VoiceLink tutorial

This project utilizes the ESP32S3 as an AI processor for voice command recognition. The following tutorial will guide you through the step-by-step implementation of the system.

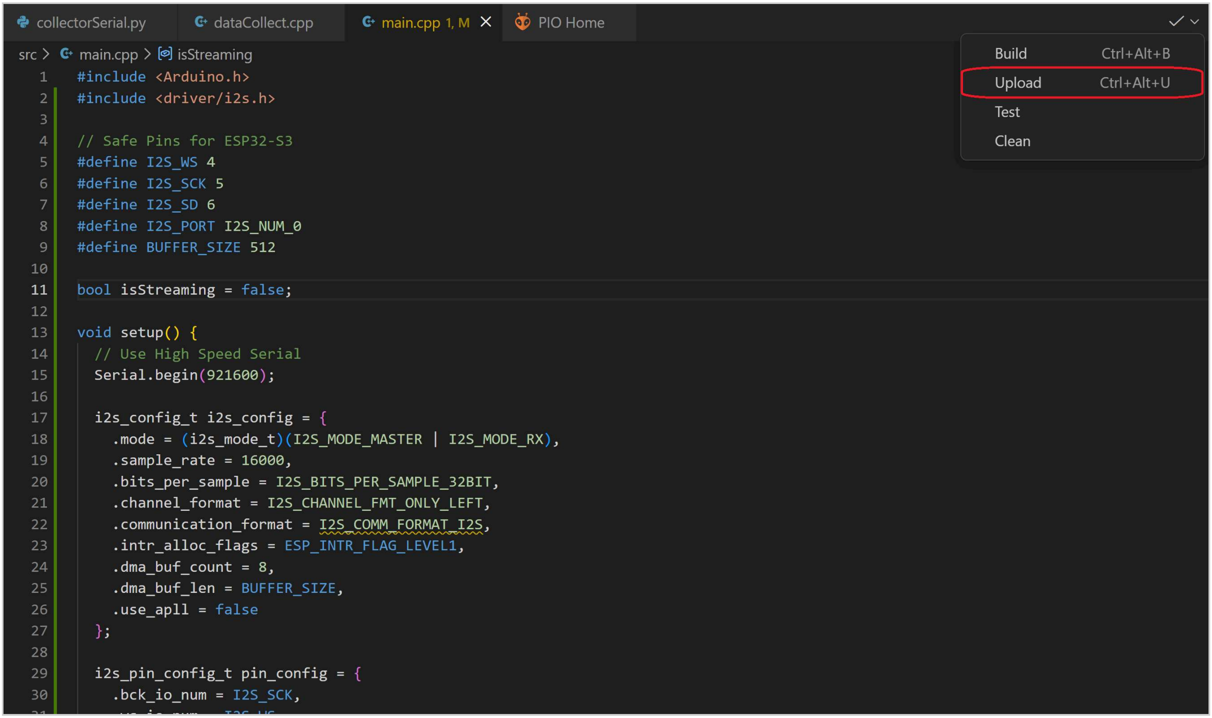
Part 1: Data Collection

In this section, we will record raw audio data from the ESP32 to build our dataset for training the AI model.

Step 1: Upload Firmware

We need to flash the ESP32 with code that reads audio from the microphone and sends it over Serial.

1. Open your project in the **PlatformIO** environment.
2. Locate the file named `dataCollection.cpp` in your file explorer.
3. Copy **all the content** from `dataCollection.cpp`.
4. Open `main.cpp` (located in the `src` folder).
5. Replace the entire content of `main.cpp` with the code you just copied.
6. **Uncomment** the code if necessary.
7. Connect your ESP32-S3 board to your computer via USB.
8. Click the **Upload** button (Right arrow icon) in PlatformIO.



Step 2: Configure Python Script

Prepare the Python script that captures audio from the USB port.

1. Check Device Manager to find your ESP32's **COM Port number** (e.g., COM3, COM9).
2. Open `collectorSerial.py`.
3. Find the line defining `COMPORT` and update it.

```
# ----------------------------------------------- //
# // // REPLACE WITH YOUR ESP32's port
COMPORT = 'COM9'  # Update to your ESP32's port
#----------------------------------------------- //
```

Step 3: Record Your First Class

We will now record the keywords.

1. Run the script: `python collectorSerial.py`
2. Enter the label you want to record (e.g., `on`, `off`, or creative names like `haha`, `hehe`).

3. When you see `[READY] Press SPACE to record...`, press **SPACE** and speak clearly into the mic.

```
--- Voice Command Data Collector ---
Enter label to record (e.g., 'on', 'off', 'background'): hehe
Collecting data for: hehe
Press 'Ctrl+C' to stop or change label.

[READY] Press SPACE to record' 60 'for label: 'hehe'
```

Step 4: Repeat & Adjust

Repeat Step 3 for your second keyword and for background noise.

- To change recording duration, adjust this line in the Python script:

```
#------------------------------------------ //
RECORD_SECONDS = 60 # Change this for longer dataset
#----------------------------------------- //
```

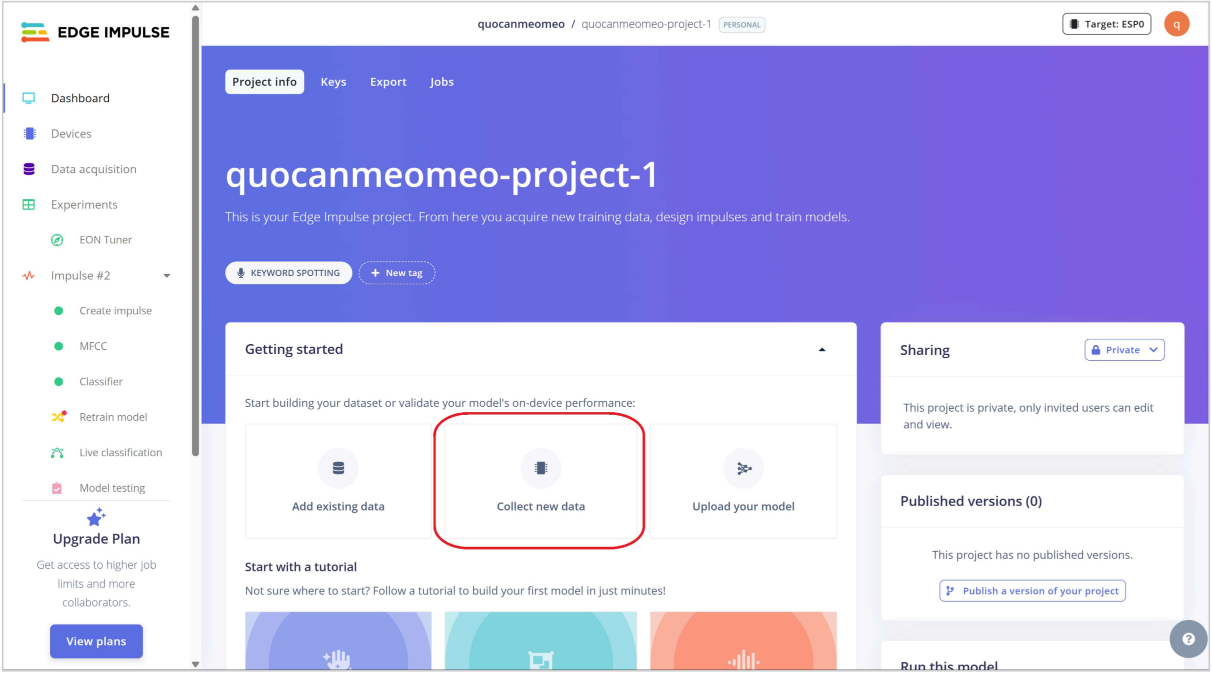
Part 2: Uploading & Splitting

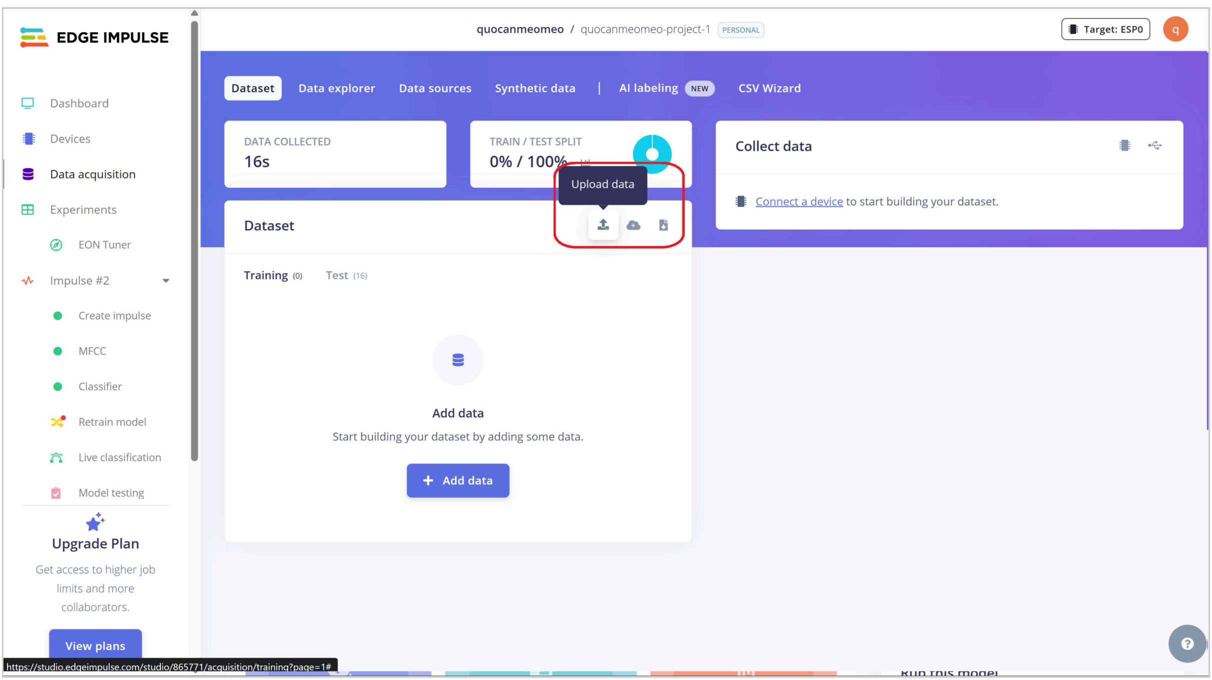
Now we upload the raw audio files to Edge Impulse and chop them into 1-second samples.

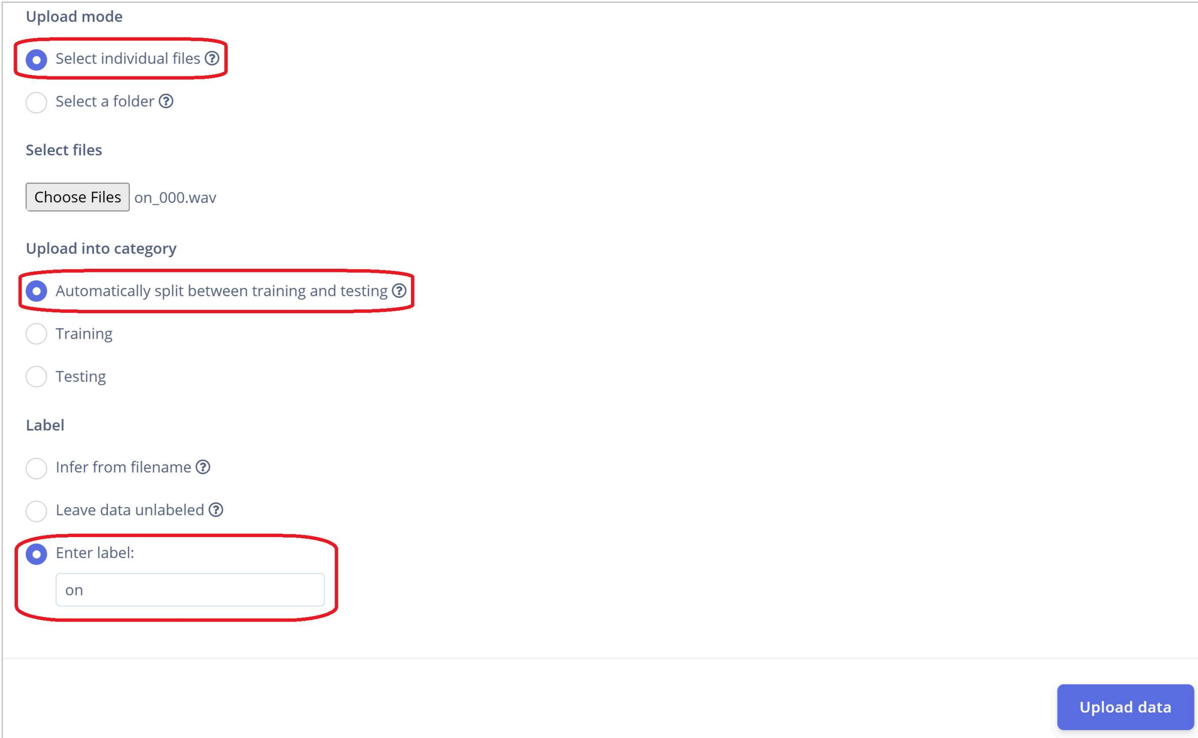
Step 1: Upload Data

1. Go to the **Data acquisition** tab in Edge Impulse.
2. Click **Collect new data** -> **Add data** -> **Upload data**.
3. Select your recorded file.
4. **Settings:**
   - Method: "Automatically split between training and testing".
   - Label: Enter the label matching your file (e.g., 'on').

5. Click **Upload data**.



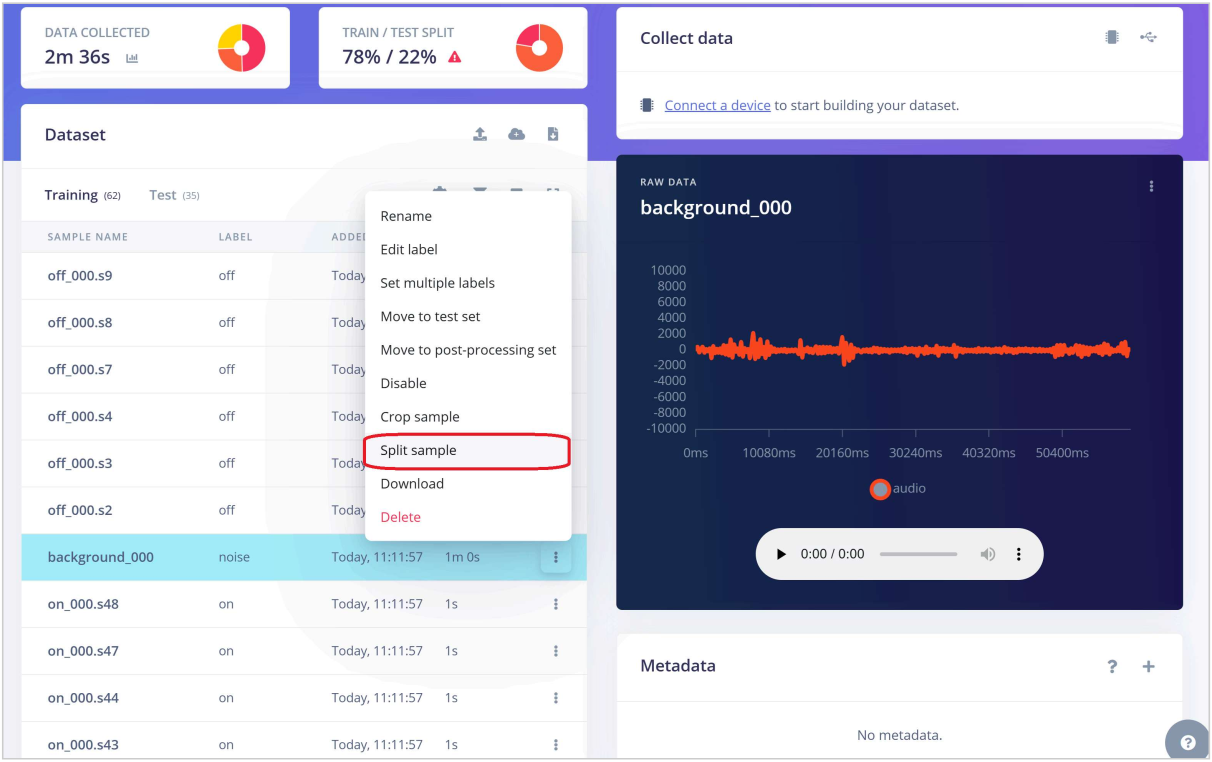




Step 2: Split Samples

Since we recorded one long file, we need to split it into individual keywords.

1. Find your uploaded file in the list.
2. Click the **three dots (⋮)** -> **Split sample**.
3. The app will auto-detect segments. **Validate** that the boxes cover the audio correctly.
4. Click **Split**.



Step 3: Repeat & Finalize

1. Repeat splitting for your other keyword file.
2. For the **Noise/Background** file: **Do NOT split the sample**. Keep it continuous.
3. Go to the **Dashboard** tab, scroll down, and click **Perform train / test split**.

Part 3: Training the Model

We will design the processing pipeline and train the Neural Network.

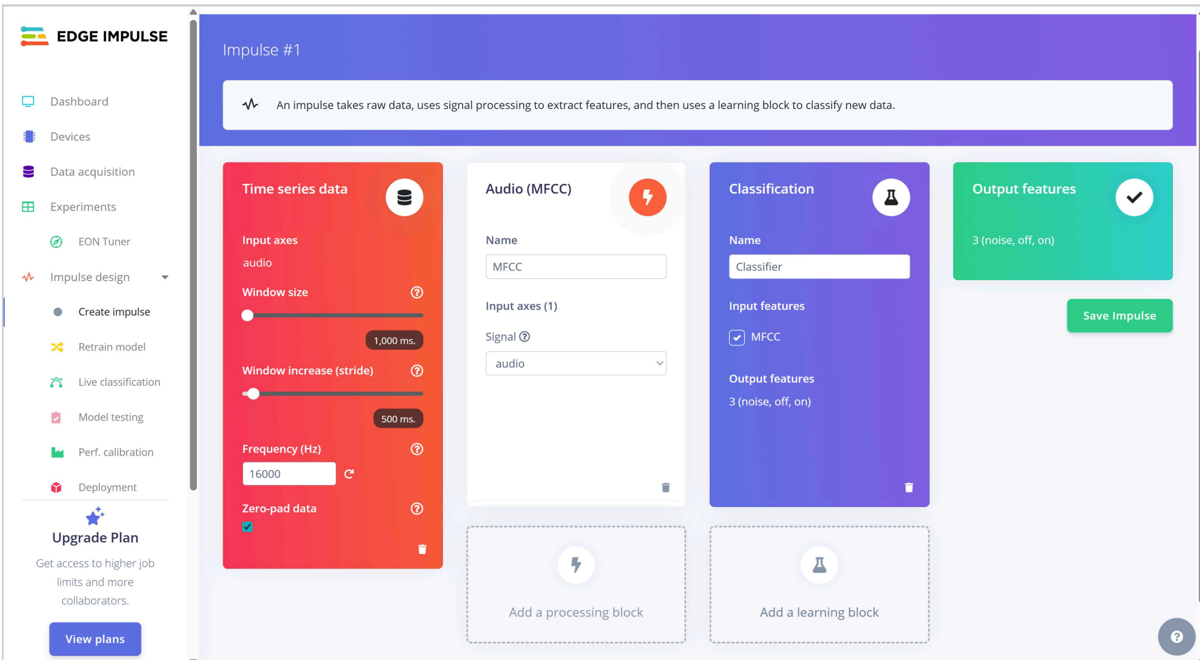
Step 1: Create Impulse

Navigate to the **Create Impulse** tab.

- **Time Series Data:**
  - Window size: `1000 ms`.
  - Window increase: `500 ms`.
  - Zero-pad data: **Unchecked**.

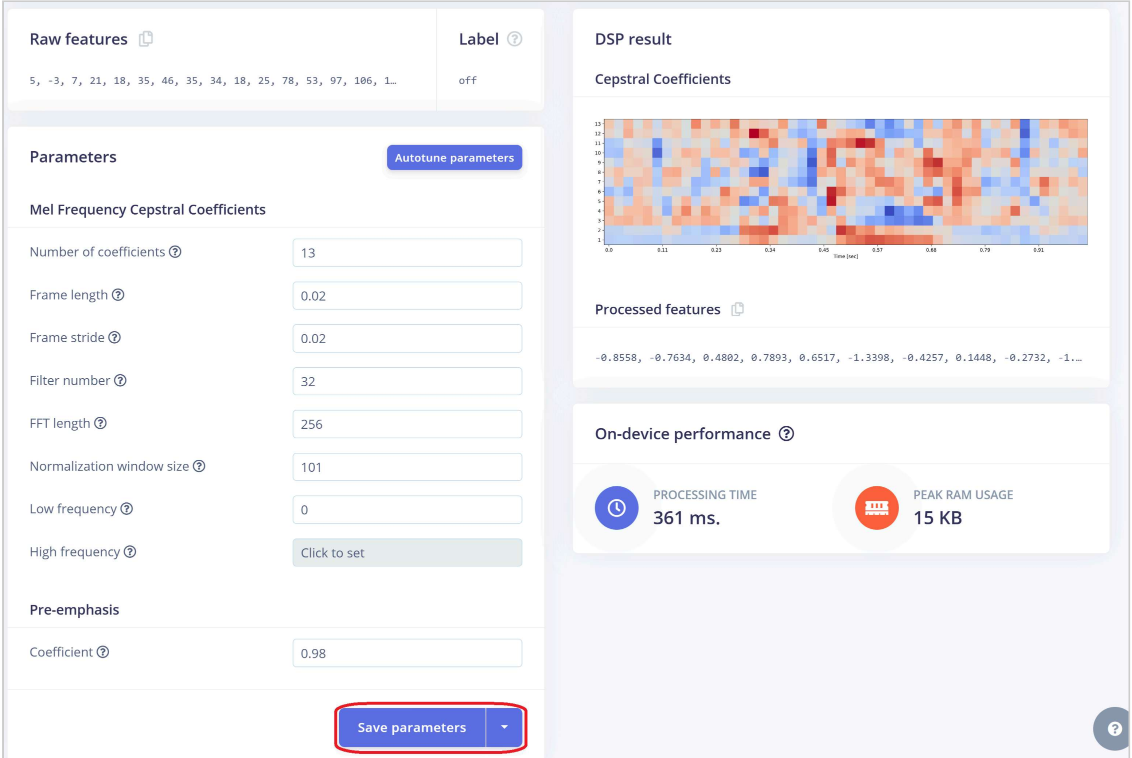
> ⚠️ **CRITICAL: Frequency Setting**
> **This must match your hardware exactly. If your data says 6392Hz, type 6392 here. Do not use 16000Hz unless the data is actually 16000Hz.**

- **Processing Block:** Add "Audio (MFCC)".
- **Learning Block:** Add "Classification (Keras)".
- Click **Save Impulse**.

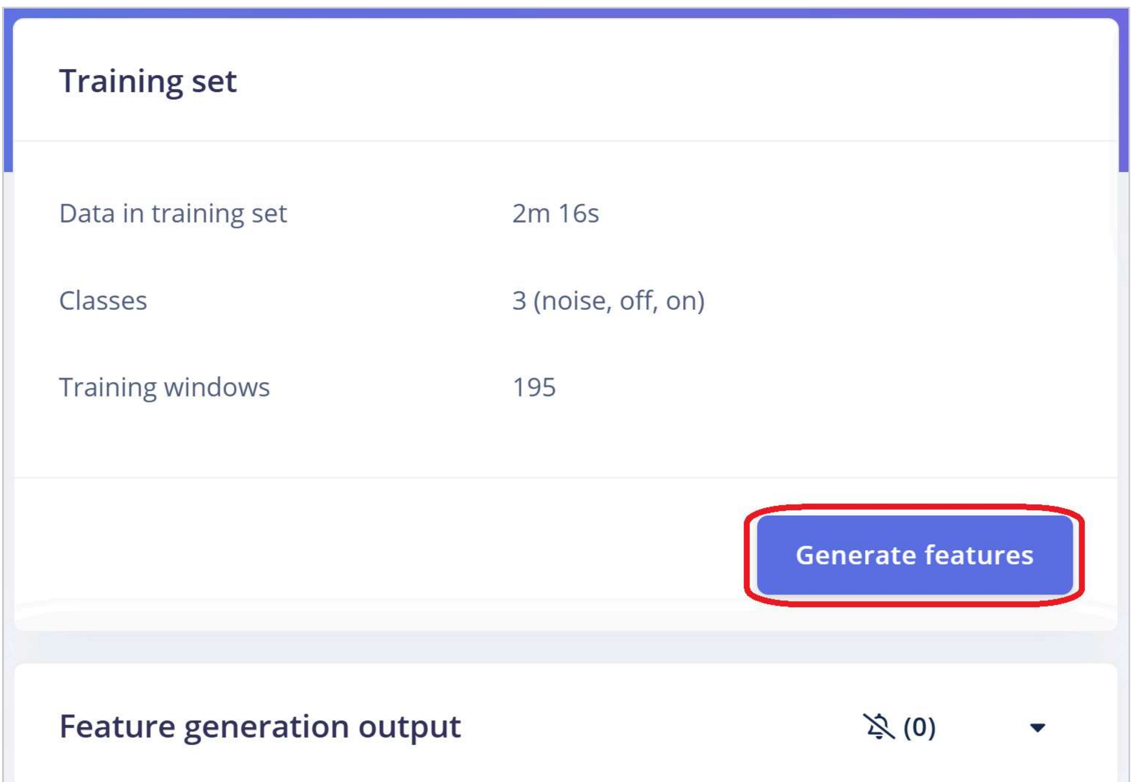


Step 2: Generate Features (MFCC)

1. Go to the **MFCC** tab.
2. Click **Save parameters** (Defaults are usually fine).



3. Click **Generate features**.

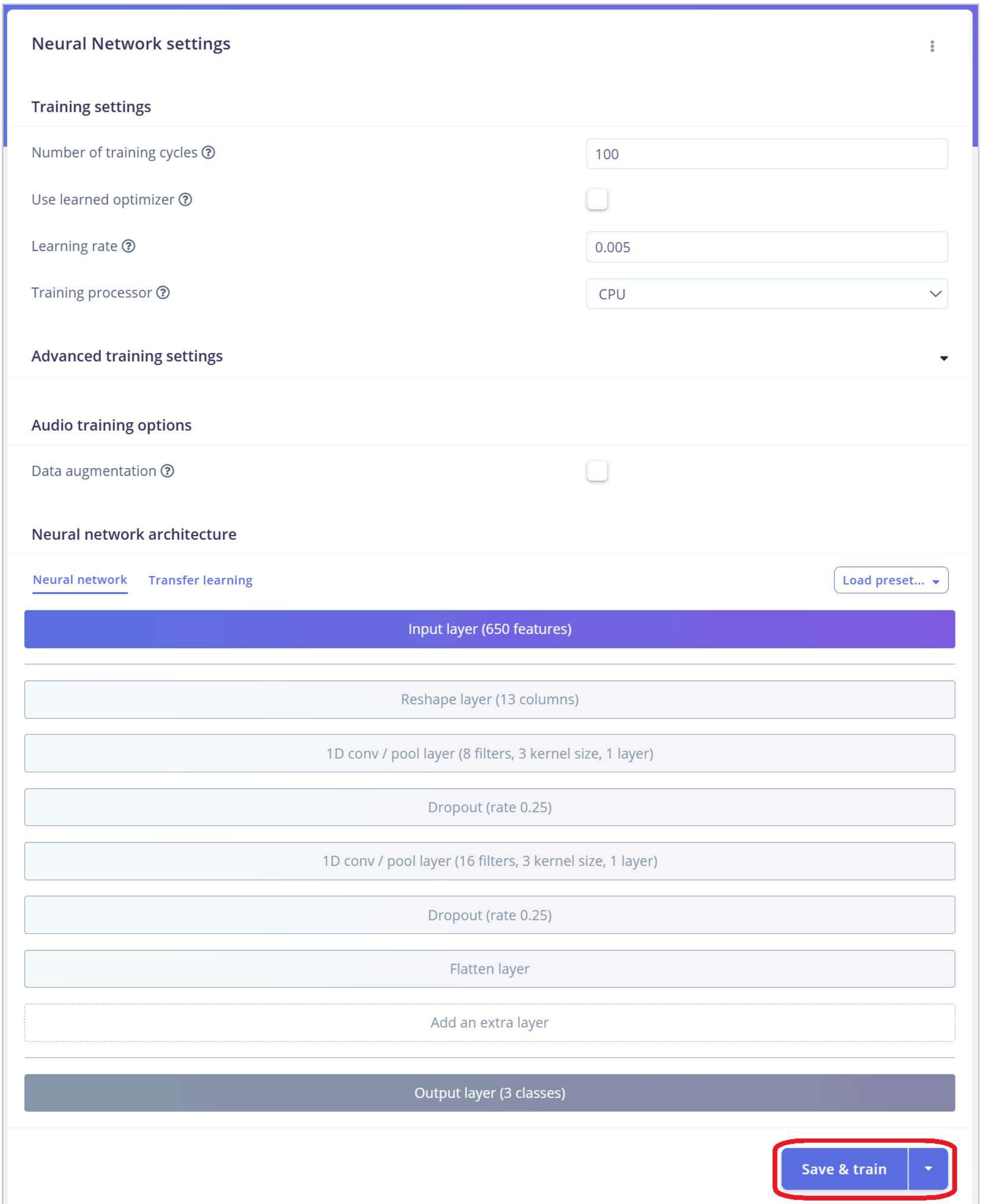


4. **Visual Check:** Look at the "Feature Explorer" graph.
   - **Good:** Distinct clusters of colors.
   - **Bad:** Dots mixed together like a smoothie.

Step 3: Classifier (Training)

Go to the **Classifier** tab to train the brain.

1. **Settings:**
   - Training cycles: Set to **60**.
   - Learning rate: `0.005`.
   - Data augmentation: **CHECKED**.
2. Click **Save & train**.



Step 4: The Result

Wait for training to finish and examine the **Confusion Matrix**.

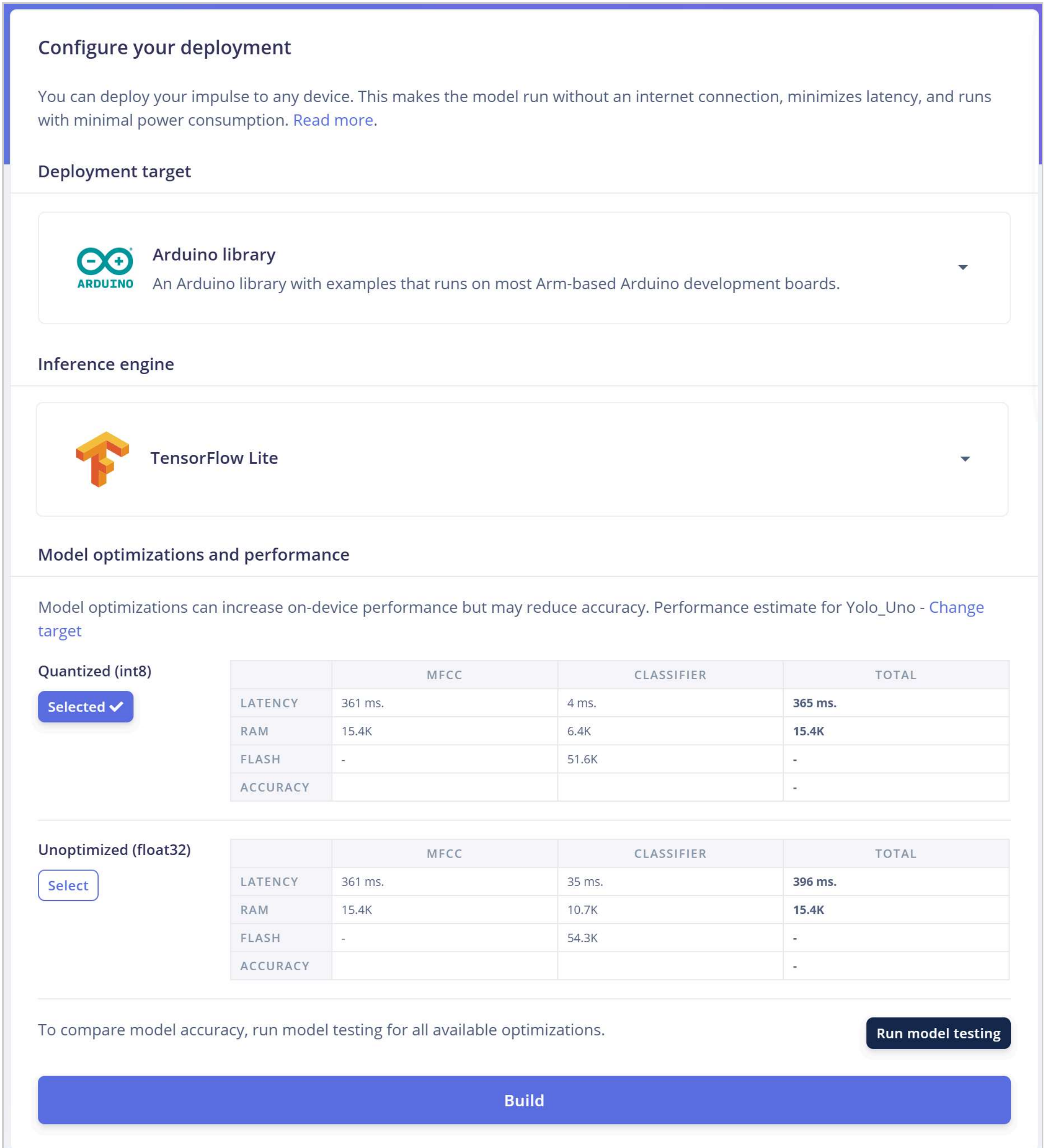
- **Goal:** >85% accuracy for Keywords, >90% for Noise.

Part 4: Deployment (The Transplant)

Goal: Move the "brain" onto the chip for offline use.

Step 1: Export the Library

- Go to the **Deployment** tab in Edge Impulse.
- Search for **Arduino Library**.
- Select **TensorFlow Lite** as Deployment engine.
- Select **Quantized (int8)**. **(Critical for ESP32 performance)**.
- Click **Build** to download the `.zip` file.



Step 2: Install in PlatformIO

1. **Unzip** the downloaded file on your computer.
2. **Drag & Drop:** Move the extracted folder (e.g., `ESP_VOICE_inferencing`) into your PlatformIO project's `lib/` folder.

> **Structure Check:** Verify your project folder looks exactly like this:

```
MyProject/
├── lib/
```

```
│   └── ESP_VOICE_inferencing/   <-- The folder you just added
├── src/
│   └── main.cpp
│   └── modelRun.cpp
└── platformio.ini
```

Step 3: The Final Code

Now we replace the data collection script with the actual AI logic.

1. Locate the file named `modelRun.cpp` in your file explorer.
2. Copy **all the content** from `modelRun.cpp`.
3. Open `main.cpp` (located in the `src` folder).
4. Replace the entire content of `main.cpp` with the code you just copied.
5. **Uncomment** the code if necessary.
6. **Important:** Update the library include line at the top of the code to match your folder name:

```
// ---------------------------------------- //
// REPLACE WITH YOUR LIBRARY
#include "quocanmeomeo-project-1_inferencing.h"
// ---------------------------------------- //
```

Step 4: Upload & Test

1. Connect your ESP32.
2. Click **Upload** in PlatformIO.
3. Open the Serial Monitor and start speaking your keywords!