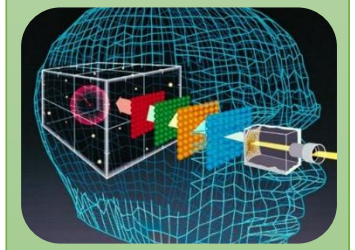
seeed studio

Hands-On Computer Vision

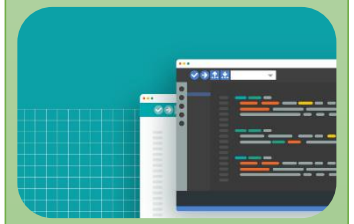
ICTP-UNU Workshop on TinyML
for Sustainable Development

Main Content



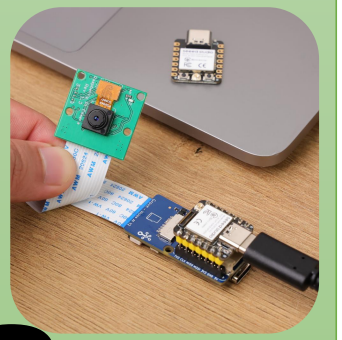
1

Introduction to Machine Vision



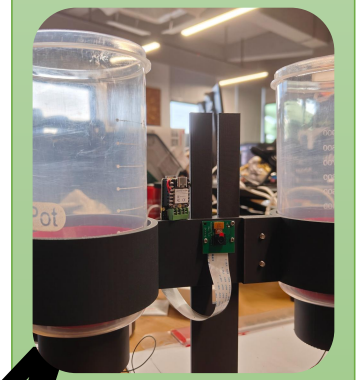
2

Arduino Environment Preparation



3

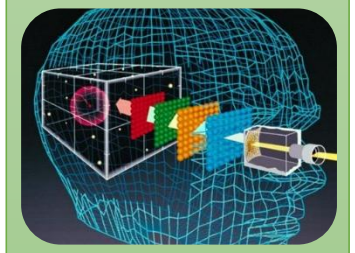
Equipment Introduction & Demonstration



4

MCU + AI Sensors = Unlimited Creative Possibilities

Main Content

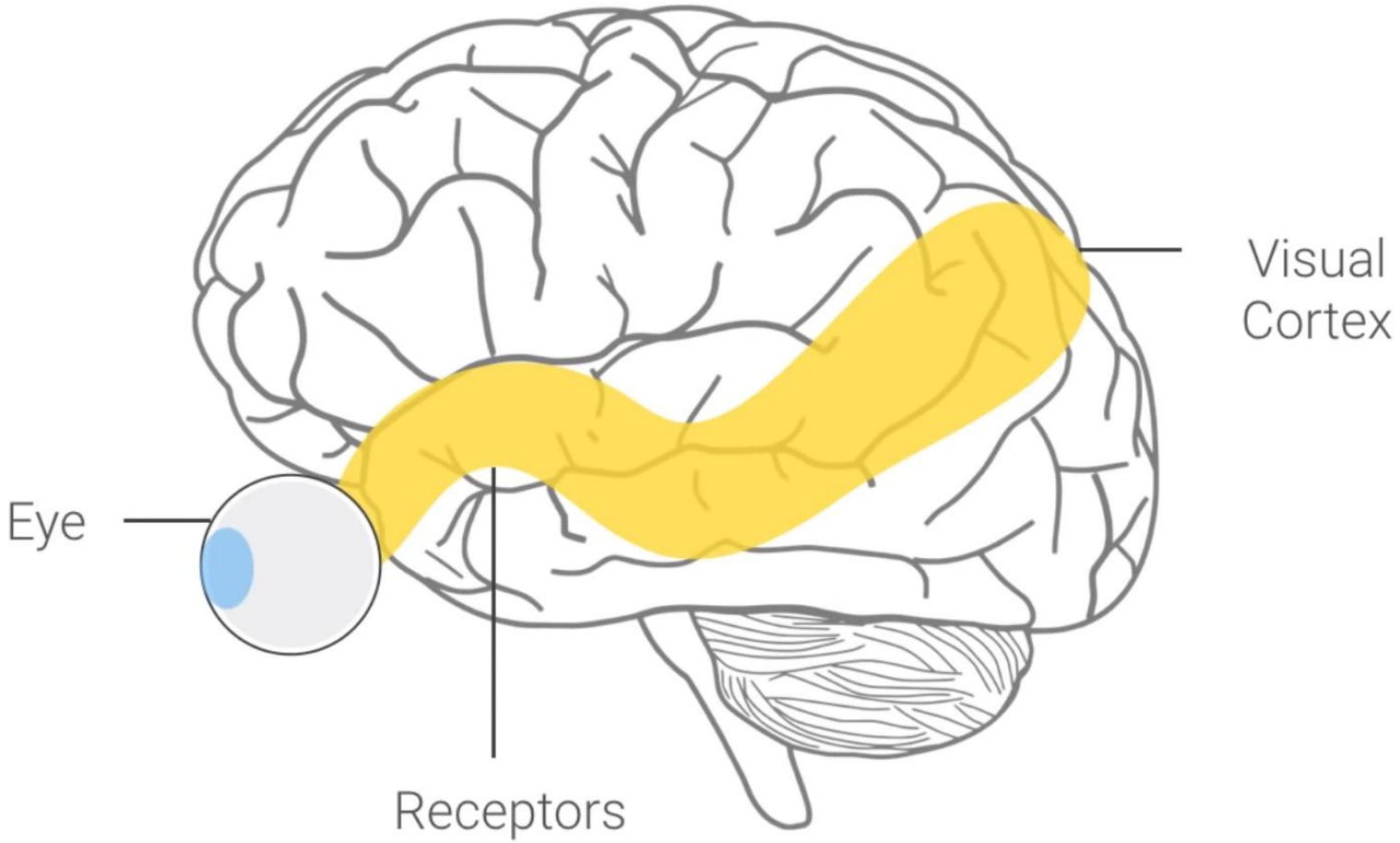


1

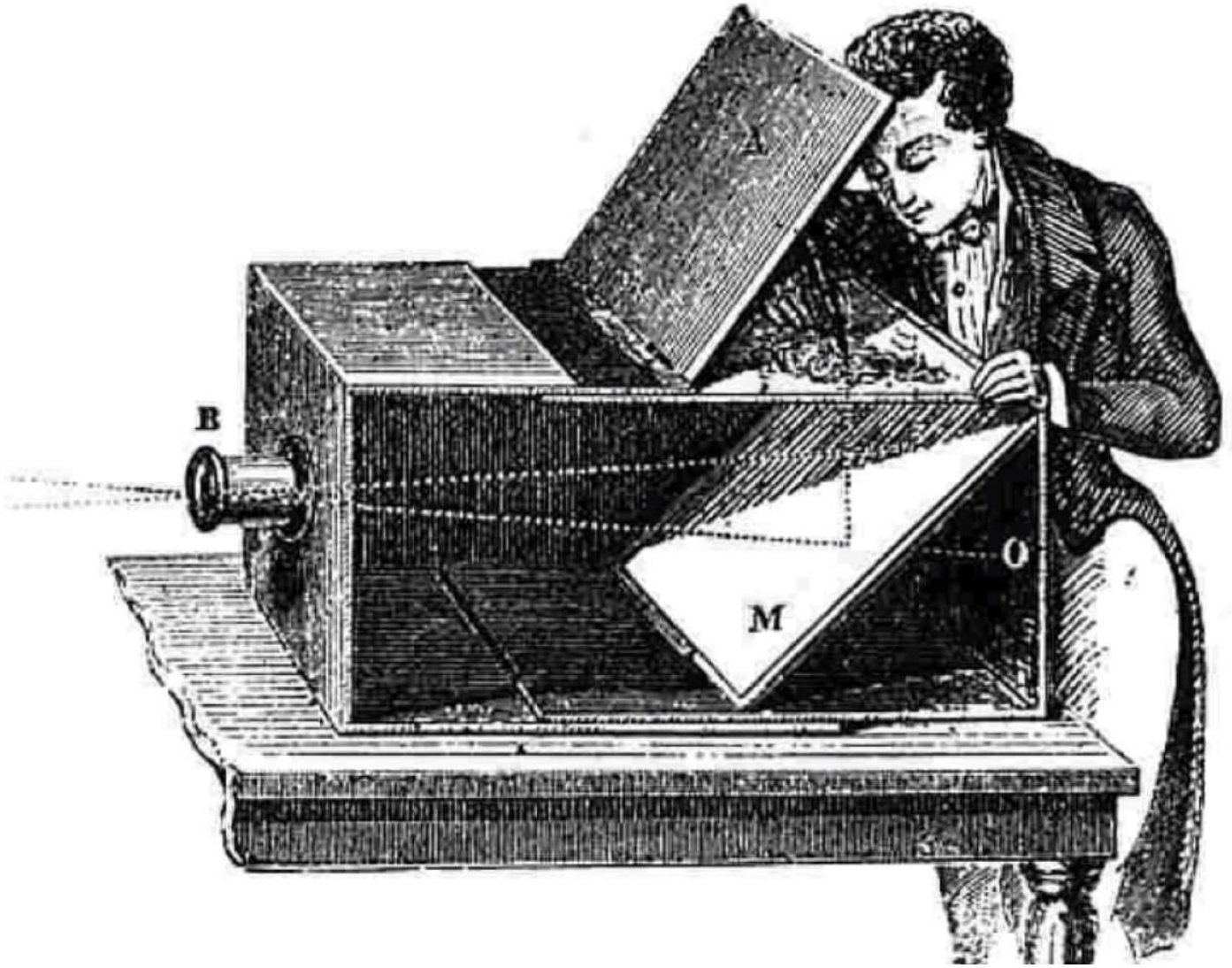
Introduction to
Machine Vision

Introduction to Machine Vision

Introduction to Machine Vision

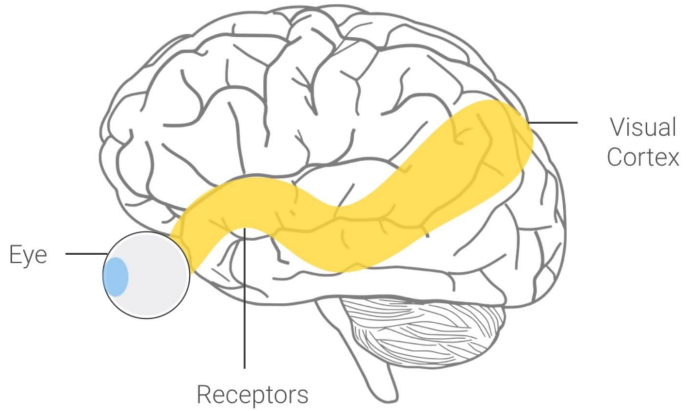


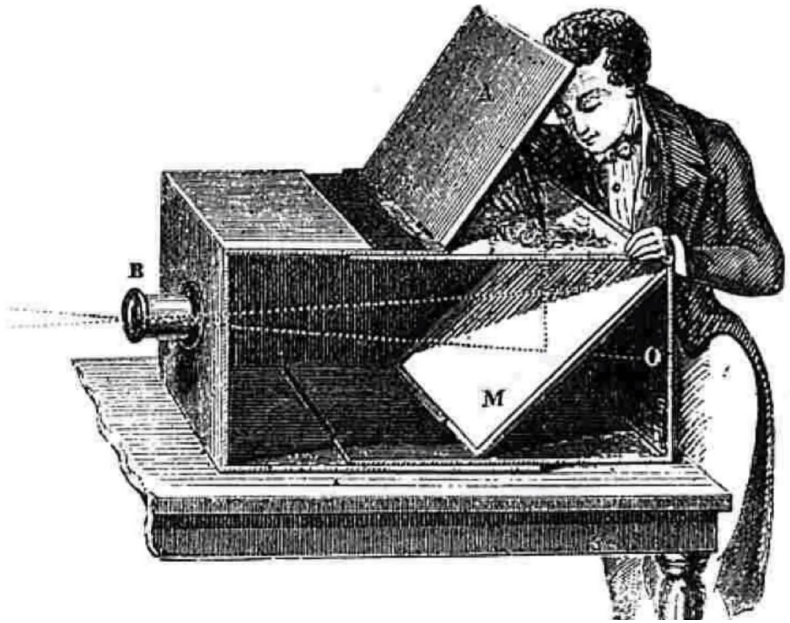
Introduction to Machine Vision



Introduction to Machine Vision

Introduction to Machine Vision





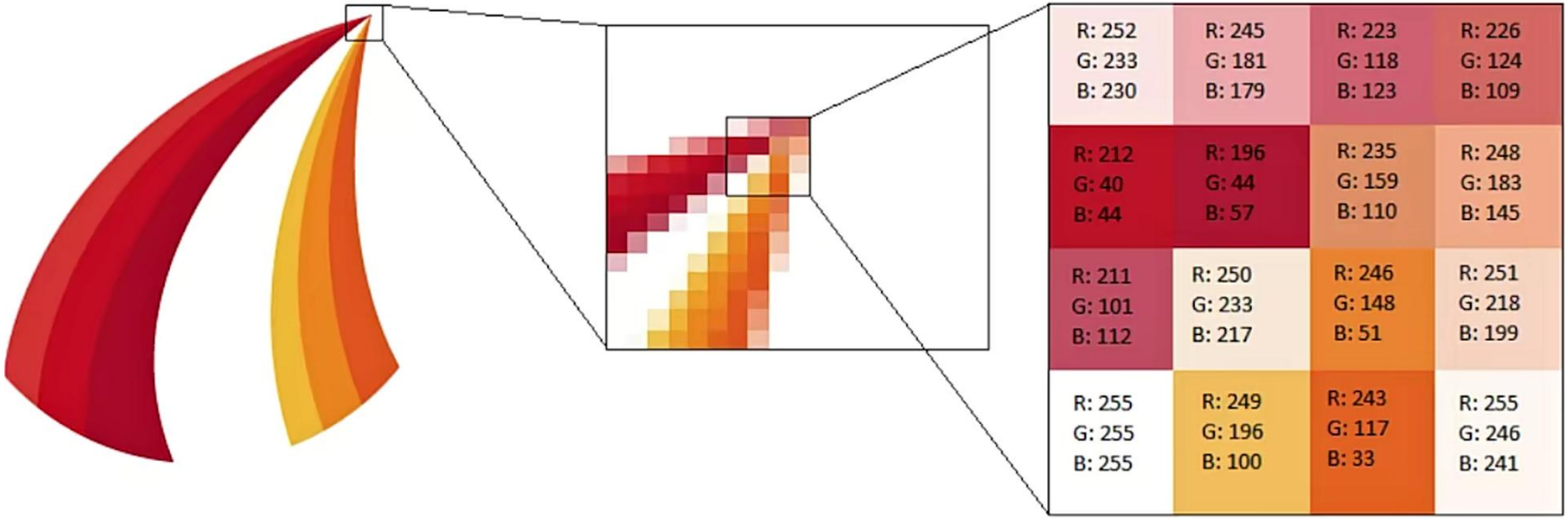
Introduction to Machine Vision

28 x 28
784 pixels

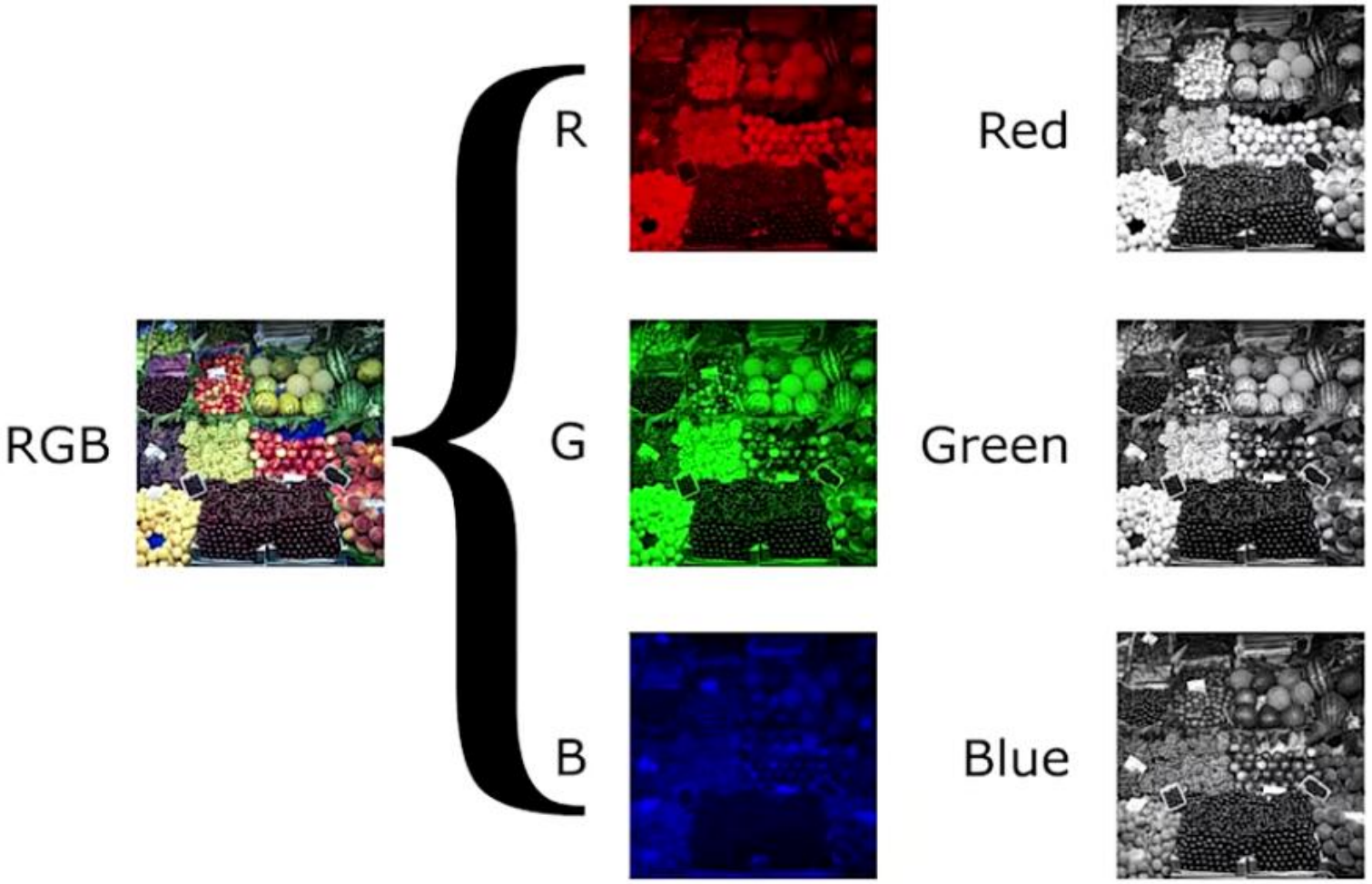
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	4	62	146	182	254	254	181	176	139	15	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	34	186	253	217	208	136	136	136	166	232	99	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	61	242	208	111	3	0	0	0	0	0	18	32	107	43	0	0	0	0	0	0
0	0	0	0	0	0	0	0	156	242	23	0	0	0	0	0	0	0	13	191	181	6	0	0	0	0	0	0
0	0	0	0	0	0	0	0	121	255	98	3	0	0	0	0	0	8	194	225	12	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	169	253	120	3	0	0	0	0	128	247	51	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	111	244	169	19	0	14	131	249	117	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	59	241	235	72	142	229	66	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	25	218	254	231	36	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	133	253	221	33	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	19	237	111	196	217	19	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	174	138	0	23	193	204	18	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	96	224	0	0	0	25	218	169	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	138	0	0	0	0	86	253	99	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	3	162	214	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	215	97	0	0	0	0	0	118	253	68	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	185	157	0	0	0	0	0	40	254	98	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	50	244	61	0	0	0	0	112	244	58	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	174	251	142	59	83	167	244	111	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	6	133	253	253	253	169	61	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A greyscale image can be understood as consisting of dark (0) and light (numbers greater than zero), the closer to 255 means the brighter the area is.

Introduction to Machine Vision



Introduction to Machine Vision



Shape 3D Array
(480*540*3)

Height

Width

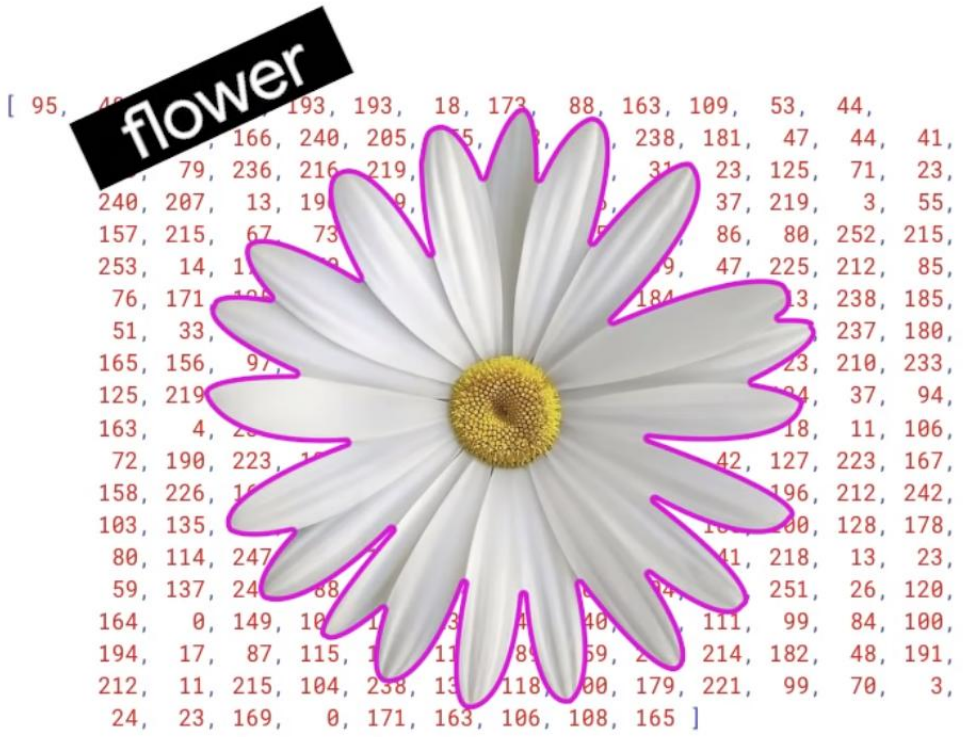
Colour Channel

Introduction to Machine Vision

```
[ 95,  48, 122, 153, 193, 193,  18, 173,  88, 163, 109,  53,  44,
  106,  87, 166, 240, 205, 155,  88, 201, 238, 181,  47,  44,  41,
  169,  79, 236, 216, 219,  15,  14,   7,  31,  23, 125,  71,  23,
  240, 207,  13, 196,   9, 113,   3, 126, 186,  37, 219,   3,  55,
  157, 215,  67,  73,  64,  38, 218, 135,  52,  86,  80, 252, 215,
  253,  14, 174,  70, 225, 225, 109, 156,  99,  47, 225, 212,  85,
   76, 171, 125,  23,  60,  84,  20, 109, 184,  49,  13, 238, 185,
   51,  33, 250, 237,  74, 174,  53, 241,  94,  18,  61, 237, 180,
  165, 156,  97,  42, 232, 255, 189, 241, 203,  34,  23, 210, 233,
  125, 219, 132, 231, 145,  64, 203, 135,   3,  87, 124,  37,  94,
  163,   4, 236,  50, 233, 244, 176,  66, 139, 164,  18,  11, 106,
   72, 190, 223, 133,  78, 230,  24, 235,  20,  42, 127, 223, 167,
  158, 226, 163, 114, 121,   1, 194, 245, 215, 199, 196, 212, 242,
  103, 135, 194,  45, 192,   4,   6,  24,  12, 185, 100, 128, 178,
   80, 114, 247,  18, 149, 215, 141, 128, 148, 241, 218,  13,  23,
   59, 137, 244,  88, 200, 174,  39, 203, 104,  40, 251,  26, 120,
  164,   0, 149, 103, 138, 239, 243,  40, 131, 111,  99,  84, 100,
  194,  17,  87, 115, 178, 110,  89,  59, 255, 214, 182,  48, 191,
  212,  11, 215, 104, 238, 132, 118, 100, 179, 221,  99,  70,   3,
   24,  23, 169,   0, 171, 163, 106, 108, 165 ]
```

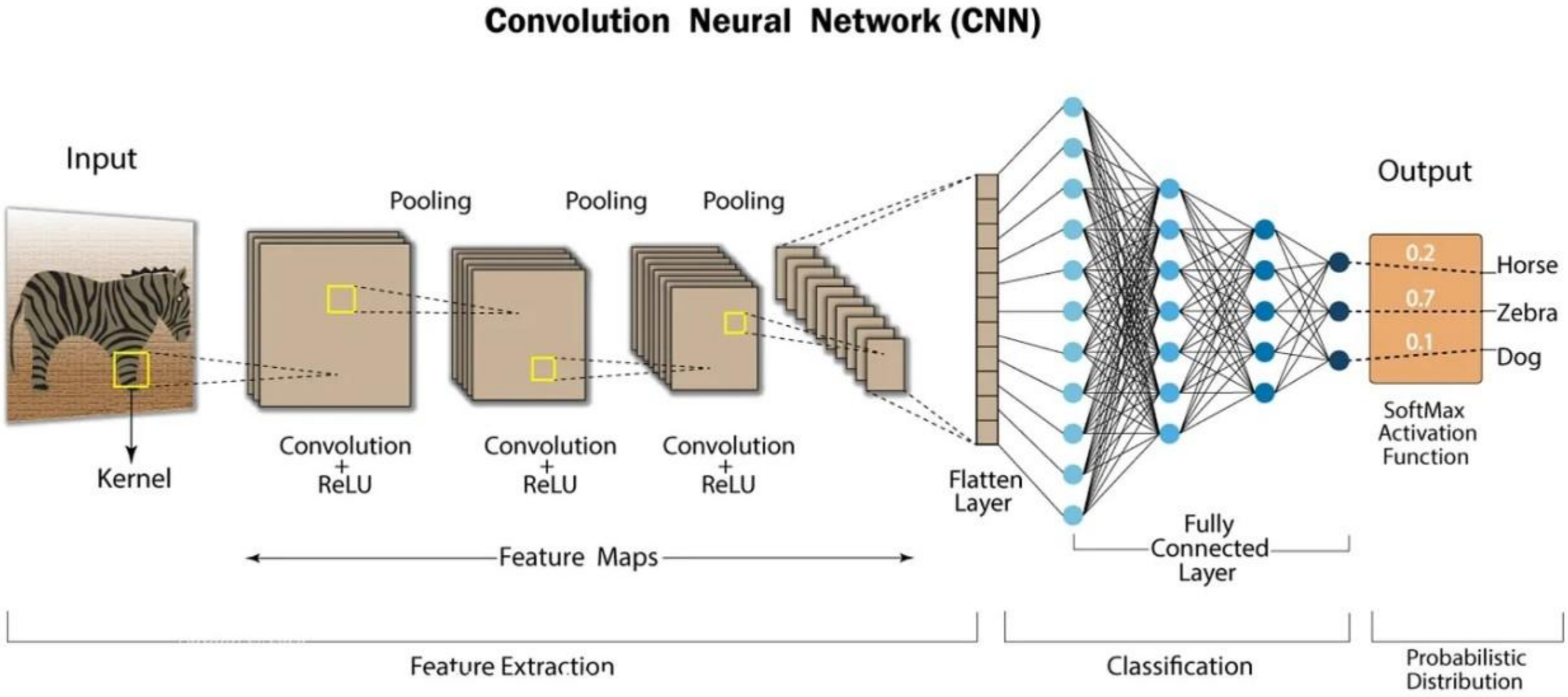
Introduction to Machine Vision

Machine Learning

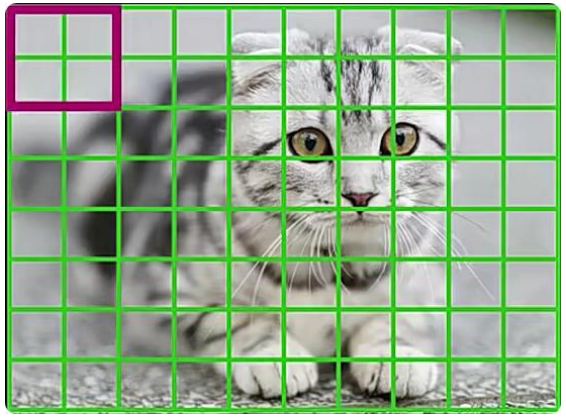


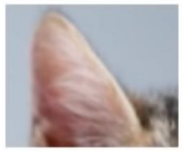
Introduction to Machine Vision

Introduction to Machine Vision

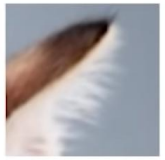


Introduction to Machine Vision





Ear



Ear

Eye

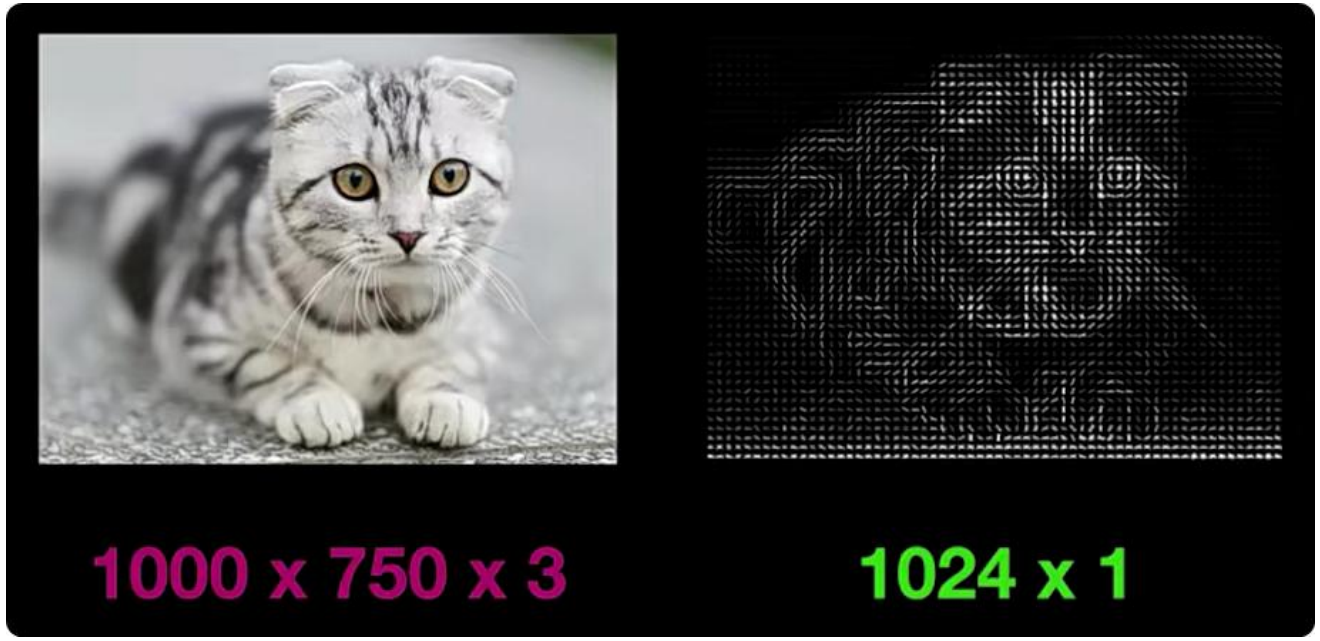
Eye

Fur

Convolutional Layers

- Convolutional layers use a set of learnable filters (also known as convolutional kernels) that slide over the input image and perform convolution operations.
- Each filter extracts specific features from the image, such as edges, textures, or shapes.
- The result of the convolution operation is a set of feature maps that represent the response of different features at various locations in the image.
- By using multiple filters, convolutional layers can extract a variety of features from the image.

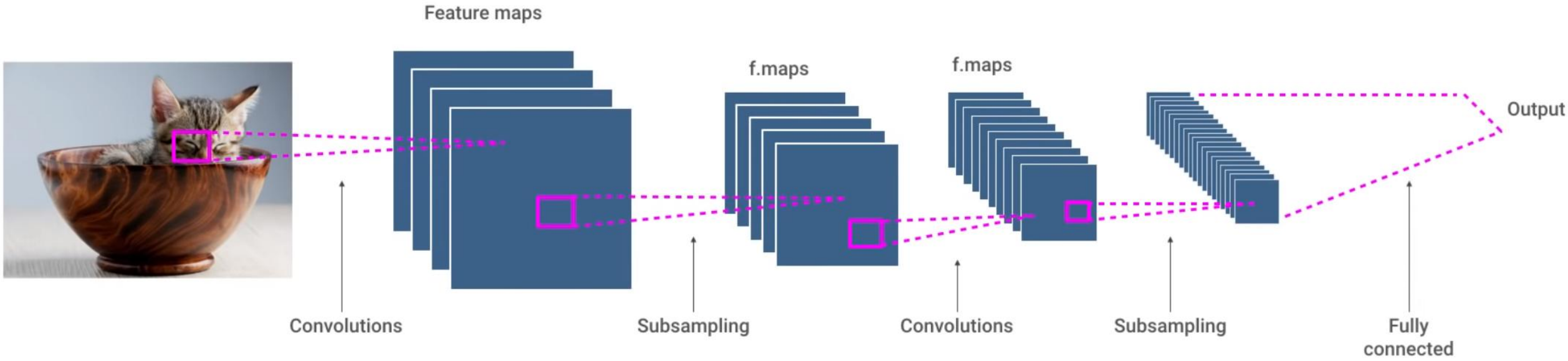
Introduction to Machine Vision



Pooling Layers

- Pooling layers are used to reduce the spatial dimensions of the feature maps while retaining the most important feature information.
- The most common pooling operation is max pooling, which selects the maximum value within each region of the feature map as the representative of that region.
- Pooling operations help to reduce the size of the feature maps, thereby reducing the computational burden of subsequent layers and providing some level of translation invariance.

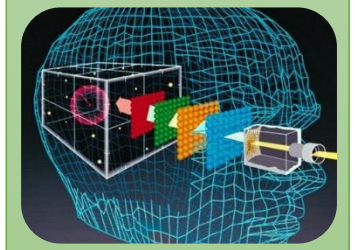
Introduction to Machine Vision



Fully Connected Layers

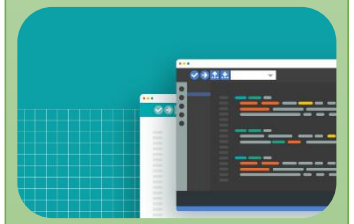
- After multiple convolutional and pooling layers, CNNs typically employ one or more fully connected layers for the final classification or prediction task.
- Fully connected layers flatten the features extracted by the previous layers and apply a weight matrix to transform them into the final output.
- Fully connected layers can learn complex relationships between features and generate the desired output based on the task requirements, such as the probability of an image belonging to a specific class.

Main Content



1

Introduction to Machine Vision



2

Arduino Environment Preparation

Arduino Environment Preparation

TABLE OF CONTENTS

About Arduino

What is Arduino?

Arduino designs, manufactures, and supports electronic devices and software, allowing people around the world to easily access advanced technologies that interact with the physical world. Our products are straightforward, simple, and powerful, ready to satisfy users' needs from students to makers and all the way to professional developers.

Find out more

Our Mission & Vision

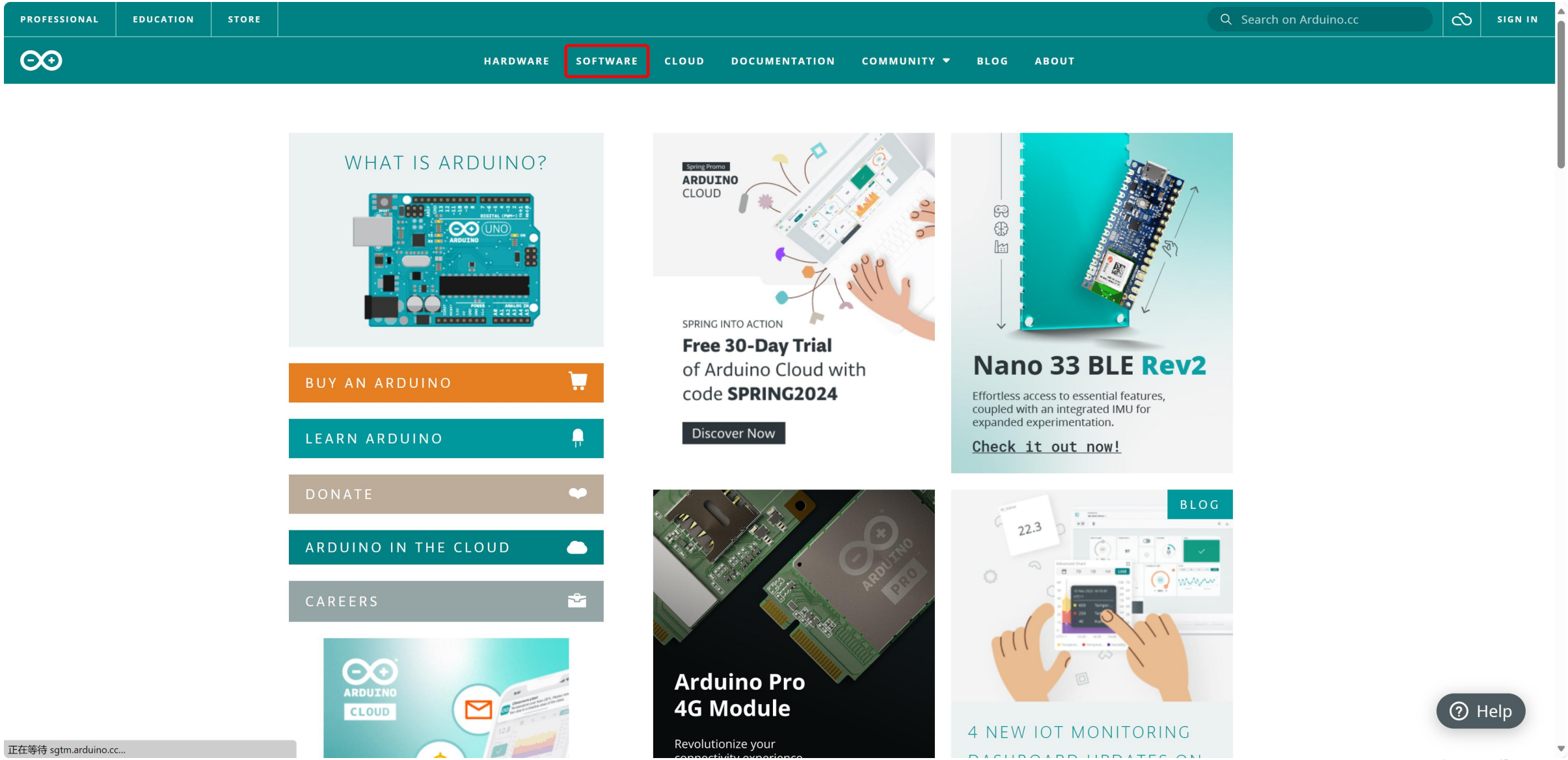
Arduino's mission is to enable anyone to enhance their lives through accessible electronics and digital technologies. There was once a barrier between the electronics, design, and programming world and the rest of the world. Arduino has broken down that barrier.

Over the years, our products have been the brains behind thousands of projects, from everyday objects to complex scientific instruments. A worldwide community, comprising students, hobbyists, artists, programmers, and professionals, has gathered around this open-source platform, their contributions adding up to an incredible amount of accessible knowledge.

Our vision is to make Arduino available to everyone, whether you are a student, maker or professional, which is why we now have three segments to our business. These segments work together as an ecosystem with a shared mindset: we started with Maker, and that has evolved into Education and PRO solutions.

Arduino Environment Preparation

https://www.arduino.cc/

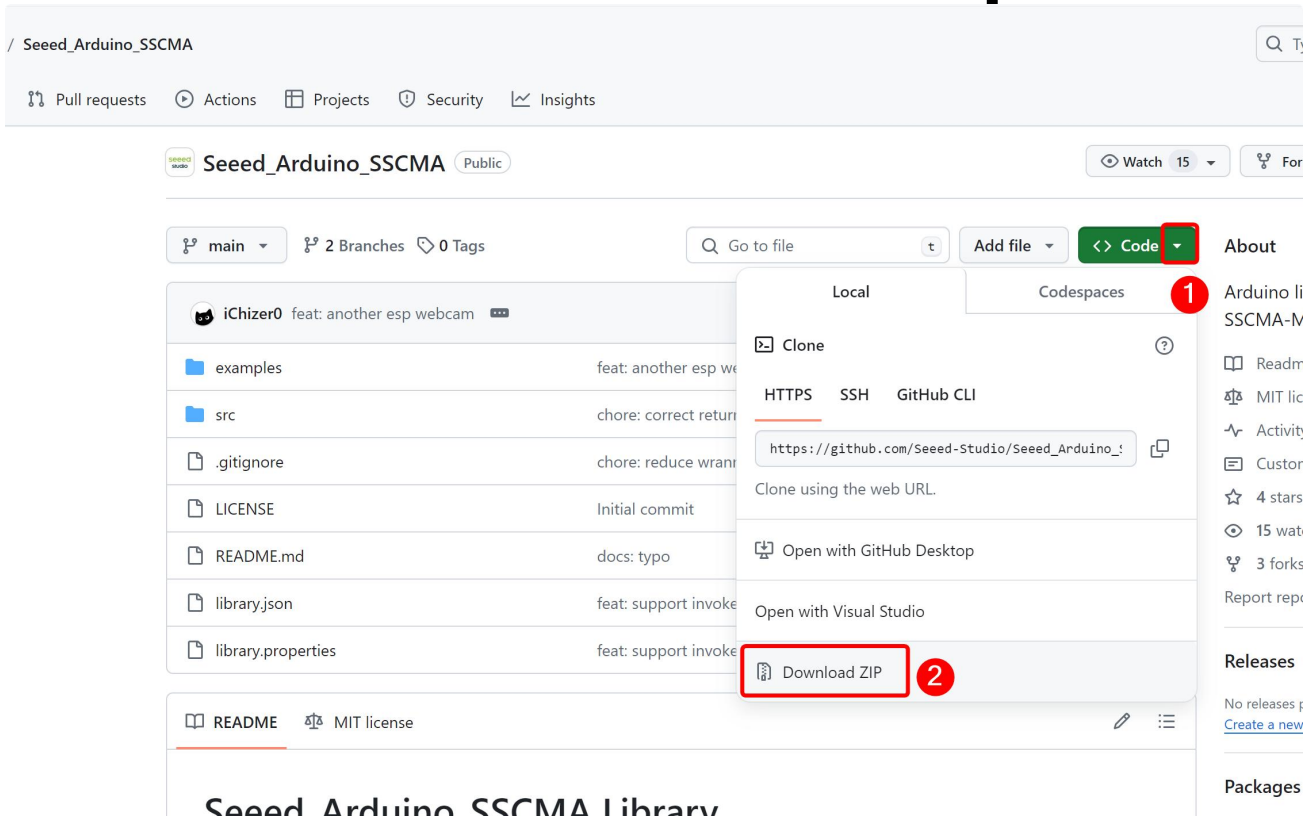


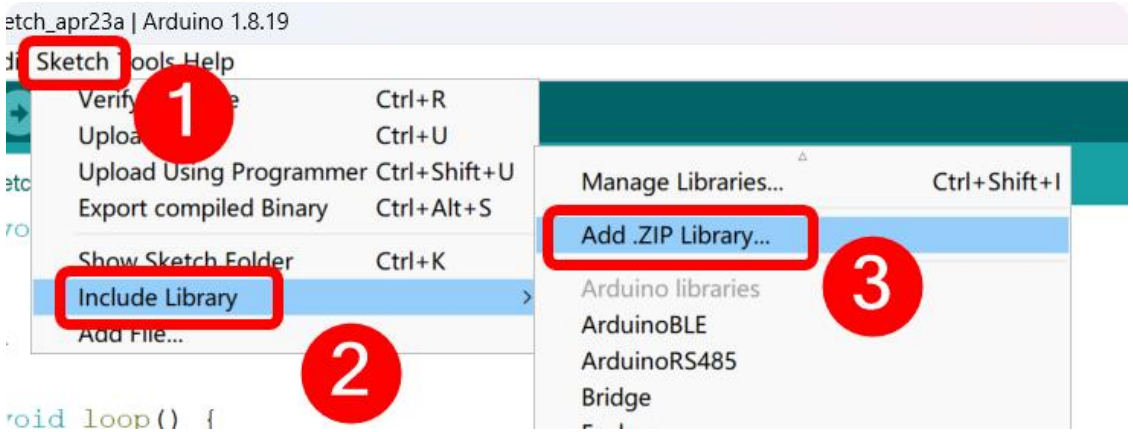
seeed studio

Arduino Environment Preparation

1. Visit the official Arduino website: https://www.arduino.cc/en/software
2. Click on the "Windows" or "Mac" button based on your operating system.
3. Download the Arduino IDE 1.8.19 installer.
4. Once the download is complete, run the installer.
5. Follow the installation wizard, accepting the license agreement and choosing the installation directory.
6. If prompted, allow the installer to install device drivers.
7. Once the installation is finished, click "Close" to exit the installer.
8. Open the Arduino IDE from the desktop shortcut or the start menu.
9. You're now ready to start using Arduino IDE 1.8.19!

Arduino Environment Preparation





1. Open your web browser and navigate to the GitHub repository: https://github.com/Seeed-Studio/Seeed_Arduino_SSCMA

2. Click on the green "Code" button and select "Download ZIP" to download the library as a ZIP file.

3. Save the ZIP file to a location on your computer where you can easily find it.

4. Open the Arduino IDE.

5. Go to Sketch > Include Library > Add .ZIP Library.

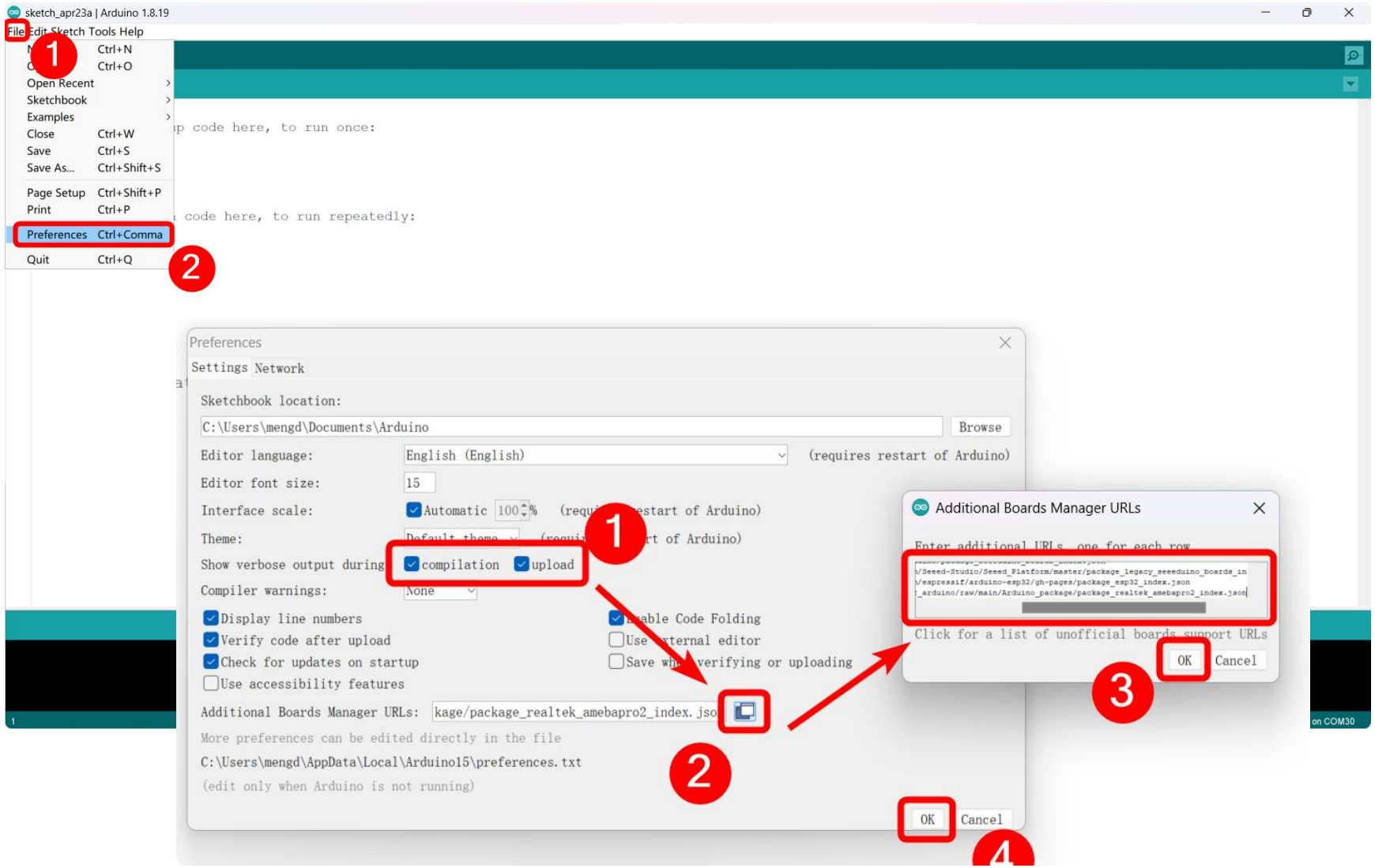
6. In the file browser window that appears, navigate to the location where you saved the downloaded ZIP file.

7. Select the ZIP file and click "Open" to add the library to your Arduino IDE.

8. The Seeed_Arduino_SSCMA library should now be installed and ready to use.

9. To verify the installation, go to Sketch > Include Library and check if "Seeed_Arduino_SSCMA" appears in the list of installed libraries.

Arduino Environment Preparation



1. Open the Arduino IDE.

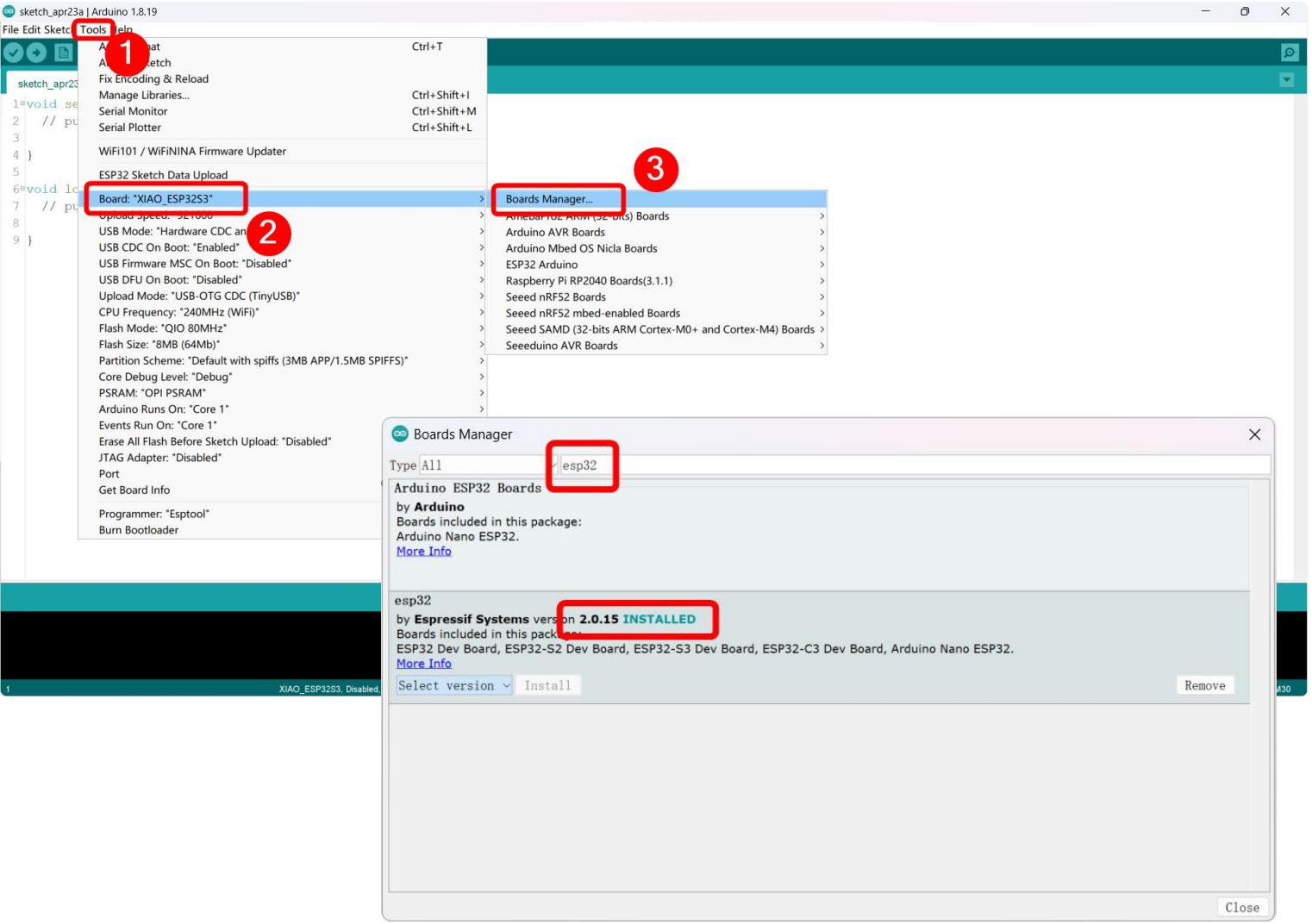
2. Go to File > Preferences.

3. In the "Additional Boards Manager URLs" field, enter the following URL:

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

4. Click "OK" to close the Preferences window.

Arduino Environment Preparation



5. Navigate to Tools > Board > Boards Manager.

6. In the Boards Manager window, search for "ESP32".

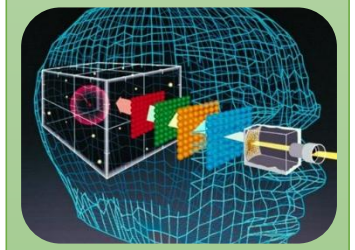
7. Locate the "ESP32 by Espressif Systems" entry and click on it.

8. Select the latest version from the dropdown menu and click "Install".

9. Wait for the installation process to complete. This may take a few minutes.

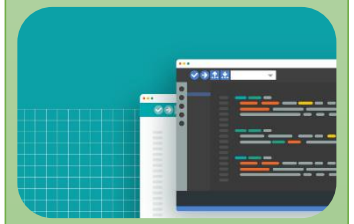
10. Once the installation is finished, close the Boards Manager window.

Main Content



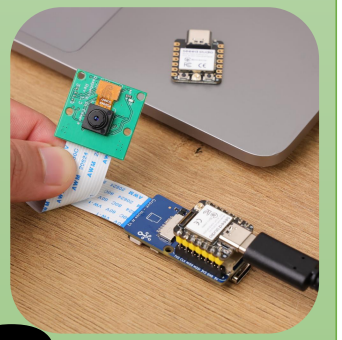
1

Introduction to Machine Vision



2

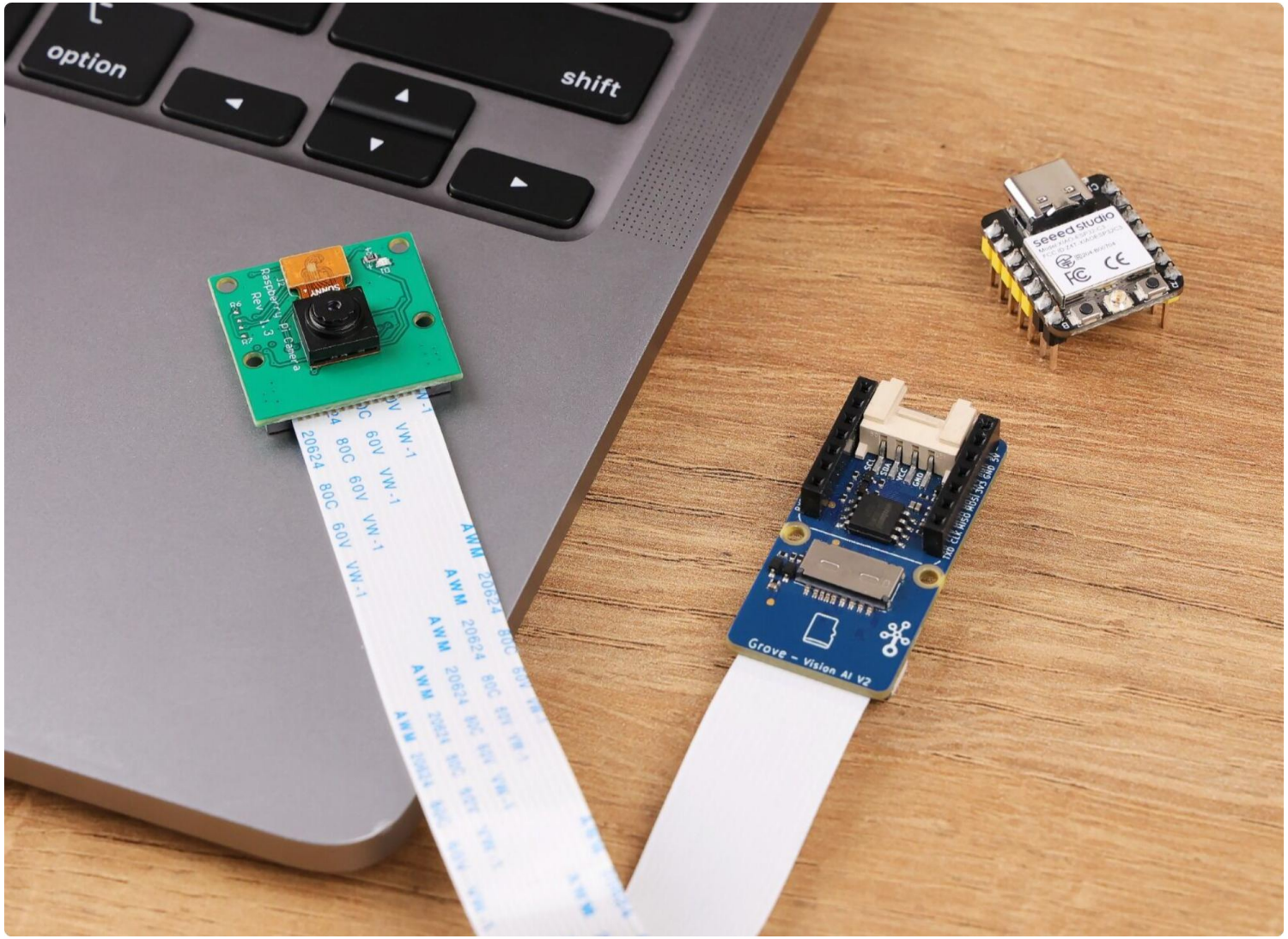
Arduino Environment Preparation



3

Equipment Introduction & Demonstration

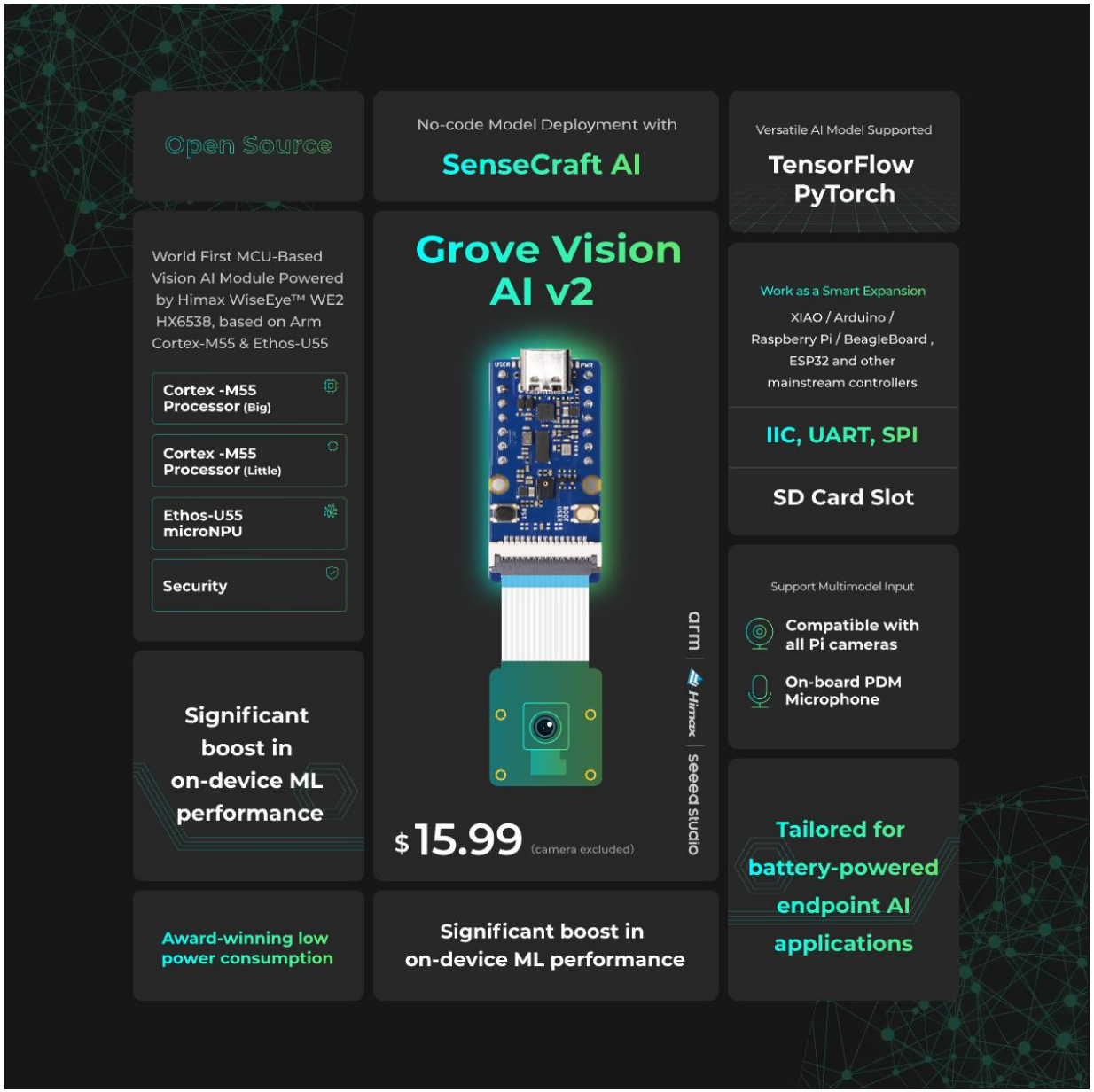
Equipment Introduction & Demonstration

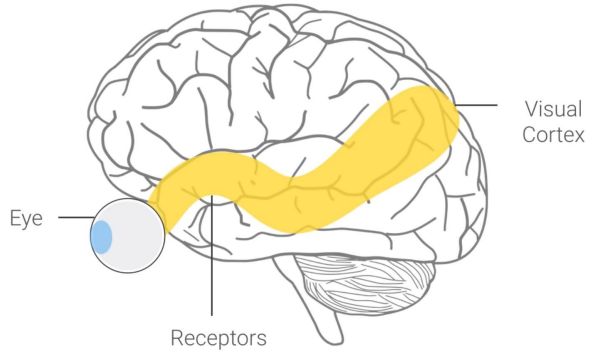


1. Grove Vision AI V2

2. XIAO ESP32C3

Equipment Introduction & Demonstration





Lighting: Lighting illuminates the object or scene to make its features visible.

Lens: This captures the image and delivers it to the sensor in the camera as light.

Capture board, frame grabber or sensor: These devices work together to process the image from the camera and convert it to a digital format as pixels.

Processor: The processor runs software and related algorithms that process the digital image and extract the required information.

Communication: These systems enable the machine vision cameras and processing system to communicate with other elements of the bigger system.

Equipment Introduction & Demonstration

Popular & Powerful SoCs Integrated

ESP32, RP2040, nRF52840, SAMD21, and more to come

Extra Tiny Size With SMD

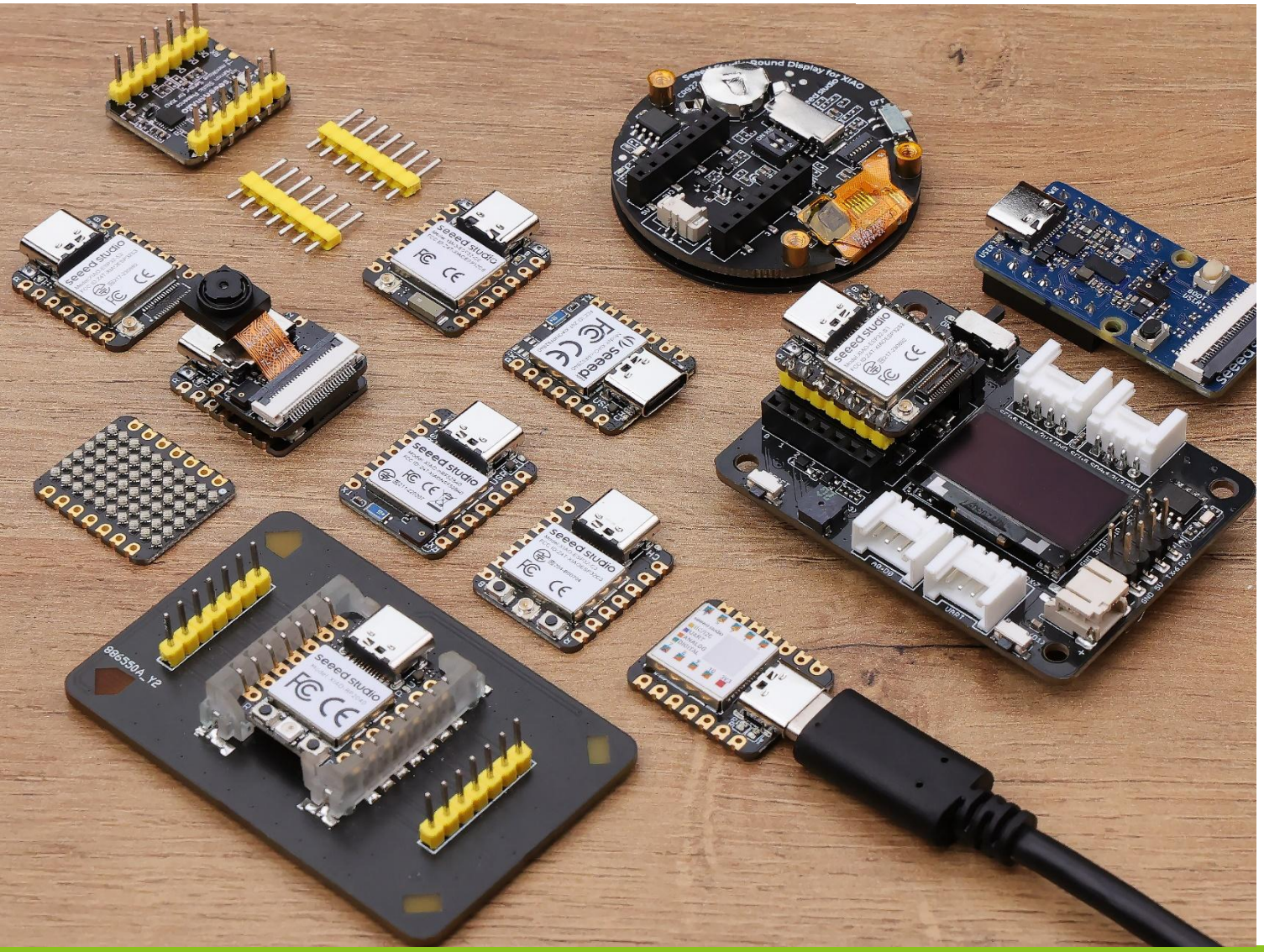
Sized at 21x17.5mm with single-sided surface mount design, ready to blend in space-constrained designs

Developer-Friendly

Natively compatible with Arduino, supporting MicroPython, and CircuitPython

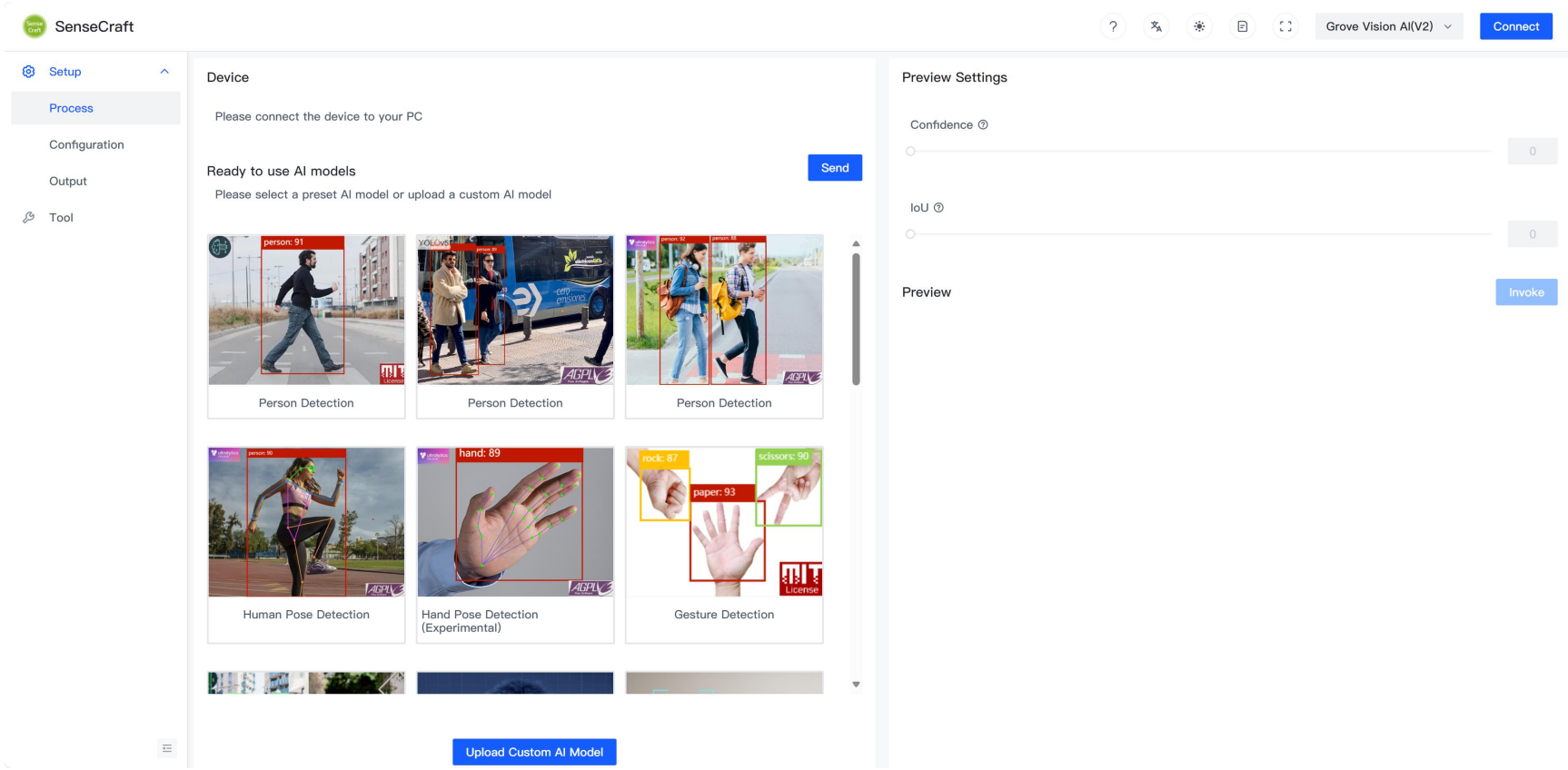
IoT Cloud Integration

A Seamless integration with AWS, Microsoft Azure, Google Cloud and more



The Seeed Studio XIAO Series is a collection of thumb-sized, powerful microcontroller units (MCUs) tailor-made for space-conscious projects requiring high performance and wireless con-connectivity. Embodying the essence of popular hardware platforms such as ESP32, RP2040, nRF52840, and SAMD21, the Arduino-compatible XIAO series is the perfect toolset for you to embrace tiny machine learning (TinyML) on the Edge.

Equipment Introduction & Demonstration

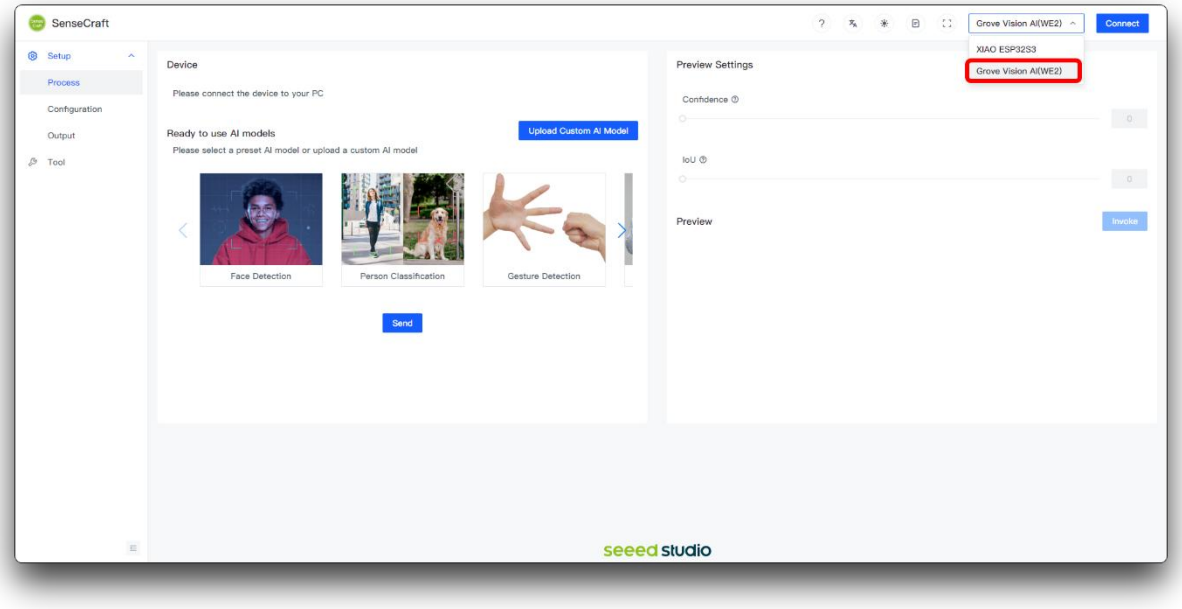


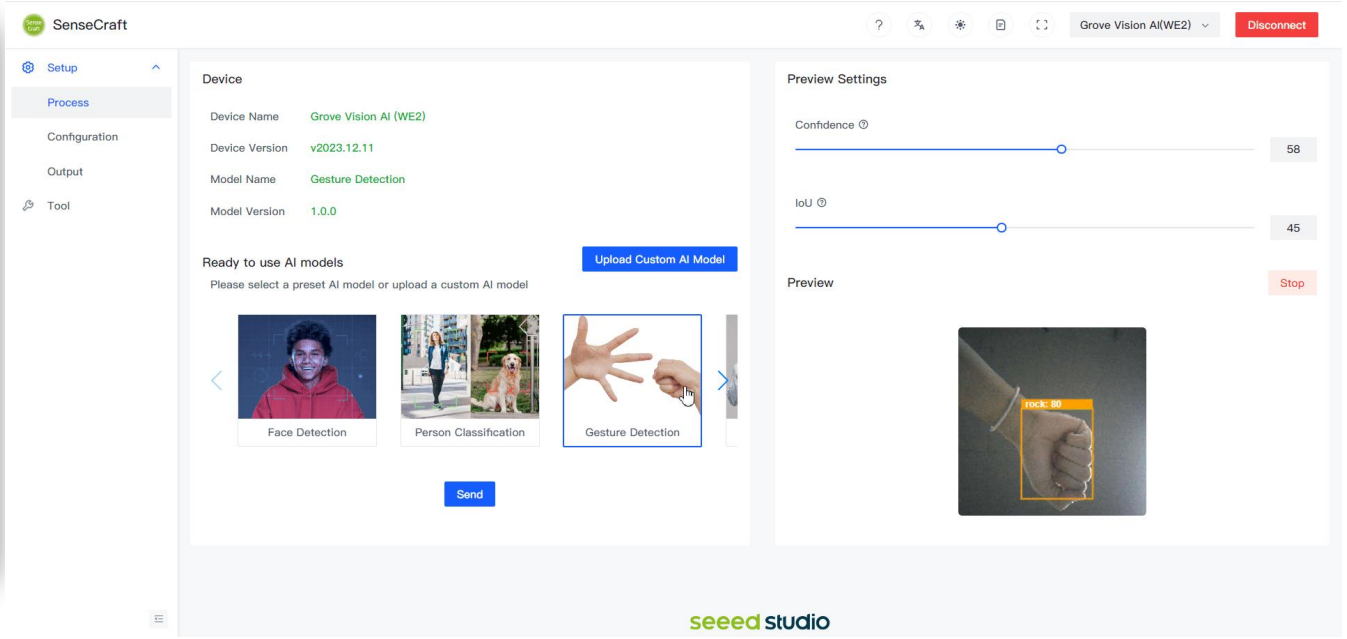
SenseCraft Model Assistant

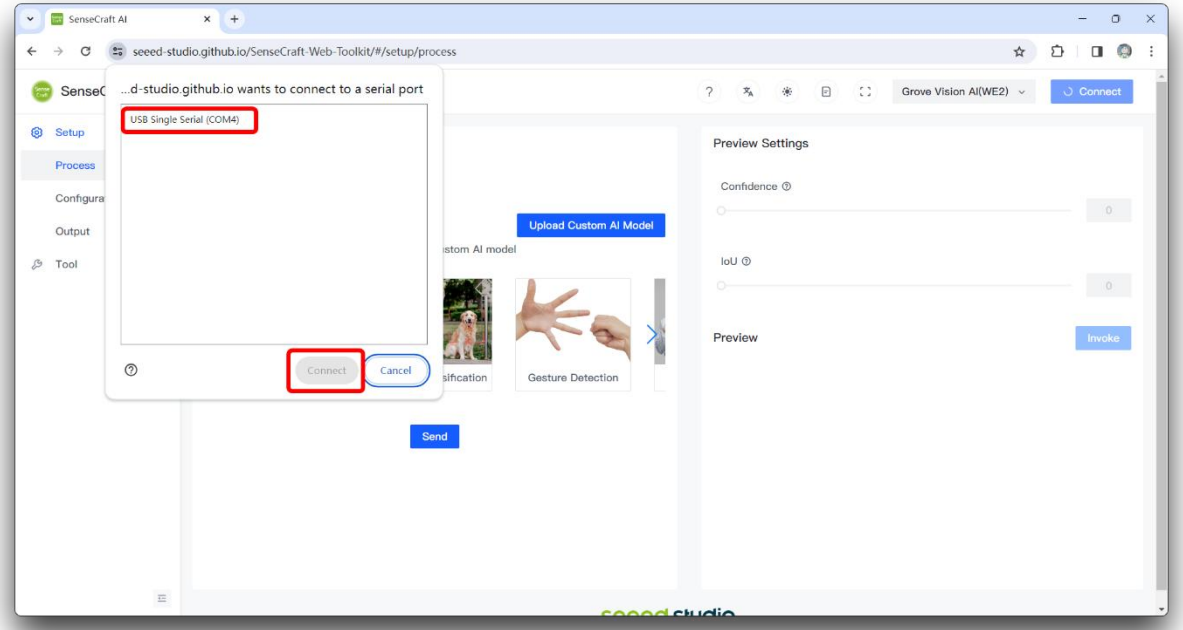
SenseCraft AI empowers users to effortlessly deploy a vast library of publicly available AI models onto their edge devices such as Recomputer (Jetson), XIAO S3, and more, and provides a seamless and user-friendly experience, allowing you to deploy public AI models directly onto your edge devices with just a few clicks. Say goodbye to complex configurations and coding – with SenseCraft AI, you can effortlessly unlock the power of AI on your devices. SenseCraft AI also allows you to upload and share your own trained AI models with the community. By publishing your models, you contribute to a growing library of shared knowledge, fostering collaboration and innovation among AI enthusiasts.

https://seeed-studio.github.io/SenseCraft-Web-Toolkit/#/setup/process

Equipment Introduction & Demonstration







First, we need to open the main SenseCraft AI Model Assistant page.

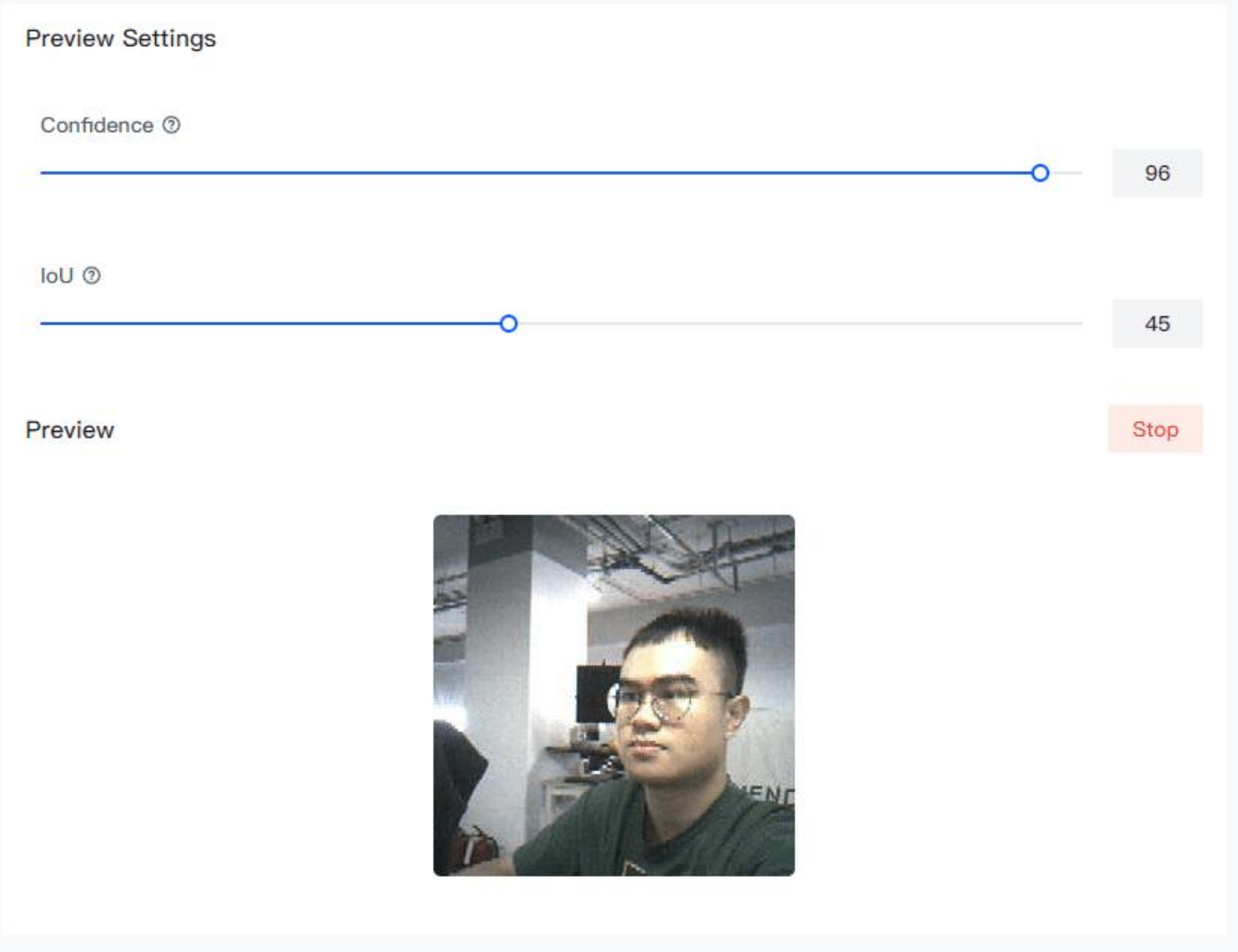
Please use a Type-C type cable to connect Grove Vision AI V2 to your computer.

In the upper right corner of the SenseCraft AI Model Assistant page, you can select **Grove Vision AI (WE2)**. Then click the **Connect** button on the far right.

In the new window that pops up, select the correct COM port for the device and click the Connect button.

Then, just select a model you want to use and click the **Send** button below. Here is an example of Gesture Detection.

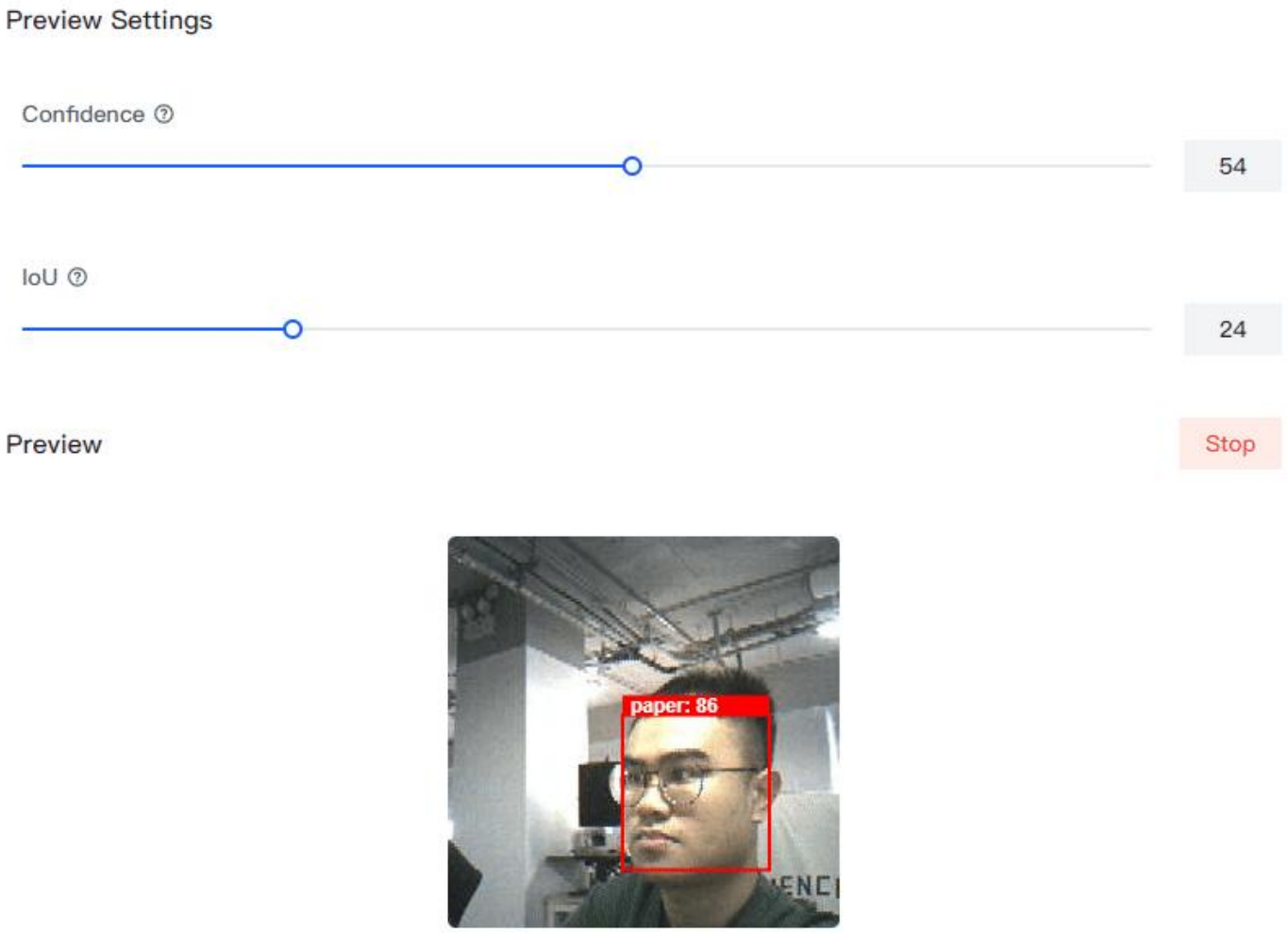
Equipment Introduction & Demonstration



Confidence

Confidence refers to the level of certainty or probability assigned by a model to its predictions.

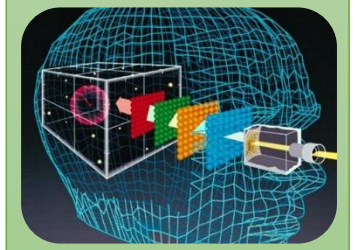
Equipment Introduction & Demonstration



IoU

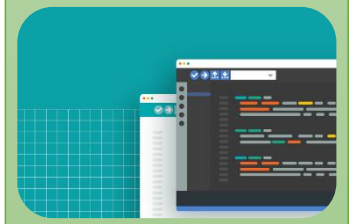
IoU is used to assess the accuracy of predicted bounding boxes compared to truth bounding boxes.

Main Content



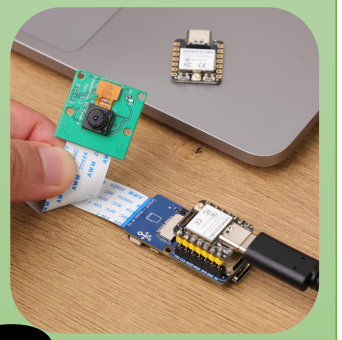
1

Introduction to Machine Vision



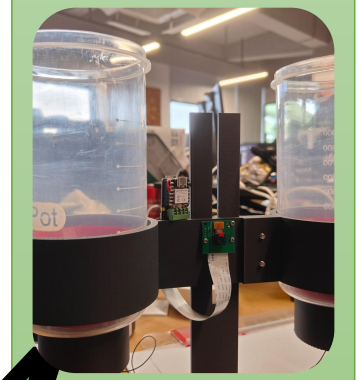
2

Arduino Environment Preparation



3

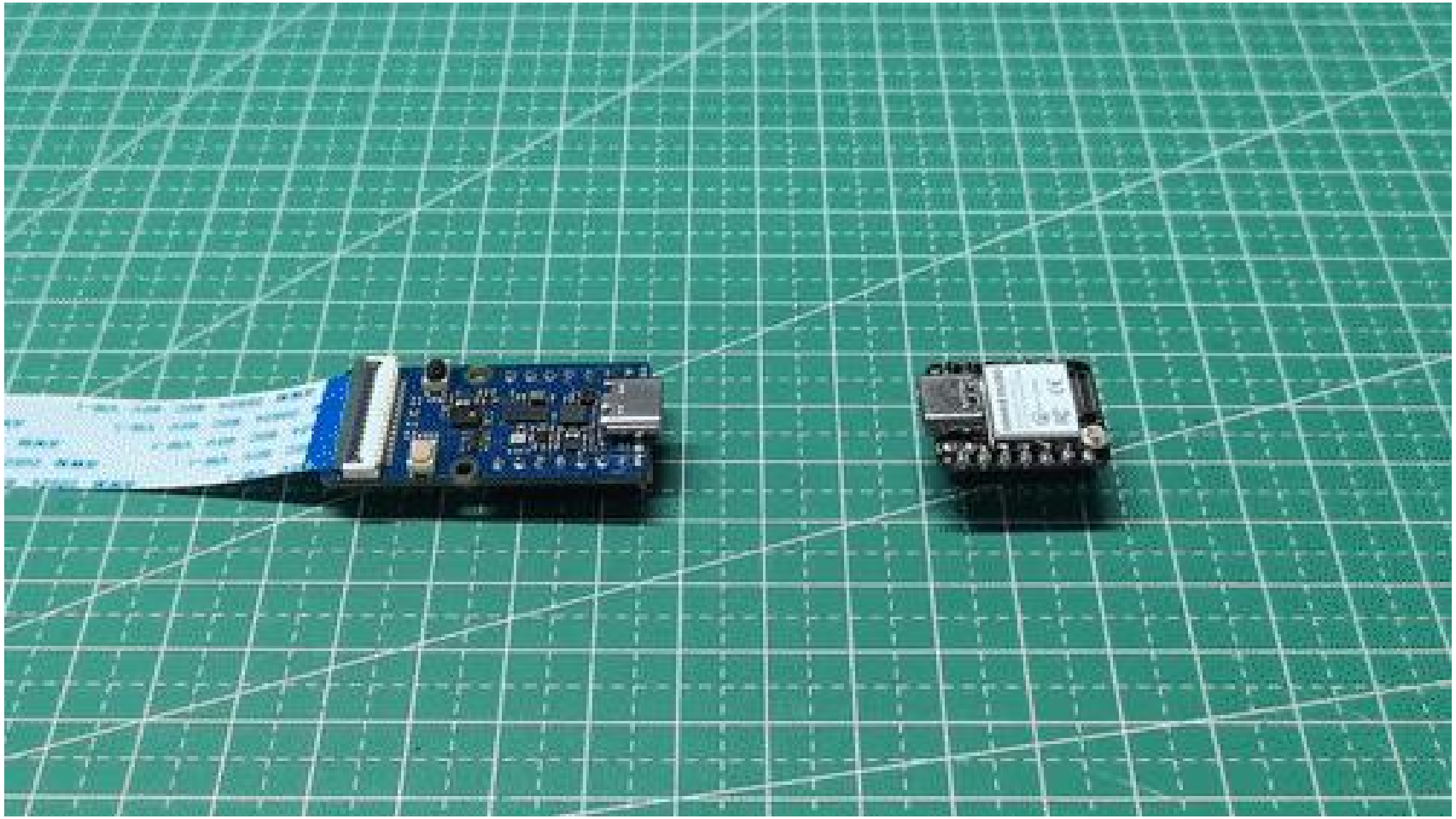
Equipment Introduction & Demonstration



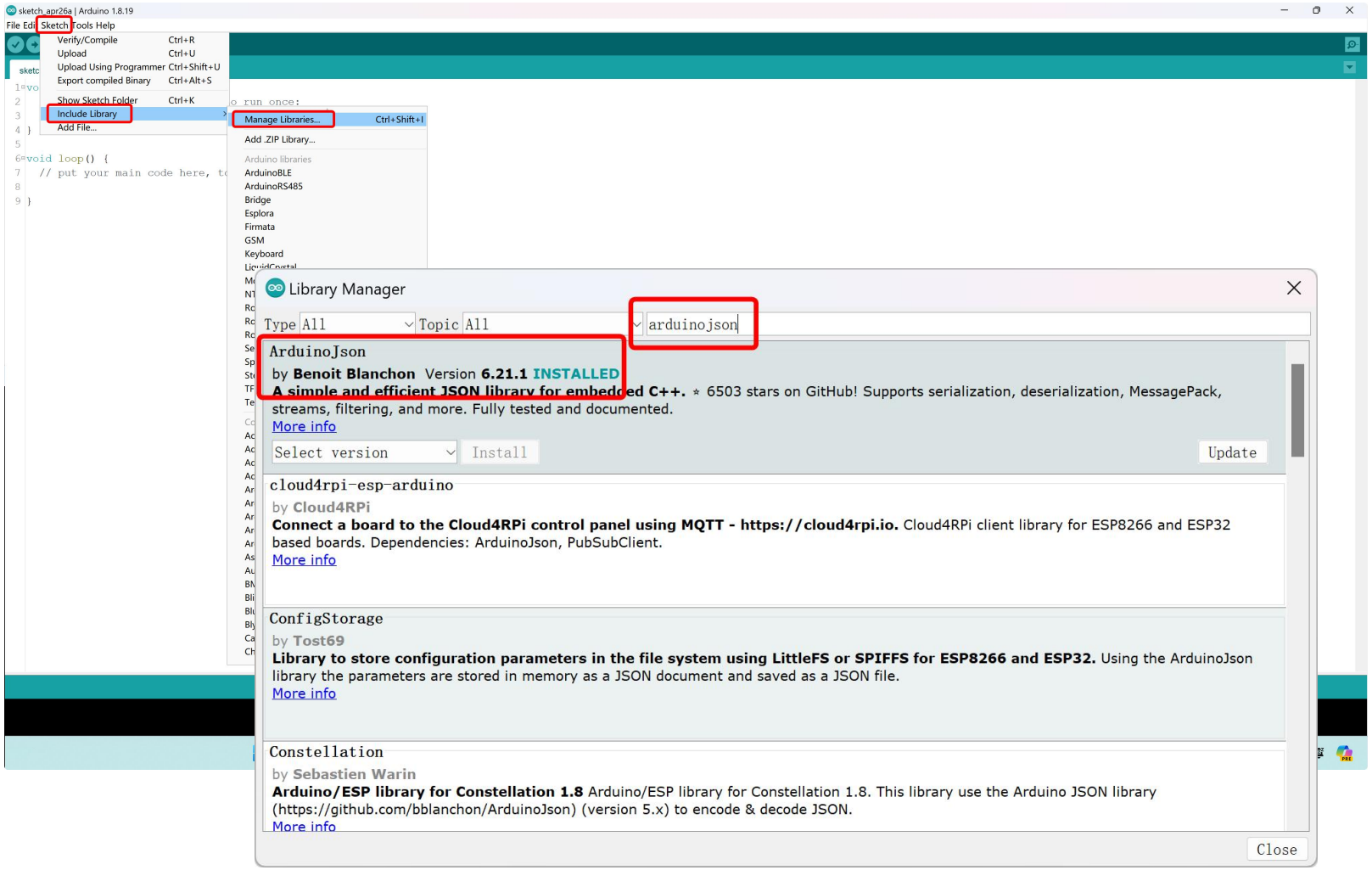
4

MCU + AI Sensors = Unlimited Creative Possibilities

MCU + AI Sensors = Unlimited Creative Possibilities

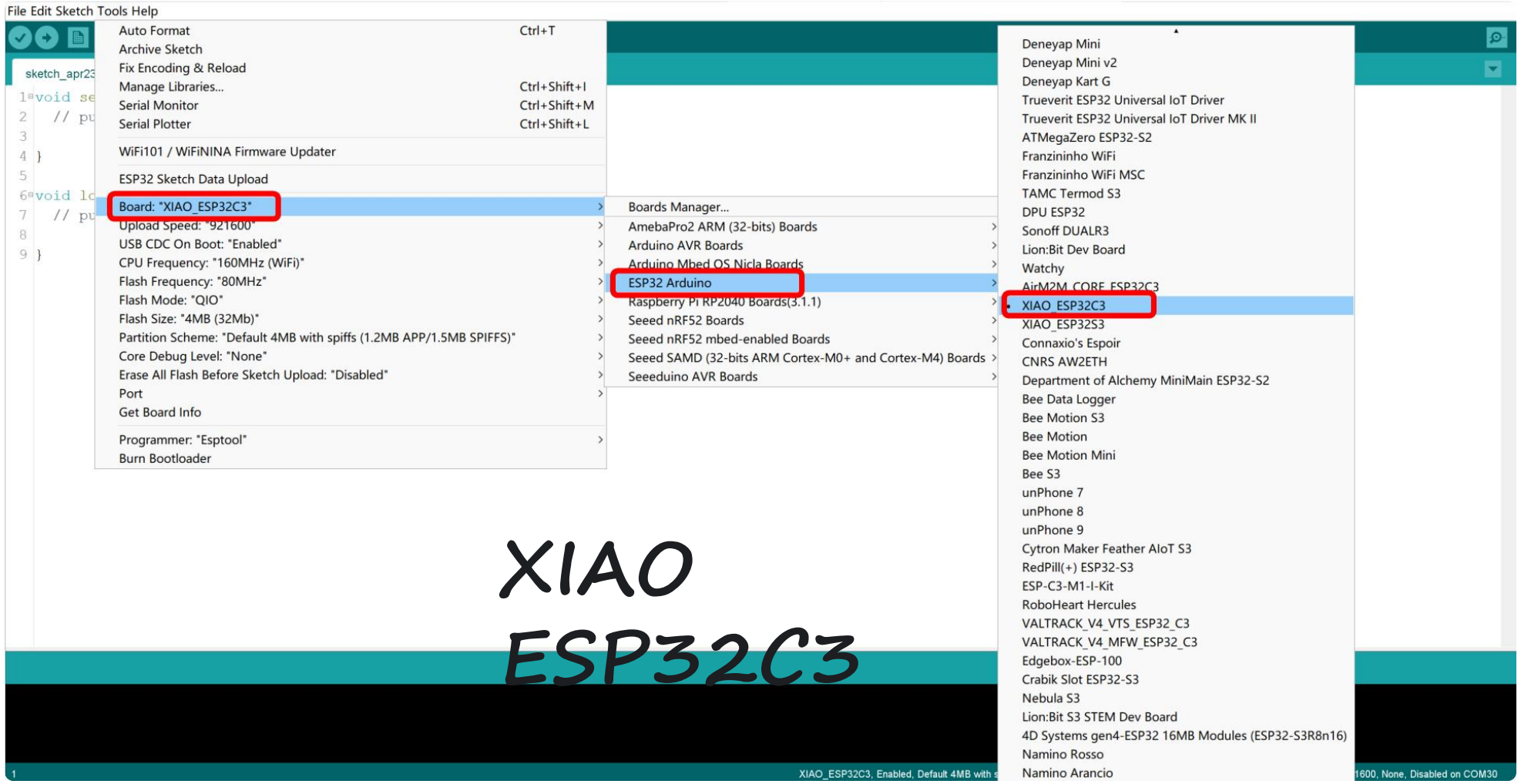


MCU + AI Sensors = Unlimited Creative Possibilities



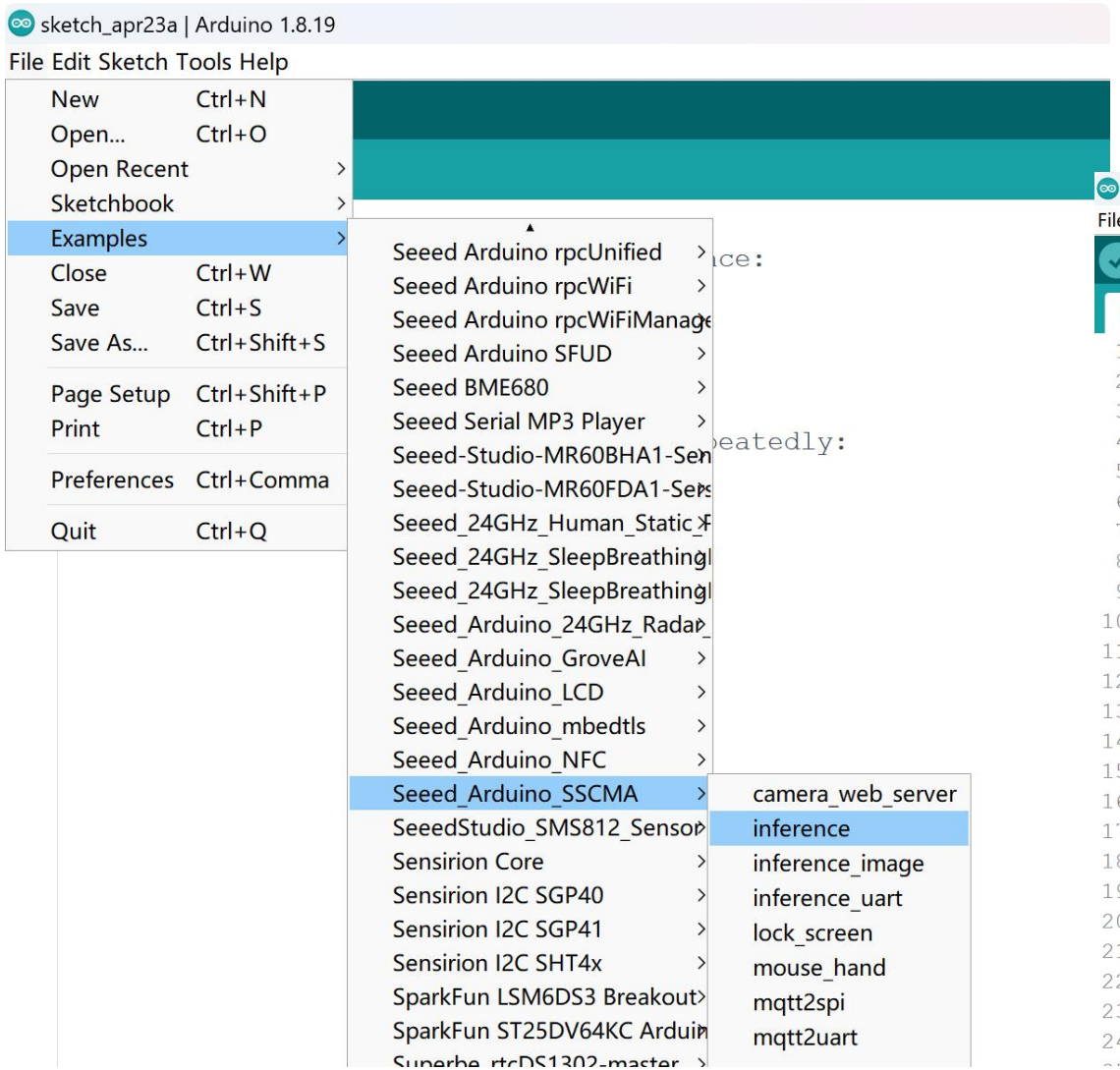
Go to the Sketch menu, then select **Include Library > Manage Libraries...**. This will open the Library Manager. In the search bar at the top of the Library Manager, type in **ArduinoJSON**. The search results will list the ArduinoJSON library. There will be an Install button next to the library. Click the Install button. The Arduino IDE will automatically download and install the library into your Arduino development environment.

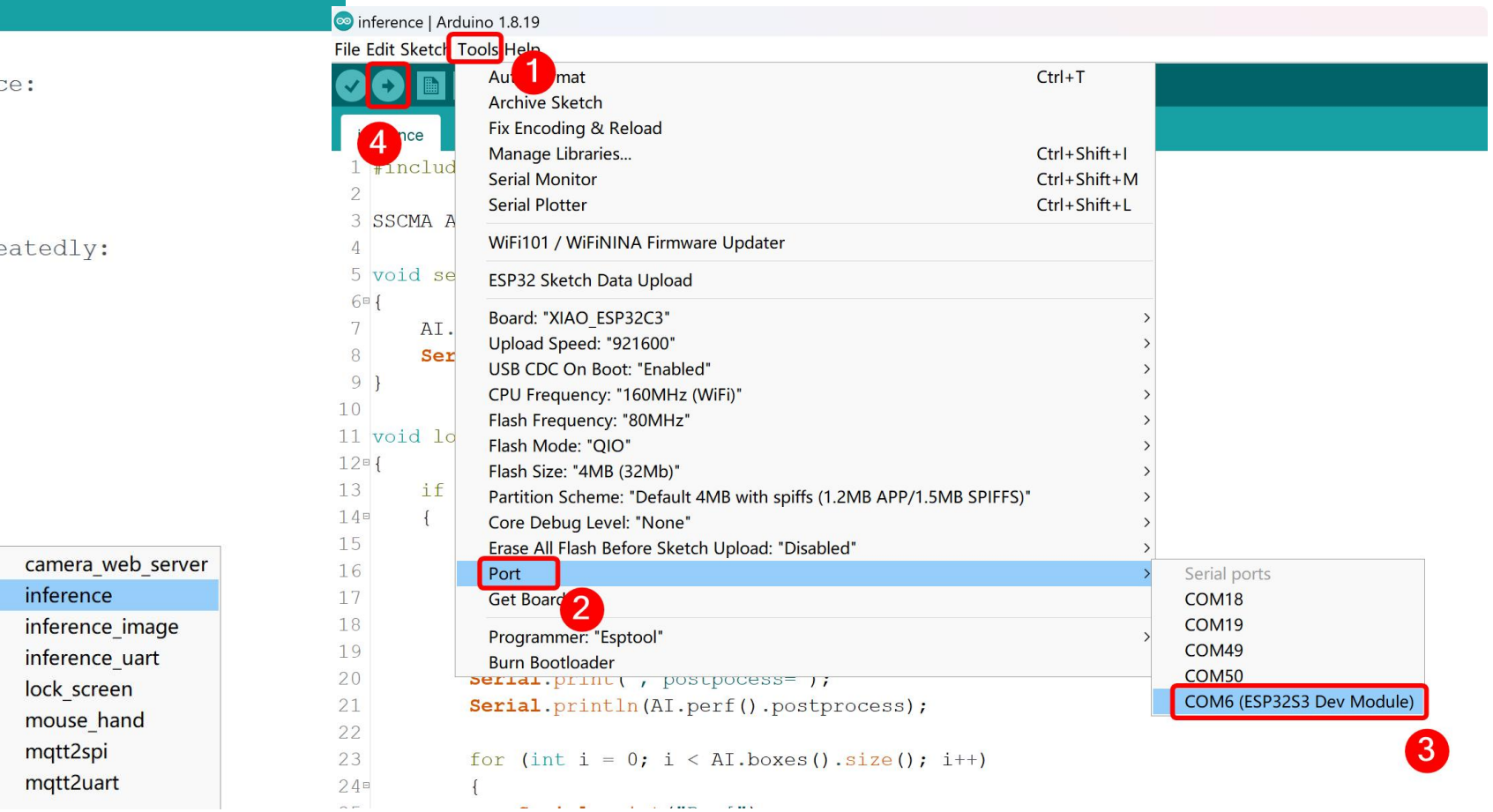
MCU + AI Sensors = Unlimited Creative Possibilities



MCU + AI Sensors = Unlimited Creative Possibilities

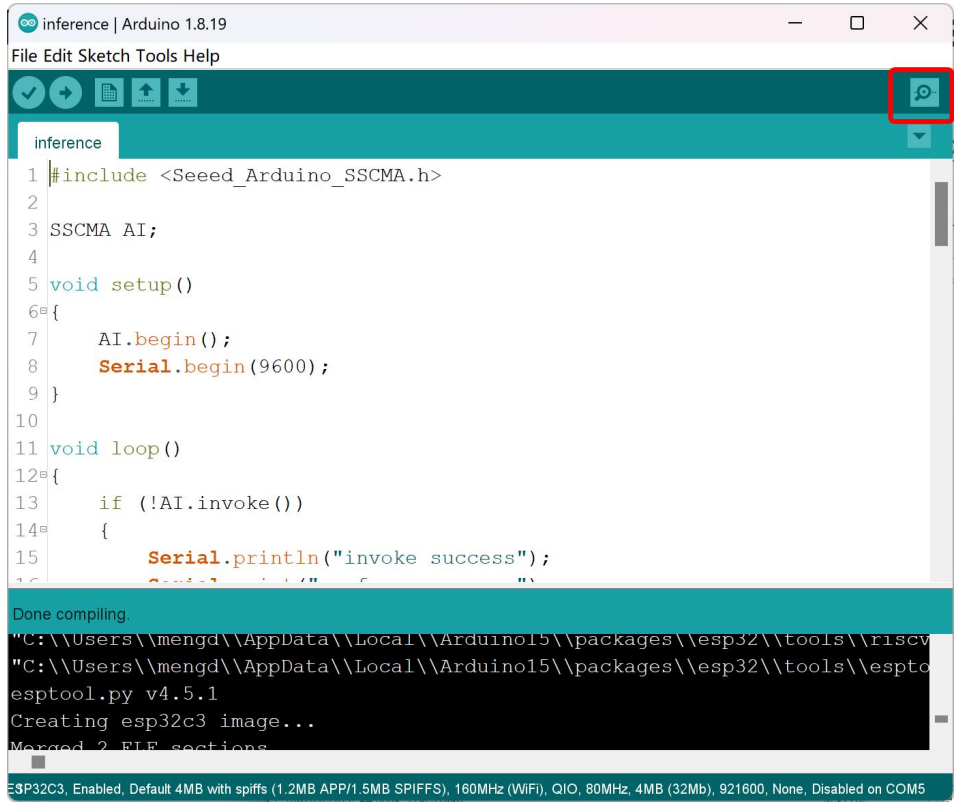
https://wiki.seeedstudio.com/grove_vision_ai_v2_software_support/#demo-1-use-xiao-to-get-recognition-results

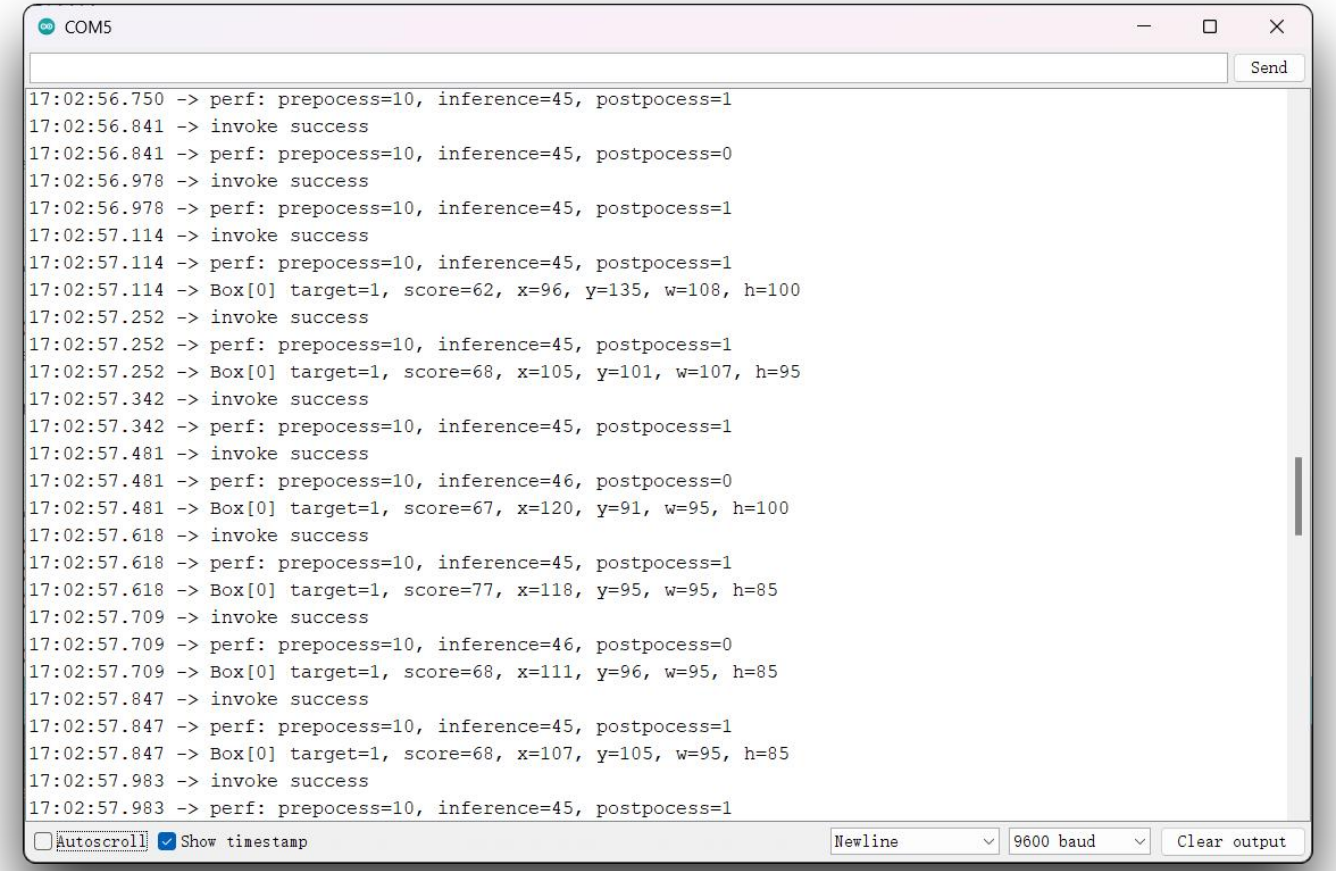




MCU + AI Sensors = Unlimited Creative Possibilities

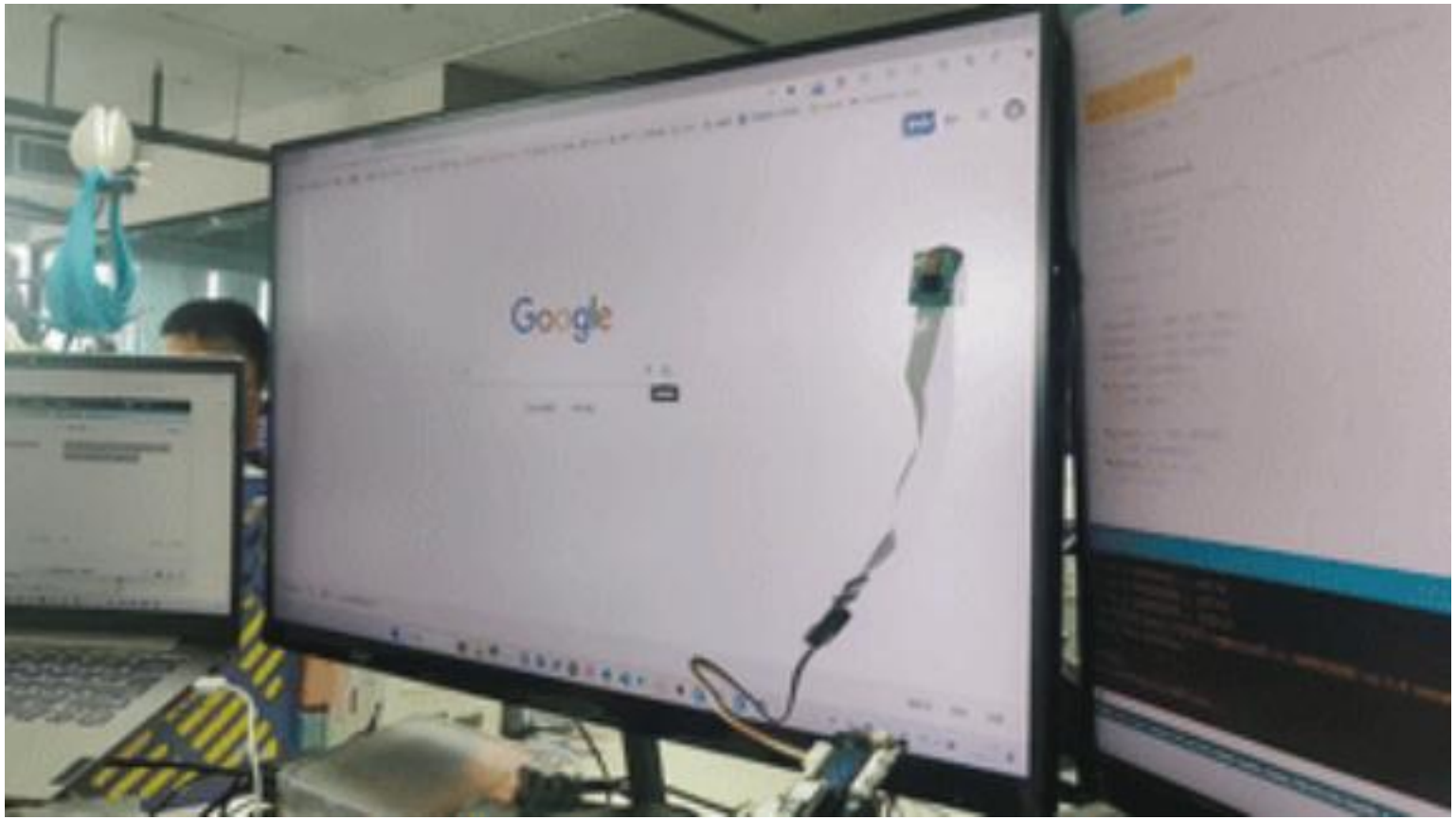
https://wiki.seeedstudio.com/grove_vision_ai_v2_software_support/#demo-1-use-xiao-to-get-recognition-results





MCU + AI Sensors = Unlimited Creative Possibilities

https://wiki.seeedstudio.com/grove_vision_ai_v2_demo/#step-2-xiao-connects-to-the-computer-and-uploads-the-programme-for-xiao-1



MCU + AI Sensors = Unlimited Creative Possibilities

More incredible creations and ideas…

Vision Challenge

Add a smart eye to your XIAO

- 20+ pre-trained models and no code deployment
- Home assistant supported
- Multi-modal with 400+ Grove extensions
- Yolo v5 & v8 33 fps - a gaming-like smooth experience
- Used as a sub-processor dedicated for AI tasks like skeleton detection

JOIN NOW

FREE products & $300+ prizes

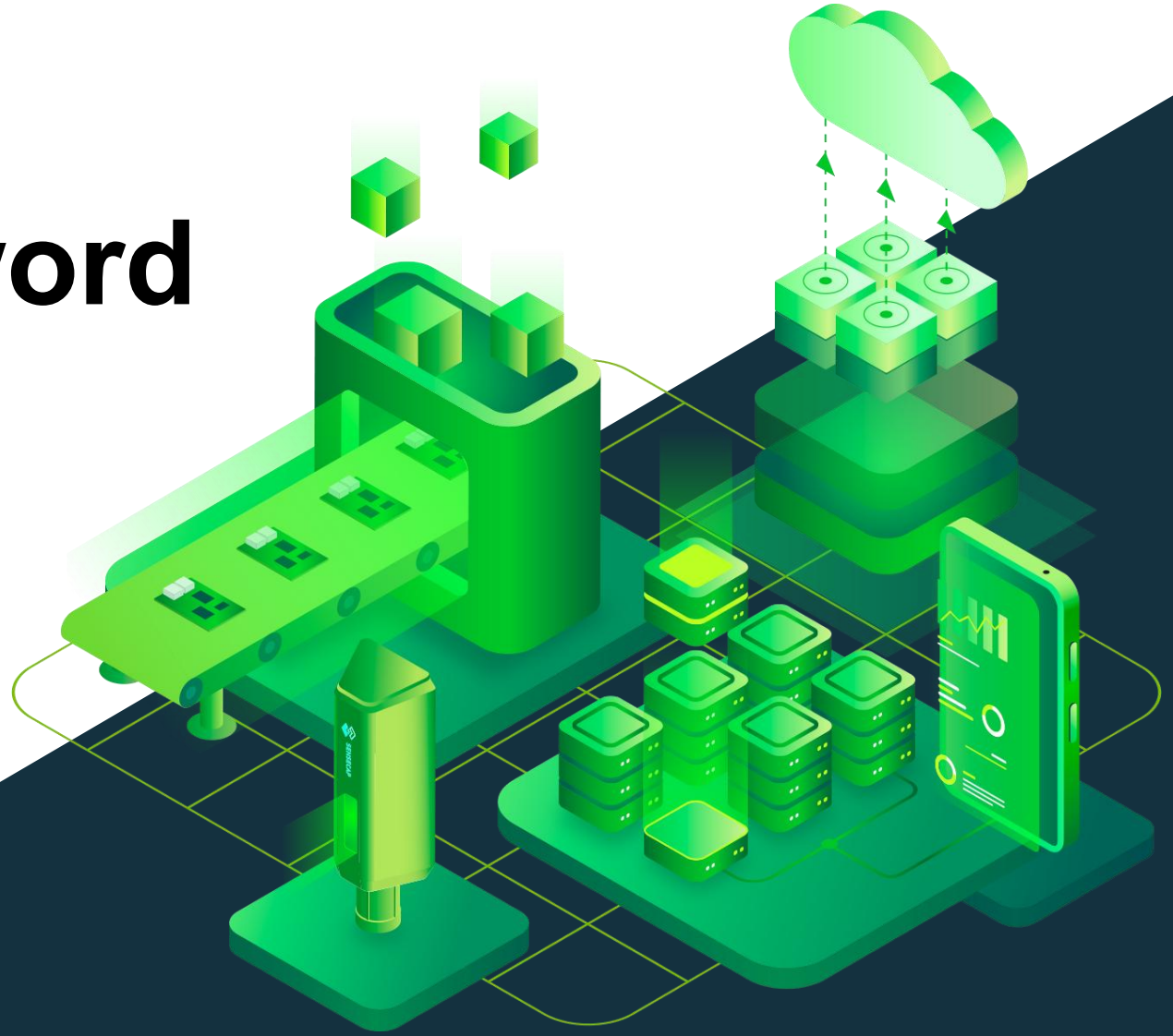
seeed studio

Thanks you!

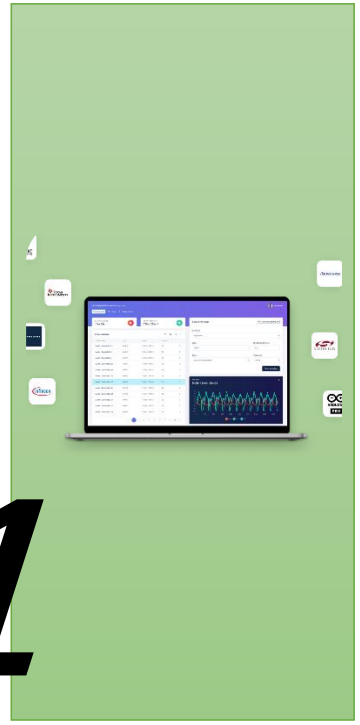
seeed studio

Hands-On Keyword Spotting

ICTP-UNU Workshop on TinyML
for Sustainable Development

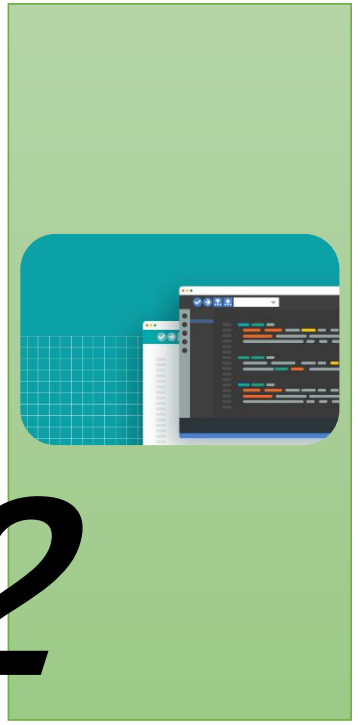


Main Content



1

Edge Impulse & XIAO ESP32S3 Sense Introduction



2

Recording Audio with XIAO ESP32S3 Sense

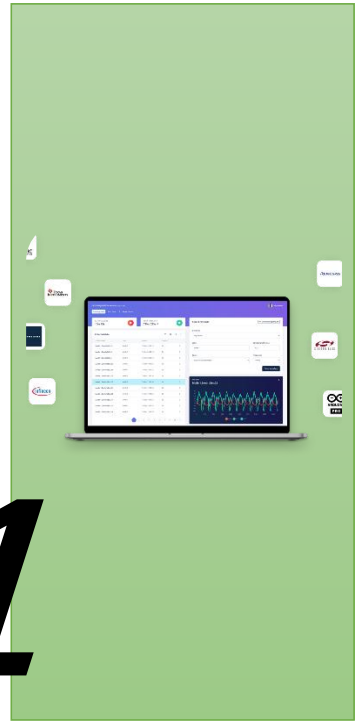
3

Training Exported Models with Edge Impulse

4

Deploying models to XIAO ESP32S3 Sense

Main Content



1

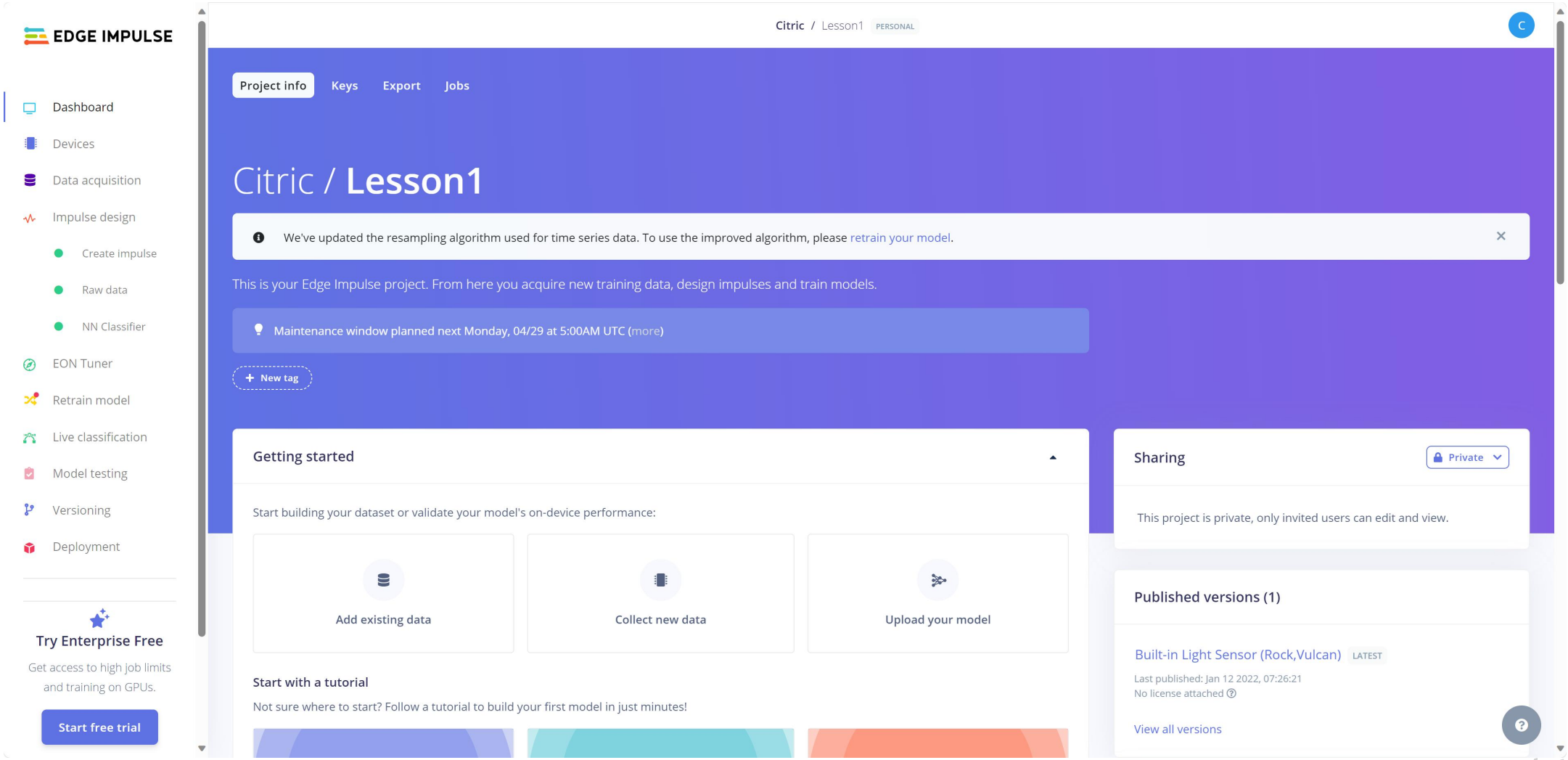
Edge Impulse &
XIAO ESP32S3 Sense
Introduction

Edge Impulse & XIAO ESP32S3 Sense Introduction

Edge Impulse is a platform for developing machine learning models specifically designed for edge devices and embedded systems. It provides a comprehensive set of tools and services that enable developers to quickly create, train, and deploy machine learning models without requiring deep expertise in machine learning.

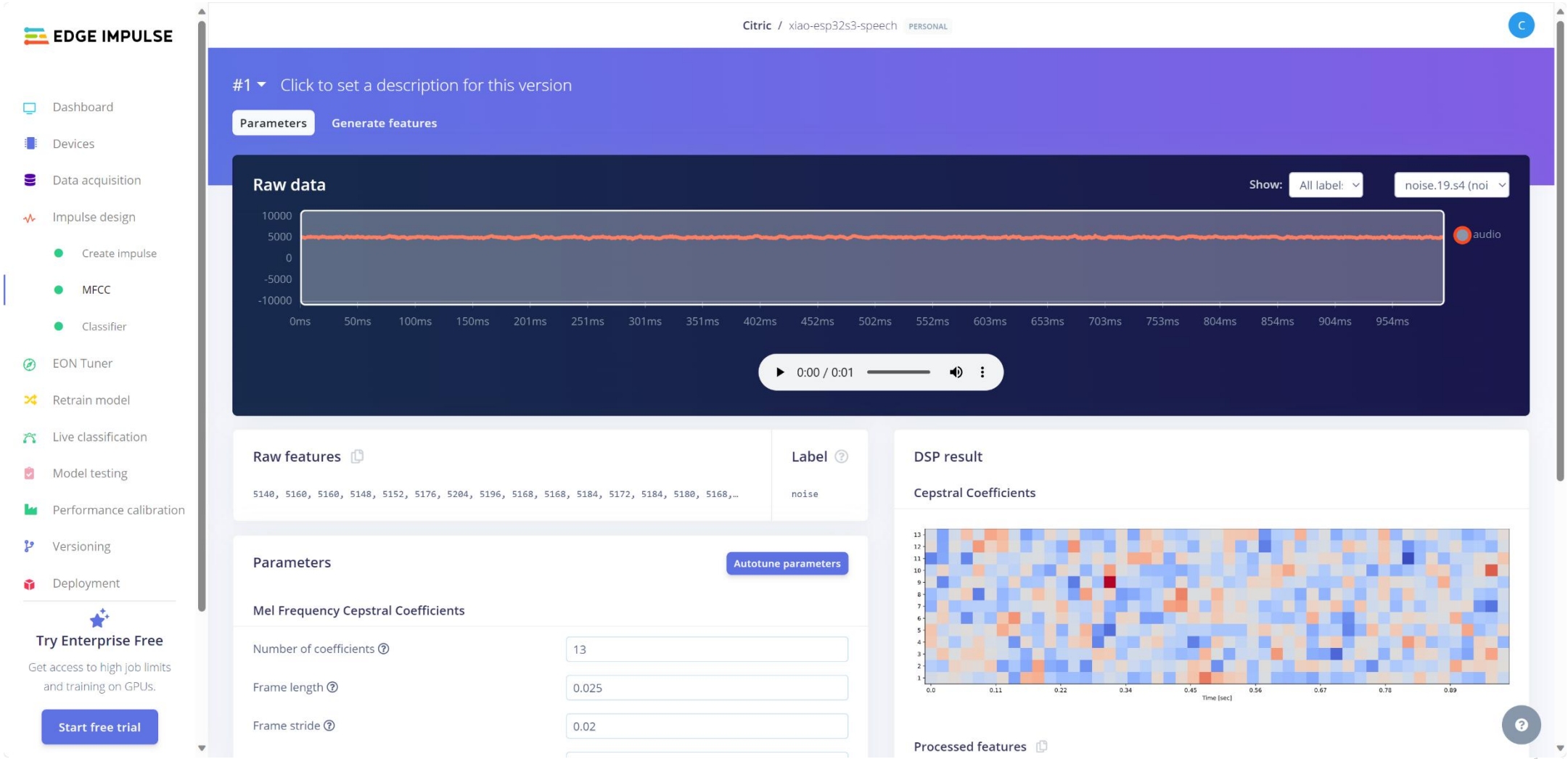
Edge Impulse & XIAO ESP32S3 Sense Introduction

Data acquisition and management



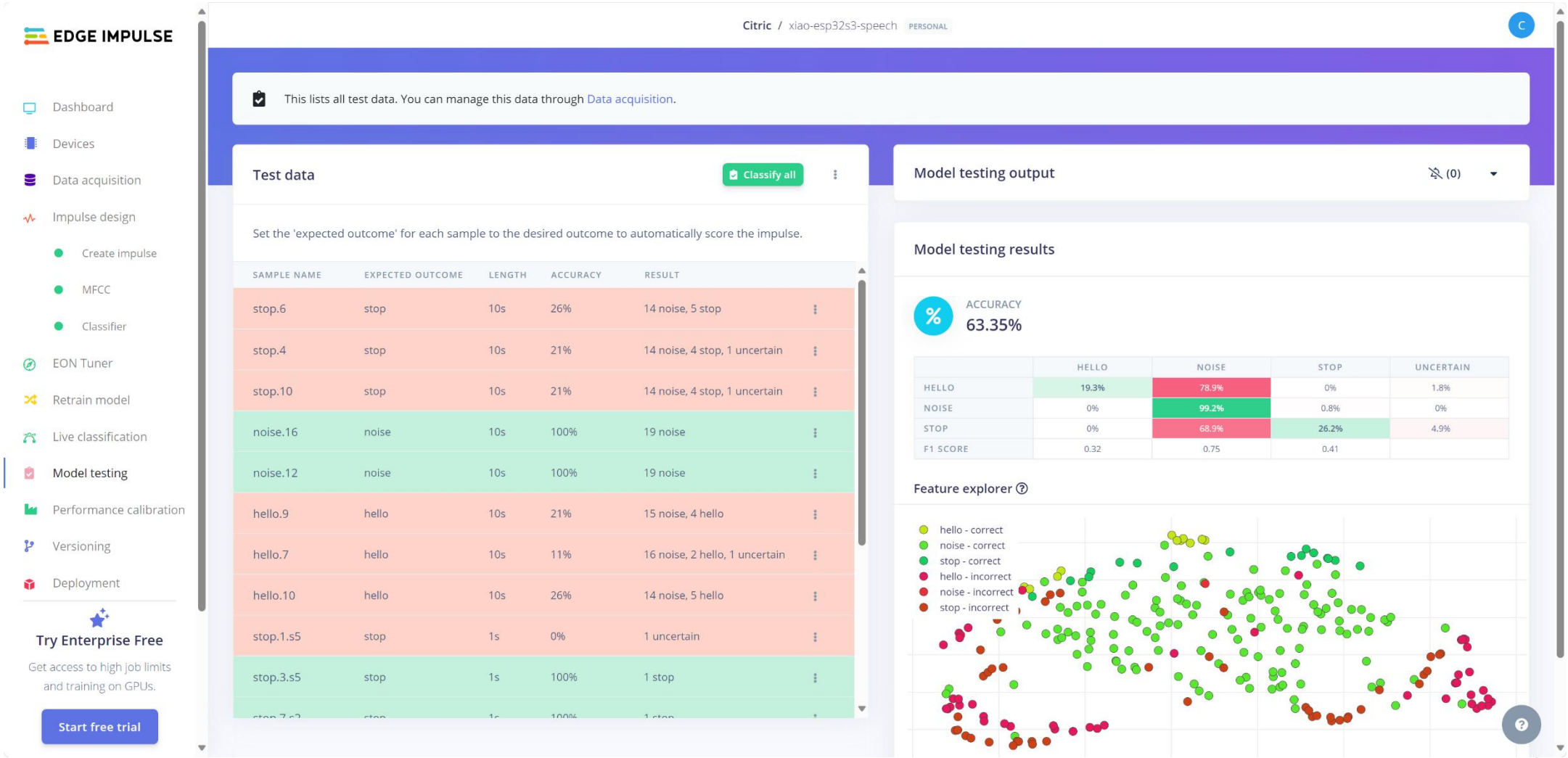
Edge Impulse & XIAO ESP32S3 Sense Introduction

Data processing and feature extraction



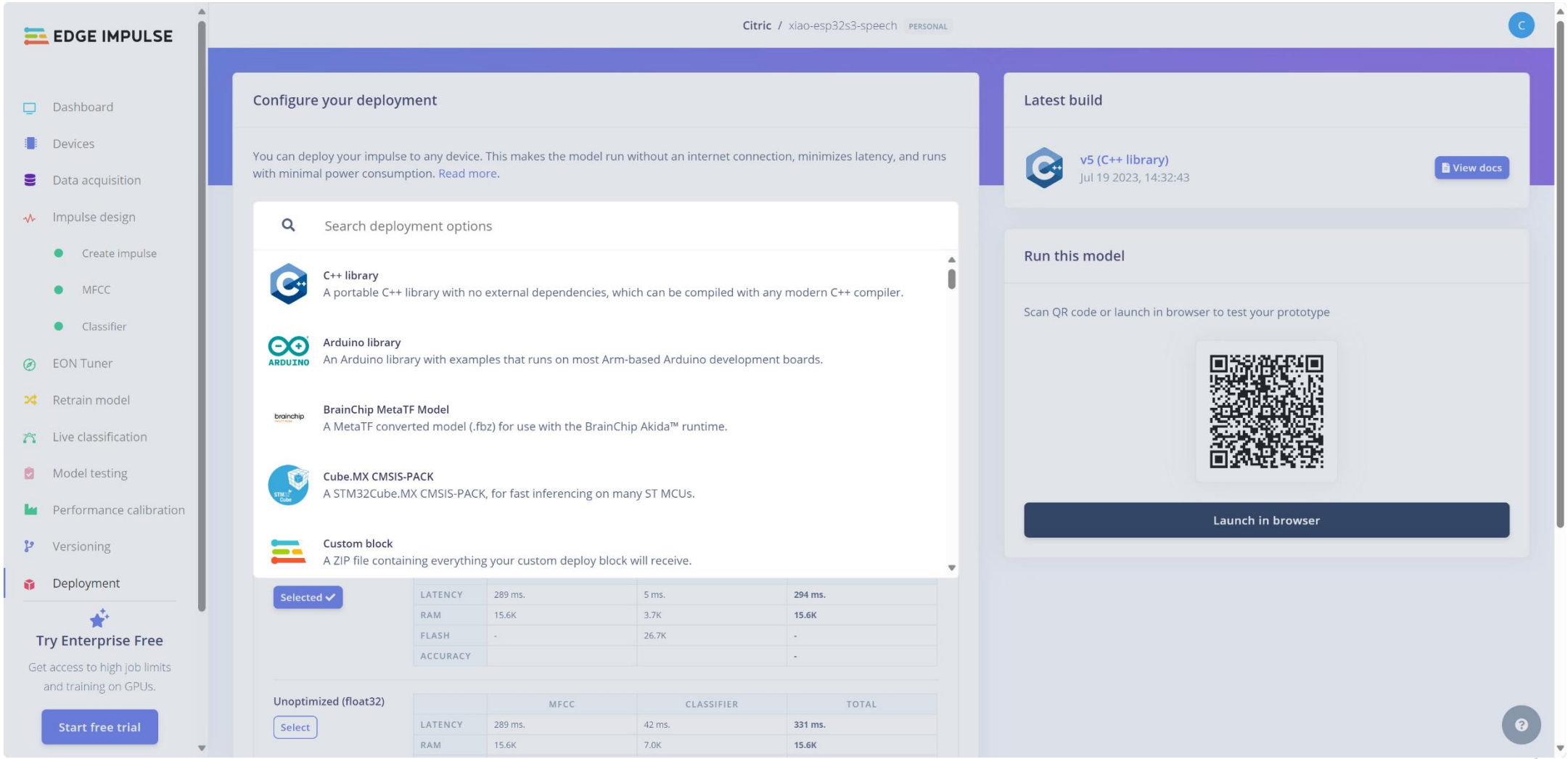
Edge Impulse & XIAO ESP32S3 Sense Introduction

Model training and optimization



Edge Impulse & XIAO ESP32S3 Sense Introduction

Model deployment and integration



Edge Impulse & XIAO ESP32S3 Sense Introduction

Seeed Studio XIAO ESP32S3 Sense

Ultra-small ESP32-S3 development board with OV2640 camera, a risging star in the fields of TinyML and Smart Home

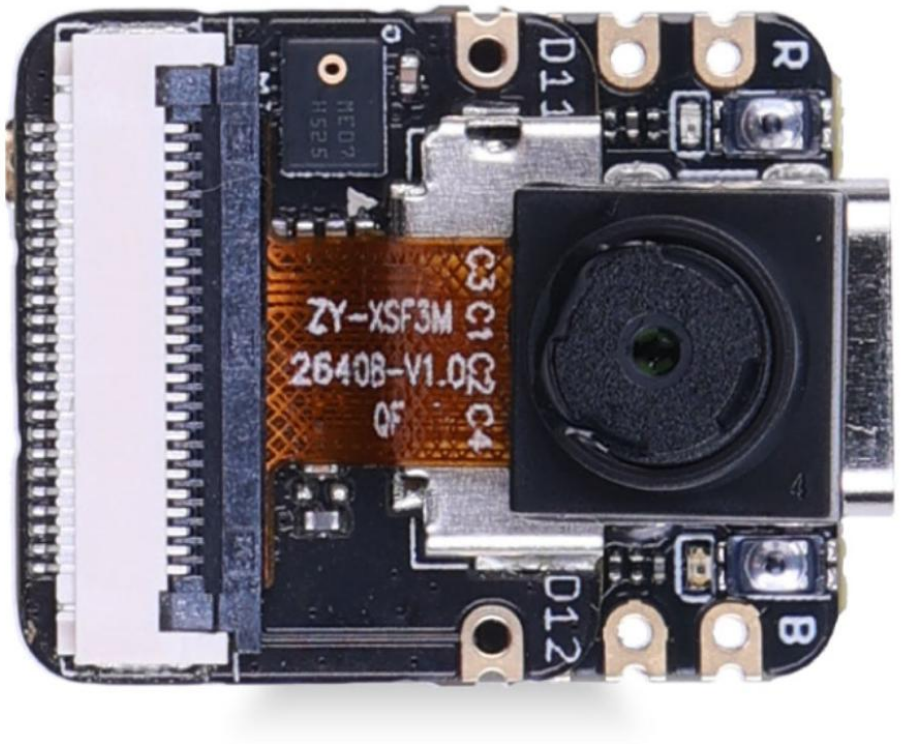
HIGH-PERFORMANCE
240MHz Xtensa 32-bit LX7 dual-core processor

MEMORY
8MB PSRAM + 8MB FLASH

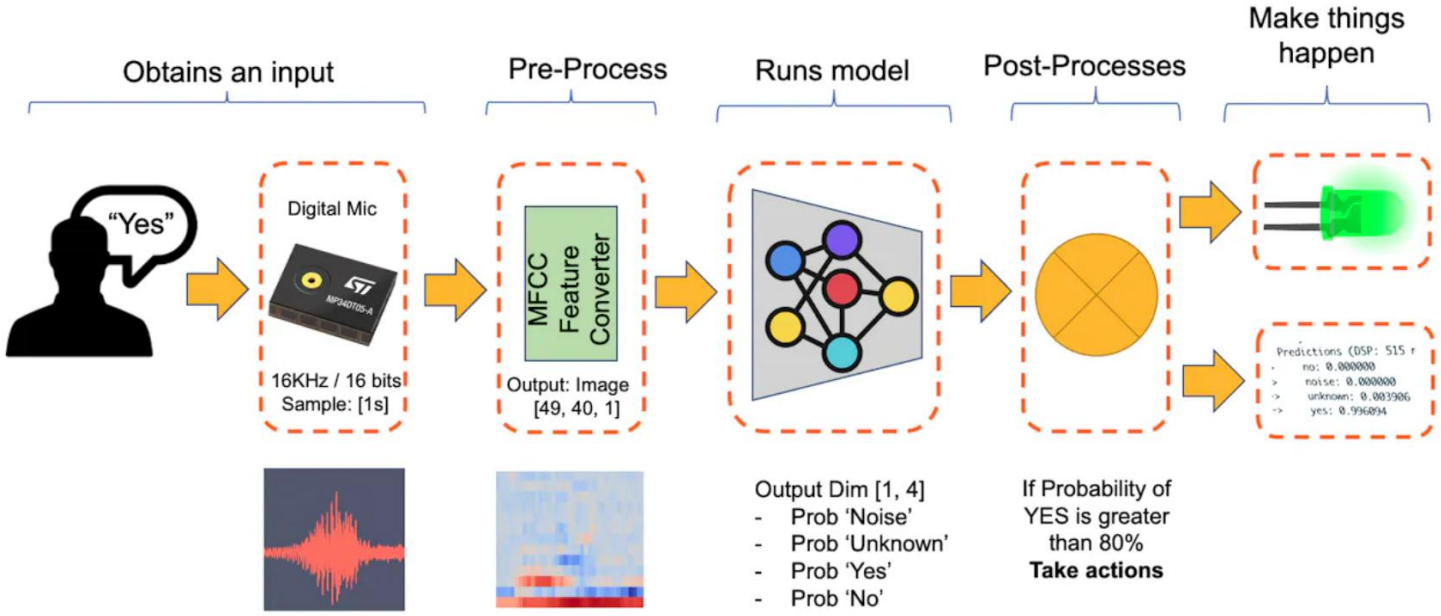
MULTI-FUNCTIONAL
Microphone/SD card slot/Detachable OV2640

WIRELESS
2.4GHz WiFi and BLE 5

TINYML-SUPPORTED
Image Processing/Speech Recognition



Edge Impulse & XIAO ESP32S3 Sense Introduction

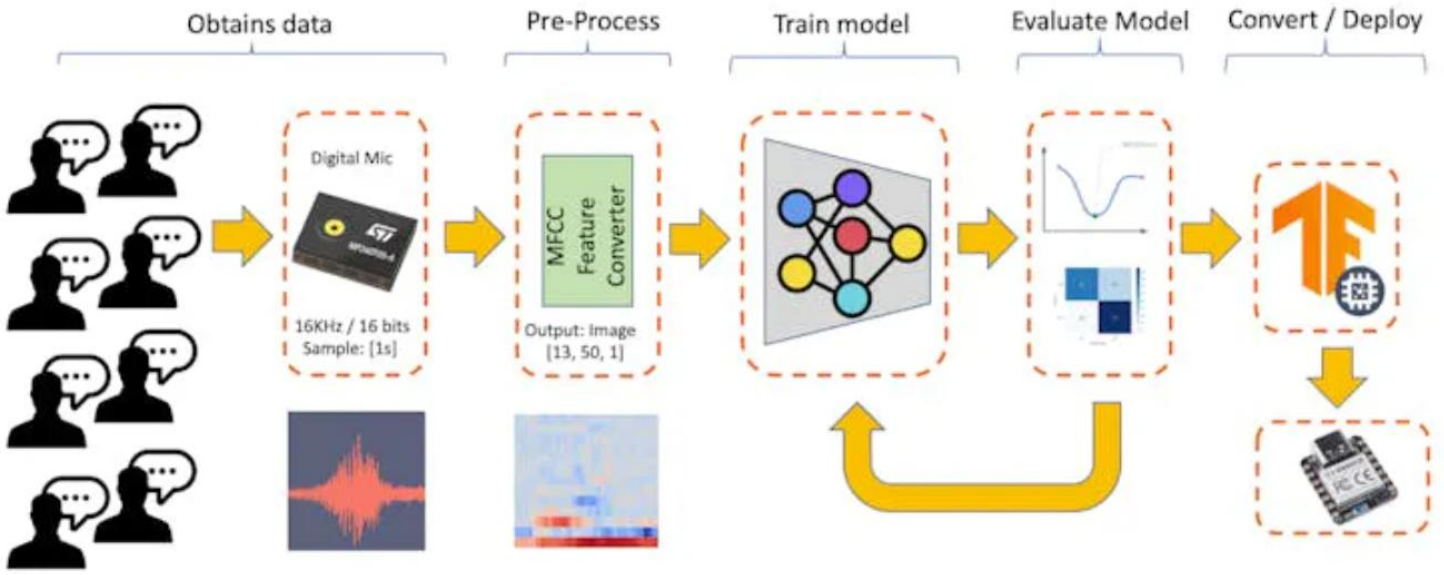


The principle of keyword spotting is based on machine learning and speech recognition technologies. First, a training dataset containing samples of keywords and non-keywords is constructed. The audio data is preprocessed and features are extracted to convert it into a suitable input format for machine learning models.

Next, the keyword detection model is trained using the training dataset. The model learns to distinguish between keyword and non-keyword samples by establishing a discriminative decision boundary. Common model architectures include CNN, RNN, and DNN, which effectively capture temporal and frequency features in speech signals.

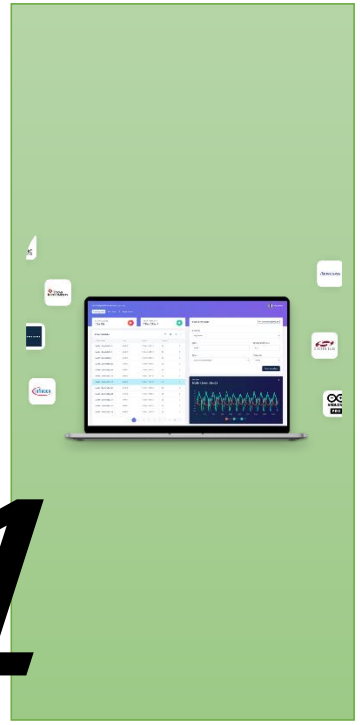
During the inference stage, the pre-trained keyword detection model takes the real-time recorded audio data as input, extracts features, and performs classification. If the model's output probability exceeds a set threshold, it is considered that the keyword has been detected, triggering the wake-up mechanism of the voice assistant.

Edge Impulse & XIAO ESP32S3 Sense Introduction



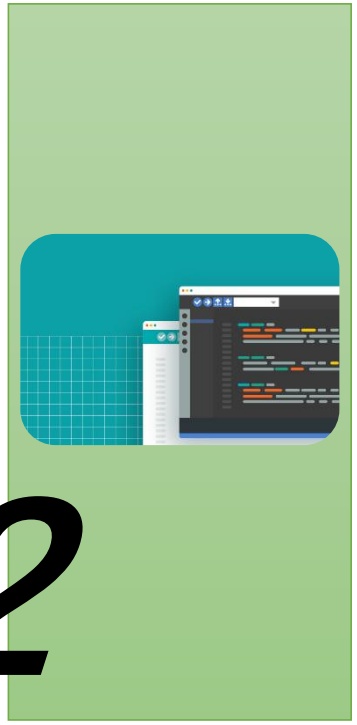
Data Acquisition: The device's microphone continuously records audio data and transmits it to the keyword detection module.
Preprocessing: The recorded audio data undergoes preprocessing, including noise reduction, silence removal, normalization, etc., to improve audio quality and reduce the impact of noise.
Feature Extraction: The preprocessed audio data is converted into a feature representation suitable for machine learning models. Common feature extraction methods include Mel-Frequency Cepstral Coefficients (MFCC) and Mel-Frequency Energy (MFE).
Keyword Detection: A pre-trained keyword detection model is used to classify the extracted features and determine whether the current audio data contains the keyword. Popular keyword detection models include Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Deep Neural Networks (DNN).
Post-processing: The results of keyword detection are post-processed, such as setting thresholds and smoothing, to improve detection accuracy and stability.
Wake-up: If the keyword is detected, the wake-up mechanism of the voice assistant is triggered, and subsequent voice commands are transmitted to the cloud for further processing.

Main Content



1

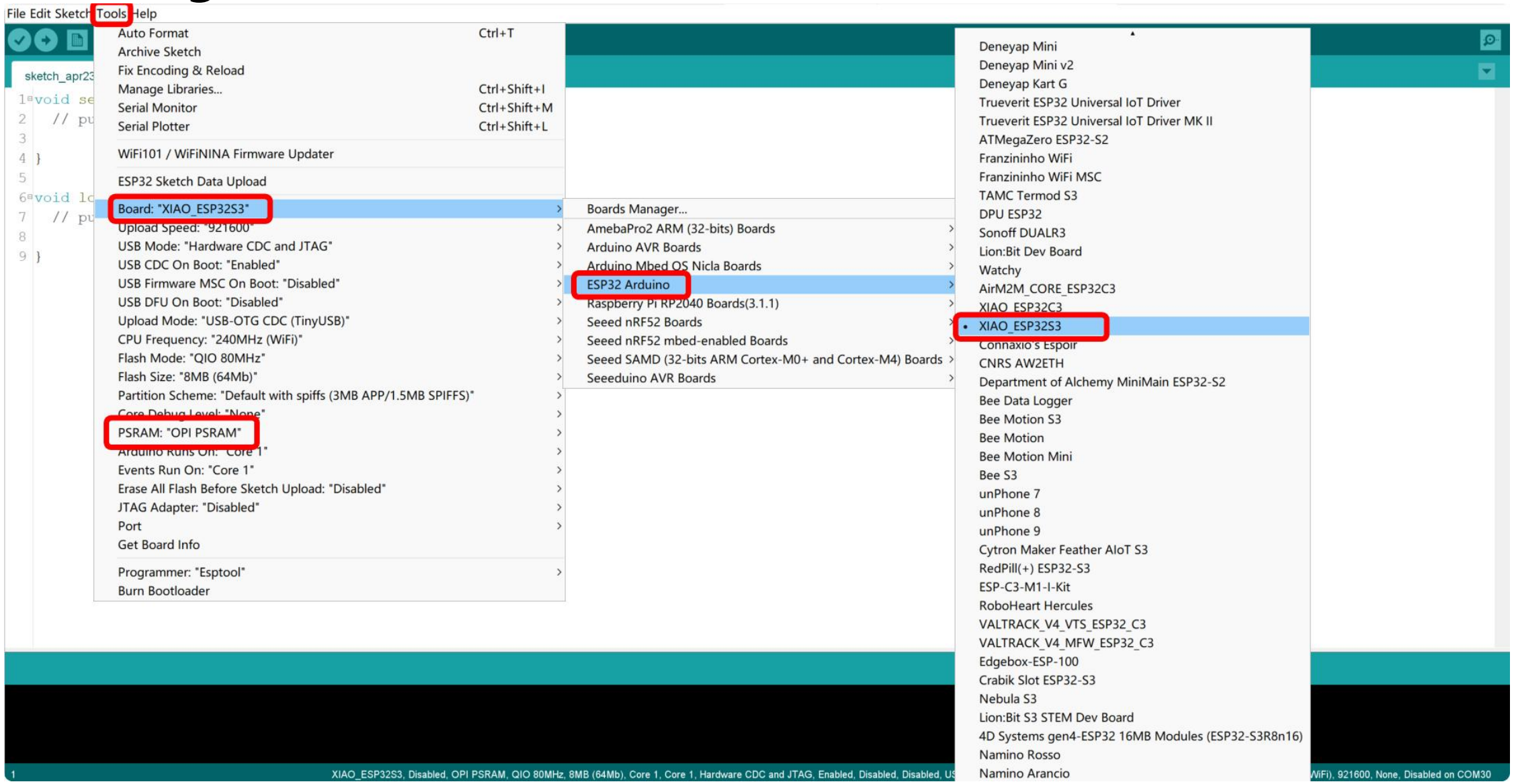
Edge Impulse &
XIAO ESP32S3 Sense
Introduction



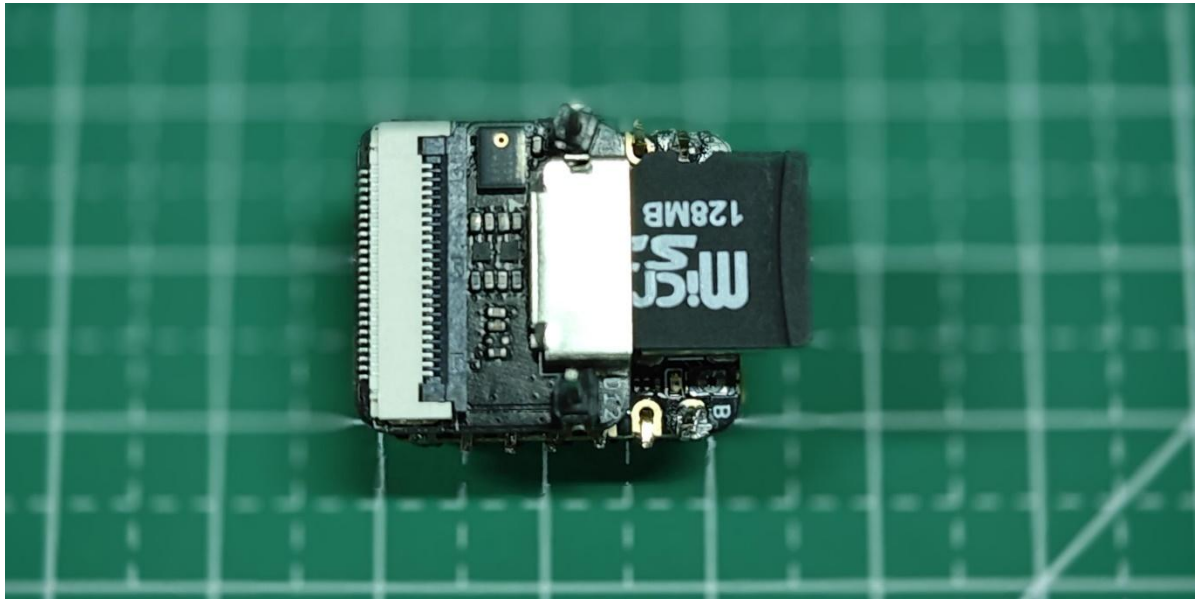
2

Recording Audio
with XIAO ESP32S3
Sense

Recording Audio with XIAO ESP32S3 Sense



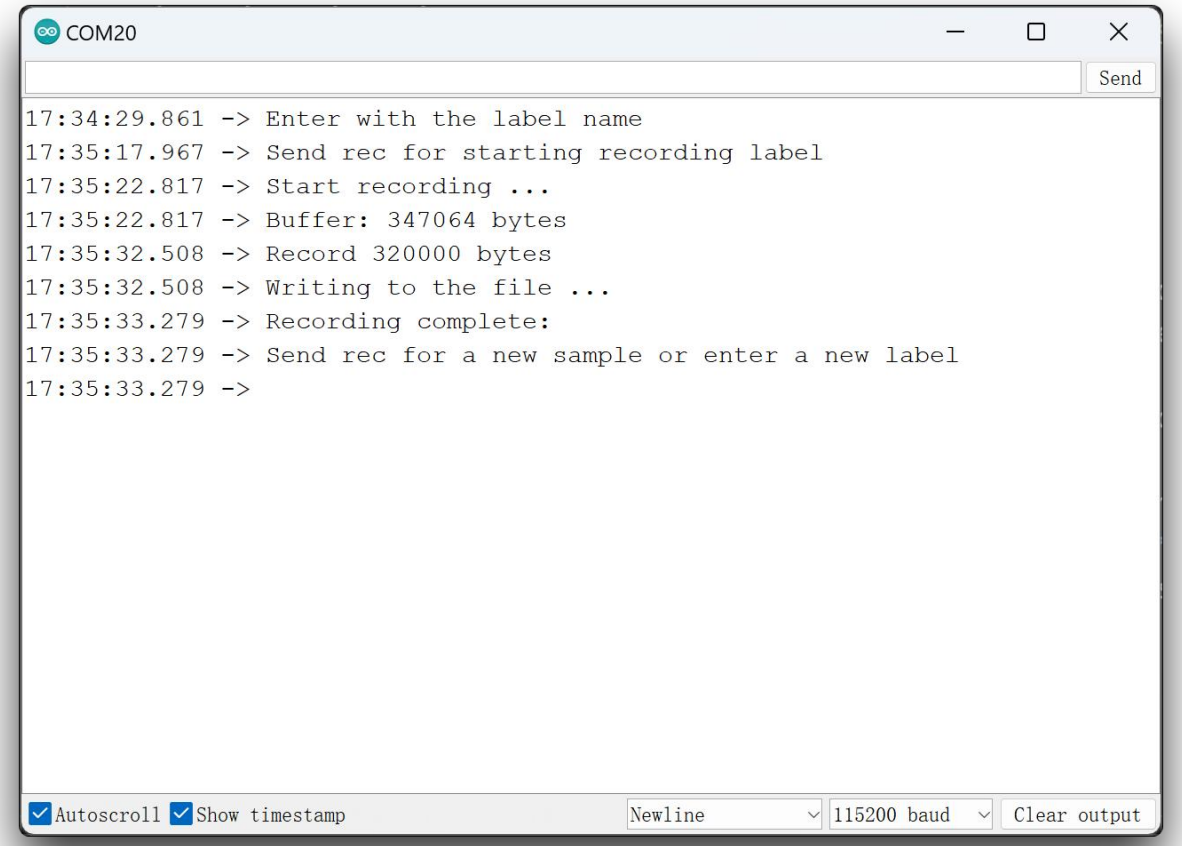
Recording Audio with XIAO ESP32S3 Sense



Insert the microSD card into the microSD card slot. Please note the direction of insertion, the side with the gold finger should face inward.

Recording Audio with XIAO ESP32S3 Sense

https://wiki.seeedstudio.com/tinyml_course_Key_Word_Spotting/#step-1-save-recorded-sound-samples-as-wav-audio-files-to-a-microsd-card



Now, upload the code to the XIAO and get samples from the keywords (hello and stop). You can also capture noise and other words. The Serial monitor will prompt you to receive the label to be recorded.

Send the label (for example, hello). The program will wait for another command: rec.

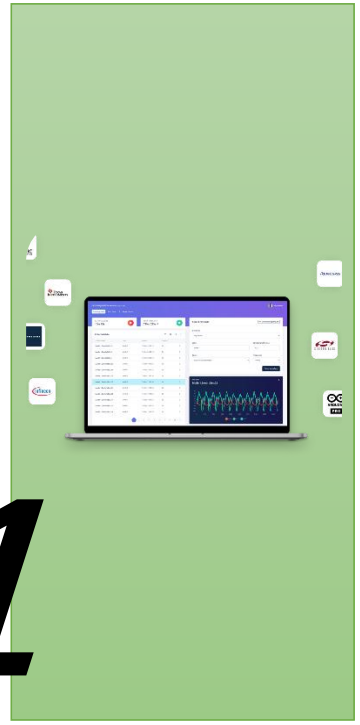
And the program will start recording new samples every time a command rec is sent. The files will be saved as hello.1.wav, hello.2.wav, hello.3.wav, etc. until a new label (for example, stop) is sent. In this case, you should send the command rec for each new sample, which will be saved as stop.1.wav, stop.2.wav, stop.3.wav, etc.

Ultimately, we will get the saved files on the SD card.

Recording Audio with XIAO ESP32S3 Sense

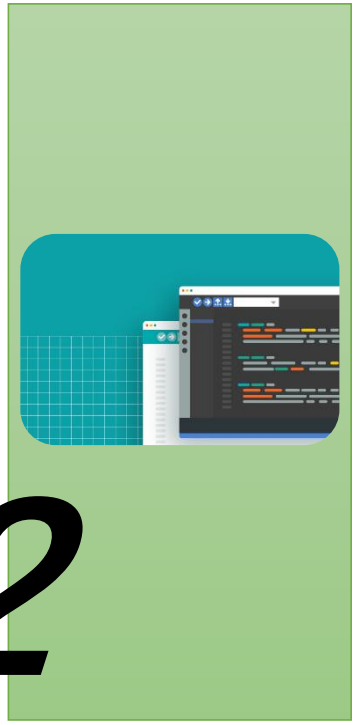
Use a card reader to save all the sound samples stored inside the SD card to your computer.

Main Content



1

Edge Impulse & XIAO ESP32S3 Sense Introduction



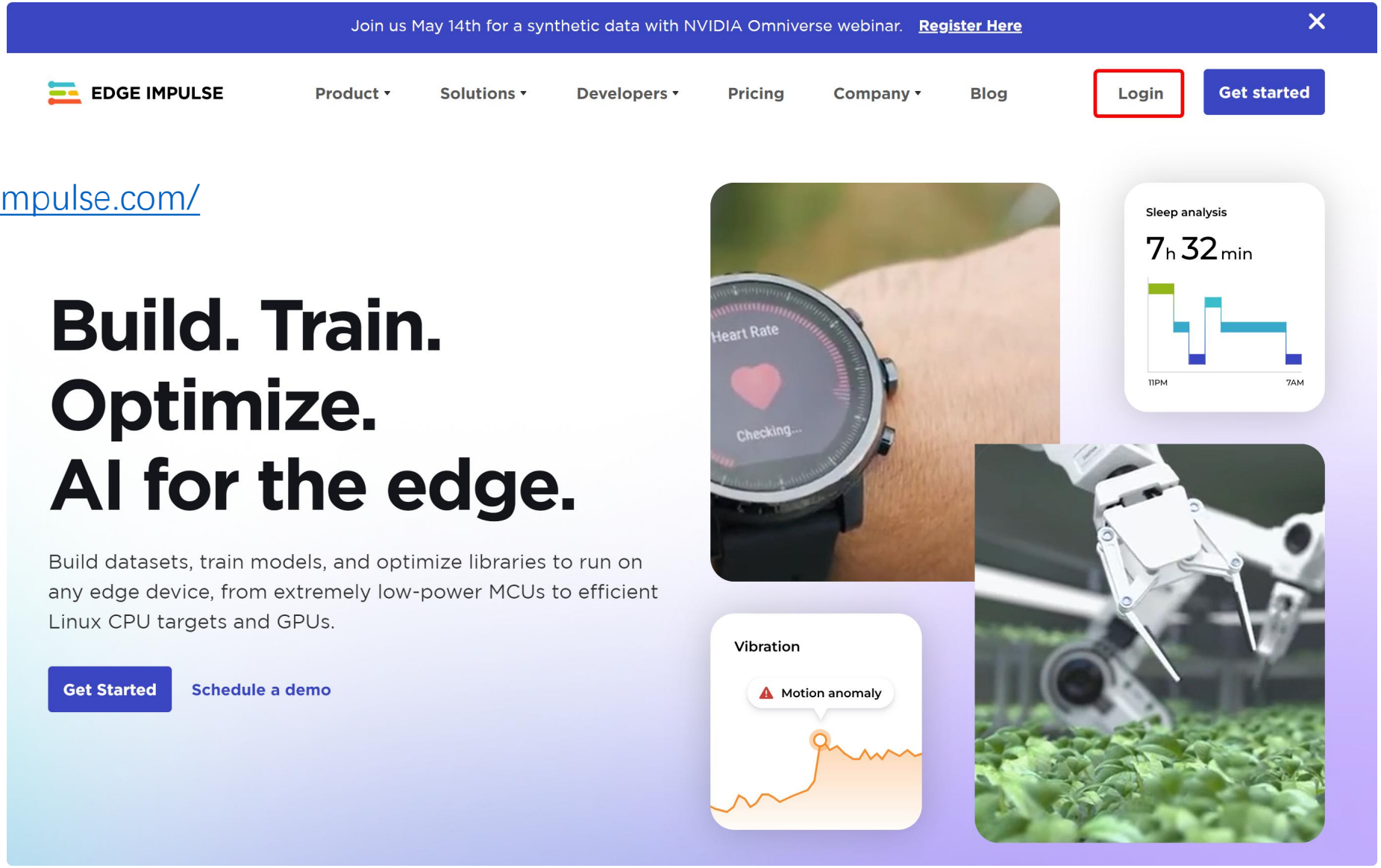
2

Recording Audio with XIAO ESP32S3 Sense

3

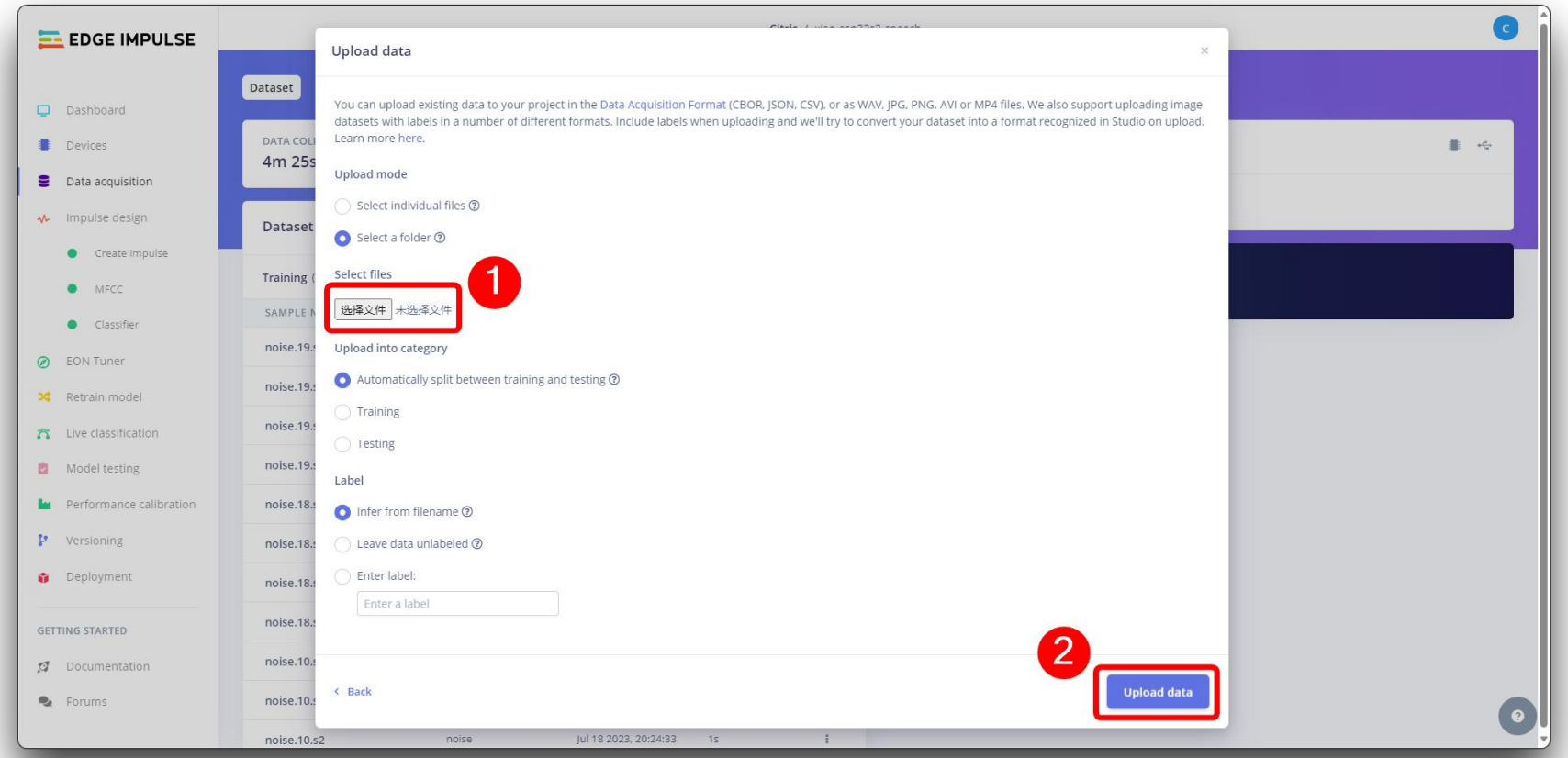
Training Exported Models with Edge Impulse

Training Exported Models with Edge Impulse



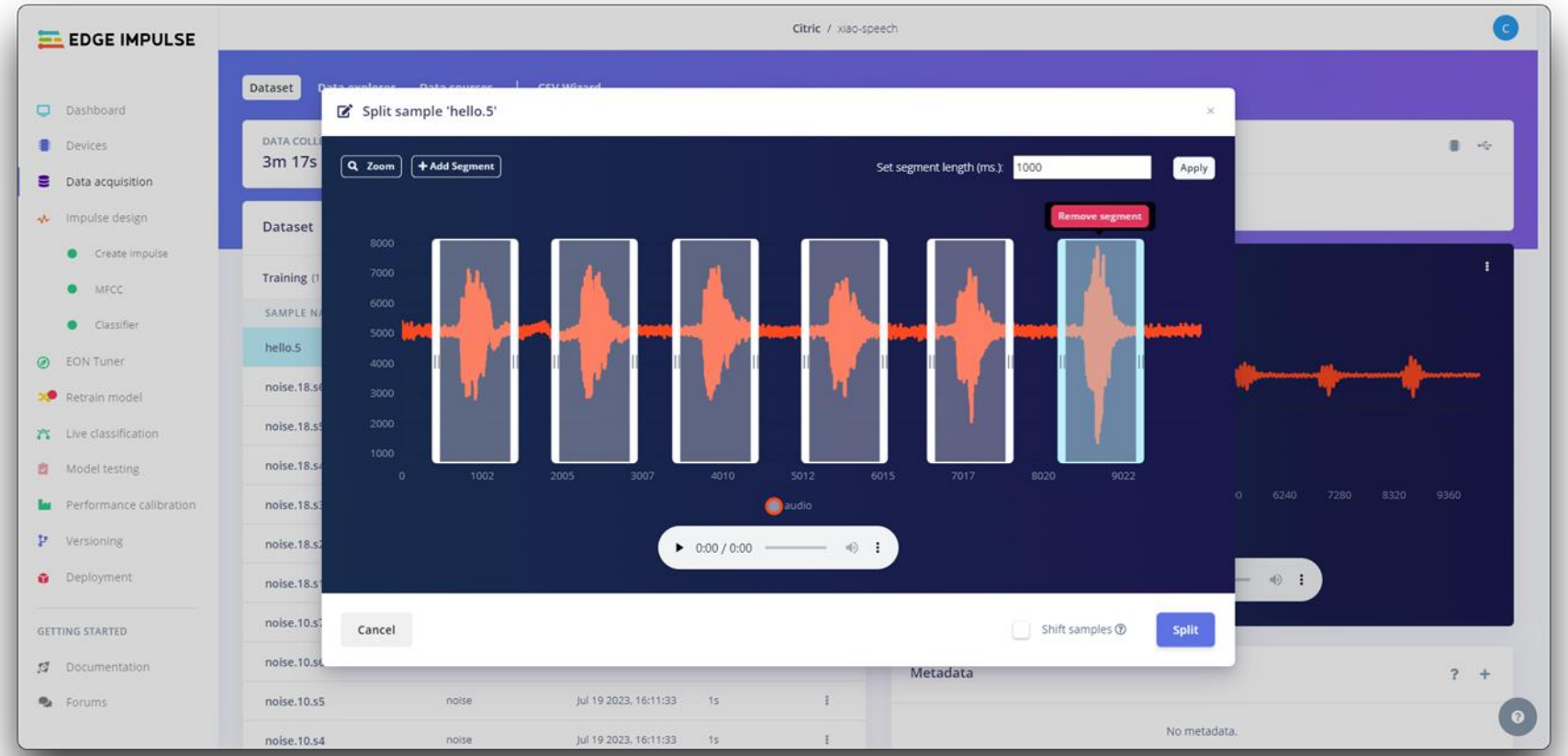
https://edgeimpulse.com/

Training Exported Models with Edge Impulse



When the raw dataset is defined and collected, we should initiate a new project at Edge Impulse. Once the project is created, select the **Upload Existing Data** tool in the **Data Acquisition** section. Choose the files to be uploaded.

Training Exported Models with Edge Impulse

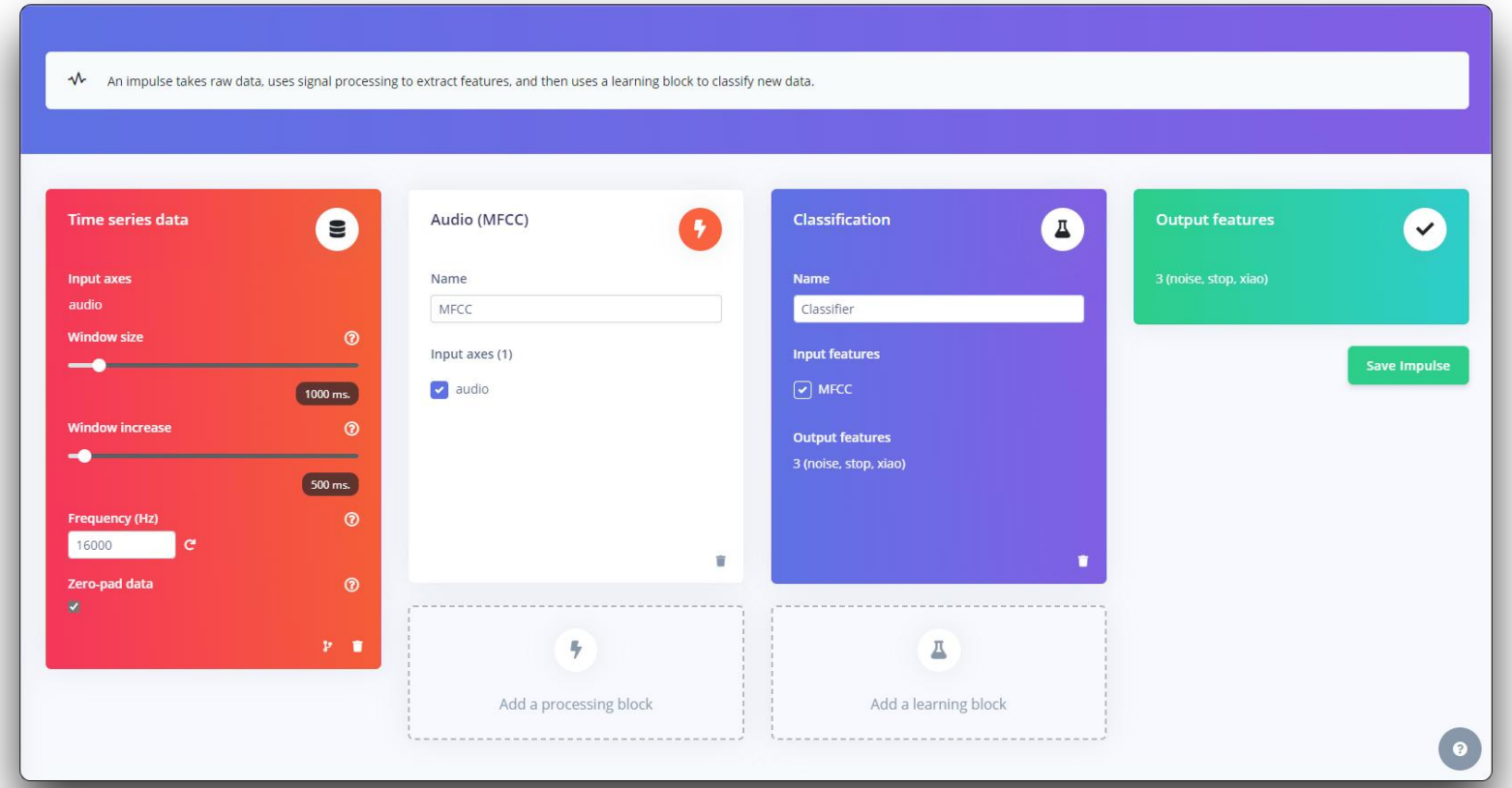


All data on dataset have a 1s length, but the samples recorded in the previous section have 10s and must be split into 1s samples to be compatible. Click on three dots after the sample name and select **Split sample**.

Once inside de tool, split the data into 1-second records. If necessary, add or remove segments.

This procedure should be repeated for all samples.

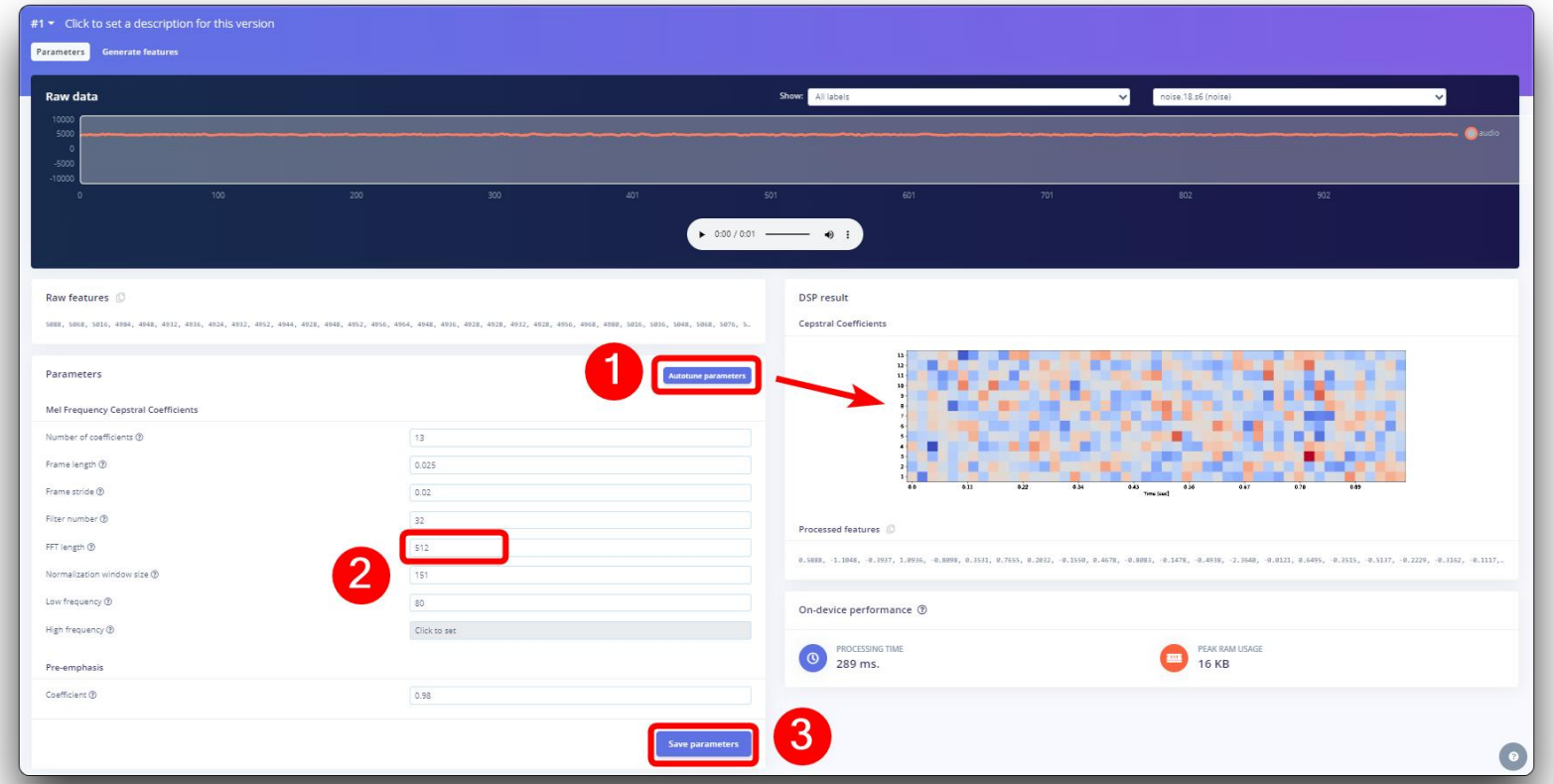
Training Exported Models with Edge Impulse



An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.

First, we will take the data points with a 1-second window, augmenting the data, sliding that window each 500ms. Note that the option **zero-pad data** is set. This is important to fill with zeros samples smaller than 1 second (in some cases, I reduced the 1000 ms window on the **split tool** to avoid

Training Exported Models with Edge Impulse

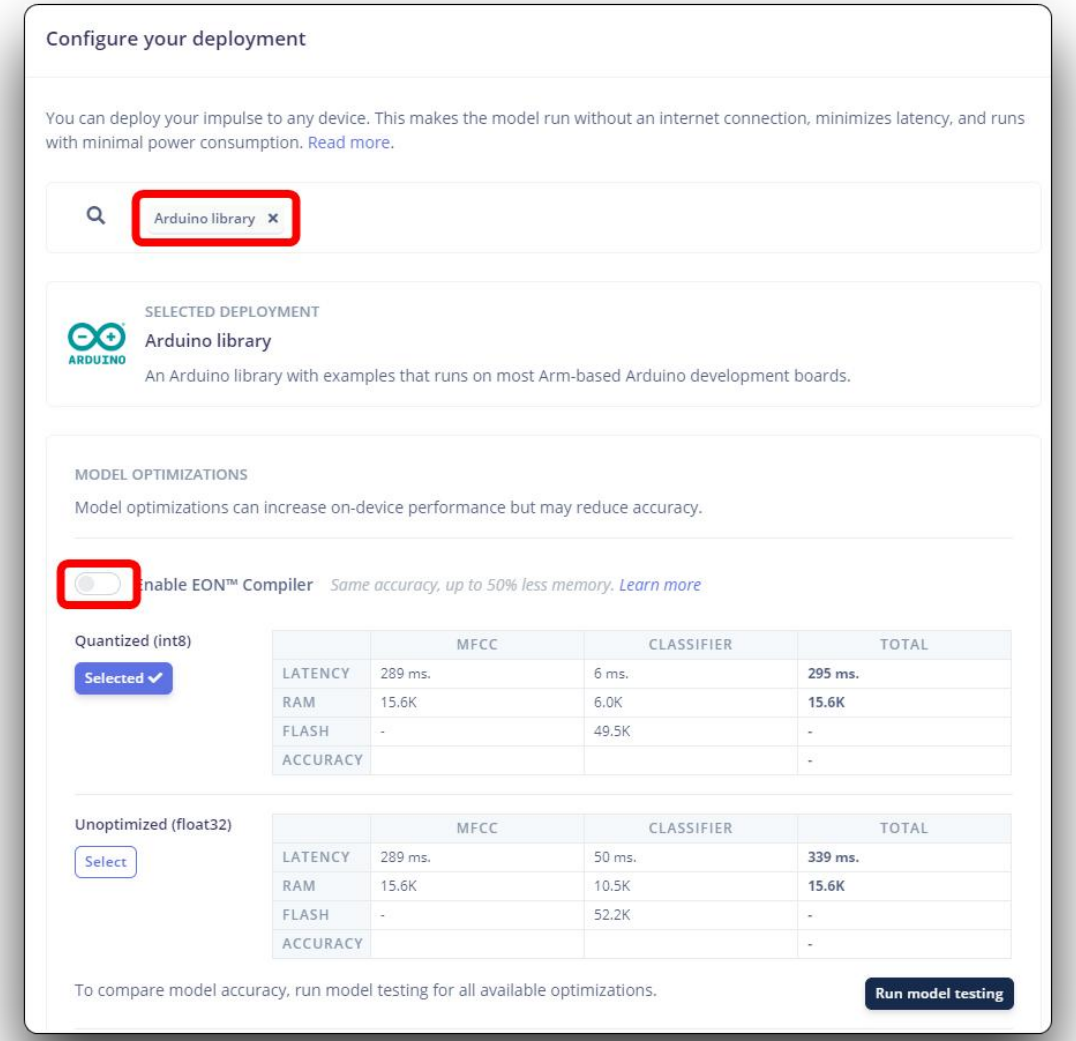


The next step is to create the images to be trained in the next phase. We can keep the default parameter values or take advantage of the DSP **Autotuneparameters option**, which we will do.

Training Exported Models with Edge Impulse

We will use a Convolution Neural Network (CNN) model. The basic architecture is defined with two blocks of Conv1D + MaxPooling (with 8 and 16 neurons, respectively) and a 0.25 Dropout. And on the last layer, after Flattening four neurons, one for each class.

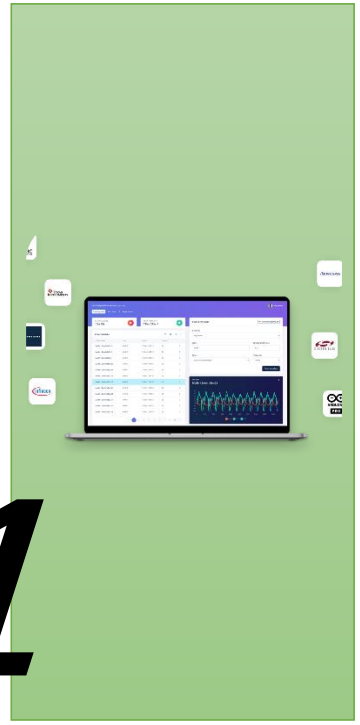
Training Exported Models with Edge Impulse



Edge Impulse will package all the needed libraries, preprocessing functions, and trained models, downloading them to your computer. You should select the option Arduino Library and at the bottom, select Quantized (Int8) and press the button Build.

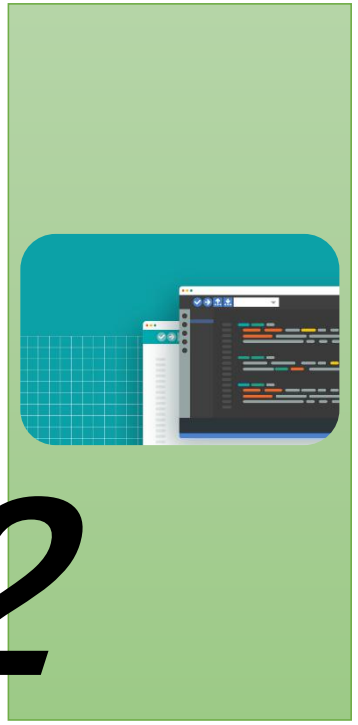
When the Build button is selected, a Zip file will be created and downloaded to your computer.

Main Content



1

Edge Impulse & XIAO ESP32S3 Sense Introduction



2

Recording Audio with XIAO ESP32S3 Sense

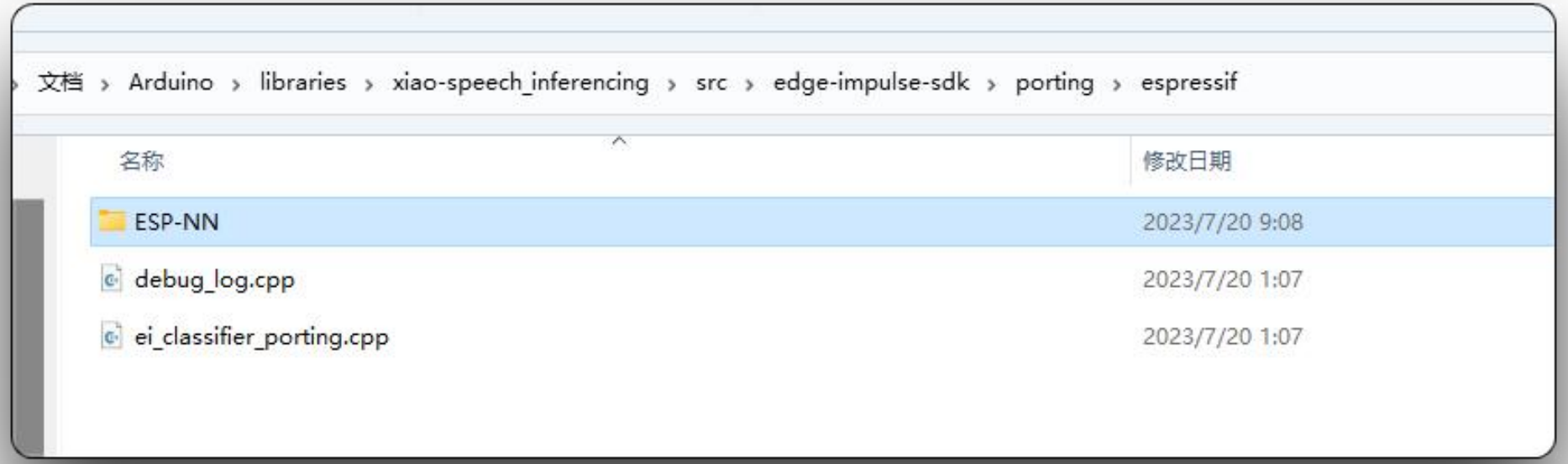
3

Training Exported Models with Edge Impulse

4

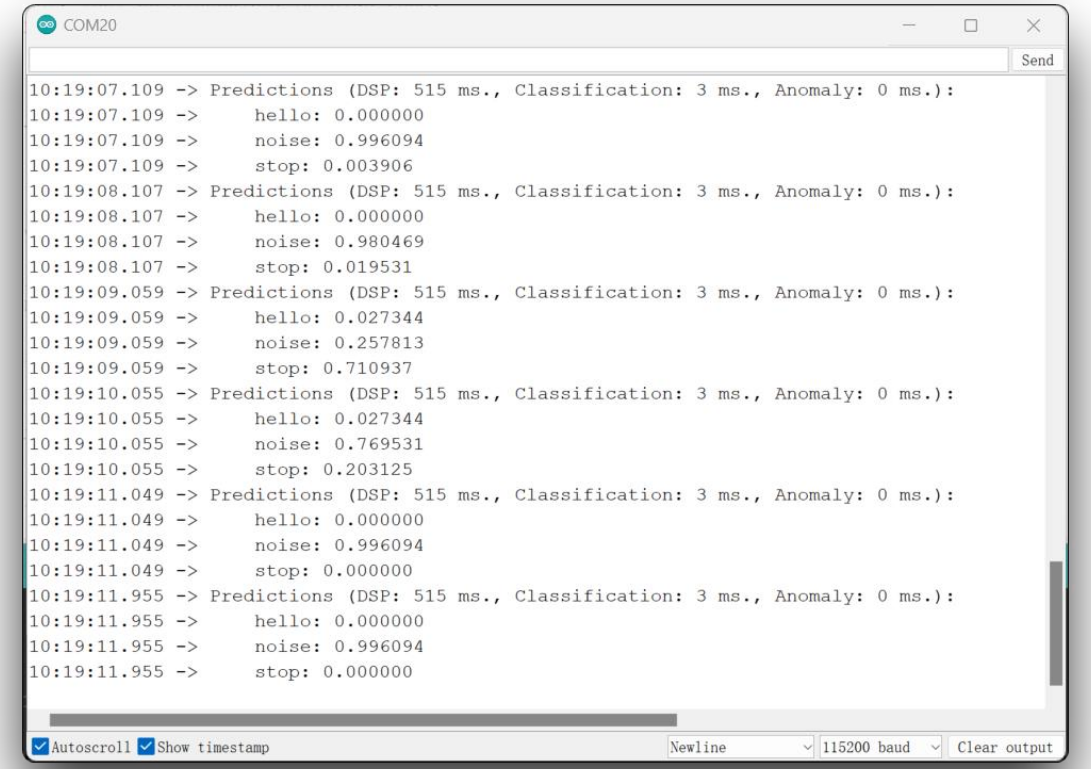
Deploying models to XIAO ESP32S3 Sense

Deploying models to XIAO ESP32S3 Sense



Before we use the downloaded library, we need to enable the ESP NN Accelerator. For that, you can download a preliminary version from the project GitHub, unzip it, and replace the ESP NN folder with it under: src/edge-impulse-sdk/porting/espressif/ESP-NN, in your Arduino library folder.

Deploying models to XIAO ESP32S3 Sense



You can find the complete code on the project's GitHub. Upload the sketch to your board and test some real inferences.

https://github.com/Mjrovai/XIAO-ESP32S3-Sense/tree/main/xiao_esp32s3_microphone_led

Deploying models to XIAO ESP32S3 Sense

```
144         // Display inference result
145         if ((pred_index == 3) && (pred_value > 0.8)){
146           digitalWrite(LED_BUILT_IN, LOW); //Turn on
147         }
148         else{
149           digitalWrite(LED_BUILT_IN, HIGH); //Turn off
150         }
```

Pred_index: Index of identified tags

Pred_value: Confidence level

LED_BUILT_IN: Pin numbering of on-board LED

Thanks you!