

Teaching Artificial Intelligence in K-12

David S. Touretzky
Carnegie Mellon University

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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.

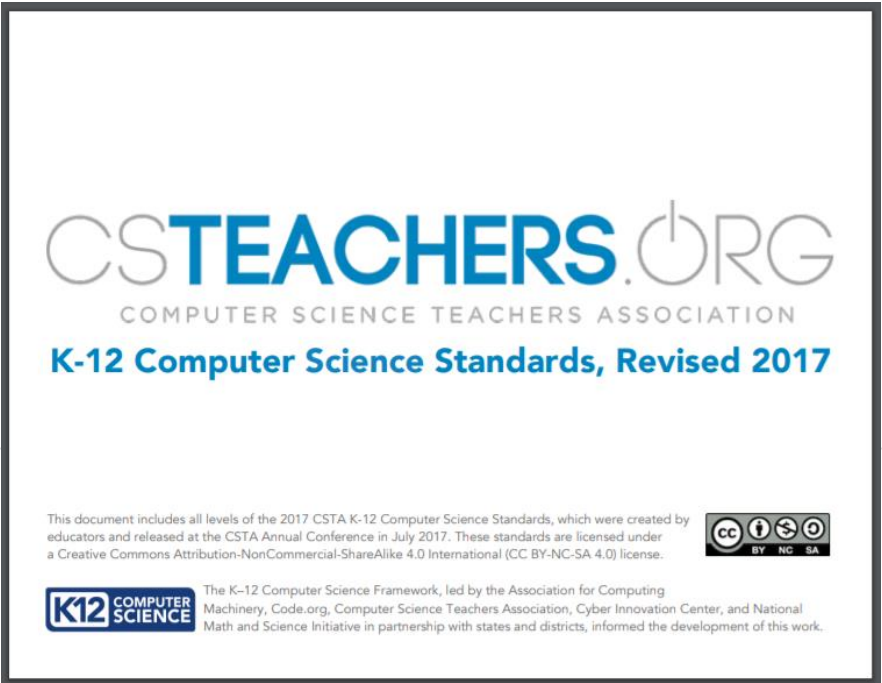


1.3 The CSTA Computer Science Standards

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

1.4 The AI4K12 Initiative



Association for the
Advancement of Artificial Intelligence

Computer Science Teachers Association



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

Carnegie Mellon University
School of Computer Science

1.5 Mission of the AI4K12 Initiative



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- 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



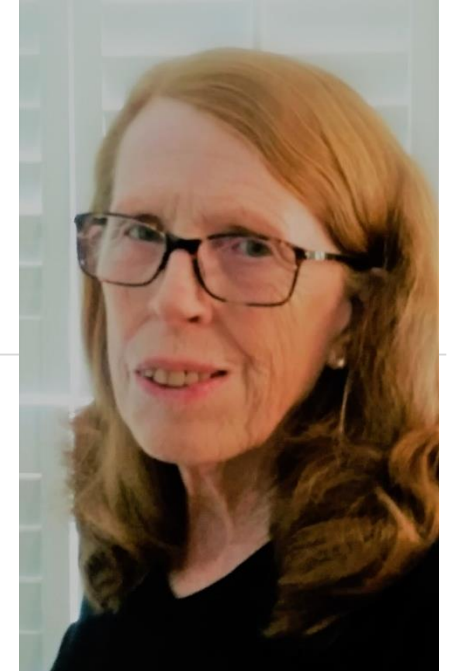
David Touretzky
Carnegie Mellon
AI4K12 Chair



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.

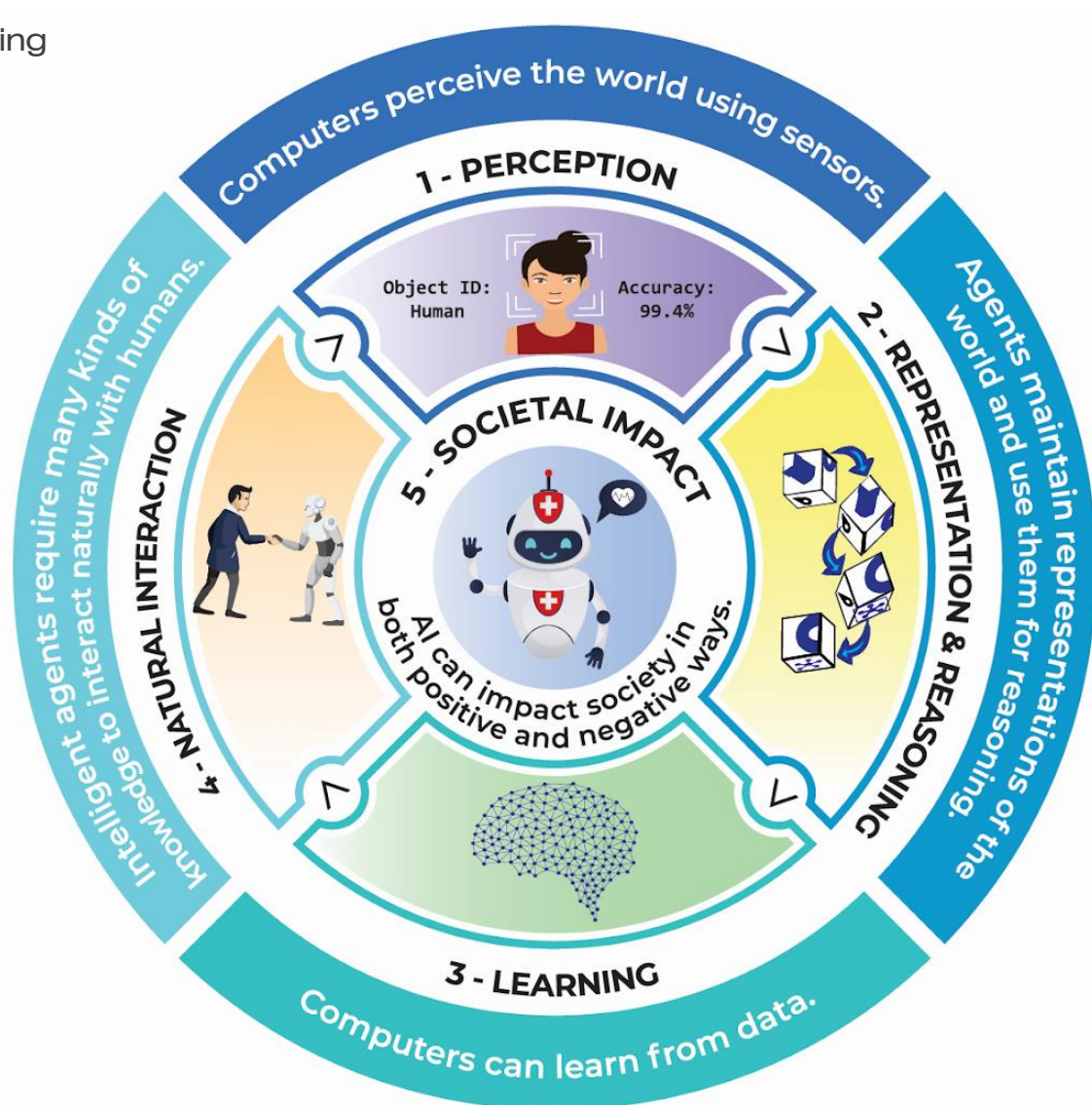


2.

The Five Big Ideas in AI

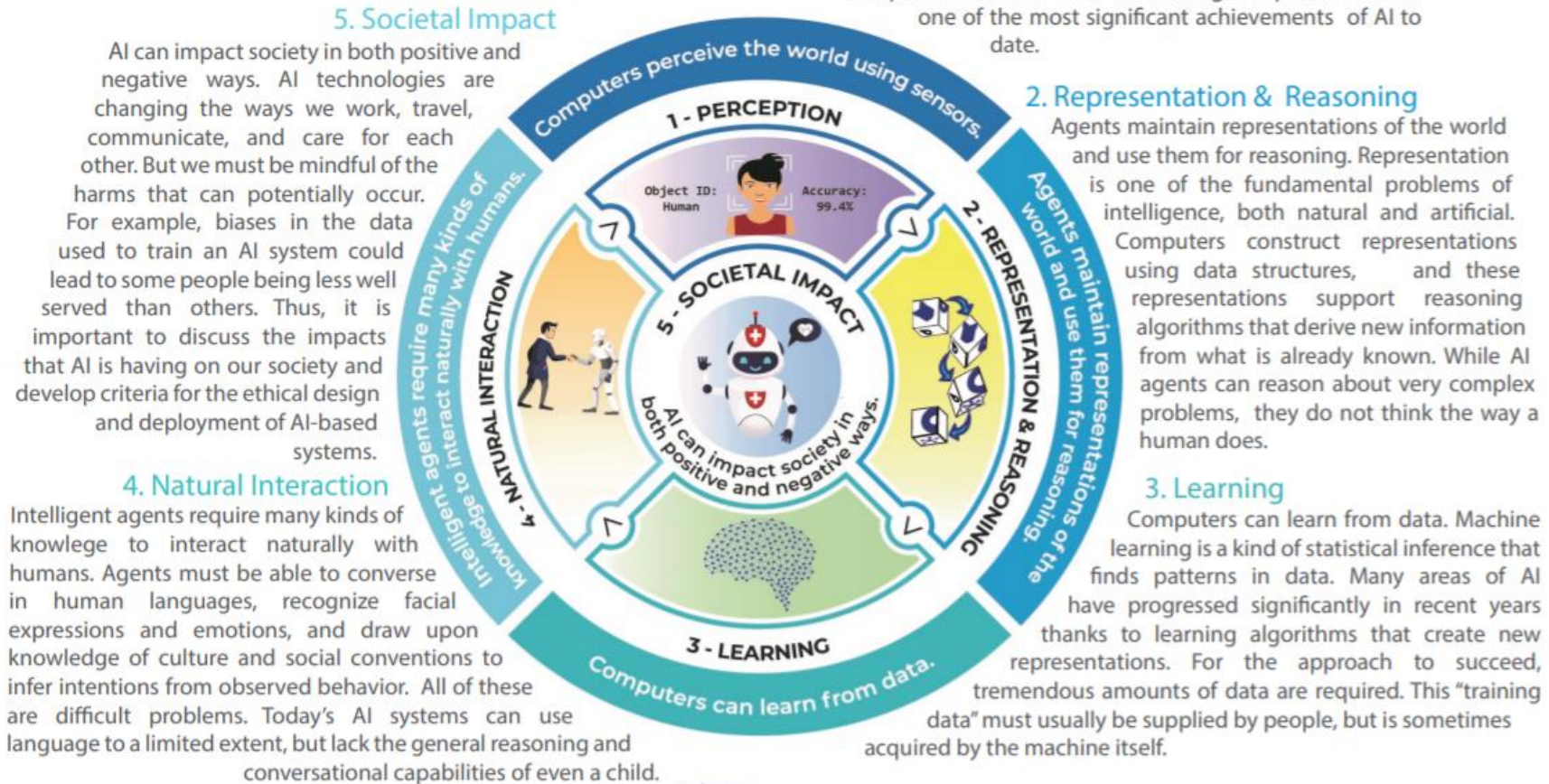
2.1 Five Big Ideas in AI

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



2.2 “Five Big Ideas in AI” Poster

Five Big Ideas in Artificial Intelligence



The AI for K-12 Initiative is a joint project of the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), funded by National Science Foundation award DRL-1846073.



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2.3 “Five Big Ideas in AI” Poster in Korean

인공지능에 관한 다섯 가지 빅 아이디어

5. 사회적 영향(Social Impact)

인공지능은 긍정적이고 부정적인 방식으로 사회에 영향을 미칠 수 있습니다. 인공지능 기술은 우리가 일하고, 여행하고, 의사소통하고, 서로를 돌보는 방식을 변화시키고 있습니다. 그러나 우리는 잠재적으로 발생할 수 있는 위험에 유의해야 합니다. 예를 들어, 인공지능 시스템을 훈련하는데 편향된 데이터를 이용하면 일부 사람들은 다른 사람들에 비해 제대로 된 지원을 받지 못하는 경우가 생길 수 있습니다. 그러므로, 인공지능이 우리 사회에 미치는 영향에 대해 논의할 필요가 있고 인공지능 기반 시스템의 윤리적 설계 및 배치에 관한 기준을 개발하는 것이 중요합니다.

4. 자연스러운 상호작용(Natural Interaction)

지능형 에이전트가 인간과 자연스럽게 상호작용하기 위해서는 많은 종류의 지식이 필요합니다. 에이전트가 관찰된 행동의 의도를 추론하기 위해서는 인간의 언어로 대화하고, 얼굴 표정과 감정을 인식하며, 사회적 관습과 문화에 대한 지식을 활용할 수 있어야 합니다. 이 모든 것들은 매우 어려운 문제들입니다. 오늘날의 인공지능 시스템은 제한된 범위에서 언어를 사용할 수 있지만, 일반적인 추론이나 대화 능력은 아이보다도 부족합니다.

1. 인식(Perception)

컴퓨터는 센서를 이용해 세상을 인식합니다. 인식은 센서에서 감지된 신호로부터 의미를 추출하는 과정입니다. 실제적인 사용을 할 수 있도록 컴퓨터가 충분히 “보고”, “듣도록” 만드는 것은 지금까지 AI의 가장 중요한 성과 중 하나입니다.

2. 표현 & 추론(Representation & Reasoning)

에이전트는 세상에 대한 표현을 만들고 이를 추론에 사용합니다. 표현은 인공지능과 자연 지능 모두에서 근본적인 문제 중 하나입니다. 컴퓨터는 자료구조의 방식으로 표현을 구성하고, 이러한 표현은 이미 알려진 것로부터 새로운 정보를 얻는 추론 알고리즘을 생성하는데 이용됩니다. 인공지능 에이전트는 매우 복잡한 문제를 추론할 수 있지만 인간의 추론 방법과는 다르게 진행 됩니다.

3. 학습(Learning)

컴퓨터는 데이터를 통해 학습합니다. 머신러닝은 데이터의 패턴을 찾는 일종의 통계적 추론입니다. 최근 몇 년 간 새로운 표현을 만들어내는 학습 알고리즘 덕분에 인공지능의 많은 영역이 크게 발전했습니다. 이러한 접근 방식이 성공하기 위해서는, 엄청난 양의 데이터가 필요합니다. 이러한 “훈련용 데이터(training data)”는 일반적으로는 사람이 제공해야 하지만, 때로는 기계 스스로 수집하기도 합니다.



This AI4K12 Initiative is a joint project of the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), funded by National Science Foundation award CNS-1646071.



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Translated by Computational Thinking Teachers Research Group in Korea

2.4 Big Idea #1: Perception

Computers perceive the world using sensors.

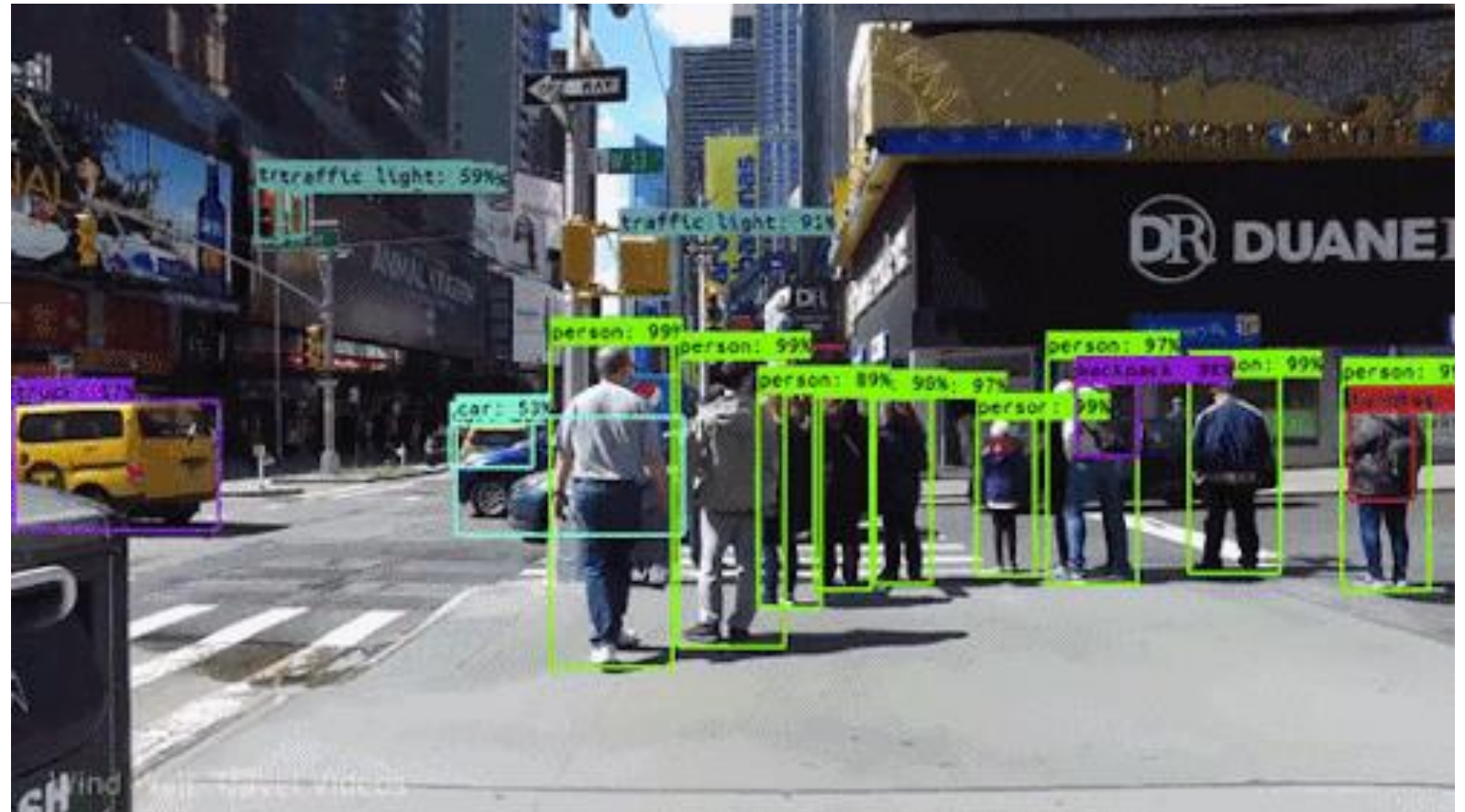
Examples:

- 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.



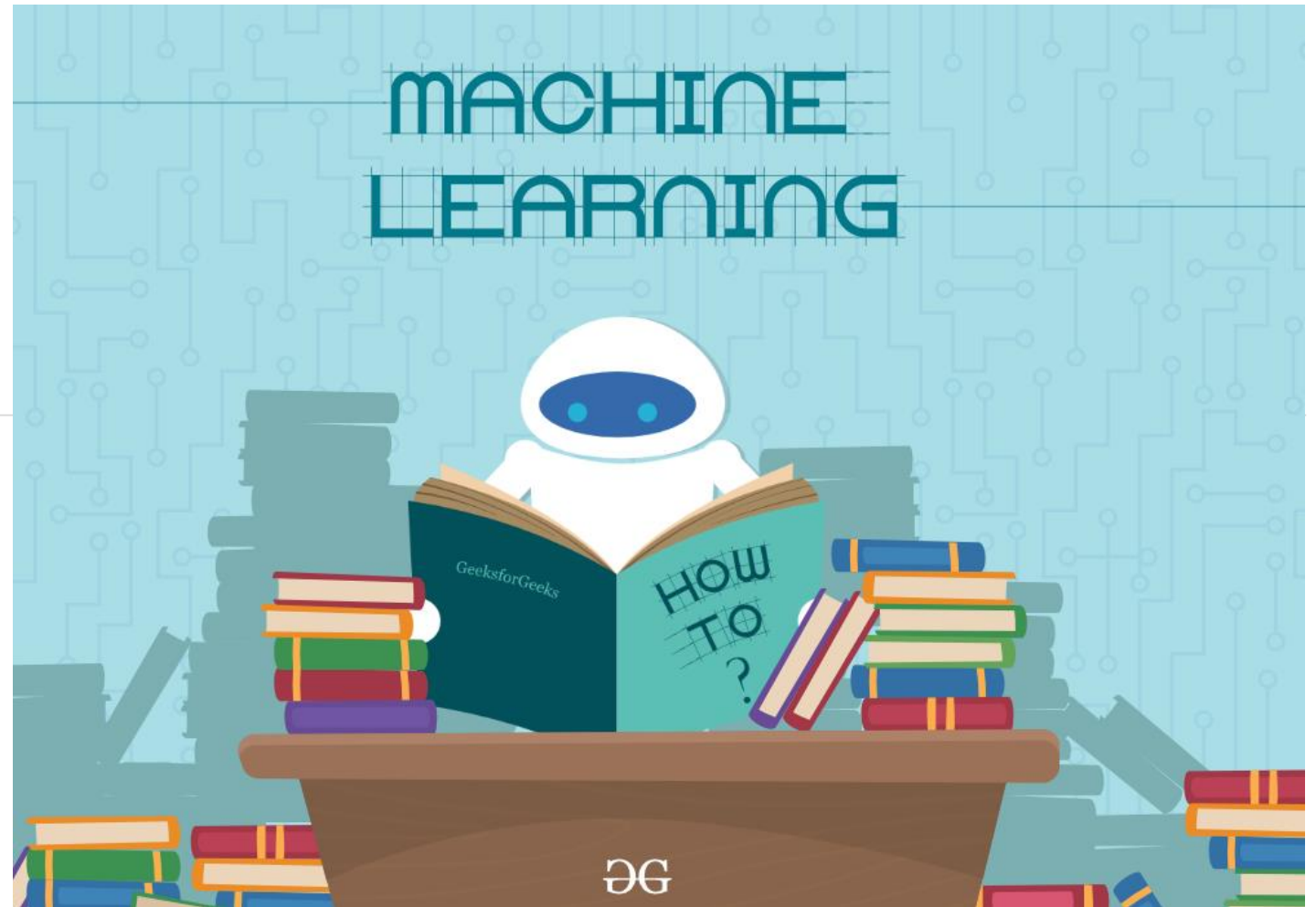
2.6 Big Idea #3: Learning

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

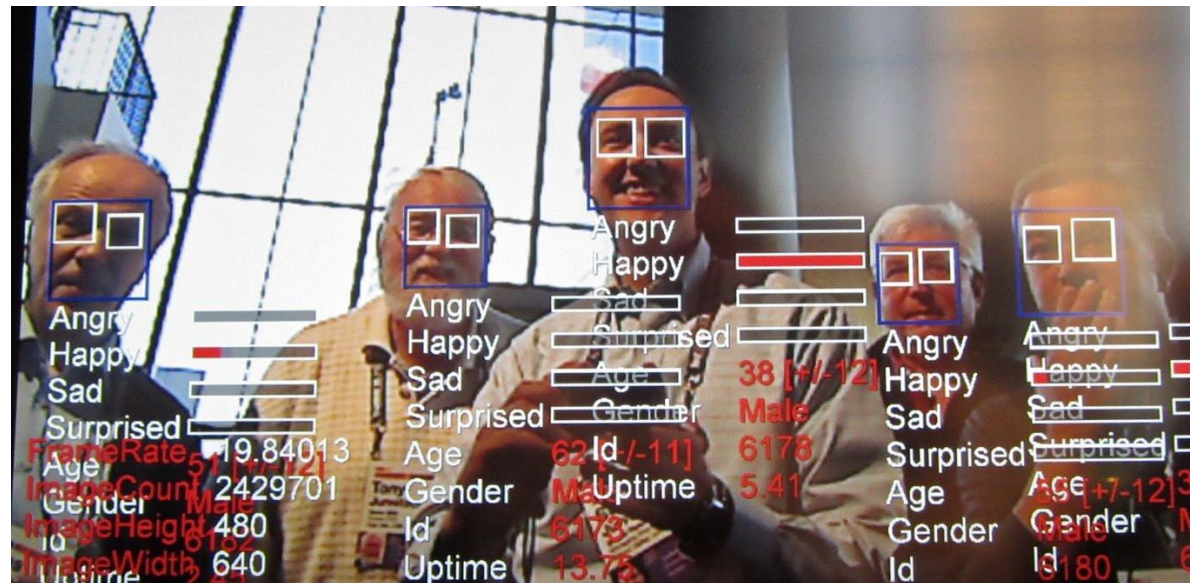
Intelligent agents require many kinds of knowledge in order to interact naturally with humans.



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

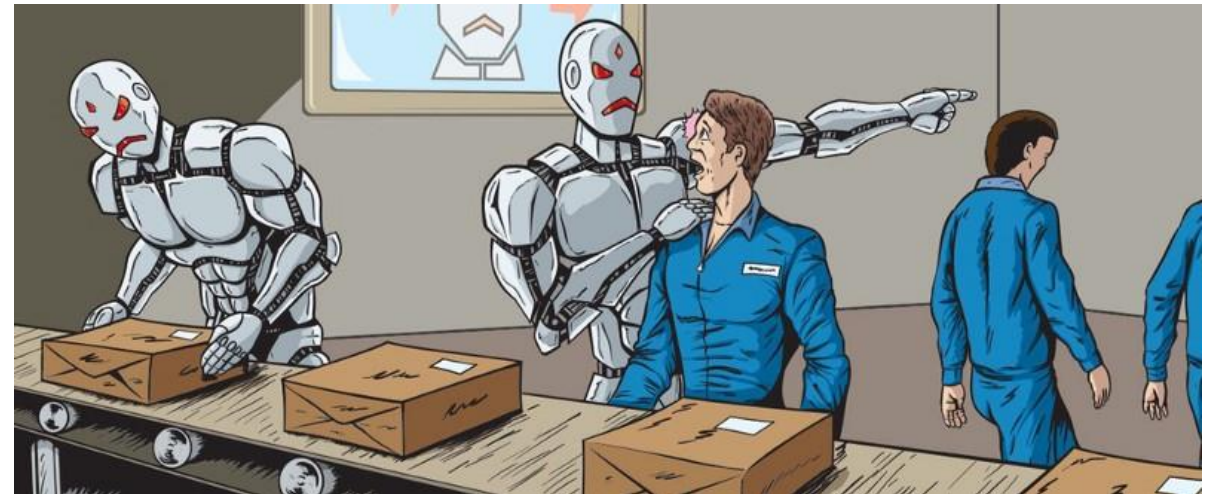
Artificial Intelligence can impact society in both positive and negative ways.

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.

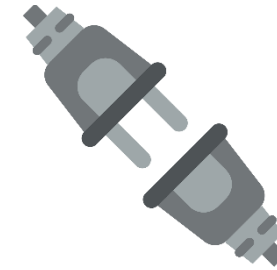
		Draft Big Idea 1 - Progression Chart			www.AI4K12.org
Big Idea #1: Perception	Computers perceive the world using sensors.	Perception is the extraction of meaning from sensory information using knowledge.	The transformation from signal to meaning takes place in stages, with increasingly abstract features 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 have no color vision; dogs are red-green colorblind. Dogs and rats can hear higher frequencies than humans.	LO: Give examples of how humans combine information from multiple 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 (Müller-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 latitude. Accelerometers measure acceleration 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



Unplugged

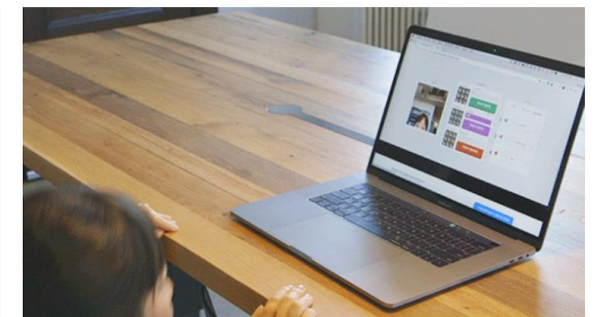
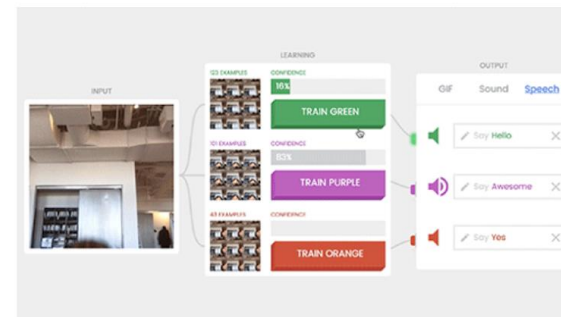
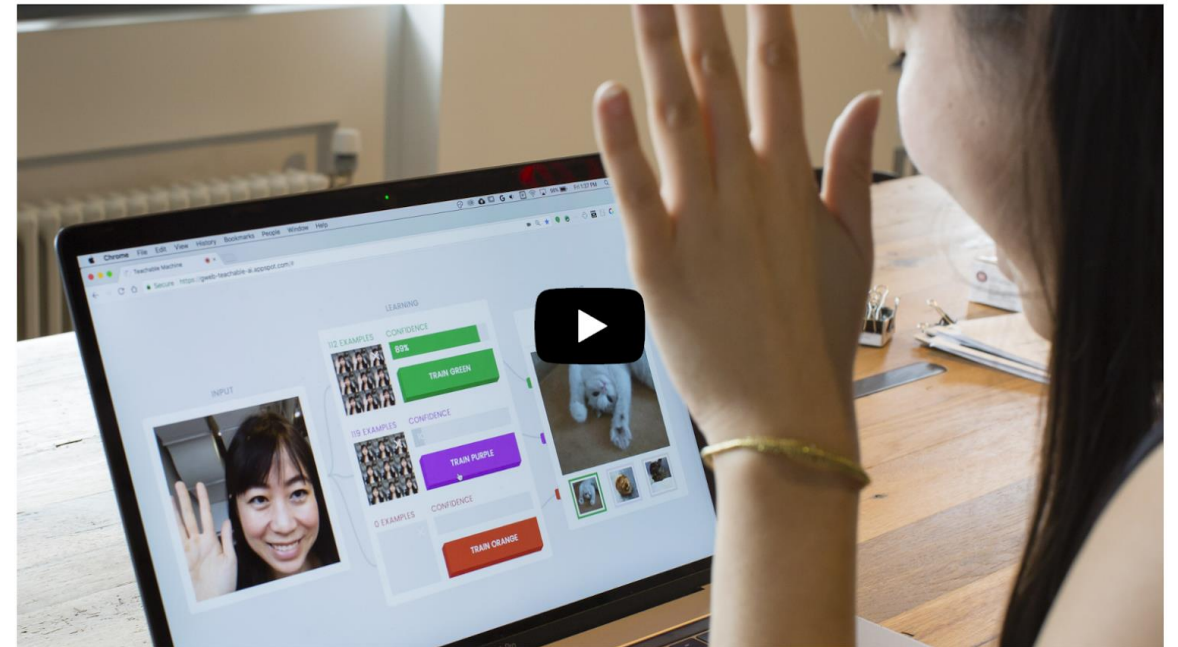


See our Resources Directory at <http://AI4K12.org> for links to resources.

3.2 Black Box Demo: Teachable Machine



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



3.3 Black Box Demo: Google's Quick, Draw

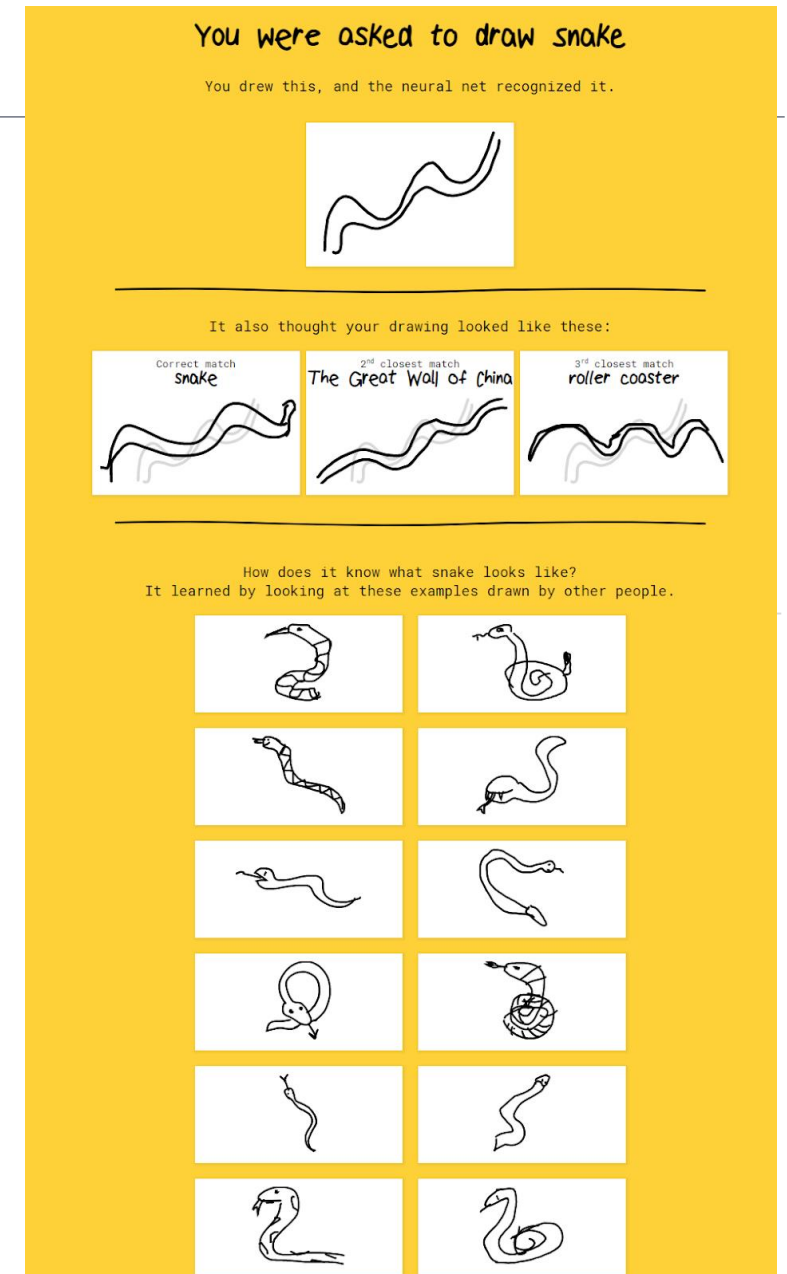
<https://quickdraw.withgoogle.com>



Can a neural network learn to recognize doodling?

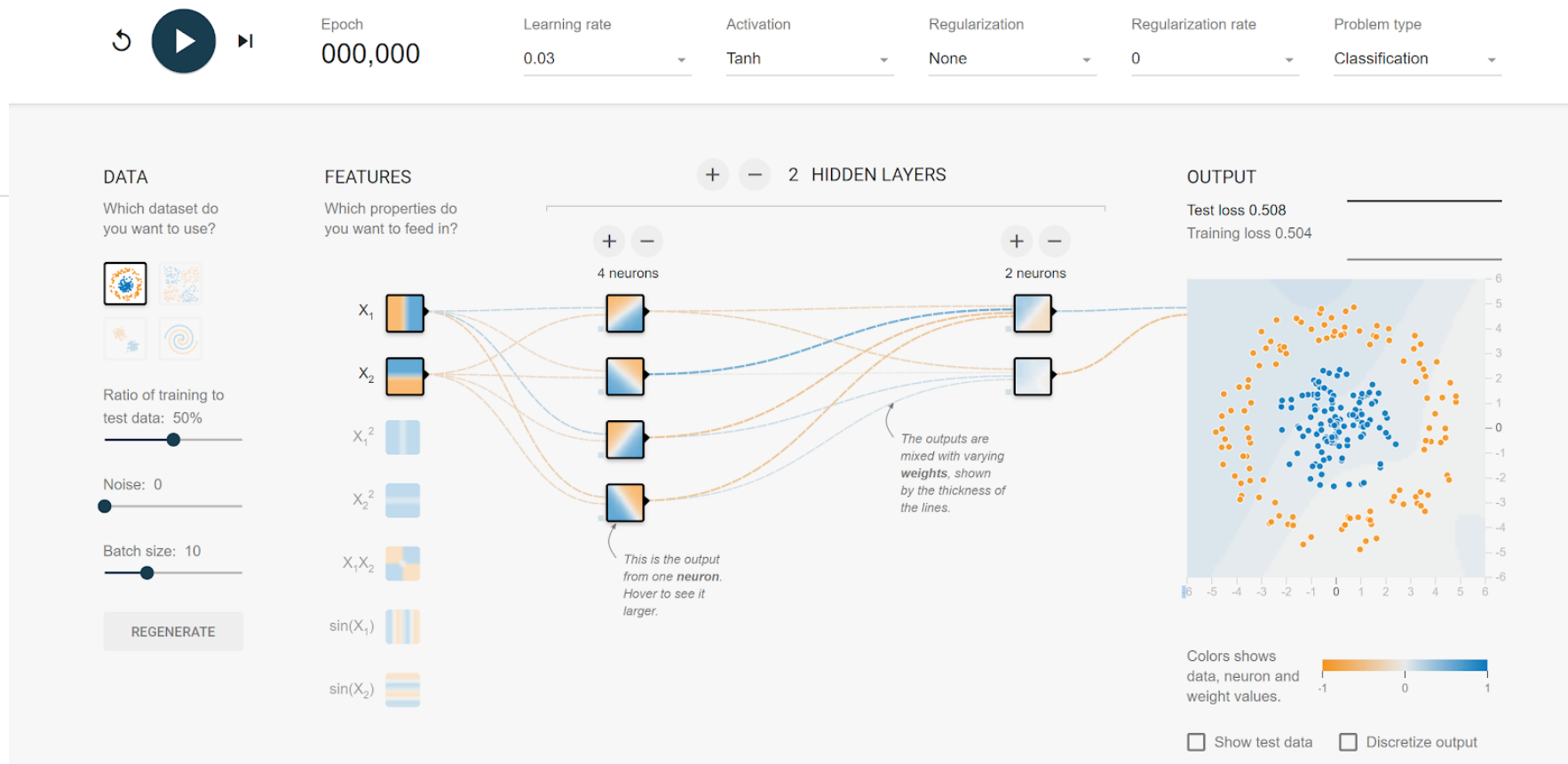
Help teach it by adding your drawings to the [world's largest doodling data set](#), shared publicly to help with machine learning research.

Let's Draw!



3.4 Glass Box Demo: TensorFlow Playground

Tinker With a **Neural Network** Right Here in Your Browser.
Don't Worry, You Can't Break It. We Promise.



3.5 Glass Box Demo: Speech Recognition

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

Speech Recognition Demo

Speak into your microphone; see the results below.

mine does the mine is because I would do all my print screens are backed up in my Dropbox

mine does the mine is because I will do all my print screens are backed up in my Dropbox

mine does the mine is because I do all my print screens are backed up in my Dropbox

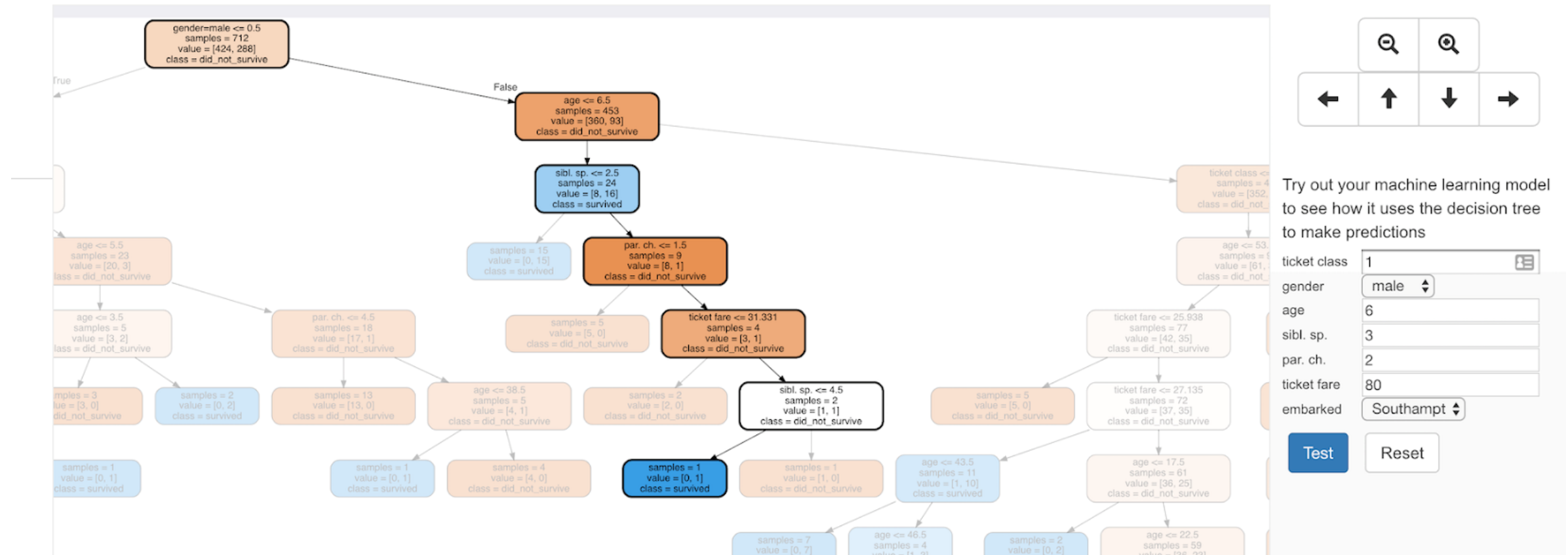
mine does but mine is because I do all my print screens are backed up in my Dropbox

mine does the mine is because I'll do all my print screens are backed up in my Dropbox

MIC ON

3.6 Black Box -> Glass Box Demo: MachineLearningForKids

<https://machinelearningforkids.co.uk>



3.7 AI Programming Frameworks or Extensions for Kids



Machine Learning for Kids

4.

Questions and Answers