Teaching AI in K-5

David S. Touretzky
Computer Science Department
Carnegie Mellon University

FDU CS Hub, March 5, 2024

CS Is Hard Enough. Why Should We Teach AI in K-5?

- AI is the new electricity.
- **Our children are growing up with AI.** By time many children arrive in kindergarten, they've spent two years conversing with Alexa.
- We must prepare for the next round of revolutionary disruption:
  - Autonomous robots everywhere.
  - Changing nature of work.
  - Demand for an AI-literate workforce.
  - AI policy issues regarding fairness, privacy/surveillance, disparate impacts of technology, etc.

The AI4K12 Initiative, a joint project of:

AAAI (Association for the Advancement of Artificial Intelligence)

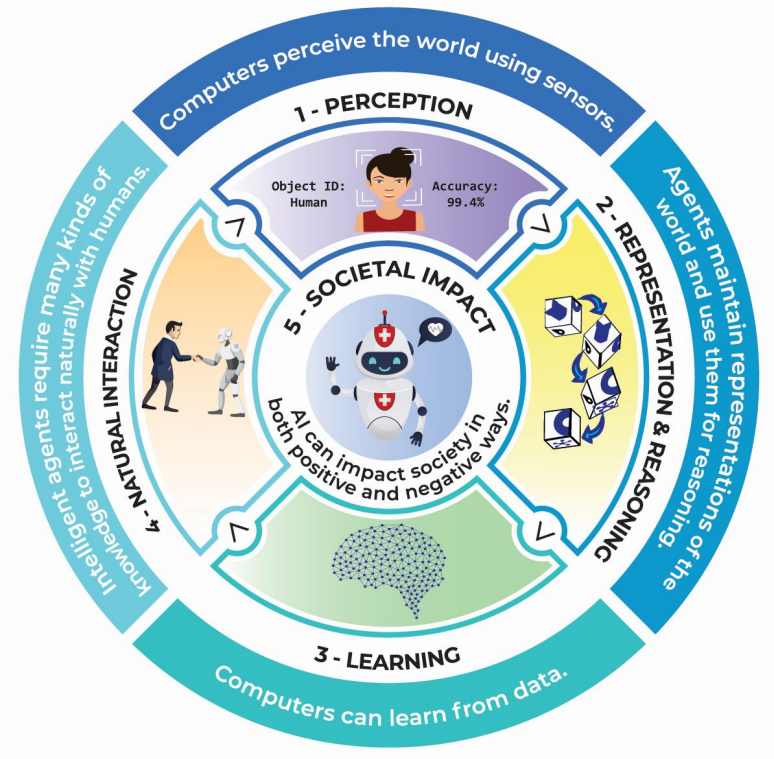
CSTA (Computer Science Teachers Association)

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

Carnegie Mellon University
School of Computer Science

Five Big Ideas in AI

1. **Perception:** Computers perceive the world using sensors.
2. **Representation and reasoning:** Agents maintain representations of the world and use them for reasoning.
3. **Learning:** Computers can learn from data.
4. **Natural interaction:** Intelligent agents require many kinds of information to interact naturally with humans.
5. **Societal impact:** AI can impact society in both positive and negative ways.



AI4K12.org

Five Big Ideas in Artificial Intelligence v.2

1. Perception

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

2. Representation & Reasoning

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

3. Learning

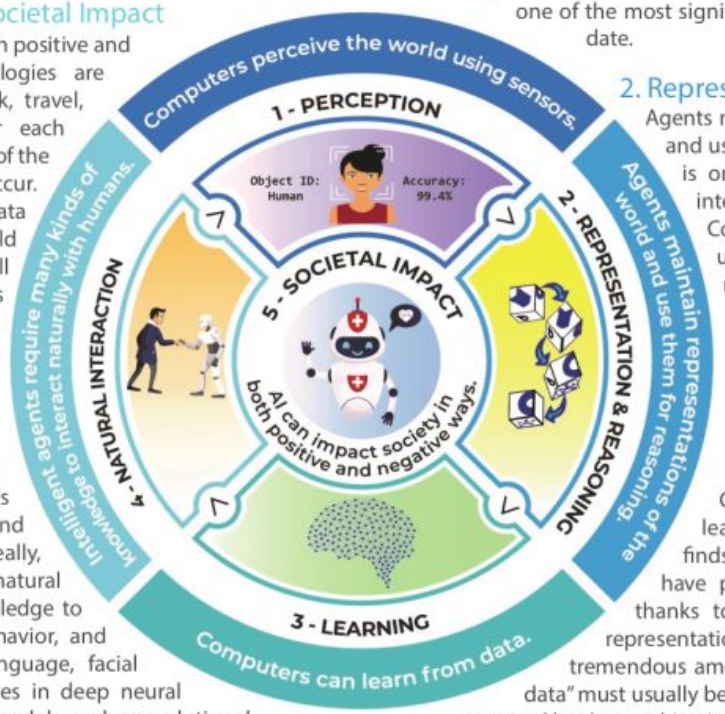
Computers can learn from data. Machine learning is a kind of statistical inference that finds patterns in data. Many areas of AI have progressed significantly in recent years thanks to learning algorithms that create new representations. For the approach to succeed, tremendous amounts of data are required.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

4. Natural Interaction

Intelligent agents require many kinds of knowledge to collaborate and interact naturally with humans. Ideally, agents will converse with us using natural language, draw upon cultural knowledge to infer intentions from observed behavior, and respond appropriately to body language, facial expressions, and emotions. Advances in deep neural networks such as large language models and convolutional neural networks are making this possible.

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.



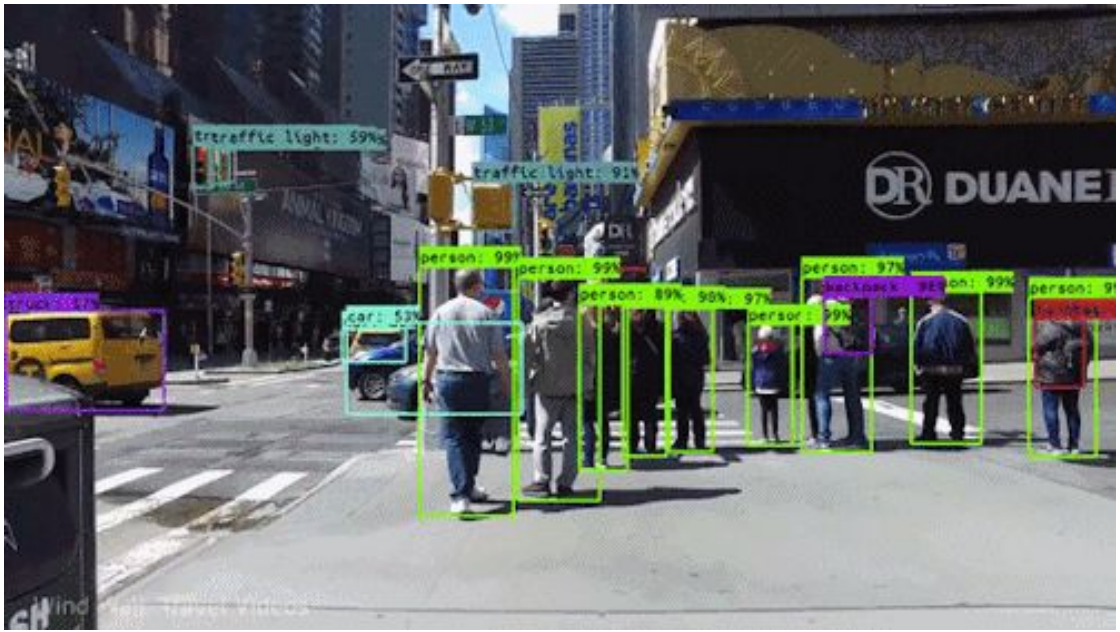
The AI for K-12 Initiative is a joint project of the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), funded by National Science Foundation award DRL-1846073

AI4K12.org

Big Idea #1: Perception

Computers perceive the world using sensors.

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



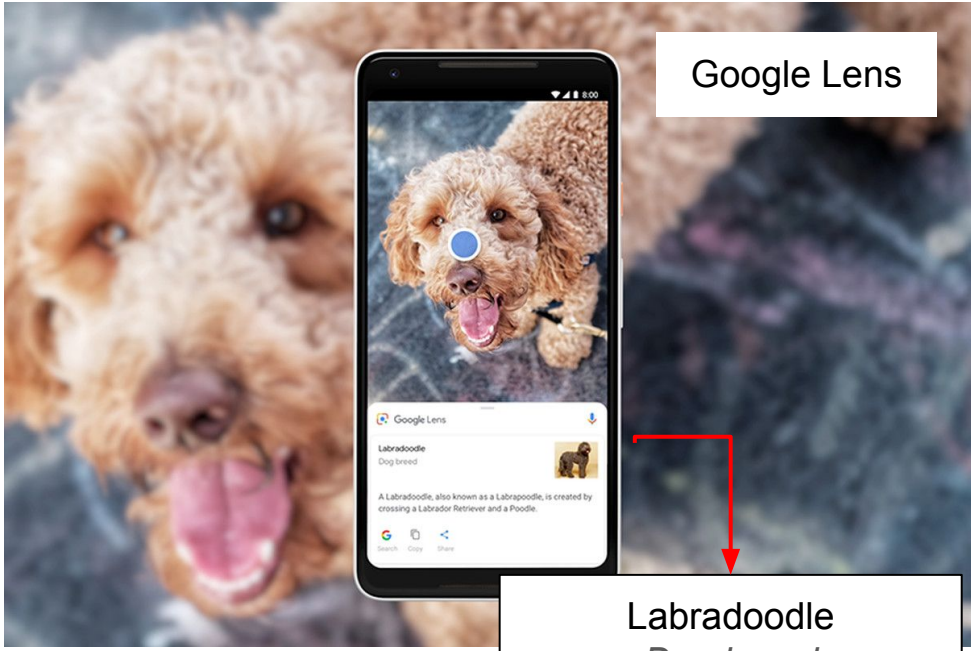
Are supermarket doors intelligent?

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

Visual Perception

Computers can see:

- Faces
- Household objects
- Road scenes



I can teach a computer to recognize what I want it to see.

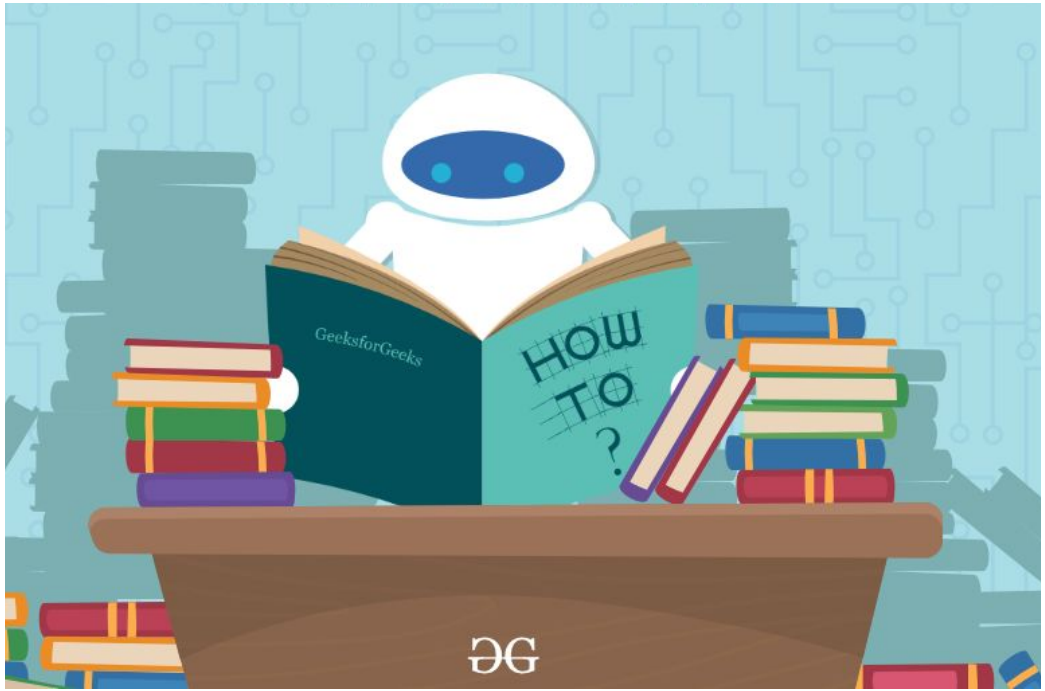
I can make artifacts (programs, devices) that use computer vision.

Big Idea #2: Representation and Reasoning

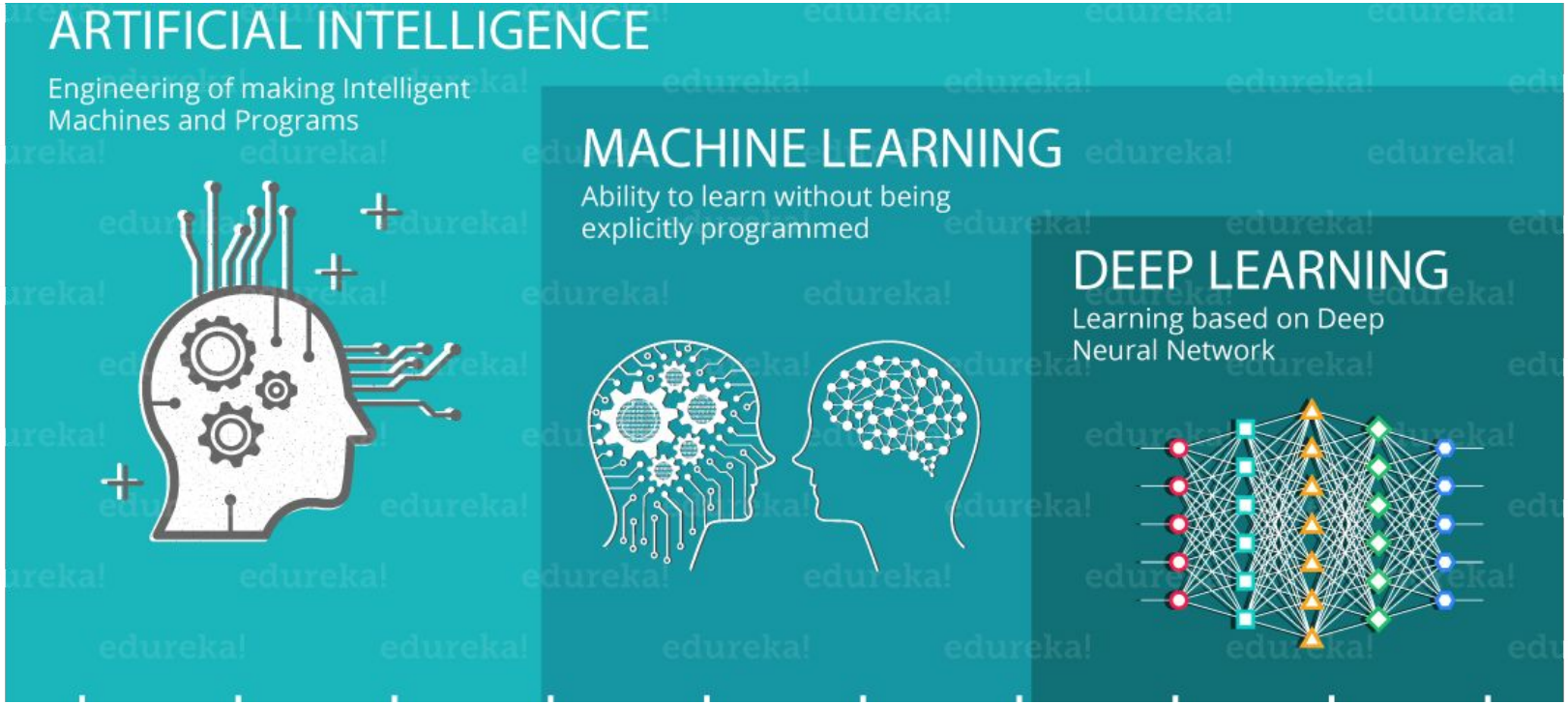
Agents maintain representations of the world, and use them for reasoning.

Big Idea #3: Learning

Computers can learn from data.



AI and Machine Learning



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

Large Language Models

- ChatGPT and the many other “large language models” (LLMs) that have recently appeared are demonstrating surprisingly good language understanding and common sense reasoning abilities.
- Huge implications for education: we can have a personalized tutor for every student.

Stable Diffusion Turbo

Mapping language to images.

Trained on billions of captioned images.

taylor swift riding a donkey in front of the eiffel tower in paris

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

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

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

Example Guidelines

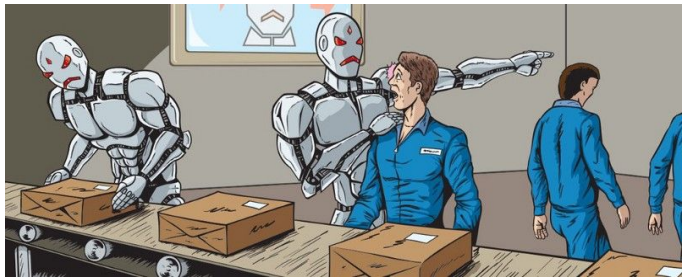
- Critically explore the positive and negative impacts of an AI system.
- Describe ways that AI systems can be designed for inclusivity.

Machine Bias: ProPublica.org

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

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

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



Example Guidelines

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

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

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

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

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

Example Guidelines

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

Let’s Try Some Demos

Today’s Demos

1. Teachable Machine
2. Speech Demo
3. Face Demo
4. Image Generation
5. Large Language Models (ChatGPT, etc.)
6. Calypso

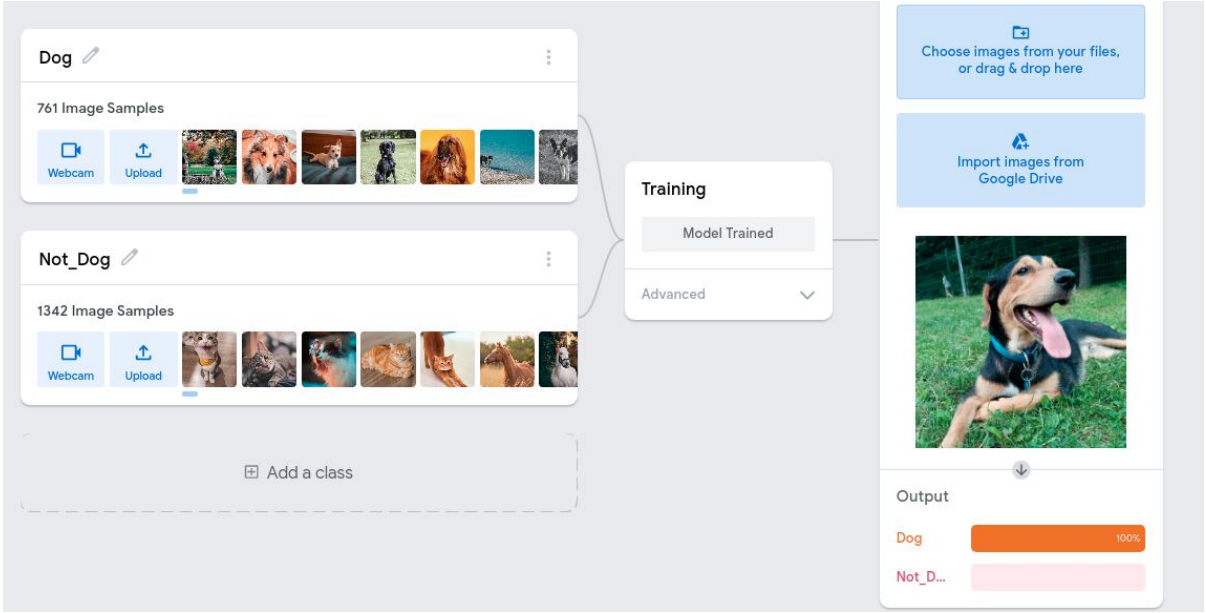
Teachable Machine

https://teachablemachine.withgoogle.com

Train a visual classifier using your webcam.

Learn about:

- Machine learning
- Computer vision



Sample Teachable Machine Activity

1. Choose your classes:
    a. thumbs up
    b. peace sign
    c. nothing (null class)
2. Collect examples of each class using your webcam.
3. Train the classifier.
4. Test the classifier:
    a. on examples similar to the training images
    b. try using your other hand
    c. try thumbs-down instead of thumbs-up, or a sideways peace sign
    d. try using someone else’s hand

Speech Demo

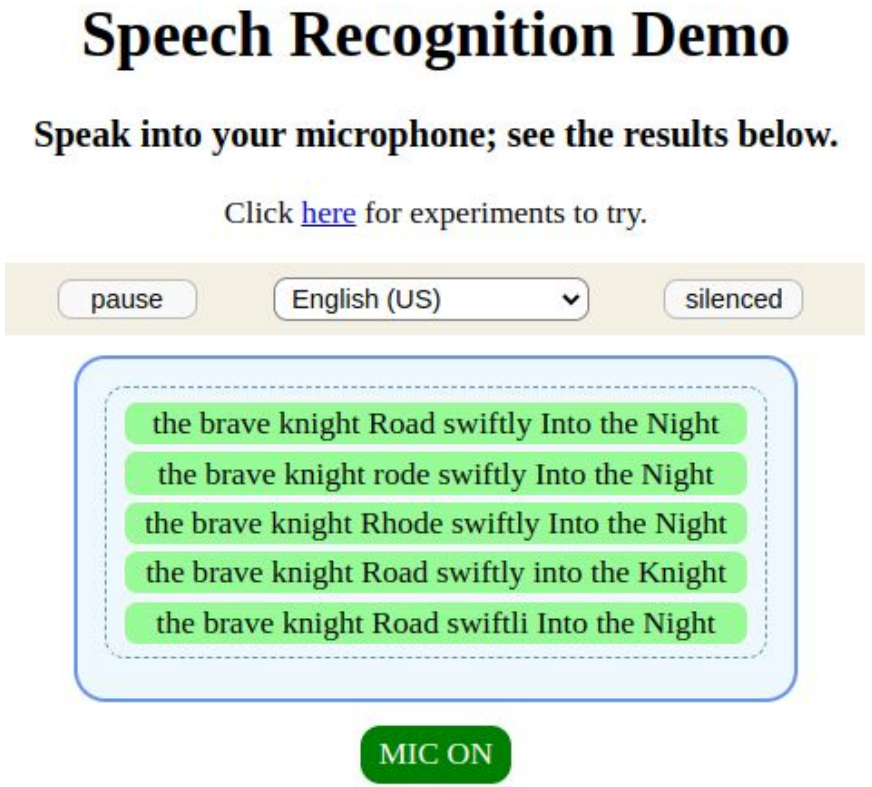
https://www.cs.cmu.edu/~dst/SpeechDemo

Experiment with speech recognition.

Learn about:

- Homophones
- Use of syntactic and semantic knowledge to resolve ambiguity in speech

See this Activity Resource Guide:
https://ai4k12.org/wp-content/uploads/2022/11/SpeechDemo-Activity-Guide-4.pdf



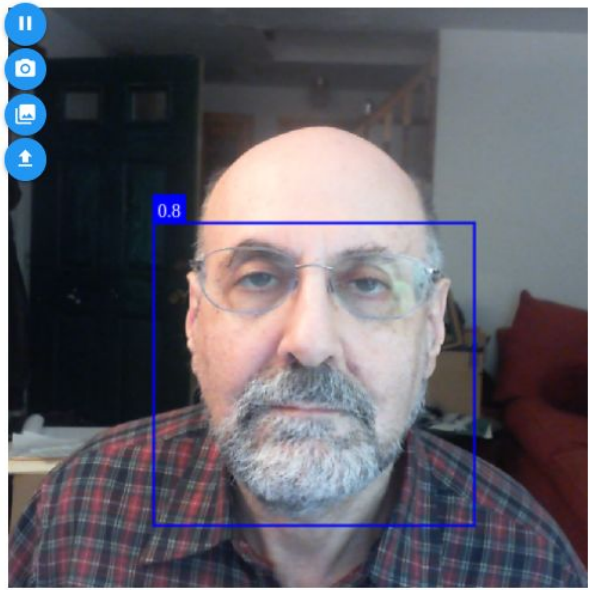
FaceDemo

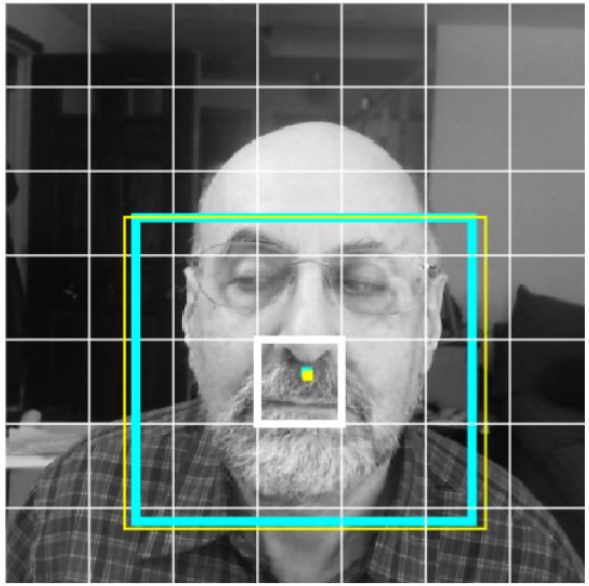
https://www.cs.cmu.edu/~dst/FaceDemo

Experiment with face detection.

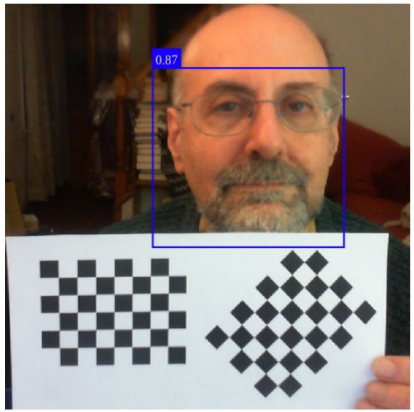
Learn about:

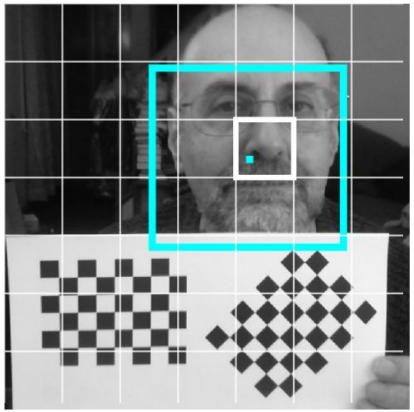
- Computer vision
- Edge detection
- Color detection

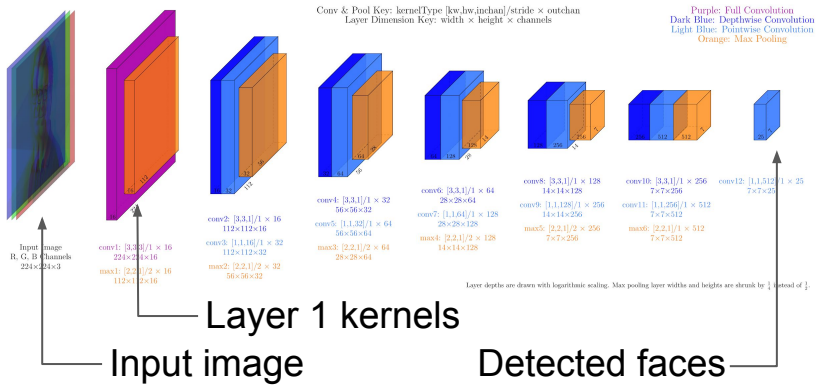


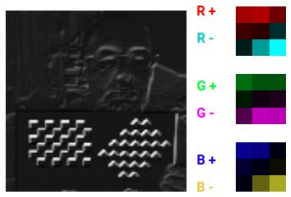


Neural Net Edge and Face Detection Demo

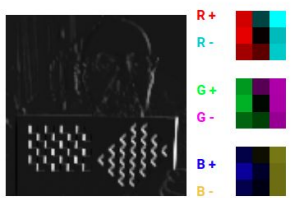




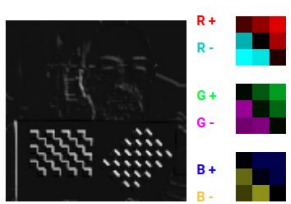




Kernel 8: Horizontal Edge Detector



Kernel 9: Vertical Edge Detector



Kernel 7: Diagonal Edge Detector

Three of 16 layer 1 kernels.

Each kernel has separate R, G, and B channels.

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

FaceDemo Experiments

Face Detection

- Try turning your head sideways, or covering your eyes with your hand.
- Try multiple faces in the same image.

Edge Detection

- Call up a “checkerboard” image on your phone.
- Select kernels 7 (diagonal), 9 (vertical), and 10 (horizontal).
- Rotate the checkerboard and see what happens.

Color Detection

- Call up a “rainbow” image on your phone.
- Select kernels 11 (red), 2 (green), and 12 (blue green).

Image Generation

Explore using generative AI to generate images from text.

Learn about:

- Generative AI
- Prompt engineering

DALL·E-2 is the most famous image generator, but there are many more now.

Safety controls try to block nudity and gore.

“A brown bear wearing a chef’s hat, using a spoon to stir a pot of spaghetti and sauce.”

What Is Generative AI?

- Programs that generate novel text, images, music, or videos, or computer code based on a text prompt.
- Use large neural networks running on powerful servers in data centers.
- Trained on massive amounts of data:
  - All of Wikipedia, most of Reddit, plus hundreds of thousands of books
  - Five billion images with captions
- Training one of these networks can cost millions of dollars.

Image Generators Your Students Can Use

- Some charge subscription fees, e.g., Midjourney

- Most require some kind of login, even if the service is free, e.g., OpenAI, Microsoft, Google.
  - If you're a teacher, sign up for a free OpenAI account to use DALLE-3.
  - Or create a free Microsoft account to use Bing's Image Creator.

- There are a few online demos that don't require a login, so children can use them. They're often slower than the commercial versions.

Hotpot.ai

https://hotpot.ai/art-generator

No login required to generate single images.

“a brown bear wearing a chef's hat, cooking spaghetti and meatballs in a pot”

StableDiffusion.fr

https://stablediffusion.fr/demo

Free demo version of Stable Diffusion.

“a brown bear wearing a chef's hat, stirring a pot of spaghetti and meatballs. 8K.”

https://huggingface.co/spaces/runwayml/stable-diffusion-v1-5

“RunwayML” on Hugging Face

Hugging Face is a major machine learning site that hosts demos from many developers.

“a brown bear wearing a chef's hat, using a spoon to stir a pot of spaghetti and sauce”

Weaker safety controls than other sites.

Craiyon.com

https://craiyon.com

Craiyon offers free demos without a login, but each image takes 60 seconds.

“a brown bear wearing a chef's hat, cooking spaghetti and meatballs in a pot”

Large Language Models

Converse with a Large Language Model (LLM).

Learn about:

- Prompt engineering
- Confabulation (“hallucination”)
- Limitations of LLMs

OpenAI’s ChatGPT is the most famous LLM.

Other examples include Google’s Gemini, Microsoft’s Copilot, Facebook’s LLaMA, Anthropic’s Claude, and many more.

Accessing LLMs

- OpenAI's GPT-3.5 is free (but you need a login). GPT-4 is much smarter but costs $20/month.
  - https://chat.openai.com
- Bing AI (Copilot) is free but requires a Microsoft login to process more than a handful or prompts per day.
  - https://www.bing.com/chat

Ways to Use an LLM Chatbot

- “Write a limerick about cherries.”
- “Quiz me on Harry Potter characters.”
- “Write a version of ‘Goldilocks and the Three Bears’ told from the point of view of the mama bear.”
- “If I dropped a bowling ball off the Empire State Building, what speed would it reach? Answer in miles per hour.”

Prompt Engineering

- Sometimes the first result we get from an LLM is not what we wanted.
- We may need to make the instructions more explicit or add more details about what we're seeking.
- For example, the bowling ball terminal velocity was initially given as 76.3 meters per second, so we changed the prompt to specify that the answer should be in miles per hour.
- Adjusting prompts this way is called "prompt engineering". It applies to image generation as well.

Confabulation

- Large language models are not yet trustworthy: they can make things up.
- This is popularly referred to as “hallucination”, but the correct term is “confabulation”.
- Several lawyers have gotten in trouble for using ChatGPT to write legal filings that turned out to contain fictional legal citations. They never checked!
- Some LLMs now try to verify their answers by doing a web search.
- In general, you should not rely on information from an LLM without verifying it with a reliable source.

Limitations of LLMs

LLMs are amazingly good at some types of reasoning, but fail spectacularly at other tasks.

The early ones were bad at math. Some newer ones have been taught to use Python or a calculator app instead of trying to do the calculation themselves.

Here is something most LLMs still cannot do:

> *“List all US states that do not contain an ‘a’ in their name.”*

Note: there are 14 such states.

Calypso

https://calypso-robotics.com

Calypso is an intelligent robot programming framework that lets students use real AI tools.

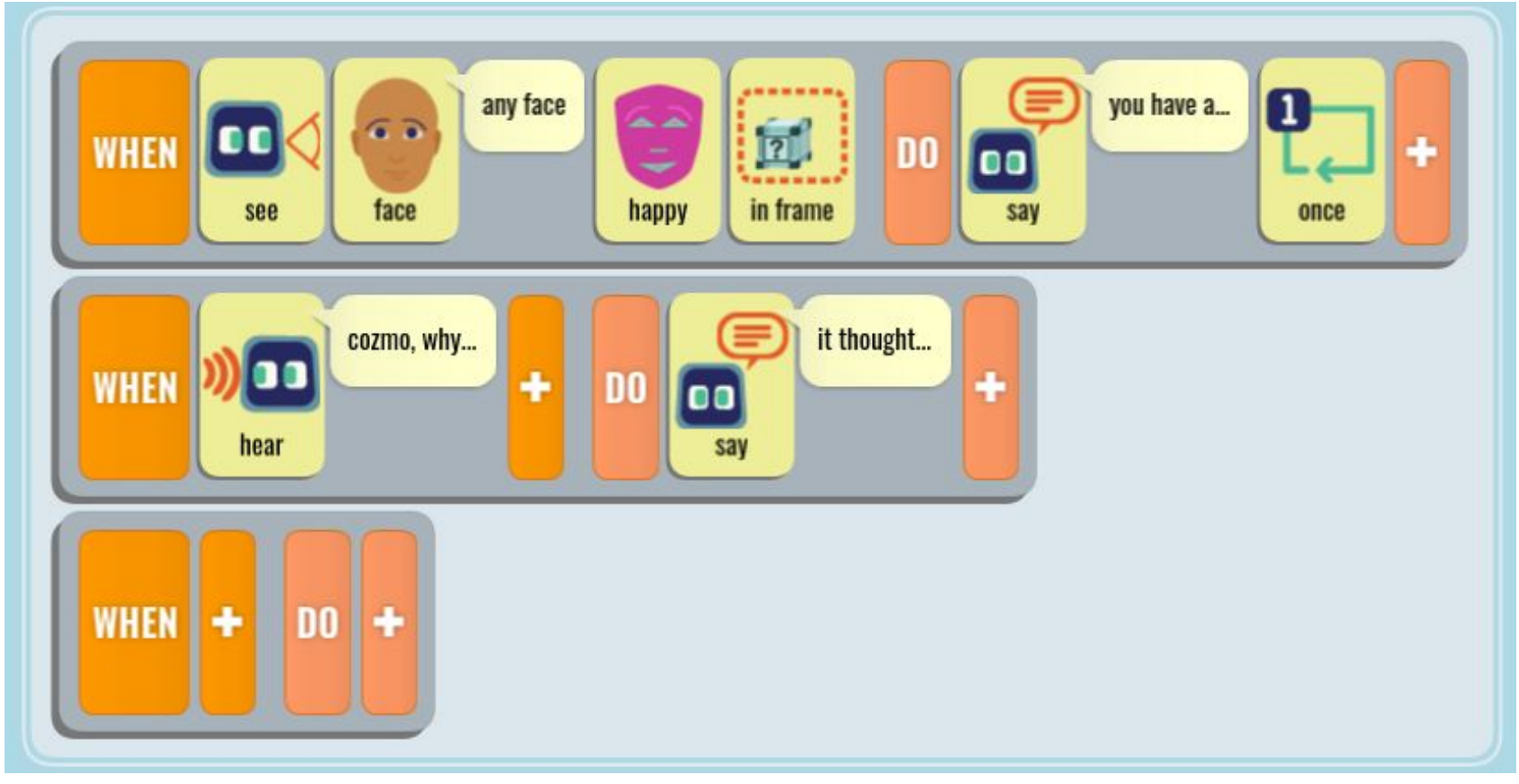
Learn about:

- Rule-based programming
- Speech recognition and generation
- Computer vision
- State machines

Can be used without a login, but personal logins are free.

Tutorial at https://www.cs.cmu.edu/~dst/Calypso/Curriculum

Calypso Demo



What can I do now to prepare to teach AI?

- Explore the many resources at AI4K12.org.
  - Videos
  - Books
  - Demonstration software
  - Curriculum materials
- Join the AI4K12 mailing list to keep up with AI education news.
- Try Cloud Calypso at https://calypso-robotics.com
- Keep an eye out for an exciting new robot (VEX AIM) coming soon for K-12.

Join Us in Growing the Community of K-12 AI Educators and Resource Developers

Visit us:

https://AI4K12.org

Join the mailing list:

https://aaai.org/Organization/mailing-lists.php

Questions?