

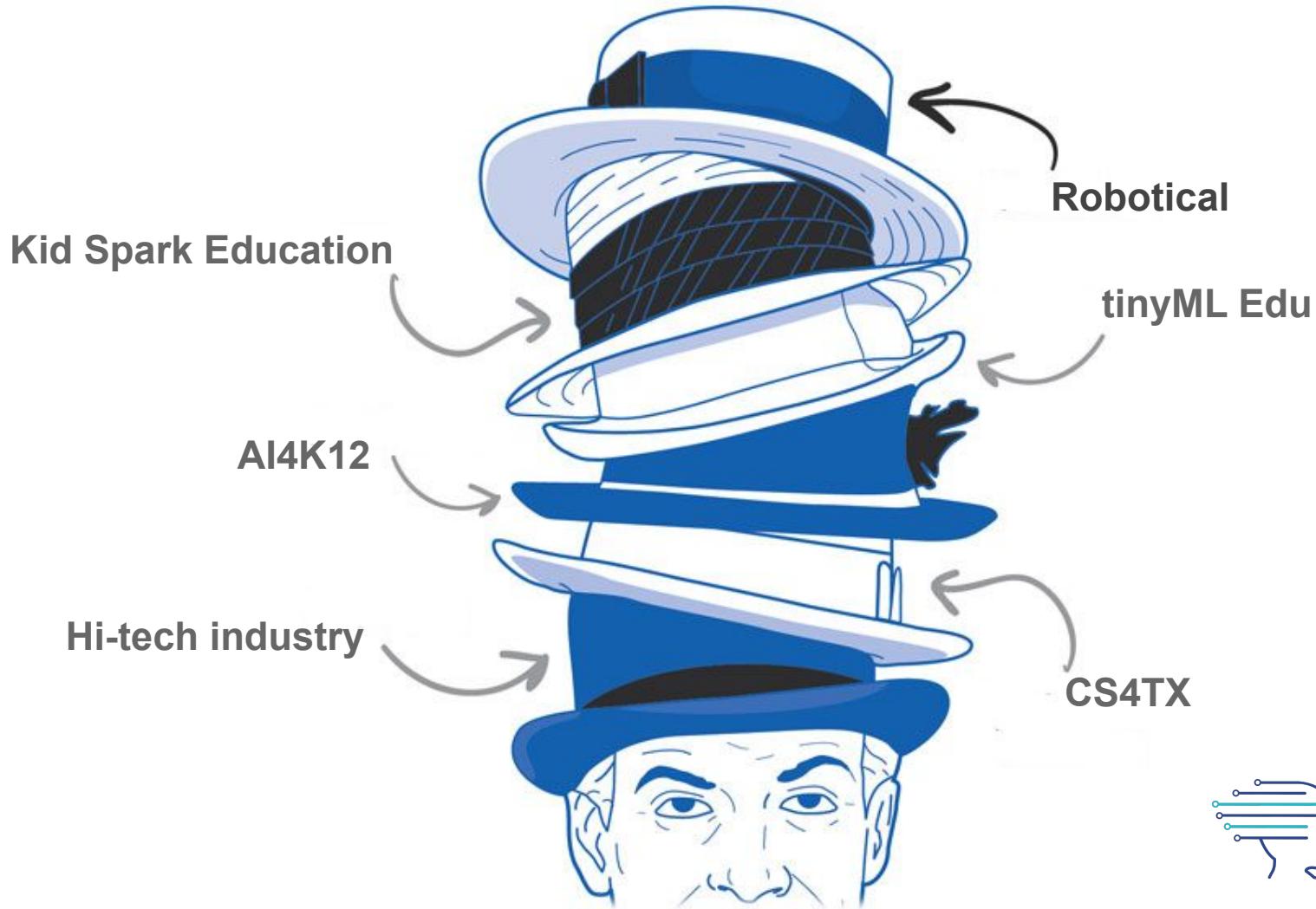
# AI Education in Primary & Secondary (K-12)

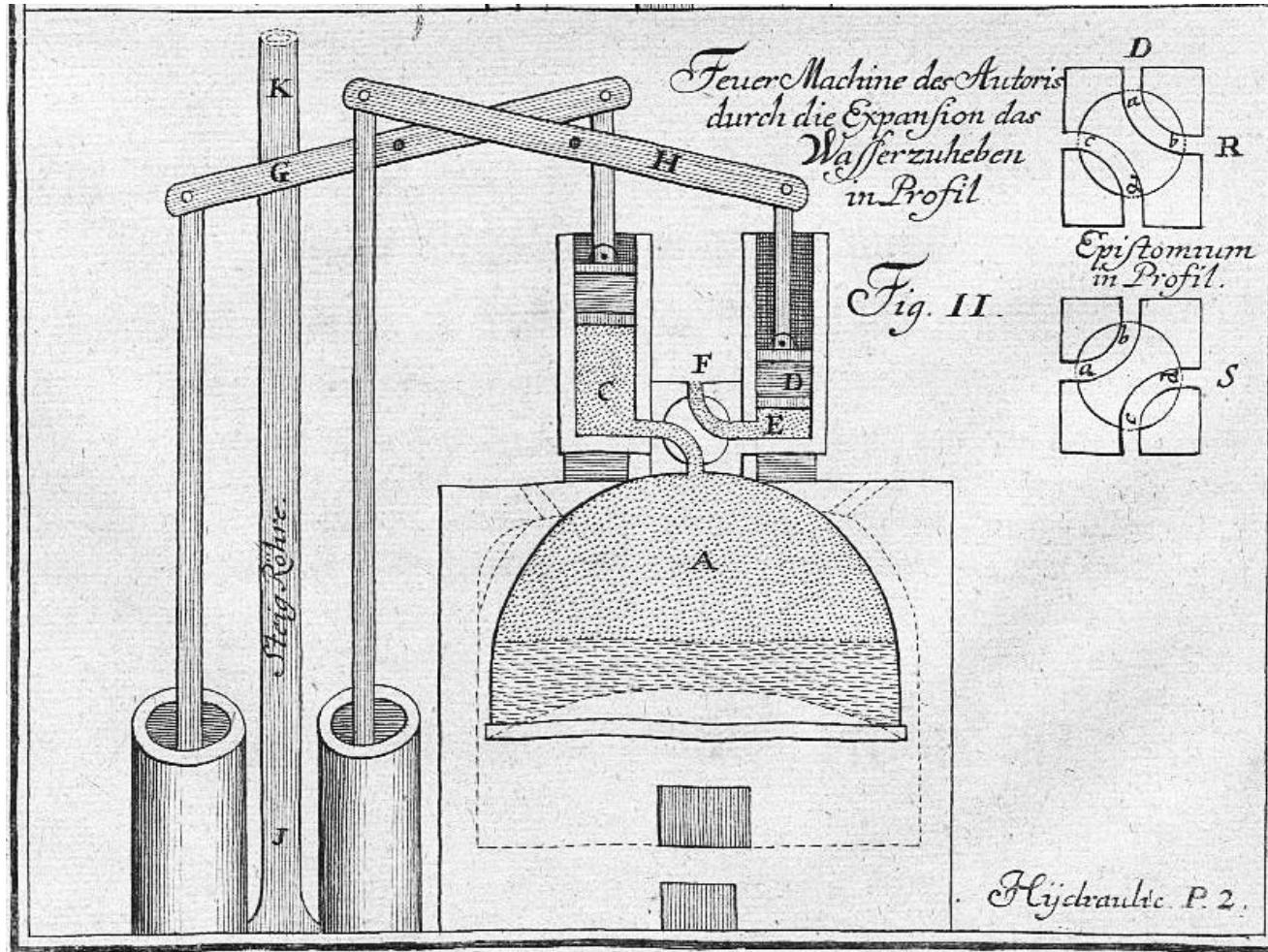
ICTP  
Hal Speed  
2021.10.22



@HalSpeed  
#AI4K12



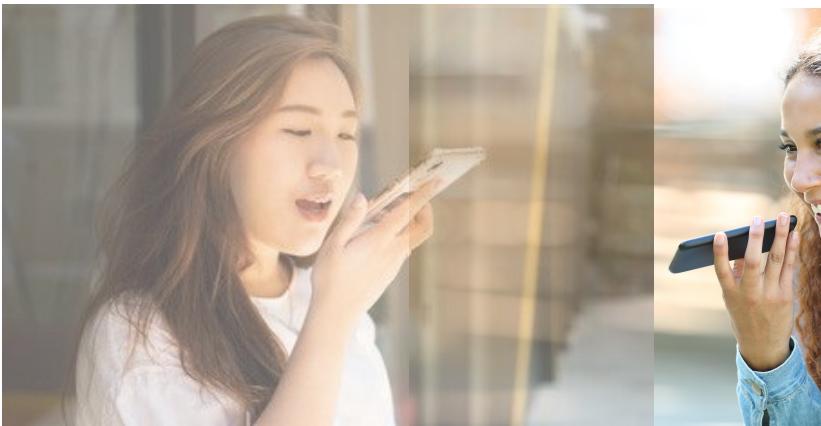






**Artificial Intelligence is powering  
our lives, economy, and workforce**

# AI is a Part of Our Everyday Lives - Seen & Unseen



A screenshot of a website interface titled "Today's Recommendations For You". A red circle highlights the title, and a red arrow points from the bottom left towards it. Below the title, there is a sample of recommended items:

- Even Faster Web Sites** (Paperback) by Steve Souders
- Simply JavaScript** (Paperback) by Kevin Yank
- The Art & Science of Java** (Paperback)

Each item has a "LOOK INSIDE!" button, a star rating, a price, and a "Fix this recommendation" link.

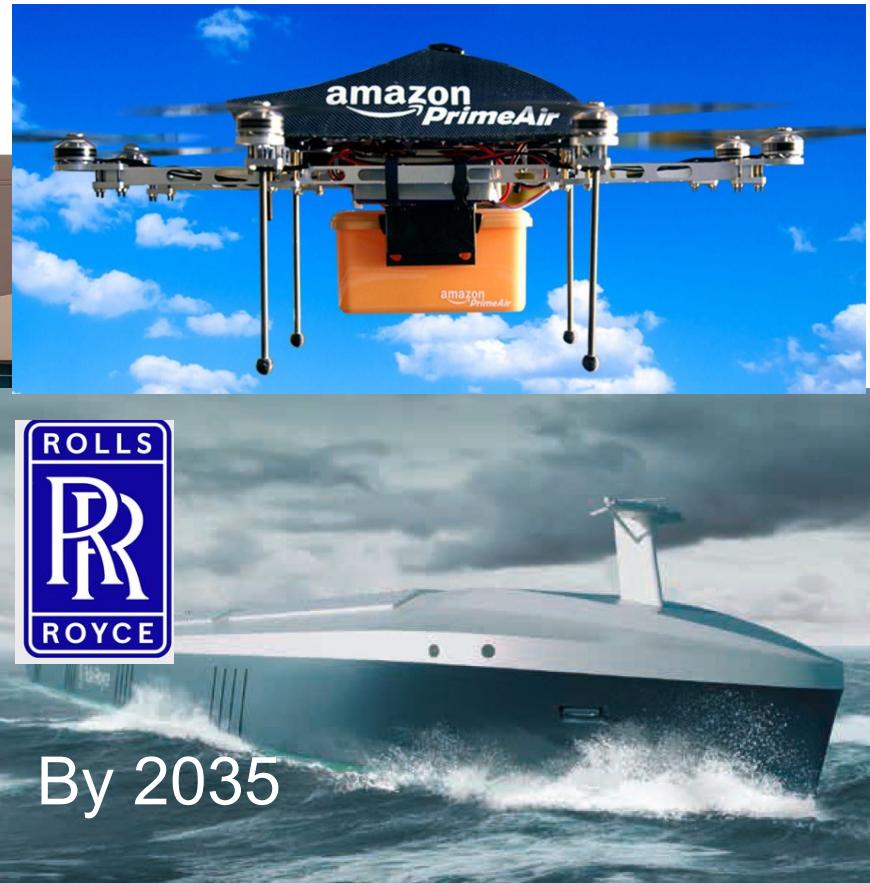
# AI in Manufacturing & Warehouses



# AI in Logistics & Shipping



WAYMO

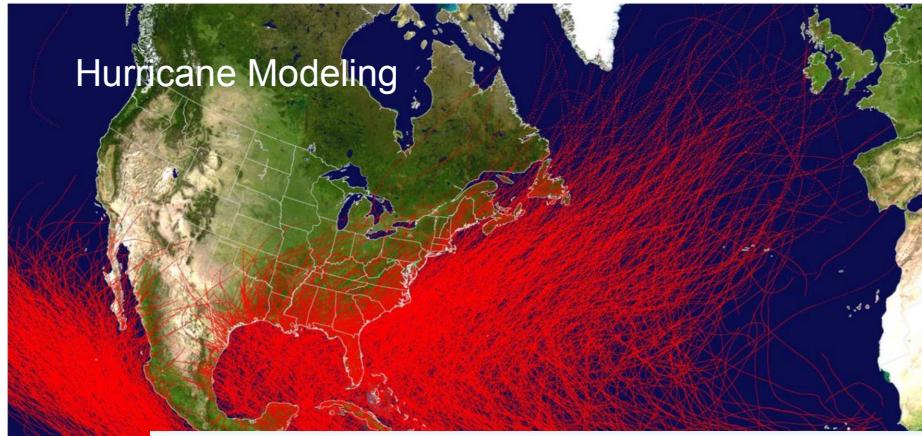


By 2035

# AI in Agriculture



# AI in Ocean & Coastal Sensing



Hurricane Modeling



Detect Harmful Algae Blooms



# AI in Fashion & Shopping



VIRTUAL GLASSES  
TRY ON APP



Style by Alexa

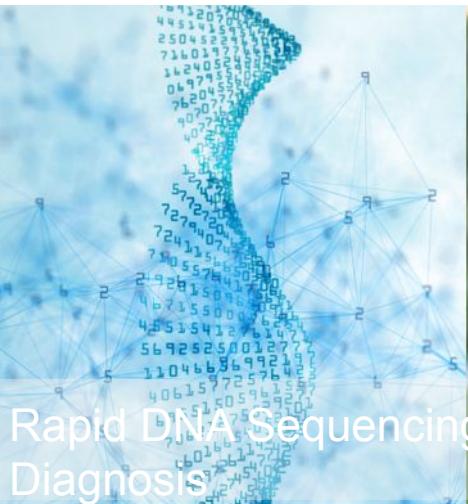


What should I wear?  
Get outfit suggestions based on your  
location and weather

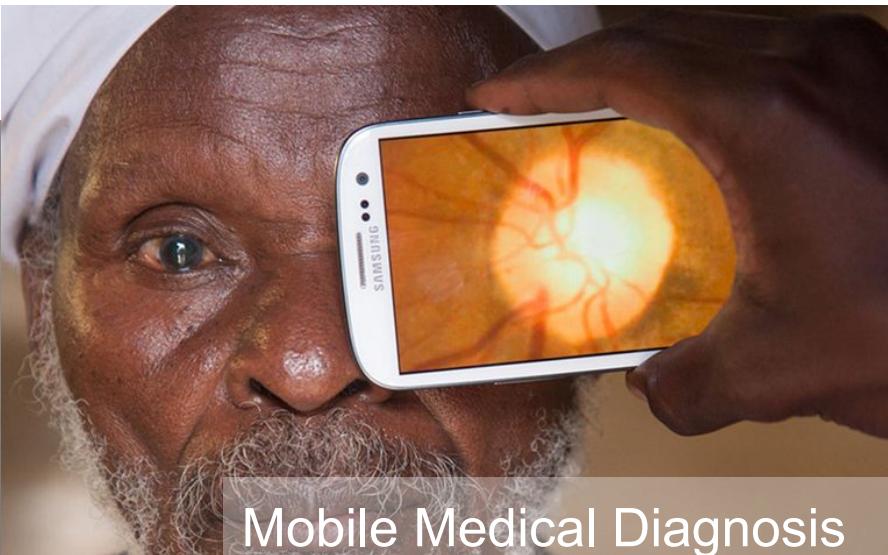
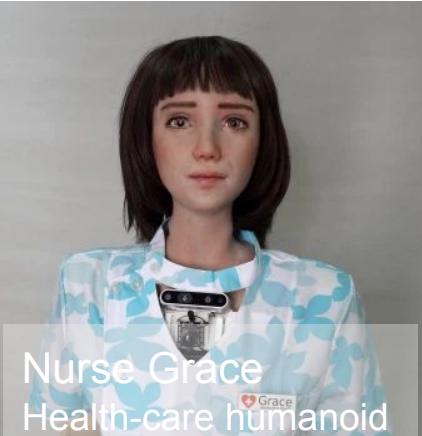


How do I look?  
Upload a photo to get instant style tips,  
right on your phone

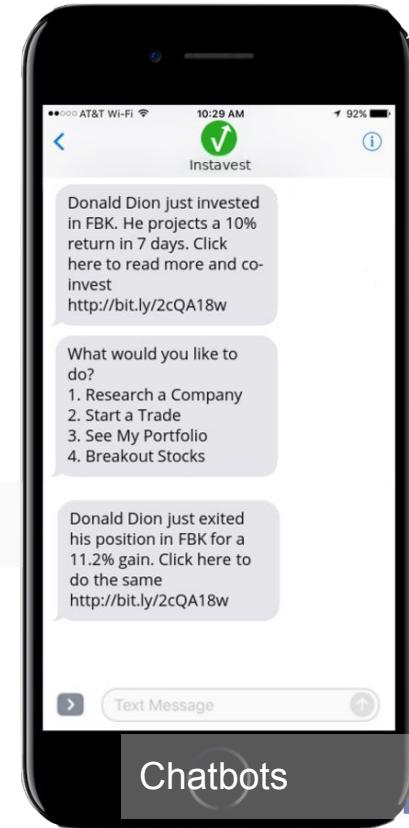
# Healthcare



Rapid DNA Sequencing & Rare Disease Diagnosis



# AI in Investment & Stock prediction





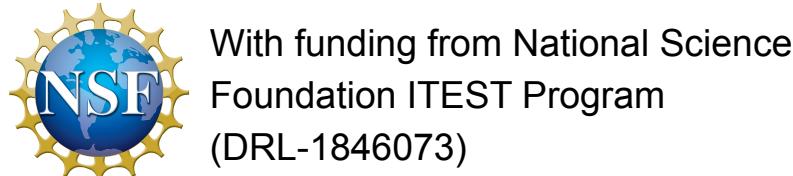
# Overview of the AI4K12 Initiative

# The AI4K12 Initiative, a joint project of:

**AAAI** (Association for the Advancement  
of Artificial Intelligence)



**CSTA** (Computer Science  
Teachers Association)



**Carnegie Mellon University**  
School of Computer Science





# Steering Committee



Dave Touretzky  
Carnegie Mellon  
AI for K-12 Working Group  
Chair



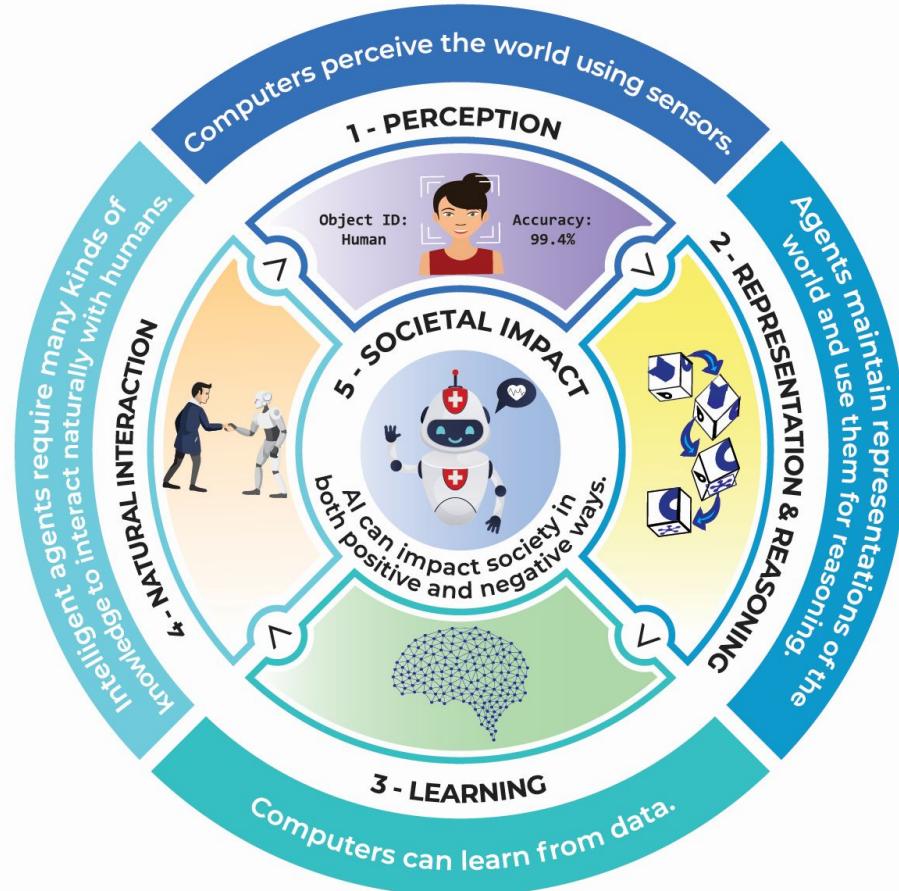
Christina Gardner-McCune  
University of Florida  
AI For K-12 Working  
Group Co-Chair



Deborah Seehorn  
Co-Chair of CSTA  
Standards Committee

# Five Big Ideas in AI

- Organizing framework for the K-12 guidelines
- 5 big ideas are enough to cover the richness of the field, but small enough to be manageable by teachers
- Not necessarily the way AI practitioners view their field, but appropriate for the needs of the K-12 audience

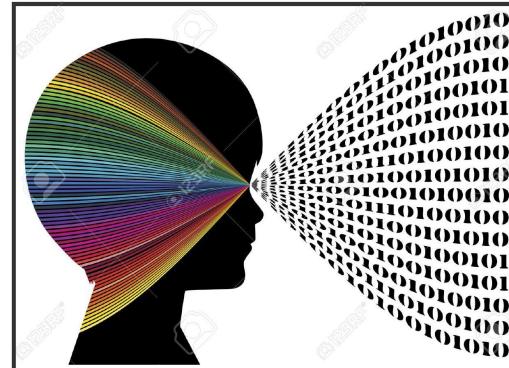
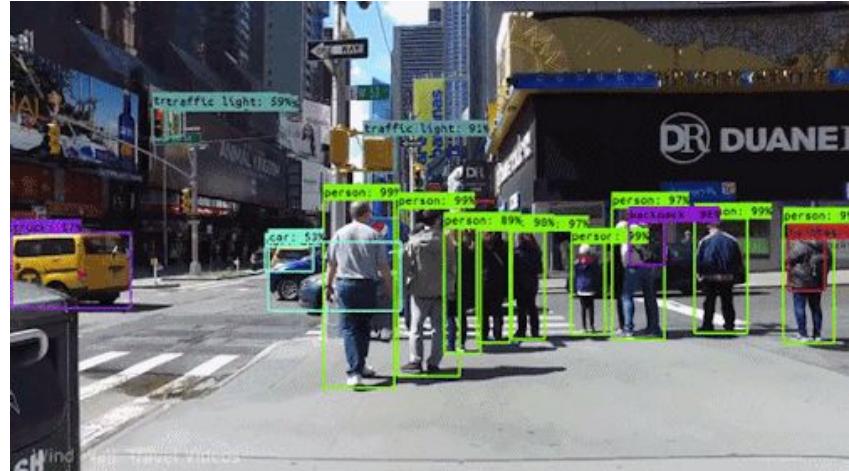


# Big Idea #1: Perception

*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



# Big Idea #1: Perception - Concept List

## 1-A: Sensing

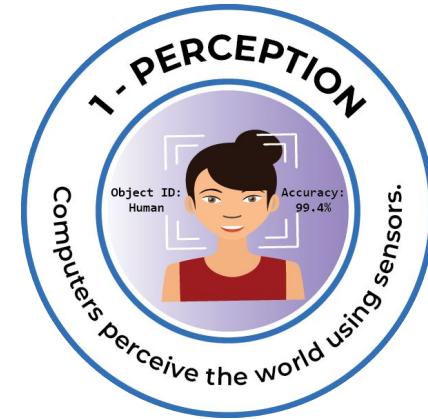
- 1-A-i: Living Things
- 1-A-ii: Computer Sensors
- 1-A-iii: Digital Encoding

## 1-B: Processing

- 1-B-i: Sensing vs. Perception
- 1-B-ii: Feature Extraction
- 1-B-iii: Abstraction Pipeline: Language
- 1-B-iv: Abstraction Pipeline: Vision

## 1-C: Domain Knowledge

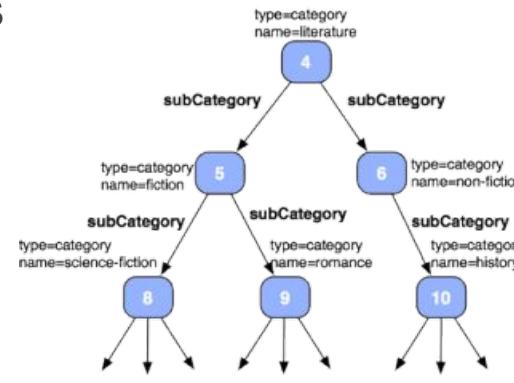
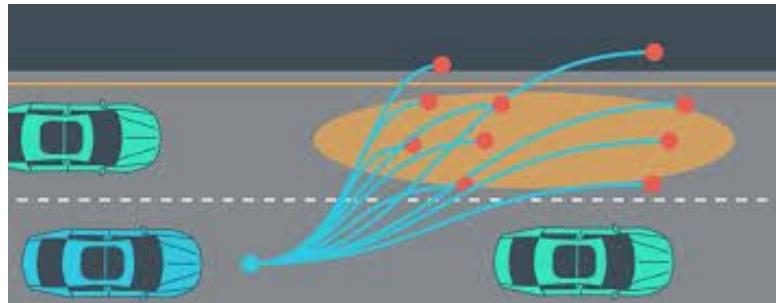
- 1-C-i: Types of Domain Knowledge
- 1-C-ii: Inclusivity



# 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



# Big Idea #2: Representation & Reasoning - Concept List

## 1-A: Representation

- 1-A-i: Abstraction
- 1-A-ii: Symbolic Representation
- 1-A-iii: Data Structures
- 1-A-iv: Feature Vectors

## 1-B: Search

- 1-B-i: State Spaces and Operators
- 1-B-ii: Combination Search

## 1-C: Reasoning

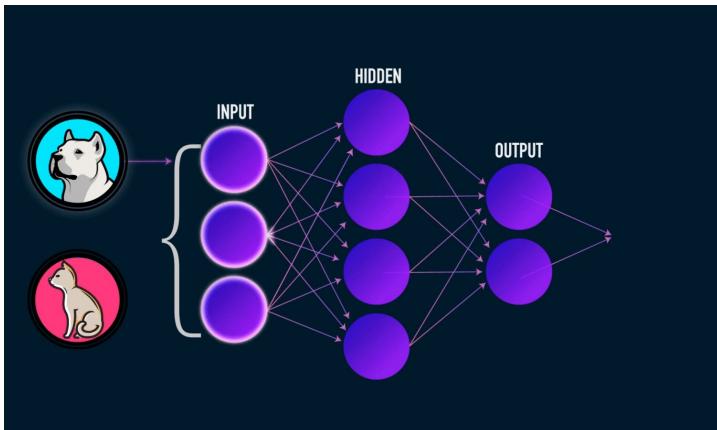
- 1-C-i: Types of Reasoning Problems
- 1-C-ii: Reasoning Algorithms



# Big Idea #3: Learning

*Computers can learn from data*

- Nature of learning
- Fundamentals of neural networks
- Datasets



# Big Idea #3: Learning - Concept List

## 1-A: Nature of Learning

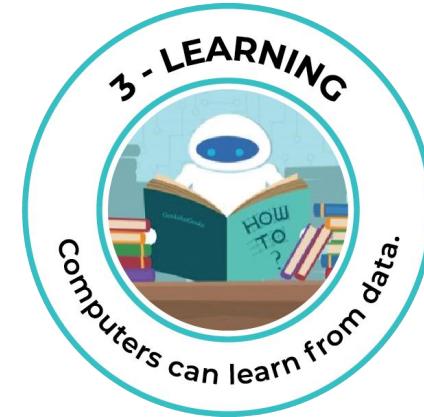
- 1-A-i: Humans vs. Machines
- 1-A-ii: Finding Patterns in Data
- 1-A-iii: Training a Model
- 1-A-iv: Constructing a Reasoner
- 1-A-v: Adjusting Parameters
- 1-A-vi: Learning from Experience

## 1-B: Neural Networks

- 1-B-i: Structure of a Neural Network
- 1-B-ii: Weight Adjustments

## 1-C: Datasets

- 1-C-i: Feature Sets
- 1-C-ii: Large Datasets
- 1-C-iii: Bias



# 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





# Big Idea #4 – What should students be able to do?

## Grades K-2:

- Identify words in stories that have positive and negative connotations.
- 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

## Grades 6-8:

- Construct a simple chatbot
- 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.

## Grades 3-5:

- Identify how humans combine multiple inputs (tone, facial expressions, posture, etc) in order to understand communication.
- Describe some tasks where AI outperforms humans, and tasks where it does not

## Grades 9-12:

- Demonstrate how sentence parsers handle ambiguity
- Explore the Google Knowledge Graph
- Identify and debate the issues of AI and consciousness

# Big Idea #5: Societal Impact

Artificial Intelligence can impact society in both positive and negative ways

- Ethics of AI making decisions about people
  - Fairness, bias, transparency, explainability, accountability
- Economic impacts of AI
- Cultural impacts of AI





# Big Idea #5 – What should students be able to do?

## Grades K-2:

- Identify common AI applications encountered in their daily lives
- Discuss whether common uses of AI technology are a good or bad thing

## Grades 6-8:

- Explain potential sources of bias in AI decision making
- Understand tradeoffs in the design of AI systems and how decisions can have unintended consequences in the function of a system

## Grades 3-5:

- Explore how behavior is influenced by bias and how it affects decision making
- Describe ways that AI systems can be designed for inclusivity

## Grades 9-12:

- Critically explore the positive and negative impacts of an AI system
- Design an AI system to address social issues (or explain how AI could be used to address a social issue)

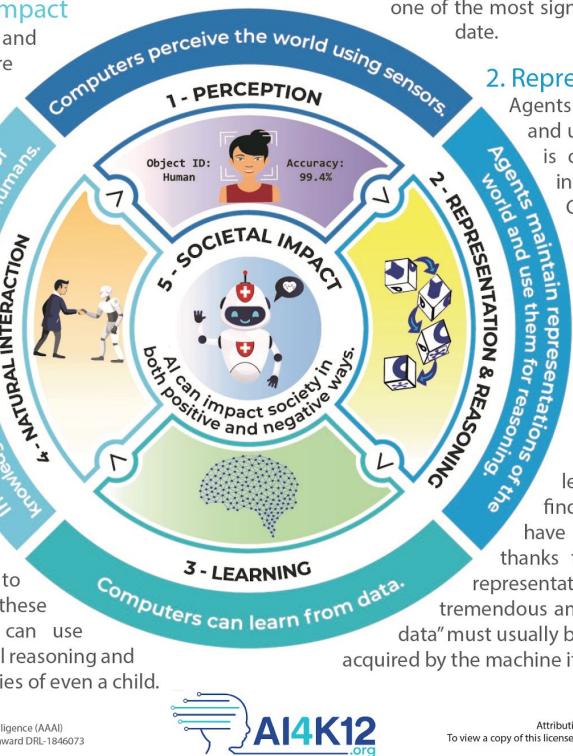
# Five Big Ideas in Artificial Intelligence

## 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.

## 4. Natural Interaction

Intelligent agents require many kinds of knowledge 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.



## 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.

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

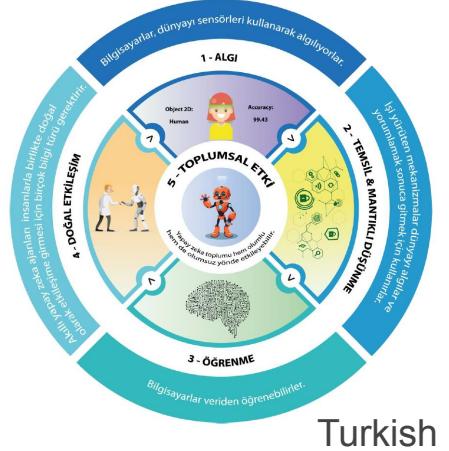
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To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-sa/4.0/>.



# Adoption of the Big Ideas

- Now being adopted by curriculum developers in the US and elsewhere.
- Translations available in Arabic, Chinese, French, German, Hebrew, Hindi, Italian, Japanese, Korean, Portuguese, Spanish, Slovenian, Tamil, Thai, and Turkish (text).



Turkish

## Spanish

### Cinco Ideas Principales en Inteligencia

#### 5. Impacto Social

La inteligencia artificial puede tener un impacto tanto positivo como negativo para la sociedad. Aunque las tecnologías han transformado la manera en que trabajamos, viajamos, nos comunicamos, y cómo nos cuidamos unos a otros; no podemos omitir que estas poseen riesgos que se deben considerar. Por ejemplo, sesgos en los datos utilizados para entrenar a los agentes pueden conllevar a que algunos grupos de personas reciban un trato inferior al esperado. Por esto mismo es que es importante discutir el impacto social que trae consigo la inteligencia artificial, y elaborar criterios que acobijen el diseño y desarrollo de sistemas inteligentes.

#### 4. Interacción Natural

Son muchos los tipos de interacciones requeridas por los agentes inteligentes para interactuar naturalmente con humanos. Tener diálogos con lenguaje natural, reconocer gestos faciales y emociones, o inferir intenciones a partir de comportamientos observados; en contextos socioculturales variados; son algunas de las tareas que estos tipos de agentes tienen que poder cumplir. Estas tareas no son para nada fáciles. Por ejemplo, aunque hoy en días los sistemas inteligentes pueden utilizar el lenguaje natural para interactuar con humanos, este es todavía limitado, y el razonamiento en cuanto a éste es aún inferior al de un infantil.

#### 1. Percepción

Los computadores perciben el mundo a través de sensores. La percepción es el proceso en el que se extrae contexto de las señales provenientes de los sensores. Uno de los mayores logros de la inteligencia artificial a la fecha, es el permitirle al computador "ver" y "escuchar" extósamente en contextos prácticos.

#### 2. Representación y Razonamiento

Los agentes crean representaciones del mundo y las utilizan para razonar. La capacidad de representar contextos es uno de los problemas fundamentales que encuentra la inteligencia tanto natural como artificial. Los computadores construyen representaciones utilizando estructuras de datos, y son estas aquellas artefactos utilizados para el razonamiento algorítmico que contribuye a la generación de nueva información, a partir del conocimiento previo del agente. No obstante, aunque los agentes inteligentes pueden razonar ante problemas complejos, estos no lo hacen como lo haría un ser humano.

#### 3. Aprendizaje

Los computadores pueden aprender de los datos. El aprendizaje de máquina es un tipo de estadística inferencial que busca patrones existentes entre volúmenes de datos. Recientemente, son varias las áreas de la inteligencia artificial que han progresado significativamente gracias a la estrategia de aprendizaje supervisado y la generación de nuevas representaciones. Para ser exitosa, esta estrategia requiere de grandes volúmenes de datos. Aunque los "datos de entrenamiento" generalmente provienen de personas, estos también pueden ser generados automáticamente por la misma máquina.



## Japanese

### 人工知能(AI)の5つの基本のアイディア

#### 1. 知覚

コンピュータはセンサを通して周囲の世界を感じる。知覚とはセンサから受け取る信号から、それが示す「意味」を引き出すプロセスでありである。実用レベルで「コンピュータが」「見たり」「聞いたり」できるようになったのは、近年のAIの最も重要な成果であると言える。

#### 2. 身の回りの世界を表現するモデルとそれをを使った判断

AIは社会に良い影響を及ぼすことも悪い影響を及ぼすこともあり得る。AIの技術は、私たちの働き方、旅行の仕方、コミュニケーションや他人への配慮の仕方などに影響を与えていく。しかし、私たちはAIが不利益をもたらすこともあることを認識していかなければいけない。例えば、AIシステムの学習に用いたデータに満ちていたバイアスが、一部の人たちに不利な結果をもたらす可能性がある。そのため、AIシステムにもたらす影響の可能性、AIを使ったシステムの開発のための倫理的な基準、AIシステムをどのように活用していくべきなどを話し合うことがとても大切である。

#### 4. 自然なインタラクション

AIと人間との間で対応するためには様々な知識や情報を必要とする。AIは人間の態度や会話をし、顔の表情や感情を認識し、文化や社会の慣習をもとに、観察された行動が何を意図するかを推測できるようではなければならない。現在のAIは限られた範囲で言葉を使うことができるが、一般的な判断をする思考能力(推論力)と会話能力は子どもにも及ばない。

#### 3. 学習

コンピュータはデータから学ぶことができる。機械学習とはデータの中にある「パターン」を導き出す、ある種の統計的推論である。近年、学習アルゴリズムとそれによって生まれる学習モデルの進歩により、様々な分野でAIが大きな進歩を遂げている。機械学習成功のために必要な大データが必要となる。「学習データ」と呼ばれるデータは、基本的に人間が提供するものであるが、コンピュータ自身が集める場合もある。



# Resources

# AI4K12 Resource Directory

<https://ai4k12.org/resources/list-of-resources/>

## Includes:

- Books and Reports (Adults)
- Children's Books
- Competitions
- Curriculum Materials
- Demos
- Online Professional Development Courses
- Online Courses for K-12 Students
- Reference Sources & Tutorials
- Resource Directories
- Software Tools & IDEs
- Videos

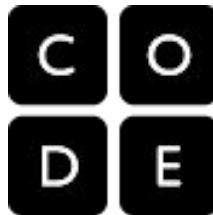
# Additional Resource Lists



<https://aiforteachers.org/>



<https://raise.mit.edu/resources.html>



<https://code.org/ai>



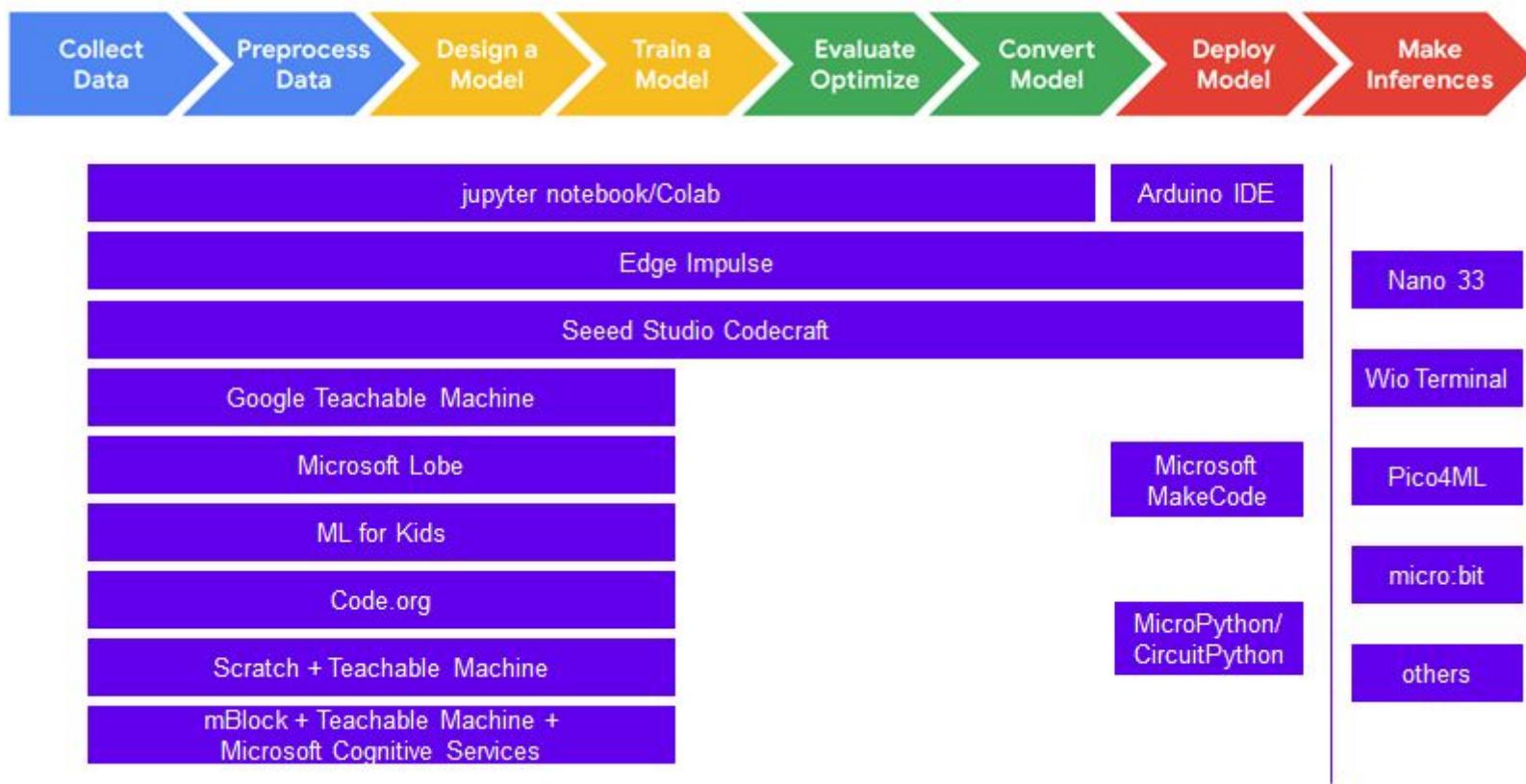
<https://www.actua.ca/ai/>



<https://tinymlx.org/4K12>



# tinyML K-12 Pipeline



# Wio Terminal

<https://www.seeedstudio.com/wio-terminal-tinyml.html>

## Hardware



### Wio Terminal

Wio Terminal is your complete AI platform to get started with TinyML and IoT - Built around the ATSAMD51P19 and ARM Cortex-M4F at 120MHz for high compatibility with various ML frameworks for microcontrollers.

## Software



### Codecraft

Codecraft is a graphical programming environment based on Scratch 3.0 that supports a great variety of hardware devices and programming languages such as Arduino, Python, C or JavaScript etc. Now it supports TinyML in collaboration with Edge Impulse!

## Learning Resources



### TinyML with Wio Terminal Free Course for Beginners

Begin your first step into the world of TinyML and Wio Terminal with detailed lessons and step-by-step projects to guide you! Now, simple hardware can also solve complex problems.

# Microsoft Farm Beats for Students

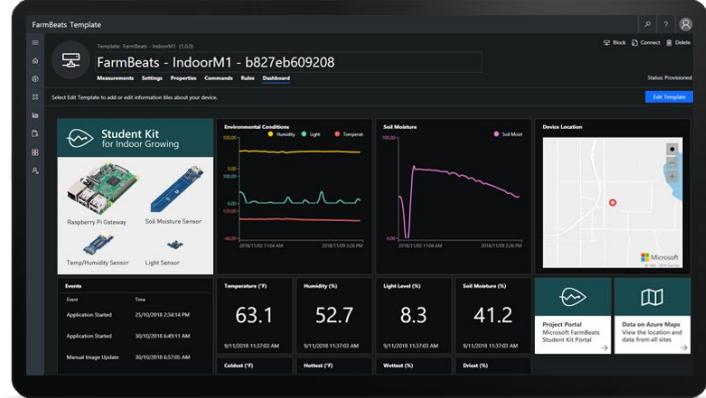
<https://aka.ms/farmbeatsforstudents>

## The easy-to-use FarmBeats kit includes

- preconfigured Microsoft Azure cloud services
- A Raspberry Pi with soil moisture, light, ambient temperature, and humidity sensors to collect data.
- The data is then visualized in an online dashboard that provides insights to help students.

## Partnership

Future Farmers of America and Microsoft are working together to create activity guides and resources to help chapters get started with using the technology.





# AutoAuto

<https://www.autoauto.ai/>

The screenshot shows the AutoAuto platform's challenge interface. At the top, there are navigation tabs: 'Resume', 'World Cohort Sampler', 'Lvl 1: Intro to Programming & AI', and 'Coco's Dashboard'. On the left, a sidebar lists challenges: Part 1 (selected), Part 2, Part 3, Part 4, Part 5 (selected), Challenge 1 (disabled), Part 6, and Challenge 1 (disabled). The main area displays 'Part 6: Mini Spy Mission'. It includes a video thumbnail showing a car performing the mission, a 'Mission' description, and starting code in Python:

```
import car
car.forward(2)
frames = car.capture()
car.plot(frames)
car.reverse()
```

Below the code, there are instructions: 'Names: Keep adjusting the time in your .forward() such that your car gets close enough to the figures without hitting them.' and 'Use a cone or box to mark where your car starts the mission.' A 'Video' link is also present.



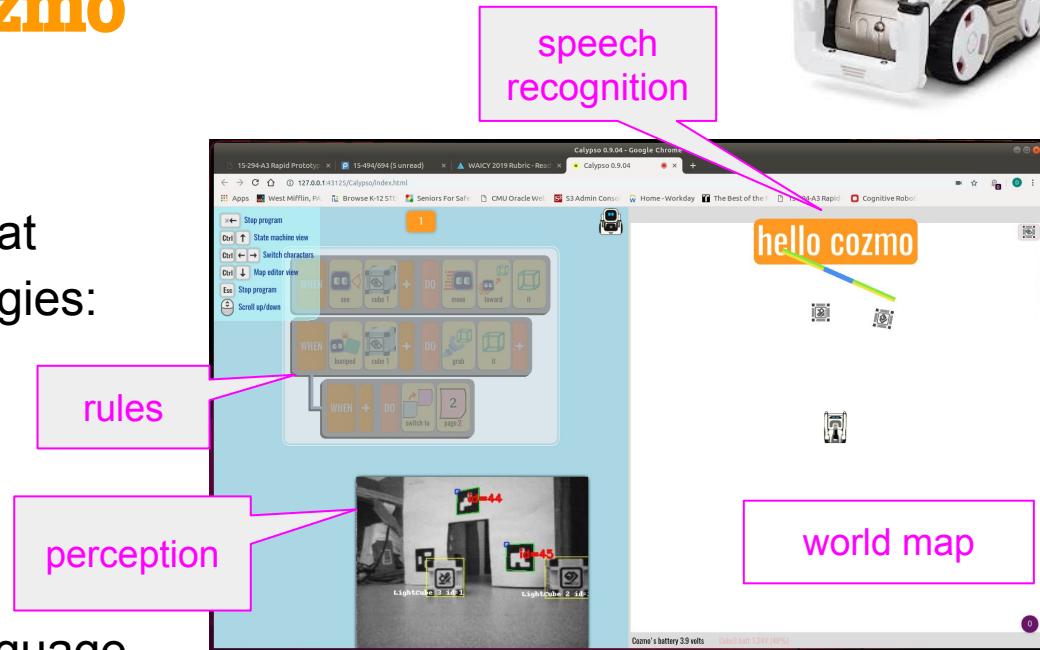


# Calypso for Cozmo



- A robot intelligence framework that Incorporates multiple AI technologies:

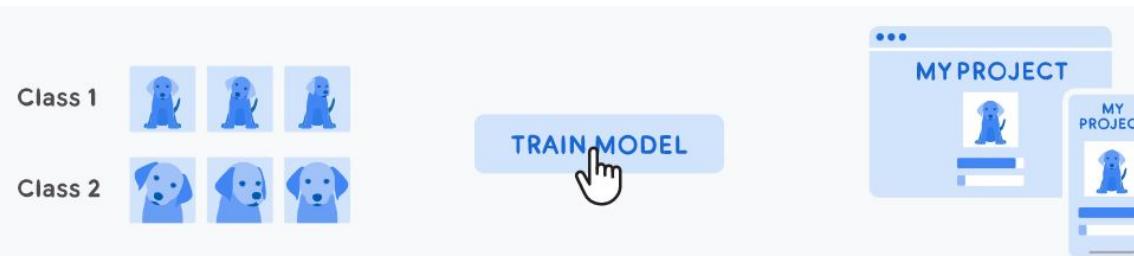
- Computer vision; face recognition
- Speech recognition and generation
- Landmark-based navigation
- Path planning
- Object manipulation



- 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>

# Teachable Machine

<https://teachablemachine.withgoogle.com/>



## 1 Gather

Gather and group your examples into classes, or categories, that you want the computer to learn.

## 2 Train

Train your model, then instantly test it out to see whether it can correctly classify new examples.

## 3 Export

Export your model for your projects: sites, apps, and more. You can download your model or host it online for free.



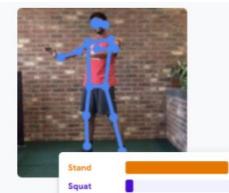
### Images

Teach a model to classify images using files or your webcam.



### Sounds

Teach a model to classify audio by recording short sound samples.



### Poses

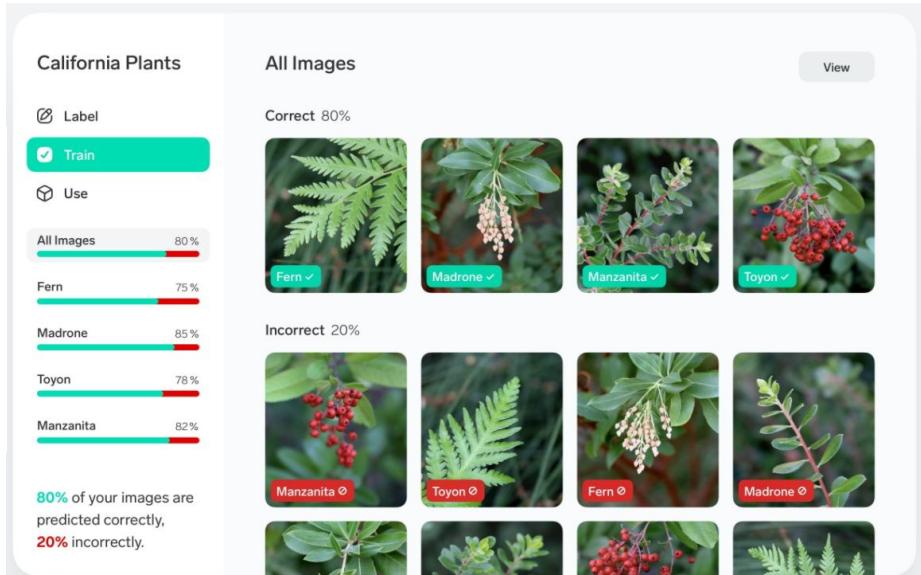
Teach a model to classify body positions using files or striking poses in your webcam.



<https://www.lob.e.ai/>

## Label, Train, Use

Lobe simplifies the process of machine learning into three easy steps. Collect and label your images. Train your model and understand your results. Then play, improve, and export your model.





# Machine Learning for Kids

<https://machinelearningforkids.co.uk>

- 1 Collect examples of things you want to be able to recognise
- 2 Use the examples to train a computer to be able to recognise them
- 3 Make a game in Scratch that uses the computer's ability to recognise them

## School Library

Create a school librarian in Scratch that suggests who a reading book might be suitable for.



Teach a computer to make recommendations

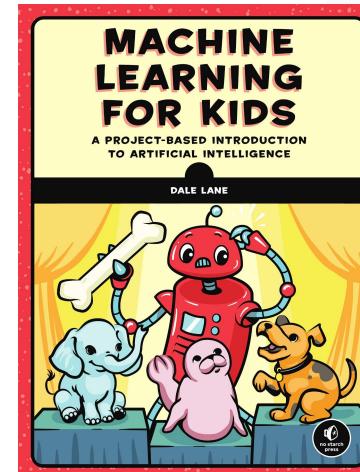
Difficulty: Intermediate

Recognising: **numbers**



Tags: predictive model, recommendations, supervised learning

Download

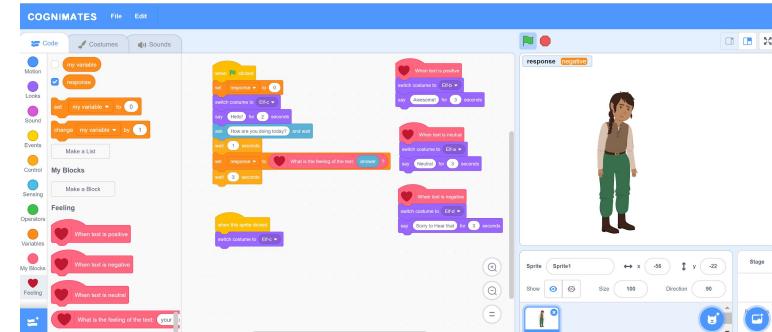
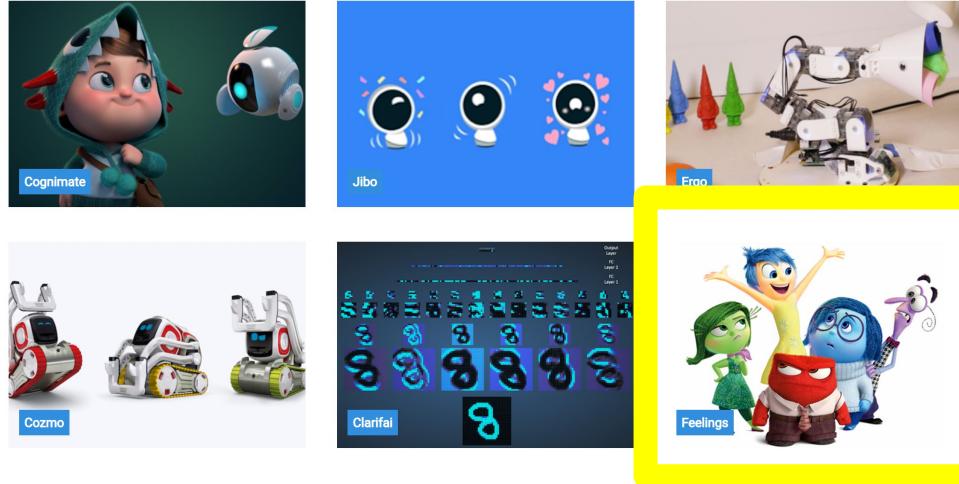




<http://cognimates.me>

Cognimates offers AI extensions for Scratch, such as:

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

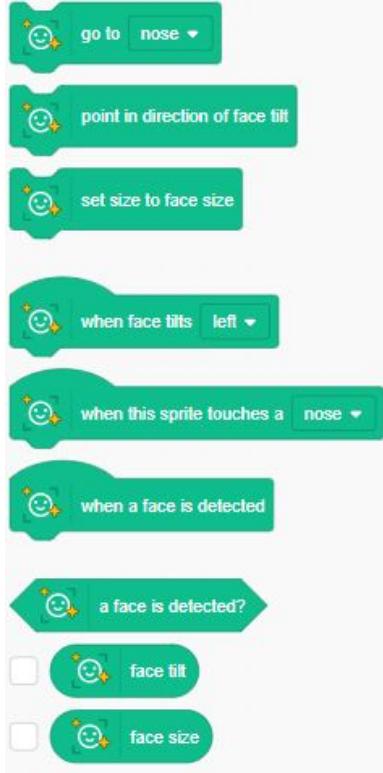




# Face Sensing

<https://lab.scratch.mit.edu/face/>

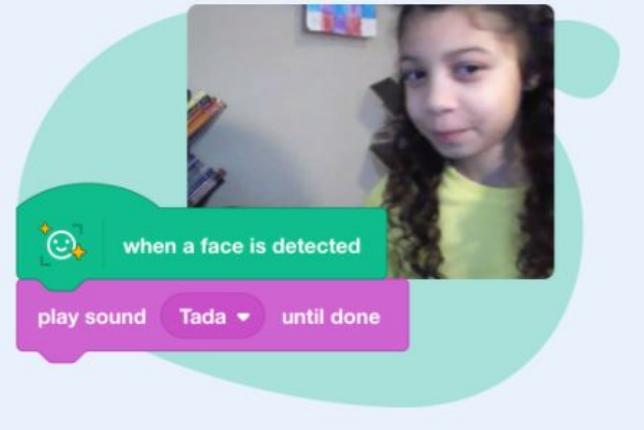
Face Sensing



Make a sprite follow your nose



Does it see you?



# Other Scratch-based Editors w/ML



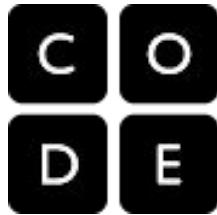
<https://scratch.techpark.jp/>



<https://stretch3.github.io/>



<https://mblock.makeblock.com/>



# Code.org Resources

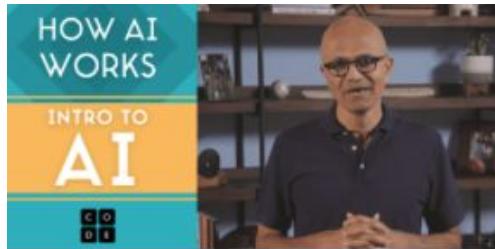
<https://code.org/ai>

## AI and Machine Learning Module

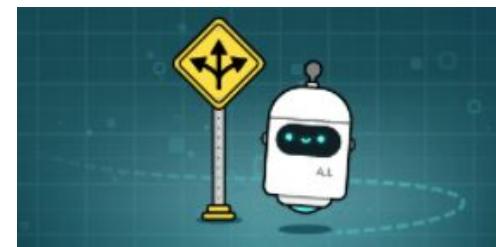
- ~ 5 week curriculum
- Standalone or optional unit in CS Discoveries



AI for Oceans  
Classifier



How AI Works  
Videos



AI and Ethics



Exploring  
Computer  
Science

# High School Curriculum Unit

<http://www.exploringcs.org/for-teachers-districts/artificial-intelligence>



Intended to be an alternative unit to either unit 5 or 6 of the ECS course

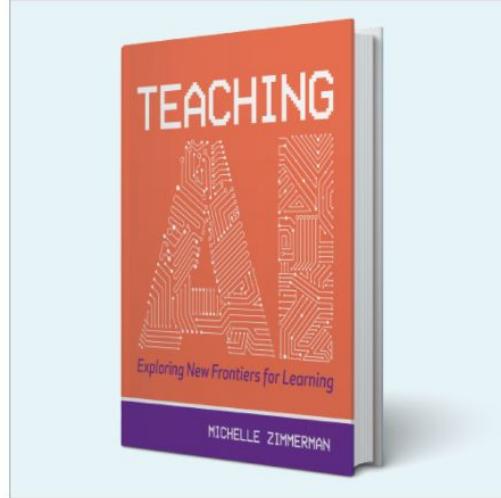
# ISTE AI in Education

<https://iste.org/areas-of-focus/AI-in-education>



AI Course on ISTE U

Fall 2021 starts Oct 4  
Spring 2022 starts Feb 7  
Summer 2022 starts July 11  
\$224/299



Teaching AI



Free AI Course

15-hour, self-paced  
High School Level





# AI4All: Online Learning

<http://ai-4-all.org/open-learning>

Interdisciplinary, Approachable AI Curriculum



AI & Drawing



AI & The Environment



AI & COVID-19

AI4ALL Open Learning empowers high school teachers of all subjects to bring AI education to their classrooms through a free, adaptable AI curriculum and teacher resources.



# ReadyAI Resources

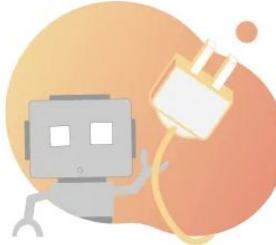
<https://www.readyai.org/>



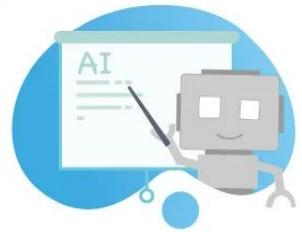
Self-paced Courses



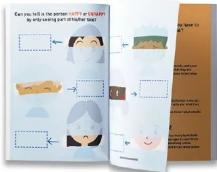
Lesson Plans



Unplugged Lessons



Teacher Training



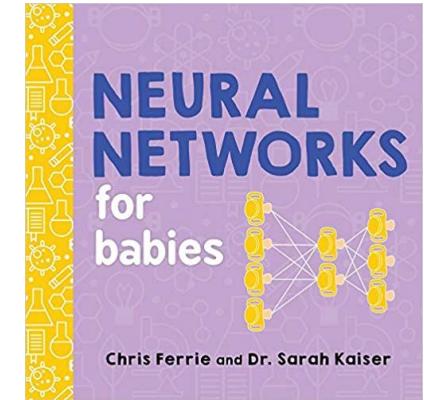
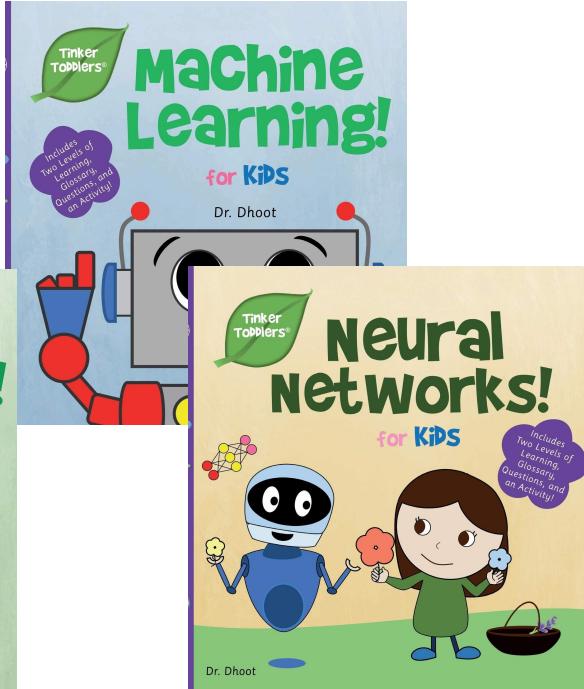
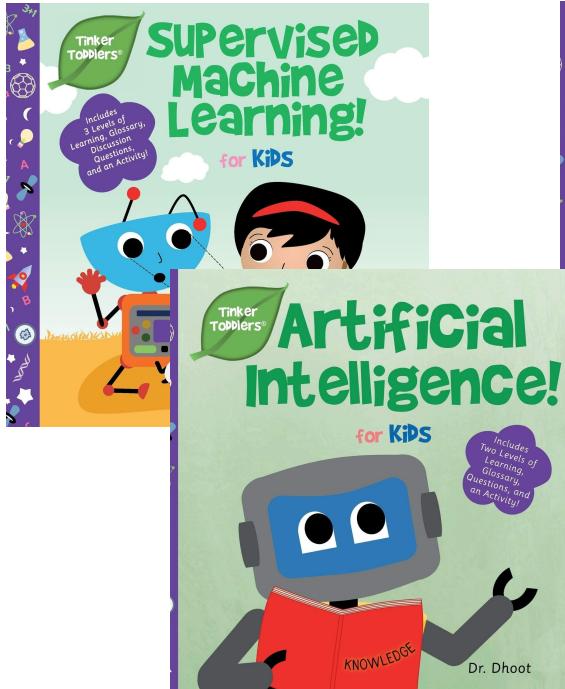
AI Picture Books



AI Teaching & Learning Kits

# Other Books for Young Students

<https://tinkertoddlers.com/>





<https://appinventor.mit.edu/explore/ai-with-mit-app-inventor>

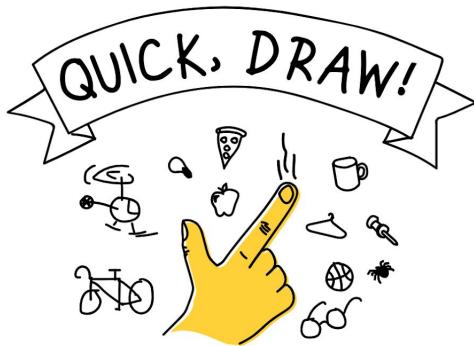
- Introduction to ML: Image Classification
- Personal Image Classifier: PICaboo
- Personal Audio Classifier
- Voice Calculator Tutorial
- Therapist Bot Tutorial
- Awesome Dancing with AI Tutorial
- Facemesh Filter Camera
- Rock Paper Scissors Tutorial





# Google 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!

You were asked to draw snake

You drew this, and the neural net recognized it.

It also thought your drawing looked like these:

Correct match snake	2 <sup>nd</sup> closest match The Great Wall of China	3 <sup>rd</sup> closest match roller coaster
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How does it know what snake looks like?  
It learned by looking at these examples drawn by other people.


# TensorFlow Playground

<https://playground.tensorflow.org>

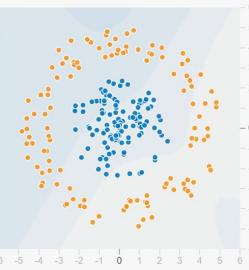
Tinker With a **Neural Network** Right Here in Your Browser.  
Don't Worry, You Can't Break It. We Promise.

Epoch 000,000    Learning rate 0.03    Activation Tanh    Regularization None    Regularization rate 0    Problem type Classification

**DATA**  
Which dataset do you want to use?  
  
Ratio of training to test data: 50%  
Noise: 0  
Batch size: 10  
**REGENERATE**

**FEATURES**  
Which properties do you want to feed in?  
 $x_1$     $x_2$     $x_1^2$     $x_2^2$     $x_1x_2$     $\sin(x_1)$     $\sin(x_2)$

**HIDDEN LAYERS**  
+ - 2 HIDDEN LAYERS  
+ - 4 neurons   + - 2 neurons  
This is the output from one neuron. Hover to see it larger.  
The outputs are mixed with varying weights, shown by the thickness of the lines.

**OUTPUT**  
Test loss 0.508   Training loss 0.504  
  
Colors show data, neuron and weight values.  
 Show test data    Discretize output



AI4K12.org

# Competition



# World AI Competition for Youth

<https://www.waicy.org/>

- For students ages 6-18
- 2021 November 20
- Registration open now

