Teaching Artificial Intelligence in K-12

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1.

Background and Overview of AI4K12

1.1 The Cozmo Robot

Cozmo was one of the first consumer robots with built-in computer vision.

1.2 Calypso for Cozmo

The Cozmo robot and the Calypso for Cozmo software framework.

Calypso

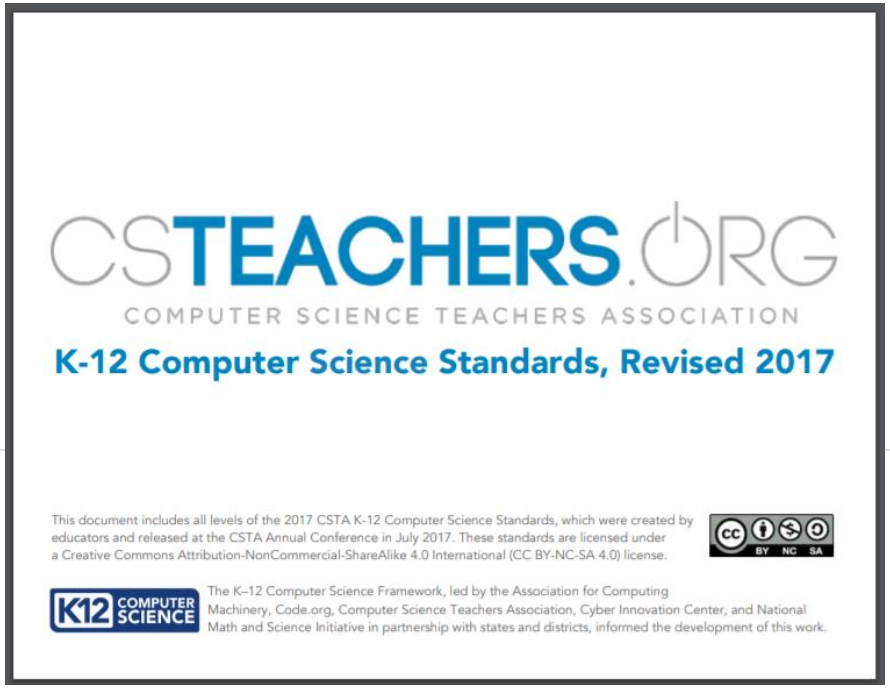
See https://Calypso.software

1.3 The CSTA Computer Science Standards

CSTA (the Computer Science Teachers Association) publishes national standards for computer science education.

There are only two sentences about Artificial Intelligence.

Both are at the high school level.



Algorithms and Programming

3B-AP-08	Describe how artificial intelligence drives many software and physical systems. *Examples include digital ad delivery, self-driving cars, and credit card fraud detection.*	Algorithms	7.2
3B-AP-09	Implement an artificial intelligence algorithm to play a game against a human opponent or solve a problem. *Games do not have to be complex. Simple guessing games, Tic-Tac-Toe, or simple robot commands will be sufficient.*	Algorithms	5.3

1.4 The AI4K12 Initiative

Association for the Advancement of Artificial Intelligence

Computer Science Teachers Association

CSTA

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

Carnegie Mellon University
School of Computer Science

1.5 Mission of the AI4K12 Initiative

1. Develop national guidelines for teaching AI in K-12.
2. Develop a curated online resource directory for K-12 teachers.
3. Foster a community of K-12 AI education researchers, teachers, curriculum writers, and resource developers.

1.6 The AI4K12 Steering Committee

David Touretzky
Carnegie Mellon
AI4K12 Chair

Christina Gardner-Mccune
University of Florida
AI4K12 Co-Chair

Fred Martin
U. Mass Lowell
(emeritus member)

Deborah Seehorn
Co-Chair of CSTA
Standards Committee

1.7 The AI4K12 Working Group

Teachers with expertise in four grade bands: K-2, 3-5, 6-8, and 9-12.

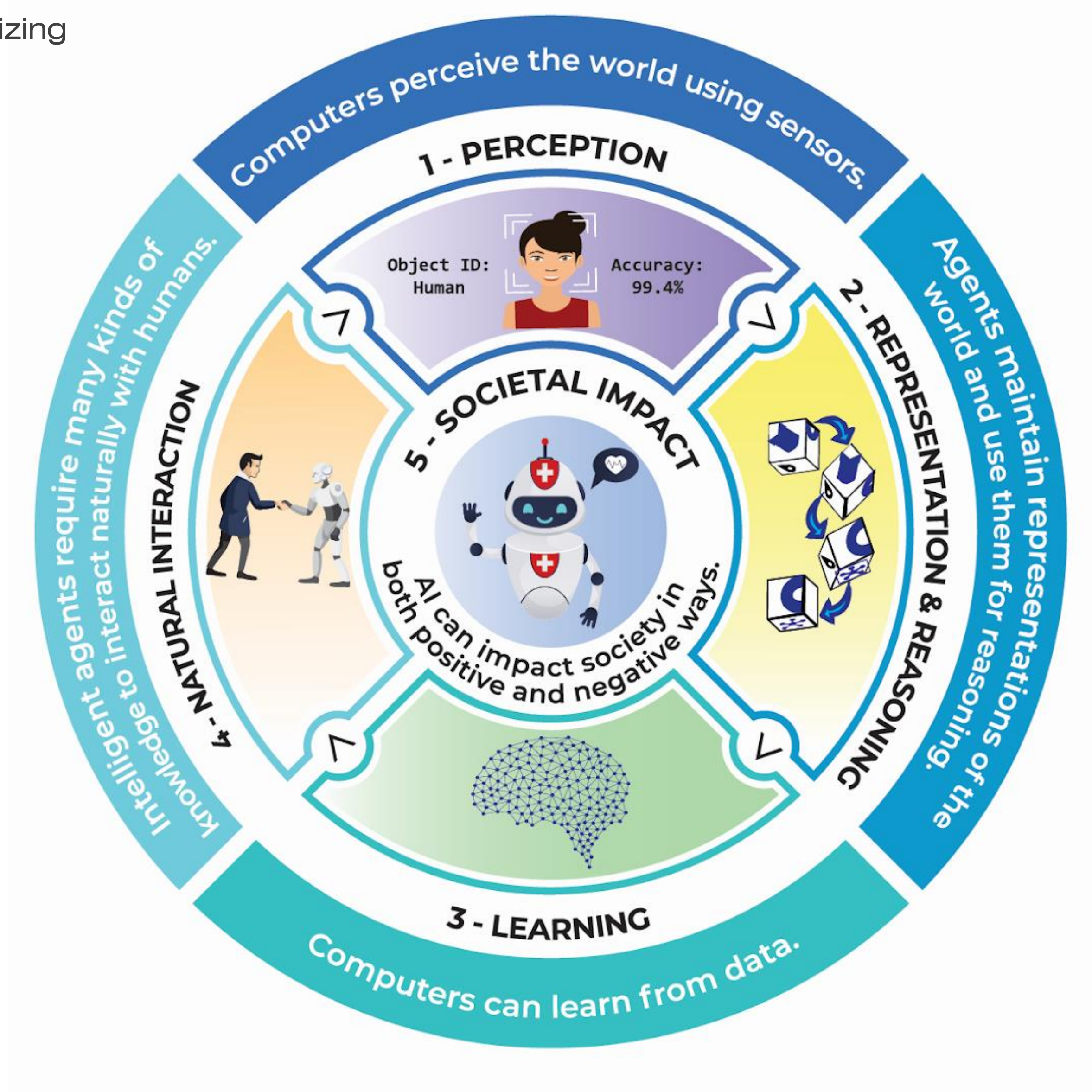
AI subject matter experts.

Computing education experts.

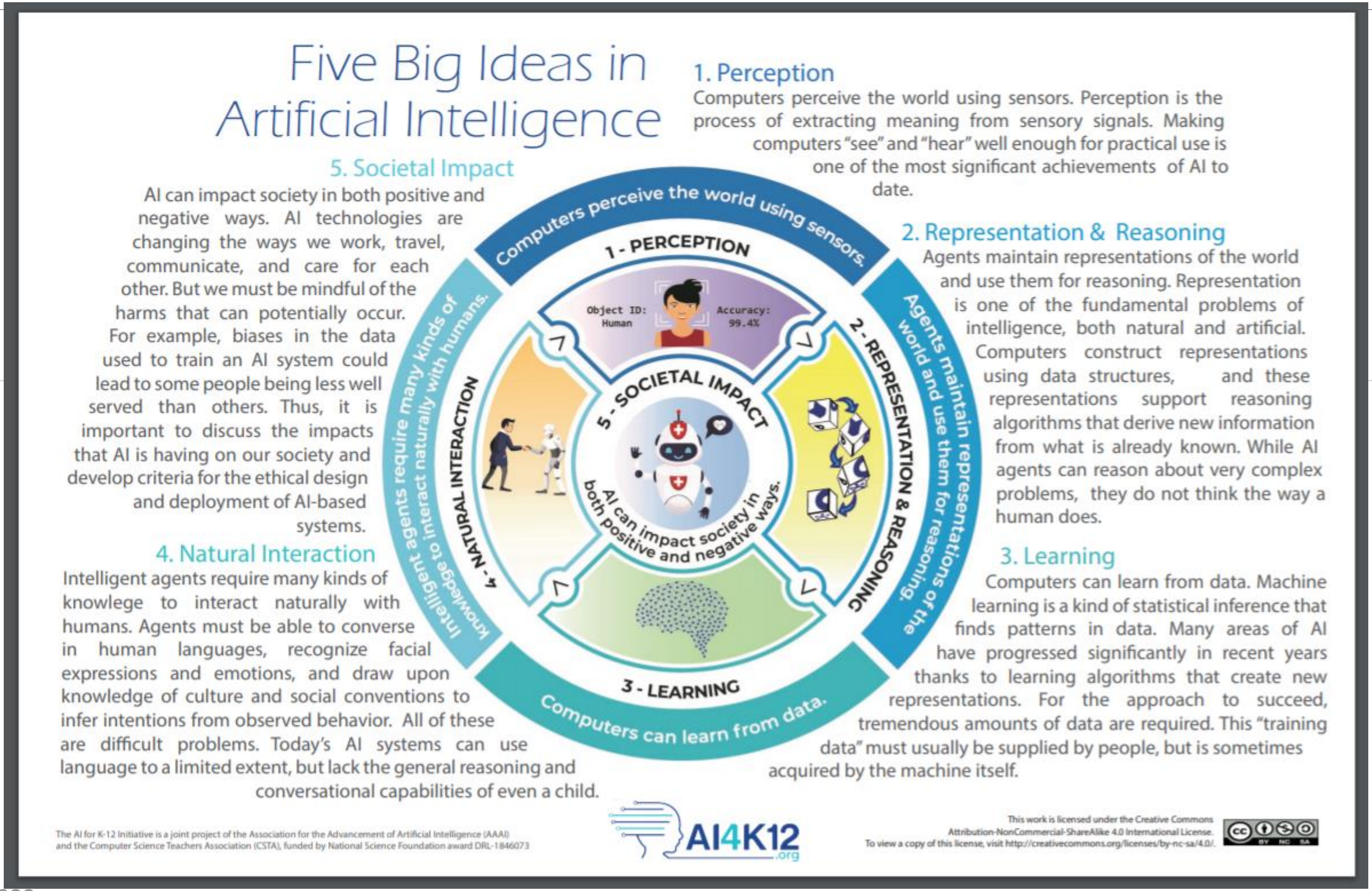
2.
The Five Big Ideas in AI

2.1 Five Big Ideas in AI

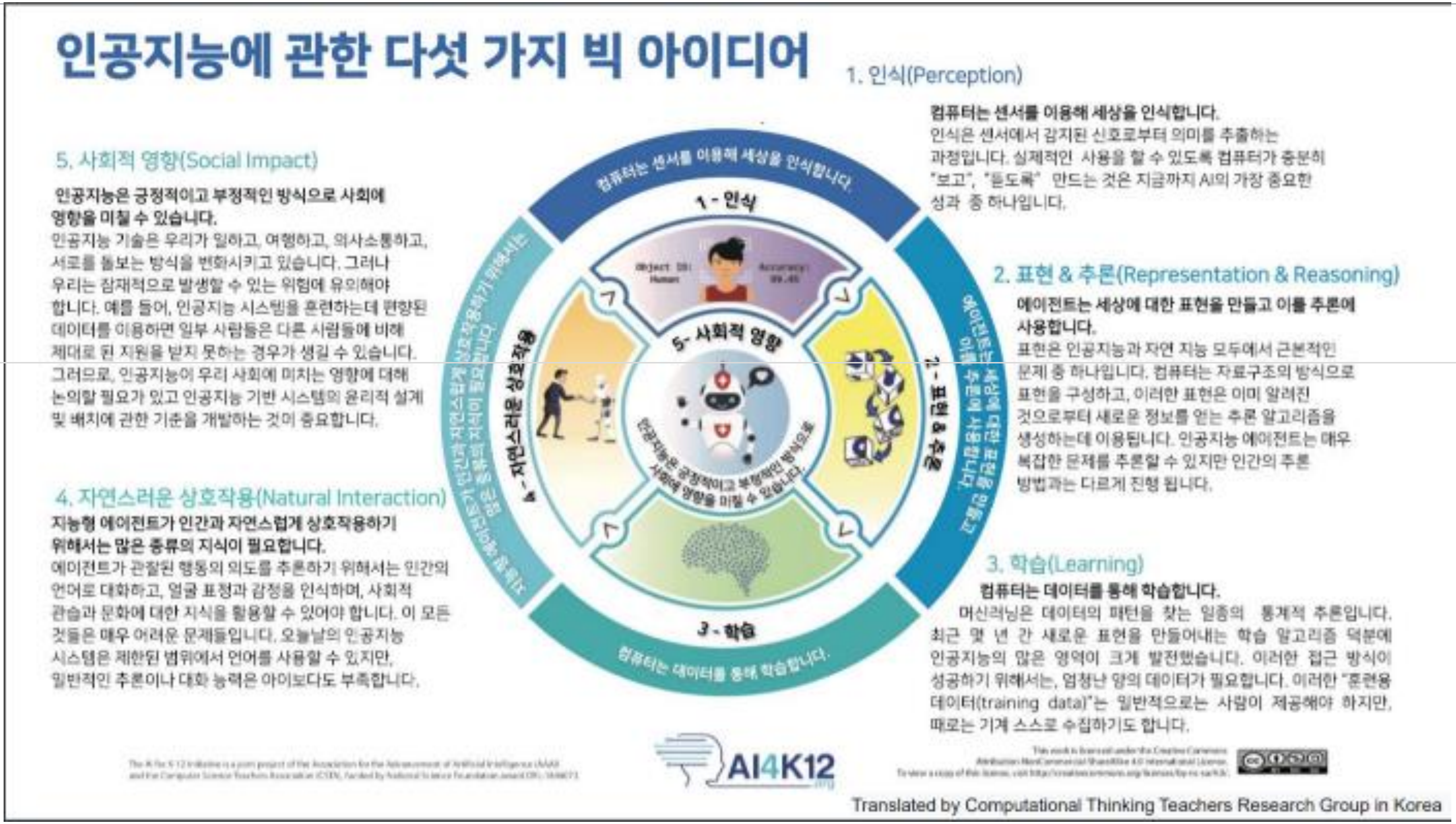
The Five Big Ideas are the organizing framework for the guidelines.



2.2 “Five Big Ideas in AI” Poster



2.3 “Five Big Ideas in AI” Poster in Korean

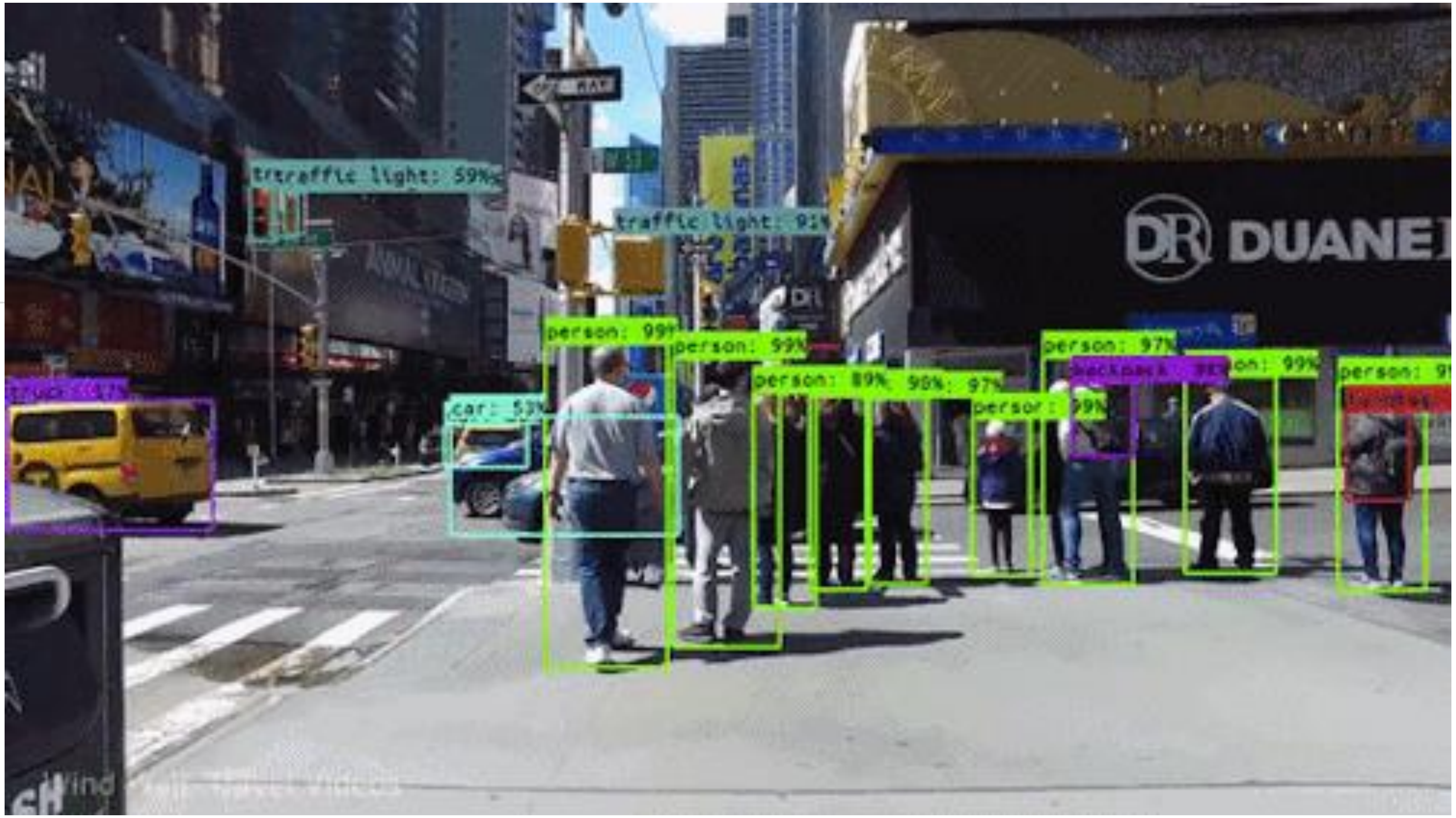


2.4 Big Idea #1: Perception

Computers perceive the world using sensors.

Examples:

- Computer vision
- Speech Recognition



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

The abstraction hierarchy:
The transformation from signal to meaning takes place in stages, with increasingly abstract features and higher level knowledge applied at each stage.

2.5 Big Idea #2: Representation and Reasoning

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

Representations are **data structures.**

- Symbolic representations
- Feature vector representations

Reasoning is done by **algorithms.**

Types of reasoning: classification, prediction, deduction, sequential decision problems, planning, optimization, etc.

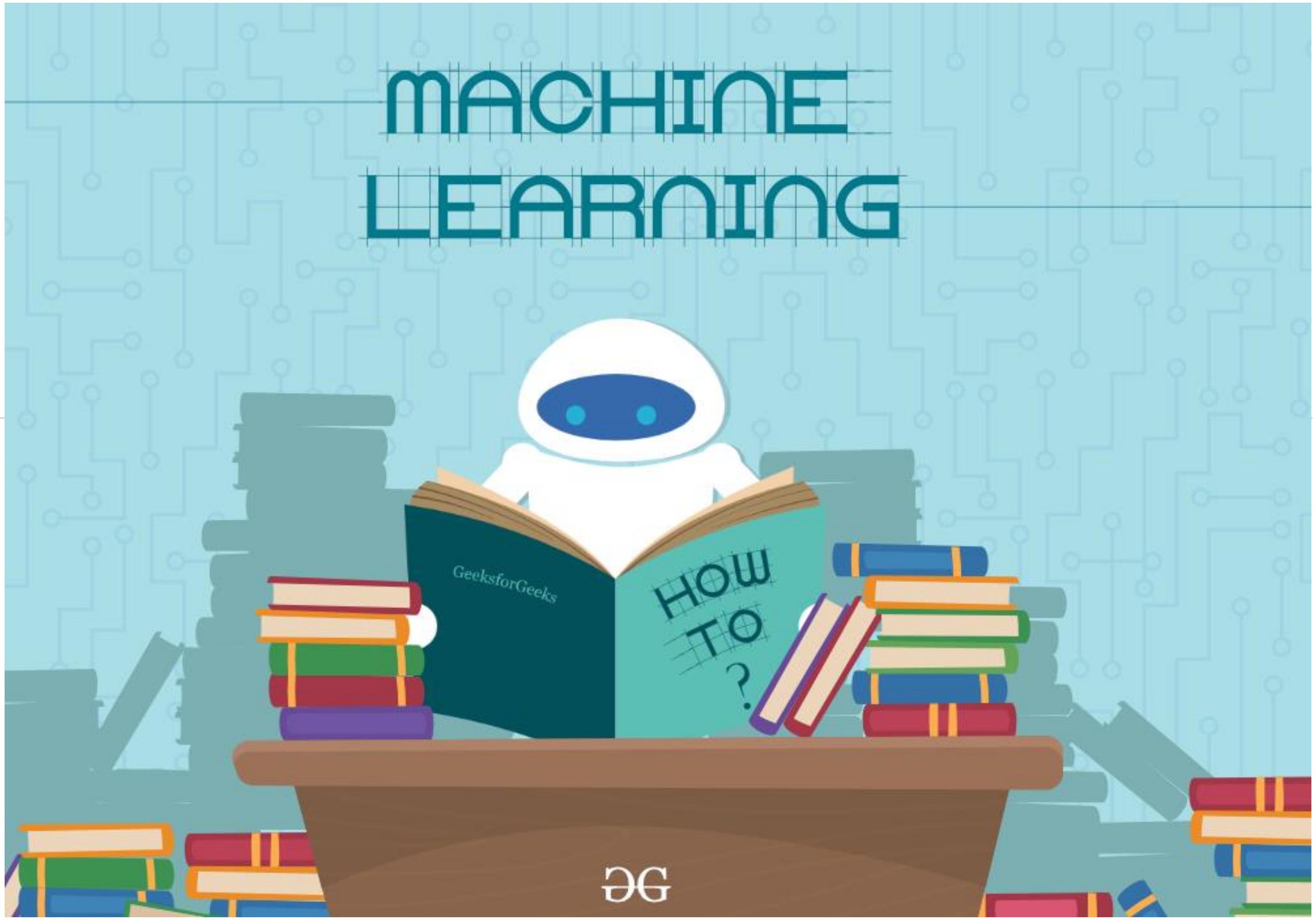
2.6 Big Idea #3: Learning

Computers can learn from data.

- Symbolic approaches, e.g., decision trees
- Neural networks, e.g., backpropagation

Key insights on machine learning:

- Learning is a change in internal representation that results in a change in behavior.
- Machine learning allows a computer to change its behavior without being explicitly programmed.



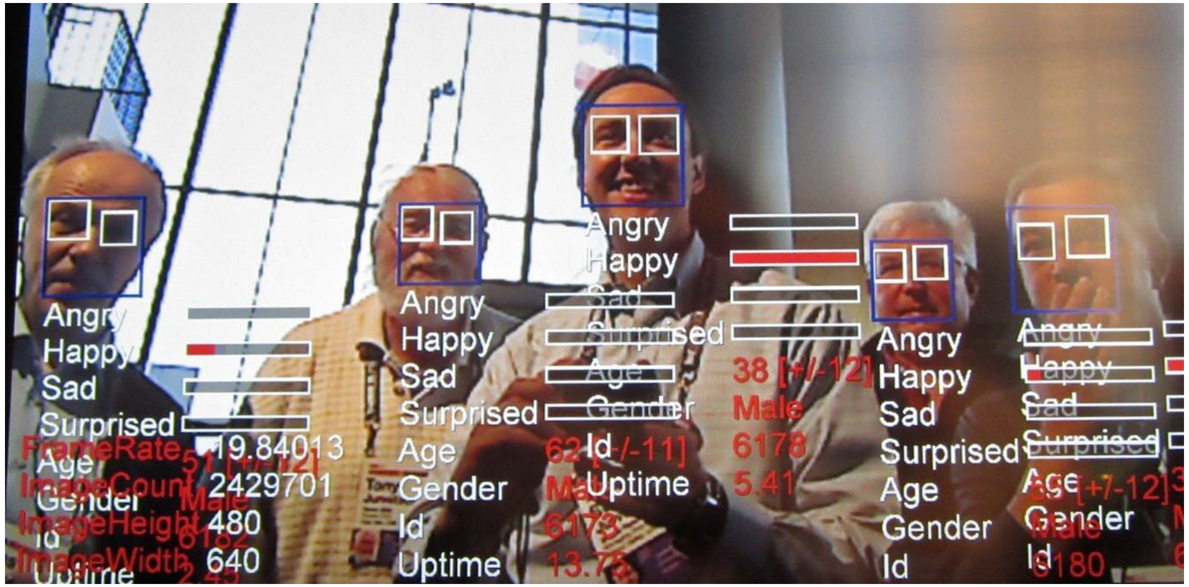
2.7 Big Idea #4: Natural Interaction

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

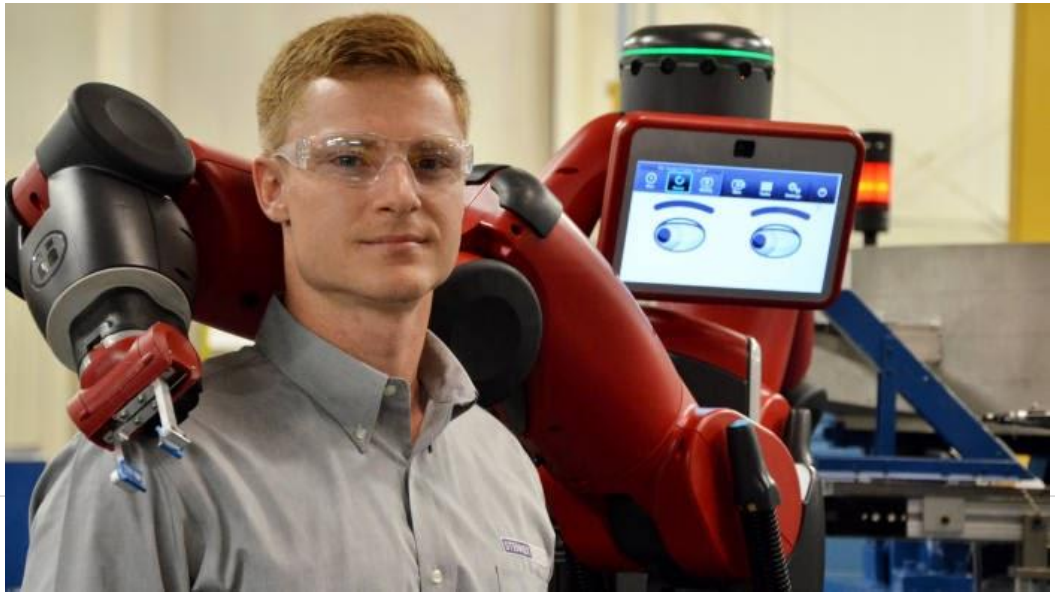
A robot in the lab of Cynthia Breazeal, MIT Media Lab

This is a broad category that covers many topics:

- Natural language understanding
- Common sense reasoning
- Affective computing (recognizing and responding to emotional states.)
- Consciousness and philosophy of mind.



2.8 Big Idea #5: Societal Impact

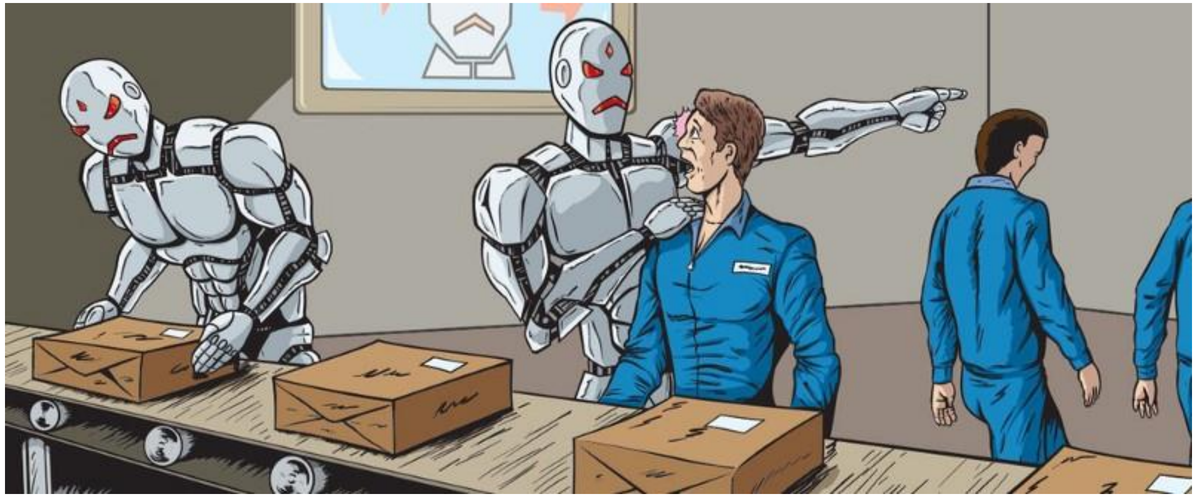


Artificial Intelligence can impact society in both positive and negative ways.

We want students to have a balanced view of AI, not just focus on the negative things.

Economic and employment impacts of AI.

- People will work alongside robots and intelligent agents.
- Some people may lose their jobs due to automation.
- Some new type of jobs will be created.
- New types of services will become possible.



2.9 Societal Impact: Ethical Application of AI Technology

AI can be used to make decisions about people:

- Who gets into college
- Who gets a job interview
- Who gets a loan or mortgage
- Sentencing or parole recommendations

Guidelines for ethical design of decision-making systems:

- Transparency: what information is driving the decision?
- Explainability: what factors led to the decision?
- Accountability: taking responsibility for outcomes.
- Fairness: treating all groups equally.

Machine Bias: ProPublica.org

2.10 Societal Impact: Cultural Implications

Would you send your child off in a self-driving car?

What relationships will people have with intelligent agents and robot companions?

How can we trust photographic and video evidence when deep fakes are so realistic?

2.11 Next Steps for the Guidelines

Big Idea #1 Grade Band Progression Chart is out for public comment.

Big Idea #3 Grade Band Progression will be the next one released.

AI4K12 .org   Draft Big Idea 1 - Progression Chart   www.AI4K12.org

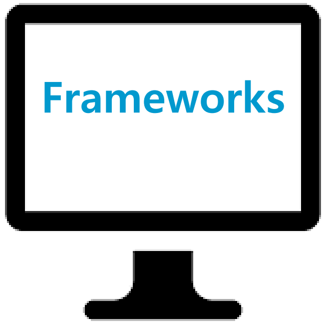
Big Idea #1: Perception	*Computers perceive the world using sensors.*	**Perception is the extraction of meaning from sensory information using knowledge.**	**The transformation from signal to meaning takes place in stages, with increasingly abstract features and higher level knowledge applied at each stage.**	**LO** = Learning Objective: what students should be able to do. **EU** = Enduring Understanding: what students should know.
Concept	**K-2**	**3-5**	**6-8**	**9-12**
Sensing (Living Things) **1-A-i**	**LO:** Identify human senses and sensory organs. **EU:** People experience the world through sight, hearing, touch, taste, and smell.	**LO:** Compare human and animal perception. **EU:** Some animals experience the world differently than people do. **Unpacked:** Bats and dolphins use sonar. Bees can see ultraviolet. Rats are have no color vision; dogs are red-green colorblind. Dogs and rats can hear higher frequences than humans.	**LO:** Give examples of how humans combine information from muliple modalities. **EU:** People can exploit correlations between senses, such as sight and sound, to make sense of ambiguous signals. **Unpacked:** In a noisy environment, speech is more understandable when the speaker's mouth is visible. People learn the sounds associated with various actions (such as dropping an object) and can recognize when the sound doesn't match their expectation.	N/A – for AI purposes, this topic has already been adequately addressed in the lower grade bands. *Other courses, such as biology or an elective on sensory psychology, could go into more detail about topics such as taste, smell, proprioception, and vestibular organs.* *Possible enrichment material: look at optical illusions (Muller-Lyer illusion, Kanizsa triangle) and ask which ones are computer vision systems also subject to.*
Sensing (Computer Sensors) **1-A-ii**	**LO:** Locate and identify sensors (camera, microphone) on computers, phones, robots, and other devices. **EU:** Computers "see" through video cameras and "hear" through microphones.	**LO:** Illustrate how computer sensing differs from human sensing. **EU:** Most computers have no sense of taste, smell, or touch, but they can sense some things that humans can't, such as infrared emissions, extremely low or high frequency sounds, or magnetism.	**LO:** Give examples of how intelligent agents combine information from multiple sensors. **EU:** Self driving cars combine computer vision with radar or lidar imaging. GPS measurement, and accelerometer data to form a detailed representation of the environment and their motion through it.	**LO:** Describe the limitations and advantages of various types of computer sensors. **EU:** Sensors are devices that measure physical phenomena such as light, sound, temperature, or pressure. **Unpacked:** Cameras have limited resolution, dynamic range, and spectral sensitivity. Microphones have limited sensitivity and frequency response. Signals may be degraded by noise, such as a microphone in a noisy environment. Some sensors can detect things that people cannot, such as infrared or ultraviolet imagery, or ultrasonic sounds.
Sensing (Digital Encoding) **1-A-iii**	N/A	**LO:** Explain how images are represented digitally in a computer. **EU:** Images are encoded as 2D arrays of pixels, where each pixel is a number indicating the brightness of that piece of the image, or an RGB value indicating the brightness of the red, green, and blue components of that piece.	**LO:** Explain how sounds are represented digitally in a computer. **EU:** Sounds are digitally encoded by sampling the waveform at discrete points (typically several thousand samples per second), yielding a series of numbers.	**LO:** Explain how radar, lidar, GPS, and accelerometer data are represented. **EU:** Radar and lidar do depth imaging: each pixel is a depth value. GPS triangulates position using satellite signals and gives a location as longitude and lattitude. Accelerometers measure accleration in 3 orthogonal dimensions. **Unpacked:** Radar and lidar measure distance as the time for a reflected signal to return to the transceiver. GPS determines position by triangulating precisely timed signals from three or more satellites. Accelerometers use orthogonally oriented strain gauges to measure acceleration in three dimensions.

V.0.1 - Released May 28, 2020   Subject to change based on public feedback   1

3.
Resources for Teaching AI in K-12

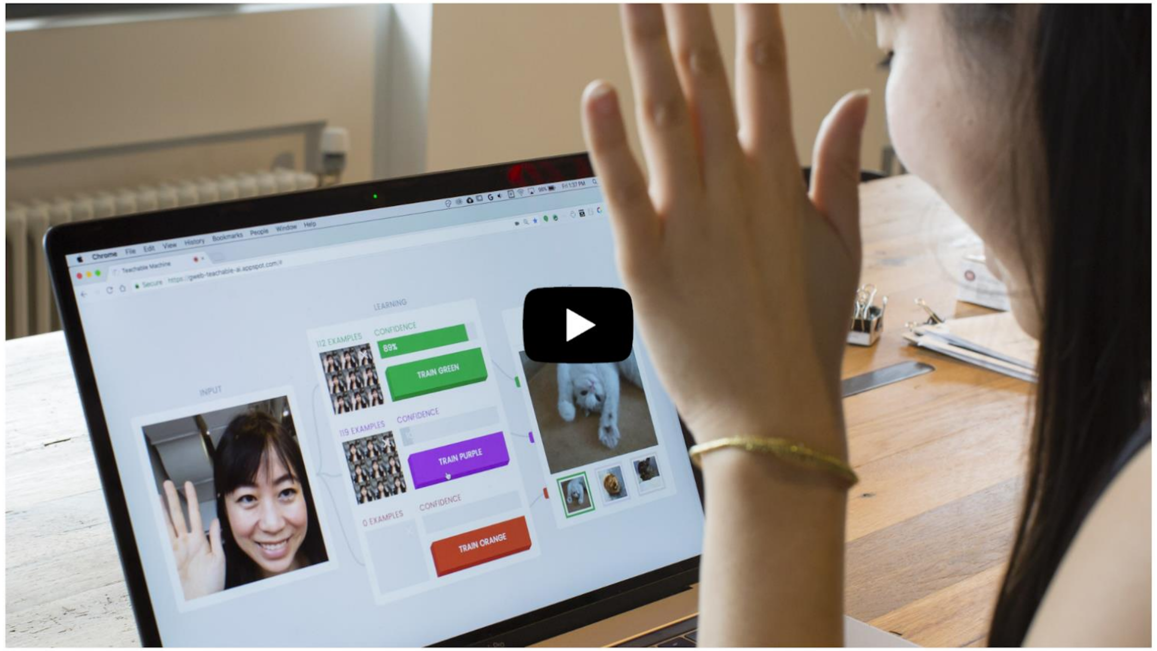
3.1 Types of Resources

- Demos: should run in the browser
  - Black box demos
  - Glass box demos
- Programming Tools
- Videos
- Unplugged Activities
- Curriculum Modules
- Professional Development for Teachers

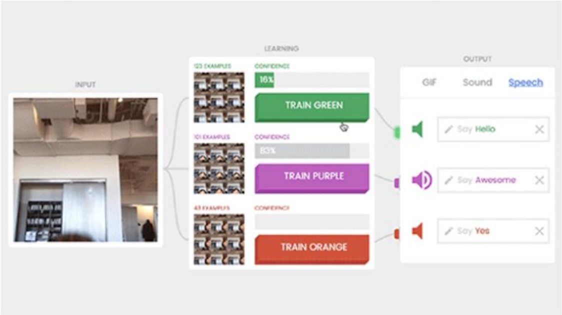


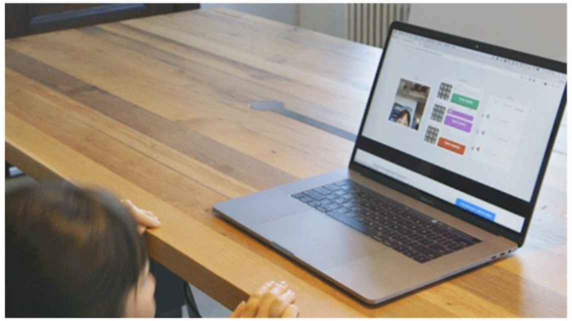
See our Resources Directory at http://AI4K12.org for links to resources.

3.2 Black Box Demo: Teachable Machine



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





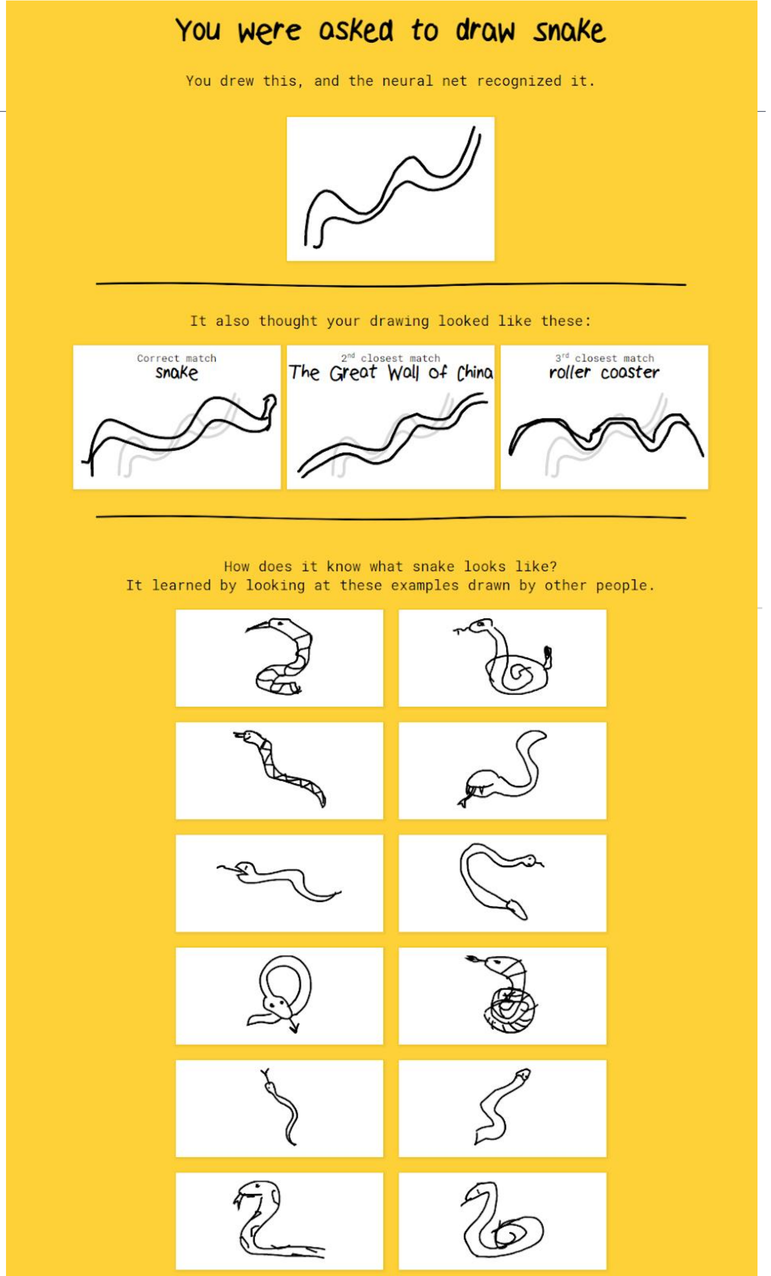
3.3 Black Box Demo: Google's Quick, Draw

https://quickdraw.withgoogle.com

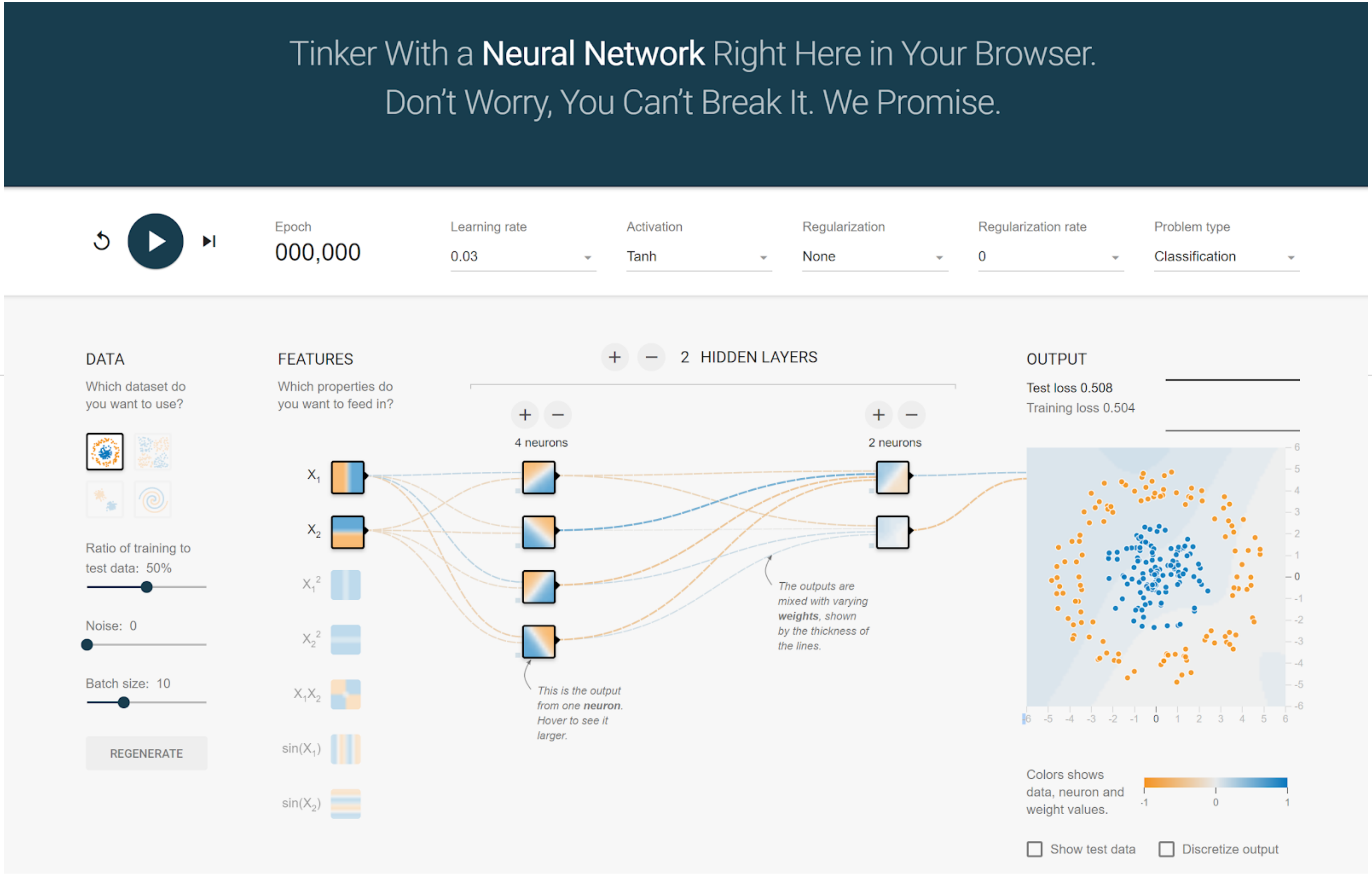
Can a neural network learn to recognize doodling?

Help teach it by adding your drawings to the world's largest doodling data set, shared publicly to help with machine learning research.

Let's Draw!



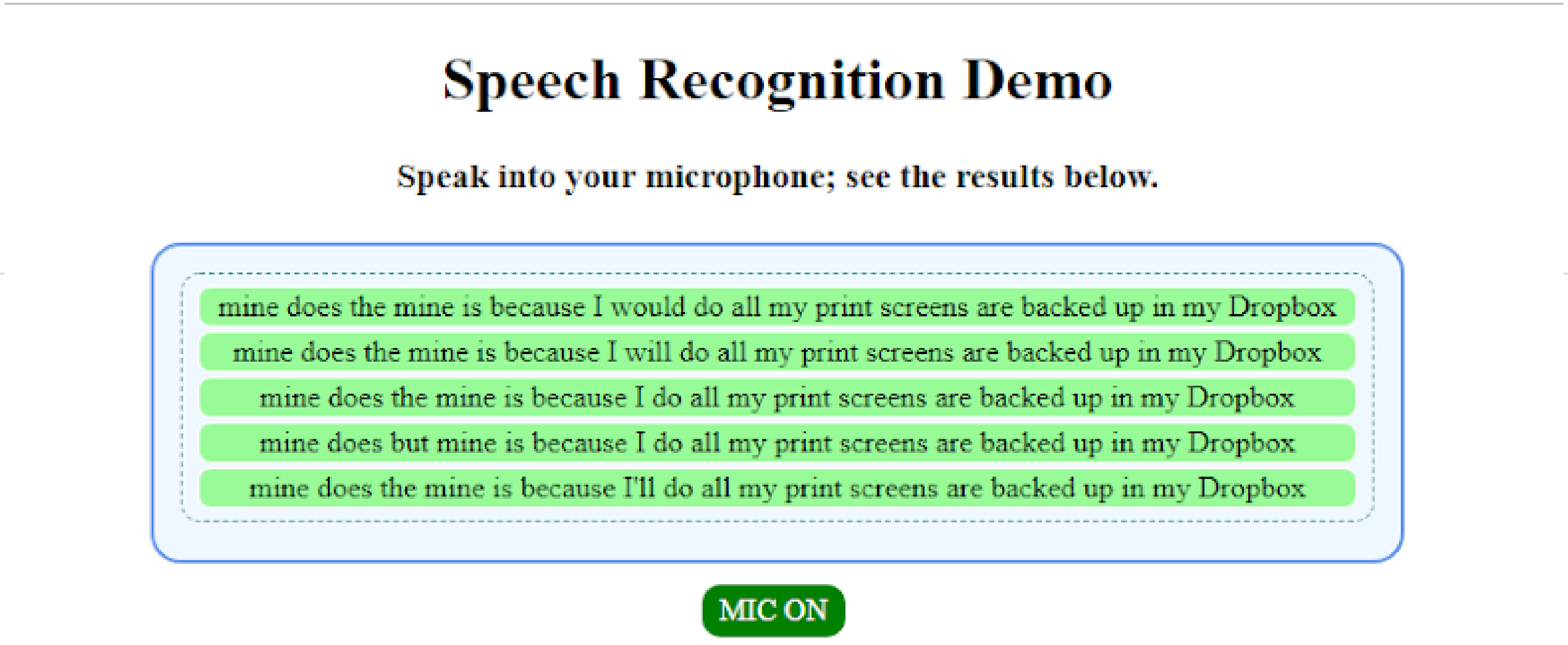
3.4 Glass Box Demo: TensorFlow Playground



https://playground.tensorflow.org

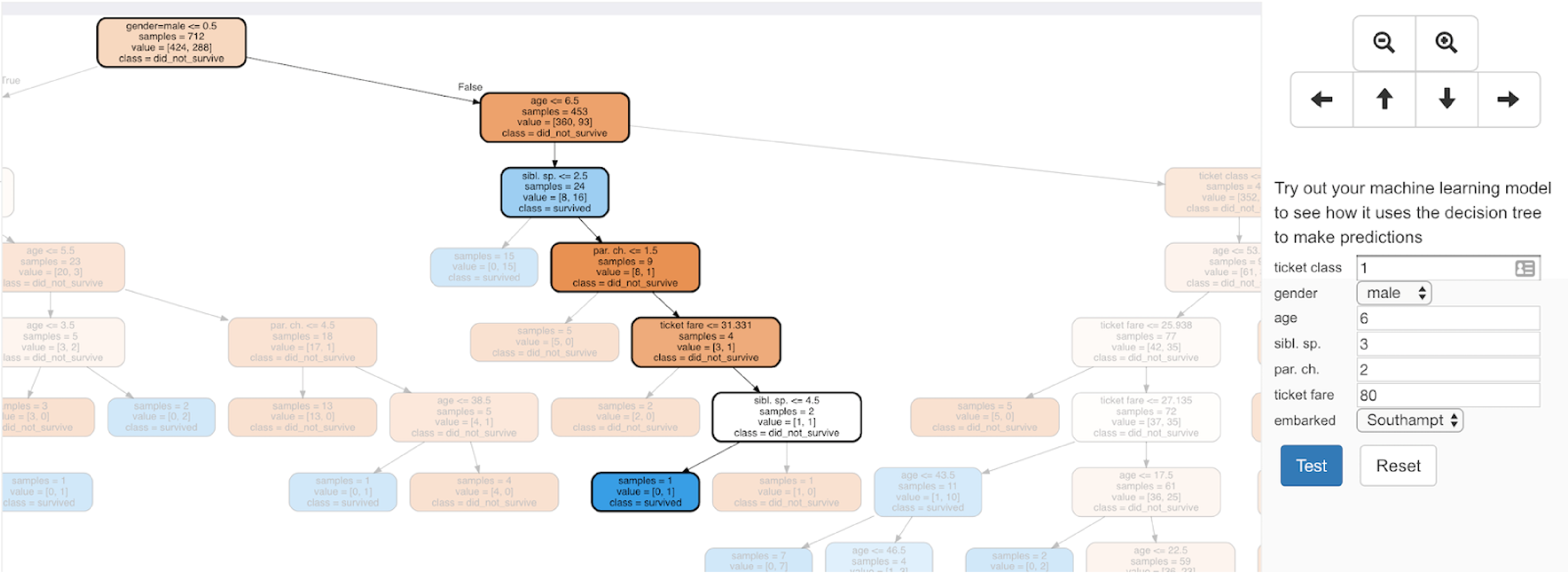
3.5 Glass Box Demo: Speech Recognition

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



3.6 Black Box -> Glass Box Demo: MachineLearningForKids

https://machinelearningforkids.co.uk



3.7 AI Programming Frameworks or Extensions for Kids

AI WITH APP INVENTOR

Calypso

COGNIMATES

eCraft2Learn

Machine Learning for Kids

4.
Questions and Answers