SMART RETAIL VERIFICATION

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Edge AI 2025

Background and Motivation

- Traditional retail relies heavily on manual item identification and checkout processes
- Growing demand for seamless, automated retail experiences
- Overcome manual item identification
- Human error in billing and stock verification
- Improve customer experience
- Lower operational costs
- Enable loss prevention by ensuring that scanned items match items taken by the customer.

Objectives

- Collection of dataset for training & Validation.
- Identifying model for Edge AI deployment.
- Model Compression
- Deployment & Testing
- Verification on Python GUI

Dataset / Data collection

- 4 classes of food item
- Total samples : 4050
- Pre-processing:
  - Resizing to 96 x96
  - Grayscale Conversion
  - Normalizing
- Augmentation:
  - Flip, Rotation
  - Brightness, Exposure
  - Shear , Blur

Edge AI Model

- FOMO : Small Size, accurate and faster
- Model compression: INT8 Quantization
- Model characteristics
  - Model Size :
  - 887 KB (Before Compression)
  - 240 KB (After Compression)
- Performance : F1 Score 89%
- Latency : 60ms

Hardware and Software specs.

- Nicla Vision : Dual ARM Cortex M7, 480MHz, 2MP Color Camera, 1MB RAM, 2MB Flash
- Software: Edge Impulse, Roboflow

Prototype & demonstration

- Camera is mounted on a stand to capture an image from the top
- Demonstration done with multiple objects

Github Link :
https://github.com/shubhamlanjewar97/SmartRetailVerification_EdgeAI_CP_330

Demo Video :
https://youtu.be/41o1G4XasQA

CP 330: Edge AI

Smart Retail Verification

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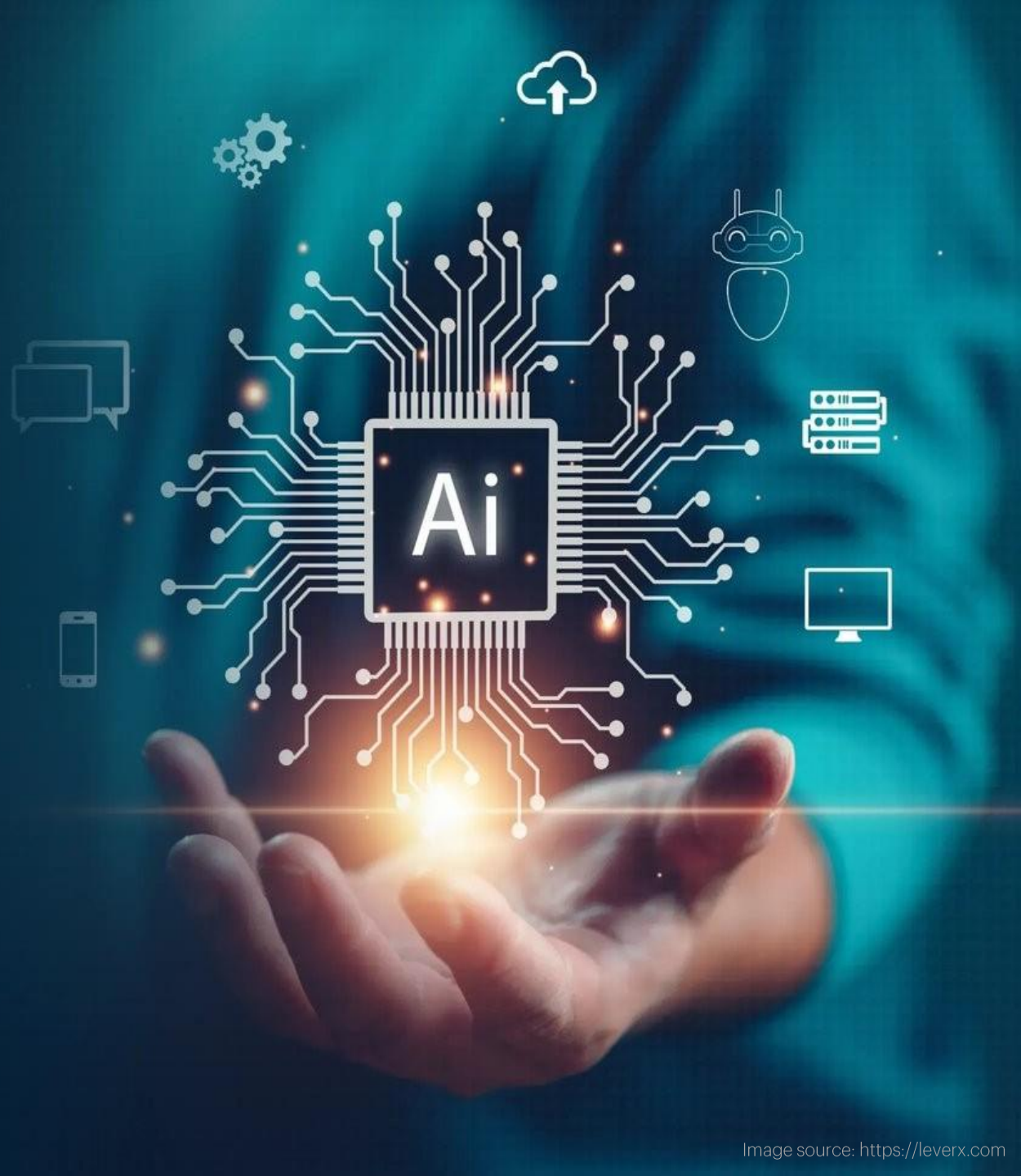


Image source: https://leverx.com

Introduction

- Smart retail verification using object detection on Nicla Vision
- Nicla Vision captures the image and does inference
- Sends object detection data to the Windows application
- Windows application provides a user interface for billing and verification

Motivation

- Traditional retail relies heavily on manual item identification and checkout processes
- Growing demand for seamless, automated retail experiences
- Manual processes lead to human errors in billing and stock verification
- Need to reduce checkout time and improve customer experience
- Enable loss prevention through verification of scanned vs. taken items

Methodology

Edge Device – Nicla Vision

- Nicla Vision captures images through the onboard camera
- Runs FOMO object detection model
- Process detections to merge nearby objects of the same class
- Sends data to PC over UART communication with costom-desined protocol

Methodology

PC Application

- Provides a GUI for the user
- Maintains product catalog with prices
- Receives detection data from the Nicla Vision
- Allows manual item entry for billing
- Performs verification between billed and detected items

Data Collection and Preprocessing

Dataset

- 4 classes [KitKat, Goodday, HiddenSeek, Unibic]
- Total Samples: 4050 (After Aggregation)
- Samples: 1350 (Before Augmentation)
- Augmentation on Roboflow
- Resizing to 96*96 and convert to grayscale

Model Development

Model Selection FOMO

- FOMO (faster objects, more objects)
- Small size, Faster inference
- Suitability for edge devices

Model Compression

- INT8 quantization
- Original peak ram usage: 363.2KB
- Compressed Size: 119.4 KB

Model

Model version: Unoptimized (float32)

Last training performance (validation set)

F1 SCORE
92.0%

Confusion matrix (validation set)

	BACKGROUND	HIDENSEEK	KITKAT	UNIBIC	GOODDAY
BACKGROUND	100.0%	0.0%	0.0%	0.0%	0.0%
HIDENSEEK	4.3%	95.7%	0%	0%	0%
KITKAT	0%	0%	100%	0%	0%
UNIBIC	11.1%	0%	0%	88.9%	0%
GOODDAY	4.2%	0%	0%	0%	95.8%
F1 SCORE	1.00	0.95	0.92	0.90	0.90

Metrics (validation set)

METRIC	VALUE
Precision (non-background)	0.89
Recall (non-background)	0.95
F1 Score (non-background)	0.92

On-device performance

Engine: EON™ Compiler (RAM optimized)

INFERENCING TIME	PEAK RAM USAGE	FLASH USAGE
115 ms.	363.2K	113.8K

Model Summary (float32)

Model

Model version: Quantized (int8)

Last training performance (validation set)

F1 SCORE
91.3%

Confusion matrix (validation set)

	BACKGROUND	HIDENSEEK	KITKAT	UNIBIC	GOODDAY
BACKGROUND	100.0%	0.0%	0.0%	0.0%	0.0%
HIDENSEEK	4.4%	95.6%	0%	0%	0%
KITKAT	0%	0%	100%	0%	0%
UNIBIC	10.8%	0%	0%	89.2%	0%
GOODDAY	8.3%	0%	0%	0%	91.7%
F1 SCORE	1.00	0.92	0.90	0.92	0.90

Metrics (validation set)

METRIC	VALUE
Precision (non-background)	0.89
Recall (non-background)	0.94
F1 Score (non-background)	0.91

On-device performance

Engine: EON™ Compiler (RAM optimized)

INFERENCING TIME	PEAK RAM USAGE	FLASH USAGE
60 ms.	119.4K	91.0K

Model Summary (int8)

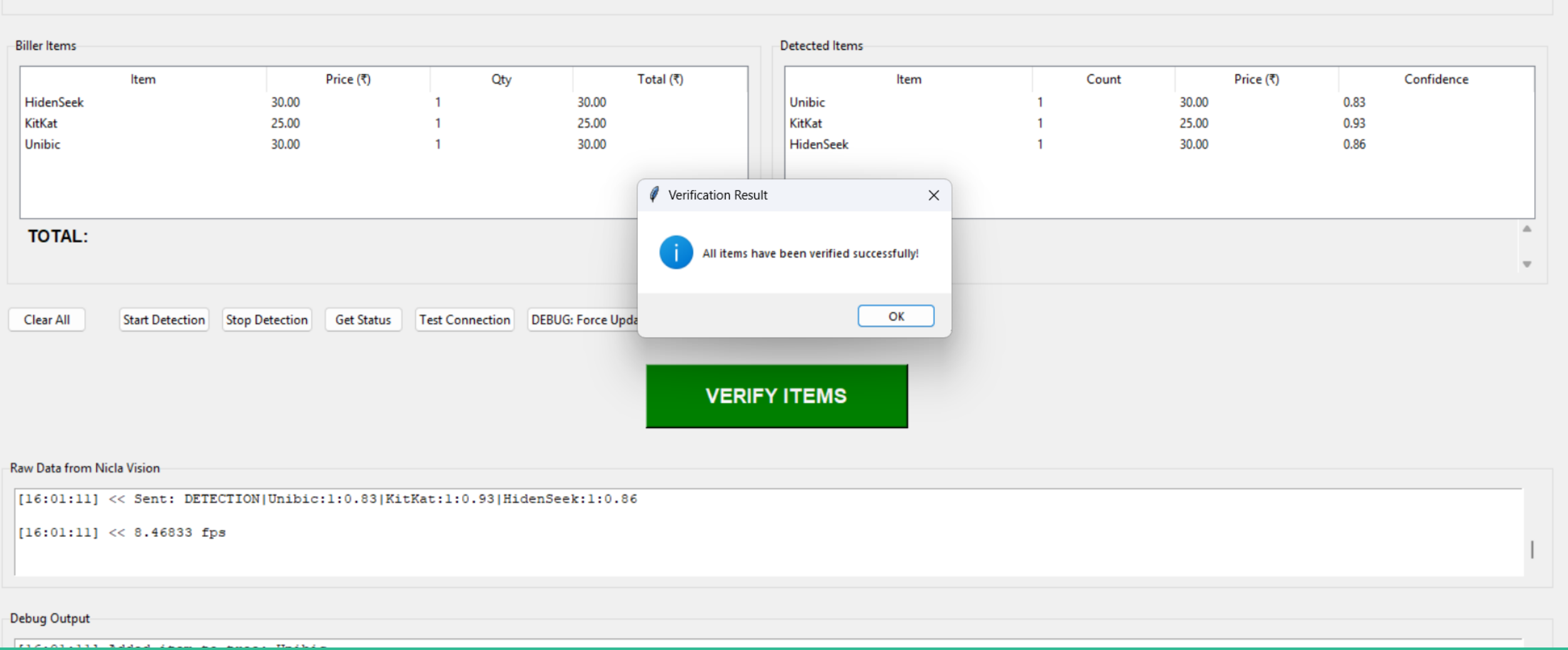
Conclusion

Project outcomes

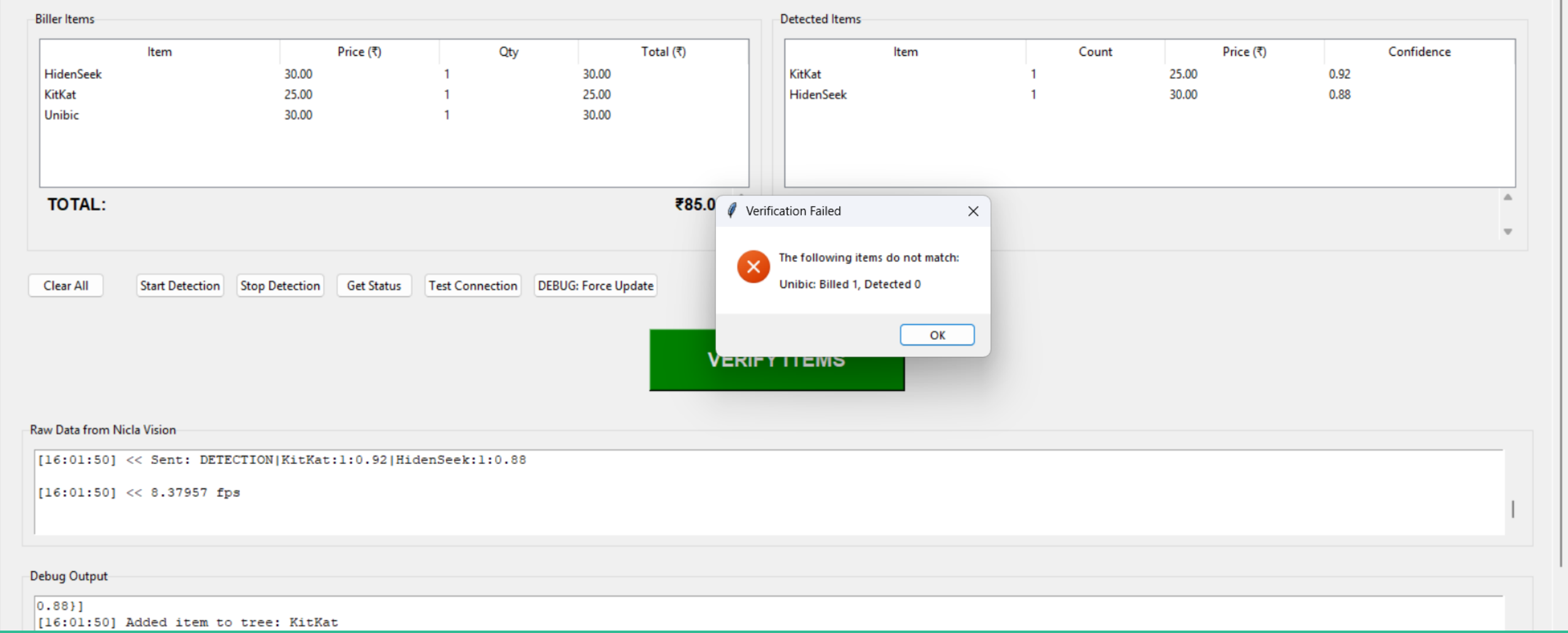
- Successful implementation of an Edge AI-based retail verification system
- Effective model compression for embedded deployment
- Creation of a user-friendly interface for retail verification
- Real-time detection and verification capabilities

Setup

Object Detection



User Interface (success case)



User Interface (fail case)

Thank you