

# Real-Time Object Detection Using Arduino Uno and Edge Impulse

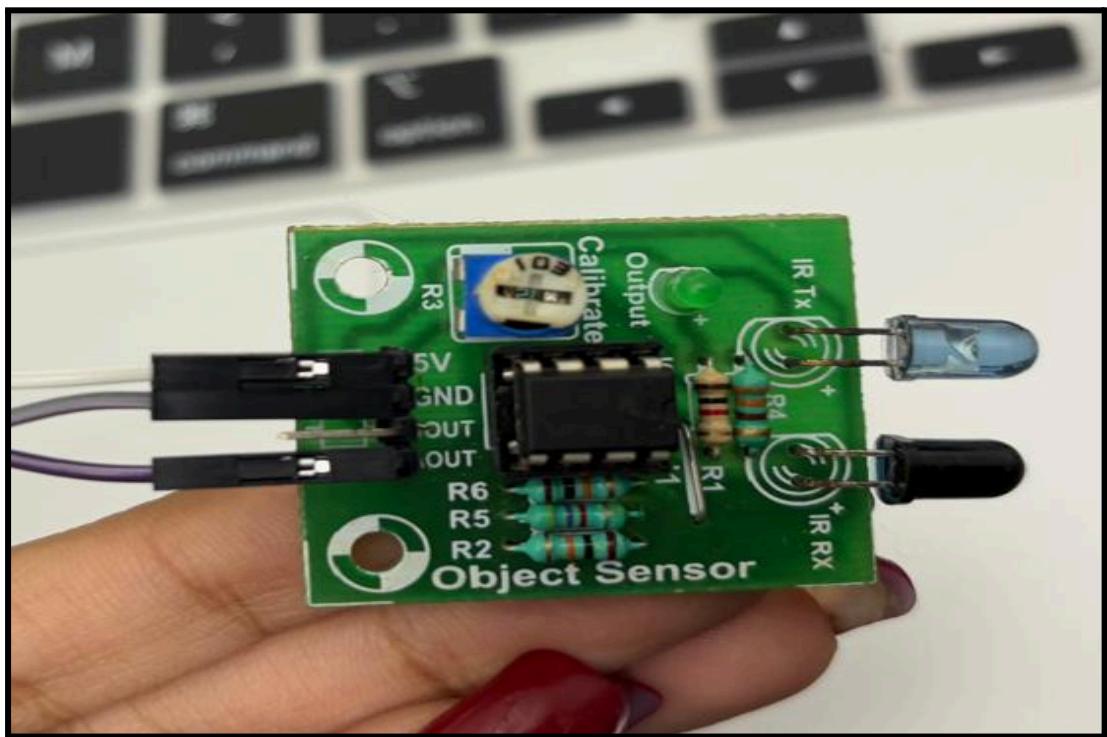
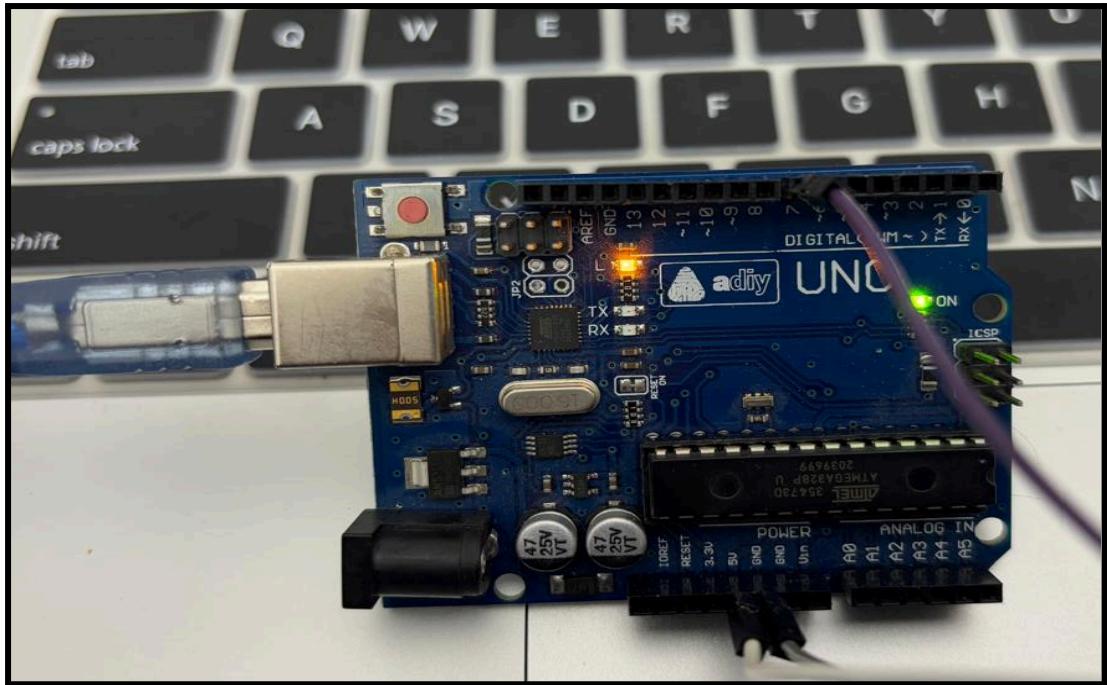
## 1. Introduction

Edge Impulse provides a platform for building machine learning models for embedded devices. This project demonstrates the integration of an Arduino Uno with an IR object sensor to collect data, train a model, and deploy it for real-time object detection using TinyML.



## 2. Components Used

- Arduino Uno
- IR Object Sensor
- USB Cable (for Arduino connection)
- Computer with macOS (or compatible OS)



### 3) Prerequisites

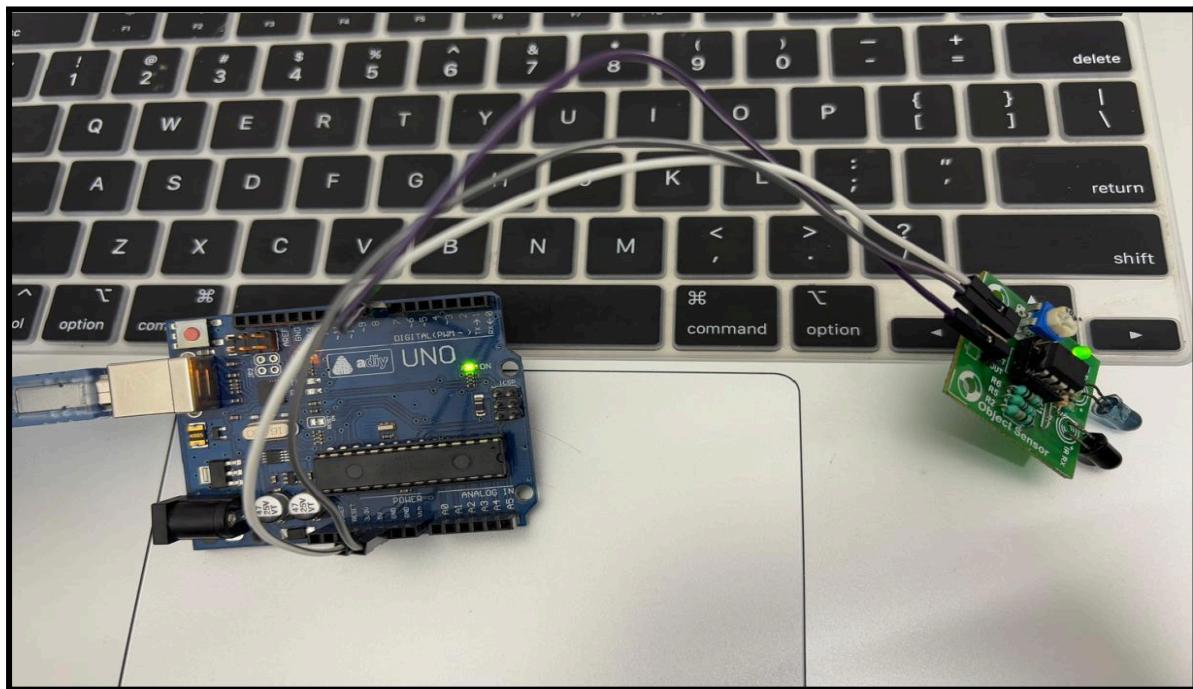
- **Install Arduino IDE:**
  - Download from Arduino IDE and install.
- **Install Edge Impulse CLI:**
  - Install Node.js first: [Node.js](#).

- Install Edge Impulse CLI using the following command:  
npm install -g edge-impulse-cli
- **Arduino CLI:**
  - Install Arduino CLI: [Arduino CLI Installation](#).
  - Add it to your PATH for terminal access.

## 4) Hardware Setup

- **Connect the IR Sensor to Arduino Uno:**
  - **VCC:** Connect to 5V on Arduino.
  - **GND:** Connect to GND on Arduino.
  - **OUT:** Connect to digital pin 7 on Arduino.
- **Verify the Wiring:**
  - Double-check connections to avoid shorts or miswiring.

### Connection:



## 5. Writing and Uploading the Arduino Code

```

const int irSensorPin = 7;

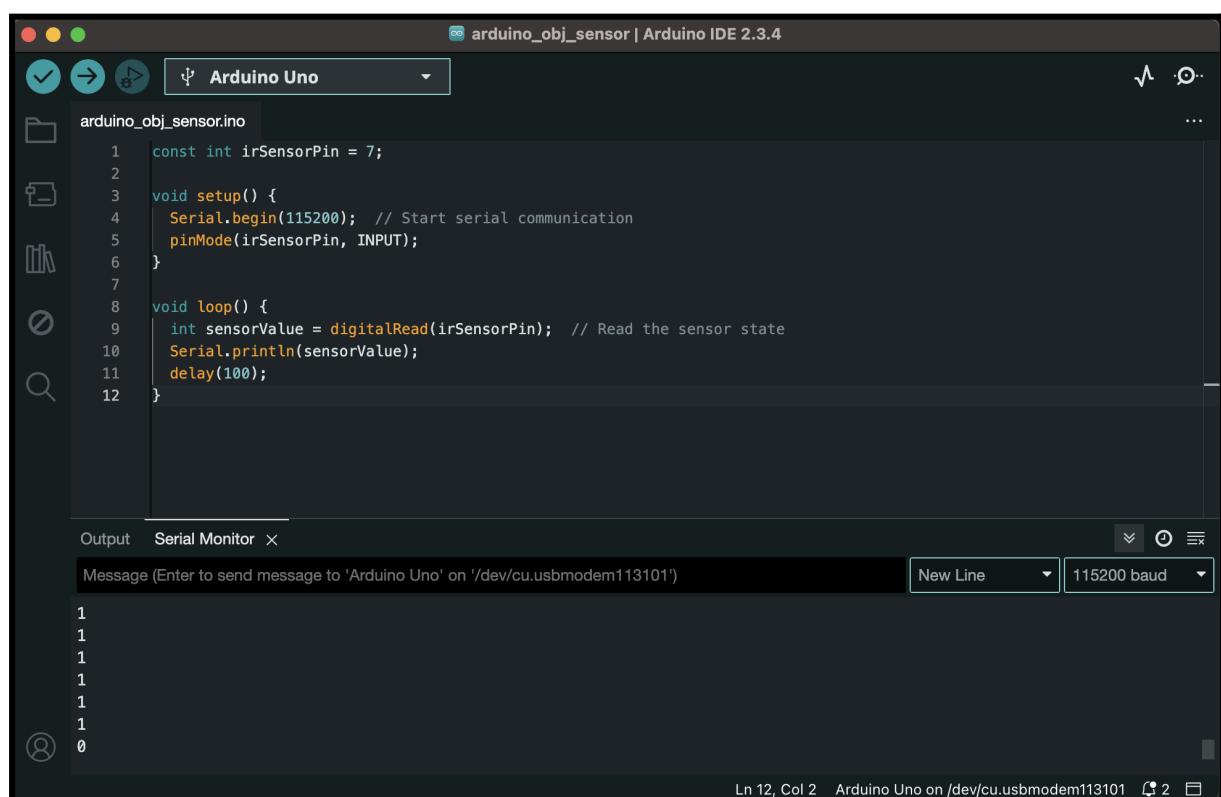
void setup() {
    Serial.begin(115200); // Start serial communication
    pinMode(irSensorPin, INPUT);
}

void loop() {
    int sensorValue = digitalRead(irSensorPin); // Read the
    sensor state
    Serial.println(sensorValue);
    delay(100);
}

```

## Test the Serial Output:

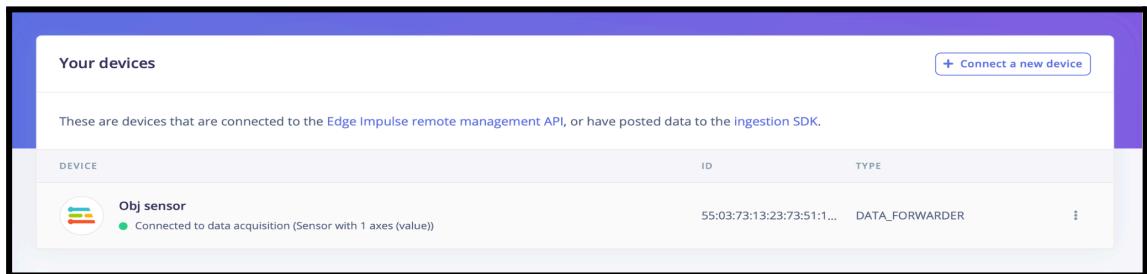
- Open the Serial Monitor in Arduino IDE.
- Verify that the sensor outputs **0** (no object) or **1** (object detected)



## 6) Connecting to Edge Impulse

- **Run Edge Impulse Data Forwarder:**
  - Open the terminal and run:

```
Edge-impulse-data-forwarder
```



## 7) Data Acquisition in Edge Impulse

- **Go to Edge Impulse Studio:**
  - Open the project in [Edge Impulse Studio](#).
- **Collect Data:**
  - Go to the **Data Acquisition** tab.
  - Click **Start Sampling**.
  - Set the duration to **1 second (1000 ms)**.
  - Label the data as **Object Detected** or **Object UnDetected** based on the sensor readings.
  - Repeat the process to collect sufficient data for both classes.

**EDGE IMPULSE**

Dataset Data explorer Data sources | CSV Wizard

DATA COLLECTED  
2m 0s

TRAIN / TEST SPLIT  
83% / 17%

Collect data

Device Obj sensor

Label Object UnDetected Sample length (ms.) 10000

Sensor Sensor with 1 axes (value) Frequency 9Hz

Start sampling

RAW DATA Click on a sample to load...

Dataset

Training (10) Test (2)

SAMPLE NAME	LABEL	ADDED	LENGTH
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object Detected.5h...	Object Detect...	Yesterday, 10:...	10s
Object Detected.5h...	Object Detect...	Yesterday, 10:...	10s
Object Detected.5h...	Object UnDet...	Yesterday, 10:...	10s

View plans

Get access to higher job limits, collaborators and a full commercial license.

Upgrade Plan

A Continue with the wizard

The screenshot shows the Edge Impulse web application's main dashboard. On the left, a sidebar contains links for Dashboard, Devices, Data acquisition, Experiments (with sub-links for EON Tuner, Impulse design, Create impulse, Flatten, Classifier, Retrain model, Live classification, and Martial practice), and Upgrade Plan. The Upgrade Plan section encourages users to get a commercial license for higher job limits and more collaborators. The main content area has tabs for Dataset, Data explorer, Data sources, and CSV Wizard. The Dataset tab is active, displaying a summary of data collection (2m 0s total, 83% train / 17% test split). Below this is a table of 12 samples, each with columns for Sample Name, Label, Added date, and Length. A 'Collect data' panel on the right allows users to specify a device (Obj sensor), label (Object UnDetected), sample length (10000 ms), sensor (Sensor with 1 axes (value)), frequency (9Hz), and start sampling. A dark blue 'RAW DATA' box at the bottom says 'Click on a sample to load...'. A red button at the bottom right says 'A Continue with the wizard'.

## Collect Sample Data:

Collect data

Device ⓘ

Obj sensor

Label

Object UnDetected

Sample length (ms.)

10000

Sensor

Sensor with 1 axes (value)

Frequency

9Hz

Sampling... (8s left)

RAW DATA

Click on a sample to load...

This screenshot shows the 'Collect data' interface. It includes fields for 'Device' (Obj sensor), 'Label' (Object UnDetected), 'Sample length (ms.)' (10000), 'Sensor' (Sensor with 1 axes (value)), and 'Frequency' (9Hz). A progress bar at the bottom indicates 'Sampling... (8s left)'. Below the interface is a dark panel labeled 'RAW DATA' with the placeholder text 'Click on a sample to load...'.

DATA COLLECTED  
2m 0s

TRAIN / TEST SPLIT  
83% / 17%

Dataset

Training (10) Test (2)

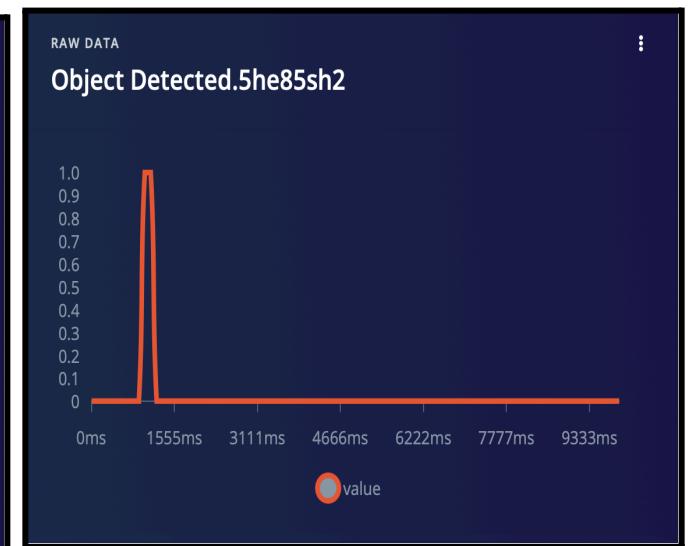
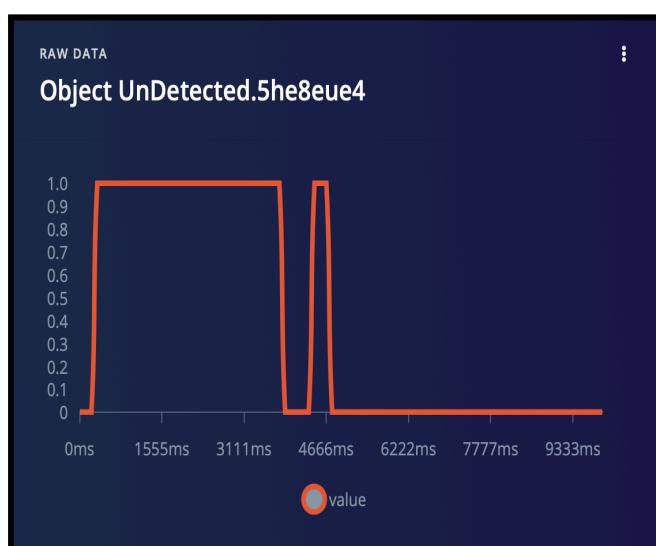
SAMPLE NAME	LABEL	ADDED	LENGTH
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object UnDetected....	Object Detect...	Yesterday, 10:...	10s
Object UnDetected....	Object UnDet...	Yesterday, 10:...	10s
Object Detected.5h...	Object Detect...	Yesterday, 10:...	10s
Object Detected.5h...	Object Detect...	Yesterday, 10:...	10s
Object Detected.5h...	Object Detect...	Yesterday, 10:...	10s
Object Detected.5h...	Object UnDet...	Yesterday, 10:...	10s

RAW DATA

1

This screenshot shows the 'Dataset' interface. It displays a table of collected samples with columns for 'SAMPLE NAME', 'LABEL', 'ADDED', and 'LENGTH'. The table lists 10 training samples and 2 test samples. At the top, it shows 'DATA COLLECTED 2m 0s' and 'TRAIN / TEST SPLIT 83% / 17%'. A navigation bar at the bottom includes icons for back, forward, and page number '1'.

## SAMPLE DATA COLLECTED:



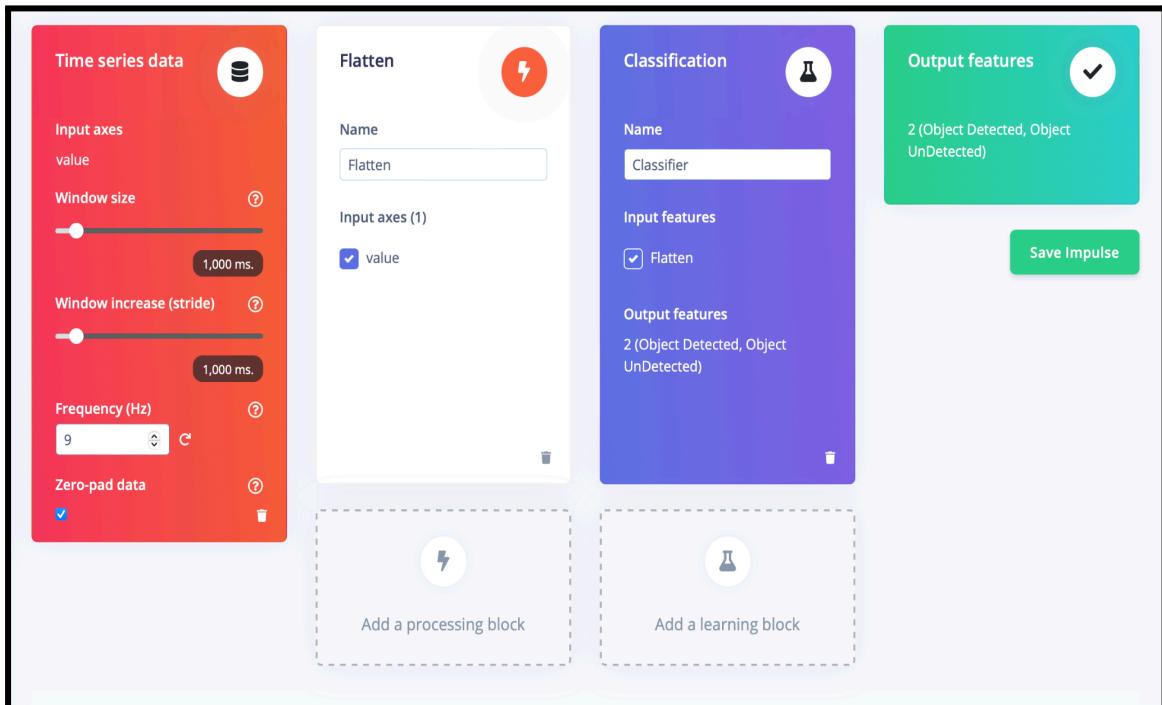


## 8) Training the Machine Learning Model

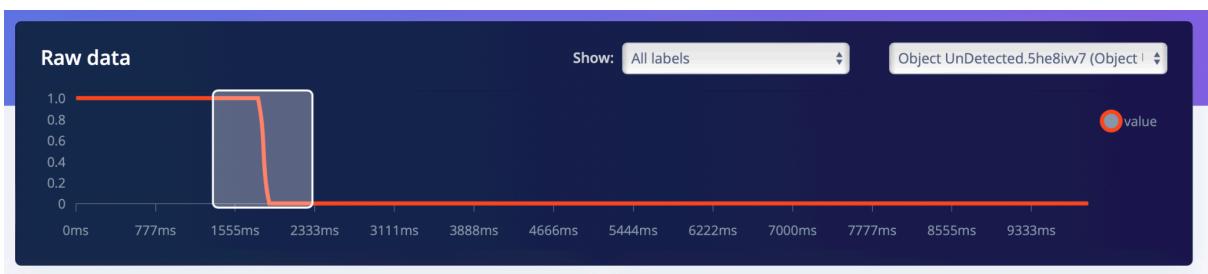
- **Impulse Design:**
  - Go to **Impulse Design** and create a pipeline.
    - **Input Block:** Time-series data.
    - **Processing Block:** Raw data.
    - **Learning Block:** Classification.
- **Train the Model:**
  - Go to the **Training** tab.

- Click **Start Training** to train the model using the labeled data.
- Evaluate the model's accuracy. Adjust the dataset if necessary.

## Creating Impulse:



## Processing block:



## Processed features:

DSP result

Processed features 

0.5556, 0.0000, 1.0000, 0.7454, 0.4969, -0.2236, -1.9500

State 

None for these settings

## Raw Features:

Raw features 	Label 
1, 1, 1, 1, 1, 0, 0, 0, 0	Object UnDetected
Parameters	
Scaling	
Scale axes 	1

## Parameters:

Parameters

Scaling

Scale axes ⓘ 1

Method

Average ⓘ

Minimum ⓘ

Maximum ⓘ

Root-mean square ⓘ

Standard deviation ⓘ

Skewness ⓘ

Kurtosis ⓘ

Moving Average ⓘ 0

**Save parameters** ▾

## 9) Testing the Model

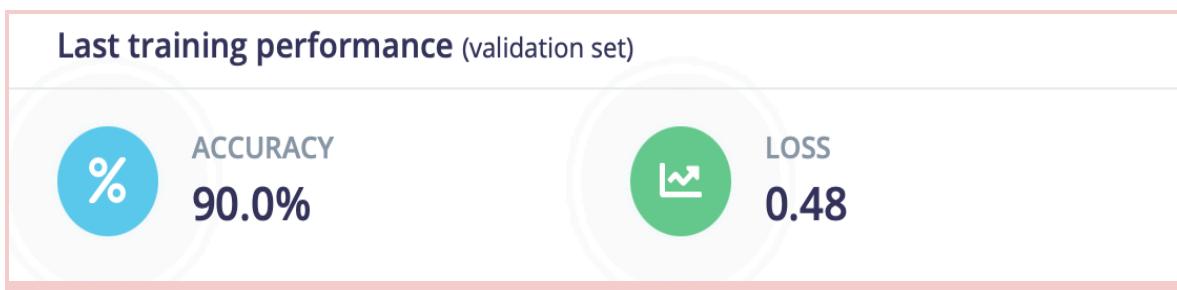
- **Test Data:**
  - Go to the **Model Testing** tab.
  - Upload test samples and evaluate the model's performance.

- Confirm that the model distinguishes between **Object Detected** and **No Object** accurately.

**Training output with:**

**ACCURACY : 90.0%**

**LOSS: 0.48**



#### Neural Network settings

##### Training settings

Number of training cycles

Use learned optimizer

Learning rate

Training processor

##### Advanced training settings

#### Neural network architecture

- Input layer (7 features)**
- Dense layer (20 neurons)
- Dense layer (10 neurons)
- Add an extra layer
- Output layer (2 classes)**

#### Training output

Model Model version:

Last training performance (validation set)

<span style="font-size: 2em;">%</span> <b>ACCURACY</b> <b>90.0%</b>	<span style="font-size: 2em;">↗</span> <b>LOSS</b> <b>0.48</b>
---	--

Confusion matrix (validation set)

	OBJECT DETECTED	OBJECT UNDETECTED
OBJECT DETECTED	77.8%	22.2%
OBJECT UNDETECTED	0%	100%
F1 SCORE	0.88	0.92

Metrics (validation set)

METRIC	VALUE
Area under ROC Curve	0.89
Weighted average Precision	0.92
Weighted average Recall	0.90
Weighted average F1 score	0.90

Data explorer (full training set)

## Confusion matrix (validation set)

	OBJECT DETECTED	OBJECT UNDETECTED
OBJECT DETECTED	77.8%	22.2%
OBJECT UNDETECTED	0%	100%
F1 SCORE	0.88	0.92

## Metrics (validation set)



METRIC	VALUE
Area under ROC Curve ⓘ	0.89
Weighted average Precision ⓘ	0.92
Weighted average Recall ⓘ	0.90
Weighted average F1 score ⓘ	0.90

## Data explorer (full training set) ⓘ

- Object Detected - correct
- Object UnDetected - correct
- Object Detected - incorrect
- Object UnDetected - incorrect

