0. ORGANIZATION
1. DIGITAL TECHNOLOGIES
2. SENSORS
3. ACTUATORS
4. COMPUTER VISION
5. GENERATIVE AI
6. NATURAL LANGUAGE PROCESSING
7. USER INTERFACES
8. CLOUD SERVICES
9. DATABASES

The slides are meant as visual support for the lecture.
They are neither a documentation nor a script.

Please do not print the slides.

Comments and feedback at n.meseth@hs-osnabrueck.de

ORGANIZATION

ILIAS
Microsoft Teams

sessions

group work

examination

working environment

visual studio code
python
tinkerforge
git

DIGITAL TECHNOLOGIES

a model for solving problems

cyber physical systems

artificial intelligence

software prototyping

cyber physical systems

sensors

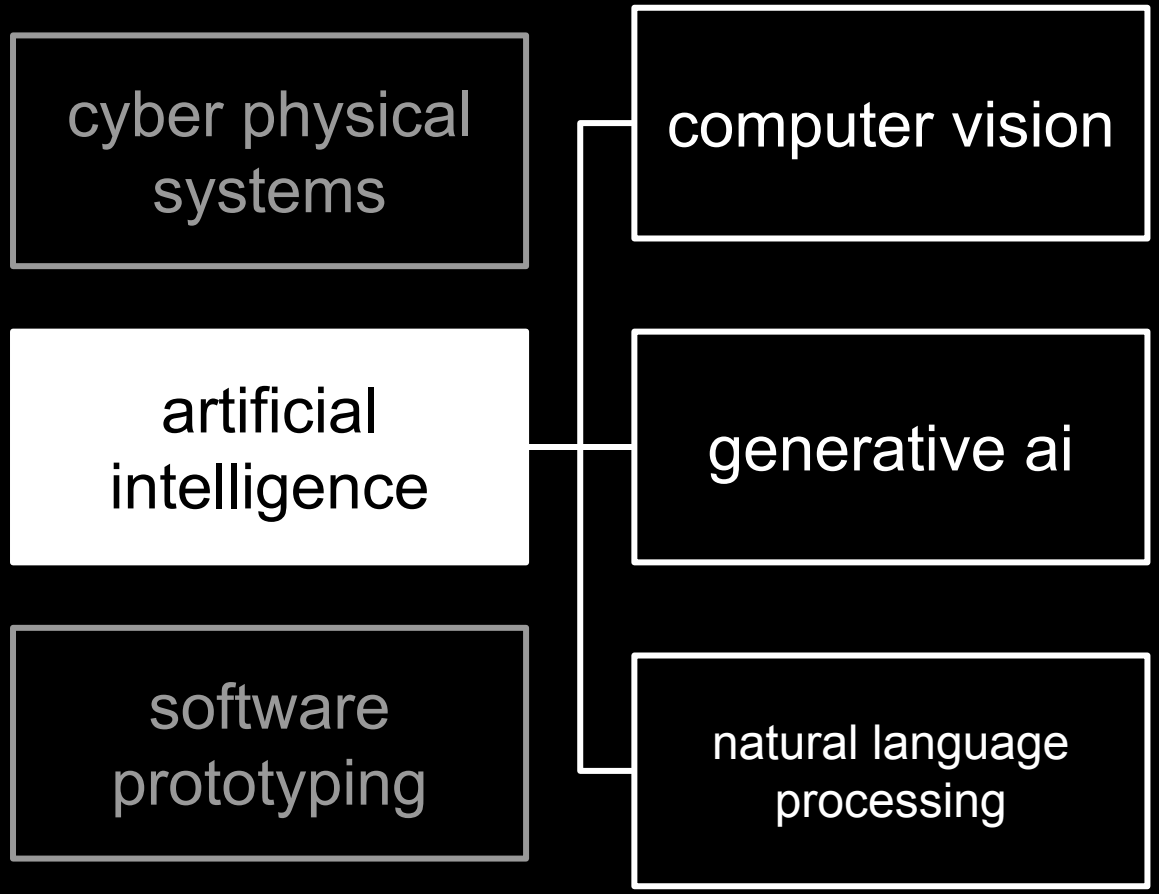
actuators

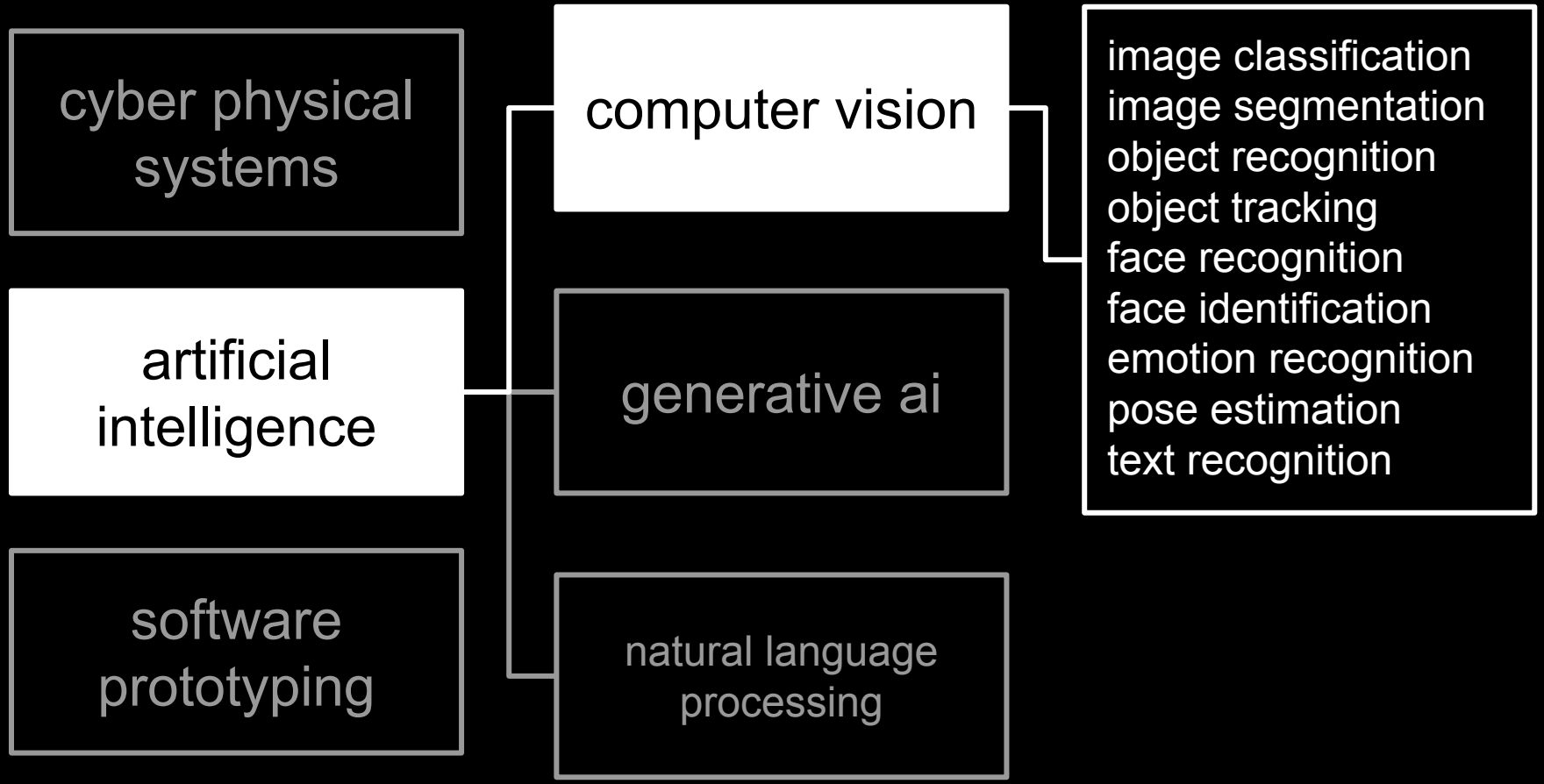
artificial intelligence

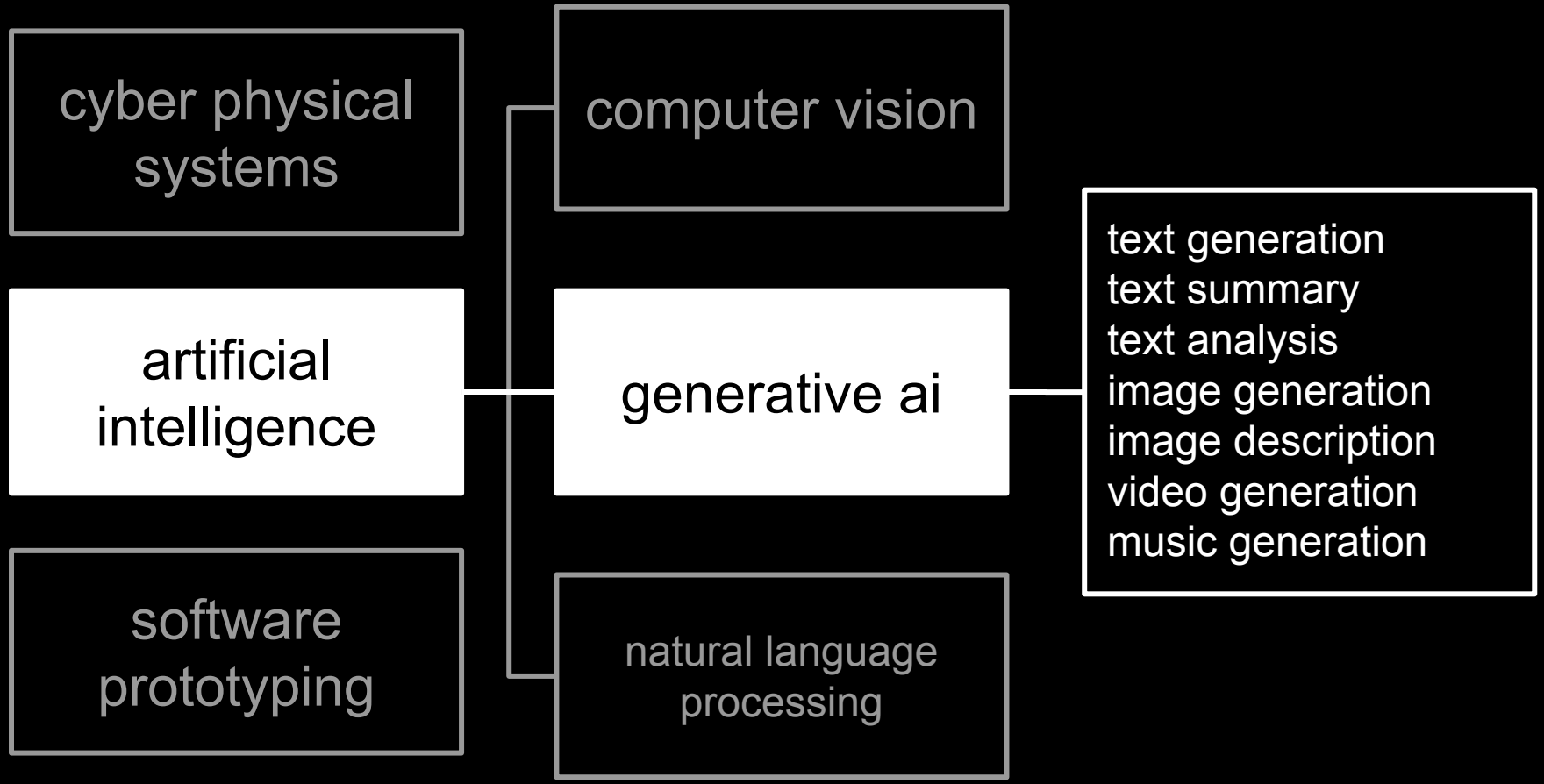
software prototyping

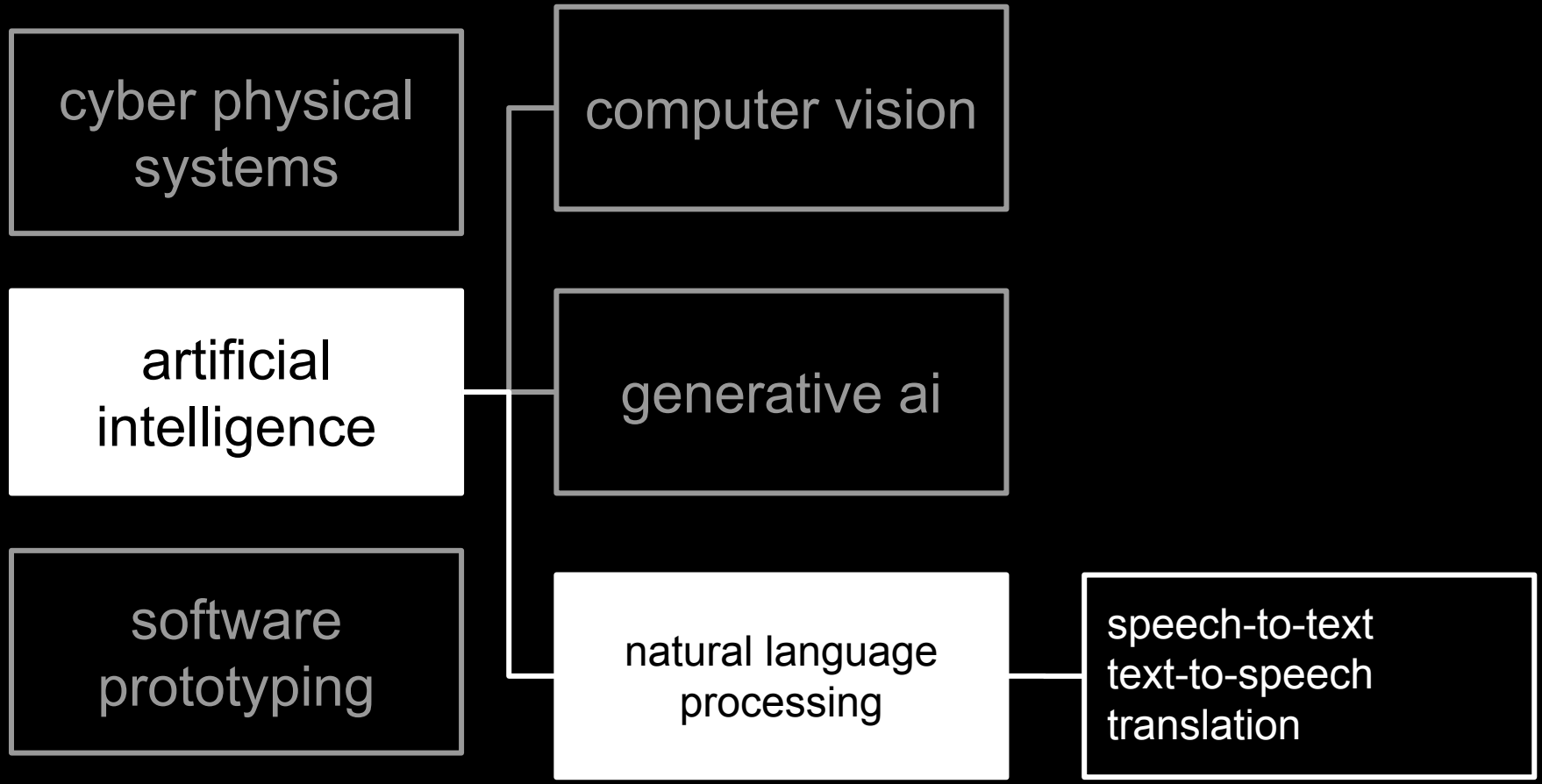
temperature
humidity
co2
uv light
ambient light
sound pressure
thermal image
camera
...

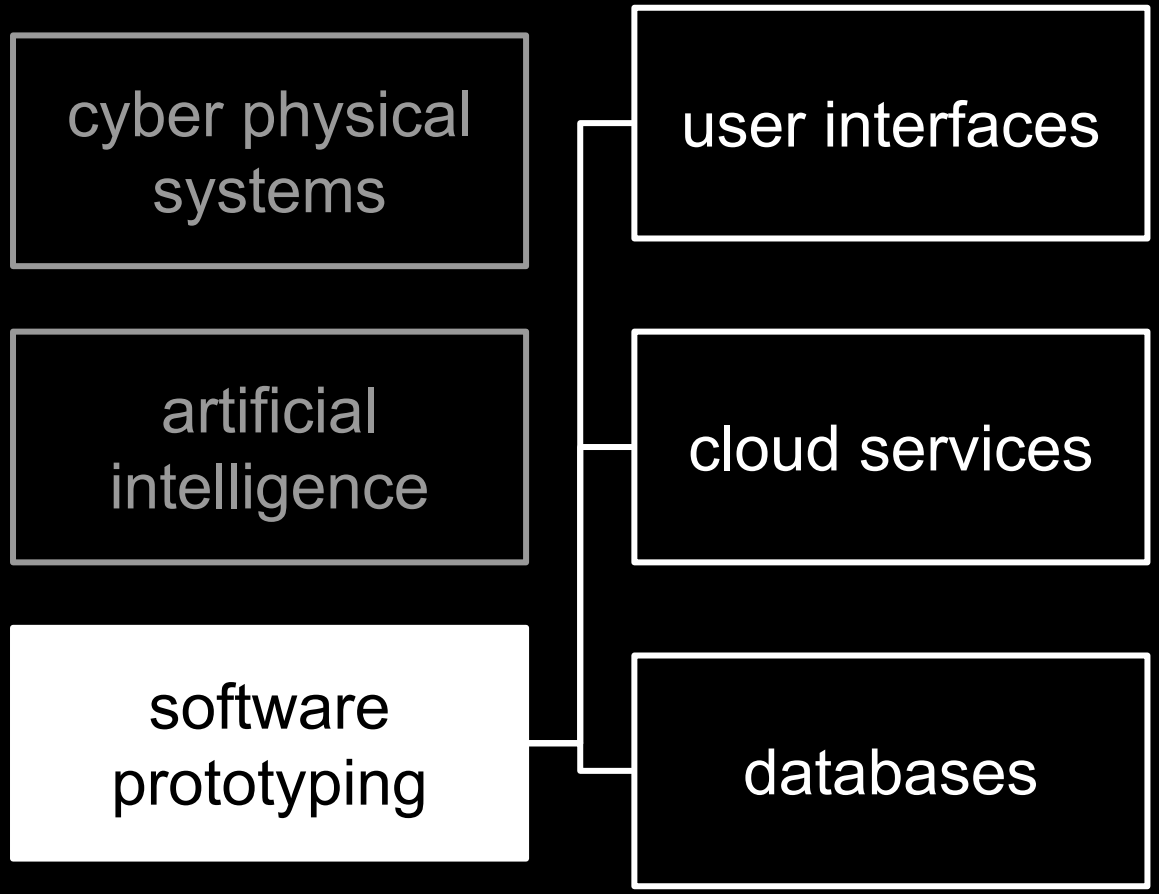
led
speaker
display
motor
…


cyber physical systems
artificial intelligence
software prototyping
computer vision
generative ai
natural language processing


cyber physical systems
artificial intelligence
software prototyping
computer vision
generative ai
natural language processing
image classification
image segmentation
object recognition
object tracking
face recognition
face identification
emotion recognition
pose estimation
text recognition


cyber physical systems
artificial intelligence
software prototyping
computer vision
generative ai
natural language processing
text generation
text summary
text analysis
image generation
image description
video generation
music generation


cyber physical systems
artificial intelligence
software prototyping
computer vision
generative ai
natural language processing
speech-to-text
text-to-speech
translation


cyber physical systems
artificial intelligence
software prototyping
user interfaces
cloud services
databases

introductory example

visual studio code
programs
python

LEDs

large language models

speech-to-text

user interface

SENSORS

temperature / humidity
rgb led button
camera
thermal imaging camera
microphone
keyboard

temperature / humidity

```
th = BrickletHumidityV2(UID, ipcon)...
```

```
th.get_humidity()
th.get_temperature()
```

```
th.register_callback(th.CALLBACK_HUMIDITY, cb_humidity)
th.register_callback(th.CALLBACK_TEMPERATURE, ...)
```

```
th.set_humidity_callback_configuration(250, False, "x", 0, 0)
th.set_temperature_callback_configuration(...)
```

rgb led button

```
btn = BrickletRGBLEDButton(UID, ipcon)...
```

```
btn.set_color(255, 0, 0)
```

```
btn.get_button_state()
```

```
btn.register_callback(...)
```

camera

OpenCV

```
import cv2
```

```
# Get video capture device (webcam)
webcam = cv2.VideoCapture(0)
```

```
# Read a frame
success, frame = webcam.read()
```

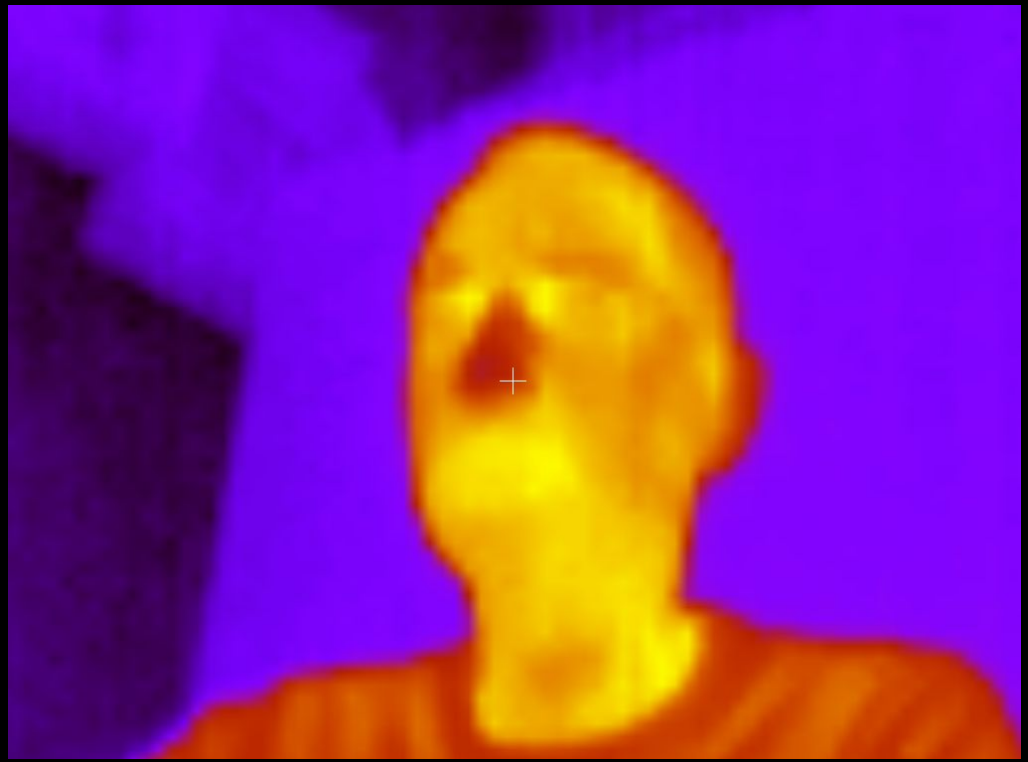
```
# Show the image from the frame
cv2.imshow("Webcam", frame)
```

```
# Save the frame as .png
cv2.imwrite("screenshot.png", frame)
```

thermal imaging camera

OpenCV

Tinkerforge



```
ti = BrickletThermalImaging(UID, ipcon)
ti.set_image_transfer_config(...)
img = ti.get_high_contrast_image()
```

```
ti.register_callback(...)
```

microphone

```
import pyaudio
```

```
# Define recording parameters
FORMAT = pyaudio.paInt16
CHANNELS = 1
RATE = 44100
CHUNK = 1024
```

```
# Get access to the microphone
audio = pyaudio.PyAudio()
```

```
# Start listening
stream = audio.open(...)
```

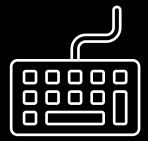
```
# Read a chunk of frames
stream.read(CHUNK)
```

```
# Stop and close stream
stream.stop_stream()
stream.close()
```

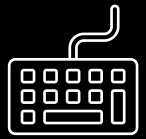
```
# Terminate access to microphone
audio.terminate()
```

keyboard

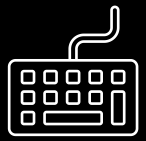
```
import keyboard
```



```
# Define a callback function for a key
def record_audio():
    print("Recording audio...")
```



```
# Add key listener
keyboard.add_hotkey("r", record_audio)
```



```
# Wait until a specific key was pressed
keyboard.wait("esc")
```

ACTUATORS

rgb led
OLED display
speaker

rgb led

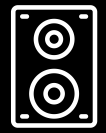
```
led = BrickletRGBLEDV2(UID, ipcon)
led.set_rgb_value(255, 0, 0)
```

OLED display

```
oled = BrickletOLED128x64V2(UID, ipcon)
oled.clear_display()
oled.write_line(0, 0, "Welcome!")
```

speaker

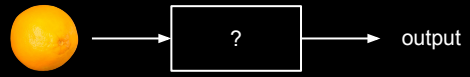
```
import simpleaudio as sa
```



```
# Create a wave object from .wav-file and play it
wav = sa.WaveObject.from_wave_file("sound.wav")
wav.play().wait_done()
```

COMPUTER VISION

BACK



finding oranges in images

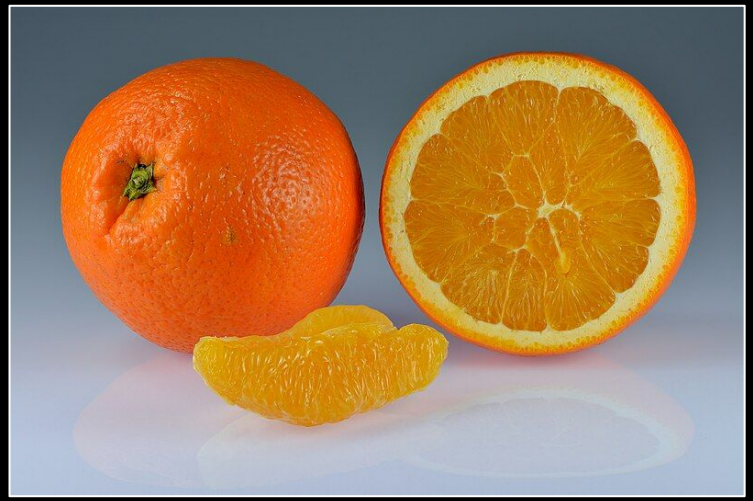


Image source: Wikimedia

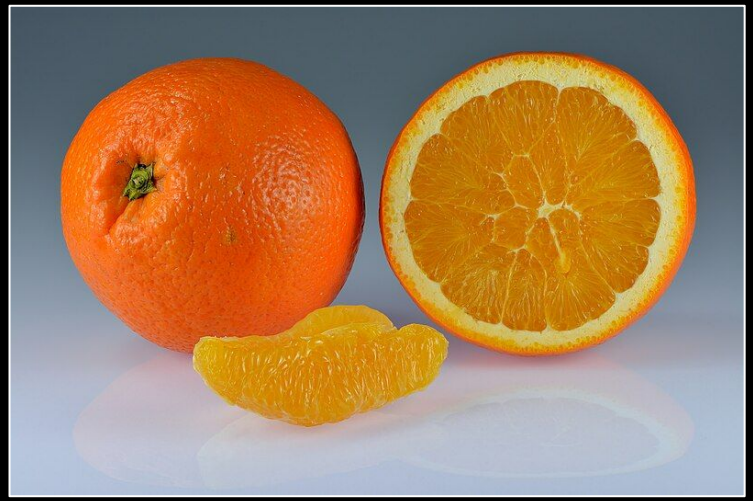


Image source: Wikimedia

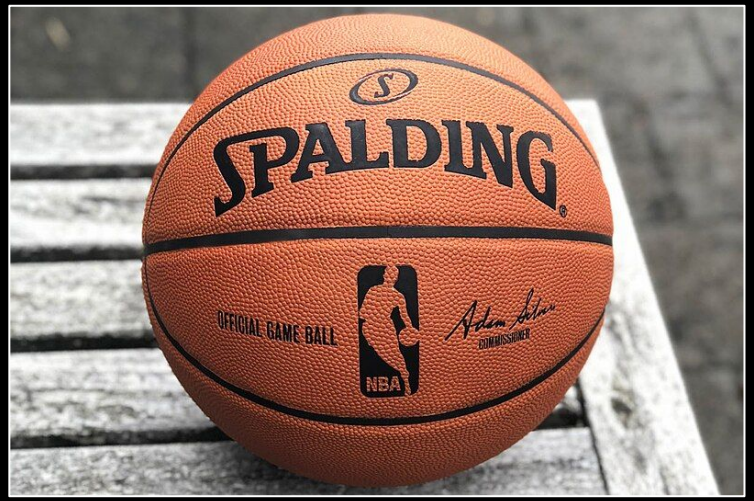
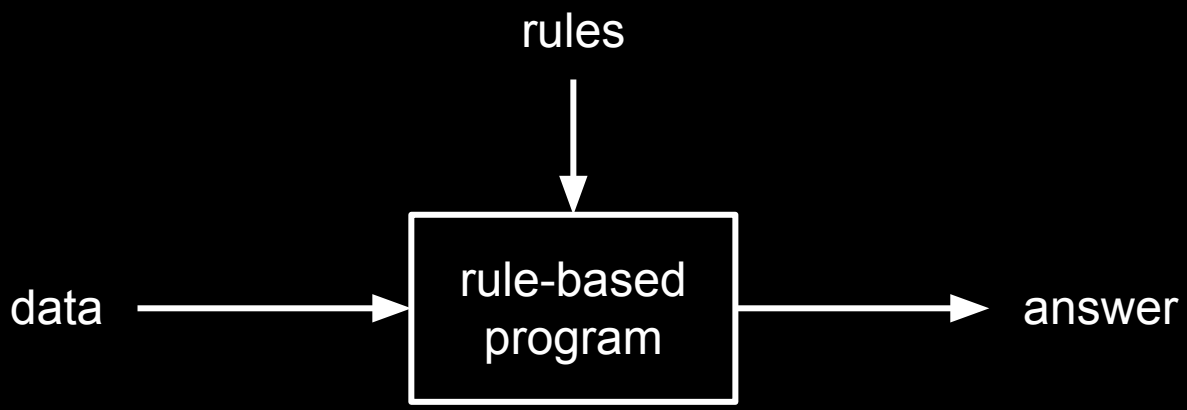
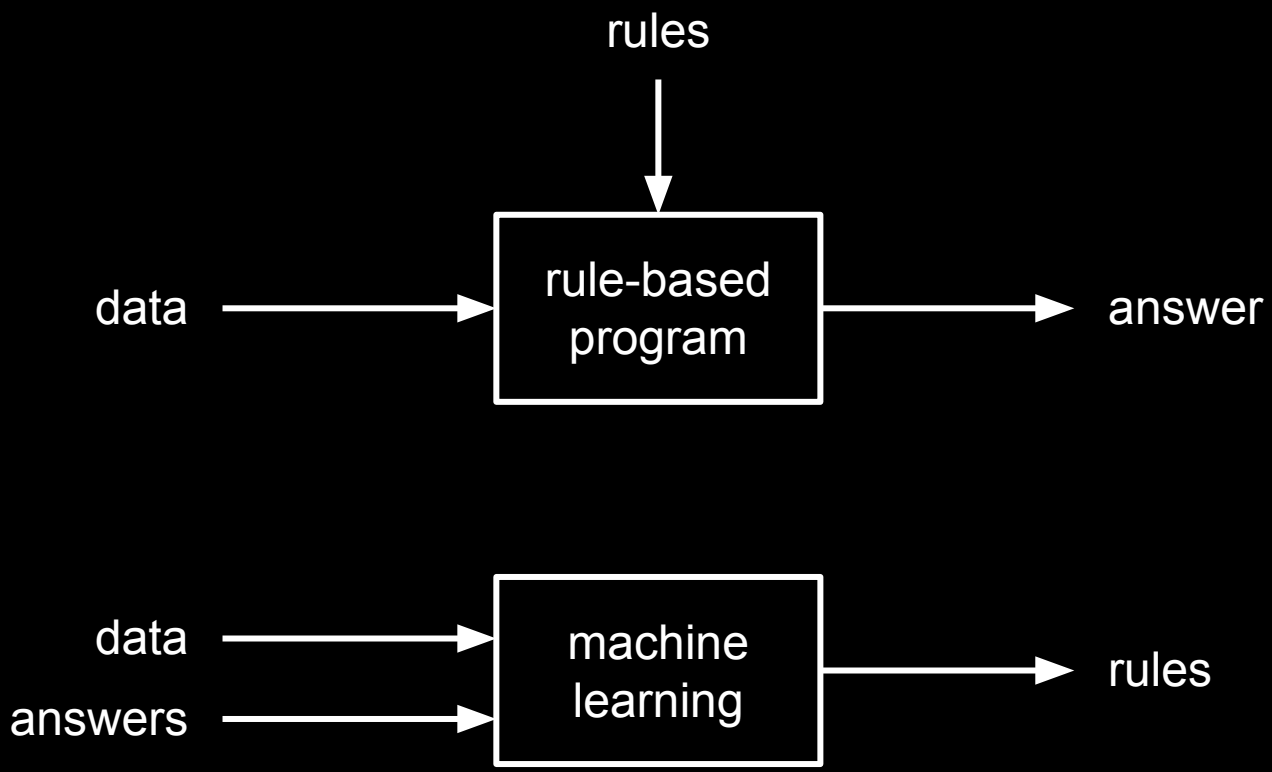


Image source: Wikimedia

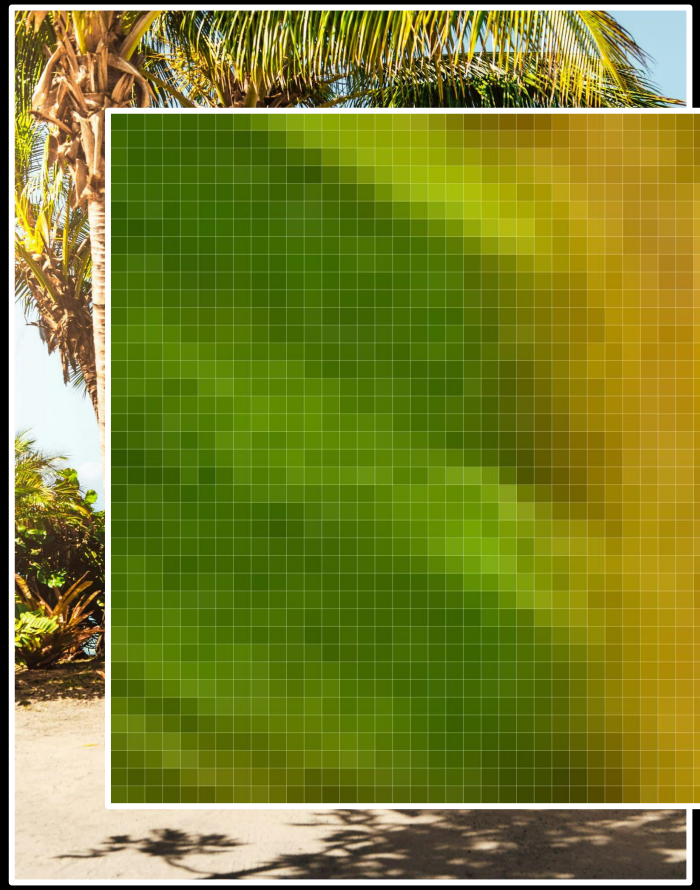
what set of rules can solve this?

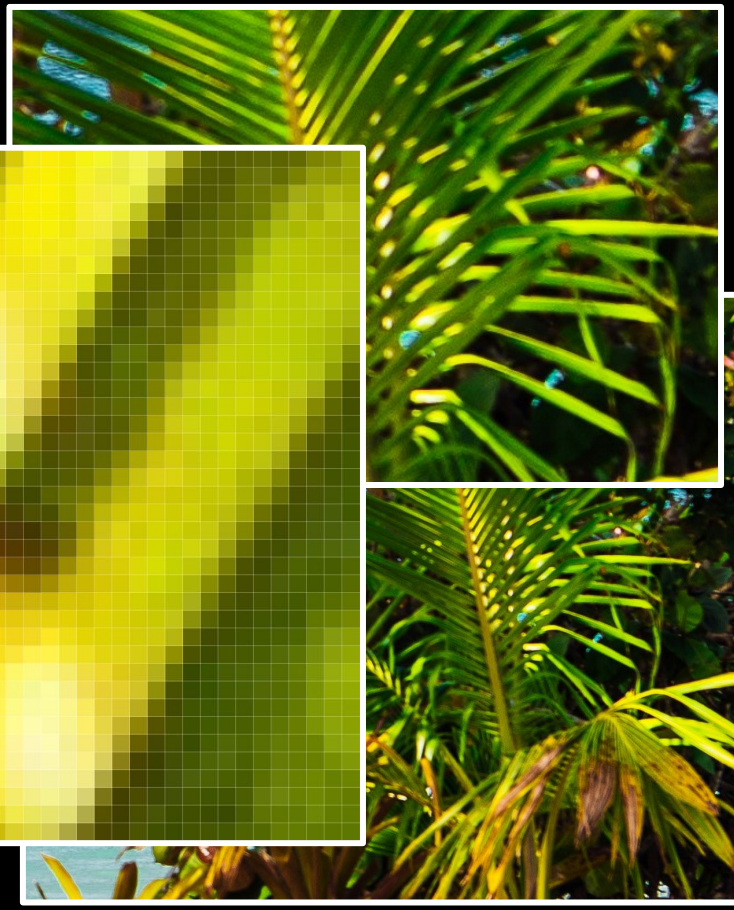
machine learning algorithms

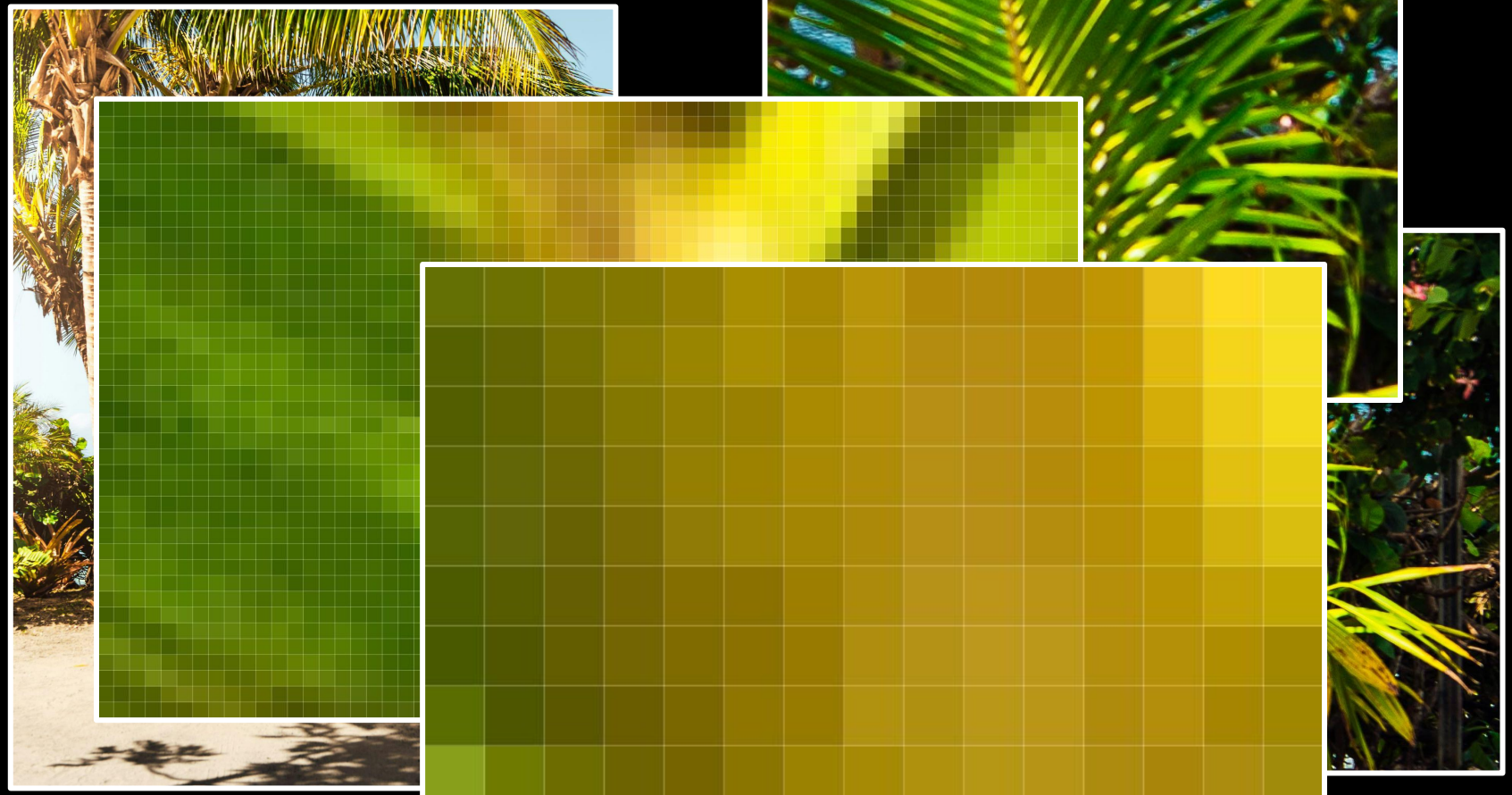

rules
data
rule-based
program
answer

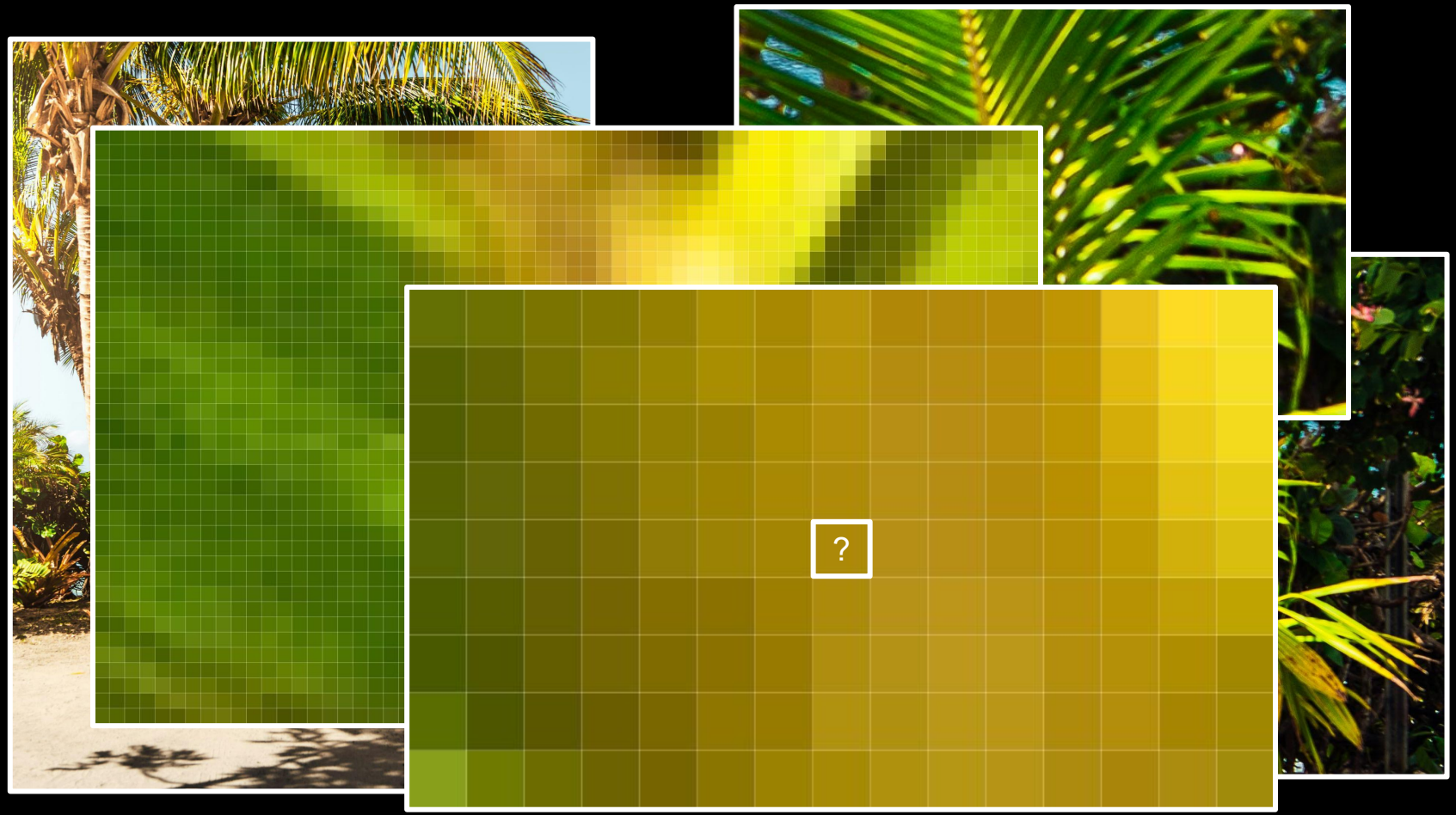

rules
data
rule-based program
answer
data
answers
machine learning
rules

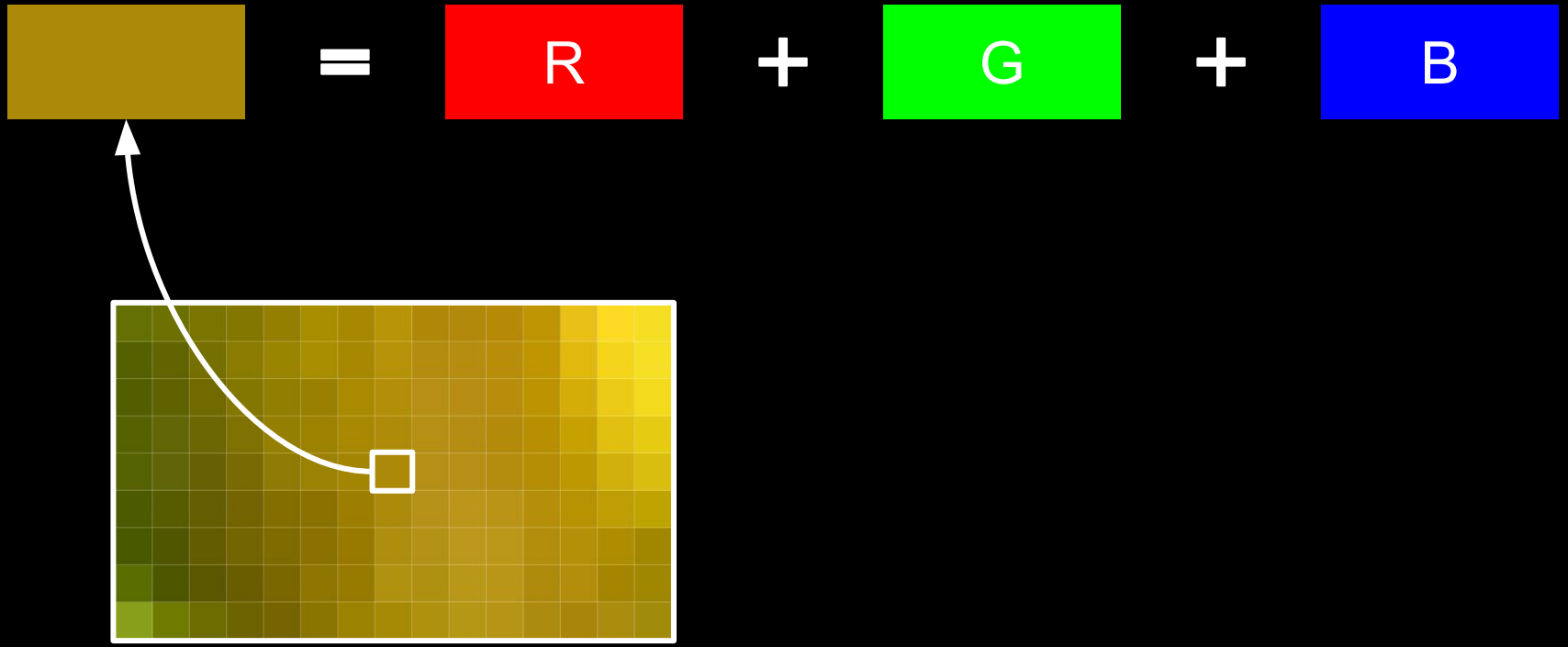
images in a computer










=
R
+
G
+
B

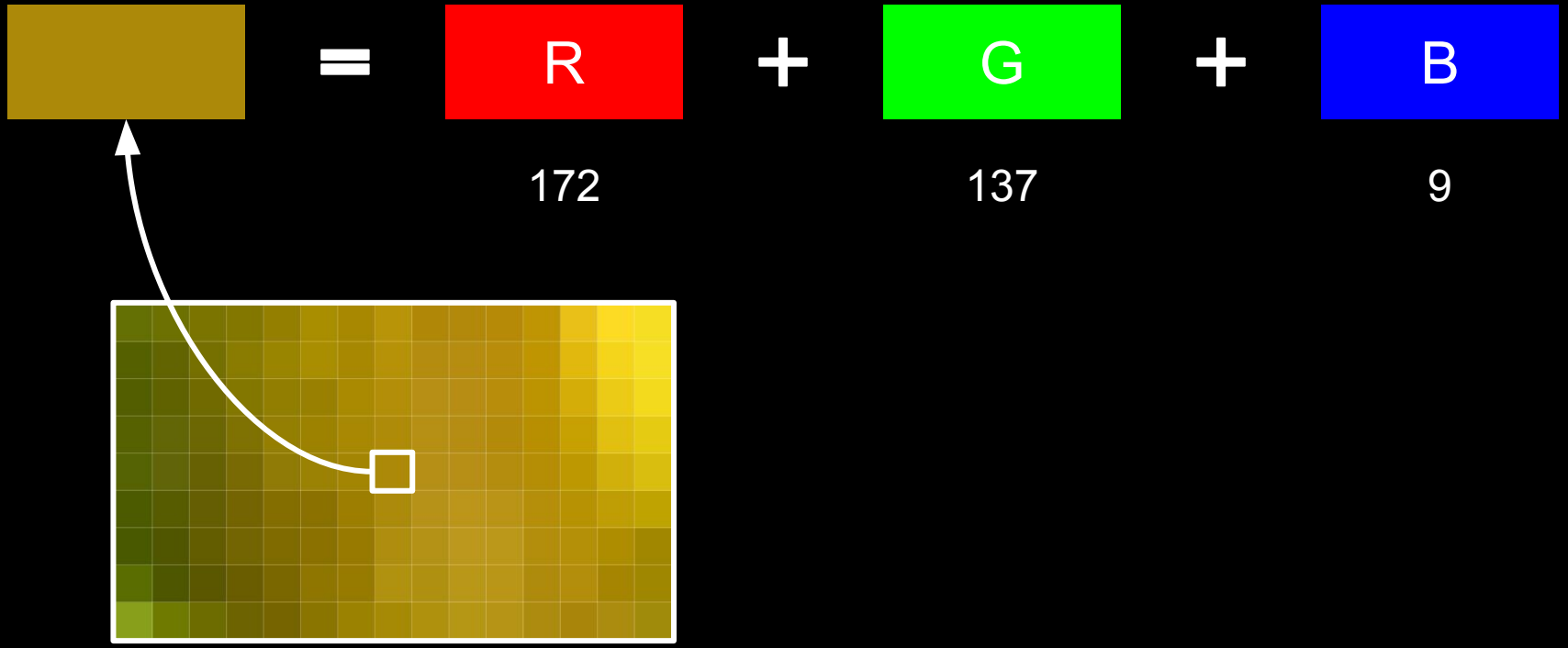

=
R
+
G
+
B
172
137
9

image classification

Q: Does an image belong to one or the other class from a fixed set of classes?

Cat or Dog?

model

"cat"

Cat or Dog?

model

"cat"

model

"dog"

Google's teachable machine

https://teachablemachine.withgoogle.com

```
pip install keras
pip install tensorflow==2.12.0
```

```
# Load the classifier and class names
model = load_model("my_model.h5")
class_names = open("labels.txt", "r").readlines()
```

```
# Convert the image t0 224 x 224
image = cv2.resize(image, (224, 224), interpolation=cv2.INTER_AREA)

# Turn into a list of pixels
image = np.asarray(image, dtype=np.float32).reshape(1, 224, 224, 3)

# Normalize each pixel's color value (-1/1)
image = (image / 127.5) - 1
```

```
# Make a prediction for the class
prediction = model.predict(image)

# Get the class with the highest confidence value
index = np.argmax(prediction)
class_name = class_names[index]

# Get the confidence score for the predicted class
confidence_score = prediction[0][index]
```


Class: Labeler
Confidence: 1.00
brother

YOLO v8 Image Classification

https://docs.ultralytics.com/

```
pip install ultralytics
```

```
# Load the classifier
from ultralytics import YOLO
model = YOLO("yolov8n-cls.pt")
```

```
# Make a prediction
results = model('cat.jpg')
```

```
# Show result
results[0].show()
```

```
# Get the top result
top = results[0].probs.top1
class_name = results[0].names[top]
print(class_name)
```

zero-shot image classification

Q: Which classes do you train your model on?

GPT-4 Vision

```
pip install openai
```

```
# import openai API and set api key
from openai import OpenAI
os.environ["OPENAI_API_KEY"] = "..."
client = OpenAI()
```

```
# define a suitable prompt for the task
prompt = "Classify the image into 'dog' or 'cat'. Return
only the word for the class of the image."
```

```
# This function is needed to encode an image to base64 for OpenAI's API
def encode_image(image_path):
  with open(image_path, "rb") as image_file:
    return base64.b64encode(image_file.read()).decode('utf-8')

image_path = "cat.webp"
image = encode_image(image_path)
```

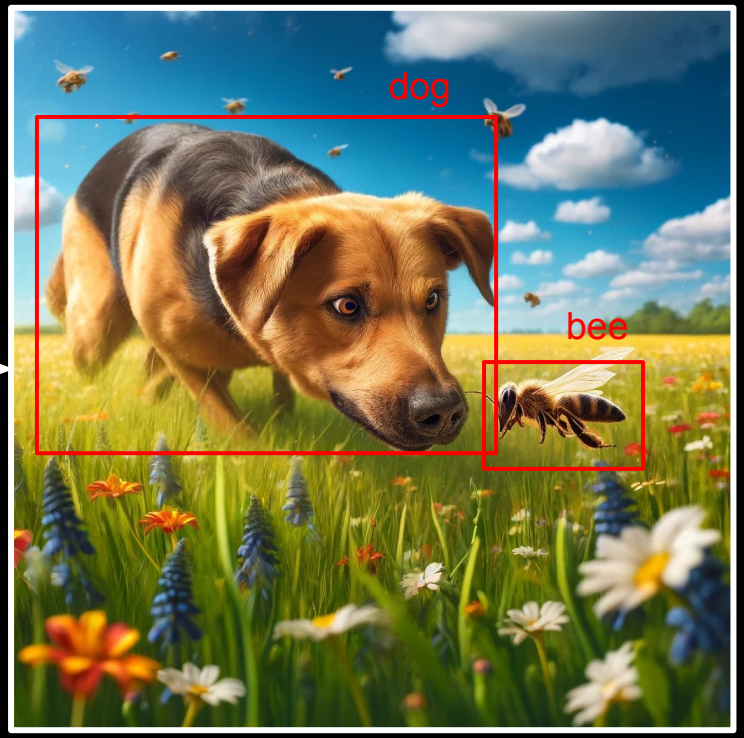
```
response = client.chat.completions.create(
  model="gpt-4-turbo",
  messages = [
    { "role": "user", "content": [
        { "type": "text", "text": prompt },
        { "type": "image_url", "image_url": { "url": f"{image}" } }
      ]
    }
  ],
  max_tokens=300,
)
```

```
# Show the answer of the classification
print(response.choices[0].message.content)
```

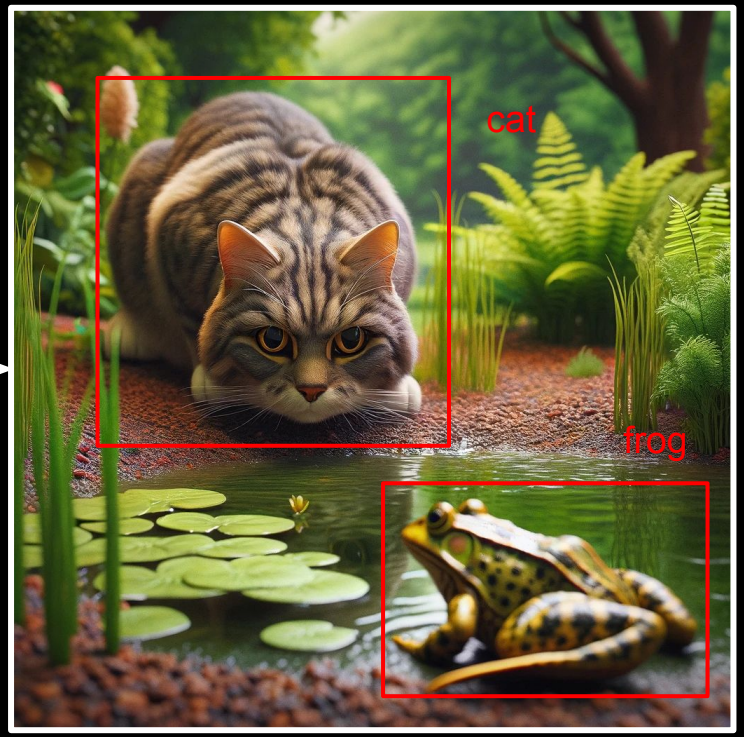
object detection

Q: Which objects are in the image and where?

AI



AI



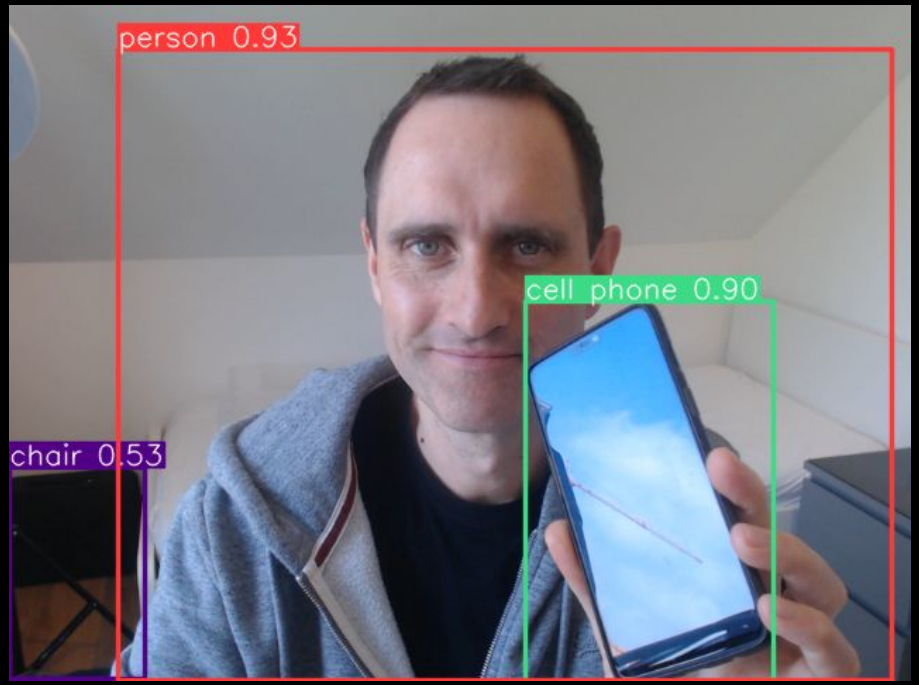
YOLO v8 Object Detection

https://docs.ultralytics.com/

```
# Load the detector
from ultralytics import YOLO
model = YOLO("yolov8n.pt")
```

```
# Make a prediction one each frame
results = model(frame)

# Annotate frame
annotated_frame = results[0].plot()
```


person 0.93
cell phone 0.90
chair 0.53

Q: Which objects do you teach your model to recognize?

zero-shot object detection

"Simple Open-Vocabulary Object Detection with Vision Transformers"

https://arxiv.org/abs/2205.06230

```
# Load the open world detector
from ultralytics import YOLO
model = YOLO("yolov8s-world.pt")
```

```
# Define custom objects to look for
model.set_classes(["person with glasses"])
```

```
# Make a prediction one each frame
results = model(frame)

# Annotate frame
annotated_frame = results[0].plot()
```

optical character recognition (OCR)

Getränke
HOFFMANN

B. Bobzin
Bramscher Straße 159
49088 O S N A B R Ü C K
Mo-Fr.08:00-19:30 Uhr Sa.08:00-19:00 Uhr
Tel.0541/684726

26.04.24 09:07 2347 00002 01 #306521

6x 20er KASTEN á 13.29
#133075 Salvus Apfelschorle 0,33 79.74 1
#000901 Pfandflasche 120x0.15 18.00 1
#000905 Leerkiste 6x1.50 9.00 1

8x 20er KASTEN á 7.79
#133734 Salvus mit Kribbel 0,33L 62.32 1
#000901 Pfandflasche 160x0.15 24.00 1
#000905 Leerkiste 8x1.50 12.00 1

Endsumme € 205.06

davon Ware EUR : 142.06
davon Pfand EUR : 63.00
abzgl. Rückpfand EUR : 0.00

MwSteuer	Netto	MwSt.	Brutto
19.00%	172.32	32.74	205.06 1

Kartenzahlung EUR : 205.06
Kartenart : Visa Debit
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VU-Nr. : 228165299
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****

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Vielen Dank
für Ihren Einkauf!

tesseract

GPT-4 Vision

```
# define a suitable prompt for the task
prompt = "Extract all food and beverage items with their
quantity and price from this receipt into a JSON list. The
receipt is in German."
```

```
response = client.chat.completions.create(
  model="gpt-4-turbo",
  response_format={ "type": "json_object" },
  messages = [
    { "role": "user", "content": [
        { "type": "text", "text": prompt },
        { "type": "image_url", "image_url": { "url": f"{image}" } }
      ]
    }
  ],
  max_tokens=300,
)
```