AI FOR GOOD Summer Camp

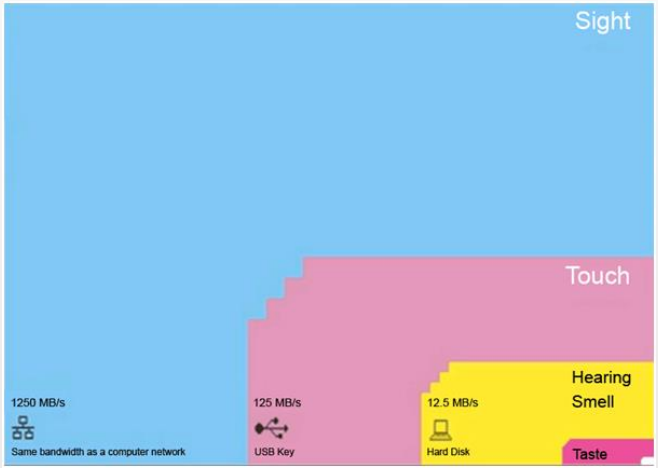
INDIANA UNIVERSITY
BLOOMINGTON

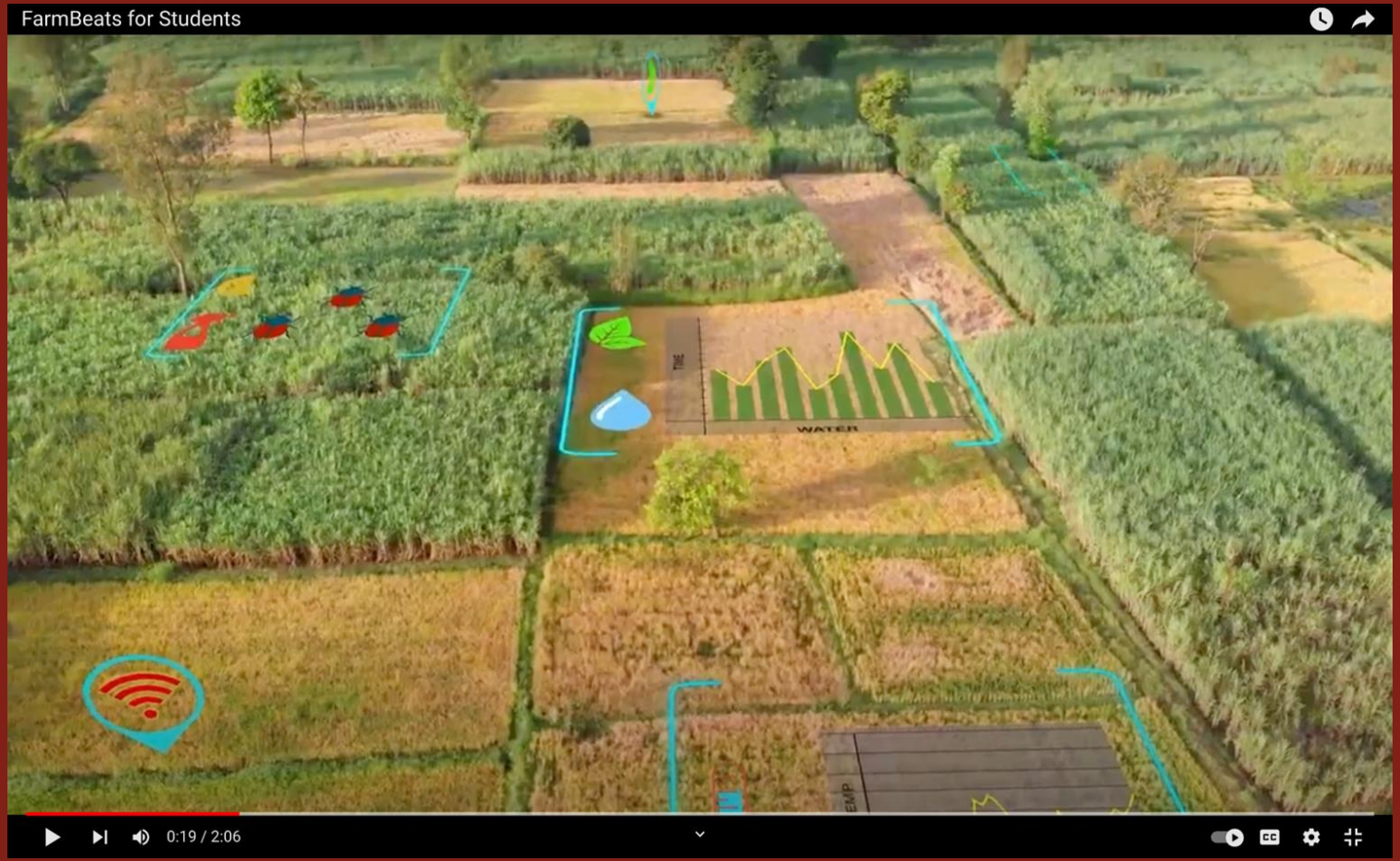
Day 4: Computer Vision

https://bit.ly/D4links

Main Ideas

- Computer Understanding needs to use numbers
- Computer Understanding is built through a variety of sensors
    - Computer Vision is the most common which uses pixels, edge detection, feature extraction, and neural networks
    - Other sensors include sound, touch, infrared, etc. (lots of options here)
    - ALL these use numbers to convey differences/understanding of the situation/object




FarmBeats for Students
WATER
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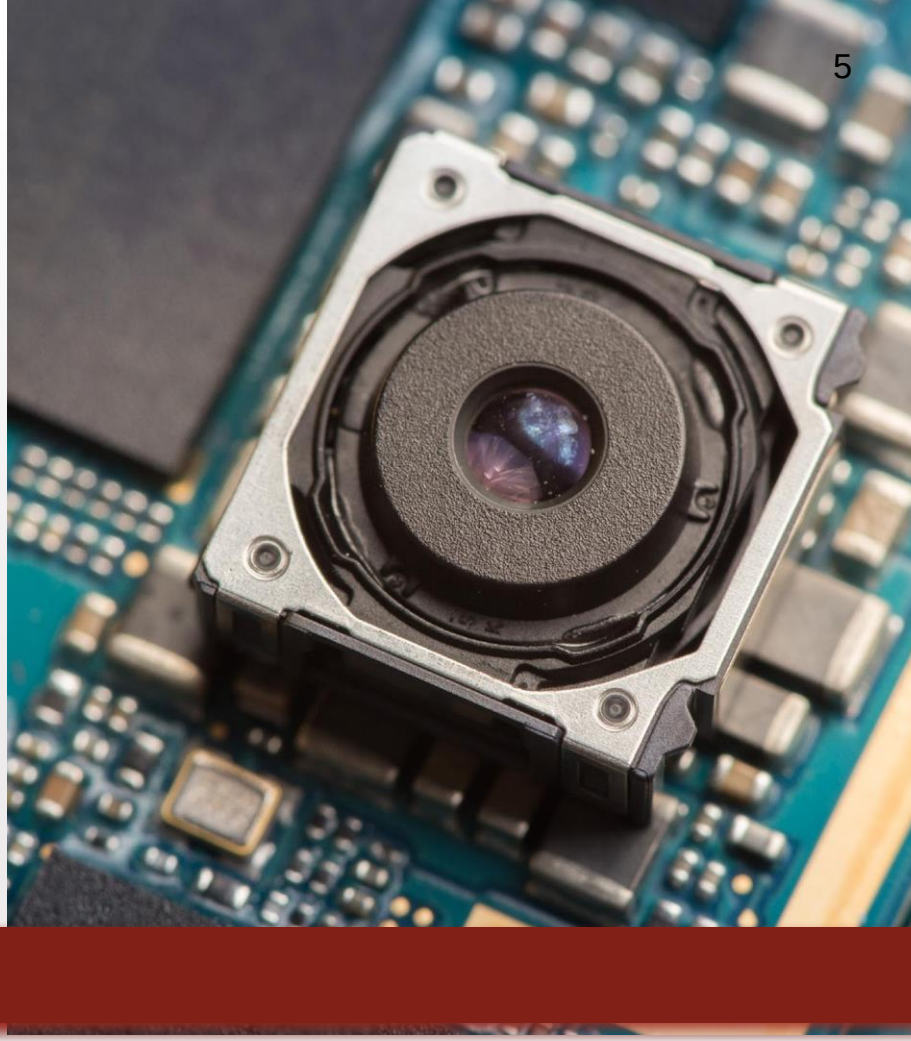
What is Computer Vision?

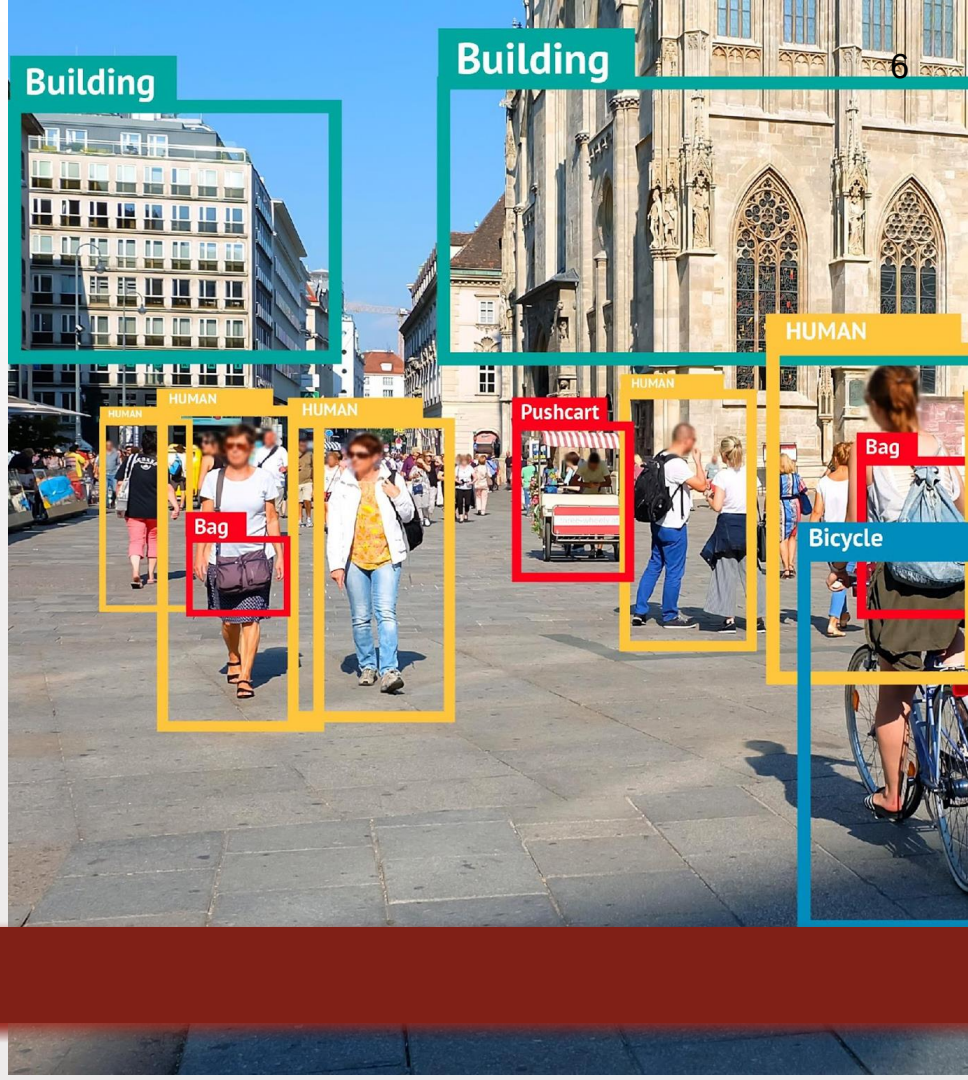
It is used to know what an image contains.

The goal of CV is to understand the content of digital images by extracting **useful/meaningful information** from the image.



What is useful/meaningful information?

CV might be used to classify, identify, verify, detect, and/or recognize objects in an image.



Where is Computer Vision used?

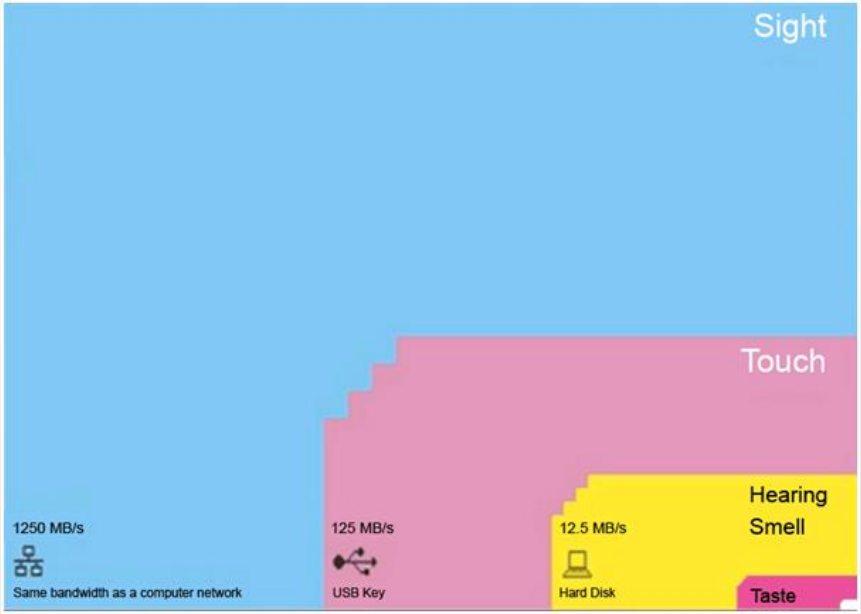
- Optical character recognition (OCR)
- Machine inspection
- Retail (e.g., automated checkouts)
- Medical imaging

- Automotive safety
- Motion capture (e.g., merging CGI with live actors in movies)
- Surveillance
- Biometrics (e.g., fingerprint and facial recognition)

Understanding images is not trivial

Images contain a lot of data!

The problem for computers is that data is not easily transformed into something they can understand. Computers don't see colors and shapes.



The problem of understanding images

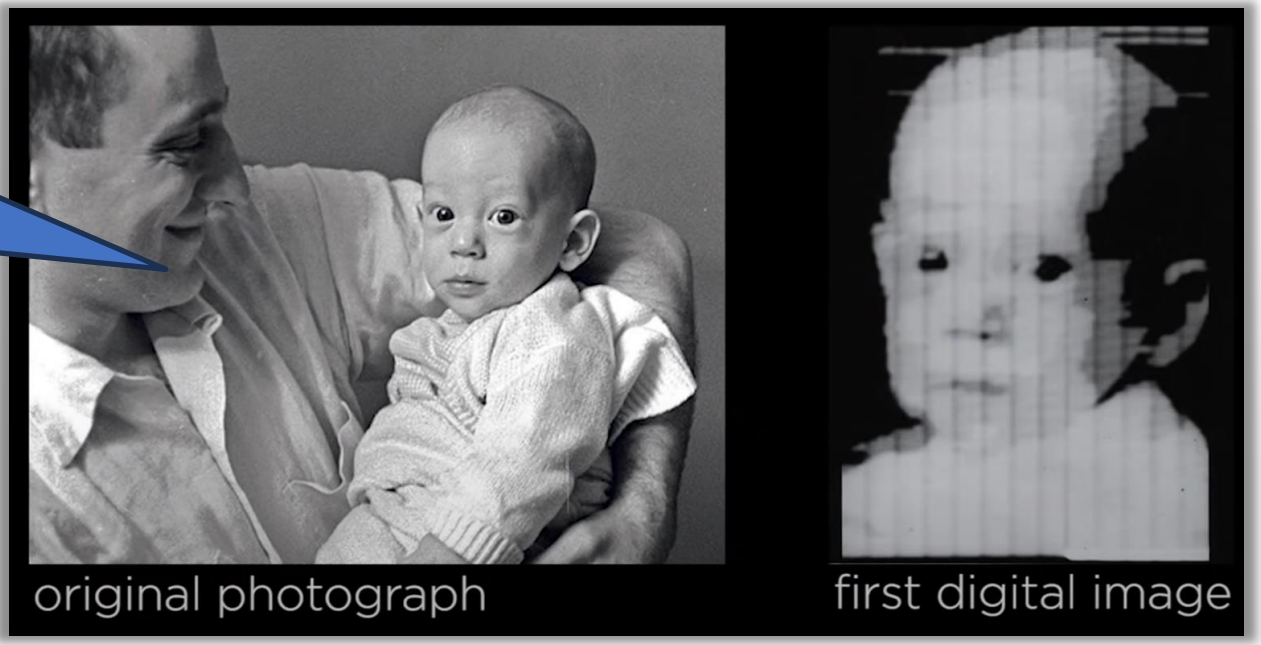
To address the problem of a computer extracting meaningful information from an image, the problem was decomposed into smaller more manageable problems:

- Pixel/Color Identification
- Edge Detection
- Shape Detection

Pixel/Color Identification

What is a Digital Picture made up of?

What would happen if computers could look at pictures? - Russell Kirsch

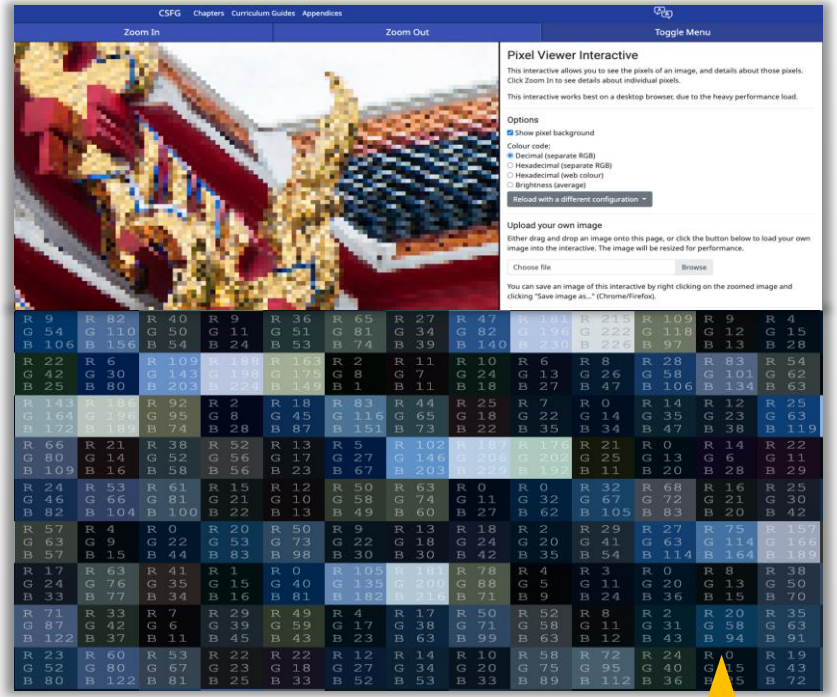


Check out your Pixels!

1. Open the camera app
2. Take a picture of yourself with the Camera program
   - Normal facial expressions
   - Just your face/hair/neck
3. Copy the photo to the desktop
   - Look for … (open folder)
   - Click and drag your photo to the desktop (making it easier to find)

Check out your Pixels!

1. Take a picture of yourself with the Camera program
   - Look for …
2. Upload the photo to the **Pixel activity program**
3. Zoom in on your pictures
4. What do you see?
   - Each pixel has different RGB numbers
5. Explore the colors of your face, hair, and eyes with RGB numbers (write some of these down)



L1

Check out your Pixels!

1. Take a picture of yourself with the Camera program
   - Look for …
2. Upload the photo to the **Pixel activity program**
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   - Each pixel has different RGB numbers
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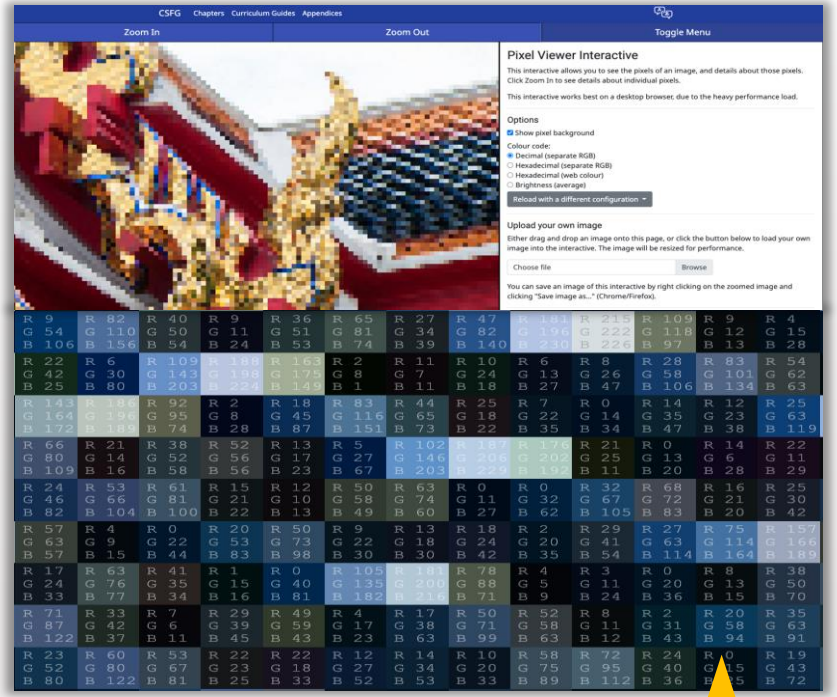
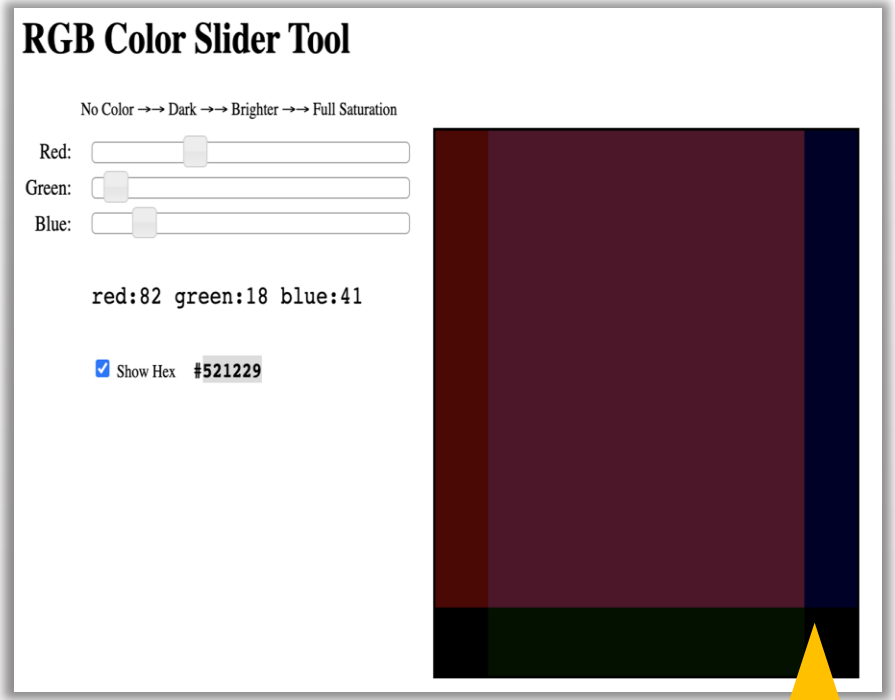


L1

RGB Slider Tool

1. Visit RGB slider tools
2. Recreate the RGB numbers from your photos into the RGB slider tools and combine the different colors
3. What happens if you change one of the sliders?

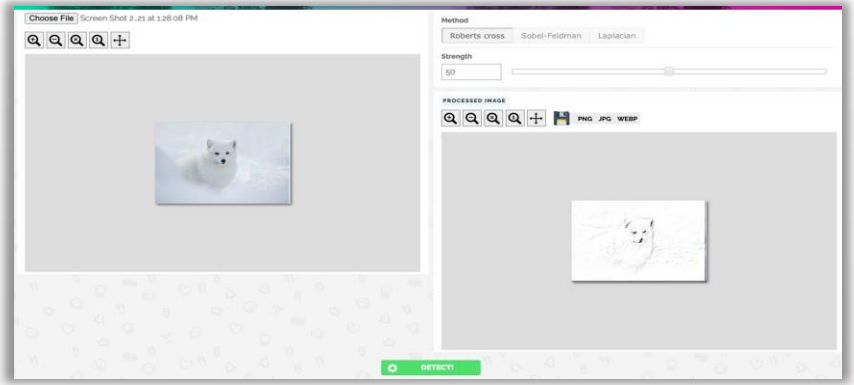


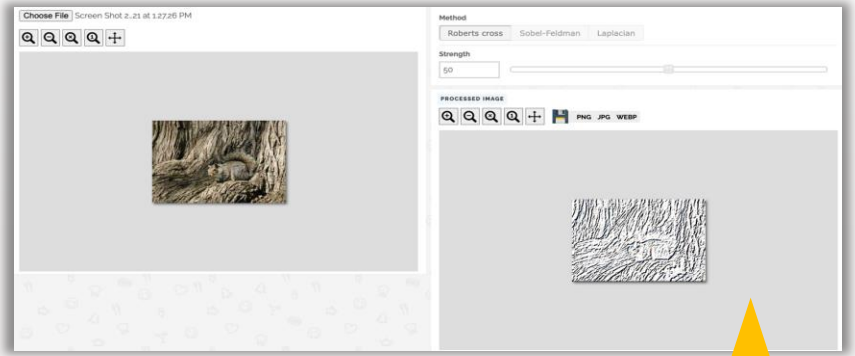
L2

Edge Detection

Edge Detection

1. Take the pictures you took from your laptop camera.
2. Upload the photos to Edge detection program.
3. Detect the edges of your faces .
4. Let's compare these with your table partners' photos
   - What's similar?
   - What's different?





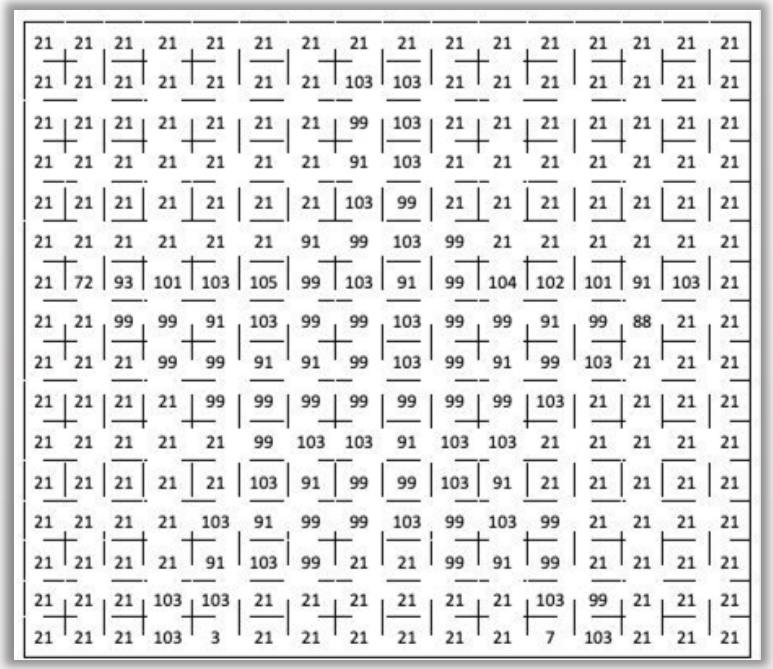
L4

Edge Detection – Unplugged

Here are the pixel values for a gray-scale image.

What do you think is in the image?

Follow the instructions on the worksheet to check your prediction.



Edge Detection - Unplugged

Image A - Star

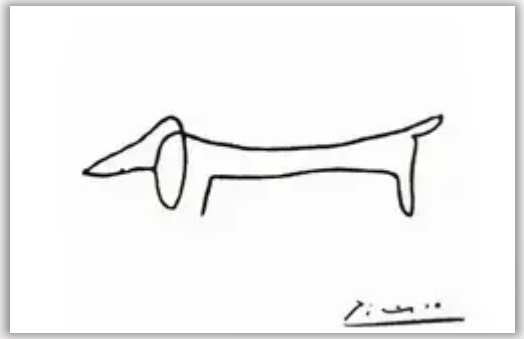
Image B - Moon

Image C - Cat

Bonus Image - Smiley Face

Shape Detection

What do you see?



Edge Detection → Shapes

Guess the Animal Shadow

Edge Detection → Shapes

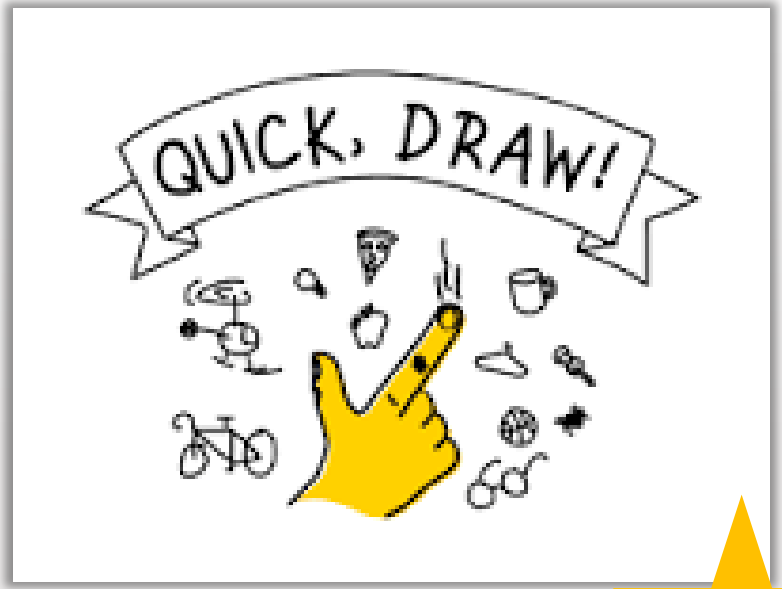
AI uses edge detection to find patterns in the form of shapes

- Visit https://bit.ly/E2S
- Work with a group on the slides assigned to your group
  - Identify the shapes on the animal pictured

L5

Demonstration: Edge Detection → Shapes

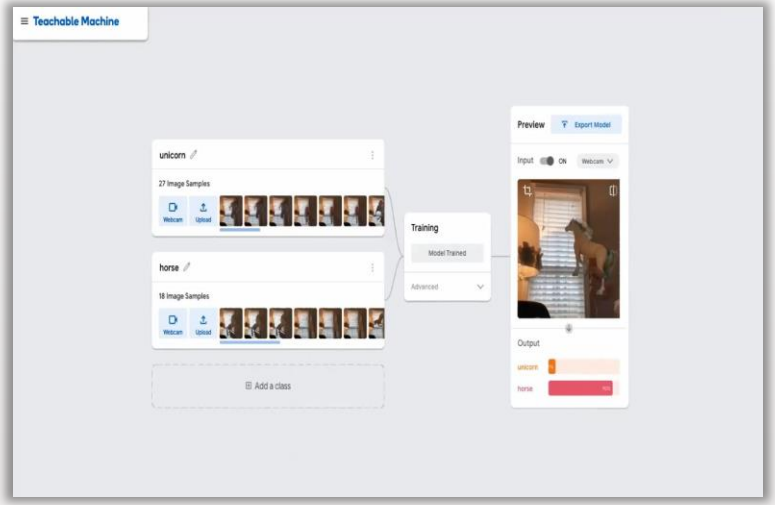
Google Quick Draw



Object Detection

Demonstration: Circle or Square

1. Visit https://teachablemachine.withgoogle.com/
2. Train the data set
   - Circles
   - Squares

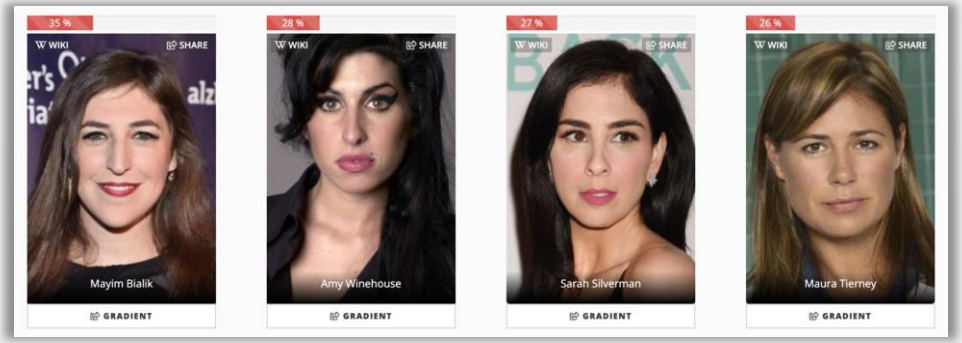


Me or a Celebrity?

What about celebrities?

Who do you look like?

https://starbyface.com/

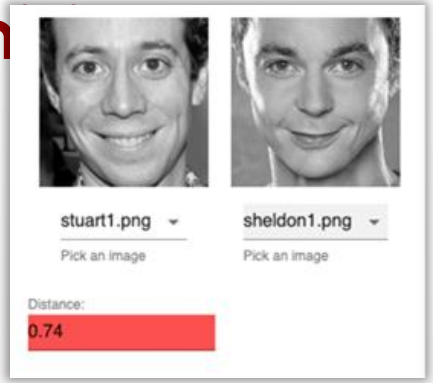


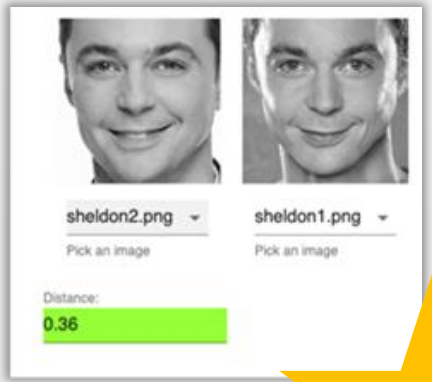
L9

How does the program find close matches?

Facial recognition = Pattern recogn

- Visit https://justadudewhohacks.github.io/face-api.js/bbt_face_similarity
- Choose two images to compare. Images with the same name before a number are different pictures of the same character.
- Check out the “distance” number and whether it is green or red. Green means the program thought it was the same person, red means it didn’t.
- Understand the distance between two images is really just math measuring the distance between the pictures





L10

Day 4: Sensors

How do we understand the world around us?

Our Five Senses

We understand the world around us by...

Seeing

Touching

Hearing

Smelling

Tasting

Animal Senses

Some animals have other sense as well...

Electroreception
Platypus

Echolocation
Bats

Infrared Radiation
Snakes

Sensing **Thinking** **Understanding**

Make a decision
Solve a problem
Learning

Input

Storage and Processing

Output

Make a decision
Solve a problem
Learning

How do computers understand the world?

Input

Storage and Processing

Output

?

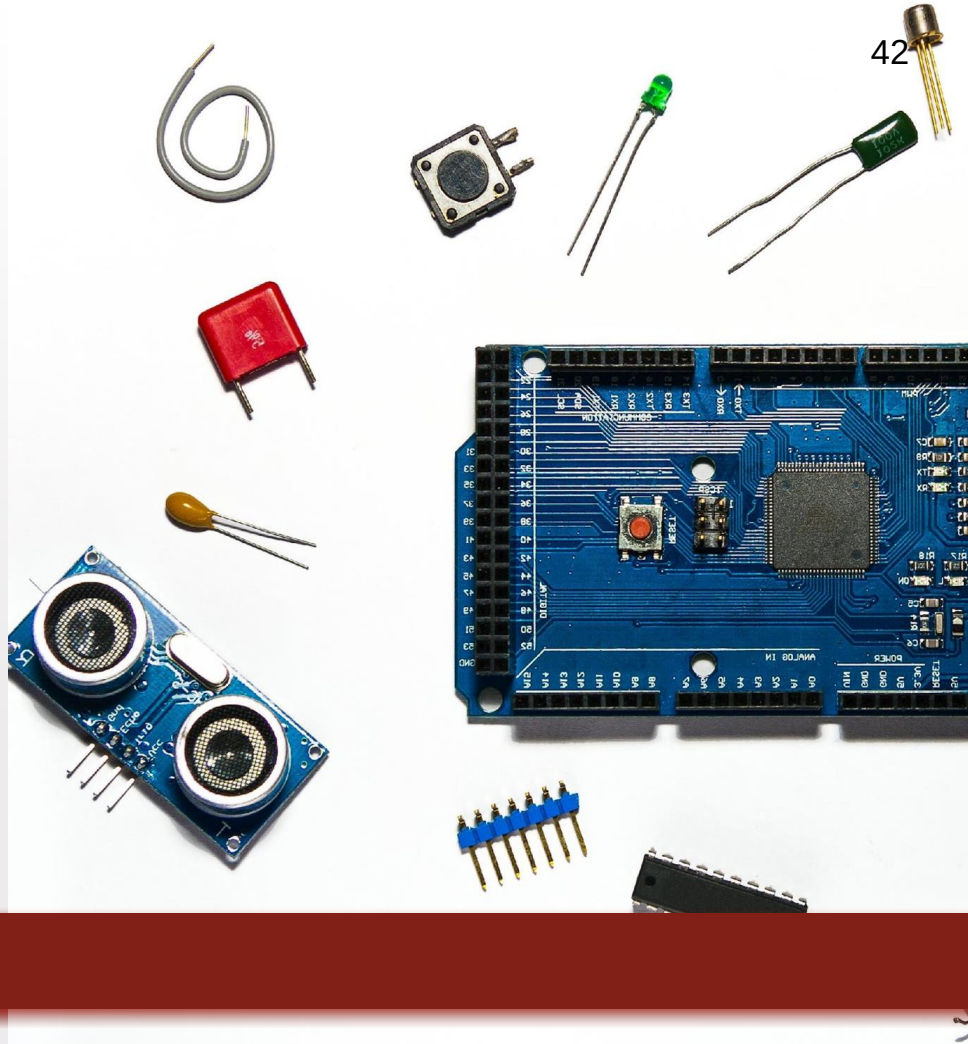
Make a decision
Solve a problem
Learning

Input	Storage and Processing	Output
SENSORS		Make a decision Solve a problem Learning

What is a sensor?

A sensor is...

... a device which **detects or measures** a physical property and records, indicates, or otherwise responds to it. (*Oxford English Dictionary*)



What sensors do you use?

Think

Individually:

- What is your favorite phone app?
- Do you know if it uses any sensors?
  - If you are unsure, use the app stores or simply Google to find out if it uses sensors.
  - If it doesn't, try to find an app that does.
- What sensors does it use? What do the sensors do?

Pair

In Pairs:

- Share with each other a brief description of the app, what sensors it uses, and what those sensors do.
- Compare the sensors used in your apps. What is the same, what is different?

Share

Share to the Class:

- What sensors you identified and what they do.

Where else might you use or find sensors in your daily life?

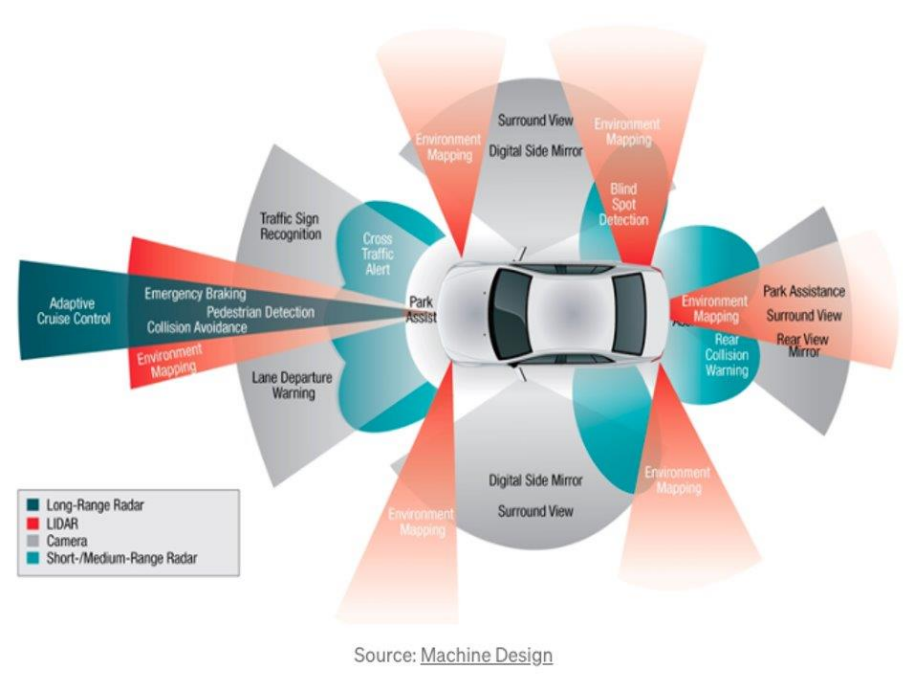
Sensors found in smart phones

- Accelerometer
- Gyroscope
- Magnetometer
- GPS
- Biometric Sensors
- Barometer
- Proximity Sensor
- Ambient Light Sensor
- Microphone
- Camera(s)

Sensors at home

- Motion Sensors
- Temperature Sensors
- Light Sensors
- Humidity Sensors
- Smoke/Carbon Monoxide detectors

Sensors in self-driving cars



Source: Machine Design

Internet of Things (IoT)

...a network of devices and sensors, that are connected to the internet. These devices and sensors can collect and share data with each other.

Internet of Things (IoT)

Smart Speaker - Google Home

Thermostat

Livestock Collar & Ear Tags

Smart Speaker - Amazon Echo

Security/Surveillance Cameras

Apple Watch

Fitness Tracker - Fitbit

Internet of Things (IoT)

Benefits:

- Energy-efficient homes
- Improved healthcare (remote patient monitoring)
- Enhanced transportation systems (smart traffic lights)

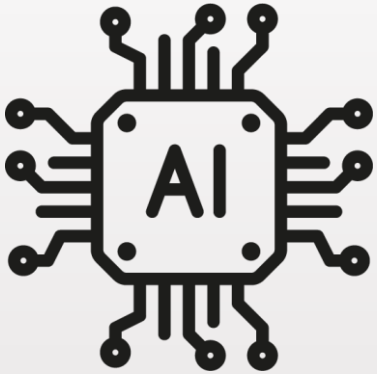
What else?

Concerns:

- Privacy
- Security
- Informed choices

What else?

How do AI and sensors work together?

Input	Storage and Processing	Output
SENSORS		Make a decision Solve a problem Learning

Activity: Sorting Bells

Sorting Bells

We have found a box of hand bells. Each bell rings a different octave from middle C to high C.

C, D, E, F, G, A, B, C

Our goal is to put them in that order.

Sorting Bells by Ear

First, let's try it by ear.

Sorting Bells by Sensors

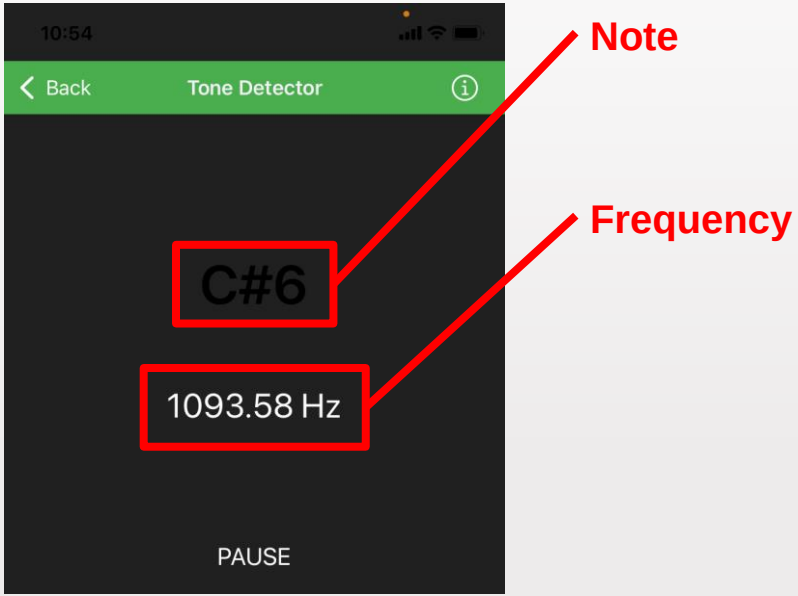
Now let's try to use a microphone and the computers sensors to measure the difference in tone and sort the bells.

We will use the Physics Toolbox Suite on an iPad. In the suite we will use the Tone Detector.

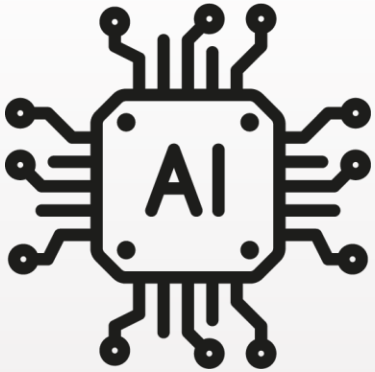
Sorting Bells by Sensors

The Tone Detector gives a readout of both the note and frequency of a sound.

Which do you think will be easier for a computer to use to sort or identify sounds?



Sorting Bells by Sensors + AI



Can we do better than just sensors?

What about AI?

With an AI model that has been trained on all the different bells can we more accurately sort them?

Activity: Physics Toolbox Suite

Sensor Exploration

Let's check out the **Physics Toolbox Suite** (iPad)!

Explore the sensors and consider these questions for each sensor:

a. What is the name of the sensor?

b. What is it detecting? How is it reporting/displaying the sensor readings?

c. How could it be used in a system to solve a problem or meet a goal?

Suggested Sensors:

- Gyroscope
- Sound Meter
- Proximeter
- Barometer

Gyroscope - Measures rotation of device (e.g., phone), one application is to detect when the device orientation has changed and rotate the screen accordingly.

Sound Meter - Measures how loud a sound is. One application of it is to warn the device user when a sound is too loud and may damage their ear drums.

Barometer - Measures air pressure, used to detect changes in weather and your altitude.

Proximity Sensor - Using a beam of light, measures how close something is to the surface of the device (e.g., phone). It is used to detect when a phone is put up to a person's ear so the screen will shut off.

Activity: Sensors for Health

What sensors do we need to help the computer understand health?

Movement is tied to our health. Physical movement and exercise can improve physical and mental health. A lack of movement or a decrease in movement can also be an indicator of a health problem. Monitoring movements is a feature of many wearables. Wearables often combine the inputs of multiple sensors to better understand how the wearer is moving.

What sensors might a wearable use to detect movements?

Sensors to detect movement

Gyroscope – to determine if the wearer is standing, sitting, or laying down.

Accelerometer – to determine how fast and in what direction the wearer is moving

GPS – to determine the wearer’s location on earth

Magnetometer – to determine wearers' orientation to earth's magnetic field.

Barometer – to determine wearer’s altitude (how many flights of stairs they have traveled)

Let's build some motion sensors

Step Counter

Count the number of steps the wearer takes.

Direction Sensor

Detect the direction the wearer is pointing (e.g., compass)

How can AI improve our motion sensors?

- AI models provide advanced pattern recognition that can distinguish between different types of movements. This helps in accurately detecting steps and filtering out false positives or irrelevant movements that may be registered as steps by simpler algorithms.
- AI can filter out the “noise” to identify what really should count as a step.

What are some other ways that AI and sensors can be used for healthcare?

What are some ethical considerations with using for healthcare?

Ethical Issues…

Ethical issues…

Privacy

- How China Is Using Artificial Intelligence in Classrooms | WSJ

Bias

- Show the article Dark skin may make a difference
- Show the Video “Coded Bias”

Ethical issues...

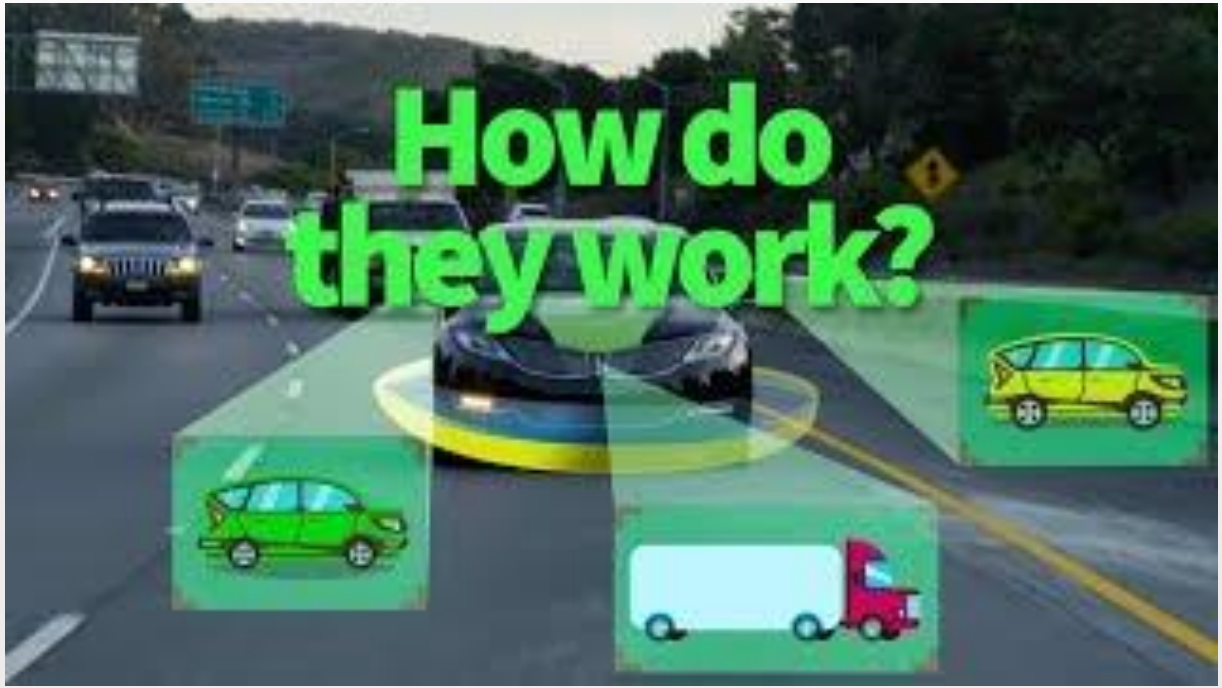
Discussion

- What do you think of using facial recognition in the education?
- Who should control the data? What process would be necessary to protect an individual's privacy?
- What should be done to avoid the bias of AI?

Mini-project 3:
Identifying & addressing challenges in auto-driving

Mini-project: Challenges in Auto-driving

- How AI powers automatic driving?



Mini-project: Challenges in Auto-driving

Group discussion: What challenges do you see in automatic driving?

- **Think about…**
  - What are some potential difficulties or obstacles that autonomous vehicles might face while driving on the roads?
  - What are the main concerns or issues that arise when considering the implementation of automatic driving technology?

Mini-project: Challenges in Auto-driving

Possible challenges to be addressed:

- Navigating complex intersections with multiple lanes and signals
- Adapting to weather conditions
- Handling unexpected obstacles, such as construction zones or debris on the road
- Merging into traffic and changing lanes safely
- Making wise decisions in high-traffic areas or congested roads
- Dealing with unpredictable behavior of other drivers on the road
- Understanding and interpreting road signs and traffic signals accurately

Webpage link

https://bit.ly/iuaigood

Mini-project: Challenges in Auto-driving

Time to fill in your " Project design template"!

- Step 1 - **"Identify a Challenge to Address": Identify a challenge you think most important to address, from the given pool or on your own idea.**
  - Example: *"Recognizing and responding to pedestrians crossing the road"*

Mini-project: Challenges in Auto-driving

AI algorithms in auto-driving: **smart computer programs** that can process information, make decisions, and control vehicles without human intervention.

- Advanced techniques to analyze data from sensors, identify objects on the road, plan safe routes, and navigate through traffic, making driving safer and more efficient.
- These algorithms usually involve techniques with **computer vision**

Mini-project: Challenges in Auto-driving

Common AI algorithms in auto-driving:

- Object Detection: Teaching computers to identify and locate objects in the environment, such as other vehicles, pedestrians, bicycles, and traffic signs
- Lane Detection: Developing algorithms to detect and track lane markings on the road, helping the vehicle stay in its lane
- Traffic Prediction: Using historical and real-time data to estimate traffic conditions and optimize route planning
- Behavior Prediction: Analyzing the behavior of other vehicles to anticipate their movements and make informed decisions
- Emotion Recognition: Identifying the emotional state of the driver or passengers to provide a personalized driving experience
- .....

Mini-project: Challenges in Auto-driving

Time to fill in your " Project design template"!

- Step 2a - **"Select the AI algorithm": Identify & Describe the AI algorithm as the solution to address the identified challenge above**
  - Example: *"1) Object Detection: Teaching computers to identify and locate pedestrians, bicycles, and other vehicles in the environment; 2) Behavior detection: computers predict objects' likely movements"*

Mini-project: Challenges in Auto-driving

Example applications of computer vision in auto-driving:

- Image Processing: Applying filters, edge detection, and color analysis to images captured by cameras to enhance visibility and extract useful information
- Feature Extraction: Identifying key visual features from images to distinguish objects, recognize patterns, and understand the surrounding environment
- Segmentation: Dividing an image into meaningful regions or objects for better object detection and analysis
- Optical Flow: Estimating the motion of objects in consecutive frames to track their movement and predict future positions
- Depth Estimation: Inferring the distance of objects from the camera using stereo vision or other depth sensing techniques

Mini-project: Challenges in Auto-driving

Time to fill in your " Project design template"!

- Step 2b - **"Select the AI algorithm": Identify the application(s) of computer vision in your solution**
  - Example: "*Computers analyze camera images to understand the environment. They recognize unique visual features of pedestrians, track their movement, and predict their intentions. This information helps the computer adjust the car's speed or direction to ensure pedestrian safety.*"

Mini-project: Challenges in Auto-driving

Now, drawing time!

- Use graphics (mind map; flow chart; table; etc.) to organize your ideas on a paper.

- Remember to demonstrate **how the identified applications of computer vision work together** to address the challenge.