

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

ICTP

Hal Speed

2021.10.22



@HalSpeed

#AI4K12



Kid Spark Education

Robotical

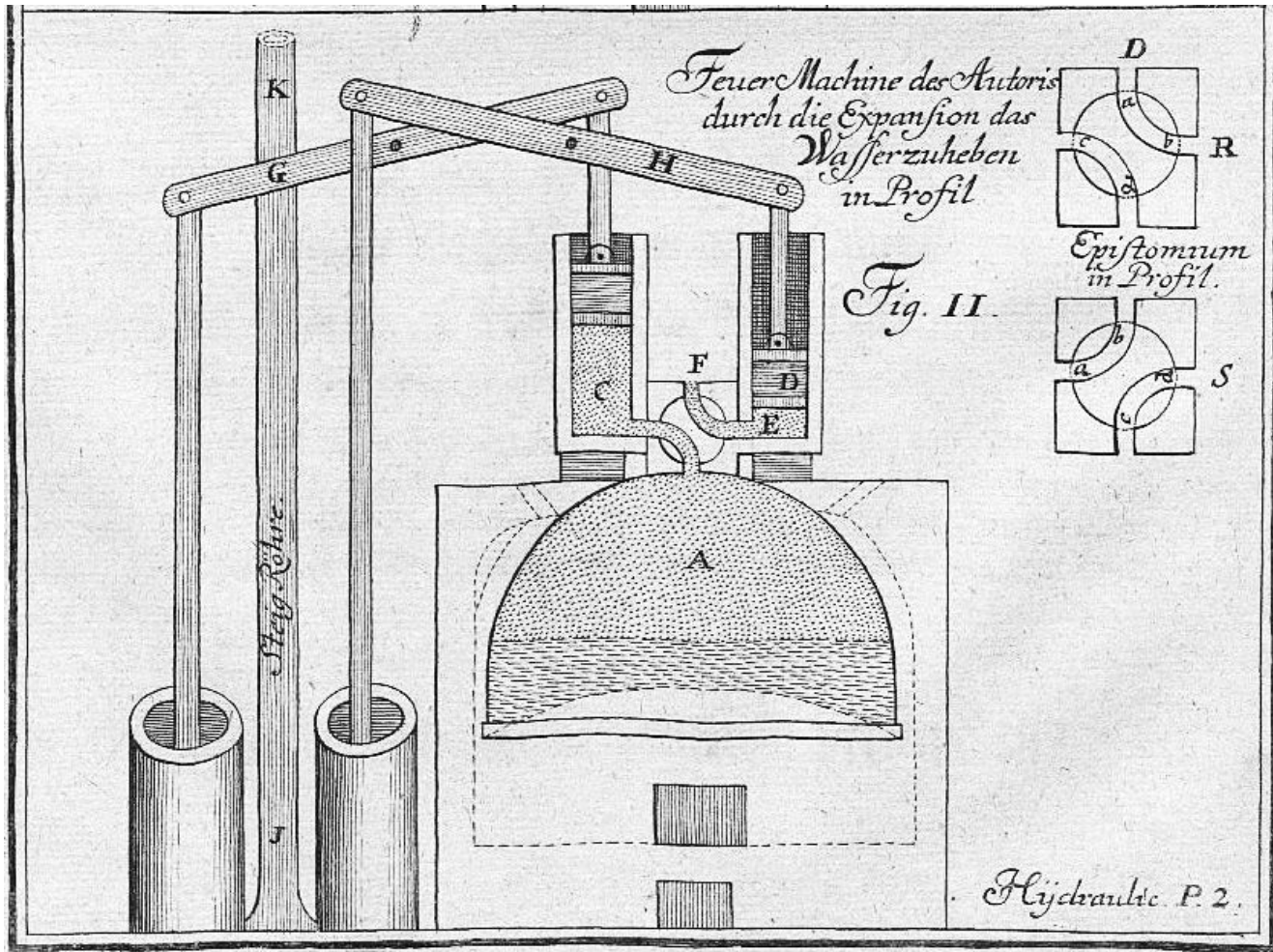
tinyML Edu

AI4K12

Hi-tech industry

CS4TX



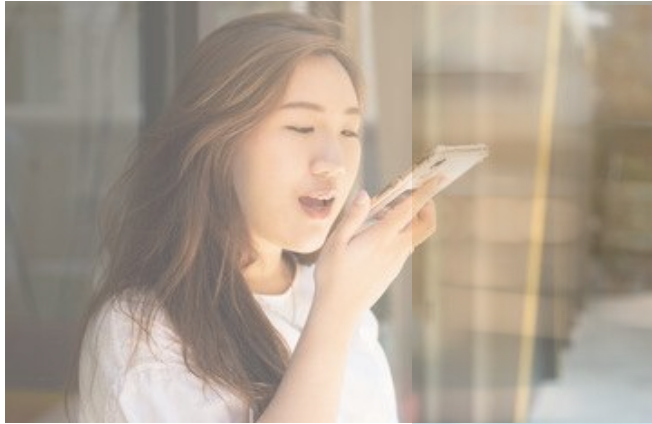




**Artificial Intelligence is powering  
our lives, economy, and workforce**



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



**Today's Recommendations for You**

Here's a daily sample of items recommended for you. Click here to [see all recommendations](#)

**LOOK INSIDE!**



**Even Faster Web Sites: Performance... (Paperback)** by Steve Souders  
★★★★★ (7) \$23.10  
[Fix this recommendation](#)

**LOOK INSIDE!**



**Simply JavaScript (Paperback)** by Kevin Yank  
★★★★★ (19) \$26.37  
[Fix this recommendation](#)

**LOOK INSIDE!**



**The Art & Science of JavaScript (Paperback)** by David Flanagan  
★★★★★ (1) \$29.99  
[Fix this recommendation](#)

# AI in Manufacturing & Warehouses





# AI in Logistics & Shipping



WAYMO

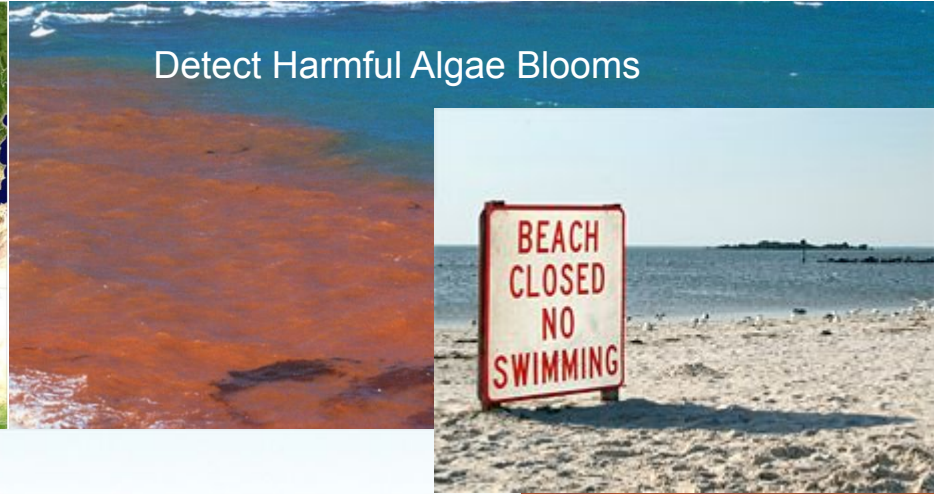
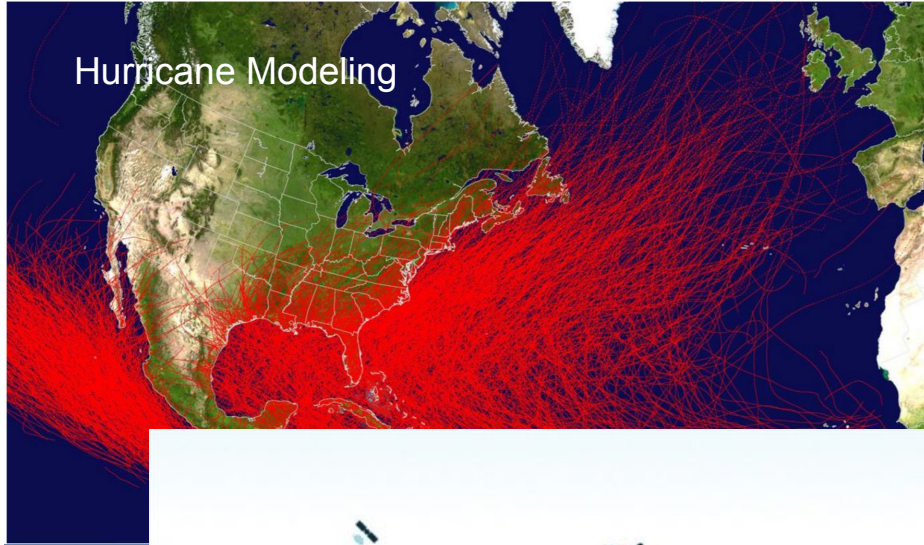


# AI in Agriculture

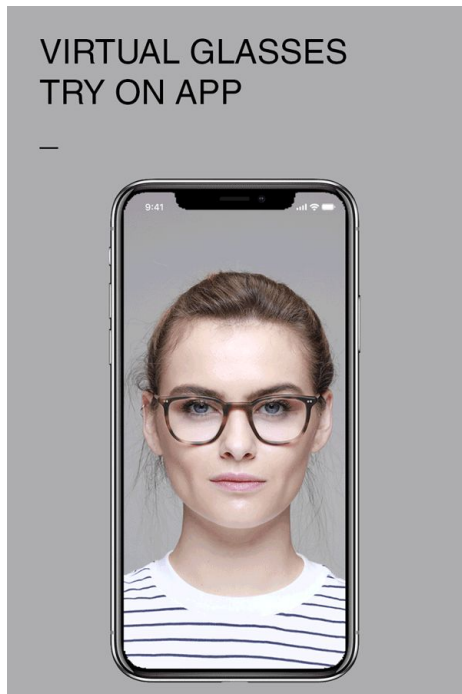




# AI in Ocean & Coastal Sensing



# AI in Fashion & Shopping



## Style by Alexa



### What should I wear?

Get outfit suggestions based on your location and weather

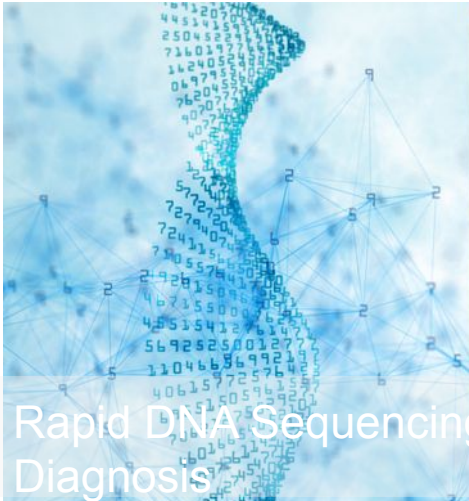
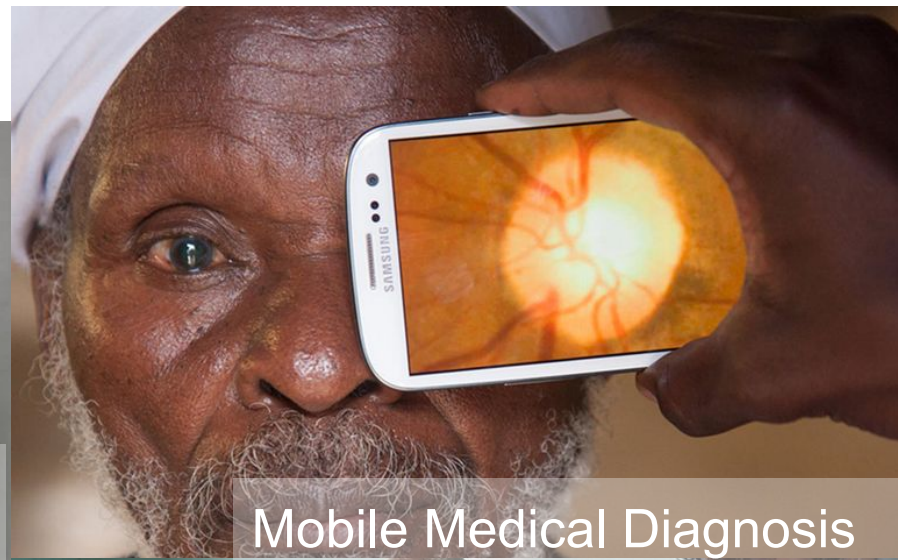
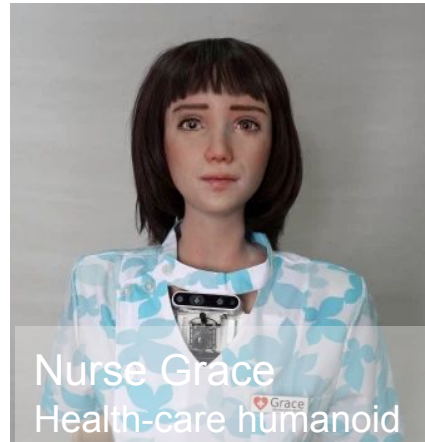


### How do I look?

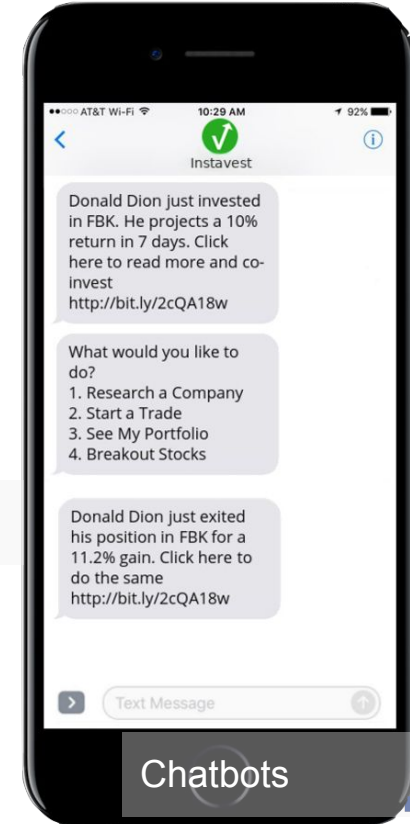
Upload a photo to get instant style tips, right on your phone



# Healthcare



# AI in Investment & Stock prediction







# Overview of the AI4K12 Initiative

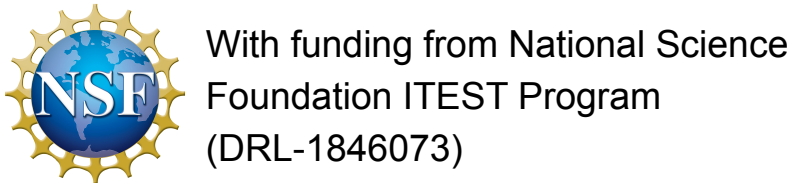


# The AI4K12 Initiative, a joint project of:

**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



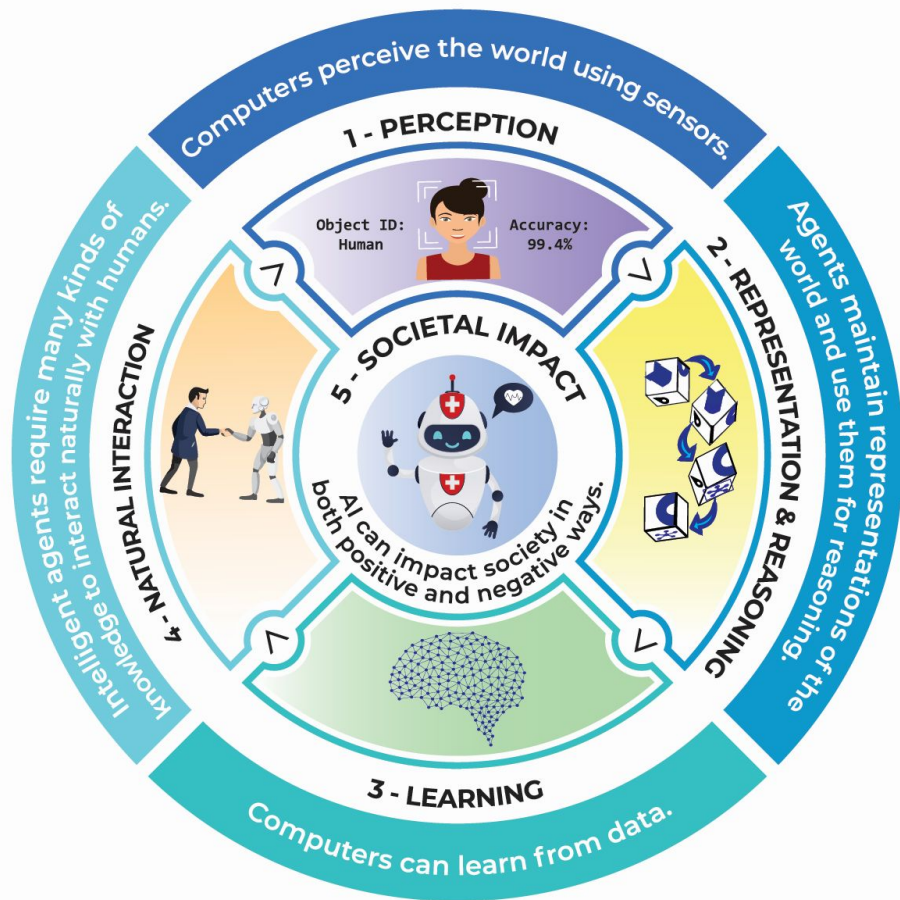
Christina Gardner-McCune  
University of Florida  
AI For K-12 Working  
Group Co-Chair



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



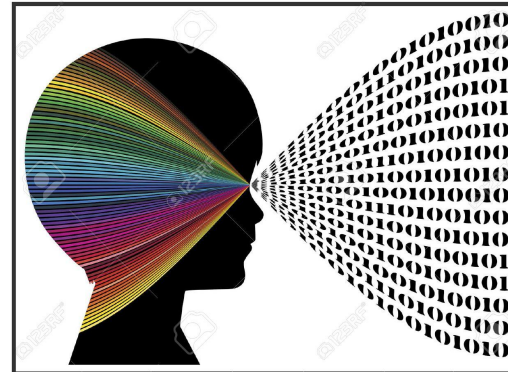
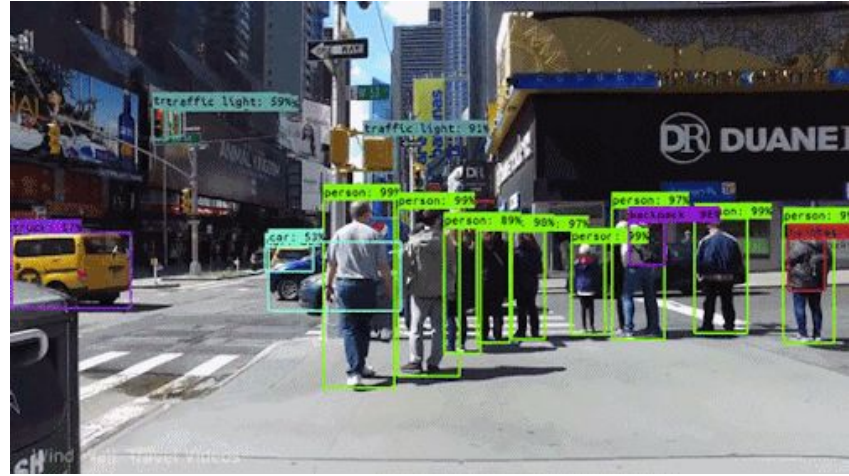


# Big Idea #1: Perception

*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

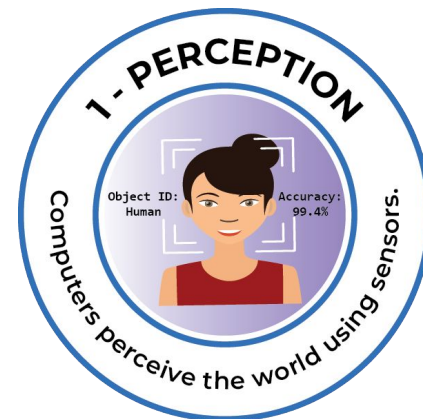
- 1-A-i: Living Things
- 1-A-ii: Computer Sensors
- 1-A-iii: Digital Encoding

## 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

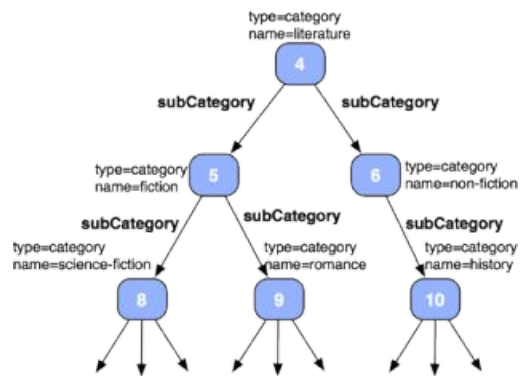
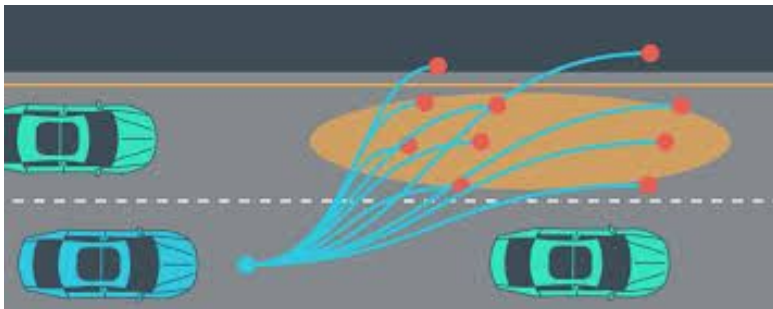
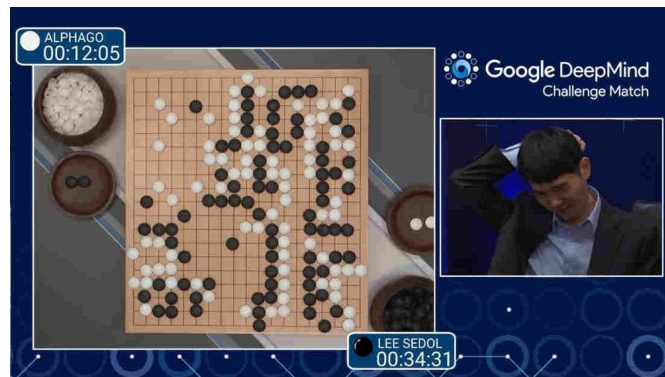
- 1-C-i: Types of Domain Knowledge
- 1-C-ii: Inclusivity



# 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

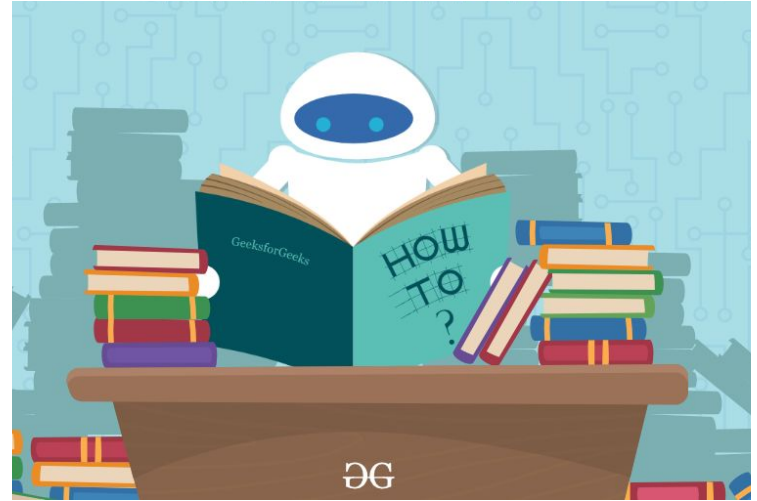
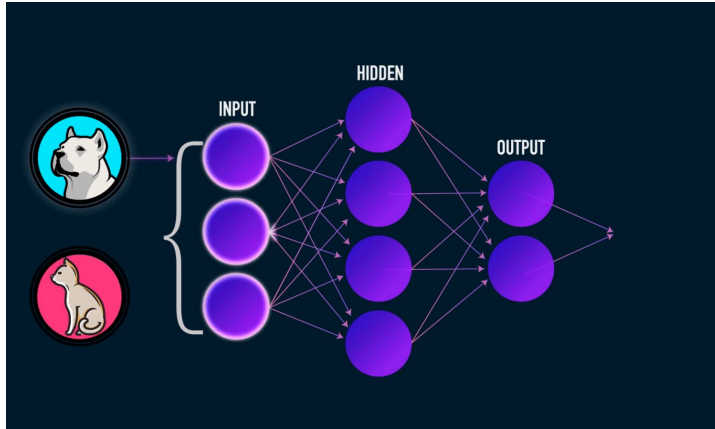




# Big Idea #3: Learning

*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

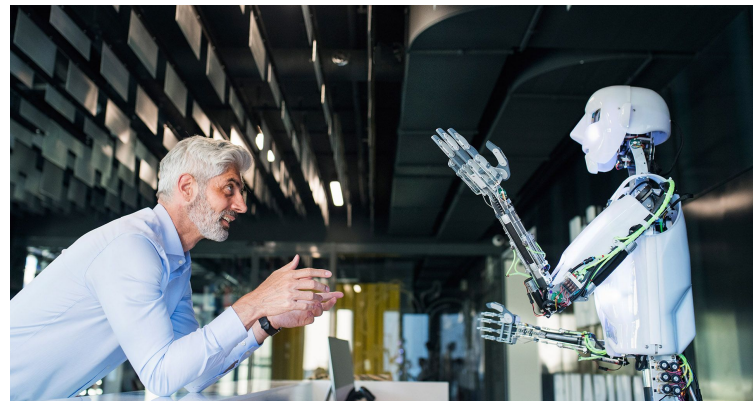
- 1-C-i: Feature Sets
- 1-C-ii: Large Datasets
- 1-C-iii: Bias

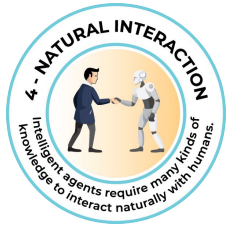


# Big Idea #4: Natural Interaction

*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

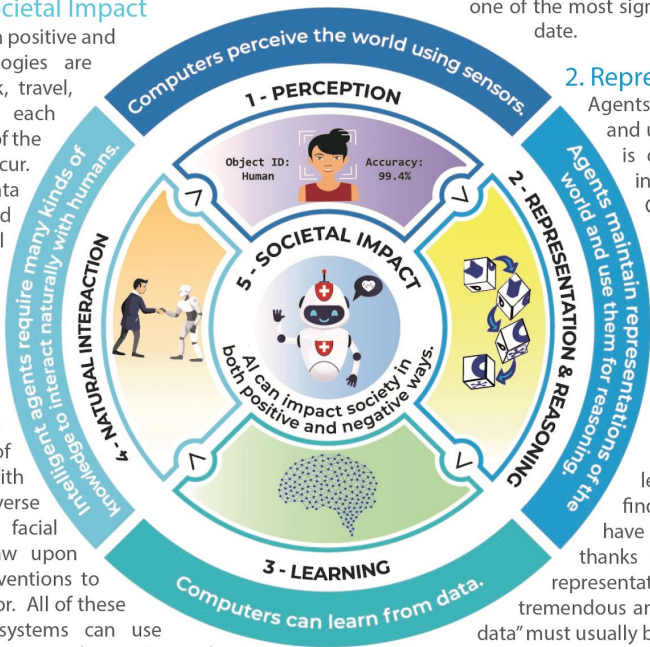
Computers perceive the world using sensors. Perception is the process of extracting meaning from sensory signals. Making computers "see" and "hear" well enough for practical use is one of the most significant achievements of AI to date.

## 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.

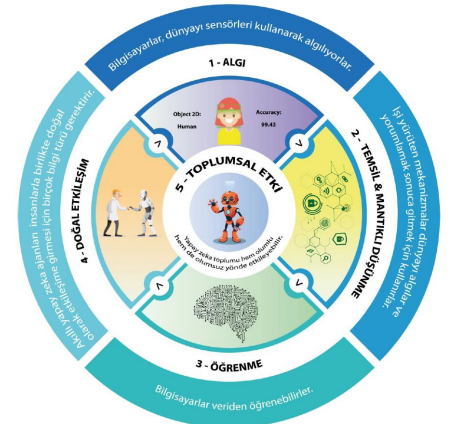


11" x 14" poster  
available for free  
download at  
**AI4K12.org**



# 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

Japanese

## 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 que utilizan inteligencia artificial están transformando la manera en que trabajamos, viajamos, nos comunicamos, y cómo nos cuidamos unos a otros; no podemos omitir que estas poseen riesgos que sí deben considerarse. Por ejemplo, segos 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 ético de sistemas inteligentes.

**4. Interacción Natural**  
Son muchos los tipos de conocimiento requeridos 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 varios; 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 día los sistemas inteligentes pueden utilizar el lenguaje natural para interactuar con humanos, este es todavía limitado, y el razonamiento en cuanto a este es aún inferior al de un infante.

### 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" extensamente 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 algunas de las herramientas utilizadas para el razonamiento algorítmico que conlleva 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 algoritmos de aprendizaje que permiten 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.



## 人工知能(AI)の5つの基本のアイデア

**5. 社会への影響**  
AIは社会に影響を及ぼすことも、悪い影響も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る。しかし、私たちがAIがもたらすことにもあることも認識しなくてはならない。例えば、AIシステムの学習に用いたデータに潜んでいたバイアスが、一部の人たちに不利な結果をもたらす可能性がある。その為、AIが社会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か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と人間が自然に対応するためには、様々な知識や情報が必要とする。AIは人間の言葉を話し、顔の表情や感情を認識し、文化や社会的慣習をもとに、観察された行動が何を意図するかを推測できるようにしなければならない。現在のAIは限られた範囲で言語を使うことはできるが、一般的な判断をする思考能力(推論力)と会話力の子にも及ばない。

### 1. 知覚

コンピュータはセンサを通して周りの世界を感じる。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」できるよくなったのは、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使った判断

AIは身の回りの世界を表現するモデルを作り、それを元に判断していく。自然界においても、人工知能においても、周りの世界の特徴を表現することは知能が直面する基本的な問題である。コンピュータは様々なデータ構造を用いてモデルを作り出す。作り出されたモデルは、既に分かっている情報から未知の情報を読み出すアルゴリズムに活用される。AIはかなりの複雑な問題解決が可能になるが、人間と同じように思考することはできない。

### 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心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み出さ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。機械学習の成功のためには膨大なデータが必要とされる。「学習データ」と呼ばれるこのデータは、基本的には人間が提供するものであるが、コンピュータ自身も集める場合もある。





# 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

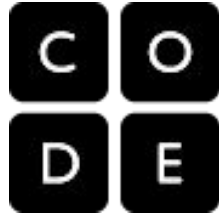
# Additional Resource Lists



<https://aiforteachers.org/>



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



<https://code.org/ai>



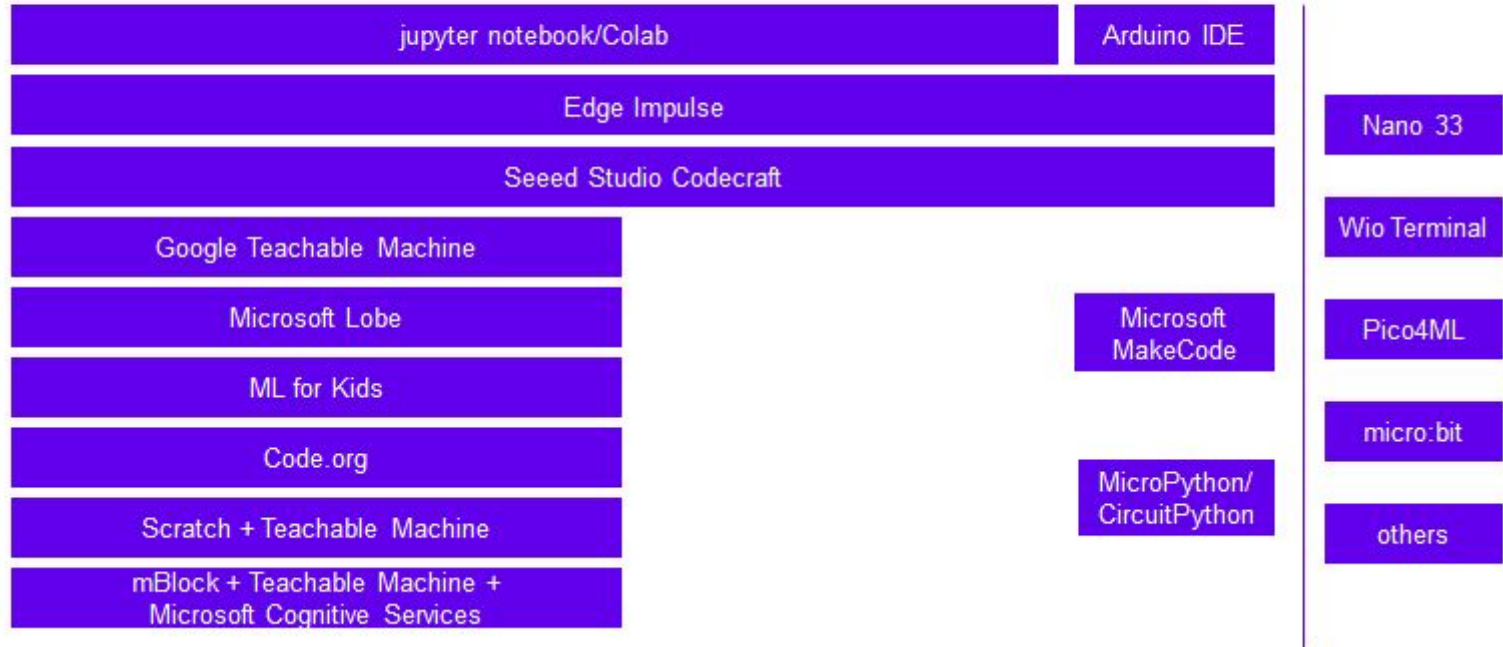
<https://www.actua.ca/ai/>



<https://tinymix.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

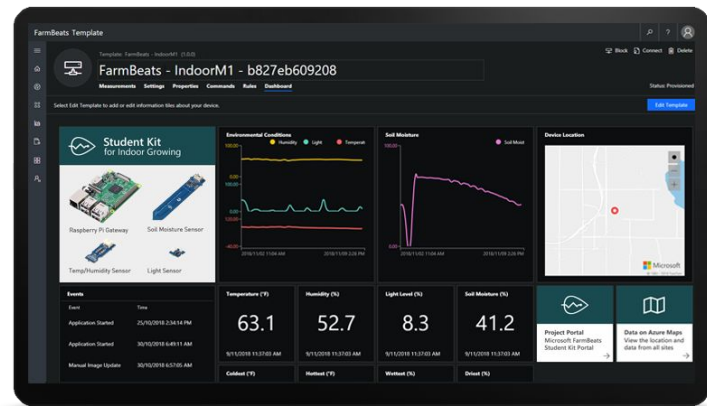
Begin your first step into the world of TinyML and Wio Terminal with detailed lessons and step-by-step projects to guide you! Now, simple hardware can also solve complex problems.

# 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

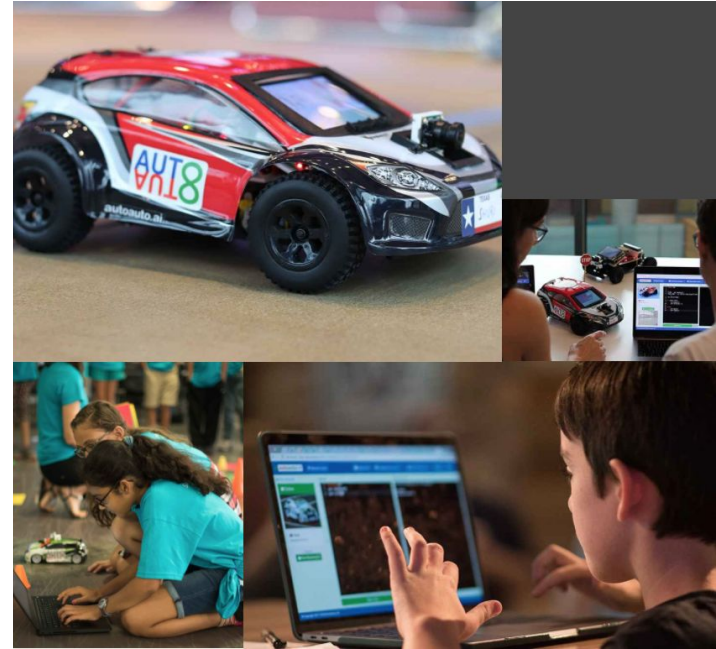
Future Farmers of America and Microsoft are working together to create activity guides and resources to help chapters get started with using the technology.



# AutoAuto

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

The screenshot shows the AutoAuto Labs interface. At the top, there are navigation options: 'Resume Lesson', 'World Cohort Sampler', 'Let 1: Intro to Programming & AI', and 'Coco's Dashboard'. A message states 'Your code has been submitted for grading.' The main content area is titled 'Part 6: Mini Spy Mission' and includes a video player, a mission description, and a code editor. The mission description reads: 'In this mission your car needs to move towards a group of figurines, take a picture and then safely return to its base. Good luck!' The code editor shows the following code:`import car  
car.forward()  
frames = car.capture()  
car.stop(frames)  
car.reverse()  
frames = car.capture()  
car.stop(frames)  
car.reverse()`





# Calypso for Cozmo



speech  
recognition

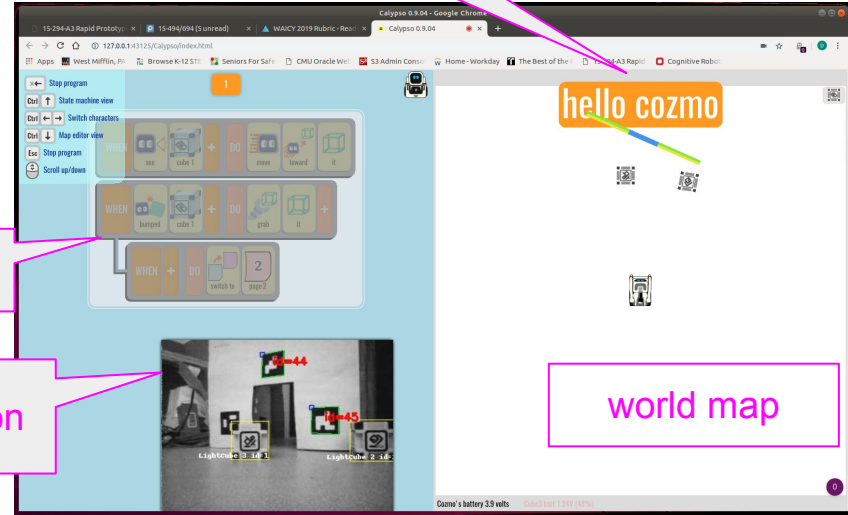
- A robot intelligence framework that incorporates multiple AI technologies:

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

rules

perception

world map



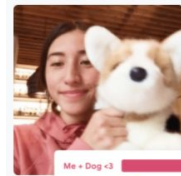
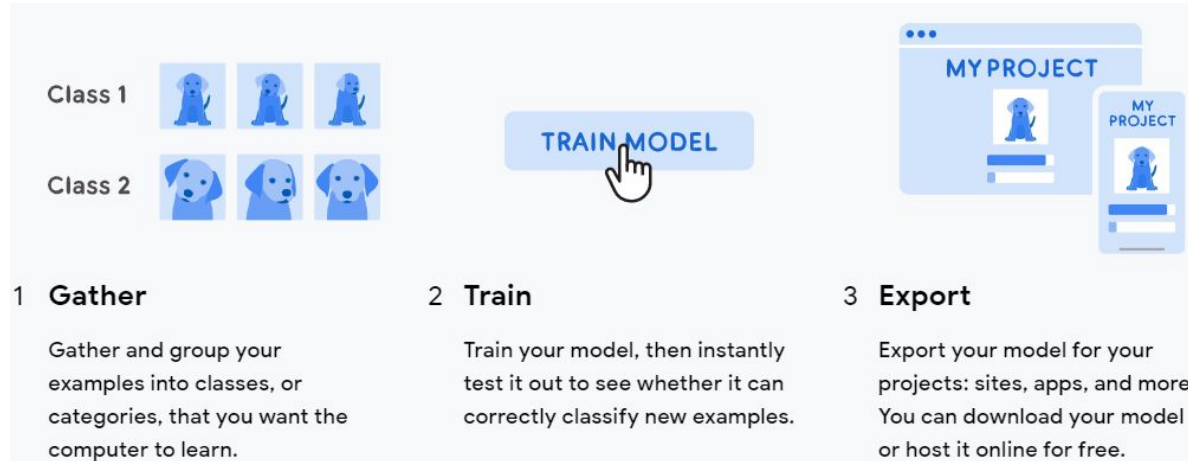
- Rule-based pattern matching language inspired by Microsoft's Kodu Game Lab
- Teaches computational thinking: "Laws of Calypso", idioms, etc.
- Web site: <https://Calypso.software>





# Teachable Machine

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



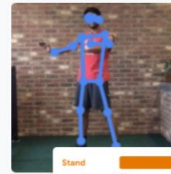
## Images

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.lobe.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.

The screenshot displays the Lobe AI interface for training a model on California Plants. On the left, a sidebar shows the training progress for five classes: All Images (80%), Fern (75%), Madrone (85%), Toyon (78%), and Manzanita (82%). The 'Train' button is highlighted in green. Below the progress bars, a summary states: "80% of your images are predicted correctly, 20% incorrectly." The main area shows a grid of images categorized into 'Correct 80%' and 'Incorrect 20%'. The 'Correct' section contains four images with green checkmarks and labels: Fern, Madrone, Manzanita, and Toyon. The 'Incorrect' section contains four images with red X marks and labels: Manzanita, Toyon, Fern, and Madrone. A 'View' button is located in the top right corner of the main area.

Class	Percentage
All Images	80%
Fern	75%
Madrone	85%
Toyon	78%
Manzanita	82%

80% of your images are predicted correctly, 20% incorrectly.



# 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



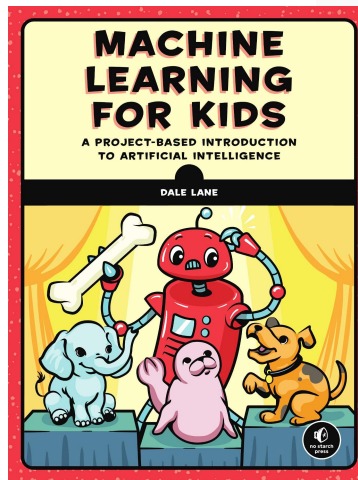
Difficulty: Intermediate

Recognising: **numbers**



Tags: predictive model, recommendations, supervised learning

Download

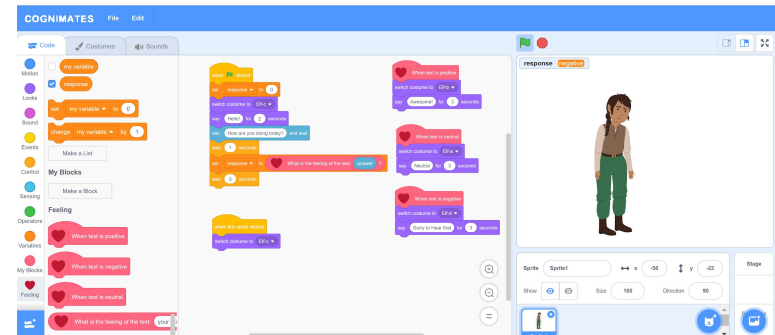
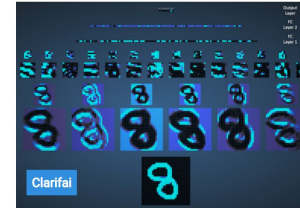
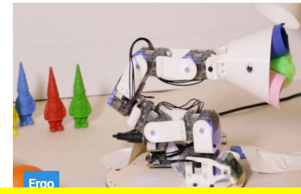
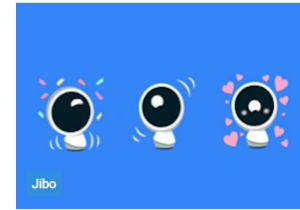
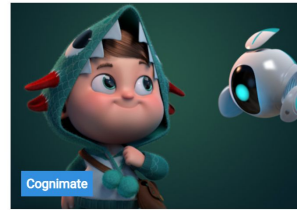




<http://cognimates.me>

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/>

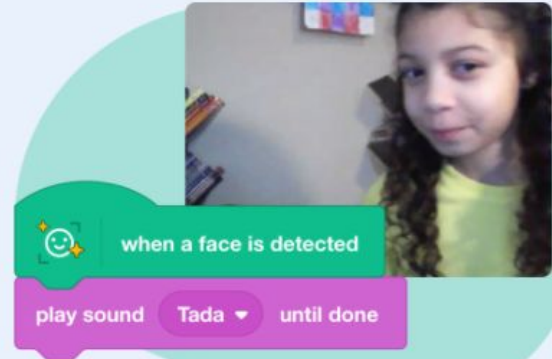
Face Sensing

- go to nose
- point in direction of face tilt
- set size to face size
- when face tilts left
- when this sprite touches a nose
- when a face is detected
- a face is detected?
- face tilt
- face size

Make a sprite follow your nose



Does it see you?



# Other Scratch-based Editors w/ML



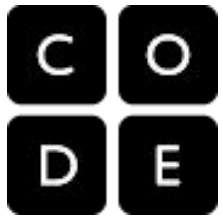
<https://scratch.techpark.jp/>



<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







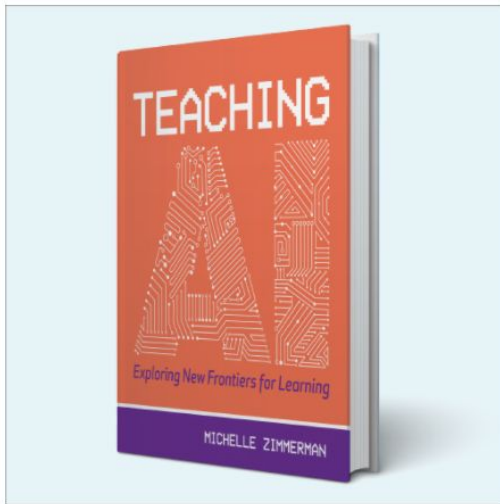
# AI in Education

<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

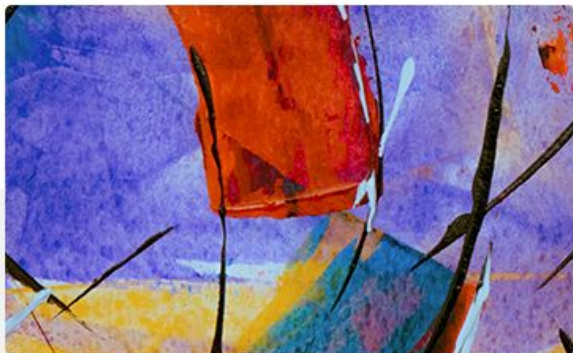




# AI4All: Online Learning

<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

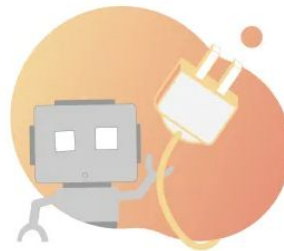
<https://www.readyai.org/>



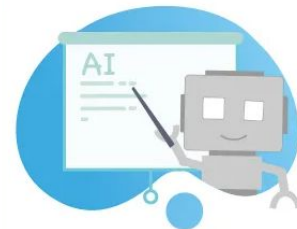
Self-paced Courses



Lesson Plans



Unplugged Lessons



Teacher Training



AI Picture Books

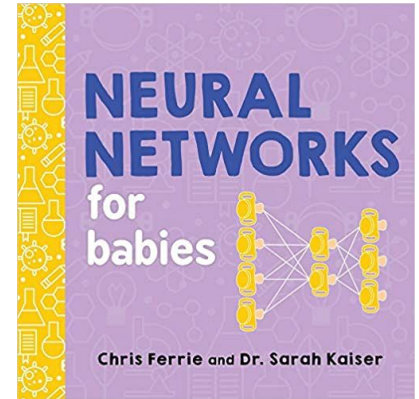
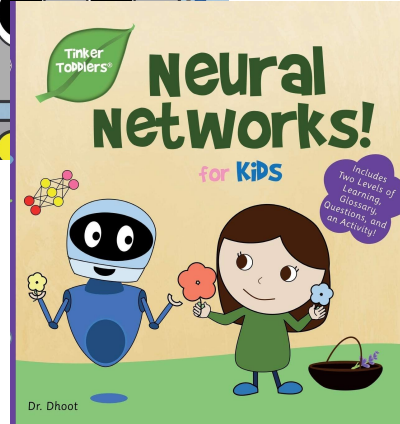
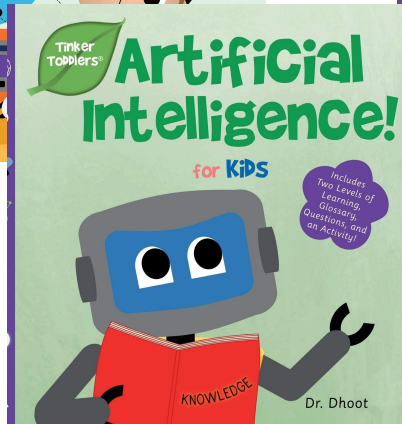


AI Teaching & Learning Kits



# 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!

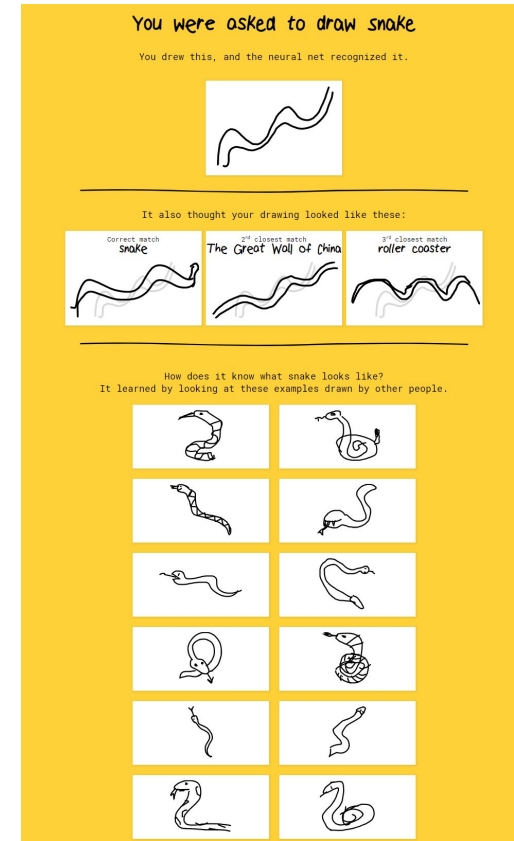
<https://quickdraw.withgoogle.com/>



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!



# 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?  
 $X_1$   
 $X_2$   
 $X_1^2$   
 $X_2^2$   
 $X_1 X_2$   
 $\sin(X_1)$   
 $\sin(X_2)$

2 HIDDEN LAYERS  
4 neurons  
2 neurons

OUTPUT: Test loss 0.508  
Training loss 0.504

Colors shows data, neuron and weight values.  
 Show test data  Discretize output

The outputs are mixed with varying weights, shown by the thickness of the lines.  
This is the output from one neuron. Hover to see it larger.

# Competition



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

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

