

Edge Computing Lab

Class: TY-AIEC

School of Computing, MIT Art Design Technology University

Academic Year: 2024-25

Experiment No. 9

TASHU DHOTE

TY AIEC

2223307

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:

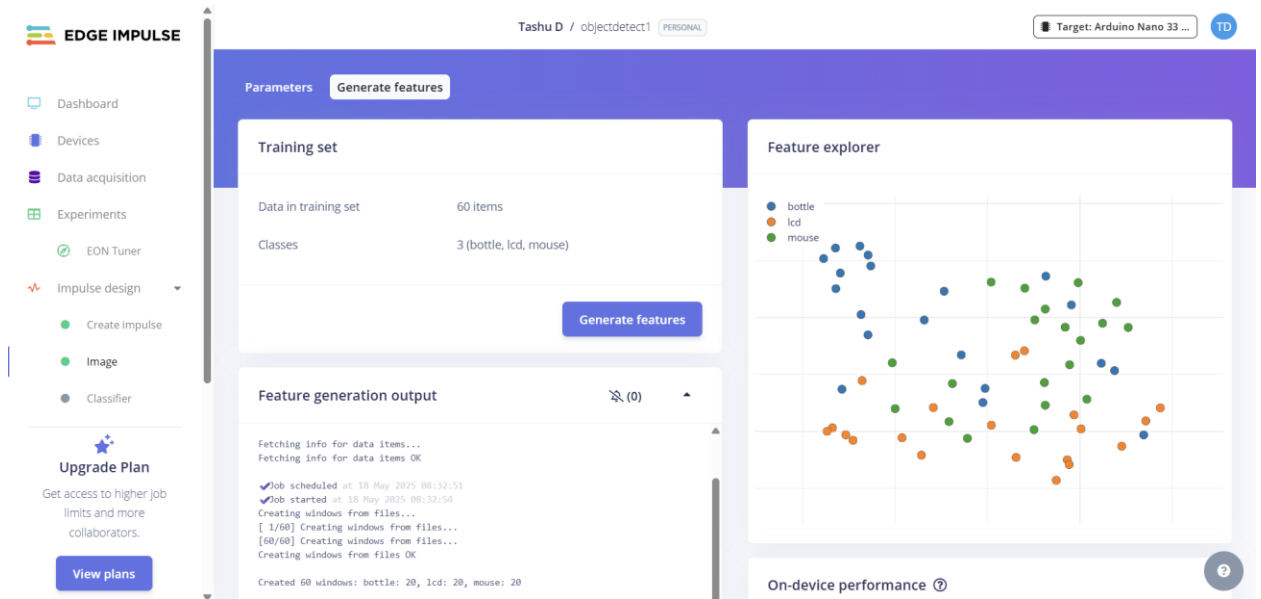
1) Dataset Image

The screenshot displays the Edge Impulse studio interface for a project named 'Tashu D / objectdetect1'. The interface is divided into several sections:

- Left Sidebar:** Contains navigation links for Dashboard, Devices, Data acquisition, Experiments, EON Tuner, and Impulse design. The 'Impulse design' section is expanded, showing options like 'Create impulse', 'Retrain model', and 'Live classification'. There is also an 'Upgrade Plan' button.
- Top Bar:** Shows the project name 'Tashu D / objectdetect1' and a 'PERSONAL' label. On the right, it indicates the target device: 'Target: Arduino Nano 33 ...'.
- Main Content Area:**
 - Dataset Section:** Displays 'DATA COLLECTED 65 items' and 'TRAIN / TEST SPLIT 0% / 100%'. Below this is a table of training samples.
 - Collect data Section:** Includes a button to 'Connect a device' to start building the dataset.
 - RAW DATA Section:** Shows a preview of the raw data for 'Icd.5pt7k3ll' with a small image of a circuit board.
 - Metadata Section:** Currently shows 'No metadata'.

SAMPLE NAME	LABELS	ADDED
Icd.5pt7k3ll	-	Today, 13:59:34
Icd.5pt7h6s1	-	Today, 13:59:34
Icd.5pt7li52	-	Today, 13:59:34
Icd.5pt7j4ov	-	Today, 13:59:34
Icd.5pt7f9f4	-	Today, 13:59:34
Icd.5pt7aqj3	-	Today, 13:59:34
Icd.5pt79lvu	-	Today, 13:59:34

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)

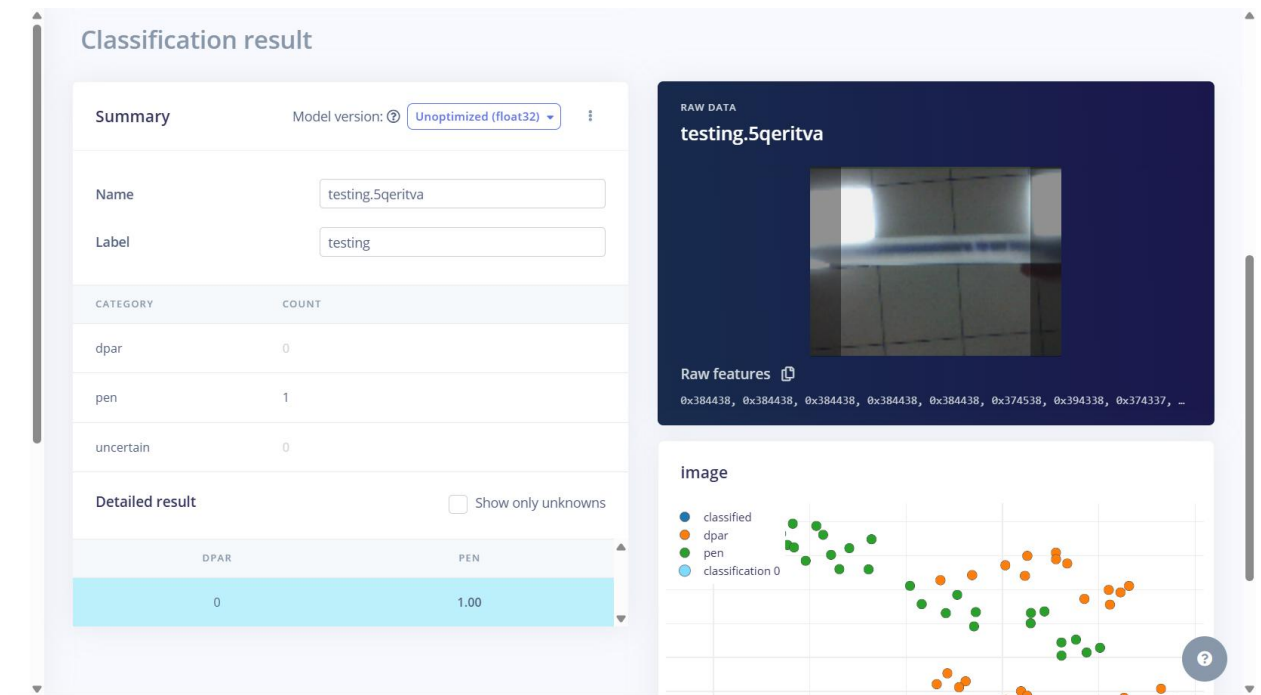


METRIC	VALUE
Area under ROC Curve ?	0.93
Weighted average Precision ?	0.93
Weighted average Recall ?	0.67
Weighted average F1 score ?	0.74

?

Data explorer (full training set) ?

4) Validation Result – Image



5) Copy the code of Arduino Sketch

```
ble33_sense_camera | Arduino IDE 2.3.6
Sketch Tools Help
Arduino Nano 33 BLE
nano_ble33_sense_camera.ino
18 #include <object_detection_inferencing.h>
19 #include <Arduino_OV767X.h> //Click here to get the library: https://www.arduino.cc/reference/en/libraries/arduino_ov767x/
20
21 #include <stdint.h>
22 #include <stdlib.h>
23
24 /* Constant variables ----- */
25 #define EI_CAMERA_RAW_FRAME_BUFFER_COLS 160
26 #define EI_CAMERA_RAW_FRAME_BUFFER_ROWS 120
27
28 #define DWORD_ALIGN_PTR(a) ((a & 0x3) ?(((uintptr_t)a + 0x4) & ~(uintptr_t)0x3) : a)
29
30 /*
31 ** NOTE: If you run into TFLite arena allocation issue.
32 ** This may be due to may dynamic memory fragmentation.
33 ** Try defining "-DEI_CLASSIFIER_ALLOCATION_STATIC" in boards.local.txt (create
34 ** if it doesn't exist) and copy this file to
35 ** <ARDUINO_CORE_INSTALL_PATH>/arduino/hardware/cmbd_core/<core_version>/.
36 ** See
37 ** (https://support.arduino.cc/hc/en-us/articles/360012076960-Where-are-the-installed-cores-located-)
38 ** to find where Arduino installs cores on your machine.
39 ** If the problem persists then there's not enough memory for this model and application.
40 */
41
42 /* Edge Impulse ----- */
43
44 class OV7675 : public OV767X {
45 public:
46     int begin(int resolution, int format, int fps);
47     void readFrame(void* buffer);
48 private:
49     int ysvncBIn;
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109 /* Function definitions ----- */
110 bool ei_camera_init(void);
111 void ei_camera_deinit(void);
112 bool ei_camera_capture(uint32_t img_width, uint32_t img_height, uint8_t *out_buf);
113 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);
114 void resizeImage(int srcWidth, int srcHeight, uint8_t *srcImage, int dstWidth, int dstHeight, uint8_t *dstImage, int i8pp);
115 void cropImage(int srcWidth, int srcHeight, uint8_t *srcImage, int startX, int startY, int dstWidth, int dstHeight, uint8_t *dstImage, int i8pp);
116
117 /**
118 * @brief Arduino setup function
119 */
120 void setup()
121 {
122     // put your setup code here, to run once:
123     Serial.begin(115200);
124     // comment out the below line to cancel the wait for USB connection (needed for native USB)
125     while (!Serial);
126     Serial.println("Edge Impulse Inferencing Demo");
127
128     // summary of inferencing settings (from model_metadata.h)
129     ei_printf("Inferencing settings:\n");
130     ei_printf("Image resolution: %dx%d\n", EI_CLASSIFIER_INPUT_WIDTH, EI_CLASSIFIER_INPUT_HEIGHT);
131     ei_printf("Frame size: %d\n", EI_CLASSIFIER_DSP_INPUT_FRAME_SIZE);
132     ei_printf("No. of classes: %d\n", sizeof(ei_classifier_inferencing_categories) / sizeof(ei_classifier_inferencing_categories[0]));
133 }
134
135 /**
136 * @brief Get data and run inferencing
137 * @param[in] debug Get debug info if true
138 */
139 void loop()
140 {
141     bool stop_inferencing = false;
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o_ble33_sense_camera | Arduino IDE 2.3.6
dit Sketch Tools Help

nano_ble33_sense_camera.ino
224 //          uu.height);
225 }
226
227 // Print the prediction results (classification)
228 else
229     ei_printf("Predictions:\r\n");
230     for (uint16_t i = 0; i < EI_CLASSIFIER_LABEL_COUNT; i++) {
231         ei_printf(" %s: ", ei_classifier_inferencing_categories[i]);
232         ei_printf("%.5f\r\n", result.classification[i].value);
233     }
234 #endif
235
236 // Print anomaly result (if it exists)
237 #if EI_CLASSIFIER_HAS_ANOMALY
238     ei_printf("Anomaly prediction: %.3f\r\n", result.anomaly);
239 #endif
240
241 #if EI_CLASSIFIER_HAS_VISUAL_ANOMALY
242     ei_printf("Visual anomalies:\r\n");
243     for (uint32_t i = 0; i < result.visual_ad_count; i++) {
244         ei_impulse_result_bounding_box_t bb = result.visual_ad_grid_cells[i];
245         if (bb.value == 0) {
246             continue;
247         }
248         ei_printf(" %s (%f) [ x: %u, y: %u, width: %u, height: %u ]\r\n",
249             bb.label,
250             bb.value,
251             bb.x,
252             bb.y,
253             bb.width,
254             bb.height);
255     }
256 #endif
257
258 while (ei_get_serial_available() > 0) {
259     if (ei_get_serial_byte() == 'b') {
260
261         // Extends the OV767X library function. Reads buf_rows VGA rows from
262         // image sensor.
263         //
264         void OV7675::readBuf()
265         {
266             int offset = 0;
267
268             uint32_t ulPin = 33; // P1.xx set of GPIO is in 'pin' 32 and above
269             NRF_GPIO_Type * port;
270
271             port = nrf_gpio_pin_port_decode(&ulPin);
272
273             for (int i = 0; i < buf_rows; i++) {
274                 // rising edge indicates start of line
275                 while ((*hrefPort & hrefMask) == 0); // wait for HIGH
276
277                 for (int col = 0; col < bytes_per_row; col++) {
278                     // rising edges clock each data byte
279                     while ((*pclkPort & pclkMask) != 0); // wait for LOW
280
281                     uint32_t in = port->IN; // read all bits in parallel
282
283                     in >>= 2; // place bits 0 and 1 at the "bottom" of the register
284                     in &= 0x3f03; // isolate the 8 bits we care about
285                     in |= (in >> 6); // combine the upper 6 and lower 2 bits
286
287                     raw_buf[offset++] = in;
288
289                     while ((*pclkPort & pclkMask) == 0); // wait for HIGH
290                 }
291                 while ((*hrefPort & hrefMask) != 0); // wait for LOW
292             }
293         } /* OV7675::readBuf() */
294     }
295 }
```

6) Screen shot of Arduino Terminal - Result

```
14 *
15 */
16
17 /* Includes ----- */
18 #include <object_detection_inferencing.h>
19 #include <Arduino_OV767X.h> //Click here to get the library: https://www.arduino.cc/reference/en/libraries/arduino\_ov767x/
20
21 #include <stdint.h>
22 #include <stdlib.h>
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