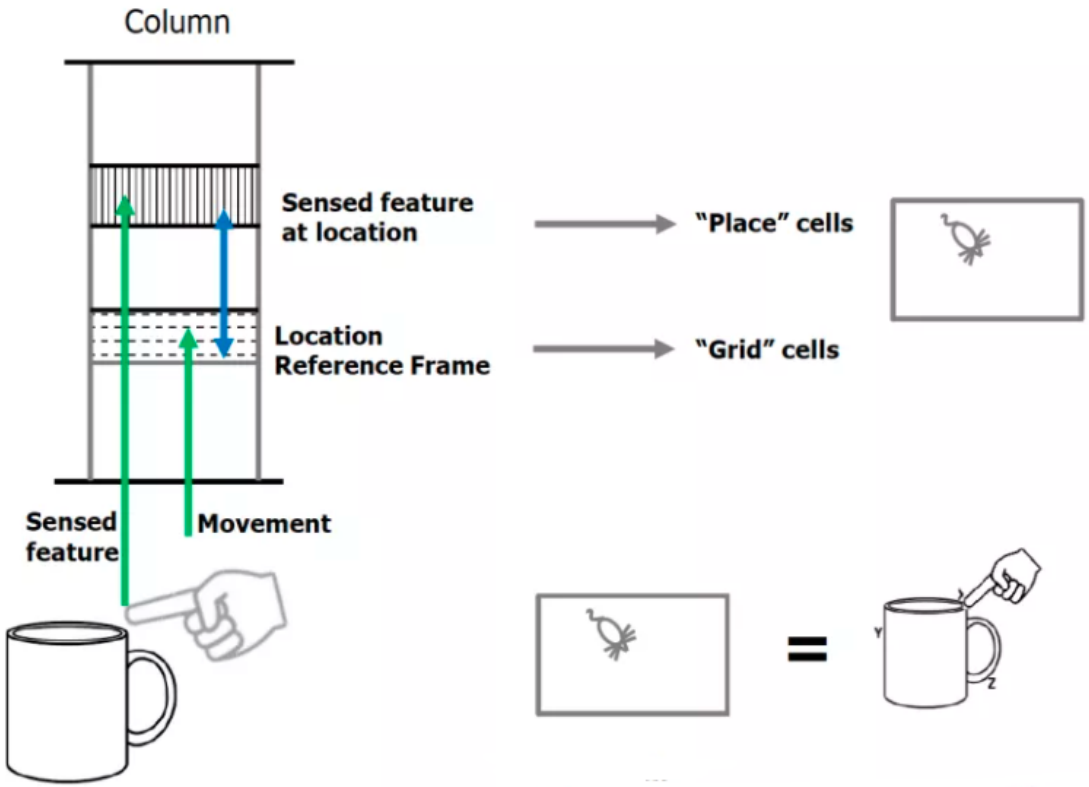
The Thousand Brains Theory

- Columns learn models by integrating sensory input and movement over time.
- There are thousands of models for every object.



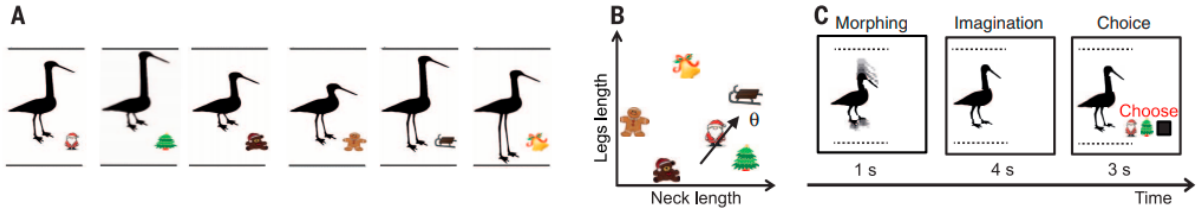
The Composition of Column

Cortical columns create models using the same machanisms as grid cells and place cells use to model environments.

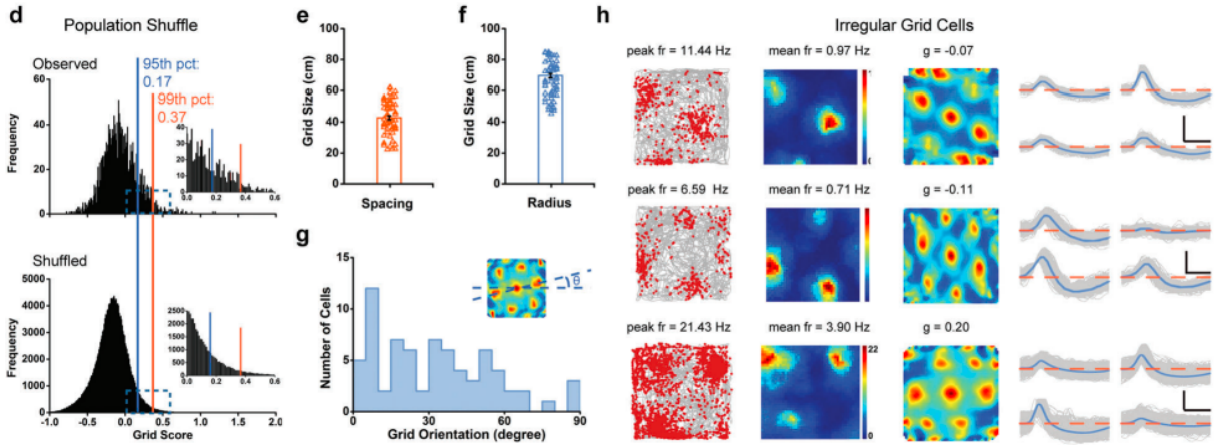


Experimental evidence

- Grid cells exist in pre-frontal cortex, used to model concepts.

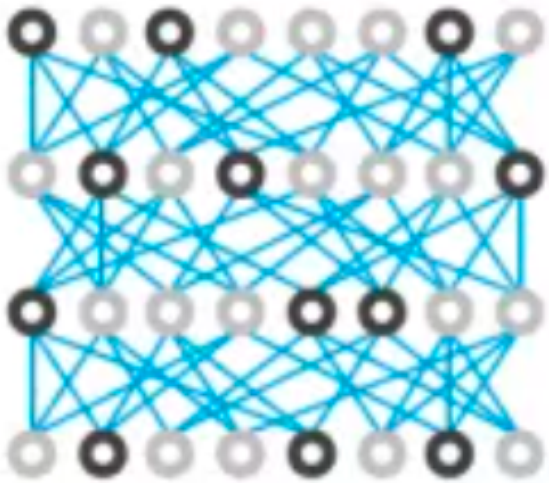


- Grid cells, place cells, border cells in Somatosensory cortex.



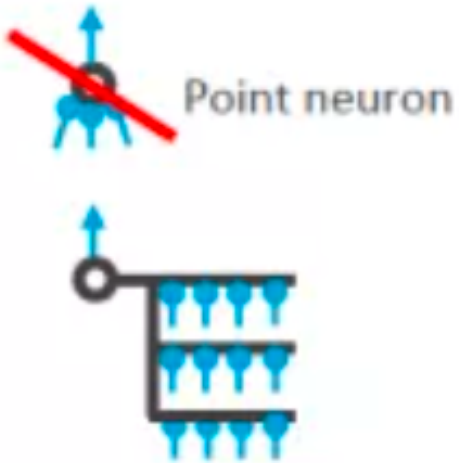
A Roadmap for Creating Machine Intelligence

- Sparsity.



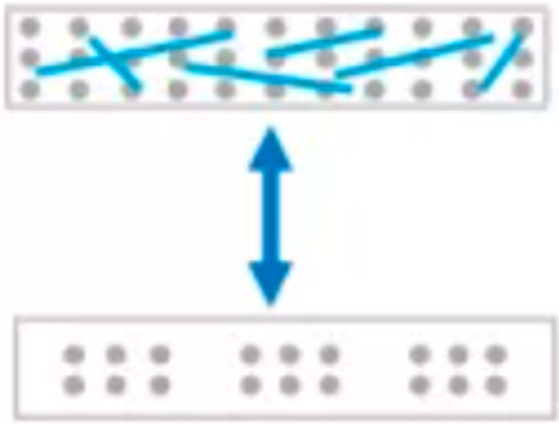
A Roadmap for Creating Machine Intelligence

- Sparsity.
- Active Dendrites.



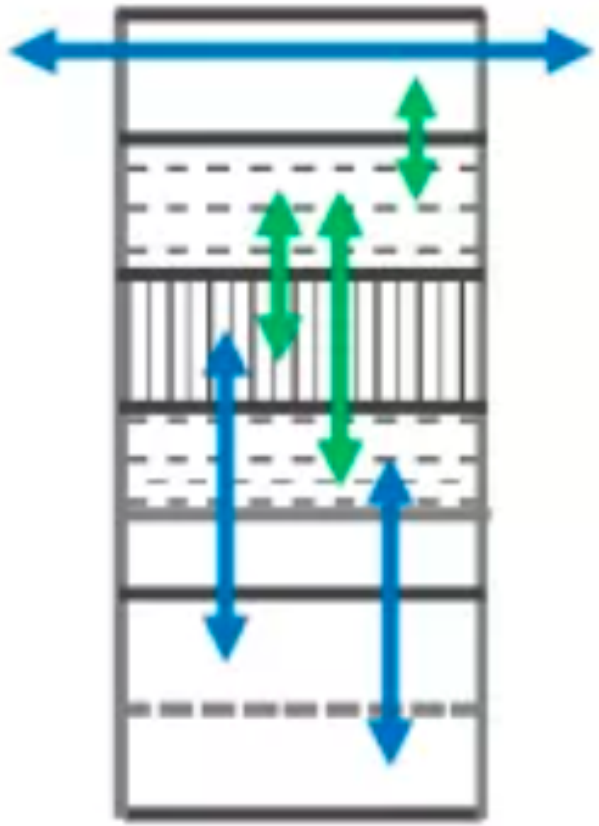
A Roadmap for Creating Machine Intelligence

- Sparsity.
- Active Dendrites.
- Reference Frames.



A Roadmap for Creating Machine Intelligence

- Sparsity.
- Active Dendrites.
- Reference Frames.
- Cortical Columns.



Thanks

- Thanks for listening!
- Q&A.