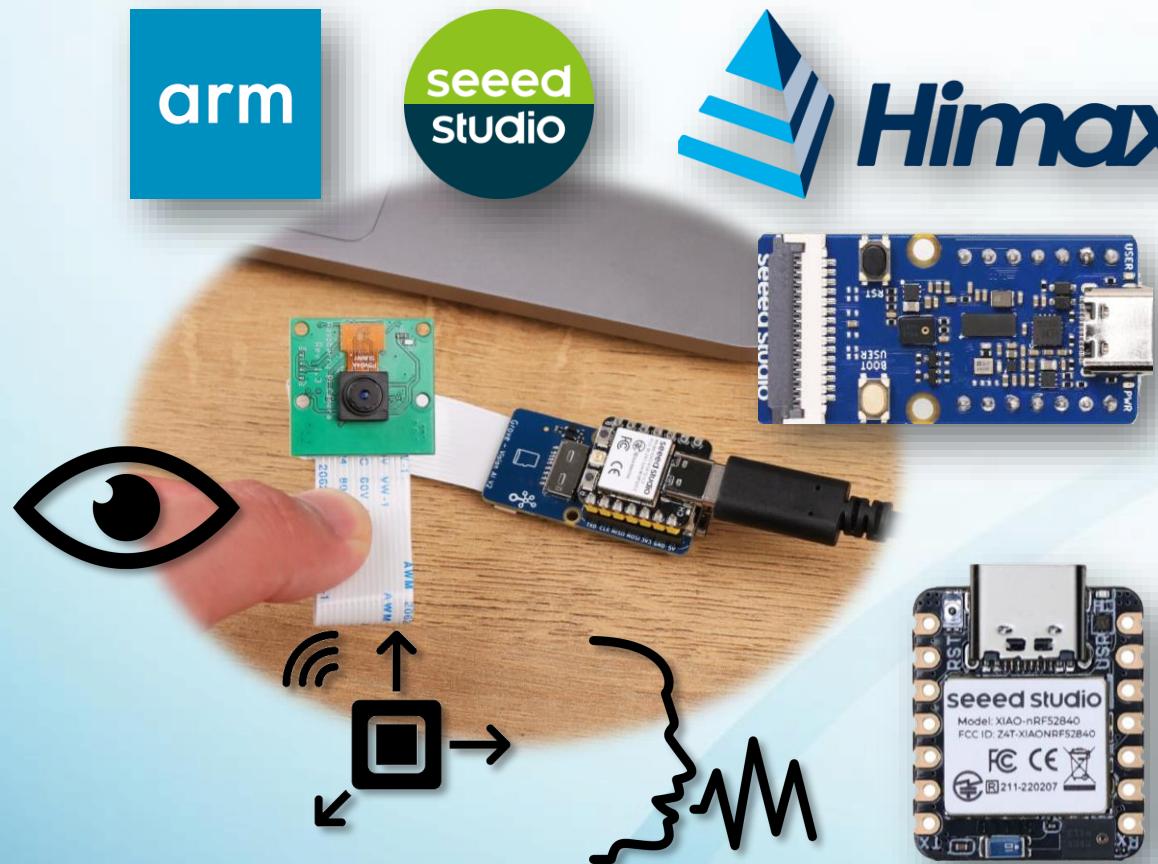


OmniXRI TinyML 小學堂 2025



歡迎加入
邊緣人俱樂部



沒有最邊



只有更邊

Cortex-M
Processor

Ethos-U
MicroNPU

【第 9 講】 運動感測器應用— 手勢辨識



歐尼克斯實境互動工作室 (OmniXRI Studio)
許哲豪 (Jack Hsu)

簡報大綱



- 9.1. 運動資料集建置
- 9.2. Edge Impulse 開發環境建置
- 9.3. 模型選用與訓練
- 9.4. 模型部署與測試

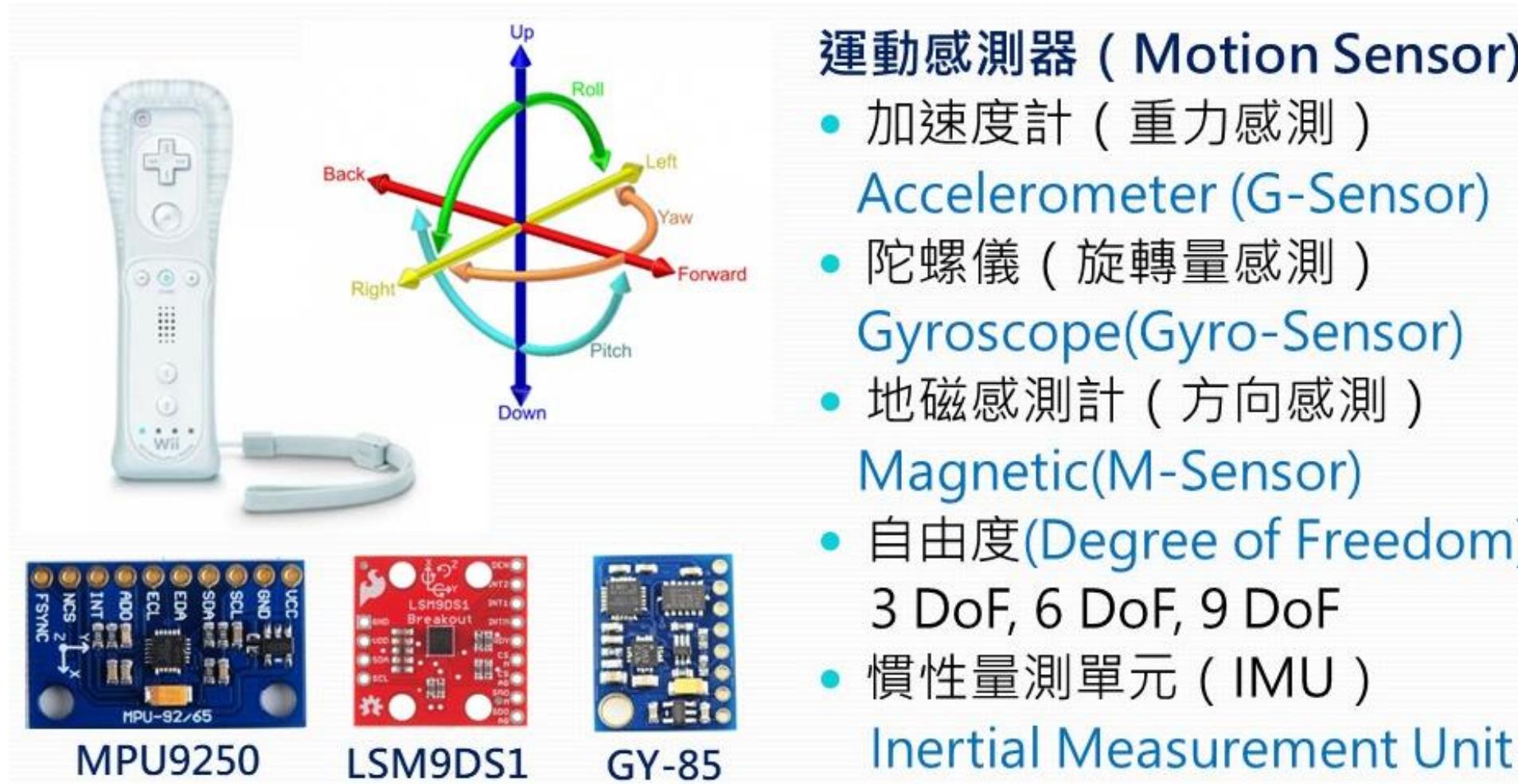
本課程完全免費，請勿移作商業用途！
歡迎留言、訂閱、點讚、轉發，讓更多需要的朋友也能一起學習。

完整課程大綱：<https://omnixri.blogspot.com/2025/03/omnixri-tinyml-2025-0.html>
課程直播清單：<https://www.youtube.com/@omnixri1784streams>



9.1. 運動資料集建置

何謂運動感測器



運動感測器 (Motion Sensor)

- 加速度計 (重力感測)
Accelerometer (G-Sensor)
- 陀螺儀 (旋轉量感測)
Gyroscope(Gyro-Sensor)
- 地磁感測計 (方向感測)
Magnetic(M-Sensor)
- 自由度(Degree of Freedom)
3 DoF, 6 DoF, 9 DoF
- 慣性量測單元 (IMU)
Inertial Measurement Unit

資料來源：<https://omnixri.blogspot.com/2022/04/20220408.html>

運動感測常見應用



人機互動
(Wii / PS Move 搖桿)



競速分析 / 駕駛習慣
(打龜號 / 車涯 04 事件)



慣性導航 / 室內定位
(GPS無法看見天空)

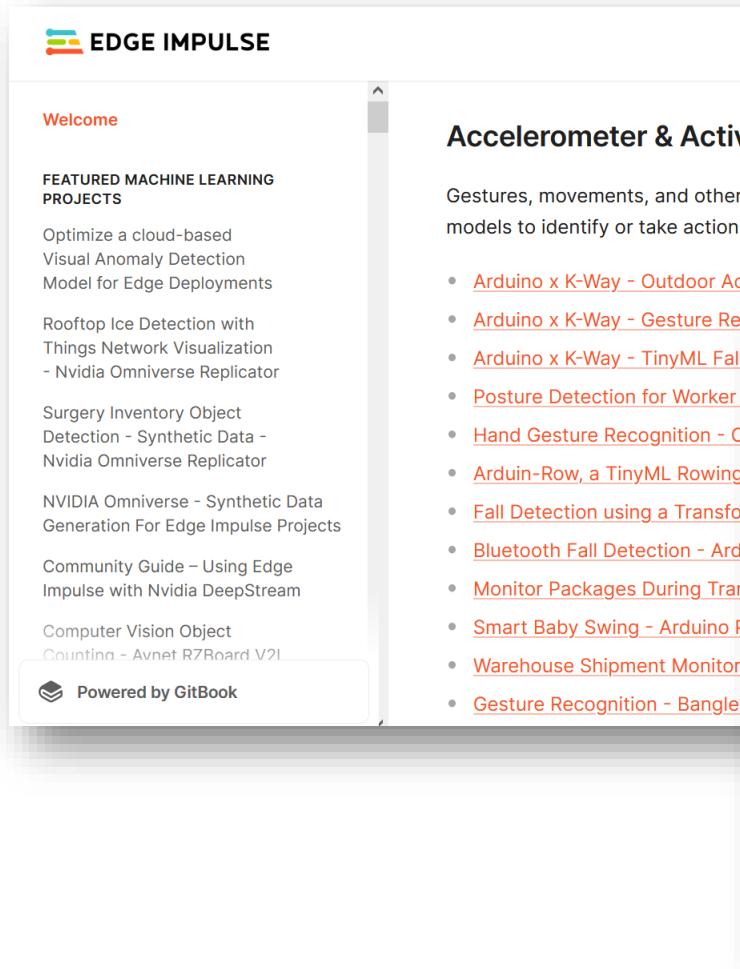


異常振動
(馬達/輸送帶)

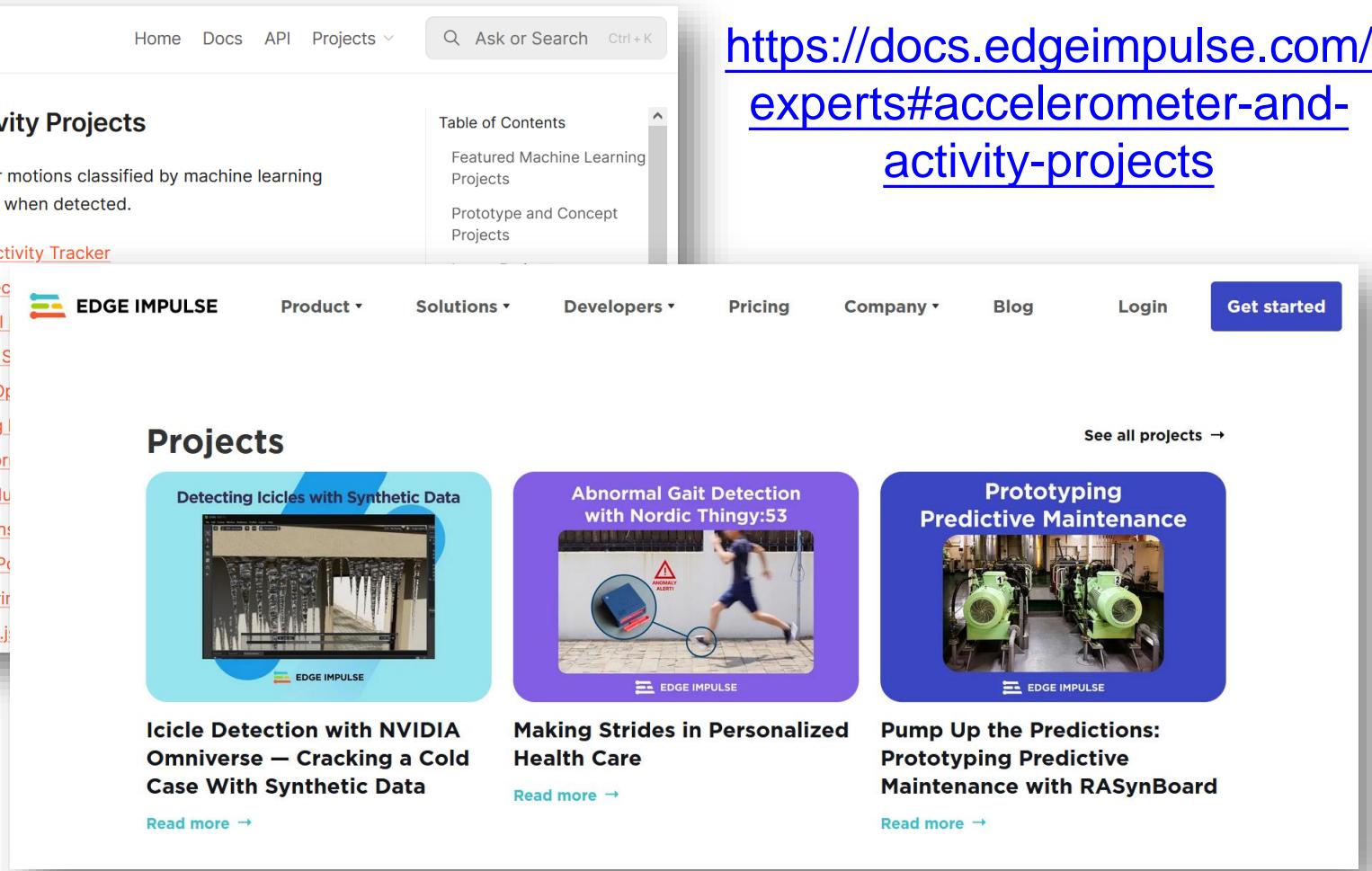


自動平衡
(平衡車、無人機、人形機器人)

Edge Impulse 運動感測相關案例

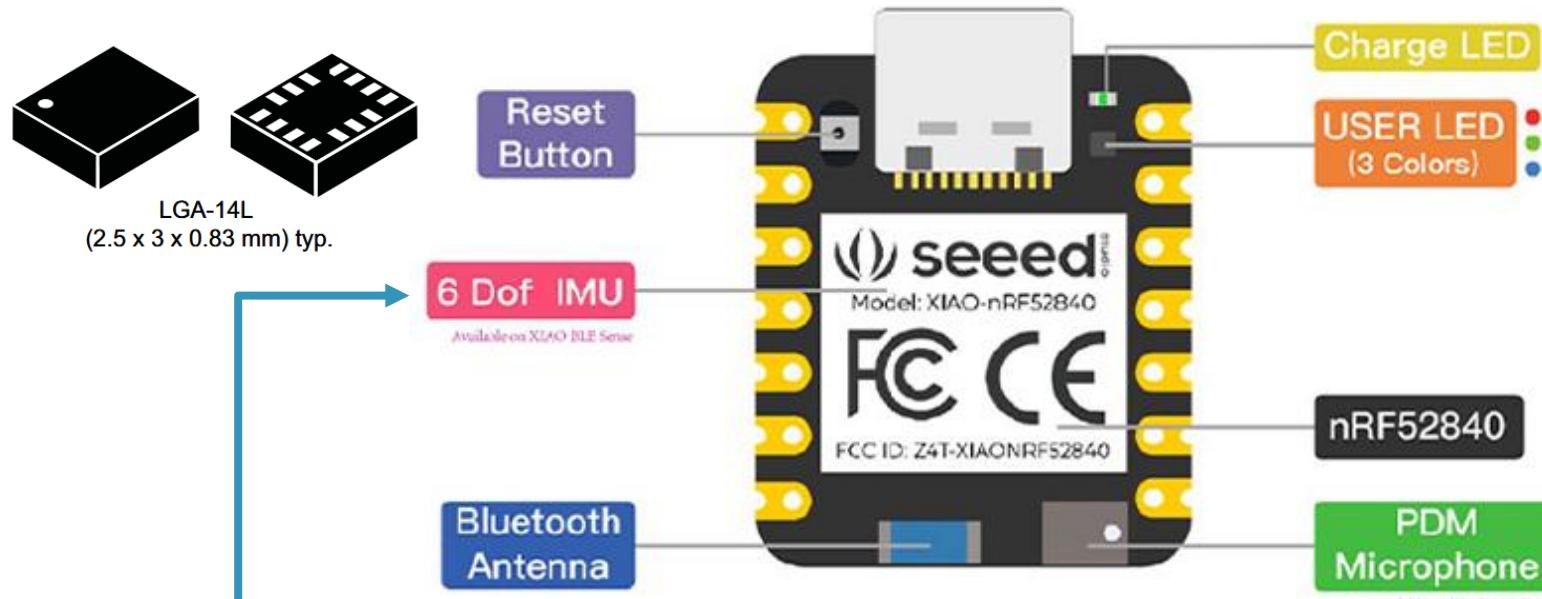


<https://docs.edgeimpulse.com/experts#accelerometer-and-activity-projects>



<https://edgeimpulse.com/blog/>

Seeed Xiao nRF52840 Sense

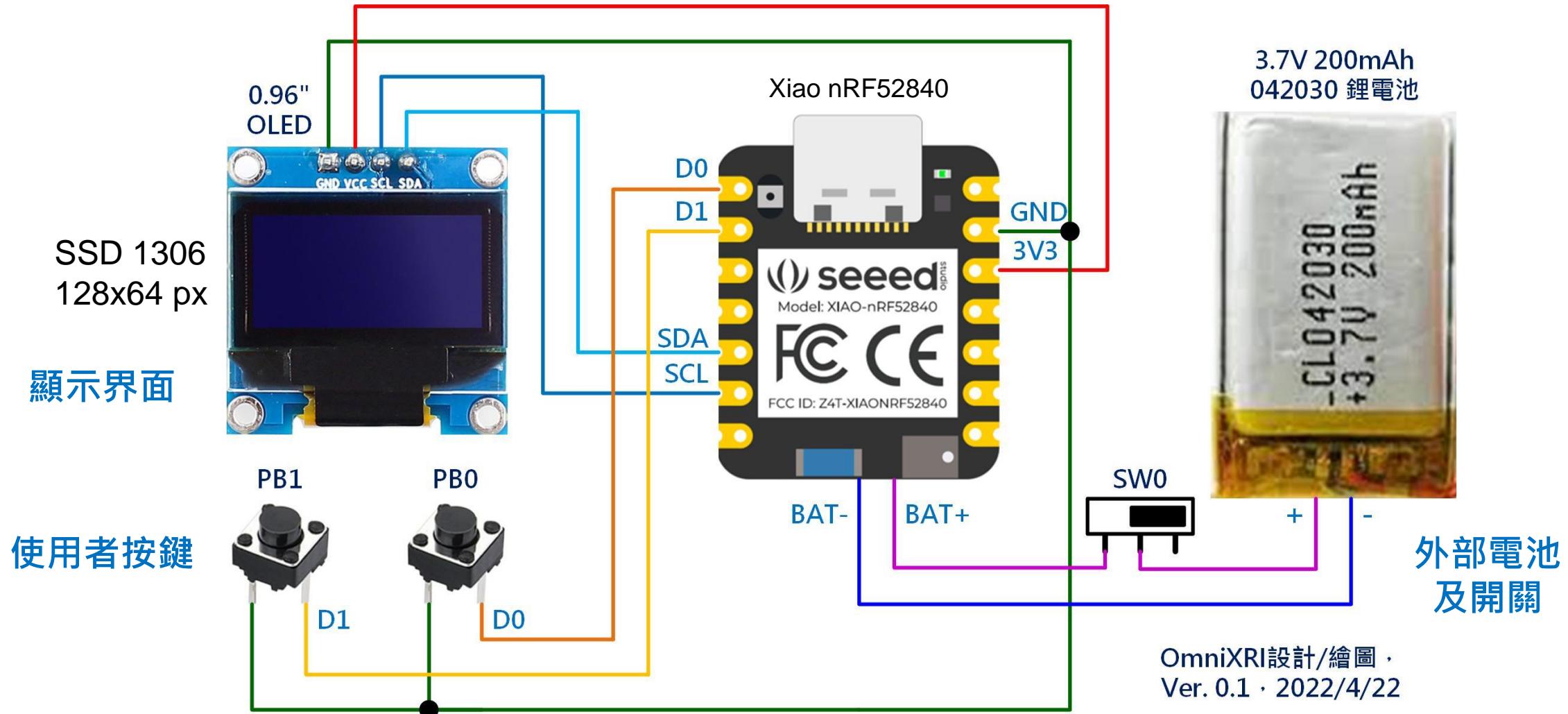


LSM6DS3TR-C

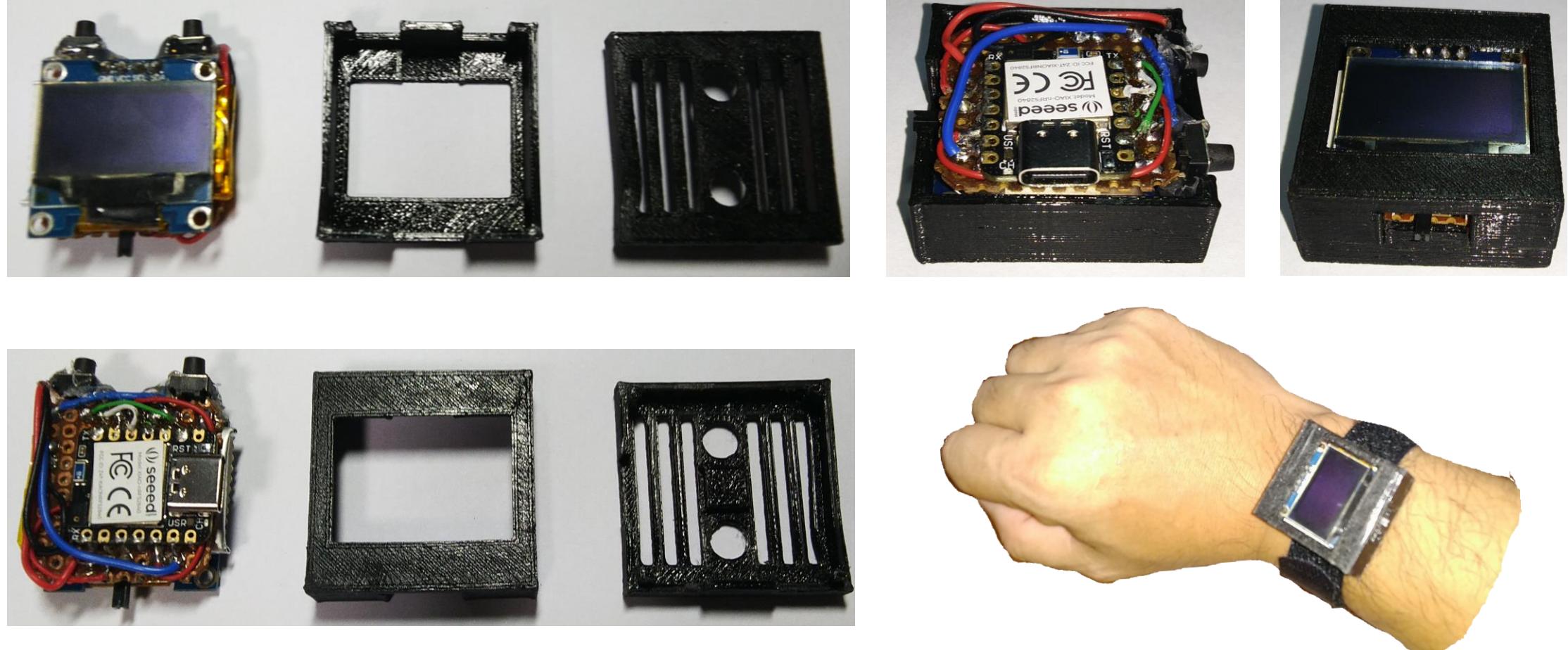
- 3D加速度計 : $\pm 2/\pm 4/\pm 8/\pm 16$ g full scale
- 3D陀螺儀 : $\pm 125/\pm 250/\pm 500/\pm 1000/\pm 2000$ dps full scale
- 工作電壓 : 1.71 V to 3.6 V
- 通訊界面 : SPI & I2 C serial interface

資料來源：https://wiki.seeedstudio.com/cn/XIAO_BLE/

Xiao nRF52840 Sense 模組 – 參考電路

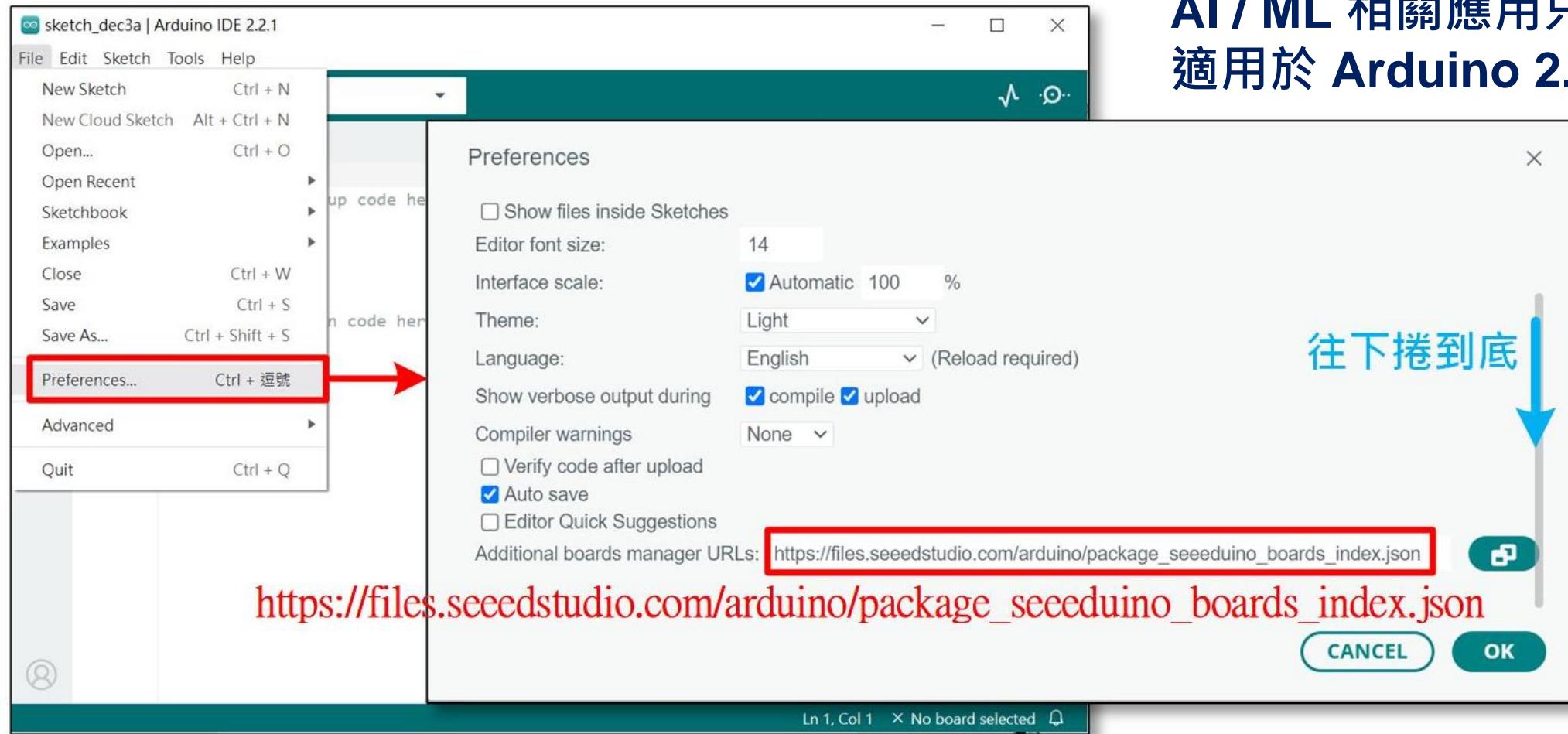


穿戴式智慧人工智慧裝置 – 參考外形



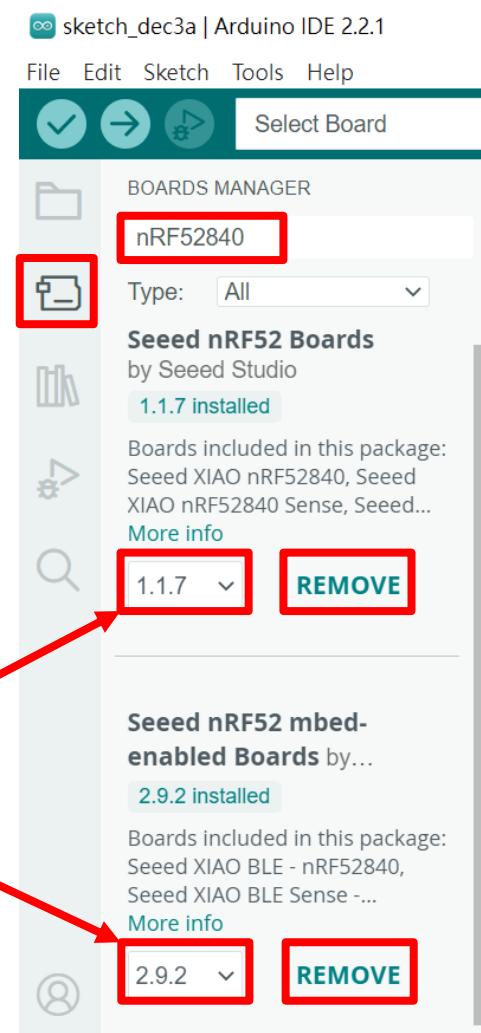
Arduino 新增開發板設定

AI / ML 相關應用只
適用於 Arduino 2.x 。



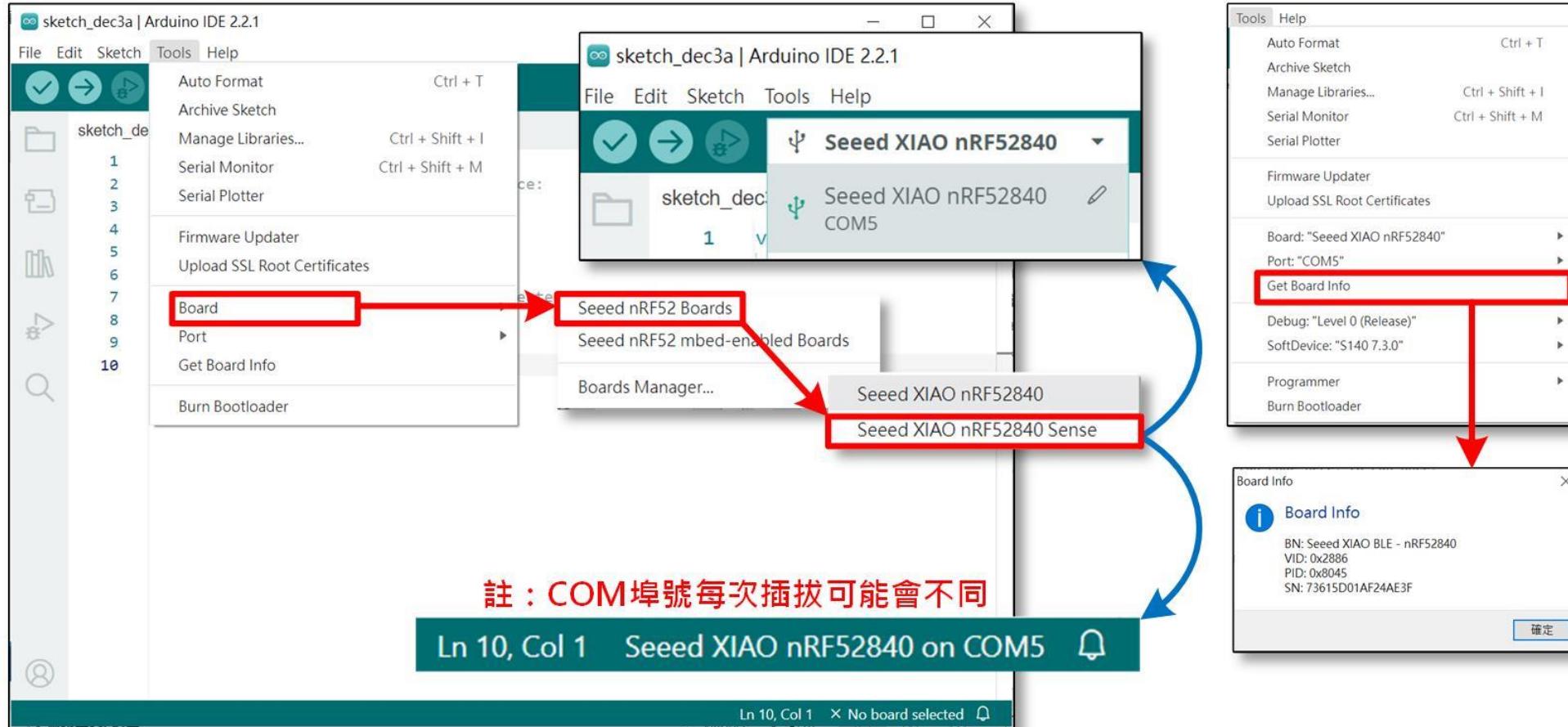
OmniXRI 整理製作, 2023/12/08

安裝Seeed nRF52840函式庫



- 點選選單 Tools > Board > Boards Manager...，或直接點選左側第二個「開發板」圖示。
- 輸入 **nRF52840** 搜尋 Seeed nRF52840 開發板相關函式庫。
- 點選「**INSTALL**」安裝下列二個函式庫。（版本可取最新的）
 - **Seeed nRF52 Boards (BLE, 低功耗功能)**
 - **Seeed nRF52 mbed-enabled Boards (PDM, IMU, ML)**
- 安裝後若不需要時，可點選「**REMOVE**」解除安裝。

指定工作開發板及埠號

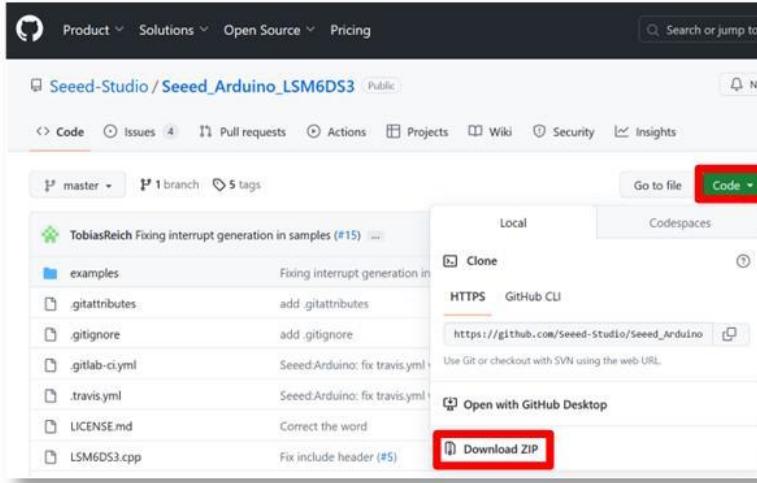


- 選擇開發板
Seeed XIAO
nRF52840
Sense
- 選擇對應埠
號
- 檢查是否連
線

OmniXRI 整理製作, 2023/12/08

安裝運動感測器（IMU）函式庫

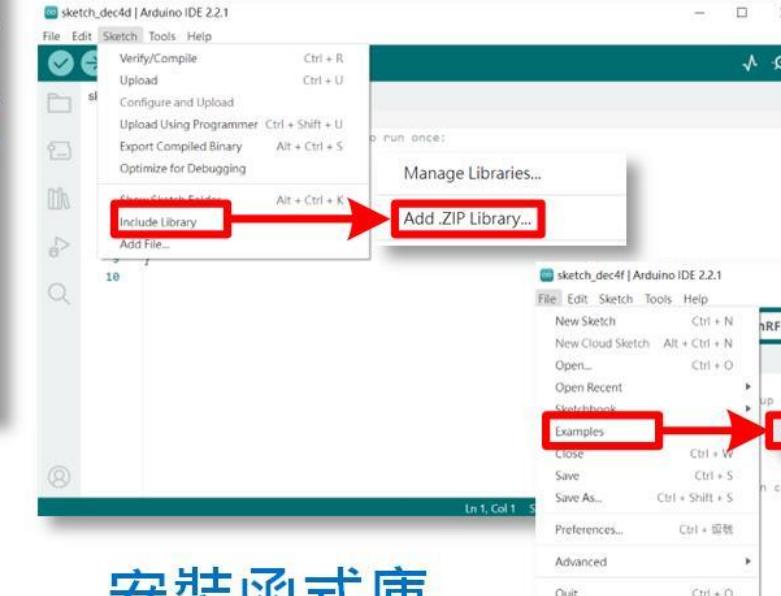
https://github.com/Seeed-Studio/Seeed_Arduino_LSM6DS3



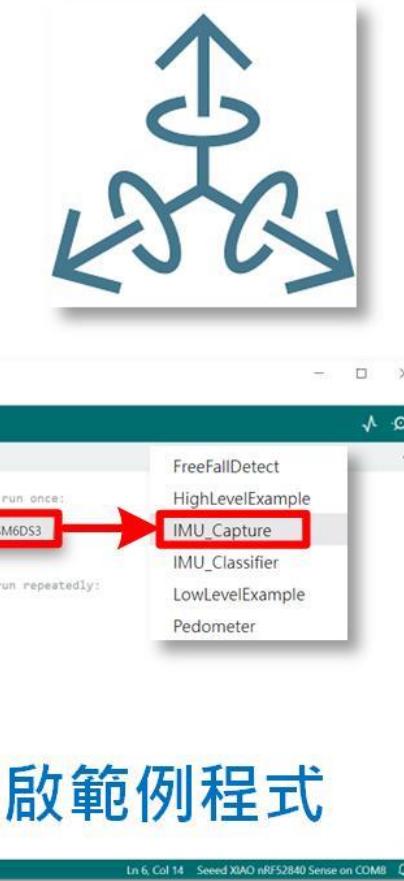
Seeed_Arduino_LSM6DS3-master.zip
下載運動感測器函式庫



https://github.com/Seeed-Studio/Seeed_Arduino_LSM6DS3



安裝函式庫



開啟範例程式

OmniXRI 整理製作, 2023/12/08

運動感測器（IMU）取值範例

File > Examples > Seeed Arduino LSM6DS3 > IMU_capture

```
#include <LSM6DS3.h>
#include <Wire.h>
LSM6DS3 myIMU(I2C_MODE, 0x6A); // 建立LSM6DS3實例並設定I2C裝置位址
float aX, aY, aZ, gX, gY, gZ; // 儲存三軸加速度及陀螺儀數值變數
const float accelerationThreshold = 2.5; // 加速度門檻值
const int numSamples = 119; // 樣本數量
int samplesRead = numSamples; // 讀取樣本數量
void setup() { // 初始化設定
    Serial.begin(9600); // 設定串例通信速度(bps)
    while (!Serial); // 等待串列埠初始化完成
    if (myIMU.begin() != 0) { // 初始化運動感測器
        Serial.println("Device error");
    } else {
        Serial.println("aX,aY,aZ,gX,gY,gZ");
    }
}
void loop() { // 無限迴圈
    // 等待取得足夠數量樣本
    while (samplesRead == numSamples) {
        // 讀取加速度計值
        aX = myIMU.readFloatAccelX();
        aY = myIMU.readFloatAccelY();
        aZ = myIMU.readFloatAccelZ();
        // 求得加速度值總合
        float aSum = fabs(aX) + fabs(aY) + fabs(aZ);
        // 檢查是否超過門檻值，若是重置已讀樣本數量
        if (aSum >= accelerationThreshold) {
            samplesRead = 0;
            break;
        }
    }
}
```

觸發值大於
門檻才輸出

```
// 檢查自上次檢測到顯著運動以來是否已讀取所有必需的樣本
while (samplesRead < numSamples) {
    samplesRead++; // 已讀取樣本數加1
    // print the data in CSV format
    Serial.print(myIMU.readFloatAccelX(), 3);
    Serial.print(',');
    Serial.print(myIMU.readFloatAccelY(), 3);
    Serial.print(',');
    Serial.print(myIMU.readFloatAccelZ(), 3);
    Serial.print(',');
    Serial.print(myIMU.readFloatGyroX(), 3);
    Serial.print(',');
    Serial.print(myIMU.readFloatGyroY(), 3);
    Serial.print(',');
    Serial.print(myIMU.readFloatGyroZ(), 3);
    Serial.println();
    // 若已讀樣本數已足夠則列印換行
    if (samplesRead == numSamples) {
        Serial.println();
    }
}
```

練習：將板子以不同方向移動及旋
轉測試讀值是否正常

IMU 連續取值輸出至 Edge Impulse

```

1 #include <LSM6DS3.h>
2 #include <Wire.h>
3
4 //Create a instance of class LSM6DS3
5 LSM6DS3 myIMU(I2C_MODE, 0x6A);      //I2C device address 0x6A
6 float aX, aY, aZ, gX, gY, gZ;
7 // const float accelerationThreshold = 2.5; // threshold of significant in G's
8 // const int numSamples = 119;
9 // int samplesRead = numSamples;
10
11 void setup() {
12   // put your setup code here, to run once:
13   Serial.begin(115200);
14   while (!Serial);
15   //Call .begin() to configure the IMUs
16   if (myIMU.begin() != 0) {
17     Serial.println("Device error");
18   } else {
19     Serial.println("aX,aY,aZ,gX,gY,gZ");
20   }
21 }
22
23 void loop() {
24   // wait for significant motion
25   // while (samplesRead == numSamples) {
26   //   // read the acceleration data
27   //   aX = myIMU.readFloatAccelX();
28   //   aY = myIMU.readFloatAccelY();
29   //   aZ = myIMU.readFloatAccelZ();
30
31   //   // sum up the absolutes
32   //   float aSum = fabs(aX) + fabs(aY) + fabs(aZ);
33
34   //   // check if it's above the threshold

```

註解或刪除
紅色框區域

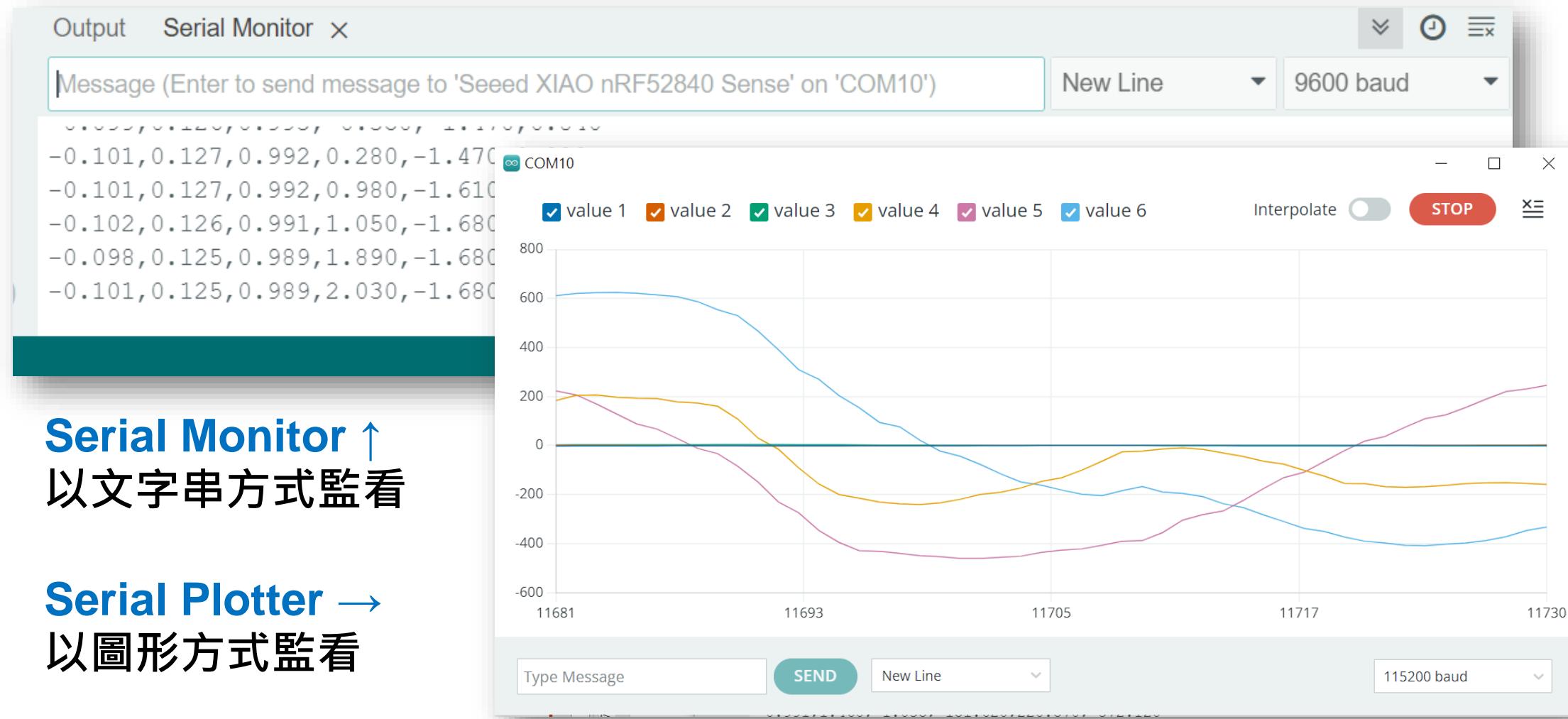
```

35   //   if (aSum >= accelerationThreshold) {
36   //     // reset the sample read count
37   //     samplesRead = 0;
38   //     break;
39   //   }
40   //
41
42   //   // check if the all the required samples have been read since
43   //   // the last time the significant motion was detected
44   //   while (samplesRead < numSamples) {
45   //     // check if both new acceleration and gyroscope data is
46   //     // available
47   //     // read the acceleration and gyroscope data
48
49   //     samplesRead++;
50
51   //     // print the data in CSV format
52   Serial.print(myIMU.readFloatAccelX(), 3);
53   Serial.print(',');
54   Serial.print(myIMU.readFloatAccelY(), 3);
55   Serial.print(',');
56   Serial.print(myIMU.readFloatAccelZ(), 3);
57   Serial.print(',');
58   Serial.print(myIMU.readFloatGyroX(), 3);
59   Serial.print(',');
60   Serial.print(myIMU.readFloatGyroY(), 3);
61   Serial.print(',');
62   Serial.print(myIMU.readFloatGyroZ(), 3);
63   Serial.println();
64
65   //   if (samplesRead == numSamples) {
66   //     // add an empty line if it's the last sample
67   //     Serial.println();
68   //   }
69   //
70 }

```

連續取值並輸出至 COM
搭配 edge-impulse-data-forwarder 可將感測器值送到雲端

監看運動感測器 (IMU) 輸出值

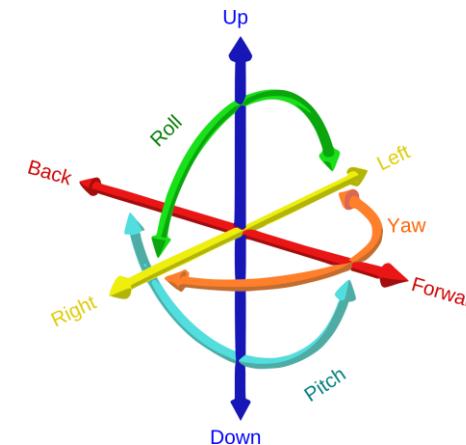


Serial Monitor ↑
以文字串方式監看

Serial Plotter →
以圖形方式監看

設計自定義操作手勢

- Start – 向前張開手掌
- Next – 由左向右快速平移並有頓點
- Prev – 由下向上擺動並有頓點
- Stop – 雙手快速交叉於胸口
- Unknow – 任意輕微擺動或不動，可為任意姿勢。
- **運動感測器必須固定在手部特定位
置以免相同動作但感測值差異過大**
- **動作設定最好於不同軸向有明顯差
異可只用加速度計而不使用陀螺儀**





9.2. Edge Impulse 開發環境建置

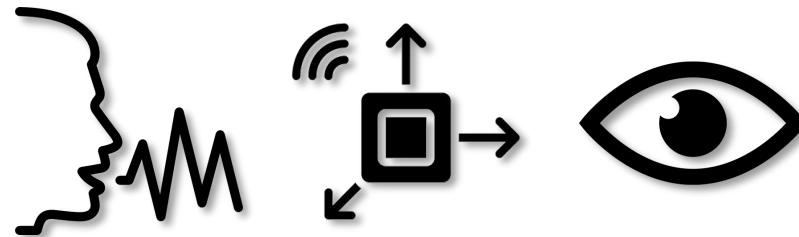
TinyML 開發流程選項

模型訓練工具名稱



TensorFlow Lite
(現更名LiteRT)

適用感測器



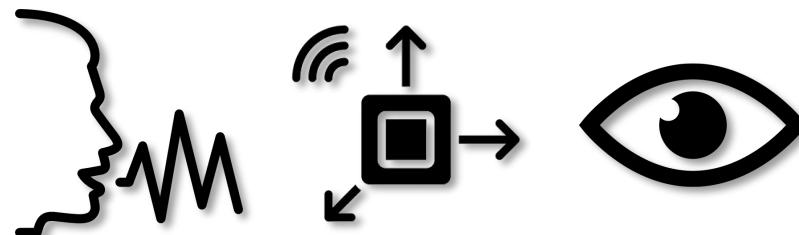
主要特色

免費版：資料集需自行建置，僅提供模型訓練及轉成 TensorFlow Lite for Microcontroller 格式。可利用雲端 Google Colab 或本地端 Jupyter Notebooks 進行模型訓練及部署。

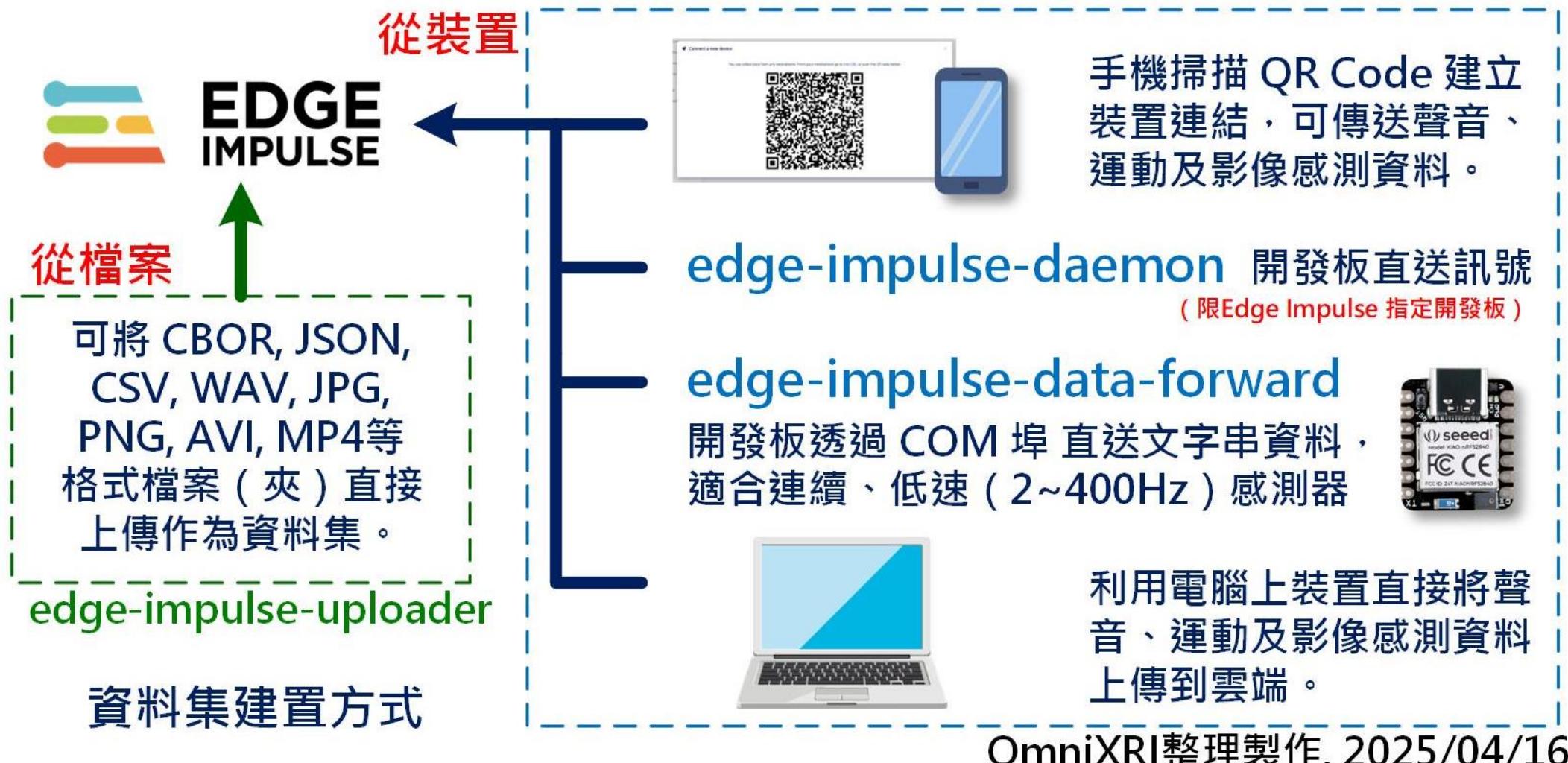
免費版：可支援各式感測器及開發板，提供一定額度資料集建置、資料前處理（特徵提取）模型訓練、模型優化及多種部署方式。亦可導入已訓練好的 TensorFlow Lite, ONNX 等模型。

免費版：影像分類可多分類、物件偵測同一模型僅能一類。事件觸發只能設一種條件。可支援雲端資料收集、模型訓練及部署，亦導入外部已訓練好之 TensorFlow Lite 模型。

SenseCraft



Edge Impulse 資料集建置方式



快速操作指令表



The screenshot shows a GitHub repository interface. On the left, the file tree for the 'main' branch is visible, including folders like Ch08_Image_Classification, Ch09_Object_Detection, Ch10_Image_Segmentation, Ch11_Pose_Estimation, Ch12_Keyword_Spotting, Ch13_Motion_Recognition, Ch14_Anomaly_Detection, Ch15_Text_Voice_Generation, Ch16_Image_Music_Generation, images, and LICENSE. The 'IMU_Quick_Guide.md' file is selected and highlighted. The main content area displays the Markdown file's content:

OmniXRI's Edge AI & TinyML 小學堂 【第13講】 實作案例 —運動辨識（快速指令表）

講師：歐尼克斯實境互動工作室 許哲豪(Jack Hsu)博士 2024/05/28 整理製作

13.1. 實驗器材及開發平台

- [Seeed Wiki - Xiao nRF52840 Sense \(英文\)](#)
- [Arduino Software Downloads](#)
- [Edge Impulse Document](#)

相關開發環境建置請參考
[OmniXRI's Edge AI & TinyML 小學堂 【第12講】 實作案例 —語音辨識（快速指令表）](#)

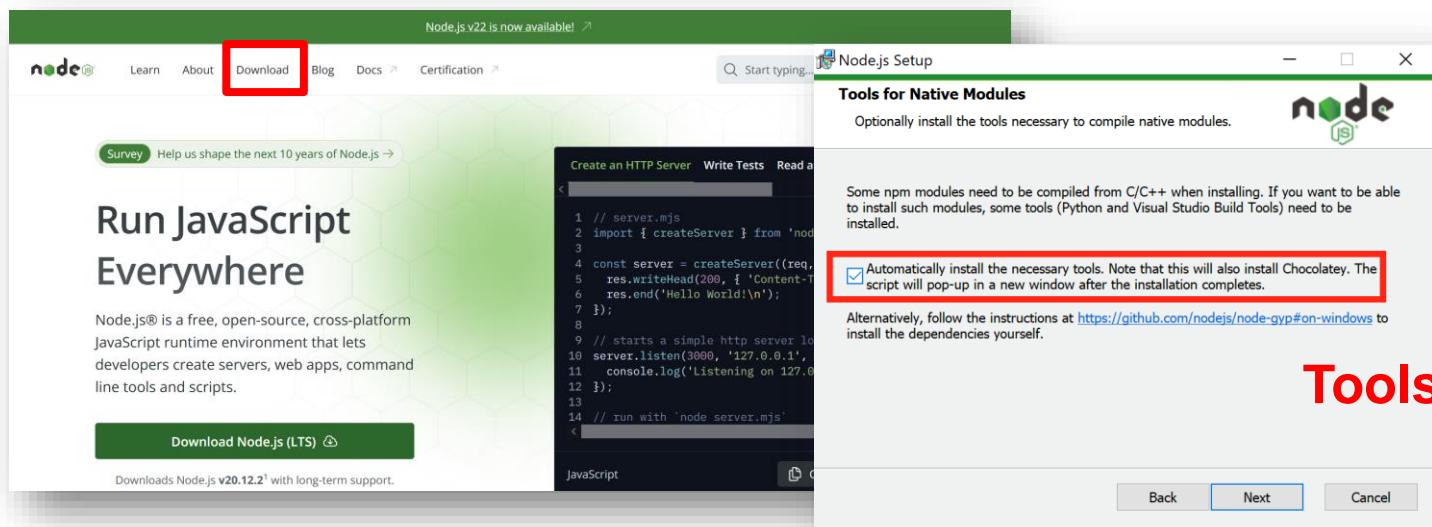
https://github.com/OmniXRI/Edge_AI_TinyML_Course_2024/blob/main/Ch13_Motion_Recognition/IMU_Quick_Guide.md

下載及安裝必要工具

1. Python 3.x



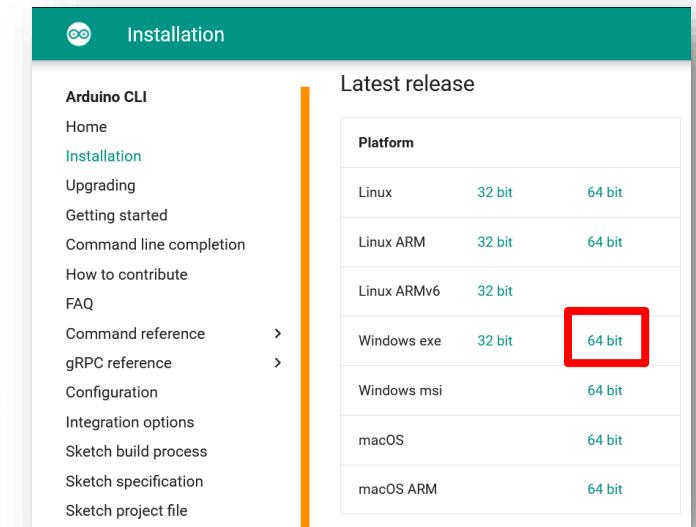
2. Node.js



(若後續 Edge Impulse 無法安裝
可換回舊版 · 例：v18.20.2 LTS)

3. Arduino CLI

(選配 · 依不同開發板需求)



安裝時要注意
記得一定要勾選
Tools for Native Modules
以 node -v 及 npm -v
檢查安裝好的版本

安裝 Edge Impulse windows 工作環境

➤ 安裝**Edge Impulse CLI**

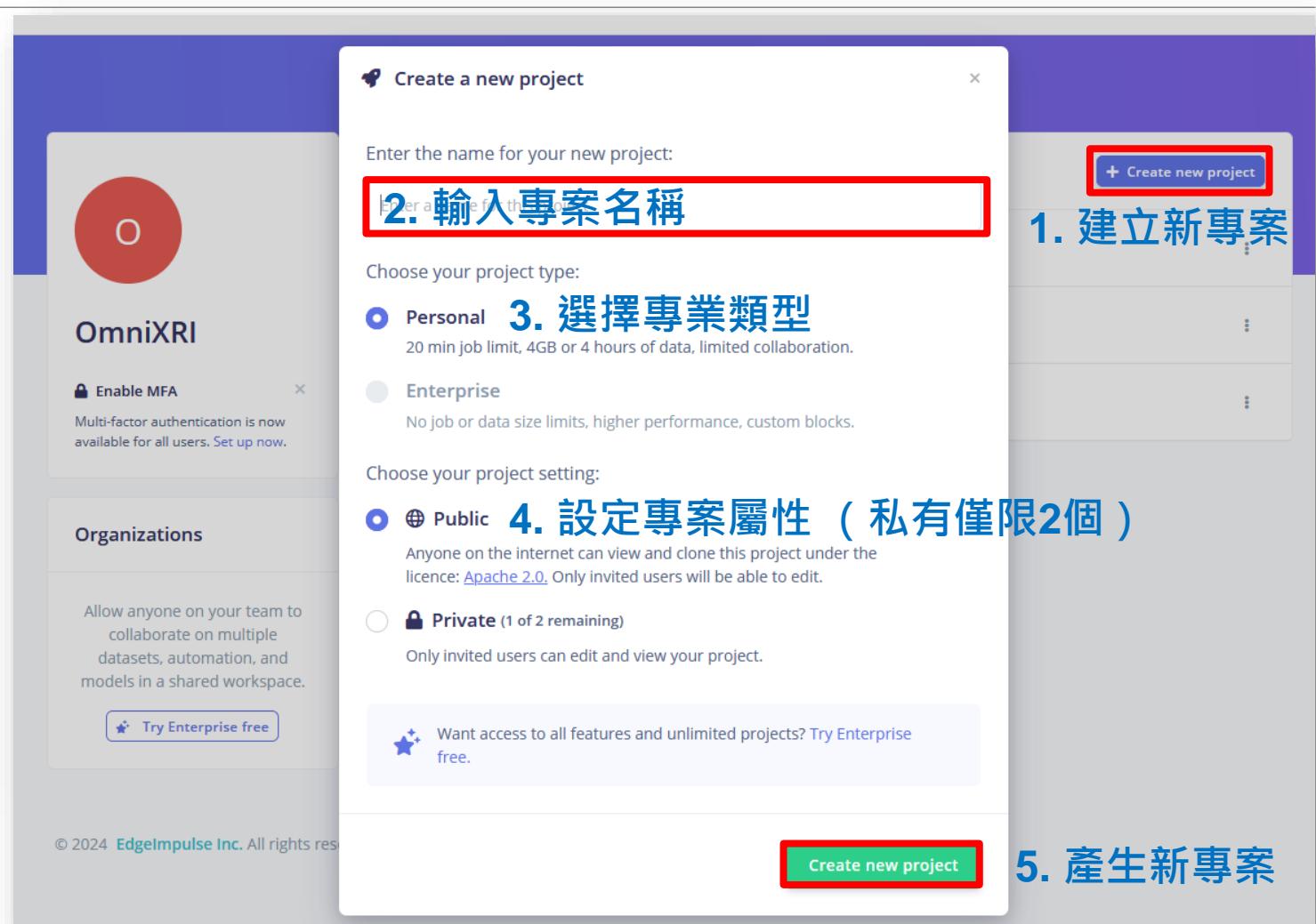
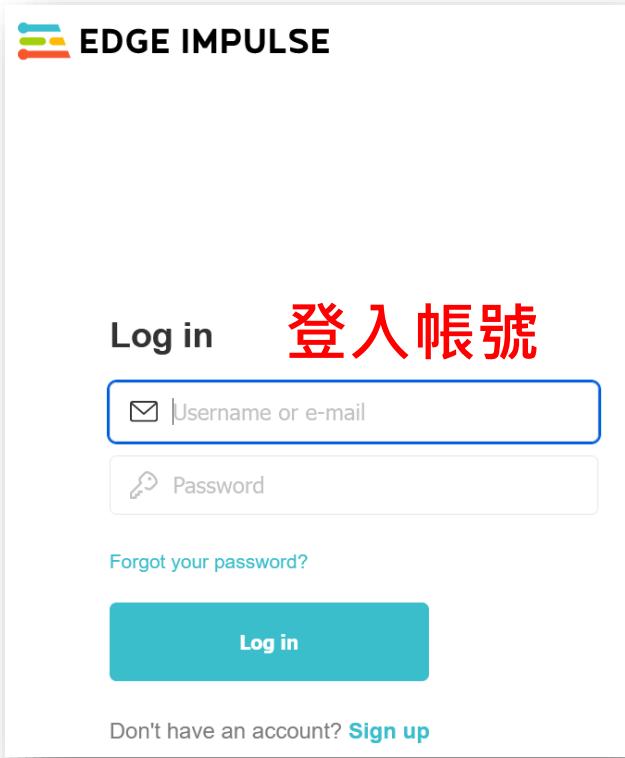
npm install -g edge-impulse-cli --force

➤ 安裝完成後會得到下列工具

- **edge-impulse-daemon** 透過 COM 埠和雲端平台連接
- **edge-impulse-uploader** 允許上傳本機檔案
- **edge-impulse-data-forwarder** 透過 COM 埠上傳開發板感測器數值
- **edge-impulse-run-impulse** 顯示裝置上運行的模型
- **edge-impulse-blocks** 建立自定義區塊
- **himax-flash-tool** 燒錄 Haimax WE-I Plus

<https://docs.edgeimpulse.com/docs/tools/edge-impulse-cli/cli-installation>

建立 Edge Impulse 新專案



This image illustrates the process of creating a new project in Edge Impulse. It consists of three main panels:

- 1. 建立新專案**: Shows the "Create a new project" dialog box. The "Create new project" button is highlighted with a red box. The text "2. 輸入專案名稱" (Input project name) is overlaid on the input field.
- 2. 選擇專業類型**: Shows the "Choose your project type" section. The "Personal" radio button is selected. The text "3. 選擇專業類型" is overlaid on this panel.
- 3. 設定專案屬性 (私有僅限2個)**: Shows the "Choose your project setting" section. The "Public" radio button is selected. The text "4. 設定專案屬性 (私有僅限2個)" is overlaid on this panel.

At the bottom right of the dialog box, there is another "Create new project" button, also highlighted with a red box. The overall background shows the Edge Impulse dashboard with various project cards.

參考資料：<https://wiki.seeedstudio.com/cn/XIAO-BLE-PDM-EI/>

啟動edge-impulse-data-forwarder

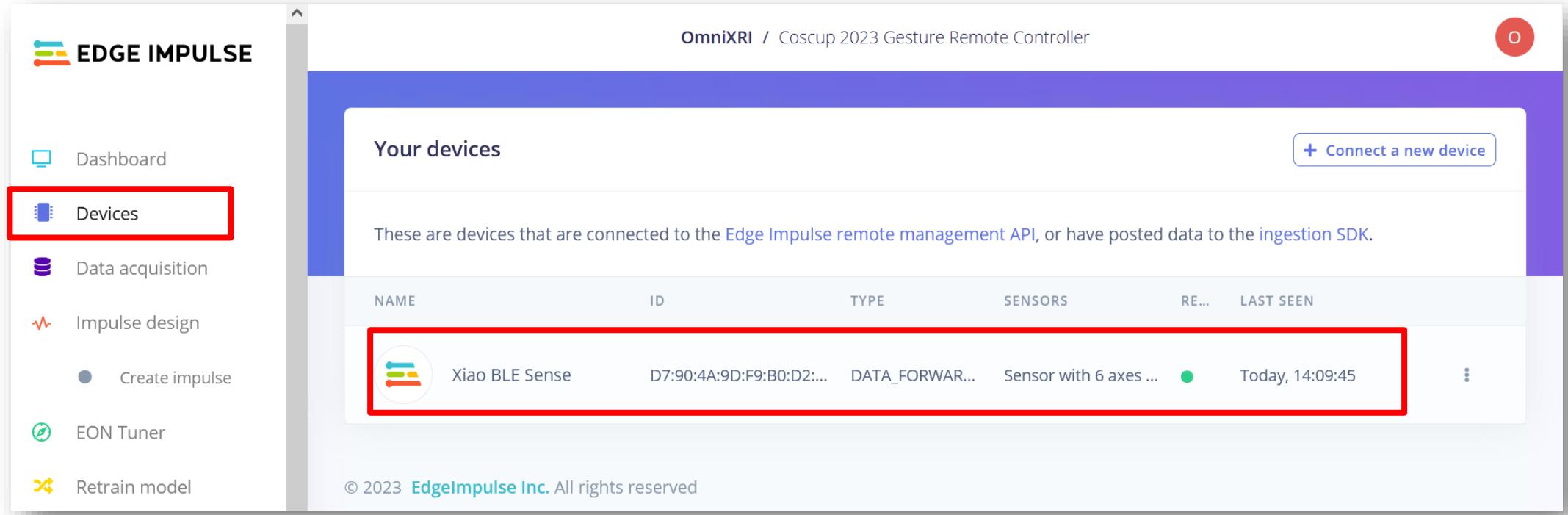
```
C:\WINDOWS\system32\cmd.exe - "node" "C:\Users\jack_\AppData\Roaming\npm\node_modules\edge-impulse-cli\build\cli\data-forwarder --clean"
C:\Users\jack_>edge-impulse-data-forwarder --clean edge-impulse-data-forwarder --clean
Edge Impulse data forwarder v1.24.1
? What is your user name or e-mail address (edgeimpulse.com)? omnixri@gmail.com 輸入帳號
? What is your password? [hidden] 輸入密碼
Endpoints:
  Websocket: wss://remote-mgmt.edgeimpulse.com
  API: https://studio.edgeimpulse.com
  Ingestion: https://ingestion.edgeimpulse.com

[SER] Connecting to COM8
[SER] Serial is connected (7F:63:29:74:0B:F4:EA:69)
[WS ] Connecting to wss://remote-mgmt.edgeimpulse.com
[WS ] Connected to wss://remote-mgmt.edgeimpulse.com

? To which project do you want to connect this device? OmniXRI / Xiao_nRF52840_IMU_Test 選擇對應專案
[SER] Detecting data frequency...
[SER] Detected data frequency: 130Hz
? 6 sensor axes detected (example values: [-0.02,-0.005,1.001,0.49,-1.4,0.84]). What do you want to call them? Separate the names with ',': aX,aY,aX,gX,gY,gZ 輸入資料數量及名稱
[WS ] Device "XiaoSense" is now connected to project "Xiao_nRF52840_IMU_Test". To connect to another project, run `edge-impulse-data-forwarder --clean`.
[WS ] Go to https://studio.edgeimpulse.com/studio/391754/acquisition/training to build your machine learning model!
[WS ] Incoming sampling request {
  path: '/api/training/data',
  label: 'OK',
  length: 10000,
  interval: 7.6923076923076925,
  hmacKey: 'd00f5918c1020b658b18569f9ee881c5',
  sensor: 'Sensor with 6 axes (aX, aY, aX, gX, gY, gZ)'
}
```

輸入帳號密碼並選定專案。準備接收來自開發板傳送的資料並給予並應的名稱。傳送的資料頻度必須大於2Hz**。**
若無法連接 COM 埠，請按開發板重置鍵一次，並請關閉 Arduino 及有可能佔用 COM 之程式。

檢查裝置是否已連線

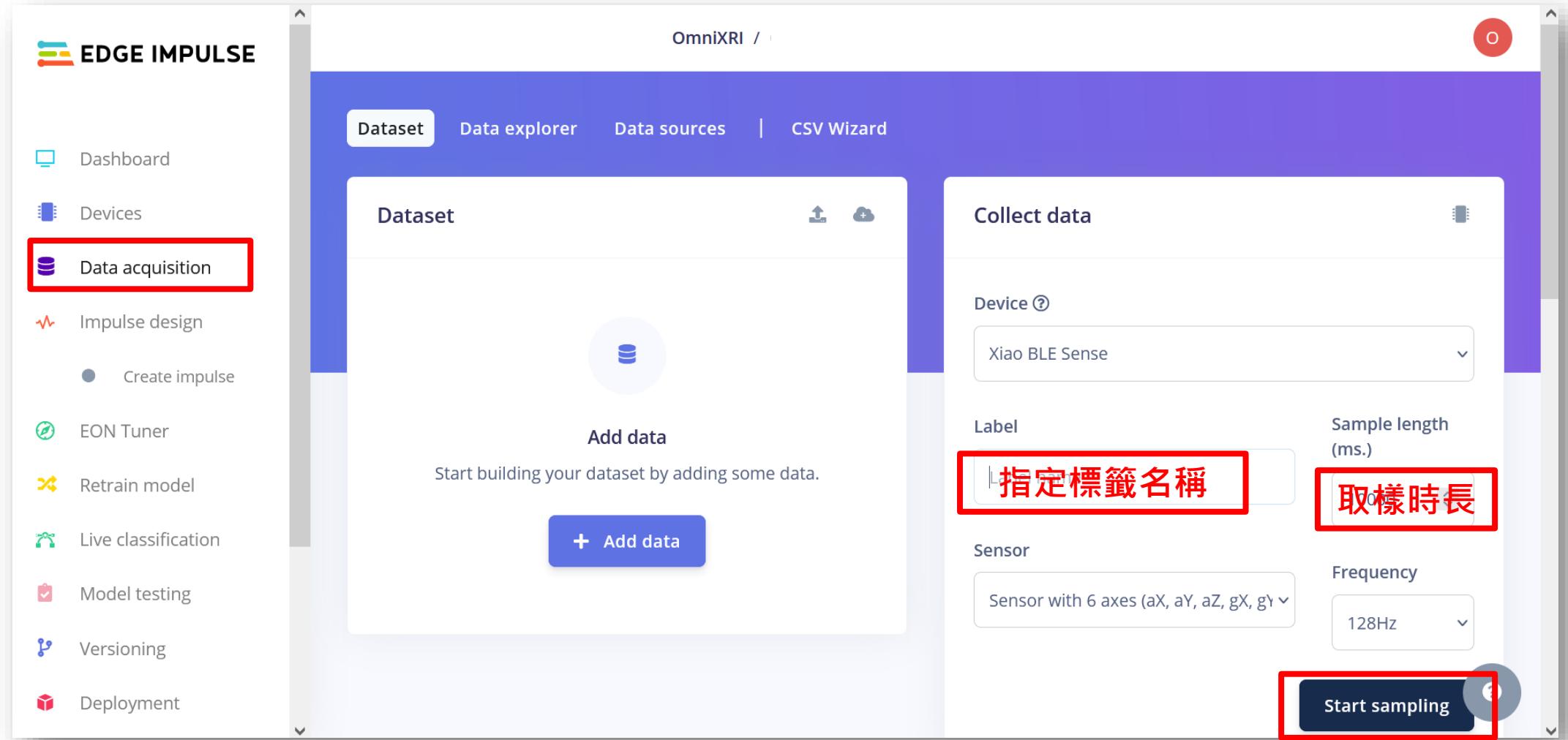


The screenshot shows the Edge Impulse web interface. On the left, a sidebar menu lists several options: EDGE IMPULSE, Dashboard, Devices (which is highlighted with a red box), Data acquisition, Impulse design, Create impulse, EON Tuner, and Retrain model. The main content area is titled "Your devices" and displays a table of connected devices. The table has columns for NAME, ID, TYPE, SENSORS, RE..., and LAST SEEN. One device, "Xiao BLE Sense", is listed with the following details: ID D7:90:4A:9D:F9:B0:D2:..., TYPE DATA_FORWARDER, SENSORS Sensor with 6 axes ..., and LAST SEEN Today, 14:09:45. A red box highlights both the "Devices" menu item and the "Xiao BLE Sense" device row.

NAME	ID	TYPE	SENSORS	RE...	LAST SEEN
Xiao BLE Sense	D7:90:4A:9D:F9:B0:D2:...	DATA_FORWARDER	Sensor with 6 axes ...	●	Today, 14:09:45

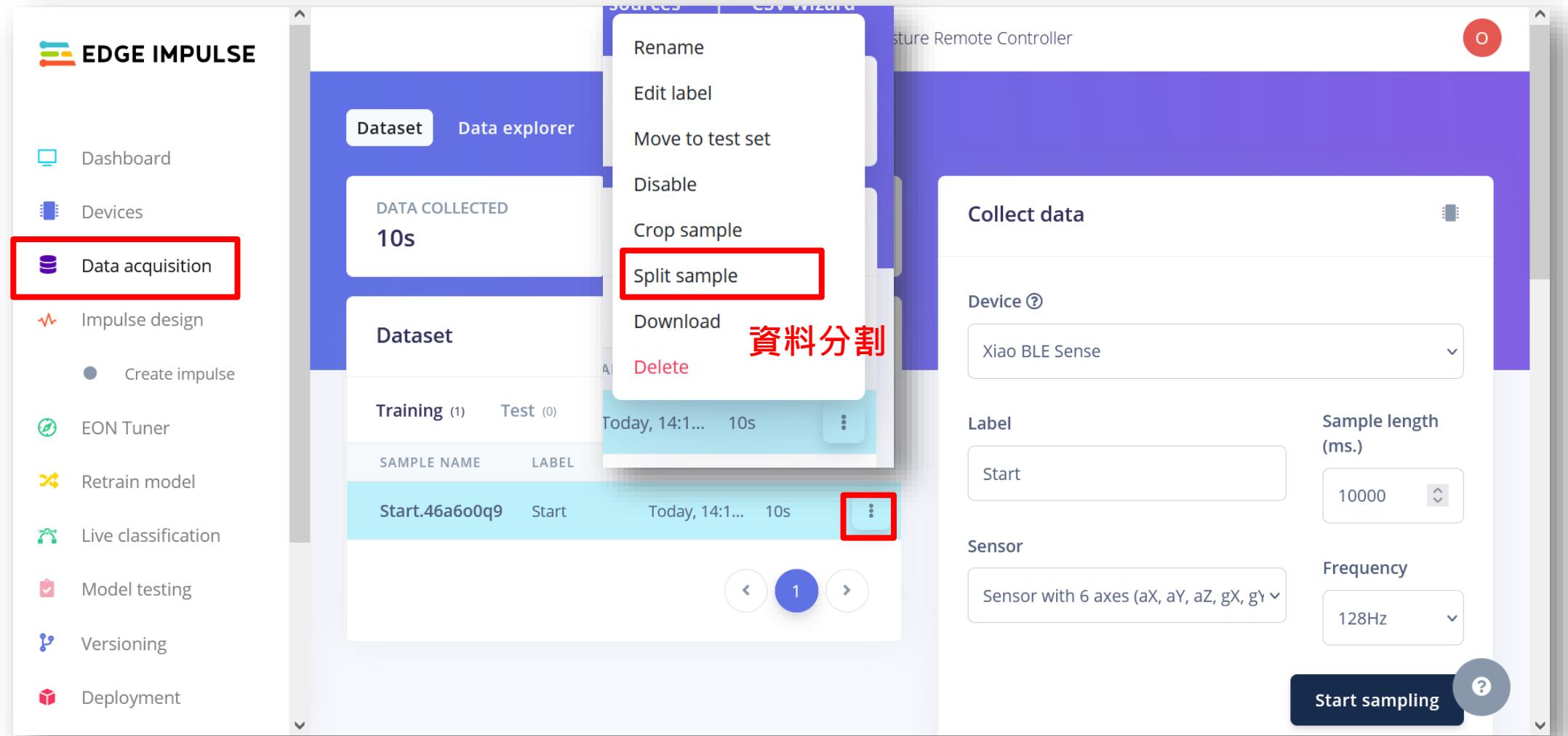
- 開發板運行IMU連續取值輸出程式。
- 啟動 **edge-impulse-data-forwarder**，將裝置連線到雲端。
- 將開發板輸出之內容，傳送到雲端。

從外部裝置取得資料



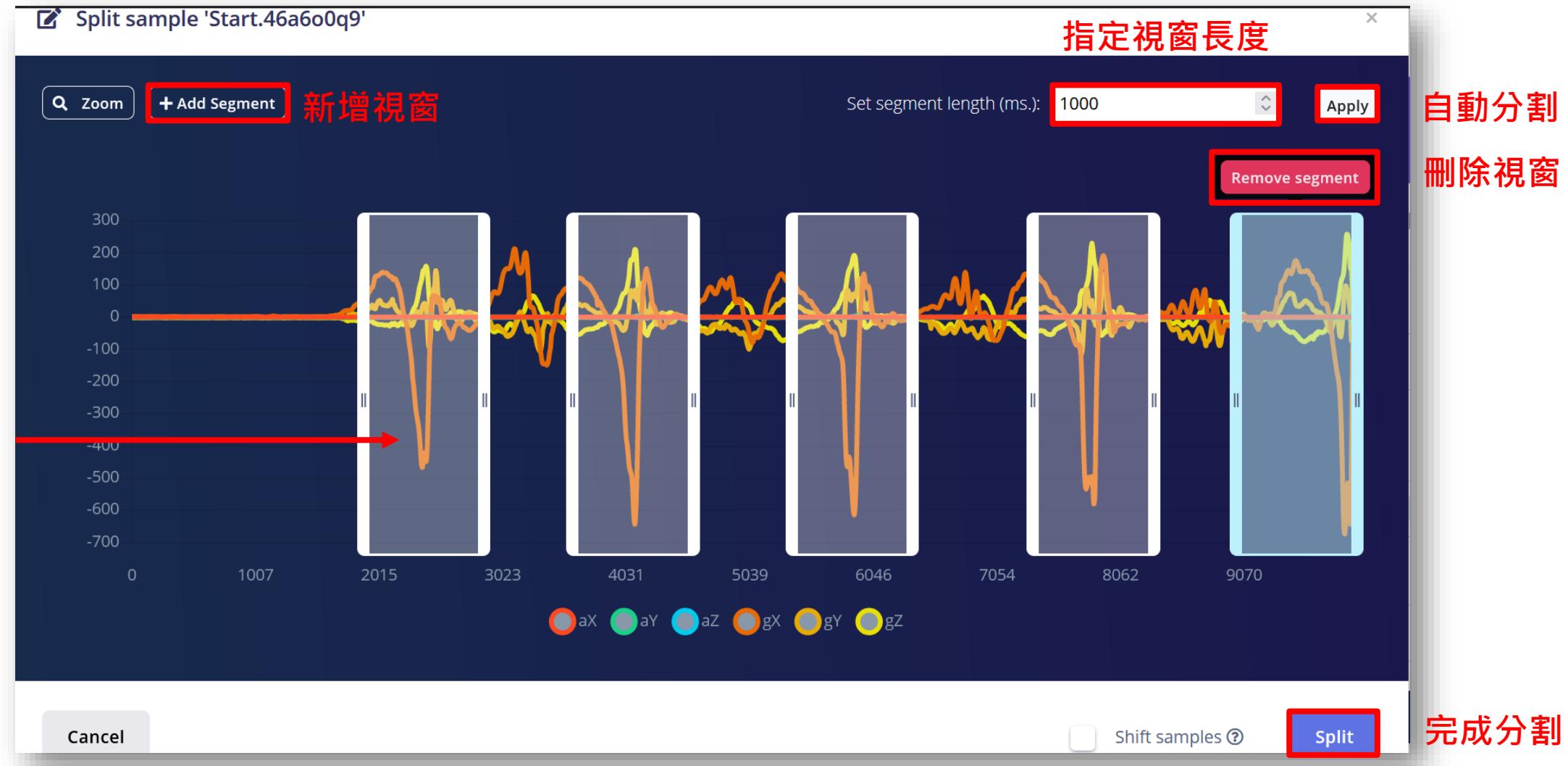
The screenshot shows the Edge Impulse interface within the OmniXRI platform. The left sidebar lists various features: Dashboard, Devices, Data acquisition (highlighted with a red box), Impulse design, Create impulse, EON Tuner, Retrain model, Live classification, Model testing, Versioning, and Deployment. The main area is titled 'Dataset' and contains a central 'Add data' button and a 'Collect data' panel. The 'Collect data' panel includes fields for 'Device' (set to 'Xiao BLE Sense'), 'Label' (highlighted with a red box and containing the text '指定標籤名稱'), 'Sample length (ms.)' (highlighted with a red box and containing the text '取樣時長'), 'Sensor' (set to 'Sensor with 6 axes (aX, aY, aZ, gX, gY)'), 'Frequency' (set to '128Hz'), and a 'Start sampling' button (highlighted with a red box). The top navigation bar shows 'OmniXRI / Dataset'.

大量收集樣本並分割成獨立可訓練樣本

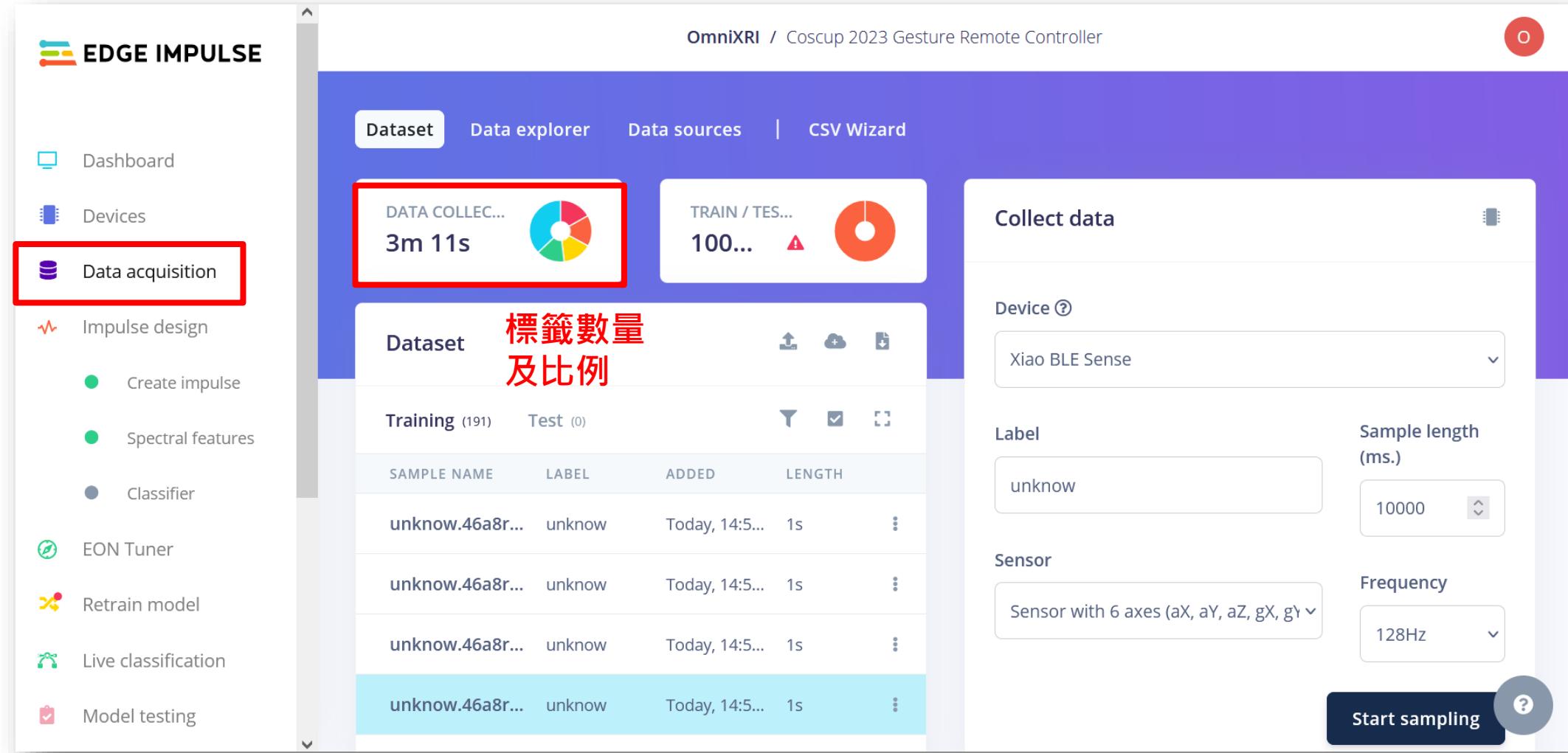


The screenshot shows the Edge Impulse web interface. On the left sidebar, the 'Data acquisition' option is highlighted with a red box. In the main area, the 'Data explorer' tab is selected, showing a dataset named 'DATA COLLECTED 10s'. A context menu is open over this dataset, with the 'Split sample' option highlighted by a red box. To the right of the menu, the text '資料分割' (Data Splitting) is displayed in red. The 'Collect data' panel on the right shows settings for a 'Xiao BLE Sense' device, a sample length of 10000 ms, and a frequency of 128Hz. A 'Start sampling' button is at the bottom.

原始資料與自動分割



反複收集分割，建立完整資料集



OmniXRI / Coscup 2023 Gesture Remote Controller

Dataset **Data explorer** **Data sources** | **CSV Wizard**

DATA COLLECT... **TRAIN / TES...**

3m 11s **100...**

標籤數量及比例

Dataset			
Training (191)	Test (0)		
SAMPLE NAME	LABEL	ADDED	LENGTH
unknow.46a8r...	unknow	Today, 14:5...	1s
unknow.46a8r...	unknow	Today, 14:5...	1s
unknow.46a8r...	unknow	Today, 14:5...	1s
unknow.46a8r...	unknow	Today, 14:5...	1s

Collect data

Device ?
Xiao BLE Sense

Label
unknow

Sample length (ms.)
10000

Sensor
Sensor with 6 axes (aX, aY, aZ, gX, gY)

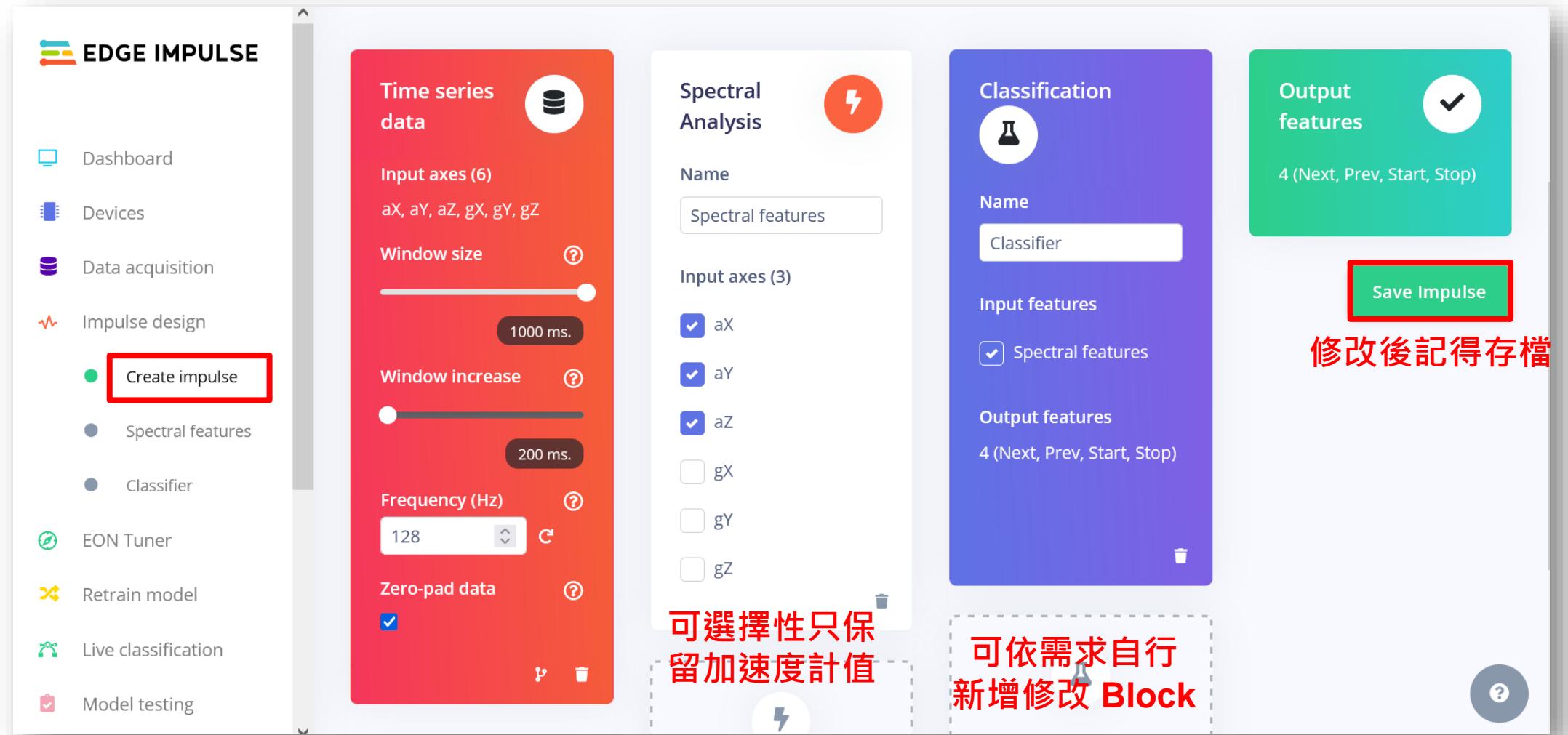
Frequency
128Hz

Start sampling



9.3. 模型選用與訓練

選擇模型及設定必要參數



EDGE IMPULSE

- Dashboard
- Devices
- Data acquisition
- Impulse design
- Create impulse**
- Spectral features
- Classifier
- EON Tuner
- Retrain model
- Live classification
- Model testing

Time series data

Spectral Analysis

Classification

Output features

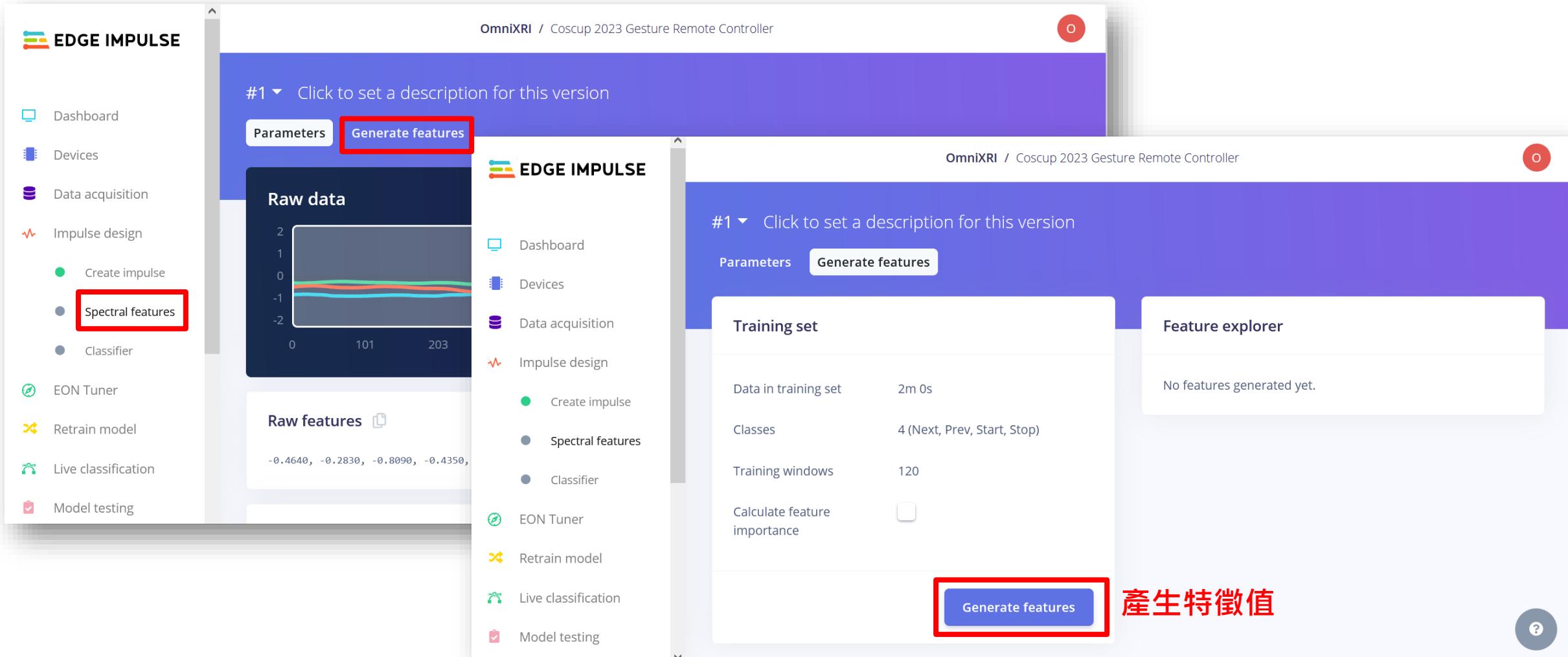
Save Impulse

修改後記得存檔

可選擇性只保留加速度計值

可依需求自行新增修改 Block

提取資料特徵



The screenshot shows the Edge Impulse web interface for a project titled "Coscup 2023 Gesture Remote Controller".

Left Sidebar:

- EDGE IMPULSE
- Dashboard
- Devices
- Data acquisition
- Impulse design
- Create impulse
- Spectral features** (highlighted with a red box)
- Classifier
- EON Tuner
- Retrain model
- Live classification
- Model testing

Main Area (Top Left):

#1 ▾ Click to set a description for this version

Buttons: Parameters (disabled), **Generate features**

Raw data: A line graph showing raw data over time. The x-axis ranges from 0 to 203, and the y-axis ranges from -2 to 2. The graph shows several horizontal lines at different levels.

Raw features: A list of feature values: -0.4640, -0.2830, -0.8090, -0.4350.

Main Area (Bottom Left):

#1 ▾ Click to set a description for this version

Buttons: Parameters, **Generate features**

Training set:

- Data in training set: 2m 0s
- Classes: 4 (Next, Prev, Start, Stop)
- Training windows: 120
- Calculate feature importance:

Feature explorer: No features generated yet.

Bottom Center: A large red box highlights the **Generate features** button.

Bottom Right: A red box contains the text **產生特徵值**.

提取特徵結果

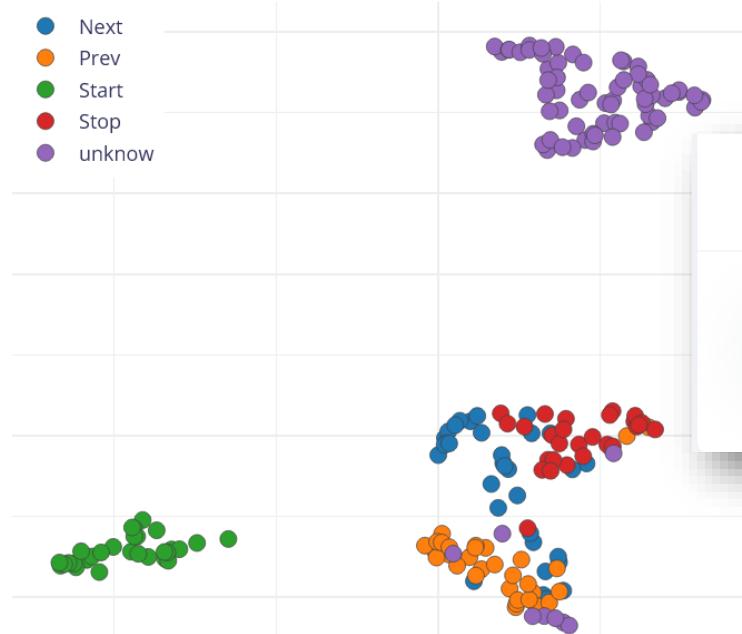
Feature generation output

```
still running...
completed 0 / 500 epochs
completed 50 / 500 epochs
completed 100 / 500 epochs
completed 150 / 500 epochs
completed 200 / 500 epochs
completed 250 / 500 epochs
completed 300 / 500 epochs
completed 350 / 500 epochs
completed 400 / 500 epochs
completed 450 / 500 epochs
Fri Jul 28 06:54:26 2023 Finished embedding
Reducing dimensions for visualizations OK
Job completed
```

(0)

Feature explorer

- Next
- Prev
- Start
- Stop
- unknown



On-device performance ⓘ

PROCESSING TIME

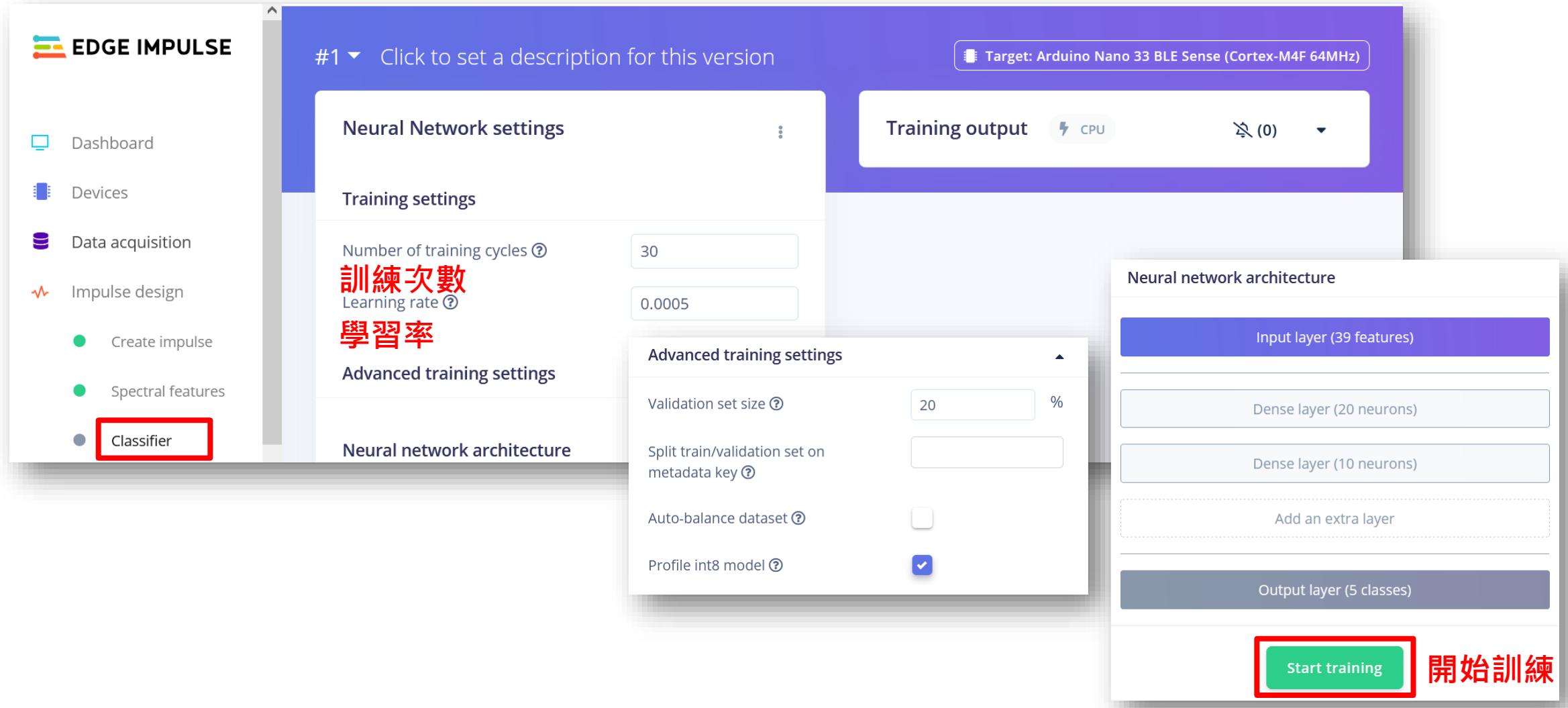

23 ms.

PEAK RAM USAGE


2 KB

以指定的硬體進行資源
使用及推論時間估測

設定分類訓練相關參數



The screenshot shows the Edge Impulse web interface for classifier setup. On the left sidebar, the 'Classifier' option is highlighted with a red box. The main area displays training settings and neural network architecture.

Training settings:

- Number of training cycles: 30
- Learning rate: 0.0005

Advanced training settings:

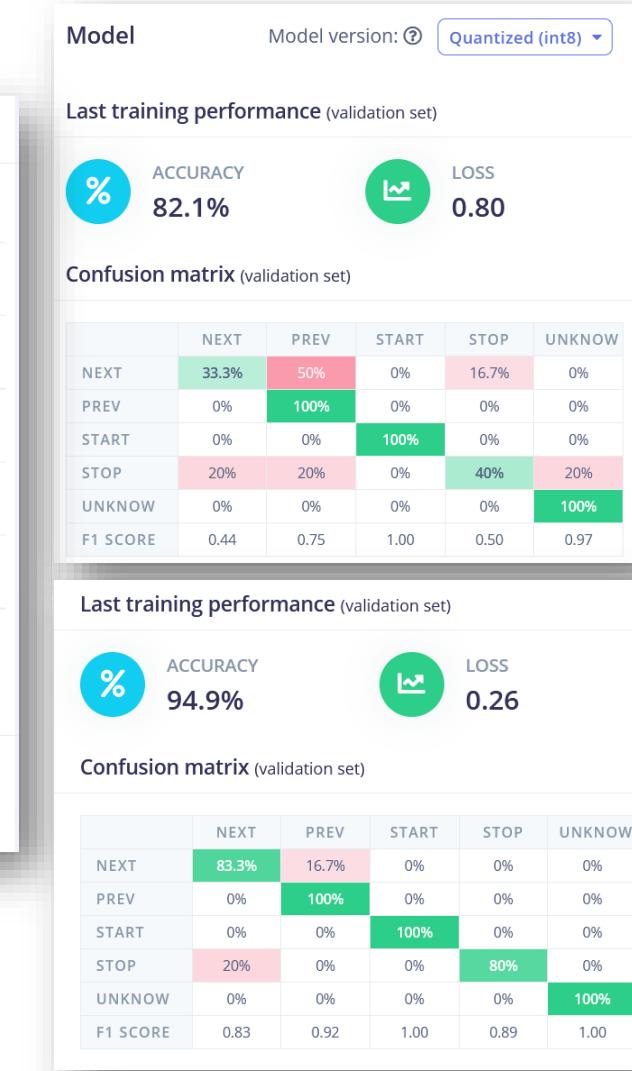
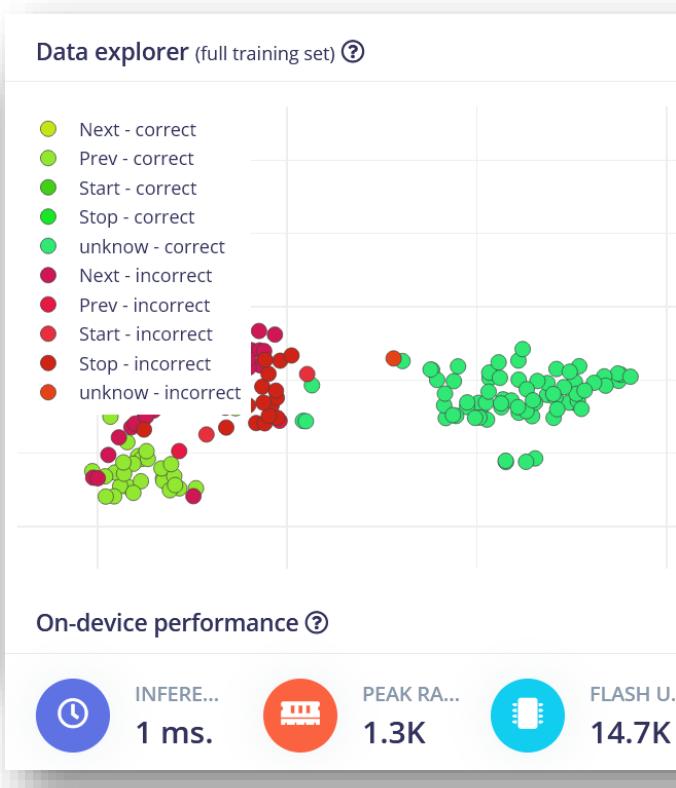
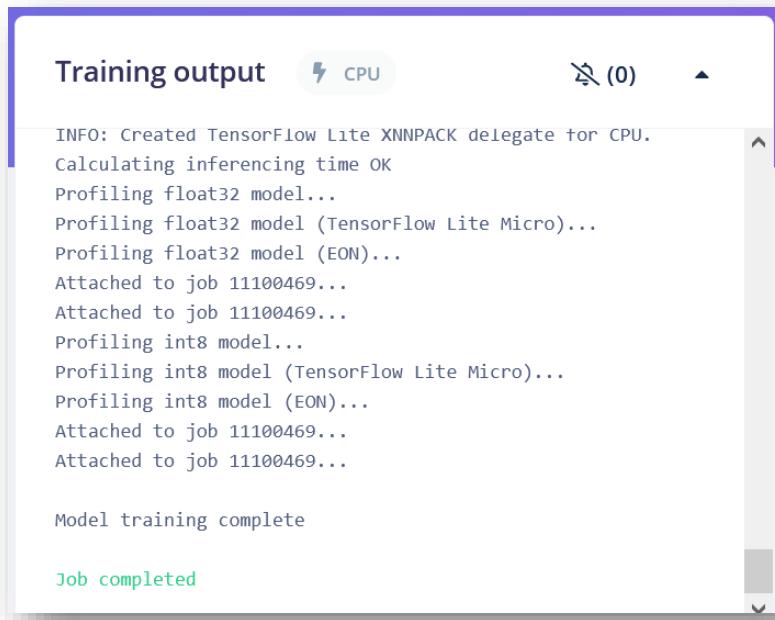
- Validation set size: 20 %
- Split train/validation set on metadata key
- Auto-balance dataset:
- Profile int8 model:

Neural network architecture:

- Input layer (39 features)
- Dense layer (20 neurons)
- Dense layer (10 neurons)
- Add an extra layer
- Output layer (5 classes)

A green button labeled 'Start training' is highlighted with a red box at the bottom right of the architecture section. The text '開始訓練' (Start Training) is overlaid in red on this button.

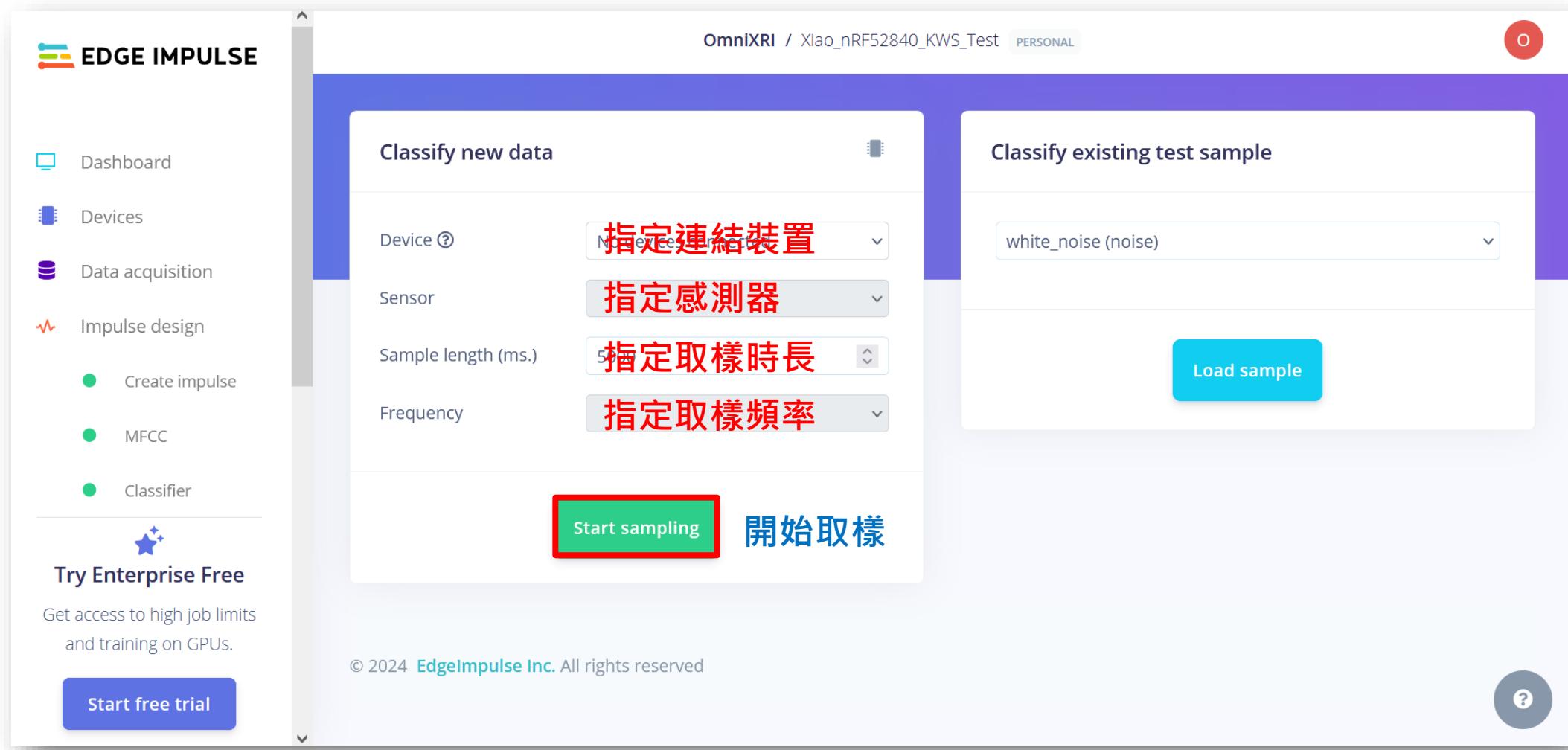
開始進行模型訓練及結果顯示



30
Epoch
結果

100
Epoch
結果

線上測試（從外部裝置取樣）

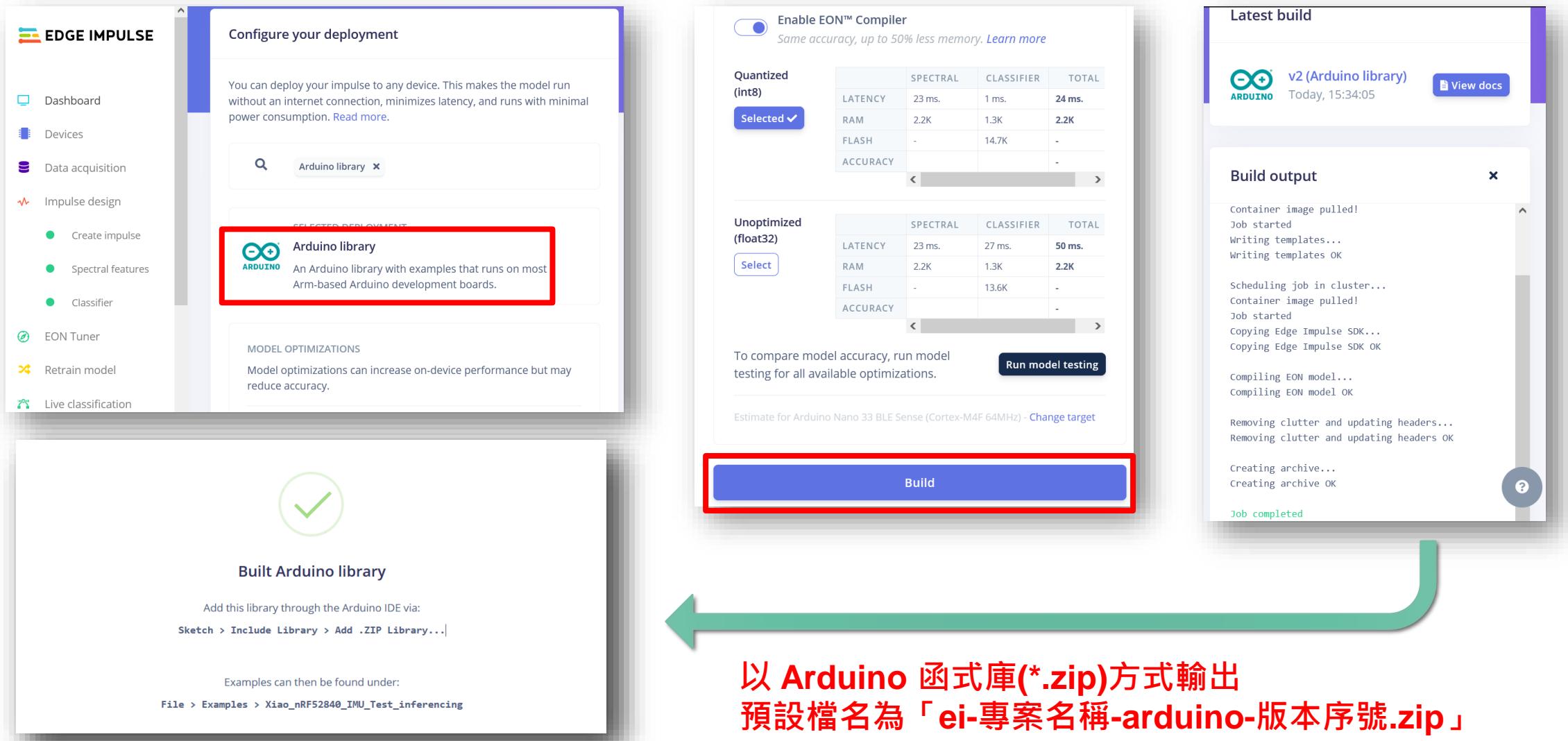


The screenshot shows the Edge Impulse web interface for a project titled "OmniXRI / Xiao_nRF52840_KWS_Test". The left sidebar includes options like Dashboard, Devices, Data acquisition, Impulse design, Create impulse, MFCC, Classifier, and a Try Enterprise Free section with a "Start free trial" button. The main area has two sections: "Classify new data" and "Classify existing test sample". In the "Classify new data" section, fields include "Device" (set to "None selected"), "Sensor" (highlighted in red with the text "指定感測器"), "Sample length (ms.)" (set to 500), and "Frequency" (highlighted in red with the text "指定取樣頻率"). A large green "Start sampling" button is highlighted with a red border and the text "開始取樣" (Start Sampling). To its right is a "Load sample" button. The "Classify existing test sample" section shows a dropdown set to "white_noise (noise)". The footer contains the copyright notice "© 2024 EdgeImpulse Inc. All rights reserved".



9.4. 模型部署與測試

選擇部署種類及設定參數



The figure consists of three screenshots of the Edge Impulse web interface:

- Screenshot 1 (Deployment Configuration):** Shows the "Configure your deployment" section. A red box highlights the "Arduino library" option under "SELECTED DEPLOYMENT".
- Screenshot 2 (Build Options):** Shows the "Build" tab with two optimization options: "Quantized (Int8)" (Selected) and "Unoptimized (float32)". Each has a table of metrics (Latency, RAM, Flash, Accuracy). A red box highlights the "Build" button.
- Screenshot 3 (Build Log):** Shows the "Latest build" log for "v2 (Arduino library)" on "ARDUINO". It details the build process: pulling a container, writing templates, scheduling a job, copying Edge Impulse SDK, compiling EON models, removing clutter, creating archives, and finally completing the job.

A large green arrow points from the "Build" button in Screenshot 2 towards the text at the bottom right.

以 Arduino 函式庫(*.zip)方式輸出
預設檔名為「ei-專案名稱-arduino-版本序號.zip」

導入 Arduino 函式庫並進行推論測試(1/2)

- 新增函式庫 **Sketch > Include Library > Add .ZIP Library ...**
- 新增範例 **File > Examples > ei- 專案名稱_inferencing > nano_ble33_sense > nano_ble33_sense_accelerometer** (原始範例輸出結果從 COM 輸出文字串)
- 經編譯會在「**#error “Invalid model for current sensor”**」這列出現「**“invalid model for current sensor”**」，主要原因為 Edge Impulse 打包時是以 Sensor_Fusion 方式處理而不是 Accelerometer 方式造成。
- 點擊選單 **File > Preferences** 找到 Sketchbook Folder，進到該路徑後，進到 \libraries\專案名稱_inferencing\src\model-parameters\ 開啟 **model_metadata.h**。找到「**#define EI_CLASSIFIER_SENSOR EI_CLASSIFIER_SENSOR_FUSION**」，將定義改成「**EI_CLASSIFIER_SENSOR_ACCELEROMETER**」存檔即可。

導入 Arduino 函式庫並進行推論測試(2/2)

- 回到 Arduino 範例後會發現使用的運動感測器不同，所以需將「`#include <Arduino_LSM9DS1.h>`」註解掉並新增下列程式

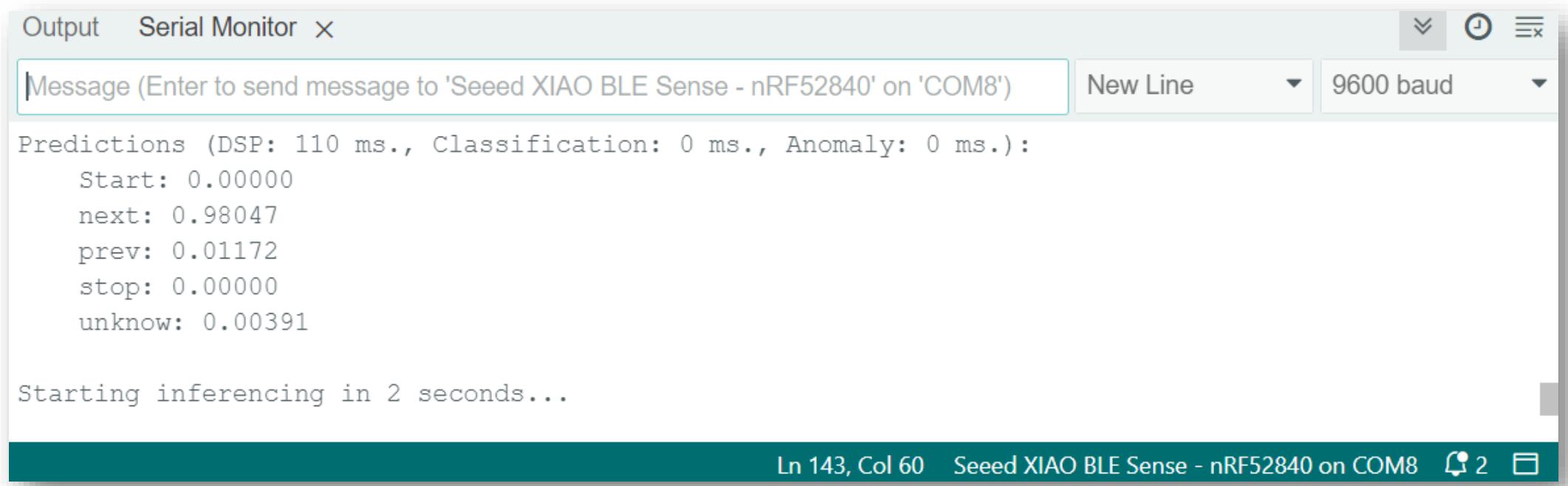
```
#include <LSM6DS3.h>
#include <Wire.h>
LSM6DS3 myIMU(I2C_MODE, 0x6A);
```

- 在Setup函式中的初始化也要將「`if (!IMU.begin()) {`」修改為「`if (!myIMU.begin()) {`」
- 另外由於讀取IMU運動感測器函式不同因此也需修改如左。
- 重新編譯前確認開發板是設定在「**Seeed nRF52 mbed-enabled Boards** > Seeed XIAO BLE Sense - nRF52840」，不然程式運行後會找不到IMU LSM6DS3。

```
17  /* Includes -----
18  #include <Xiao_nRF52840_IMU_Test_inferencing.h>
19  // #include <Arduino_LSM9DS1.h> //Click here to get the libr
20  #include <LSM6DS3.h>
21  #include <Wire.h>
22  /* Constant defines -----
23  #define CONVERT_G_TO_MS2      9.80665f
24  #define MAX_ACCEPTED_RANGE    2.0f           // starting 03/2022
25
26  LSM6DS3 myIMU(I2C_MODE, 0x6A);      //I2C device address 0x6A
```

```
99  //           IMU.readAcceleration(buffer[ix], buffer[ix + 1],
100  buffer[ix]     = myIMU.readFloatAccelX();
101  buffer[ix + 1] = myIMU.readFloatAccelY();
102  buffer[ix + 2] = myIMU.readFloatAccelZ();
```

手勢辨識結果（Arduino部份）



The screenshot shows the Arduino IDE's Serial Monitor window. The title bar says "Output" and "Serial Monitor". The message input field contains "Message (Enter to send message to 'Seeed XIAO BLE Sense - nRF52840' on 'COM8')". The baud rate is set to "9600 baud". The main text area displays the following output:

```
Predictions (DSP: 110 ms., Classification: 0 ms., Anomaly: 0 ms.):
Start: 0.00000
next: 0.98047
prev: 0.01172
stop: 0.00000
unknow: 0.00391

Starting inferencing in 2 seconds...
```

The status bar at the bottom shows "Ln 143, Col 60 Seeed XIAO BLE Sense - nRF52840 on COM8" and a green progress bar.

- 推論結果，包括前處理(DSP)、分類及異常時間(ms)
- 將五個標籤的置信度顯示出來，1.0為完全正確，0.0為完全不正確，可設置門檻值來限制置信度不高之答案。
- **No Code**型式，範例程式直接編譯上傳，不需改寫任何程式，輸出結果由 COM 接收文字串。

Arduino 2.0 快速(增量)編譯



如何讓Arduino 2.0 快速編譯 (增量編譯)

非常重要：

強烈建議一定要採用**Arduino CLI** 增量編譯方式更新程式修改，否則每次將耗費大量時間，增加碳排量。

工作內容	Arduino IDE	Arduino CLI
第一次編譯上傳	19~20min	19~20min
未修改程式第二次編譯上傳	19~20min	< 1min
修改程式後編譯上傳	19~20min	1~2min

<https://omnixri.blogspot.com/2024/10/arduino-20.html>

參考文獻

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<https://hackmd.io/1PK1URhIQ7GutcWgpgsWbg#TinyMLMCU-AI%E7%B3%BB%E5%88%97>
- 許哲豪，【課程簡報】20240509_慈濟醫資_穿戴式人工智慧工作坊_利用TinyML技術快速搭建微型智慧應用
<https://omnixri.blogspot.com/2024/05/20240509tinyml12.html>
- 許哲豪，OmniXRI's Edge AI & TinyML 小學堂 【第13講】實作案例—運動辨識（快速指令表）
https://github.com/OmniXRI/Edge_AI_TinyML_Course_2024/blob/main/Ch13_Motion_Recognition/IMU_Quick_Guide.md

延伸閱讀

- 許哲豪，如何讓 Arduino 2.0 快速編譯（增量編譯）

<https://omnixri.blogspot.com/2024/10/arduino-20.html>

- Seeed, Xiao nRF52840 Sense – Embedded ML – Motion Recognition based on Edge Impulse

<https://wiki.seeedstudio.com/XIAOEI/>

- Github, Seeed-Studio / Seeed_Arduino_LSM6DS3

https://github.com/Seeed-Studio/Seeed_Arduino_LSM6DS3

- Seeed, Xiao nRF52840 Sense – Embedded ML – Getting Started with TensorFlow Lite on Seeed Studio XIAO nRF52840 Sense

<https://wiki.seeedstudio.com/XIAO-BLE-Sense-TFLite-Getting-Started/>

沒有最邊



只有更邊



歡迎加入
邊緣人俱樂部



YOUTUBE 直播 : <https://www.youtube.com/@omnixri1784streams>



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[開 源 : https://github.com/OmniXRI](#)