Title: Smart, automated system for product labeling and traceability, capable of verifying product quality parameters and applying or validating labels.

Inno Taggers Team Members: Pathipati Tharun, Gara Sanjana

Abstract:

A smart, autonomous system to improve product labeling and traceability accuracy, security, and transparency. By taking advantage of machine learning, and blockchain technology, the system authenticates product quality parameters in real time and assigns or authenticates dynamic labels that indicate compliance, authenticity, and lifecycle status. The main purpose is to increases supply chain transparency, minimizes counterfeit risk, and builds consumer trust with digital twin architecture and interactive labeling.

1. Introduction

It is important to ensure quality in the products and in the modern days ensuring quality is quite challenging. There are so many errors in the traditional labelling systems which lack real time updates. To address these issues, we introduce a system that automates product labelling based on verified data and offers end-to-end traceability. We have taken the RoHs(Restriction of Hazardous Substances) as the main parameter to ensure that electrical and electronic equipment is safe.

2. System Overview

Key Components:

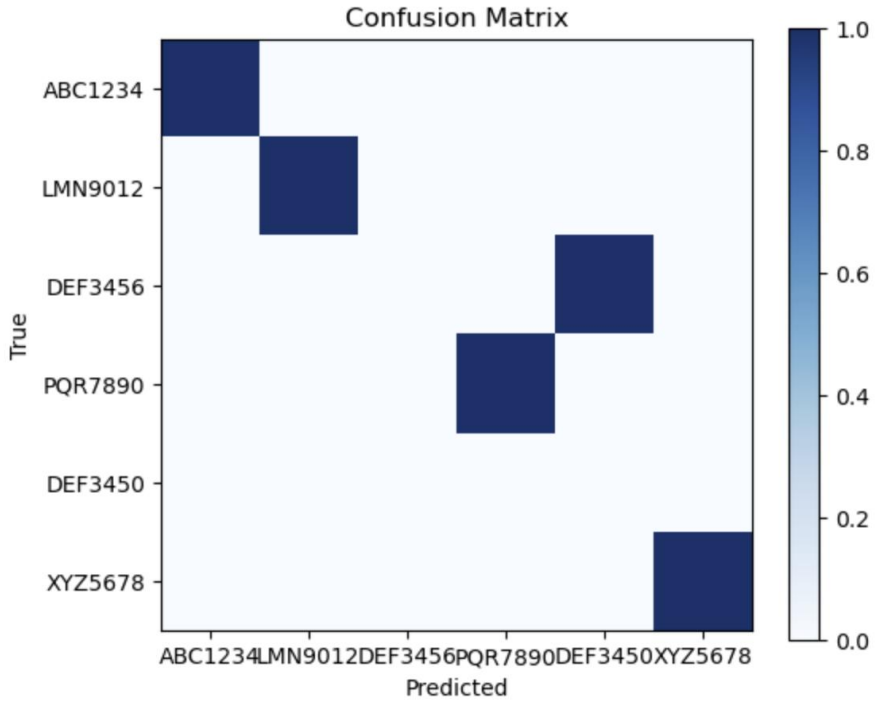
- AI-Based Quality Analysis: Data is analyzed using AI to determine product status and compliance.

- Labeling Engine: Based on the verified data, a label is generated or validated dynamically using QR/NFC technology.

- Digital Twin Module: A virtual model of the product stores lifecycle data, accessible via the label scan.

3. Analysis

The model correctly classified the majority of the classes with high accuracy. Specifically, the classes ABC1234, LMN9012, DEF3456, PQR7890, and XYZ5678 were all predicted with perfect accuracy, showing a normalized score of 1.0 on the diagonal of the matrix.



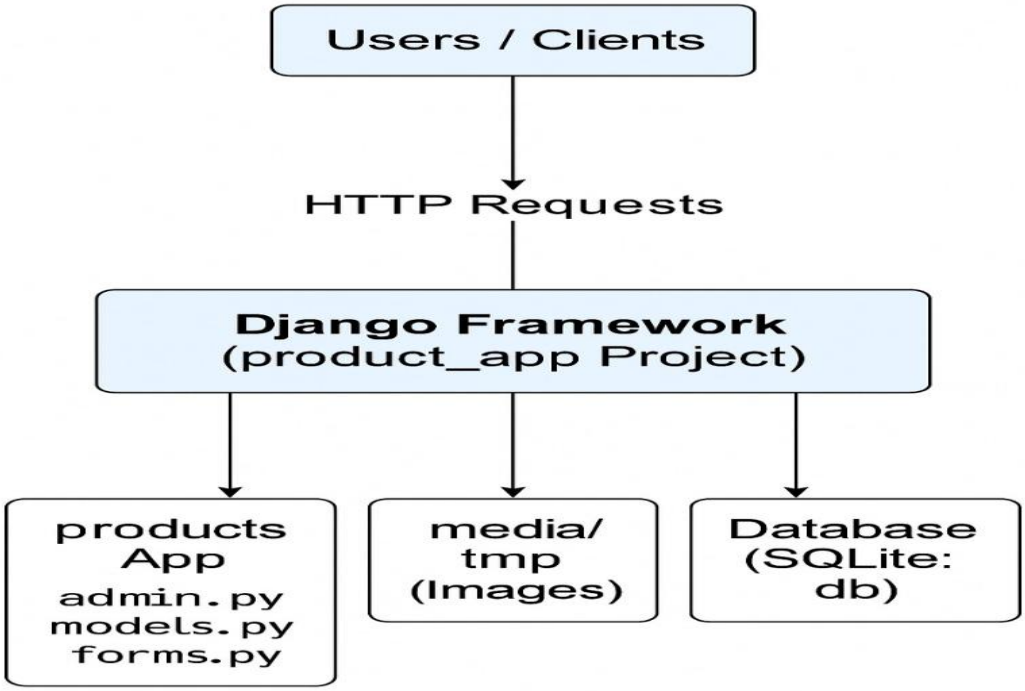
Accuracy: 0.80 (80% of total predictions were correct).

Macro Average (Unweighted): 0.67 for precision, recall, and F1-score, reflecting the average performance across all classes equally.

Weighted Average: 0.80, accounting for class imbalance by weighting scores according to support

	precision	recall	f1-score	support
ABC1234	1.00	1.00	1.00	1
DEF3450	0.00	0.00	0.00	0
DEF3456	0.00	0.00	0.00	1
LMN9012	1.00	1.00	1.00	1
PQR7890	1.00	1.00	1.00	1
XYZ5678	1.00	1.00	1.00	1
accuracy			0.80	5
macro avg	0.67	0.67	0.67	5
weighted avg	0.80	0.80	0.80	5

4. Architecture Diagram



5. Process Flow

1.The production stage: Sensors gather information about the quality of the goods as they are being made.AI analyzes the data to ensure the product meets defined thresholds.

2. Label Generation: If the quality standards are met, a secure QR/NFC label is generated and linked to the product's digital twin.

3.Checks RoHs: It checks the RoHs compliance of the product based on that it says wheather the product is safe or not

4. Consumer Interaction: Consumers scan the label using smartphones to verify authenticity and view the product journey.

6. Contribution

Person 1 (Pathipati Tharun)

Responsibilities:

Backend Development: Designed and implemented Django models (models.py) for product management.

OCR Pipeline Integration: Developed the core logic to integrate OCR functionalities within the Django views.

Jupyter-Based Evaluation: Led the creation of the OCR evaluation notebook (ocr_evaluation_metrics_demo.ipynb) for performance analysis.

Database & Media Handling: Managed database setup (db.sqlite3) and media file configuration for image uploads.

Environment Setup: Configured project dependencies and managed requirements.txt.

Person 2 (Gara Sanjana)

Responsibilities:

1. **Admin & Forms Interface**: Developed Django admin customizations (admin.py) and product input forms (forms.py).
2. **Frontend Integration**: Handled the integration of OCR and form validation into the frontend templates and views.
3. **Testing & QA**: Wrote and executed test scripts (test_add_product_ocr.py, test_ocr.py) to ensure application reliability.

4. **Documentation**: Authored the README_OCR_ENHANCEMENTS.md and structured usage instructions for the OCR enhancements.
5. **Project Structure & UI Enhancement**: Contributed to organizing the app structure and enhancing the user experience in forms and results display.

7. Use Case Scenarios

- Pharmaceuticals: Ensures medicine integrity during transit and storage.

- Food & Beverages: Detects spoilage risks through temperature sensors.

- Luxury Goods: Provides verifiable proof of origin and ownership history.

- Electronics: Tracks compliance certifications and warranty data.

8. Technology Stack

- Hardware: RFID/QR/NFC tags, Arduino/Raspberry Pi sensor nodes

- Software: Python (AI models), Node.js backend, MongoDB, Ethereum (for blockchain)

- Cloud: AWS IoT Core, Azure Blockchain Services

- Tools: TensorFlow for anomaly detection, Power BI for visualization

9. Benefits

- Better Quality Control: Instant checking of goods.

- Increased Traceability: Following each unit from raw material

to consumer.

- Anti-Counterfeiting: Anti-fraud labels based on blockchain technology.

- Customer Trust: Open data enhances brand credibility and user trust.

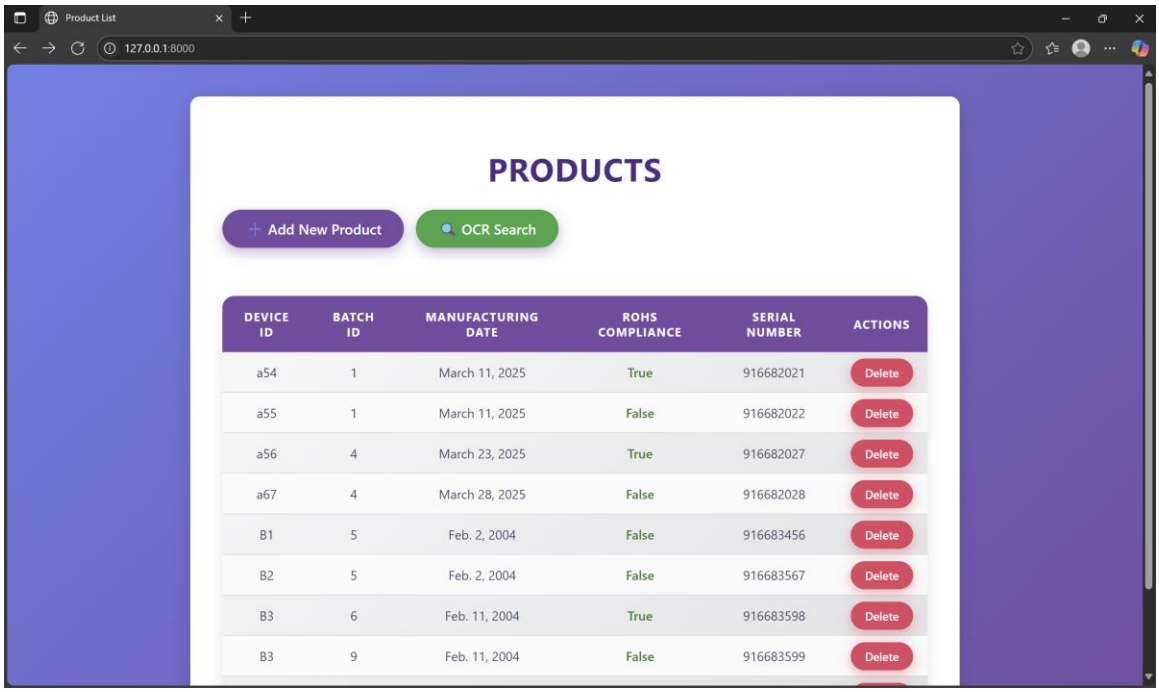
10. Challenges and Mitigation

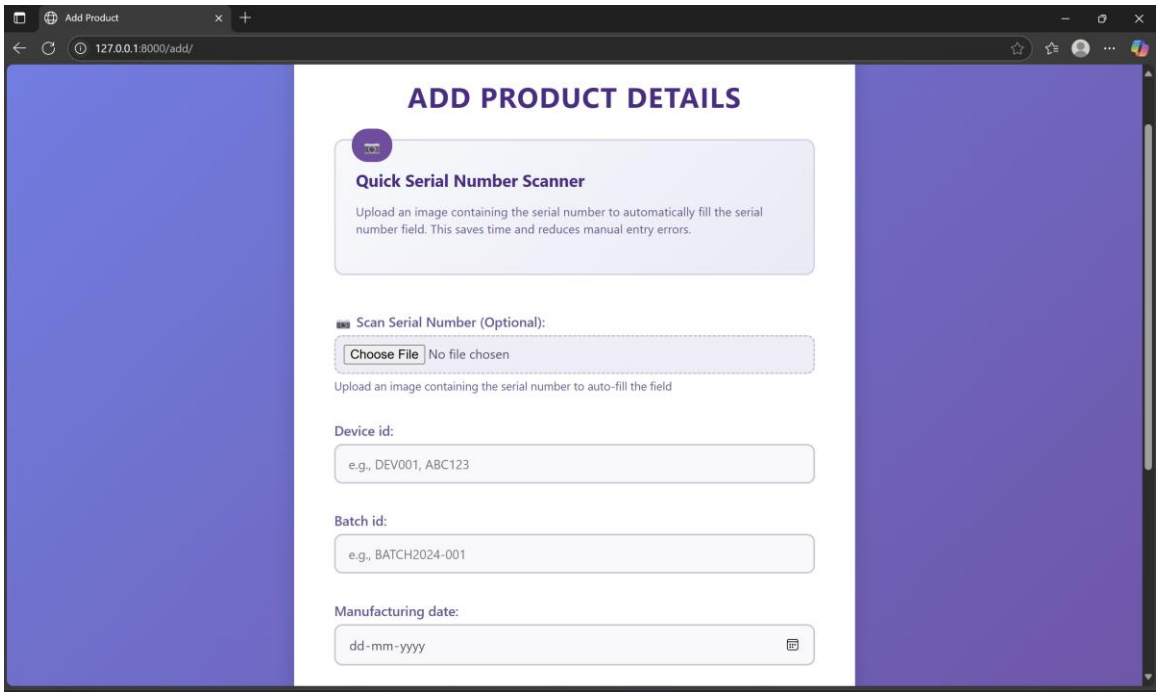
Challenge: Sensor calibration errors - Solution: Routine validation of algorithms and ML correction algorithms

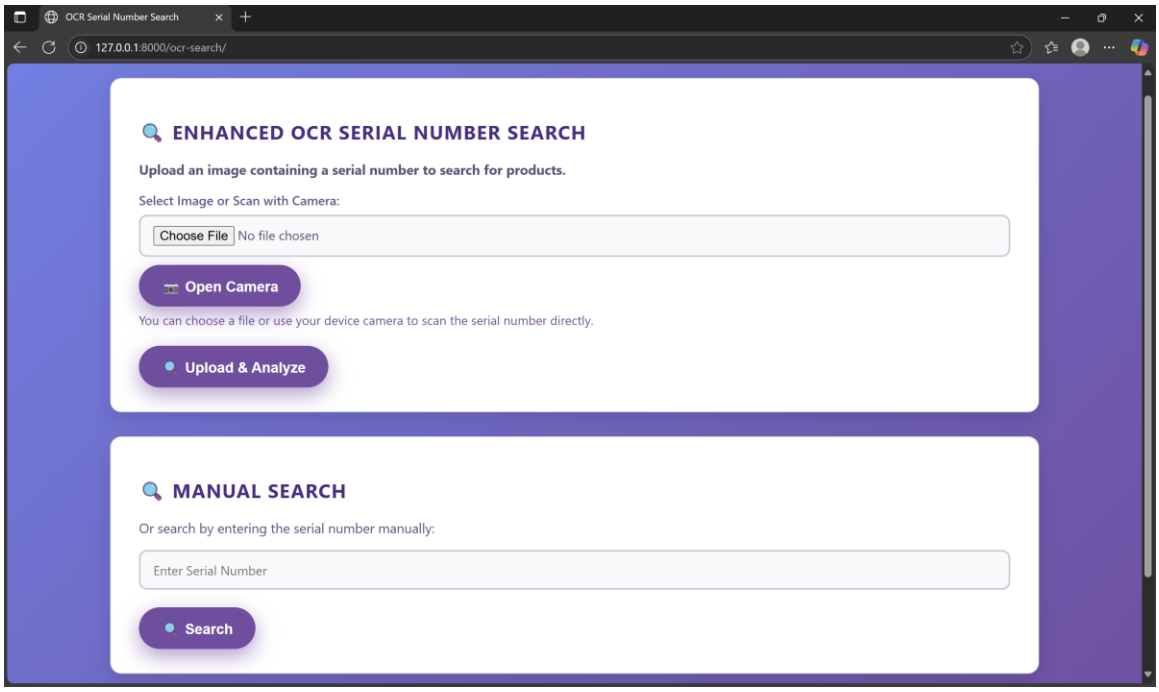
Challenge: Data overloading - Solution: Cloud-based analytics and edge filtering

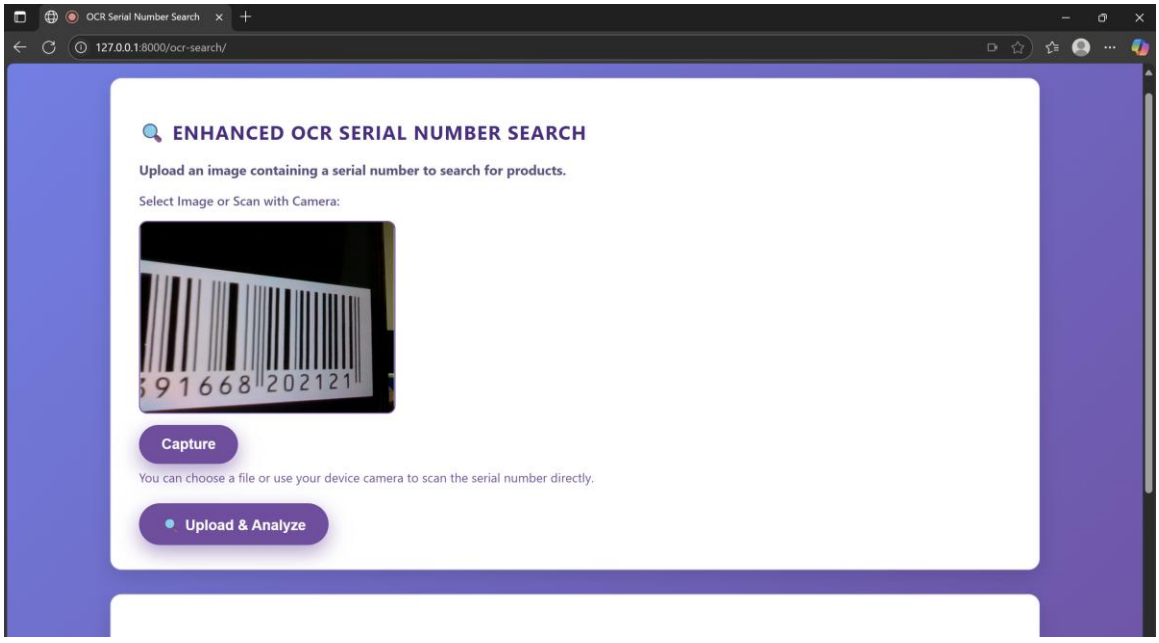
Challenge: Integration with legacy systems - Solution: API-based connectors and modular architecture

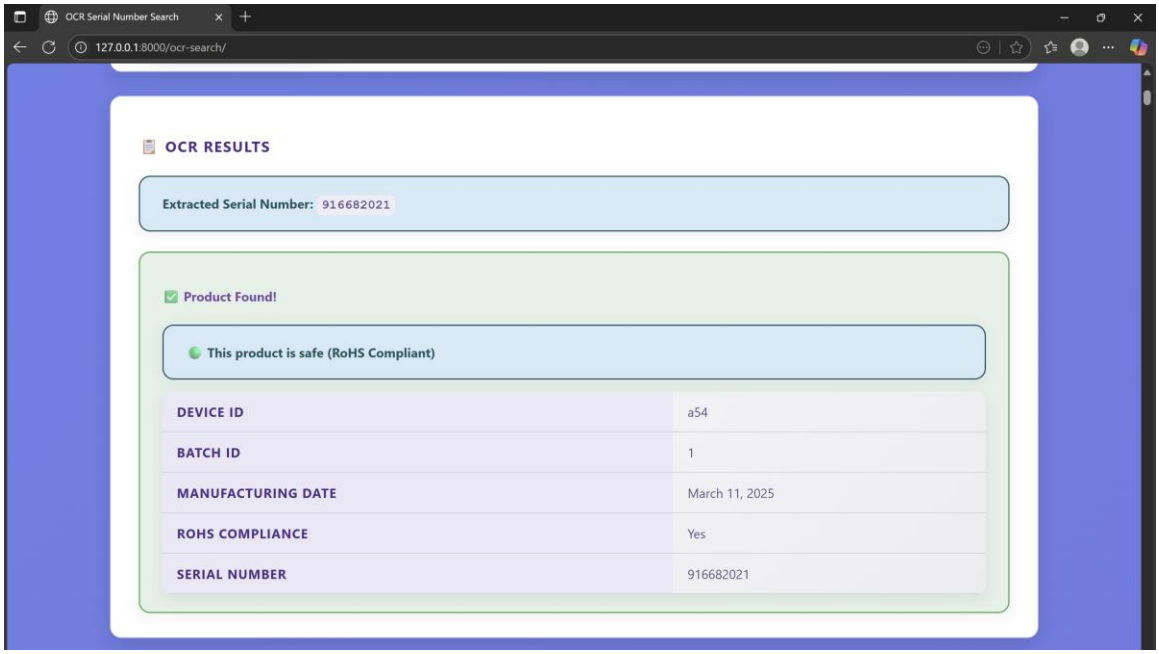
11. Output Screens:






OCR Serial Number Search
127.0.0.1:8000/ocr-search/
ENHANCED OCR SERIAL NUMBER SEARCH
Upload an image containing a serial number to search for products.
Select Image or Scan with Camera:
Choose File No file chosen
Open Camera
You can choose a file or use your device camera to scan the serial number directly.
Upload & Analyze
MANUAL SEARCH
Or search by entering the serial number manually:
Enter Serial Number
Search


OCR Serial Number Search
127.0.0.1:8000/ocr-search/
ENHANCED OCR SERIAL NUMBER SEARCH
Upload an image containing a serial number to search for products.
Select Image or Scan with Camera:
91668 202121
Capture
You can choose a file or use your device camera to scan the serial number directly.
Upload & Analyze



12. Conclusion

The system represents a leap towards intelligent, secure, and transparent supply chains. By integrating the real-time quality monitoring, dynamic labeling, and traceability, it empowers, manufacturers and consumers with actionable insights and trusted products. Future work may explore integrating predictive analytics for proactive maintenance of data and AI-based fraud detection.

13. GitHub link

https://github.com/PathipatiTharun/Intel-Unnati-Internship