Edge Computing Lab

Class: TY-AIEC

School of Computing, MIT Art Design Technology University

Academic Year: 2024-25

Experiment No. 9

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Introduction

The Object Detection using Camera on Edge Computing Devices

Objective: Build a project to detect an object using Edge Computing

Tasks:

- Generate the dataset for customized object
- Configure Edge Impulse for Object Detection
- Building and Training a Model
- Deploy on Edge Computing Device

Introduction

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

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:

1. Create an Account and New Project:
    - Sign up for an Edge Impulse account.
    - Create a new project from the dashboard.

2. 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.

3. 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.

4. 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.

5. 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.

6. Train the Model:

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

7. Test the Model:

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

8. 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.

9. Run Inference:

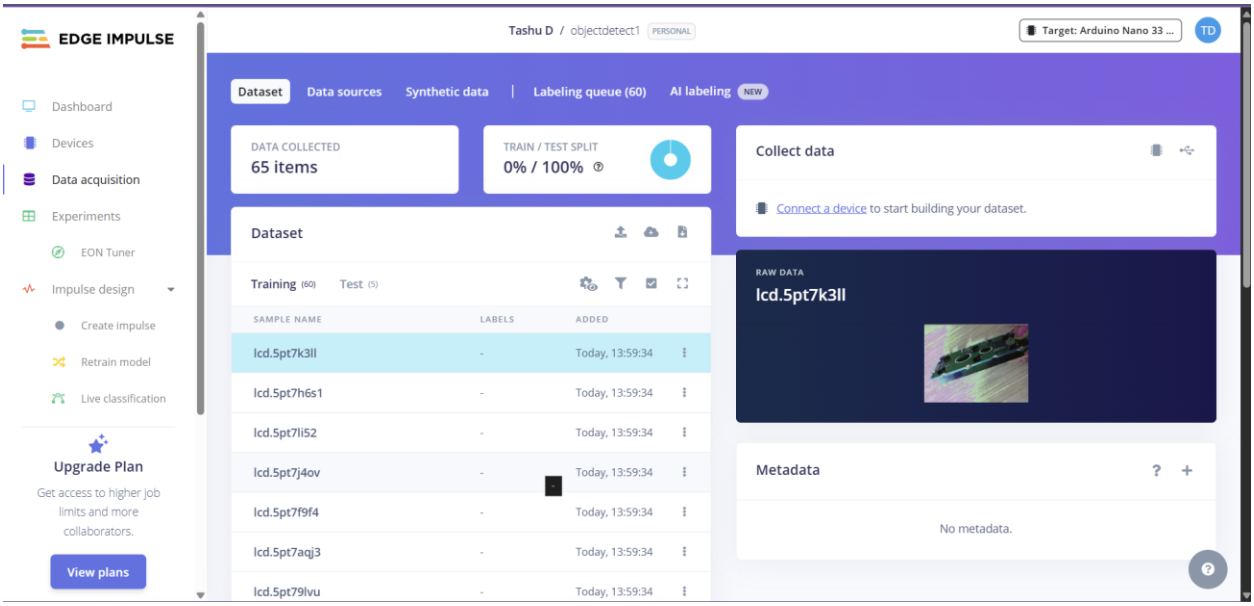
- With the model deployed, run inference on the edge device to see it classifying data in real-time.

10. Monitor:

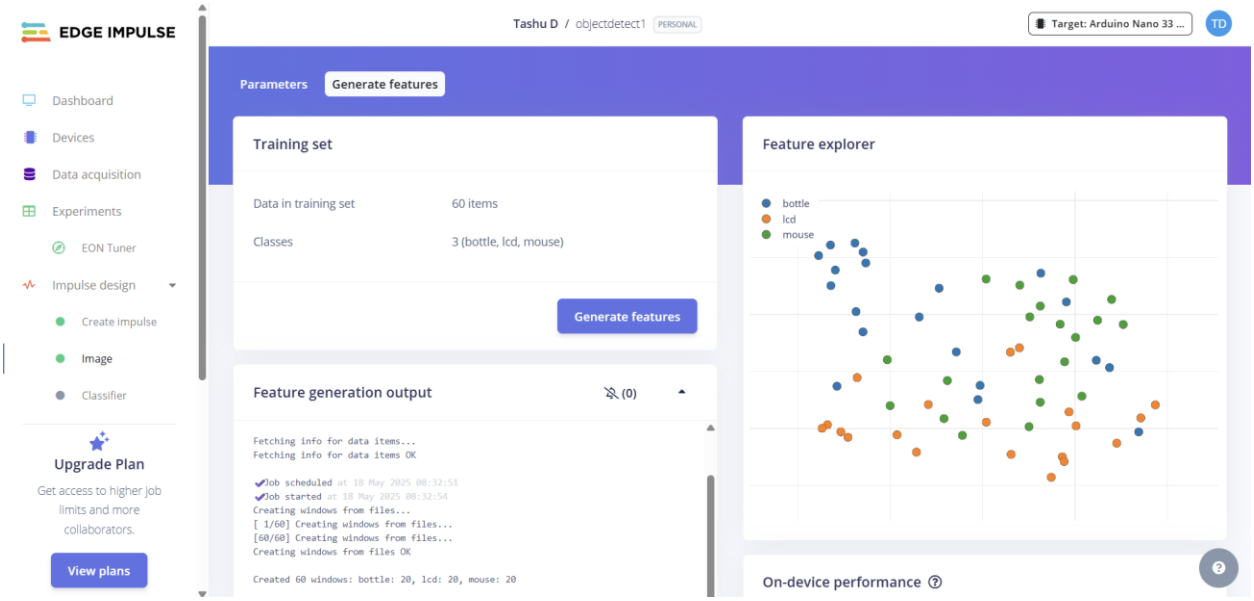
- You can monitor the performance of your device through the Edge Impulse studio.

Paste your Edge Impulse project's Results:

1) Dataset Image



2) Feature extraction - Image



3) Accuracy / Loss - Confusion Matrix – image

Model

Model version: Quantized (int8)

Last training performance (validation set)

ACCURACY
66.7%

LOSS
0.81

Confusion matrix (validation set)

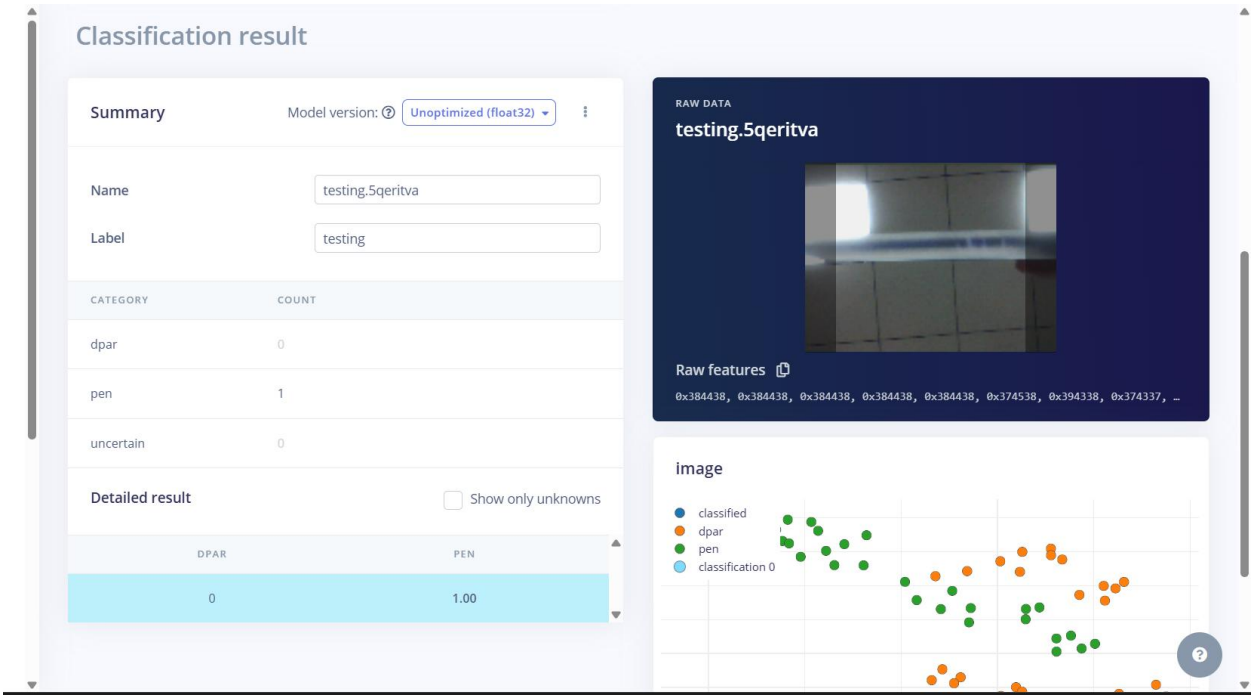
	BOTTLE	LCD	MOUSE
BOTTLE	57.1%	42.9%	0%
LCD	0%	100%	0%
MOUSE	0%	25%	75%
F1 SCORE	0.73	0.33	0.86

Metrics (validation set)

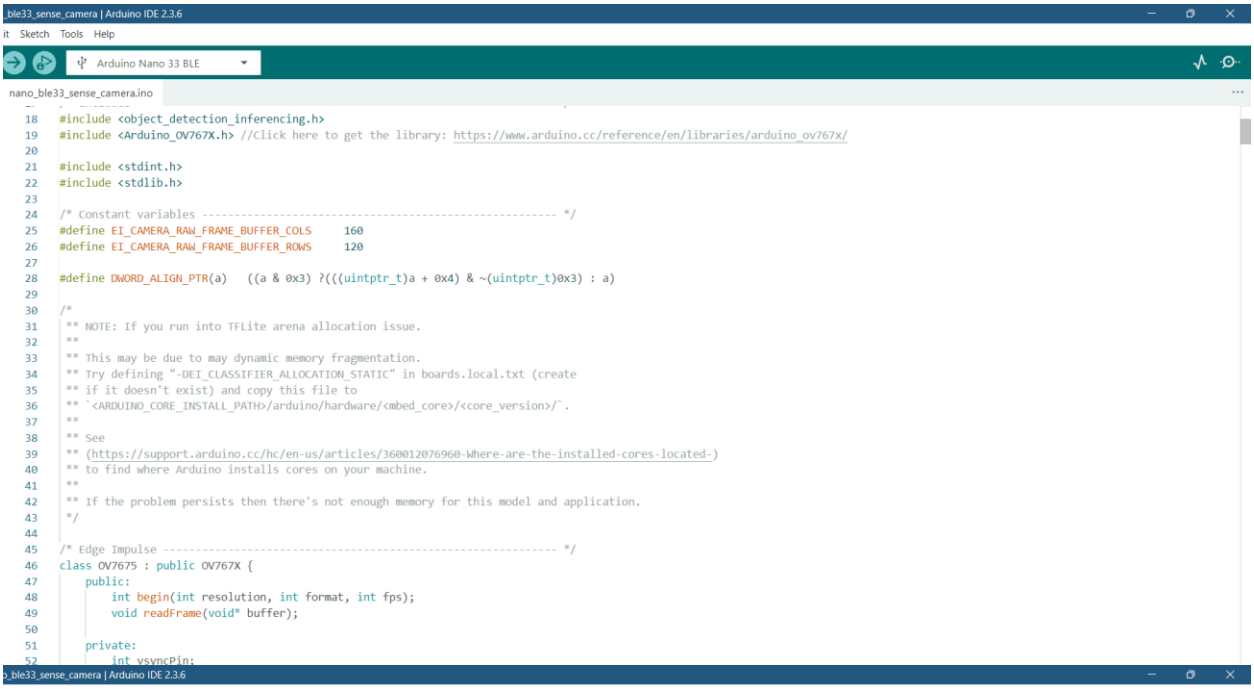
METRIC	VALUE
Area under ROC Curve	0.93
Weighted average Precision	0.93
Weighted average Recall	0.67
Weighted average F1 score	0.74

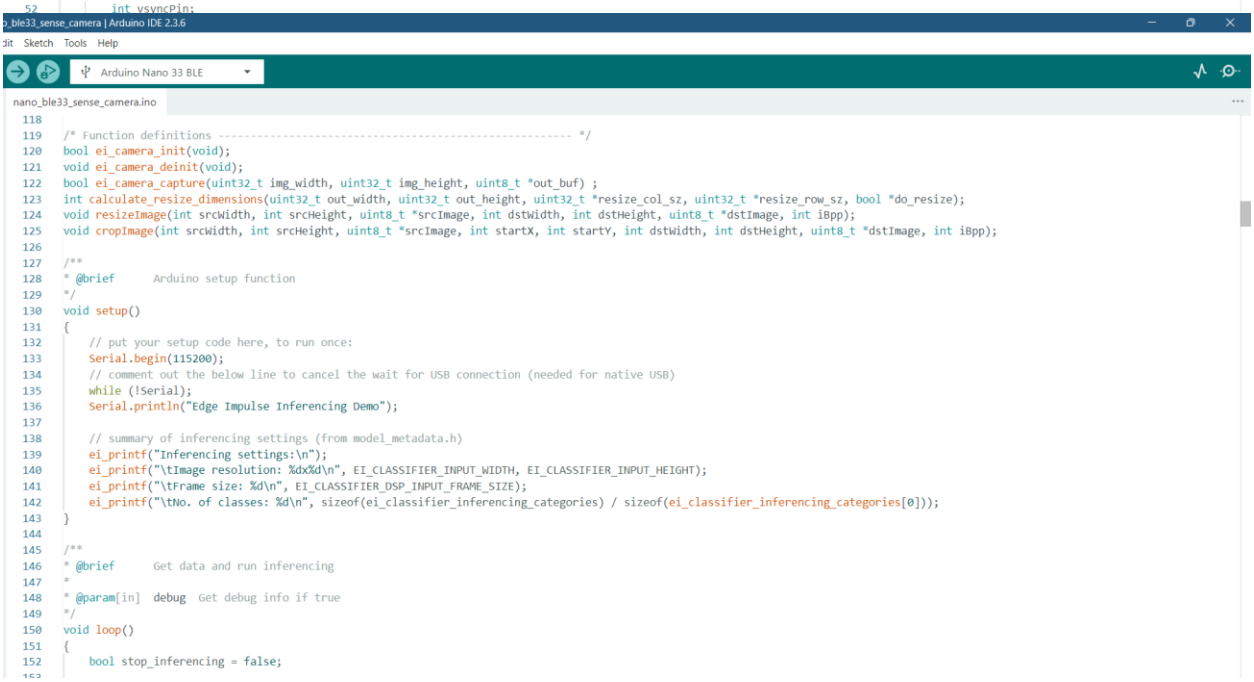
Data explorer (full training set)

4) Validation Result – Image



5) Copy the code of Arduino Sketch


ble33_sense_camera | Arduino IDE 2.3.6
it Sketch Tools Help
Arduino Nano 33 BLE
nano_ble33_sense_camera.ino
#include <object_detection_inferencing.h>
#include <Arduino_OV767X.h> //Click here to get the library: https://www.arduino.cc/reference/en/libraries/arduino_ov767x/
#include <stdint.h>
#include <stdlib.h>
/* Constant variables --- */
#define EI_CAMERA_RAW_FRAME_BUFFER_COLS 160
#define EI_CAMERA_RAW_FRAME_BUFFER_ROWS 120
#define DWORD_ALIGN_PTR(a) ((a & 0x3) ?(((uintptr_t)a + 0x4) & ~(uintptr_t)0x3) : a)
/*
** 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.
*/
/* Edge Impulse --- */
class OV7675 : public OV767X {
public:
int begin(int resolution, int format, int fps);
void readFrame(void* buffer);
private:
int vsyncPin;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Arduino Nano 33 BLE
nano_ble33_sense_camera.ino
/* Function definitions --- */
bool ei_camera_init(void);
void ei_camera_deinit(void);
bool ei_camera_capture(uint32_t img_width, uint32_t img_height, uint8_t *out_buf) ;
int calculate_resize_dimensions(uint32_t out_width, uint32_t out_height, uint32_t *resize_col_sz, uint32_t *resize_row_sz, bool *do_resize);
void resizeImage(int srcWidth, int srcHeight, uint8_t *srcImage, int dstWidth, int dstHeight, uint8_t *dstImage, int iBpp);
void cropImage(int srcWidth, int srcHeight, uint8_t *srcImage, int startX, int startY, int dstWidth, int dstHeight, uint8_t *dstImage, int iBpp);
/**
* @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");
// summary of inferencing settings (from model_metadata.h)
ei_printf("Inferencing settings:\n");
ei_printf("\tImage resolution: %dx%d\n", EI_CLASSIFIER_INPUT_WIDTH, EI_CLASSIFIER_INPUT_HEIGHT);
ei_printf("\tFrame size: %d\n", EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE);
ei_printf("\tNo. of classes: %d\n", sizeof(ei_classifier_inferencing_categories) / sizeof(ei_classifier_inferencing_categories[0]));
}
/**
* @brief Get data and run inferencing
*
* @param[in] debug Get debug info if true
*/
void loop()
{
bool stop_inferencing = false;

o_ble33_sense_camera | Arduino IDE 2.3.6

dit Sketch Tools Help

Arduino Nano 33 BLE

nano_ble33_sense_camera.ino

```
            bb.height);
        }

    // Print the prediction results (classification)
#else
        ei_printf("Predictions:\r\n");
        for (uint16_t i = 0; i < EI_CLASSIFIER_LABEL_COUNT; i++) {
            ei_printf("  %s: ", ei_classifier_inferencing_categories[i]);
            ei_printf("%.5f\r\n", result.classification[i].value);
        }
#endif

    // Print anomaly result (if it exists)
#if EI_CLASSIFIER_HAS_ANOMALY
        ei_printf("Anomaly prediction: %.3f\r\n", result.anomaly);
#endif

#if EI_CLASSIFIER_HAS_VISUAL_ANOMALY
        ei_printf("Visual anomalies:\r\n");
        for (uint32_t i = 0; i < result.visual_ad_count; i++) {
            ei_impulse_result_bounding_box_t bb = result.visual_ad_grid_cells[i];
            if (bb.value == 0) {
                continue;
            }
            ei_printf("  %s (%f) [ x: %u, y: %u, width: %u, height: %u ]\r\n",
                    bb.label,
                    bb.value,
                    bb.x,
                    bb.y,
                    bb.width,
                    bb.height);
        }
#endif

        while (ei_get_serial_available() > 0) {
            if (ei_get_serial_byte() == 'b') {
```

o_ble33_sense_camera | Arduino IDE 2.3.6

dit Sketch Tools Help

Arduino Nano 33 BLE

nano_ble33_sense_camera.ino

```
//
// Extends the OV767X library function. Reads buf_rows VGA rows from the
// image sensor.
//
void OV7675::readBuf()
{
    int offset = 0;

    uint32_t ulPin = 33; // P1.xx set of GPIO is in 'pin' 32 and above
    NRF_GPIO_Type * port;

    port = nrf_gpio_pin_port_decode(&ulPin);

    for (int i = 0; i < buf_rows; i++) {
        // rising edge indicates start of line
        while ((*hrefPort & hrefMask) == 0); // wait for HIGH

        for (int col = 0; col < bytes_per_row; col++) {
            // rising edges clock each data byte
            while ((*pclkPort & pclkMask) != 0); // wait for LOW

            uint32_t in = port->IN; // read all bits in parallel

            in >>= 2; // place bits 0 and 1 at the "bottom" of the register
            in &= 0x3f03; // isolate the 8 bits we care about
            in |= (in >> 6); // combine the upper 6 and lower 2 bits

            raw_buf[offset++] = in;

            while ((*pclkPort & pclkMask) == 0); // wait for HIGH
        }

        while ((*hrefPort & hrefMask) != 0); // wait for LOW
    }
} /* OV7675::readBuf() */
```

6) Screen shot of Arduino Terminal - Result

```
 *
 */

/* Includes ---------------------------------------------------------------- */
#include <object_detection_inferencing.h>
#include <Arduino_OV767X.h> //Click here to get the library: https://www.arduino.cc/reference/en/libraries/arduino_ov767x/

#include <stdint.h>
#include <stdlib.h>
```

Output Serial Monitor

Message (Enter to send message to 'Arduino Nano 33 BLE' on 'COM3') New Line 9600 baud

```
13:31:48.450 -> Edge Impulse Inferencing Demo
13:31:48.450 -> Inferencing settings:
13:31:48.450 ->         Image resolution: 96x96
13:31:48.450 ->         Frame size: 9216
13:31:48.450 ->         No. of classes: 2
13:31:48.450 ->
13:31:48.450 -> Starting inferencing in 2 seconds...
13:31:50.432 -> Taking photo...
```