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Number: 2223118

Experiment No 8

Introduction

The "magic wand" project that can recognize gestures using an accelerometer and an ML classification model on Edge Devices

Objective: Build a project to detect the accelerometer values and convert them into gestures

Tasks:

● Generate the dataset for Accelerometer Motion (Up-Down, Left-Right)

● Configure BLE Sense / Mobile for Edge Impulse

● Building and Training a Model

● Deploy on Nano BLE Sense / Mobile Phone

Introduction

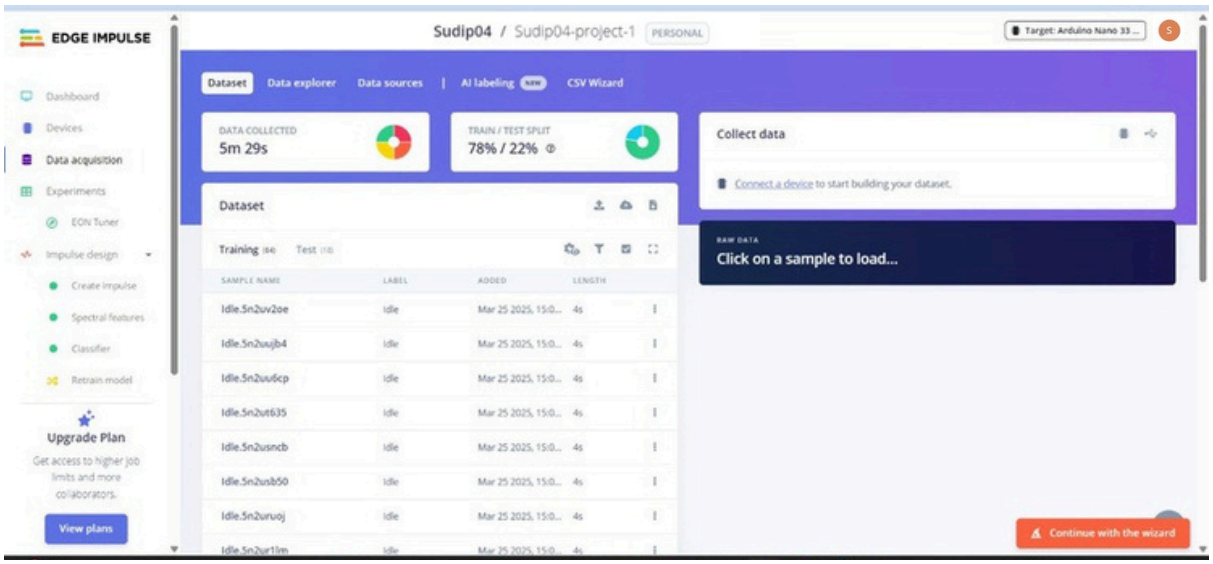
Edge Impulse is a development platform for machine learning on edge devices, targeted at developers who want to create intelligent device solutions. The " Accelerometer Motion "sensor reading equivalent in Edge Impulse would typically involve creating a simple machine learning model that can run on an edge device, like classifying sensor data or recognizing a basic pattern.

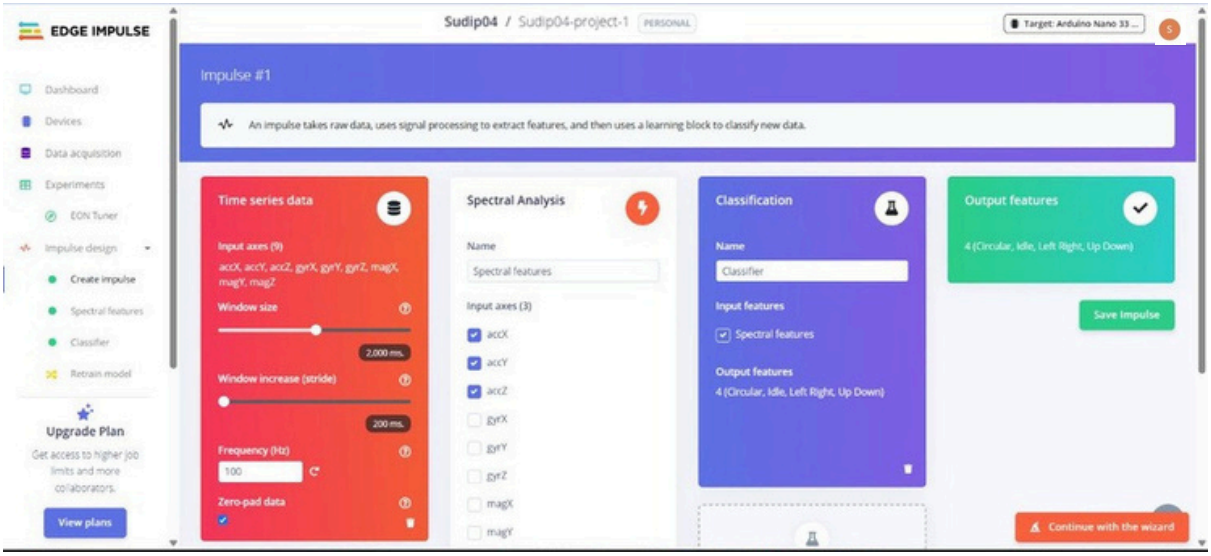
Materials Required

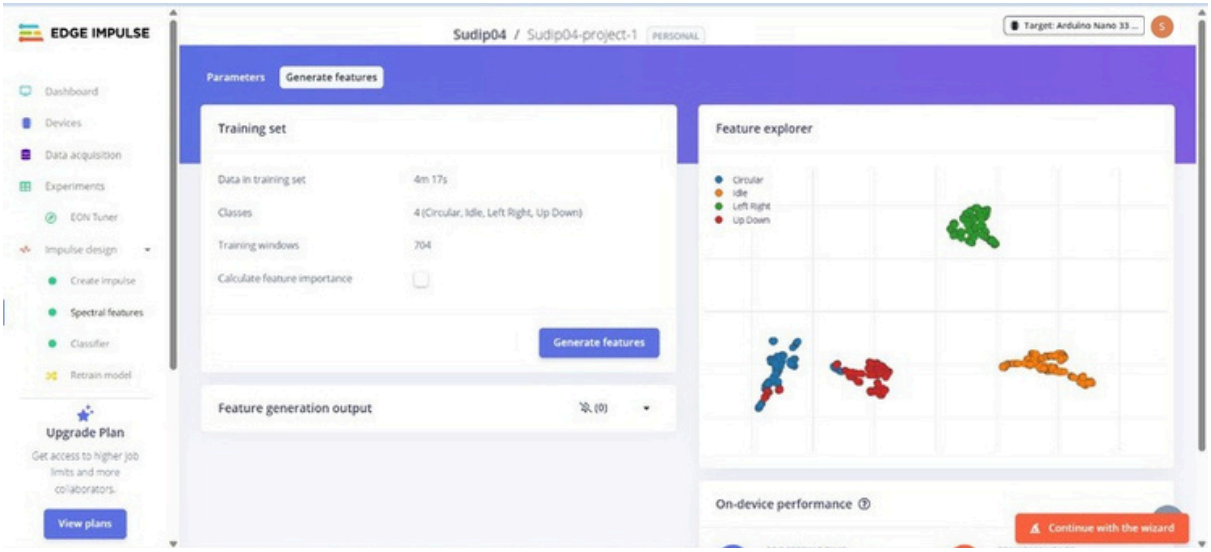
• Nano BLE Sense Board

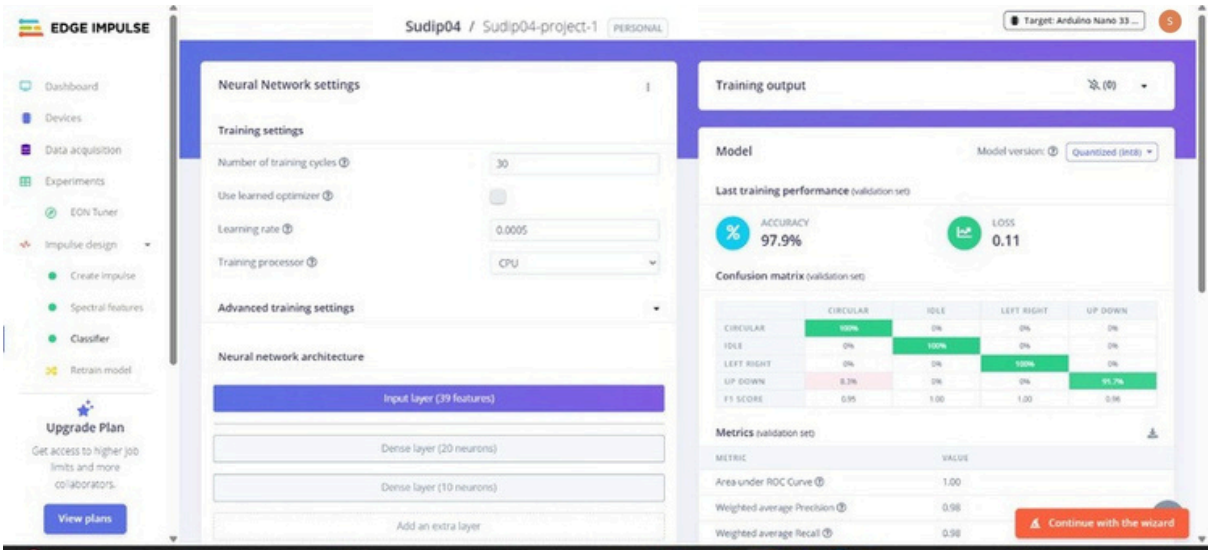
ECL Experiment 8

1. Dataset Image




EDGE IMPULSE
Sudip04 / Sudip04-project-1
PERSONAL
Target: Arduino Nano 33 ...
Dashboard
Devices
Data acquisition
Experiments
EON Tuner
Impulse design
Create impulse
Spectral features
Classifier
Retrain model
Upgrade Plan
Get access to higher job limits and more collaborators.
View plans
Impulse #1
An impulse takes raw data, uses signal processing to extract features, and then uses a learning block to classify new data.
Time series data
Input axes (9)
accX, accY, accZ, gyrX, gyrY, gyrZ, magX, magY, magZ
Window size
2,000 ms.
Window increase (stride)
200 ms.
Frequency (Hz)
100
Zero-pad data
Spectral Analysis
Name
Spectral features
Input axes (3)
accX
accY
accZ
gyrX
gyrY
gyrZ
magX
magY
Classification
Name
Classifier
Input features
Spectral features
Output features
4 (Circular, Idle, Left Right, Up Down)
Output features
4 (Circular, Idle, Left Right, Up Down)
Save Impulse
Continue with the wizard


EDGE IMPULSE
Sudip04 / Sudip04-project-1
PERSONAL
Target: Arduino Nano 33 ...
Parameters
Generate features
Dashboard
Devices
Data acquisition
Experiments
EON Tuner
Impulse design
Create impulse
Spectral features
Classifier
Retrain model
Upgrade Plan
Get access to higher job limits and more collaborators.
View plans
Training set
Data in training set
4m 17s
Classes
4 (Circular, Idle, Left Right, Up Down)
Training windows
704
Calculate feature importance
Generate features
Feature generation output
(0)
Feature explorer
Circular
Idle
Left Right
Up Down
On-device performance
Continue with the wizard


EDGE IMPULSE
Sudip04 / Sudip04-project-1
PERSONAL
Target: Arduino Nano 33 ...
Dashboard
Devices
Data acquisition
Experiments
EON Tuner
Impulse design
Create impulse
Spectral features
Classifier
Retrain model
Upgrade Plan
Get access to higher job limits and more collaborators.
View plans
Neural Network settings
Training settings
Number of training cycles
30
Use learned optimizer
Learning rate
0.0005
Training processor
CPU
Advanced training settings
Neural network architecture
Input layer (39 features)
Dense layer (20 neurons)
Dense layer (10 neurons)
Add an extra layer
Training output
Model
Model version:
Quantized (int8)
Last training performance (validation set)
ACCURACY
97.9%
LOSS
0.11
Confusion matrix (validation set)
CIRCULAR
IDLE
LEFT RIGHT
UP DOWN
F1 SCORE
Metrics (validation set)
METRIC
VALUE
Area under ROC Curve
1.00
Weighted average Precision
0.98
Weighted average Recall
0.98
Continue with the wizard

```
/* Edge Impulse ingestion SDK
 * Copyright (c) 2022 EdgeImpulse Inc.
 *
 * Licensed under the Apache License, Version 2.0 (the "License");
 * you may not use this file except in compliance with the License.
 * You may obtain a copy of the License at
 * http://www.apache.org/licenses/LICENSE-2.0
 *
 * Unless required by applicable law or agreed to in writing, software
 * distributed under the License is distributed on an "AS IS" BASIS,
 * WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
 * See the License for the specific language governing permissions and
 * limitations under the License.
 *
 */

/* Includes ---------------------------------------------------------------
*/
#include <r0hi7-project-1_inferencing.h>
#include <Arduino_LSM9DS1.h> //Click here to get the library:
https://www.arduino.cc/reference/en/libraries/arduino_lsm9ds1/

/* Constant defines -------------------------------------------------------
*/
#define CONVERT_G_TO_MS2    9.80665f
/**
 * When data is collected by the Edge Impulse Arduino Nano 33 BLE Sense
 * firmware, it is limited to a 2G range. If the model was created with a
 * different sample range, modify this constant to match the input values.
 * See https://github.com/edgeimpulse/firmware-arduino-nano-33-ble-
sense/blob/master/src/sensors/ei_lsm9ds1.cpp
 * for more information.
 */
#define MAX_ACCEPTED_RANGE 2.0f

/*
 ** NOTE: If you run into TFLite arena allocation issue.
 **
 ** This may be due to may dynamic memory fragmentation.
 ** Try defining "-DEI_CLASSIFIER_ALLOCATION_STATIC" in boards.local.txt
(create
 ** if it doesn't exist) and copy this file to
 **
`<ARDUINO_CORE_INSTALL_PATH>/arduino/hardware/<mbed_core>/<core_version>/`.
 **
 ** See
```

```
 ** (https://support.arduino.cc/hc/en-us/articles/360012076960-Where-are-the-installed-cores-located-)
 ** to find where Arduino installs cores on your machine.
 **
 ** If the problem persists then there's not enough memory for this model and application.
 */

/* Private variables ------------------------------------------------------- */
static bool debug_nn = false; // Set this to true to see e.g. features generated from the raw signal
static uint32_t run_inference_every_ms = 200;
static rtos::Thread inference_thread(osPriorityLow);
static float buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE] = { 0 };
static float inference_buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE];

/* Forward declaration */
void run_inference_background();

/**
* @brief      Arduino setup function
*/
void setup()
{
    // put your setup code here, to run once:
    Serial.begin(115200);
    // comment out the below line to cancel the wait for USB connection (needed for native USB)
    while (!Serial);
    Serial.println("Edge Impulse Inferencing Demo");

    if (!IMU.begin()) {
        ei_printf("Failed to initialize IMU!\r\n");
    }
    else {
        ei_printf("IMU initialized\r\n");
    }

    if (EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME != 3) {
        ei_printf("ERR: EI_CLASSIFIER_RAW_SAMPLES_PER_FRAME should be equal to 3 (the 3 sensor axes)\n");
        return;
    }

    inference_thread.start(mbed::callback(&run_inference_background));
}
```

```
/**
 * @brief Return the sign of the number
 *
 * @param number
 * @return int 1 if positive (or 0) -1 if negative
 */
float ei_get_sign(float number) {
    return (number >= 0.0) ? 1.0 : -1.0;
}

/**
 * @brief      Run inferencing in the background.
 */
void run_inference_background()
{
    // wait until we have a full buffer
    delay((EI_CLASSIFIER_INTERVAL_MS * EI_CLASSIFIER_RAW_SAMPLE_COUNT) + 100);

    // This is a structure that smoothens the output result
    // With the default settings 70% of readings should be the same before classifying.
    ei_classifier_smooth_t smooth;
    ei_classifier_smooth_init(&smooth, 10 /* no. of readings */, 7 /* min. readings the same */, 0.8 /* min. confidence */, 0.3 /* max anomaly */);

    while (1) {
        // copy the buffer
        memcpy(inference_buffer, buffer, EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE * sizeof(float));

        // Turn the raw buffer in a signal which we can the classify
        signal_t signal;
        int err = numpy::signal_from_buffer(inference_buffer, EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE, &signal);
        if (err != 0) {
            ei_printf("Failed to create signal from buffer (%d)\n", err);
            return;
        }

        // Run the classifier
        ei_impulse_result_t result = { 0 };

        err = run_classifier(&signal, &result, debug_nn);
        if (err != EI_IMPULSE_OK) {
            ei_printf("ERR: Failed to run classifier (%d)\n", err);
            return;
        }
```

```
        // print the predictions
        ei_printf("Predictions ");
        ei_printf("(DSP: %d ms., Classification: %d ms., Anomaly: %d ms.)",
            result.timing.dsp, result.timing.classification,
result.timing.anomaly);
        ei_printf(": ");

        // ei_classifier_smooth_update yields the predicted label
        const char *prediction = ei_classifier_smooth_update(&smooth,
&result);
        ei_printf("%s ", prediction);
        // print the cumulative results
        ei_printf(" [ ");
        for (size_t ix = 0; ix < smooth.count_size; ix++) {
            ei_printf("%u", smooth.count[ix]);
            if (ix != smooth.count_size + 1) {
                ei_printf(", ");
            }
            else {
              ei_printf(" ");
            }
        }
        ei_printf("]\n");

        delay(run_inference_every_ms);
    }

    ei_classifier_smooth_free(&smooth);
}

/**
* @brief      Get data and run inferencing
*
* @param[in] debug Get debug info if true
*/
void loop()
{
    while (1) {
        // Determine the next tick (and then sleep later)
        uint64_t next_tick = micros() + (EI_CLASSIFIER_INTERVAL_MS * 1000);

        // roll the buffer -3 points so we can overwrite the last one
        numpy::roll(buffer, EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE, -3);

        // read to the end of the buffer
        IMU.readAcceleration(
            buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 3],
            buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 2],
```

```
            buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 1]
        );

        for (int i = 0; i < 3; i++) {
            if (fabs(buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 3 + i]) >
MAX_ACCEPTED_RANGE) {
                buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 3 + i] =
ei_get_sign(buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 3 + i]) *
MAX_ACCEPTED_RANGE;
            }
        }

        buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 3] *= CONVERT_G_TO_MS2;
        buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 2] *= CONVERT_G_TO_MS2;
        buffer[EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE - 1] *= CONVERT_G_TO_MS2;

        // and wait for next tick
        uint64_t time_to_wait = next_tick - micros();
        delay((int)floor((float)time_to_wait / 1000.0f));
        delayMicroseconds(time_to_wait % 1000);
    }
}

#if !defined(EI_CLASSIFIER_SENSOR) || EI_CLASSIFIER_SENSOR !=
EI_CLASSIFIER_SENSOR_ACCELEROMETER
#error "Invalid model for current sensor"
#endif
```

6. Output

Edge Impulse Inferencing Demo IMU initialized Predictions (DSP: 5 ms., Classification: 10 ms., Anomaly: 3 ms.): Idle [9, 0, 0, 1] Predictions (DSP: 5 ms., Classification: 9 ms., Anomaly: 2 ms.): Idle [10, 0, 0, 0] Predictions (DSP: 5 ms., Classification: 11 ms., Anomaly: 3 ms.): Left Right [0, 0, 9, 1] Predictions (DSP: 6 ms., Classification: 10 ms., Anomaly: 2 ms.): Left Right [0, 0, 10, 0] Predictions (DSP: 5 ms., Classification: 11 ms., Anomaly: 3 ms.): Circular [7, 2, 0, 1] Predictions (DSP: 5 ms., Classification: 10 ms., Anomaly: 2 ms.): Circular [8, 1, 0, 1] Predictions (DSP: 6 ms., Classification: 9 ms., Anomaly: 3 ms.): Up Down [0, 1, 1, 8] Predictions (DSP: 5 ms., Classification: 11 ms., Anomaly: 2 ms.): Up Down [0, 1, 1, 8] Predictions (DSP: 5 ms., Classification: 10 ms., Anomaly: 3 ms.): Idle [9, 0, 1, 0] Predictions (DSP: 5 ms., Classification: 10 ms., Anomaly: 2 ms.): Idle [10, 0, 0, 0]