Edge Computing Laboratory
Lab Assignment 6

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Title

Keyword Spotting Project like “OK, Google,” “Alexa,” on Edge Devices using Microphone
Objective: Build a project to detect the keywords using a built-in sensor on Nano BLE Sense / Mobile Phone **Tasks:**

- Generate the dataset for keyword
- Configure BLE Sense / Mobile for Edge Impulse
- Building and Training a Model

Run the project Keyword Spotting like “OK, Google,” “Alexa
Introduction

Edge Impulse is a development platform for machine learning on edge devices, targeted at developers who want to create intelligent device solutions. The "Hello World" 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

Theory

GPIO (General Purpose Input/Output) pins on the Raspberry Pi are used for interfacing with other electronic components. BCM numbering refers to the pin numbers in the Broadcom SOC channel, which is a more consistent way to refer to the GPIO pins across different versions of the

Here’s a high-level overview of steps you'd follow to create a "Hello World" project on Edge Impulse:

Steps to Configure the Edge Impulse:

Create an Account and New Project:

- Sign up for an Edge Impulse account.
- Create a new project from the dashboard.

Connect a Device:

- You can use a supported development board or your smartphone as a sensor device.
- Follow the instructions to connect your device to your Edge Impulse project.

Collect Data:

- Use the Edge Impulse mobile app or the Web interface to collect data from the onboard sensors.
- For a "Hello World" project, you could collect accelerometer data, for instance.

Create an Impulse:

- Go to the 'Create impulse' page.
- Add a processing block (e.g., time-series data) and a learning block (e.g., classification).
- Save the impulse, which defines the machine learning pipeline.

Design a Neural Network:

- Navigate to the 'NN Classifier' under the 'Learning blocks'.
- Design a simple neural network. Edge Impulse provides a default architecture that works well for most basic tasks.

Train the Model:

- Click on the 'Start training' button to train your machine learning model with the collected data.

Test the Model:

- Once the model is trained, you can test its performance with new data in the 'Model Testing' tab.

Deploy the Model:

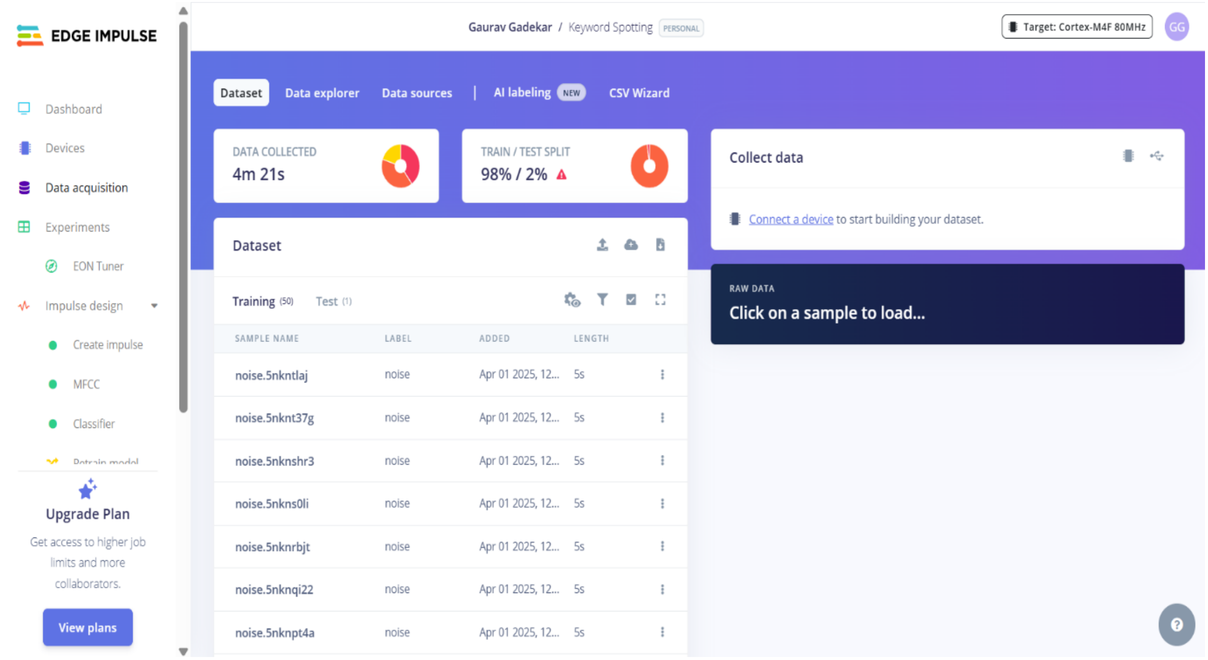
- Go to the 'Deployment' tab.
- Select the deployment method that suits your edge device (e.g., Arduino library, WebAssembly, container, etc.).
- Follow the instructions to deploy the model to your device.

Run Inference:

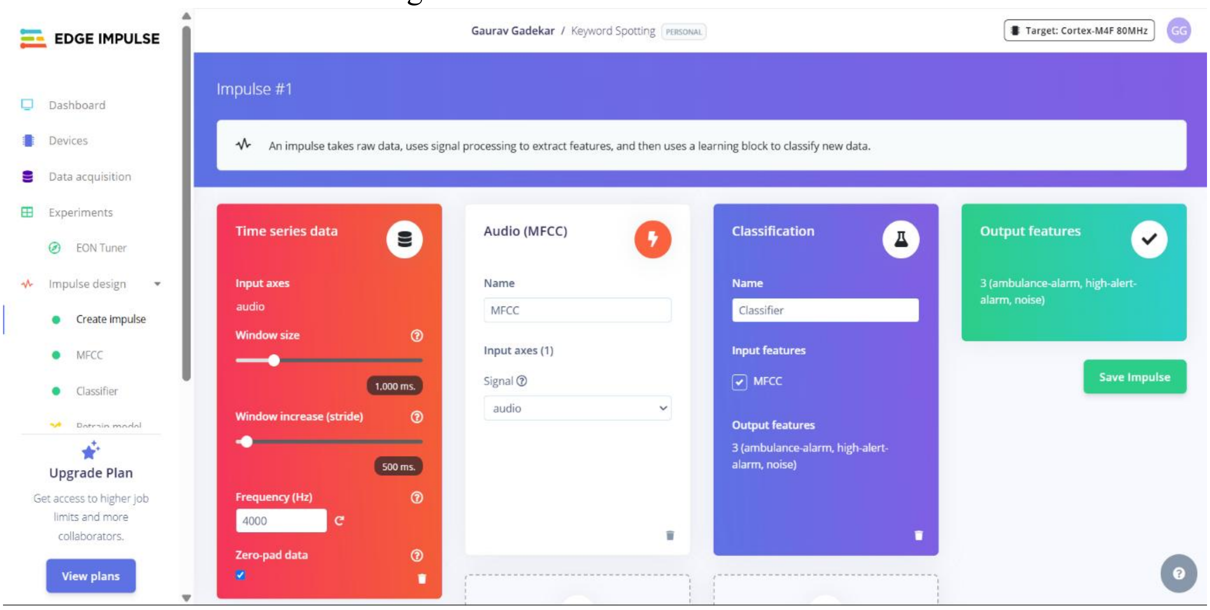
- With the model deployed, run inference on the edge device to see it classifying data in realtime.
- Monitor:
- You can monitor the performance of your device through the Edge Impulse studio.

Screenshots:

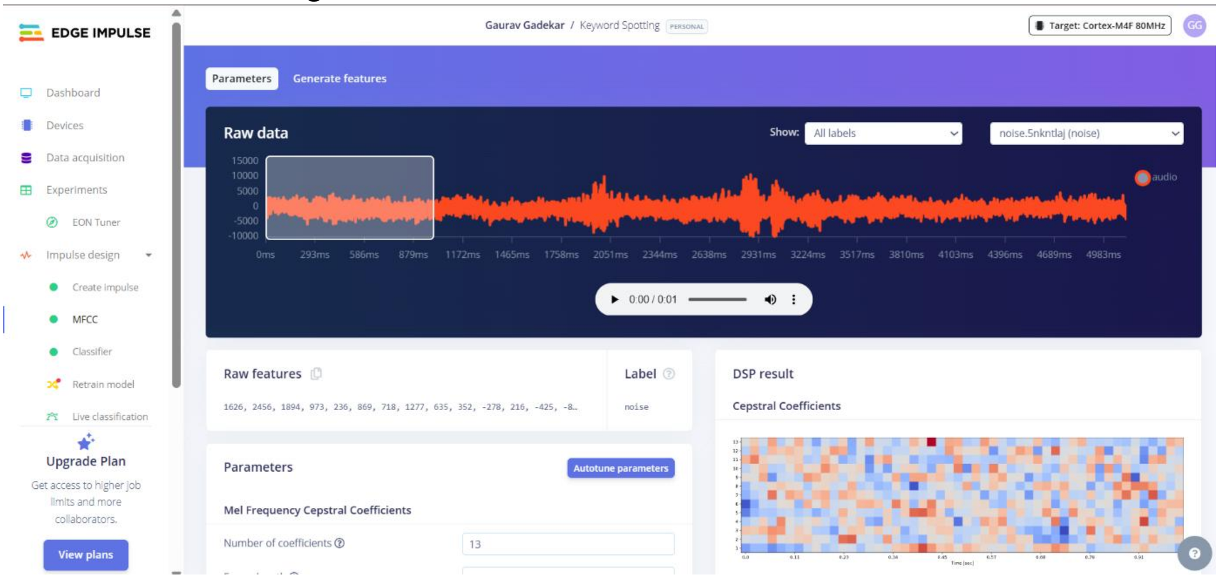
1. Dataset Image



2. Feature extraction - Image



3. Validation Result – Image



4. Copy the code of Arduino Sketch

```
/* 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 <Gaurav-gadekar-Keyword-Spotting.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-
  blesense/blob/master/src/sensors/ei_lsm9ds1.cpp
* for more information.
 */
#define MAX_ACCEPTED_RANGE  2.0f
// -DEI_CLASSIFIER_ALLOCATION_STATIC
```

```
/*
 ** 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-theinstalled-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
```

5. Screen shot of Arduino Terminal – Result