Artificial Intelligence Thinking in K-12

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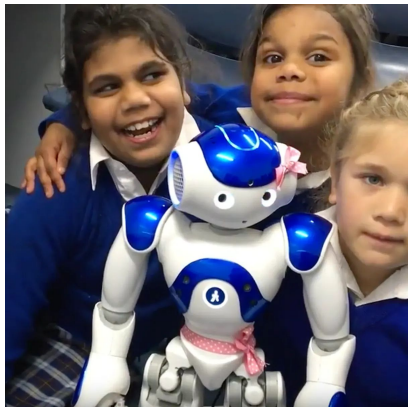
Why should children be learning about AI at all?

1. For the same reason they learn about electricity: *AI is powering the next industrial revolution.*

   We need informed citizens who understand the issues raised by new technology, because AI is bringing huge economic and social changes.

2. Children are growing up with AI all around them. They should not regard it as magic.

3. Encourage thinking about AI-related careers.



The AI4K12 Initiative, a joint project of:

AAAI (Association for the Advancement of Artificial Intelligence)

CSTA (Computer Science Teachers Association)

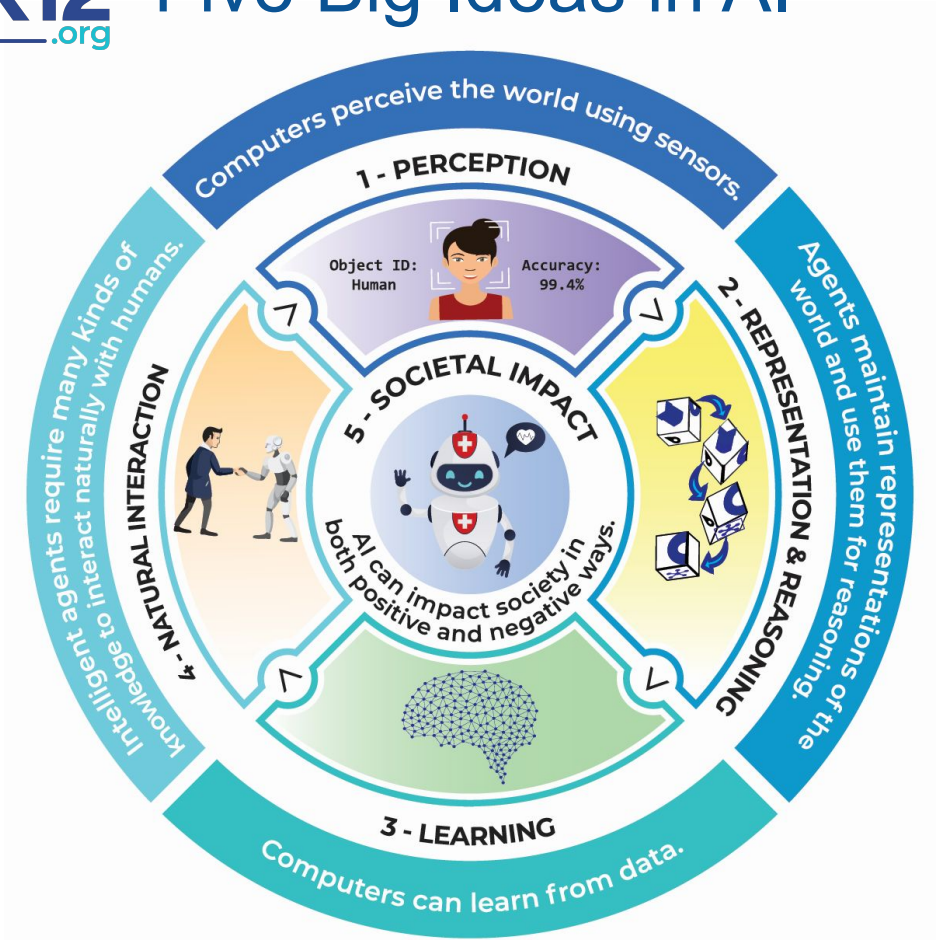
With funding from National Science Foundation ITEST Program (DRL-1846073)

Carnegie Mellon University
School of Computer Science

AI4K12.org Initiative: Mission

- Develop national guidelines for teaching AI in K-12
  - Modeled after the CSTA standards for computing education.
  - Four grade bands: K-2, 3-5, 6-8, and 9-12
  - What should students know?
  - What should students be able to do?
- Develop a curated AI resource directory for K-12 teachers
- Foster a K-12 AI Education Research and Practice Community & Resource Developers

Five Big Ideas in AI

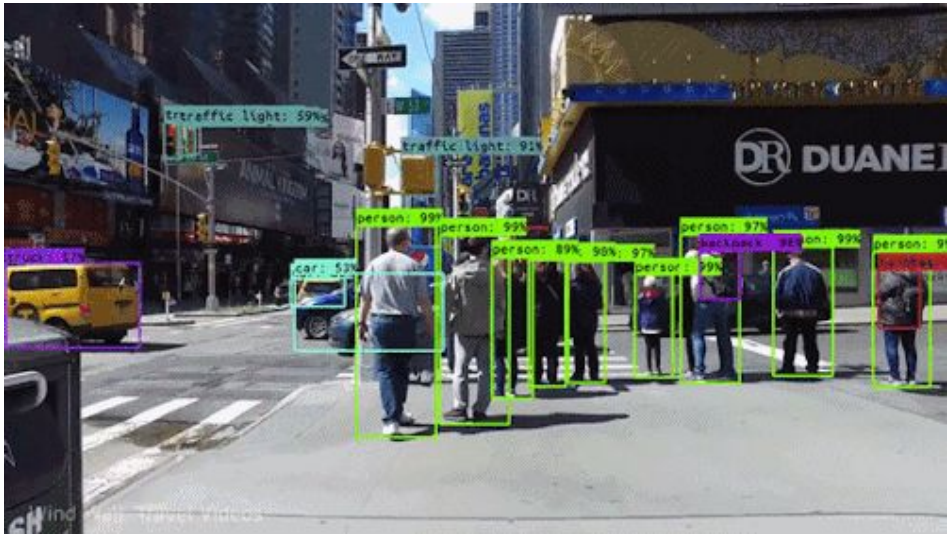


Big Idea #1: Perception

Computers perceive the world using sensors.

Perception is the extraction of *meaning* from sensory signals using knowledge.

- Human senses vs. computer sensors
- Types of perception: vision, speech recognition etc.
- How perception works: algorithms



Example Guidelines

- Identify sensors on computers, robots, and intelligent appliances.
- Explain how sensor limitations affect computer perception.
- Explain that perception systems may draw on multiple algorithms as well as multiple sensors.
- Build an application using multiple sensors and types of perception (possibly with Scratch plugins, or Calypso).

Are Supermarket Doors Intelligent?

This is what you get when your automatic doors have sensing but not perception.

Big Idea #2: Representation and Reasoning

Agents maintain representations of the world, and use them for reasoning.

- Types of representations
- Families of algorithms and the work they do
- Representation supports reasoning: algorithms operate on representations

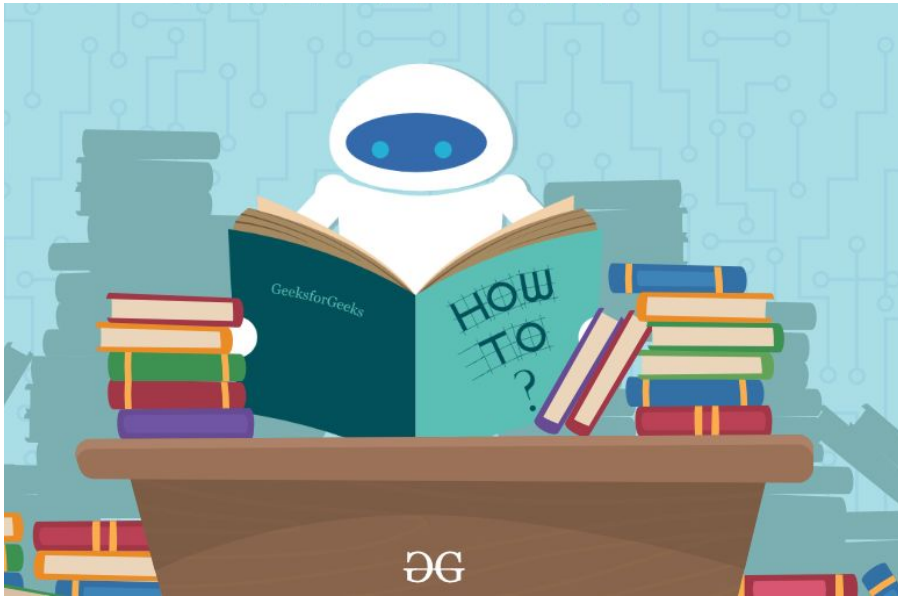
Example Guidelines

- Create/design a representation of an (animal) classification system using a tree structure.
- Draw a search tree for tic-tac-toe
- Describe how AI representations support reasoning to answer questions
- Describe the differences between types of search algorithms

Big Idea #3: Learning

Computers can learn from data.

- Nature of learning
- Fundamentals of neural networks
- Data sets



Example Guidelines

- Modify an interactive machine learning project by training its model..
- Describe how algorithms and machine learning can exhibit biases.
- Identify bias in a training data set and extend the training set to address the bias
- Train a neural net (1-3 layers) using *TensorFlow Playground*
- Trace and experiment with a simple ML algorithm

Big Idea #4: Natural Interaction

Intelligent agents require many kinds of knowledge to interact naturally with humans.

- Natural language understanding
- Common sense reasoning
- Affective computing & interaction (e.g. with robots, or speech agents)
- Consciousness and philosophy of mind

Example Guidelines

- Recognize and label facial expressions into appropriate emotions (happiness, sadness, anger) and explain why they are labeled the way they are
- Experiment with software that recognizes emotions in facial expressions
- Construct a simple chatbot
- Describe some tasks where AI outperforms humans, and tasks where it does not
- Explain and give examples of how language can be ambiguous
- Reason about the nature of intelligence, and identify approaches to determining whether an agent is or is not intelligent.

Big Idea #5: Societal Impact (1 of 3)

"Artificial Intelligence can impact society in both positive and negative ways."

- **Ethics of AI making decisions about people**
  - Fairness and bias
  - Transparency and explainability
  - Accountability

Example Guidelines

- Critically explore the positive and negative impacts of an AI system.

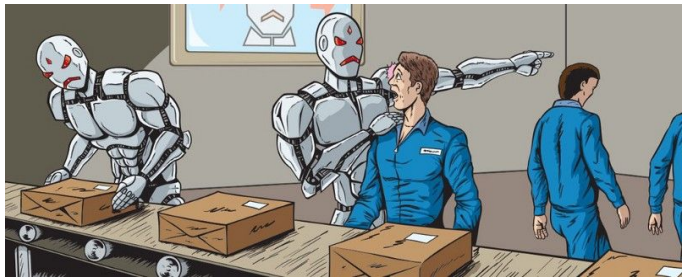
- Describe ways that AI systems can be designed for inclusivity.

Machine Bias: ProPublica.org

Big Idea #5: Societal Impact (2 of 3)

"Artificial Intelligence can impact society in both positive and negative ways."

- **Economic impacts of AI**
  - Increased productivity
  - New types of services
  - Reduction in of some types of jobs
  - New career opportunities



Example Guidelines

- Design and explain how an AI system can be used to address a social issue.

- Understand tradeoffs in the design of AI systems and how decisions can have unintended consequences in the function of a system.

Big Idea #5: Societal Impact (3 of 3)

“Artificial Intelligence can impact society in both positive and negative ways.”

- **AI & Culture**
  - Living with intelligent assistants and robot companions.
  - Would you let your child travel unaccompanied in a self-driving car?
  - New YouTube genre: self-driving car mishaps.

Example Guidelines

- Critically explore the positive and negative impacts of an AI system.
- Describe the debate about whether people should be polite to agents and robots.

Five Big Ideas in Artificial Intelligence

1. Perception

Computers perceive the world using sensors. Perception is the process of extracting meaning from sensory signals. Making computers "see" and "hear" well enough for practical use is one of the most significant achievements of AI to date.

2. Representation & Reasoning

Agents maintain representations of the world and use them for reasoning. Representation is one of the fundamental problems of intelligence, both natural and artificial. Computers construct representations using data structures, and these representations support reasoning algorithms that derive new information from what is already known. While AI agents can reason about very complex problems, they do not think the way a human does.

3. Learning

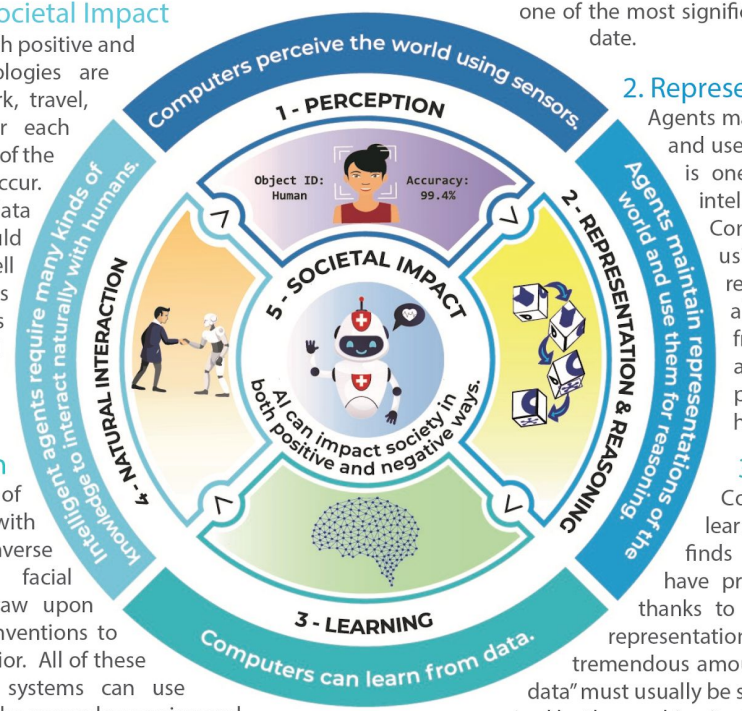
Computers can learn from data. Machine learning is a kind of statistical inference that finds patterns in data. Many areas of AI have progressed significantly in recent years thanks to learning algorithms that create new representations. For the approach to succeed, tremendous amounts of data are required. This "training data" must usually be supplied by people, but is sometimes acquired by the machine itself.

4. Natural Interaction

Intelligent agents require many kinds of knowlege to interact naturally with humans. Agents must be able to converse in human languages, recognize facial expressions and emotions, and draw upon knowledge of culture and social conventions to infer intentions from observed behavior. All of these are difficult problems. Today's AI systems can use language to a limited extent, but lack the general reasoning and conversational capabilities of even a child.

5. Societal Impact

AI can impact society in both positive and negative ways. AI technologies are changing the ways we work, travel, communicate, and care for each other. But we must be mindful of the harms that can potentially occur. For example, biases in the data used to train an AI system could lead to some people being less well served than others. Thus, it is important to discuss the impacts that AI is having on our society and develop criteria for the ethical design and deployment of AI-based systems.



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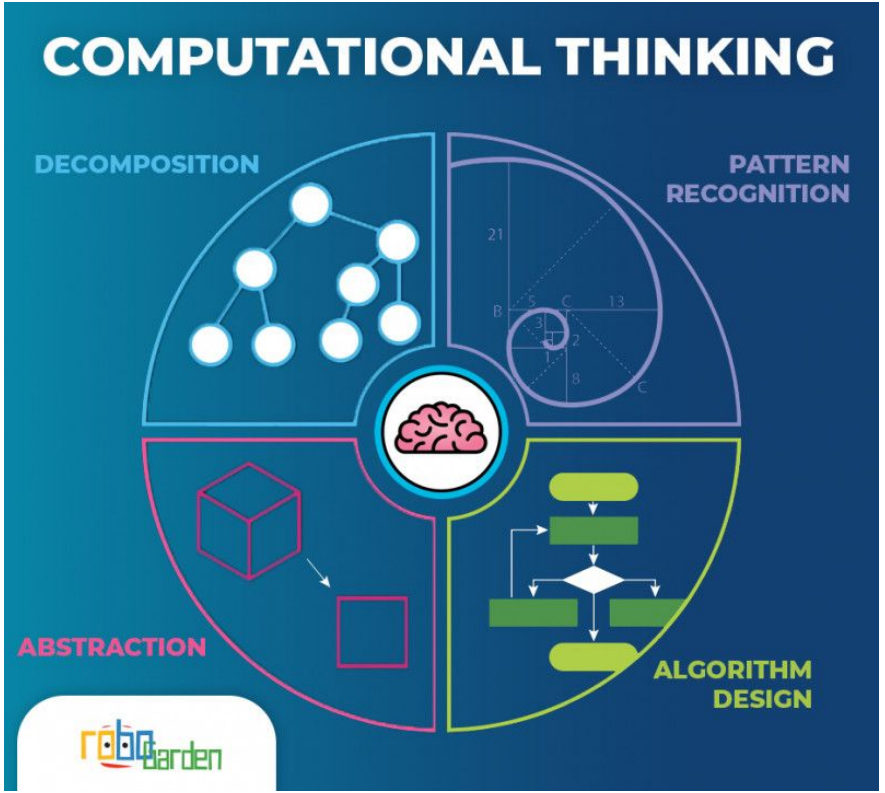
AI4K12.org

11x14 Poster available for free download at AI4K12.org

What is computational thinking?

1. Problem decomposition
2. Pattern recognition
3. Abstraction
4. Algorithms



What might “AI thinking” look like?

- Perception
- Knowledge representation
- Reasoning
- Learning

An analogy: playing with numbers

1. Math by pencil and paper

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4. Programming: easy(?) experimenting with algorithms (e.g., Newton-Raphson)

An analogy: playing with numbers

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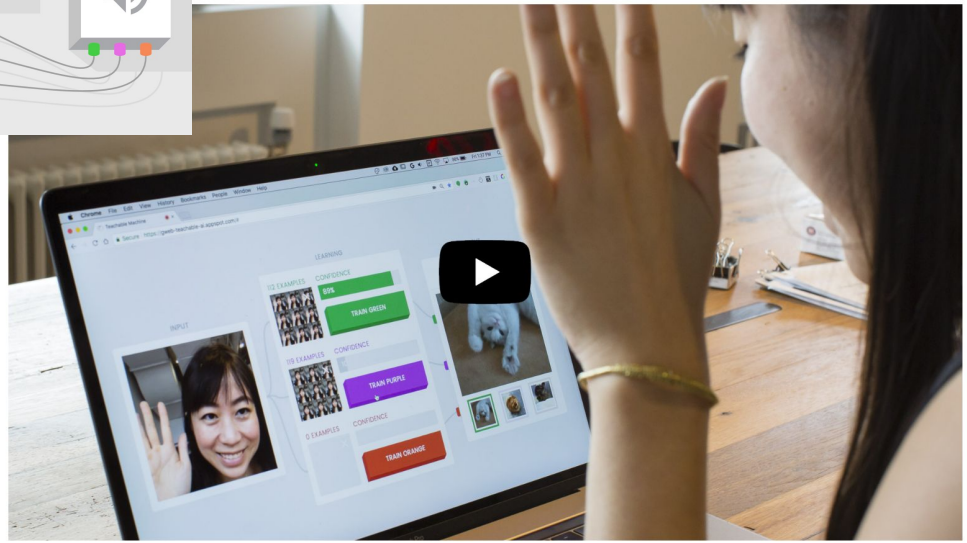
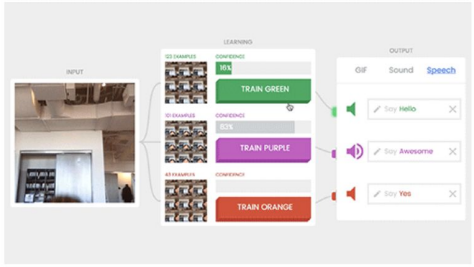
3. Spreadsheets: chains of equations; easy “what if” calculations
4. Programming: easy(?) experimenting with algorithms (e.g., Newton-Raphson)
5. AI: easy experimentation with computer vision, language understanding, generative algorithms, and more.

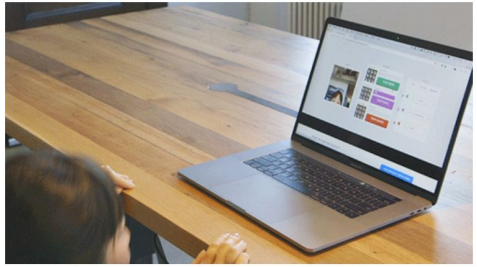
TEACHABLE MACHINE

Built with TensorFlow

- Teach a machine using your camera.
- Live, in the browser.
- No coding required.



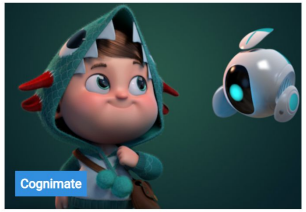


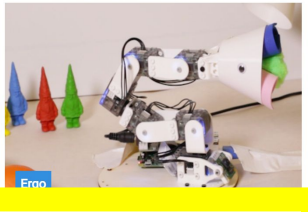


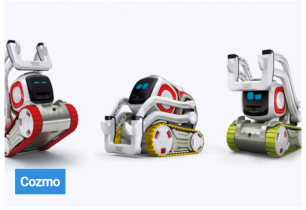
https://experiments.withgoogle.com/teachable-machine

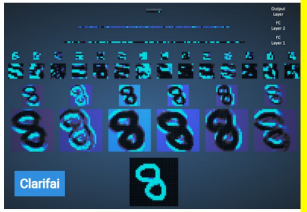
COGNIMATES

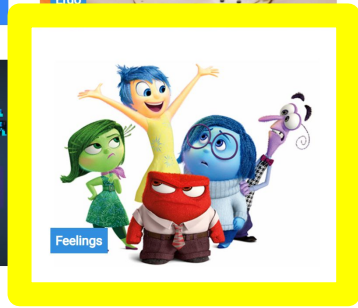
http://cognimates.me





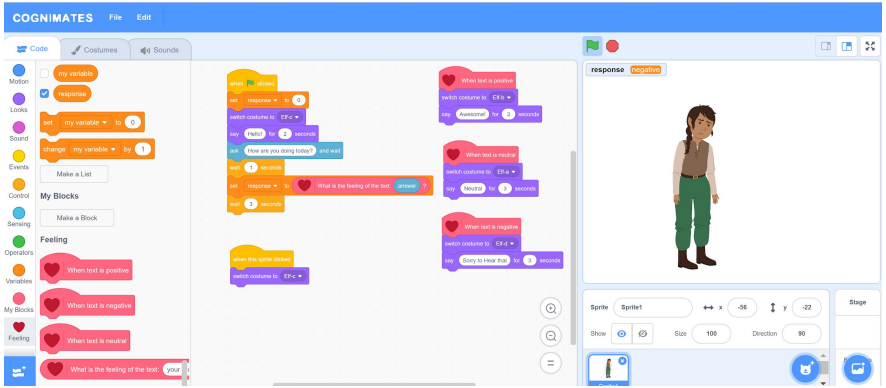




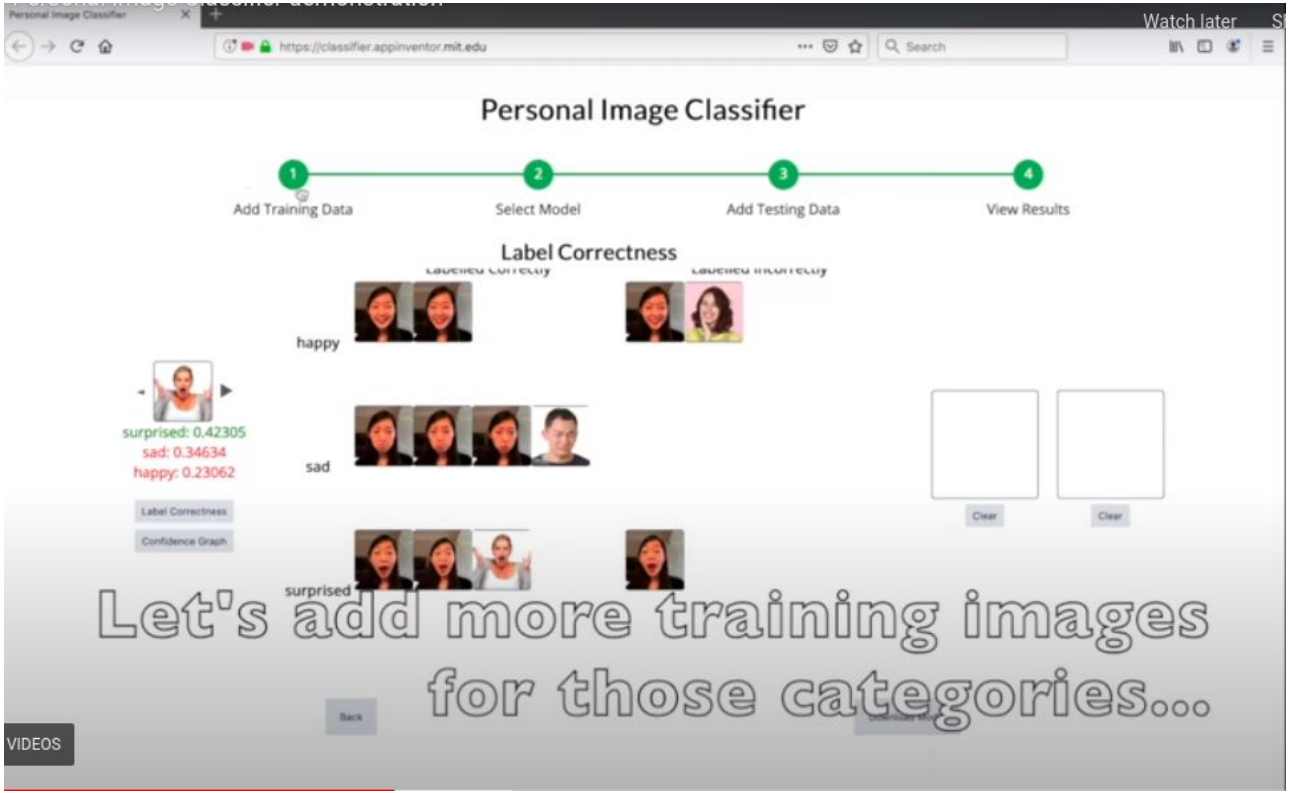


Cognimates offers AI extensions for Scratch, such as:

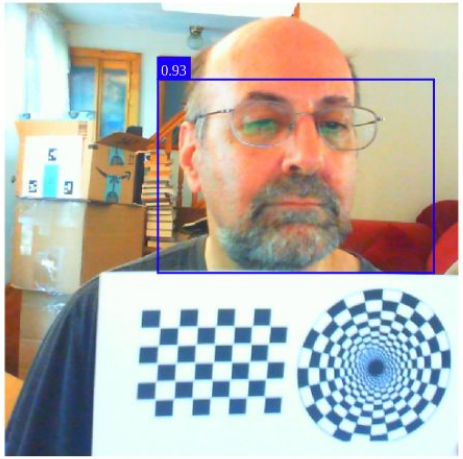
- speech recognition
- sentiment analysis
- visual pattern detection
- robot control



AI Extensions for MIT APP Inventor

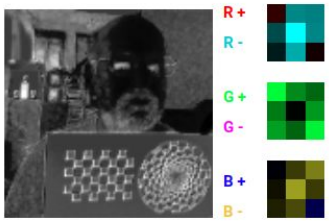


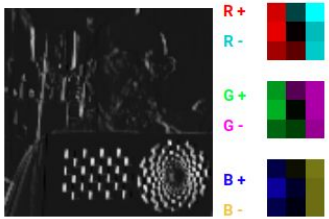
Edge and Face Detection Demo



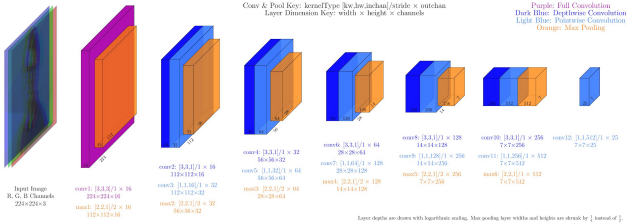
Convolutional Layer : 4

Convolutional Layer : 1





Real-time face detection by a deep neural network (TinyYoloV2)



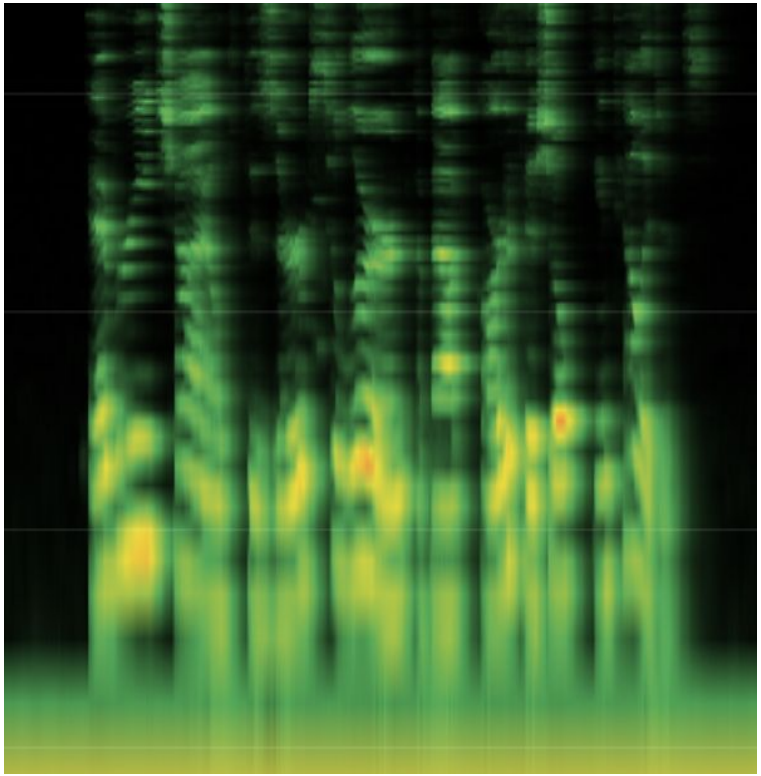
https://www.cs.cmu.edu/~dst/FaceDemo

AI and Language

Real-Time Spectrogram Demo

Speech spectrogram of me saying *“Every child deserves to learn about artificial intelligence.”*

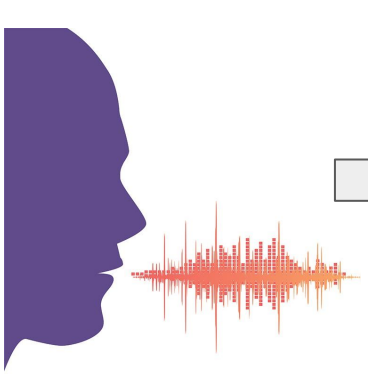
https://creatability.withgoogle.com/seeing-music

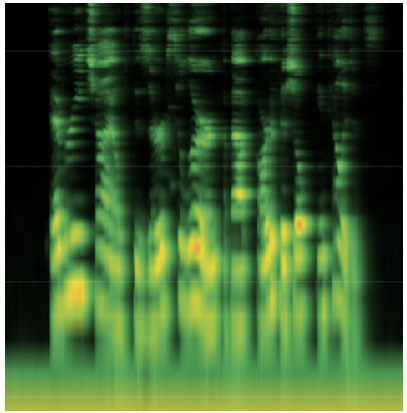


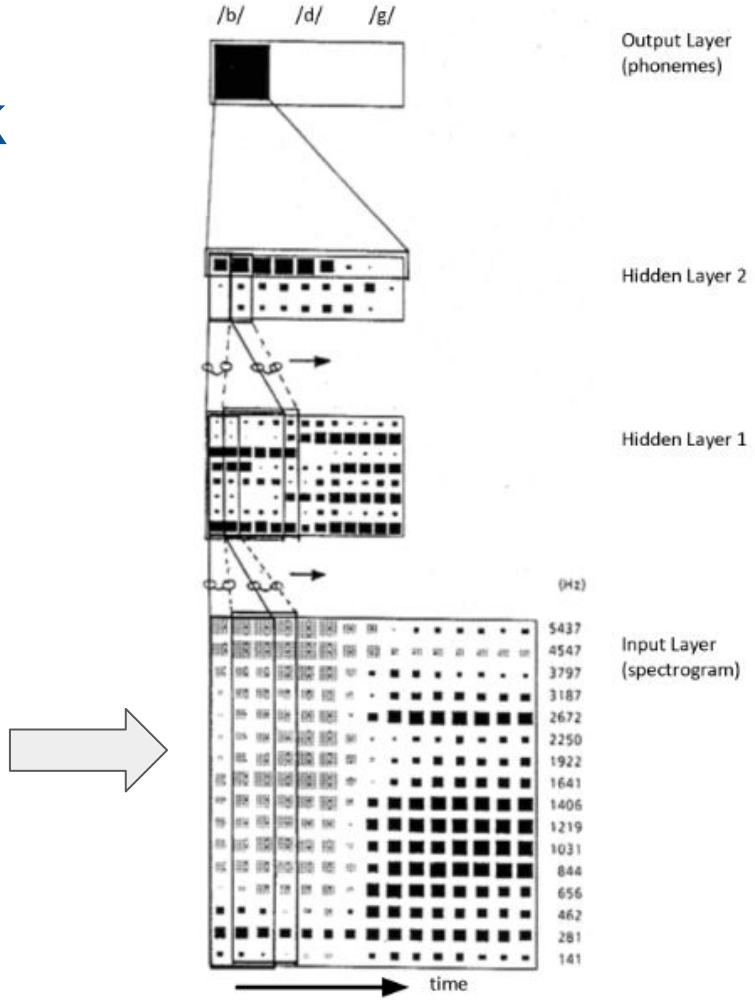
Time Delay Neural Network

Early convolutional neural net from 1980s.

Spectrograms go in; phonemes come out.

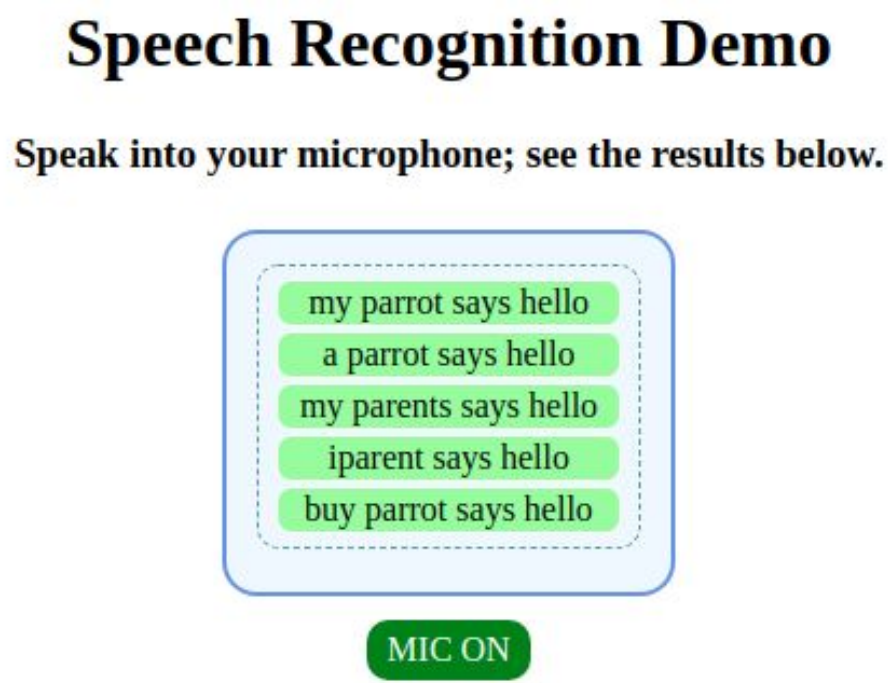




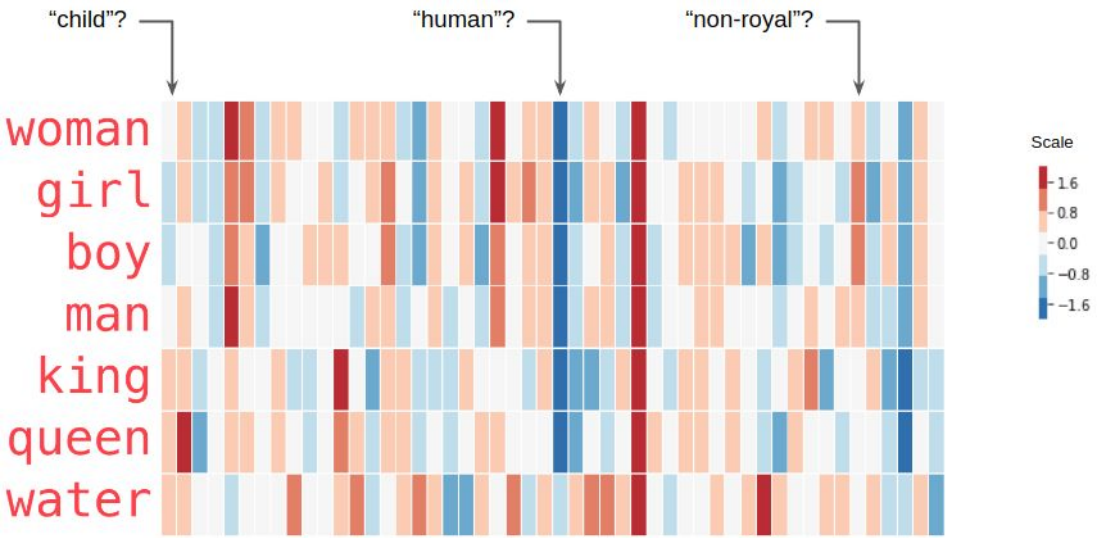


Google Speech API: Embrace the ambiguity!

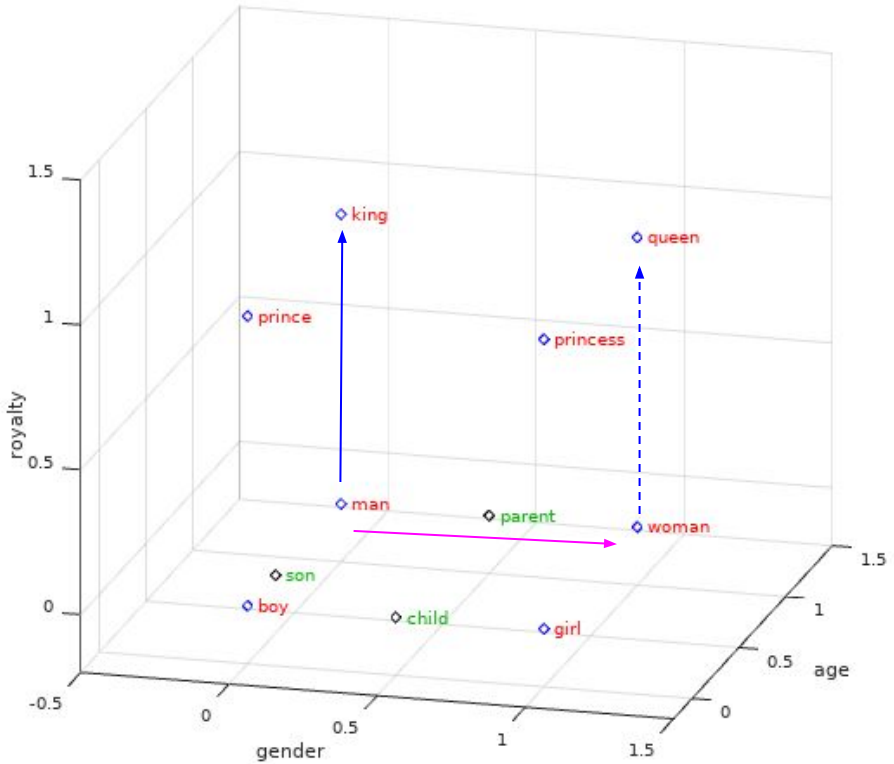
https://www.cs.cmu.edu/~dst/SpeechDemo



Word embeddings created by machine learning



Exploring semantic feature space



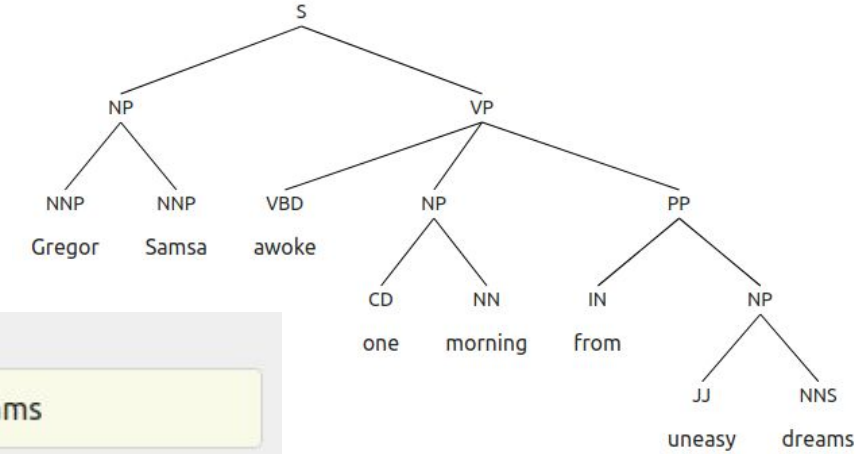
Sentence Diagramming

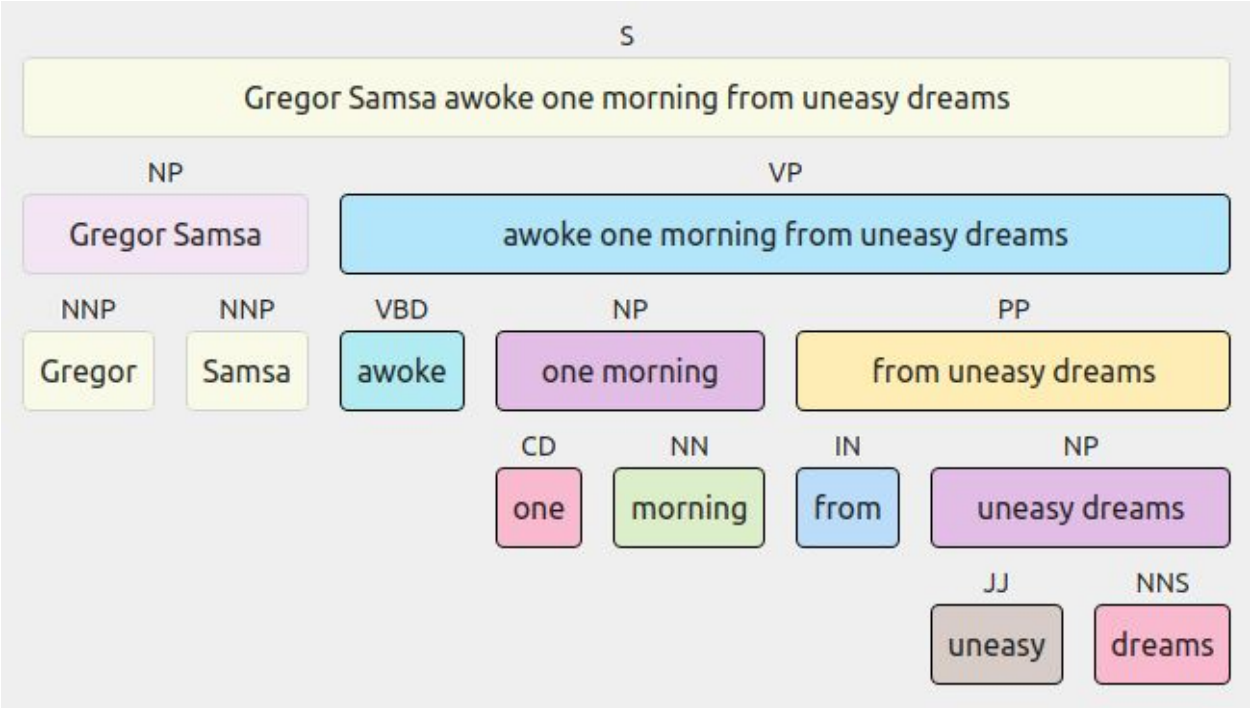
As Gregor Samsa awoke one morning from uneasy dreams
he found himself transformed in his bed into a monstrous vermin.

Kafka, *Metamorphosis*

Berkeley Neural Parser

https://parser.kitaev.io/





Parser Experiments: Statistics Mimic Semantics

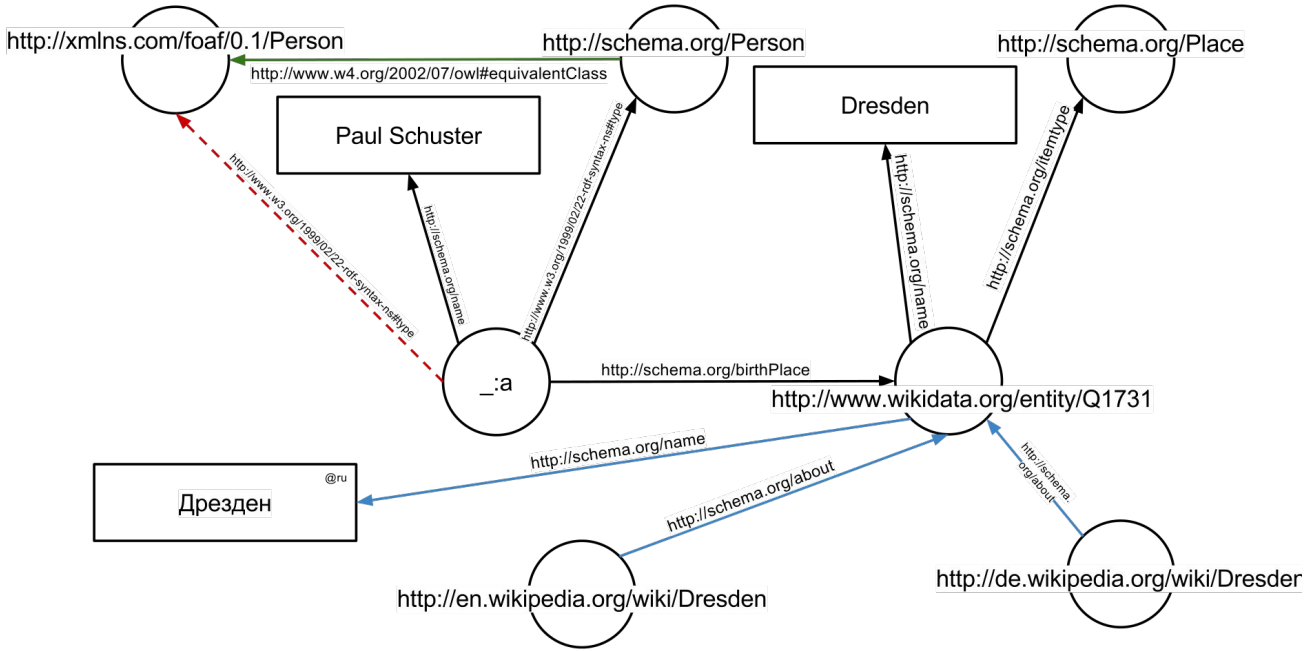
https://parser.kitaev.io/

1. John saw the man with binoculars.
2. John *easily* saw the man with binoculars.
3. John easily saw the man with *groceries.*

1. John saw the man with one eye.
2. John saw the man with one leg.
3. John saw the man with one ear.

Scenes From the AI Future (1)

The semantic web as a common good.



Scenes from the AI Future (2)

Self-driving vehicles will be everywhere...

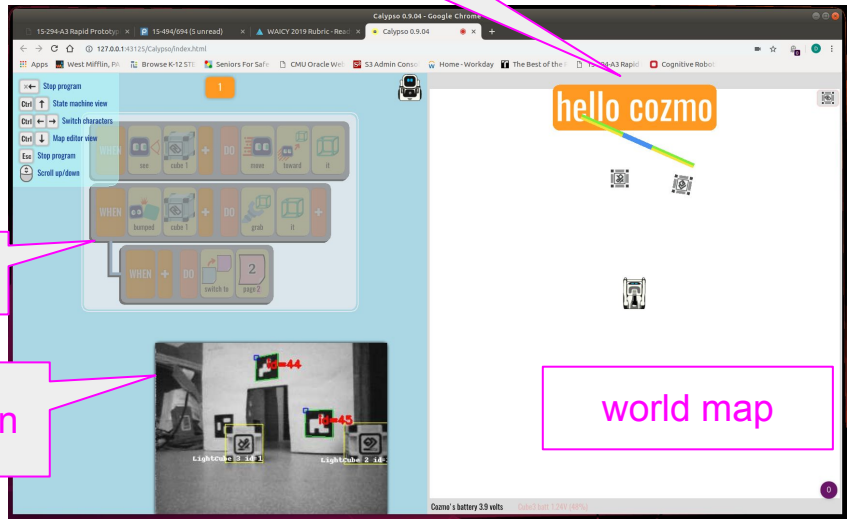
Scenes from the AI Future (3)

Vision-guided mobile manipulators in the classroom

Cozmo robot from Anki / Digital Dream Labs

Robomaster S1 from DJI

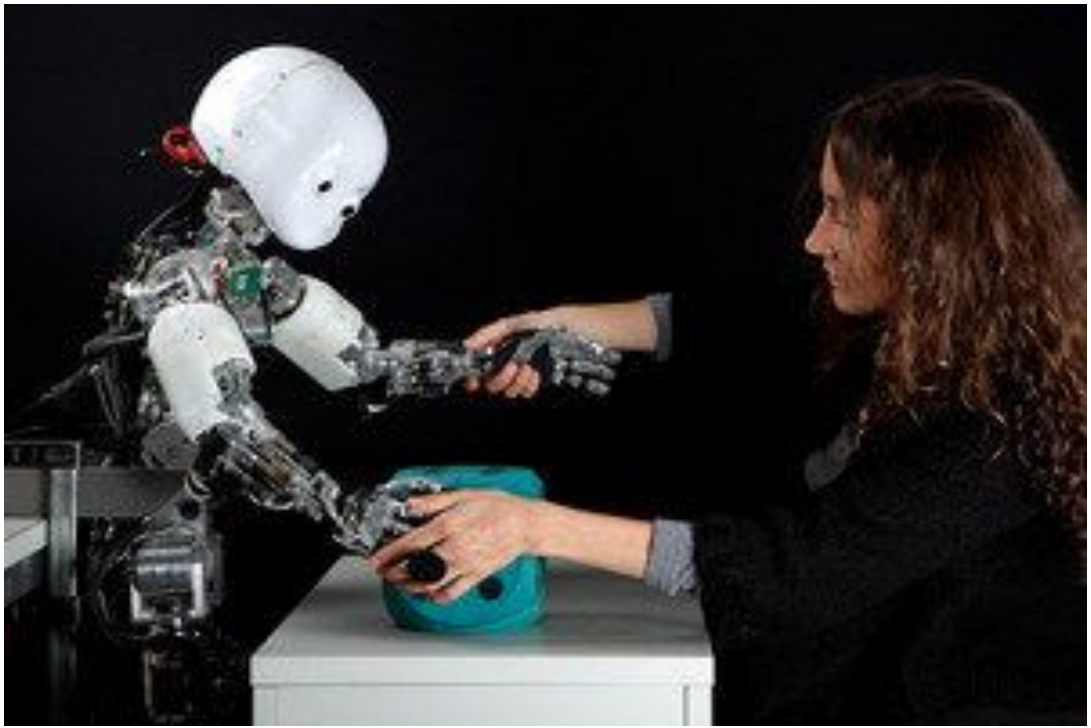
Calypso for Cozmo



- A robot intelligence framework that Incorporates multiple AI technologies:
  - Computer vision; face recognition
  - Speech recognition and generation
  - Landmark-based navigation
  - Path planning
  - Object manipulation
- Rule-based pattern matching language inspired by Microsoft's Kodu Game Lab
- Teaches computational thinking: "Laws of Calypso", idioms, etc.
- Web site: https://Calypso.software or https://calypso-robotics.com

Scenes from the AI Future (4)

Learning by demonstration.



Join Us in Developing the Guidelines, or Help Grow the Community of AI Resource Developers

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