



MICROPROCESSOR BASED SYSTEM DESIGN (CS-301)

OPEN ENDED LAB REPORT

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PROJECT: OBJECT RECOGNITION SYSTEM

OBJECTIVE

To develop a real-time object detection system using the ESP32-CAM and Edge Impulse platform, capable of recognizing and classifying Pakistani currency notes (**2 classes: 50pkr and 20 pkr**). The objective is to demonstrate edge AI capabilities on low-power embedded hardware by deploying a trained machine learning model on that performs image-based currency classification efficiently.

HARDWARE COMPONENTS

- **ESP32-CAM** - for capturing real-time images and running the machine learning model.
- **FTDI Programmer (USB to Serial Adapter)** - used to program the ESP32-CAM via USB.
- **Jumper Wires** - to establish necessary electrical connections.
- **OLED Display** - to visually display the classification result.
- **Mini USB to TTL Serial Converter Cable** - for connecting FTDI adapter to laptop

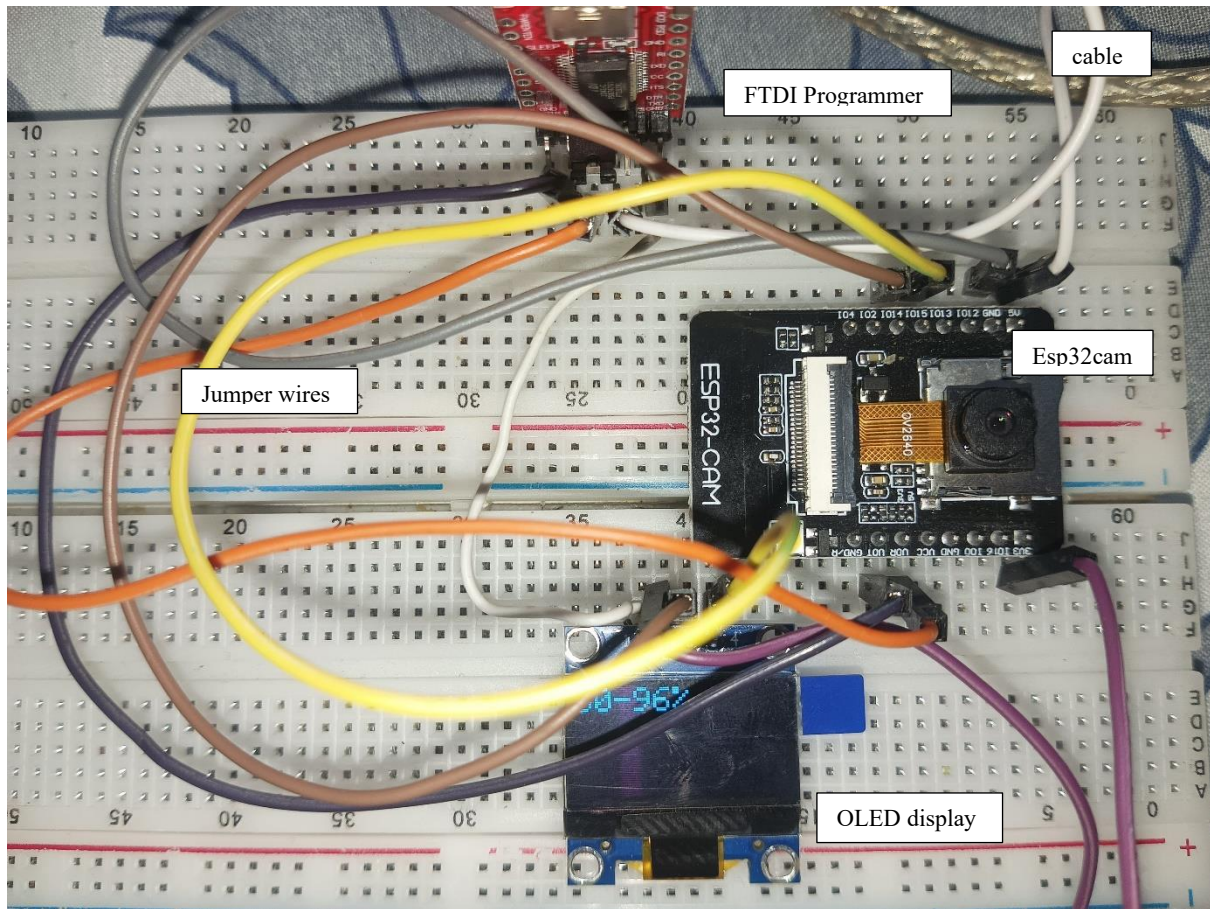
SOFTWARE / TECHNOLOGIES

- **Edge Impulse** - to collect data, train, and deploy the machine learning model.
- **Arduino IDE** - for writing and uploading firmware to the ESP32-CAM.
- **ESP32 Board Manager** - to integrate ESP32 support into the Arduino IDE.

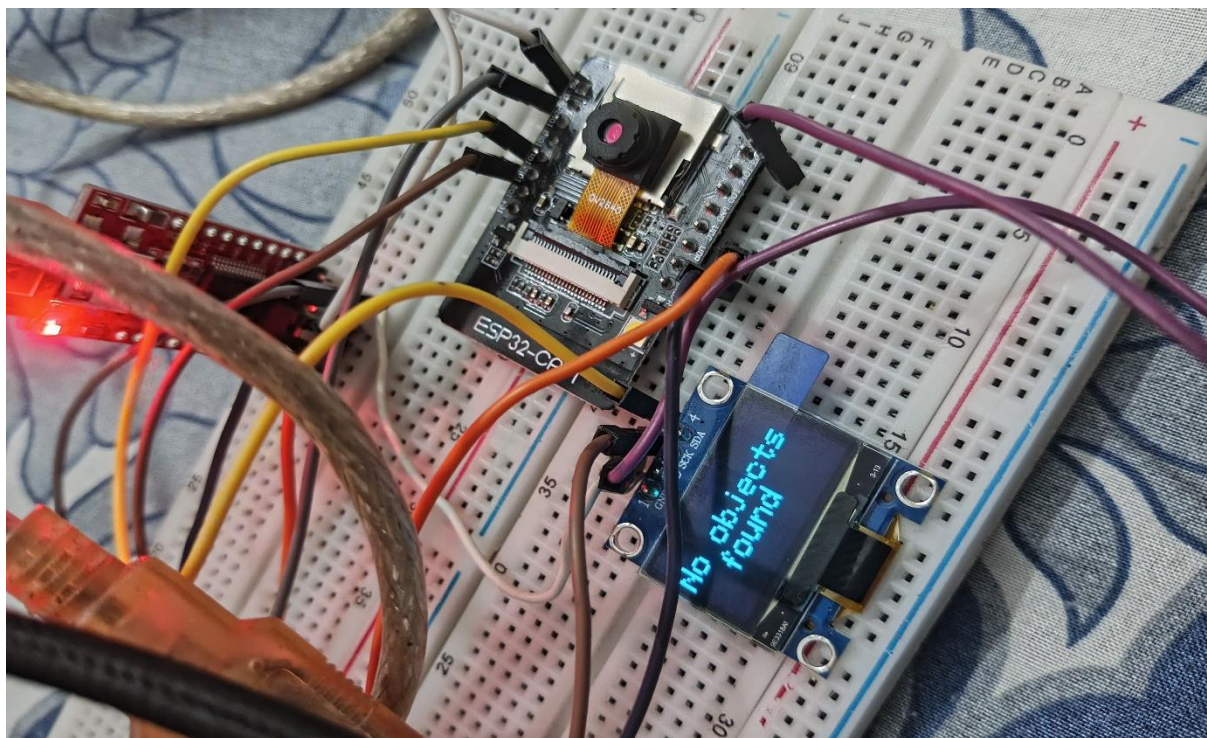
FUTURE IMPLEMENTATION'S

- Expand dataset to include Rs. 10, 100, 500, 1000, and 5000 for full Pakistani currency recognition
- Integrate into a smart donation box to detect and log inserted amounts
- Assist visually impaired users by identifying notes with audio feedback.

HARDWARE CIRCUIT



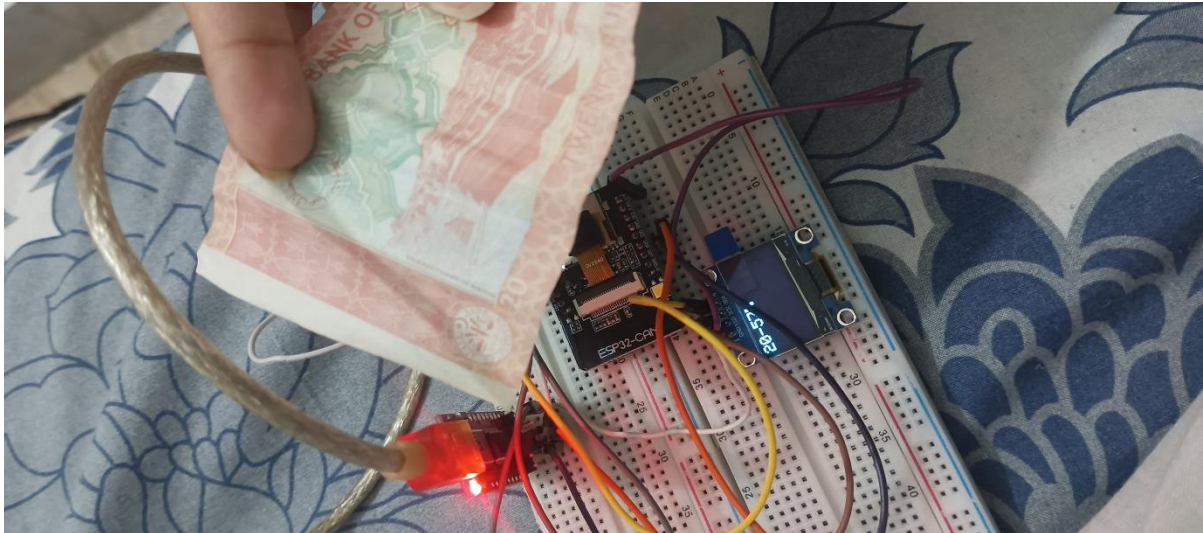
CASE I: No objects found




```
Output Serial Monitor X
Message (Enter to send message to 'AI Thinker ESP32-CAM' on 'COM3')

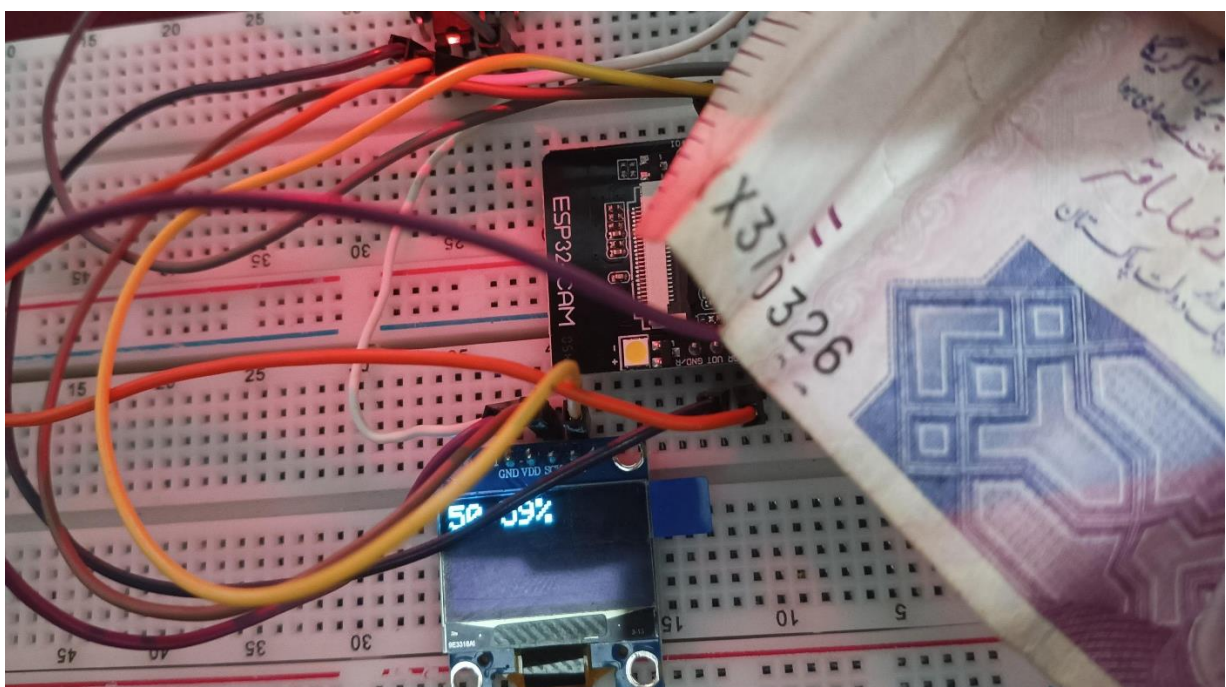
14:25:53.447 -> s.):
14:25:53.447 -> No objects found
14:25:53.447 -> Predictions (DSP: 8 ms., Classification: 812 ms., Anomaly: 0 ms.):
14:25:53.447 -> No objects found
14:25:53.447 -> Predictions (DSP: 8 ms., Classification: 812 ms., Anomaly: 0 ms.):
14:25:53.447 -> No objects found
14:25:53.941 -> Predictions (DSP: 8 ms., Classification: 812 ms., Anomaly: 0 ms.):
14:25:53.941 -> No objects found
```

CASE I : 20 Pkr detection



```
-----
14:31:01.675 -> Predictions (DSP: 8 ms., Classification: 812 ms., Anomaly: 0 ms.):
14:31:01.708 -> 20 (0.535156) [ x: 32, y: 64, width: 8, height: 8 ]
```

CASE II : 50 Pkr detection



```
14:30:00.640 -> Predictions (DSP: 8 ms., Classification: 812 ms., Anomaly: 0 ms.):  
14:30:00.640 -> 50 (0.574219) [ x: 16, y: 64, width: 8, height: 8 ]
```

DATASET

CLASS 0: 50 Pkr



CLASS 1: 20 Pkr detection




MODEL TRAINING

Platform: Edge Impulse

MODEL: FOMO (Faster Objects, More Objects) MobileNetV2 0.35

- FOMO: A lightweight object detection model designed for edge devices.
- MobileNetV2 0.35: A highly efficient neural network architecture scaled down (0.35x) to run on low-power devices.



FOMO (Faster Objects, More Objects) MobileNetV2 0.35

Choose a different model

Output layer (2 classes)

Training parameters

Neural Network settings

Training settings

Number of training cycles ?

60

Use learned optimizer ?

☐

Learning rate ?

0.001

Training processor ?

CPU

Data augmentation ?

☒

Advanced training settings

Neural network architecture

Input layer (27,648 features)

Train/Test splitting

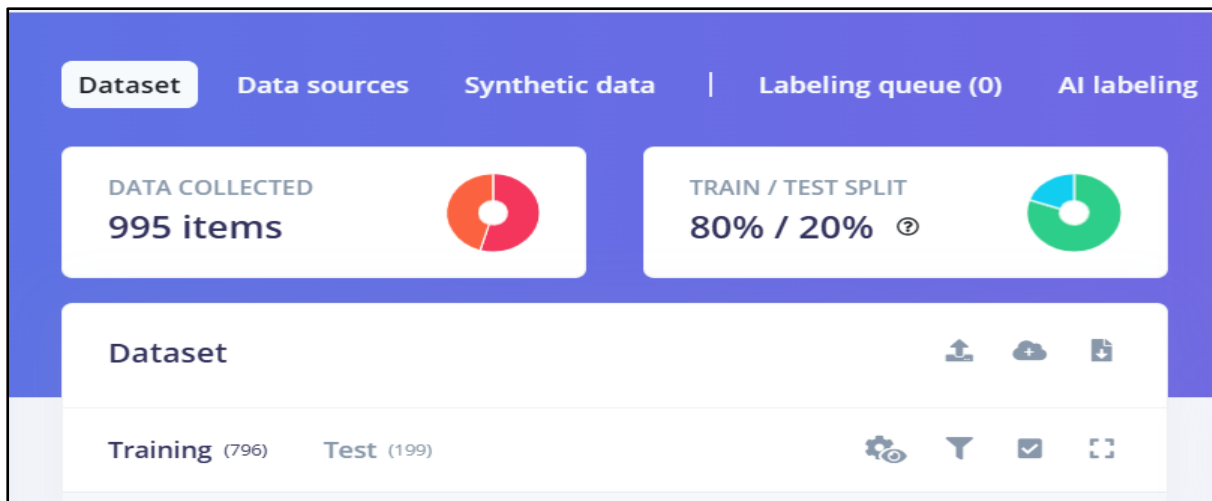


Image size

The screenshot shows a configuration interface for image size. It is divided into four main sections: 'Image data' (red), 'Image' (light blue), 'Object Detection (Images)' (purple), and 'Output features' (green). The 'Image data' section has 'Input axes' set to 'image', 'Image width' and 'Image height' both set to '96', and 'Resize mode' set to 'Fit shortest'. The 'Image' section has 'Name' set to 'Image', 'Input axes (1)' set to 'Image', and 'Image' set to 'image'. The 'Object Detection (Images)' section has 'Name' set to 'Object detection', 'Input features' checked for 'Image', and 'Output features' set to '2 (20, 50)'. The 'Output features' section has 'Output features' set to '2 (20, 50)' and a 'Save Impulse' button.

Image : color depth

The screenshot shows a configuration interface for image color depth. It is titled 'Parameters' and has a section for 'Image'. The 'Color depth' is set to 'RGB' with a dropdown arrow. At the bottom right, there is a 'Save parameters' button with a dropdown arrow.

Evaluation Matrix

Model

Model version: ?

Quantized (int8) ▼

Last training performance (validation set)



F1 SCORE ?

89.9%

Confusion matrix (validation set)

	BACKGROUND	20	50
BACKGROUND	100.0%	0.0%	0.0%
20	5.3%	94.7%	0%
50	16.3%	0%	83.8%
F1 SCORE	1.00	0.92	0.86

Metrics (validation set)



METRIC	VALUE
Precision (non-background) ?	0.90
Recall (non-background) ?	0.90
F1 Score (non-background) ?	0.90