

Hierarchical Temporal Memory (HTM)

Computational Cognitive Neuroscience

COSC 521, Spring 2019

Corey Johnson

Resources for information on HTM

Numenta.org

HTM school

NuPIC

Jeff Hawkins 2004 book:

On Intelligence: How a New Understanding of the Brain will Lead to the Creation of Truly Intelligent Machines

(Note: some slide graphics are from Numenta.org, HTM school)

Hierarchical

- Higher levels → abstraction & permanence

Temporal

- Change over time: patterns

Memory

- Sparse Distributed Representation (SDR)

HTMs

- Biologically plausible model for intelligence
- Based on pyramidal neurons
- Neocortex micro-columns as building blocks

"The neocortex comprises about 75% of the volume of the human brain and it is the seat of most of what we think of as intelligence." -Jeff Hawkins

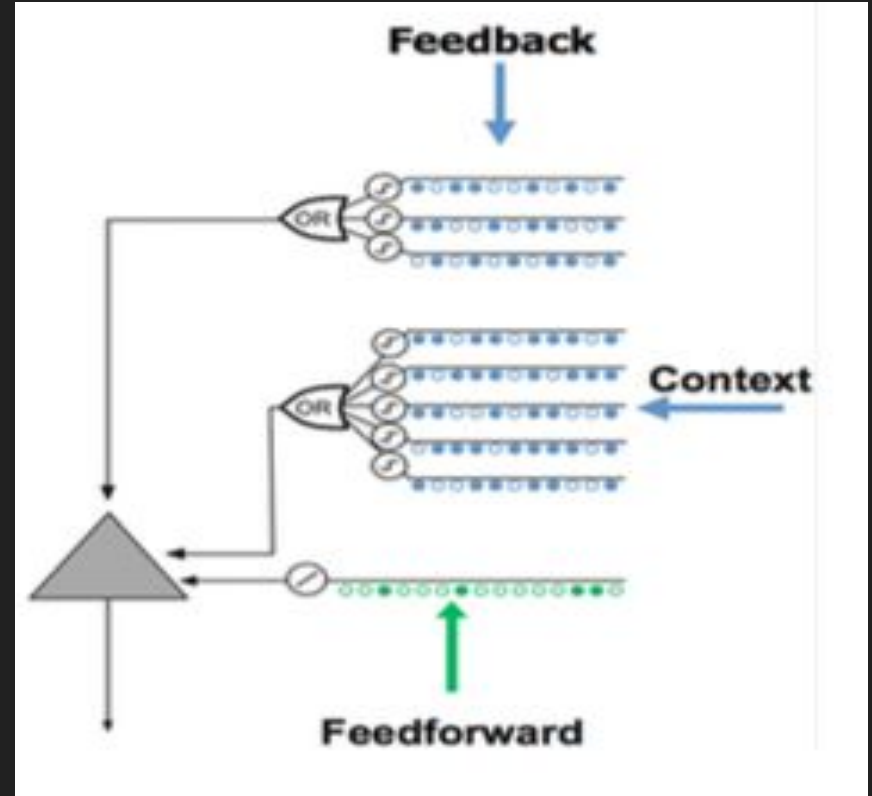
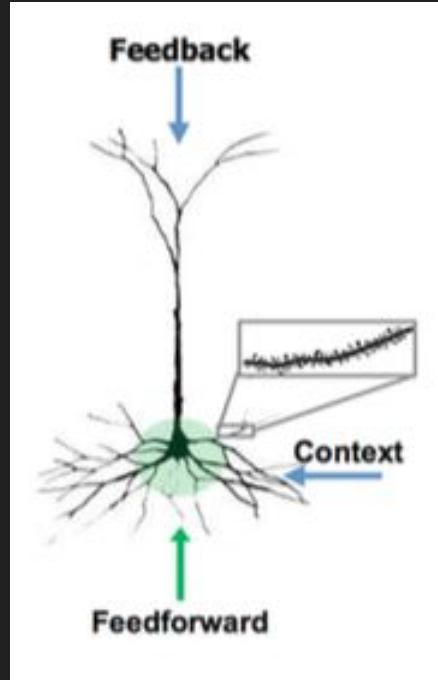
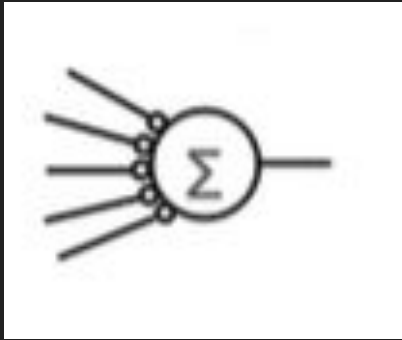
HTMs continued

- Can learn / recall / infer high-order sequences
- Local learning rules, no global supervisor (HW)
- Relies on sparse distributed representation (SDR)
 - Fault tolerance
 - High capacity
- Learns by modeling the growth of new synapses

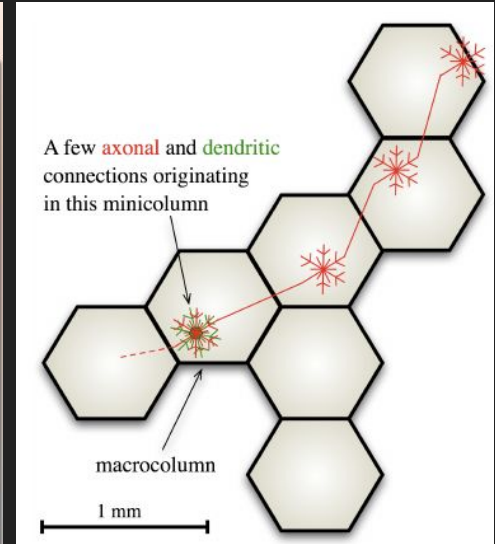
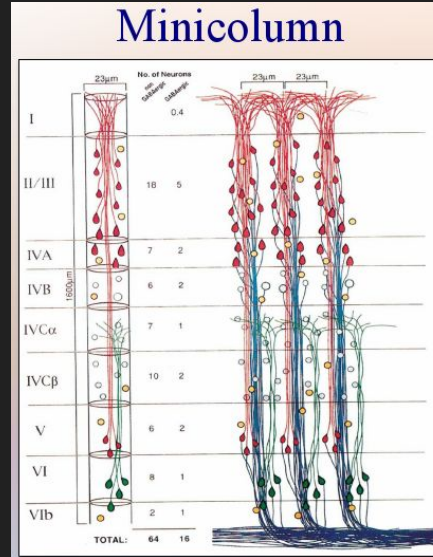
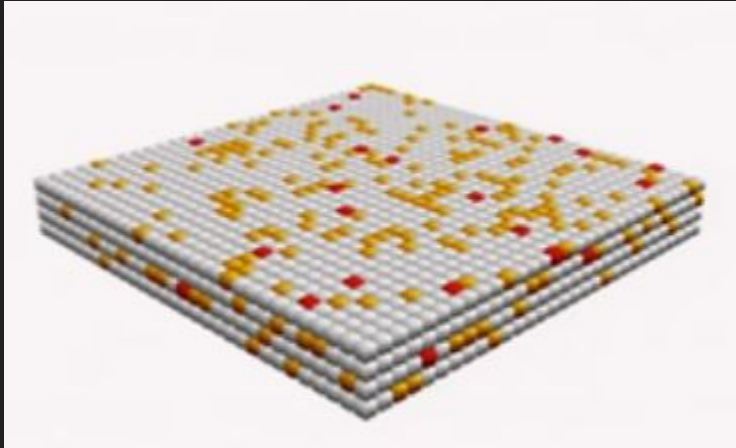
ANN

Pyramidal

HTM



HTM Layers



(Lect. 2 slides)

Sparse Distributed Representation

Fundamental to HTM systems

SDR: 'Language of intelligence'

Sparse as opposed to dense binary code, many bits are needed

SDR bit similarity → similar semantic meaning

Semantic error is key to generalization

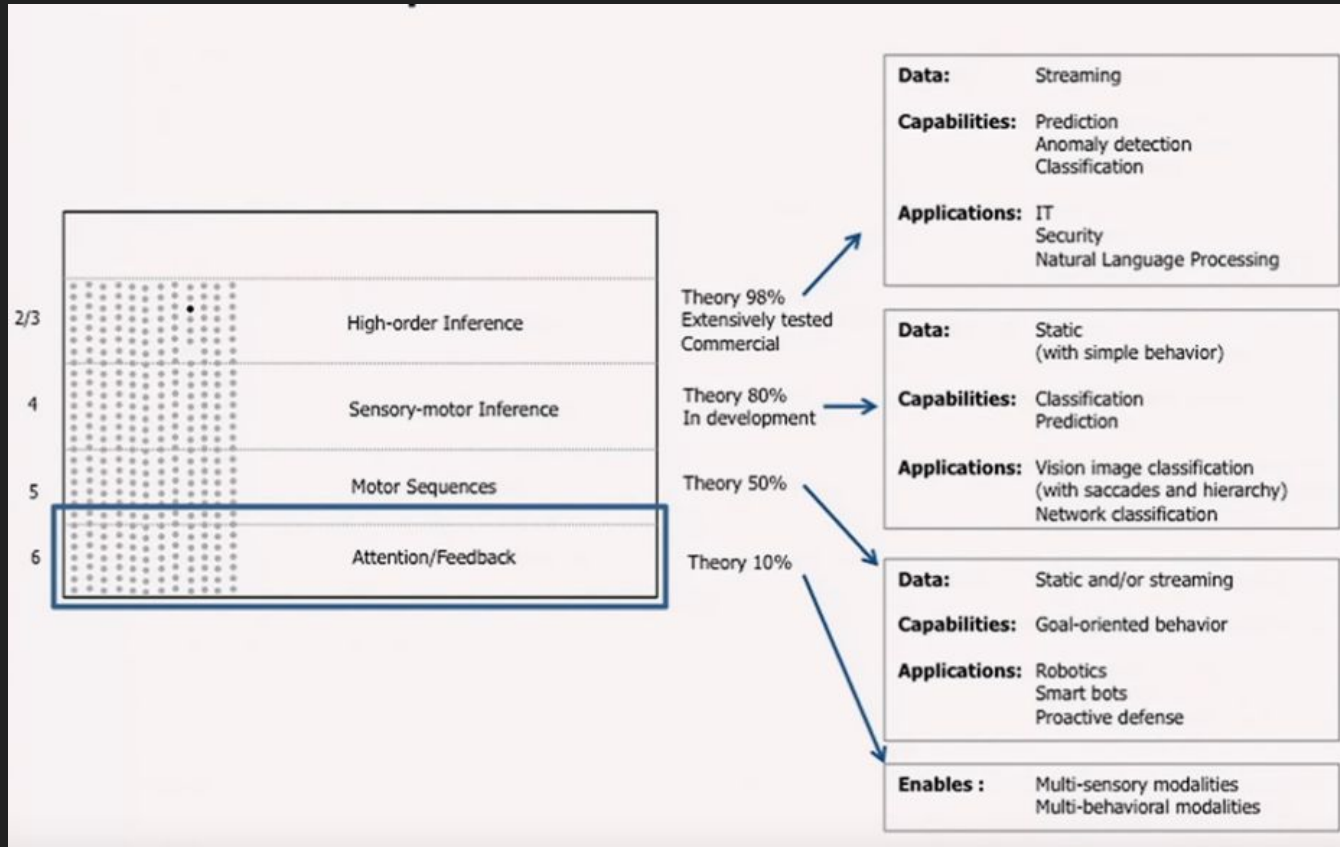
Cell only needs a few connections to neighbor to match pattern

Applications

Good for:

- Data streams that change over time: text, GPS, dates, numbers
 - Data with inherent structure
 - System where many models are required rather than one large one
-
- Prediction
 - Anomaly detection
 - Classification

HTM theory is still evolving



Home of the HTM Community

Welcome to [Numenta.org](https://numenta.org), home of Numenta's HTM community and open source projects. If you want to learn about Numenta the company visit [Numenta.com](https://numenta.com).

Machine Intelligence Starts Here

[Hierarchical Temporal Memory](#) is a foundational technology for the future of machine intelligence based upon the biology of the neocortex. Because Numenta is committed to making this technology accessible to everyone, all HTM software and ongoing research is open source. This allows you to work with our technology in whatever way works best for you – learn about the theory, dive into the source code, or start your own implementation. Some of our community members have written their own versions of HTM systems in other languages and platforms. Others have created detailed visualizations, experiments, and applications.









The neocortex is a logical system that we'll understand fully in time. HTM theory reflects our current understanding of how the neocortex works, and HTM code reduces that theory to practice. HTM is continually being updated as we learn more about the brain. We believe HTM will play a critical role in the creation of truly intelligent machines.









Community Resources

| | |
|------------|--|
| Discussion | HTM Forum |
| Code | Numenta Github HTM Community Github |
| Videos | YouTube |
| Technical | Papers |
| License | AGPLv3 |
| Events | Meetup |
| Blog | Blog |
| HTM School | See the latest episode below! |



HTM School videos

-  **HTM Overview (Episode 0)**
HTM School
-  **Bit Arrays (Episode 1)**
HTM School
-  **SDR Capacity & Comparison (Episode 2)**
HTM School
-  **SDR Overlap Sets and Subsampling (Episode 3)**
HTM School
-  **SDR Sets & Unions (Episode 4)**
HTM School
-  **Scalar Encoding (Episode 5)**
HTM School
-  **Datetime Encoding (Episode 6)**
HTM School
-  **Spatial Pooling: Input Space & Connections (Episode 7)**
HTM School

-  **Spatial Pooling: Learning (Episode 8)**
HTM School
-  **Boosting (Episode 9)**
HTM School
-  **Topology (Episode 10)**
HTM School
-  **Temporal Memory Part 1 (Episode 11)**
HTM School
-  **Temporal Memory Part 2 (Episode 12)**
HTM School
-  **Cortical Circuitry (Episode 13)**
HTM School
-  **Grid Cells (Episode 14)**
HTM School
-  **Framework for Intelligence (Episode 15)**
HTM School

Implementations

Hierarchical Temporal Memory (HTM) is a theory of intelligence that can be implemented in most computer programming languages. Below are descriptions of several HTM implementations currently active within our community. For detailed descriptions of HTM algorithms, see our living text, [Biological and Machine Intelligence](#). It contains pseudocode for both the [spatial pooling](#) and [temporal memory](#) algorithms (PDFs).

NuPIC, or the **Numenta Platform for Intelligent Computing**, is an HTM implementation created by Numenta and open-sourced in June 2013. This codebase is the original HTM codebase, and is architected in a way that allows algorithmic experimentation in Python, but more performant versions of HTM algorithms in C++.

NuPIC Core (C++)

Our C++ codebase contains all HTM algorithms written in C++, and SWiG language bindings to Python. Language bindings to other environments should be added here.

This codebase exposes the [Network API](#), which is the primary low-level interface for creating HTM systems.

<http://github.com/numenta/nupic.core>

NuPIC (Python)

The NuPIC Python codebase contains Python code implementations of HTM. Through this interface, users may specify whether their code runs Python algorithms or the faster C++ algorithms using the Python bindings provided in **nupic.core**.

In addition to providing Python bindings to the **nupic.core** [Network API](#), this codebase also includes a higher-level client API called the Online Prediction Framework (OPF), which is tuned towards experimentation with predictions, anomaly detection, and [identifying optimal model parameters \(swarming\)](#).

<http://github.com/numenta/nupic>



HTM Studio

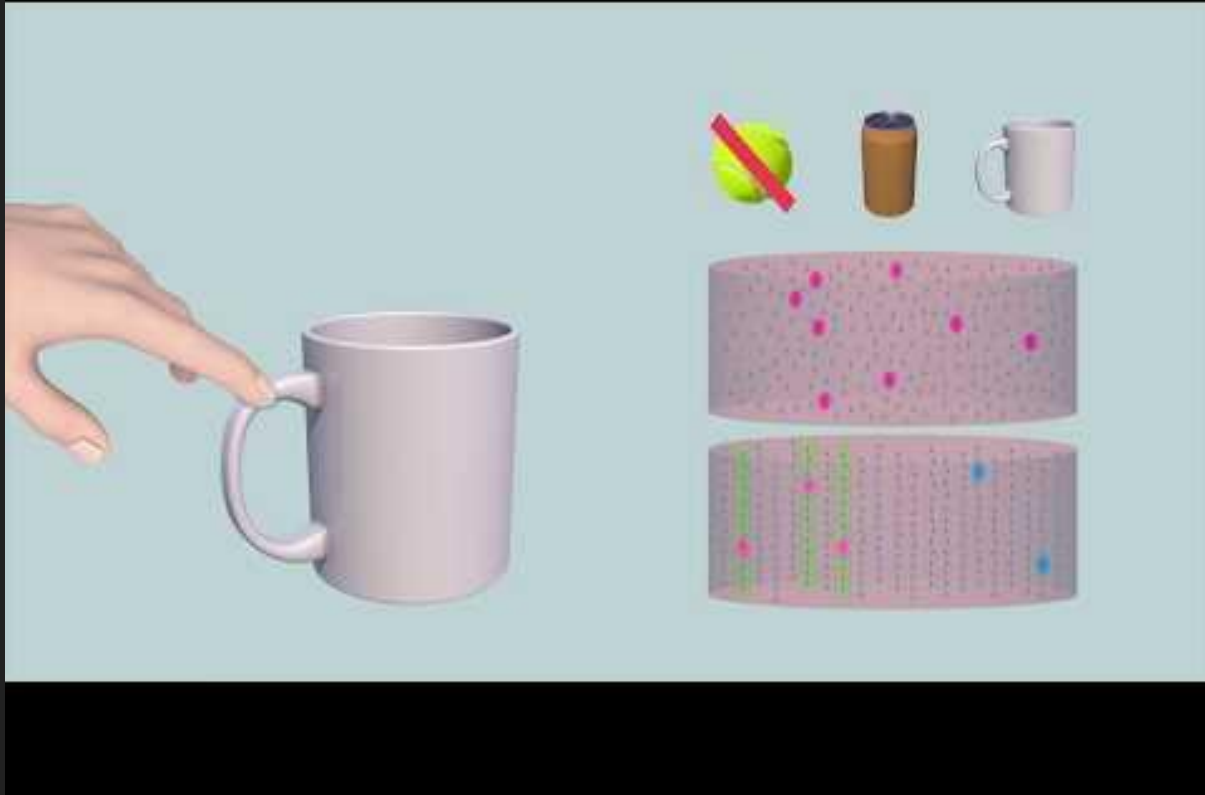
Find Real-Time Anomalies in your Streaming Data

HTM Studio allows you to test whether our Hierarchical Temporal Memory (HTM) algorithms will find anomalies in your data. With just one click, you can uncover anomalies other techniques cannot find in your numeric, time-series data, in minutes.





[Video Link: https://youtu.be/v-VvFRar5TY](https://youtu.be/v-VvFRar5TY)



[Video Link: https://youtu.be/X50GY0mdHlw](https://youtu.be/X50GY0mdHlw)



HTM Studio for Anomaly Detection

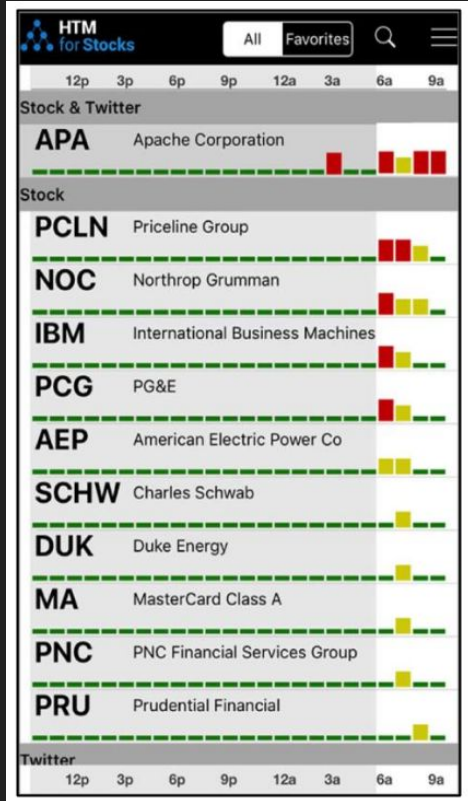
GoAnimate



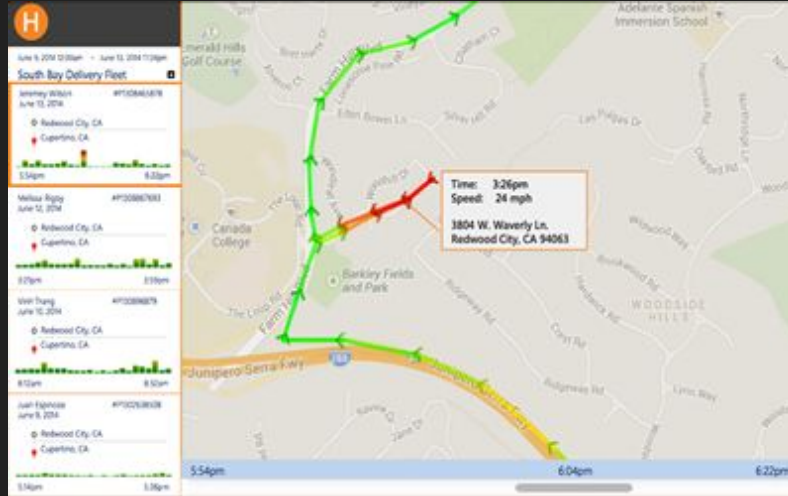
Numenta

[Video Link: https://youtu.be/Nqoruj4eCb8](https://youtu.be/Nqoruj4eCb8)

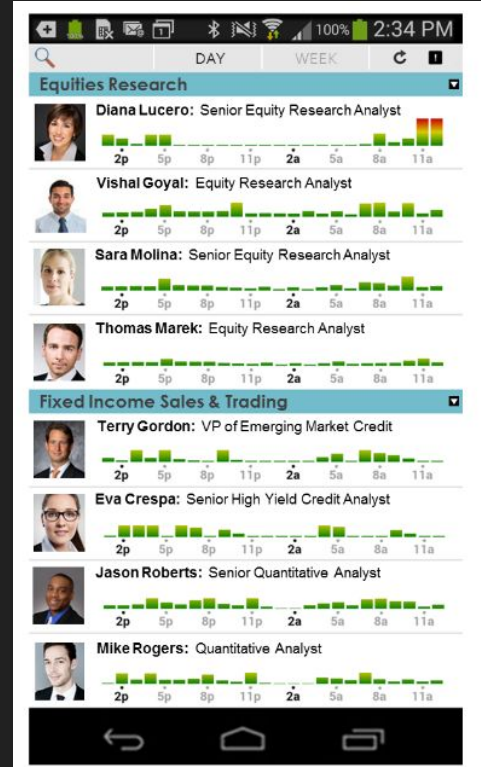
Stocks



Geospatial



Rogue Behavior



Conclusion

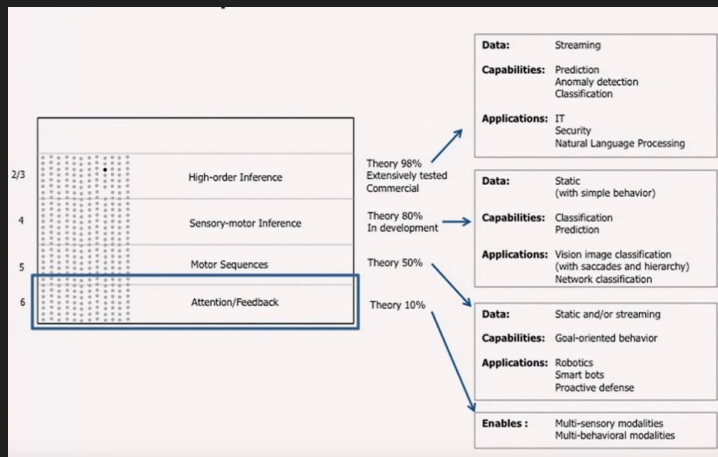
HTM aims to be a biologically-constrained theory of intelligence

You may hear more about HTMs in the future

Needs killer app moment like DCNN (ImageNet) or DRL (Go/Chess)

Resources:

- Numenta.org
- HTM School
- NuPIC code
- HTM Studio



Questions / Comments / Thoughts?

Thanks!

(For more information on HTMs, please see Numenta.org)