INTEL UNNATI INDUSTRIAL TRAINING PROGRAM-2025
PROBLEM STATEMENT-5

Smart Product Labelling and Traceability System for Quality Control Automation

BY

TEAM ALGORHYTHM (MRCET)

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PROJECT INFORMATION

Problem Statement No.	PS-5
Problem statement	Design and implement a smart, automated system for labelling and traceability

BINARY BOLTZ TEAM

Team Leader	Bochkar Nikhith
Team Members	Banisetty Janeshwar Rao Jakkireddy Sri Charan Reddy
Institution	Malla Reddy College of Engineering and Technology

MENTORS

Faculty Mentor	Dr. P. Harikrishna
Industry Mentor	Mr. Anil Kumar

INTEL UNNATI INDUSTRIAL TRAINING PROGRAM – 2025

CERTIFICATE

This is to certify that the project submitted by the team Algorhythm has been approved and successfully completed as part of the Intel Unnati Industrial Training Program - 2025. The project has been built as a response to PS-5: **Smart Product Labelling and Traceability System for Quality Control Automation**

BY

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1. ABSTRACT

In modern manufacturing environments—particularly within industries such as electronics, medical devices, and automotive components—the demand for accurate, real-time, and intelligent quality control systems has grown significantly. The *Smart Product Labeling and Traceability System for Quality Control Automation* addresses this need by offering a robust, integrated platform that automates product identification, compliance verification, labeling, and traceability across the production line.

This system is designed around a web-based user interface that allows operators to input product data by either scanning a QR code using a live camera or uploading an image containing the QR code. Once the QR code is processed, the backend—developed using Python (Flask or FastAPI)—decodes the embedded Batch ID and queries production records stored in structured CSV datasets (batch_dataset.csv and tools_dataset.csv). The system retrieves corresponding metadata such as tool IDs, tool names, production time shifts, managers, and remarks, presenting the complete traceability history of the batch.

An integrated AI module enhances the reliability of label inspection by performing OCR (Optical Character Recognition) and defect detection using pre-trained models (e.g., YOLOv5 or EasyOCR). Based on the analysis, the system can automatically trigger actions such as label printing or rejection of defective units via simulated or actual hardware actuators. This adds an intelligent quality layer to the labeling process, ensuring compliance with RoHS and manufacturing standards.

All results, including the retrieved production data and inspection outcomes, are appended in real time to a traceability log (traceability_log.csv) with timestamps, enabling thorough audits and record-keeping. The architecture is modular, supporting integration with embedded systems like Arduino or Raspberry Pi for sensor input, actuator control, and label printing.

This project represents a practical implementation of Industry 4.0 principles. By combining mechatronic simulation, machine learning, web technologies, and structured data handling, it delivers a scalable and intelligent solution for quality control and traceability automation in industrial settings.

2. INTRODUCTION

2.1. Objective:

The primary objective of this project is to design and implement a **Smart Product Labeling and Traceability System** that automates the process of product verification, labeling, and traceability in a manufacturing environment. The system aims to ensure that each product unit is accurately identified, quality-checked, and appropriately labeled with relevant production and compliance data such as Batch ID, Tool ID, Manufacturing Date, RoHS compliance, and a serial identifier in the form of a QR code or barcode.

This project integrates various technologies including:

- **Computer vision** for QR code detection and label quality validation,
- **Mechatronics and sensor-actuator simulation** for automated handling,
- **Machine learning or OCR** for detecting defects or validating label content,
- **CSV-based data management** for structured logging and metadata retrieval, and
- **Web technologies** to provide a user-friendly interface for operators.

The system is also designed to simulate real-time hardware control actions such as label printing and unit rejection, based on verification outcomes. Furthermore, it maintains a structured traceability log for audit and compliance purposes. The ultimate goal is to demonstrate how such an intelligent, automated system can increase production reliability, reduce human error, and support quality control processes in line with Industry 4.0 standards.

2.2. Problem Statement:

Design and implement a smart, automated system for labelling and traceability.

2.3. Background of project:

In contemporary manufacturing industries—particularly in electronics, medical devices, and automotive components—ensuring product quality, regulatory compliance, and end-to-end traceability has become a critical requirement. As production scales and supply chains become increasingly complex, manufacturers are expected to implement advanced labeling systems that not only identify individual products but also track their journey through every stage of the manufacturing process.

Traditional labeling methods, often reliant on manual or semi-automated systems, are prone to human error, inconsistency, and a lack of integration with real-time quality checks. Such limitations can lead to incorrect labeling, undetected defects, and compliance failures, all of whic

affect product reliability and brand trust. Furthermore, regulatory frameworks (Restriction of Hazardous Substances) compliance, product serialization, and ba require manufacturers to maintain accurate and auditable records for every unit pr

The rise of Industry 4.0 introduces a paradigm shift in manufacturing by integrating smart technologies such as automation, data analytics, artificial intelligence (AI), and the Internet of Things (IoT) into the production environment. In this context, intelligent labelling and traceability systems have become essential for bridging the gap between physical product handling and digital quality assurance.

2.4. Scope of the project:

The scope of this project encompasses the design, development, and simulation of a **Smart Product Labeling and Traceability System** for quality control automation in a manufacturing environment. The system is intended to support small to mid-scale production lines that require accurate product identification, traceability, and compliance with quality standards.

2.5. Project features:

1. QR Code-Based Batch Identification:

- Supports both live webcam scanning and static image uploads.
- Extracts an 8-digit unique Batch ID embedded in the QR code.
- Provides flexibility in input methods to suit various operational environments.

2. Integrated Production Data Mapping:

- Retrieves detailed information (Tool ID, Tool Name, Time Shift, Manager, Remarks) associated with the Batch ID from batch_dataset.csv and tools_dataset.csv.
- Uses a composite key (ToolID + TimeShift) for accurate matching.
- Presents the mapped data in a clean, tabular UI format.

3. Real-Time Label Validation using AI/OCR:

- Incorporates AI-based modules (EasyOCR or YOLOv5) to validate printed label content.
- Detects label printing errors, missing fields, or surface defects.
- Offers visual inspection functionality for quality assurance automation.

4. Traceability Logging:

- Automatically appends each transaction (with full metadata and timestamp) to traceability_log.csv.
- Enables trace-back of production history for auditing and compliance.
- Ensures logs are chronologically ordered and non-duplicative.

5. Web-Based User Interface:

- Developed using HTML, CSS, and JavaScript for seamless user experience.
- Provides clear feedback on validation results.
- Offers options to rescan, upload new QR images, or view the status of previc
-

6. Backend Processing in Python:

- Uses Flask or FastAPI to manage backend logic and route handling.
- Leverages OpenCV and Pyzbar for QR decoding.
- Performs all data operations using Pandas for efficient CSV handling.

3. SYSTEM REQUIREMENTS

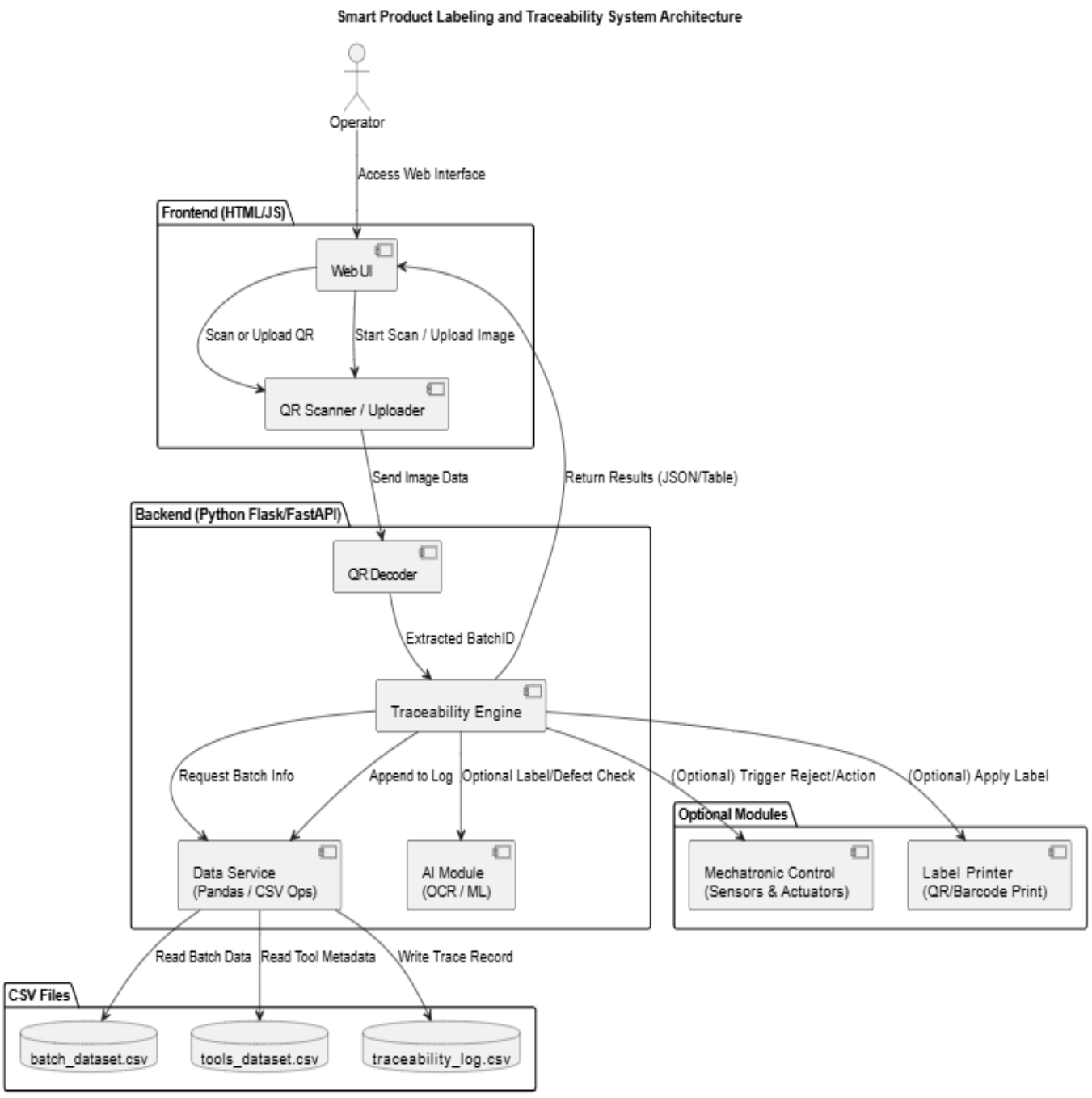
3.1. Hardware Requirements:

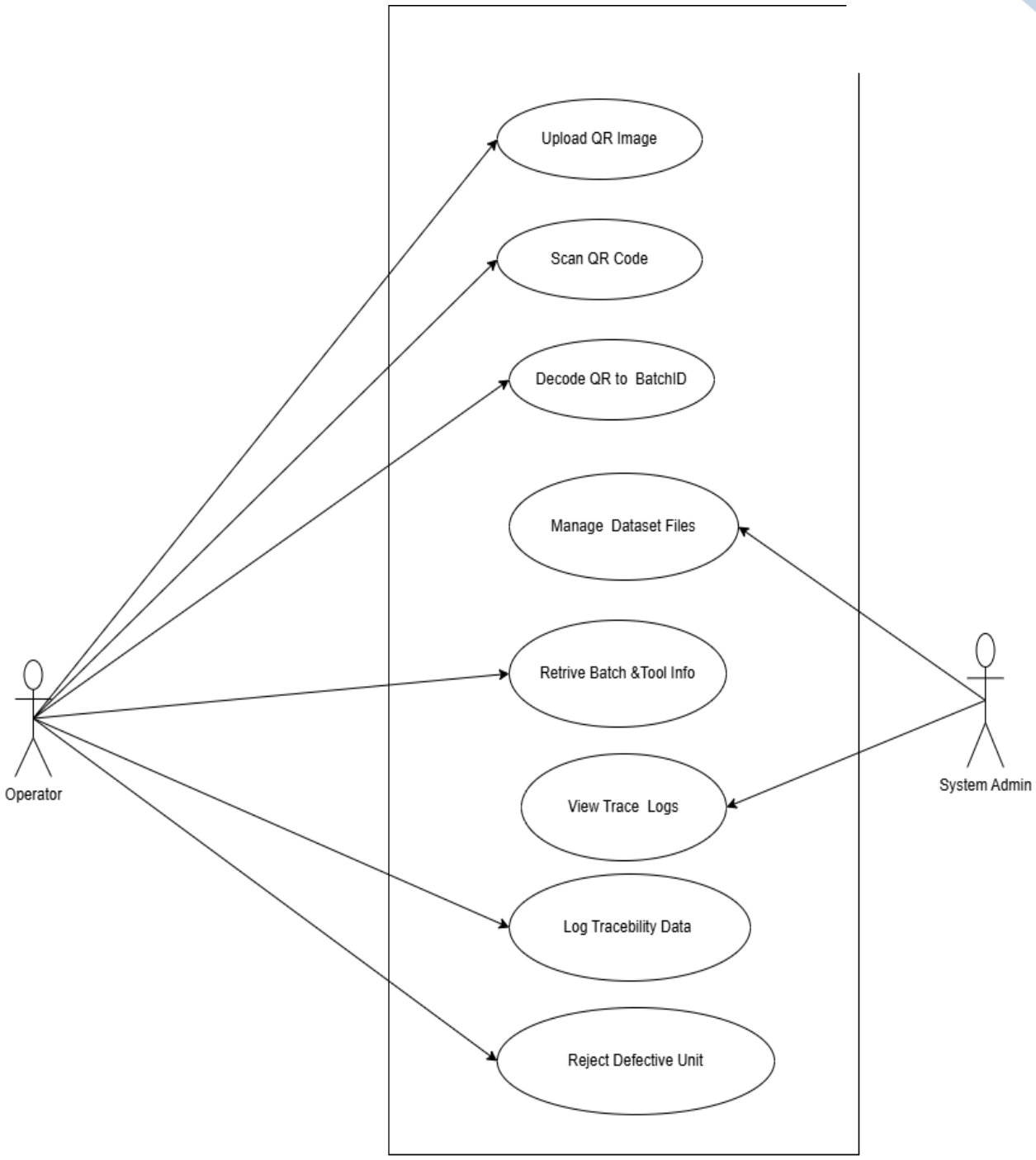
- Processor: intel Core i5 or equivalent
- RAM: 8 GB minimum
- Storage: 256 GB SSD

3.2. Software Requirements:

- **Operating System:**
  Windows 10 / 11, Ubuntu 20.04 or later
- **Environment:**
  Google Colab
- **Python:**
  Python 3.8 or later.
- **Required Libraries and Frameworks:**
  PyTorch
  OpenCV
  pyzbar
  pandas

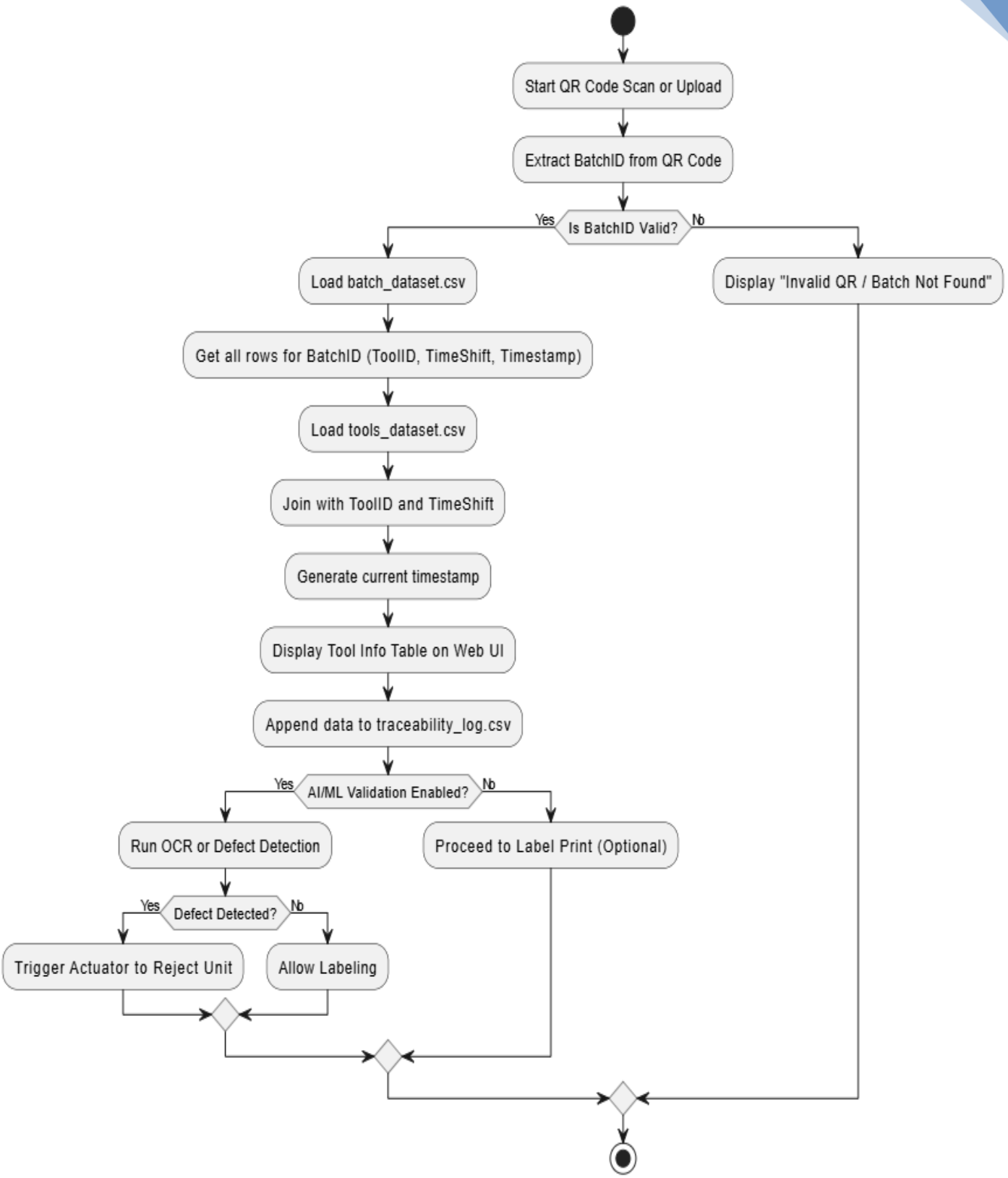
4.UML DIAGRAMS

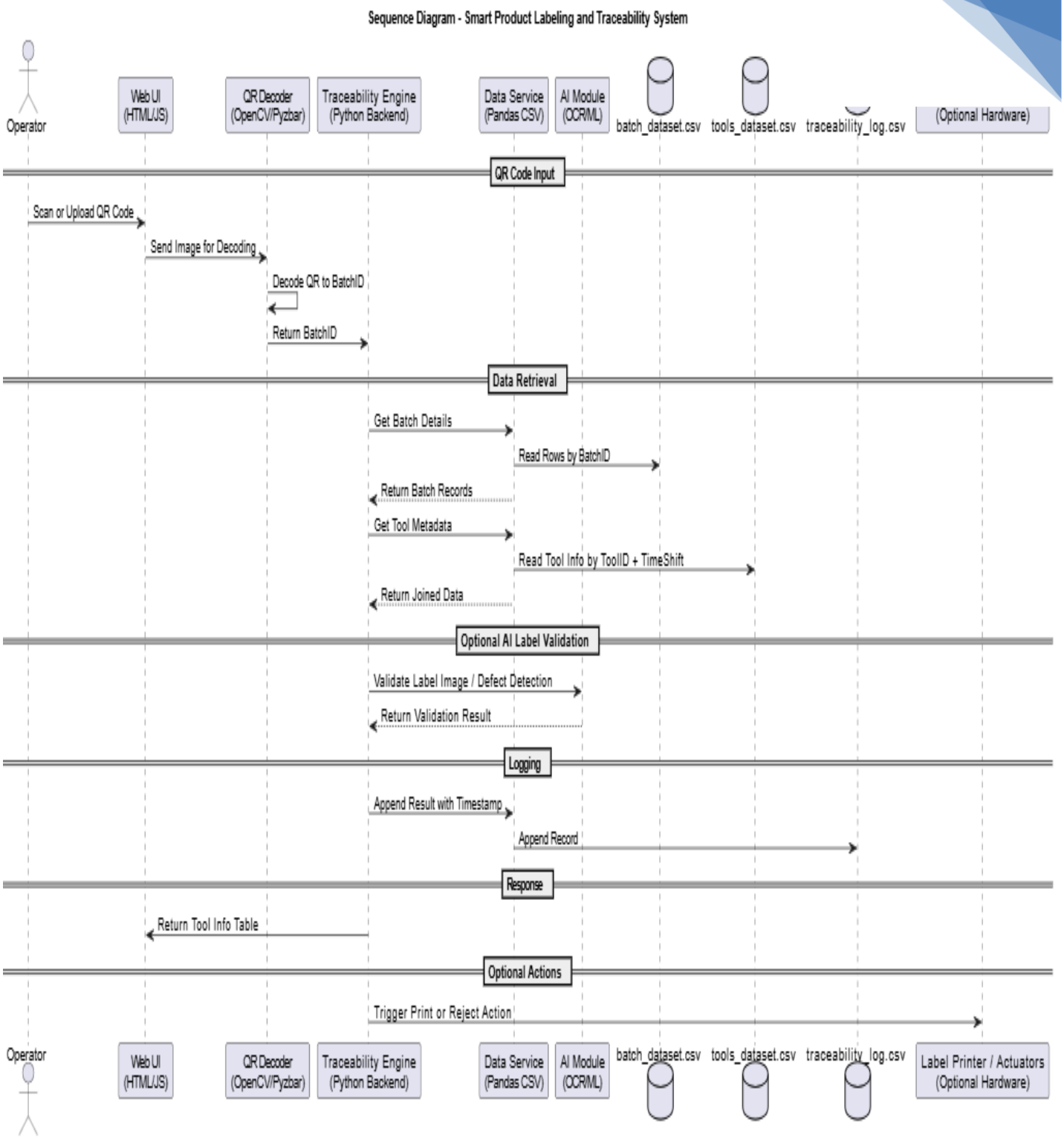




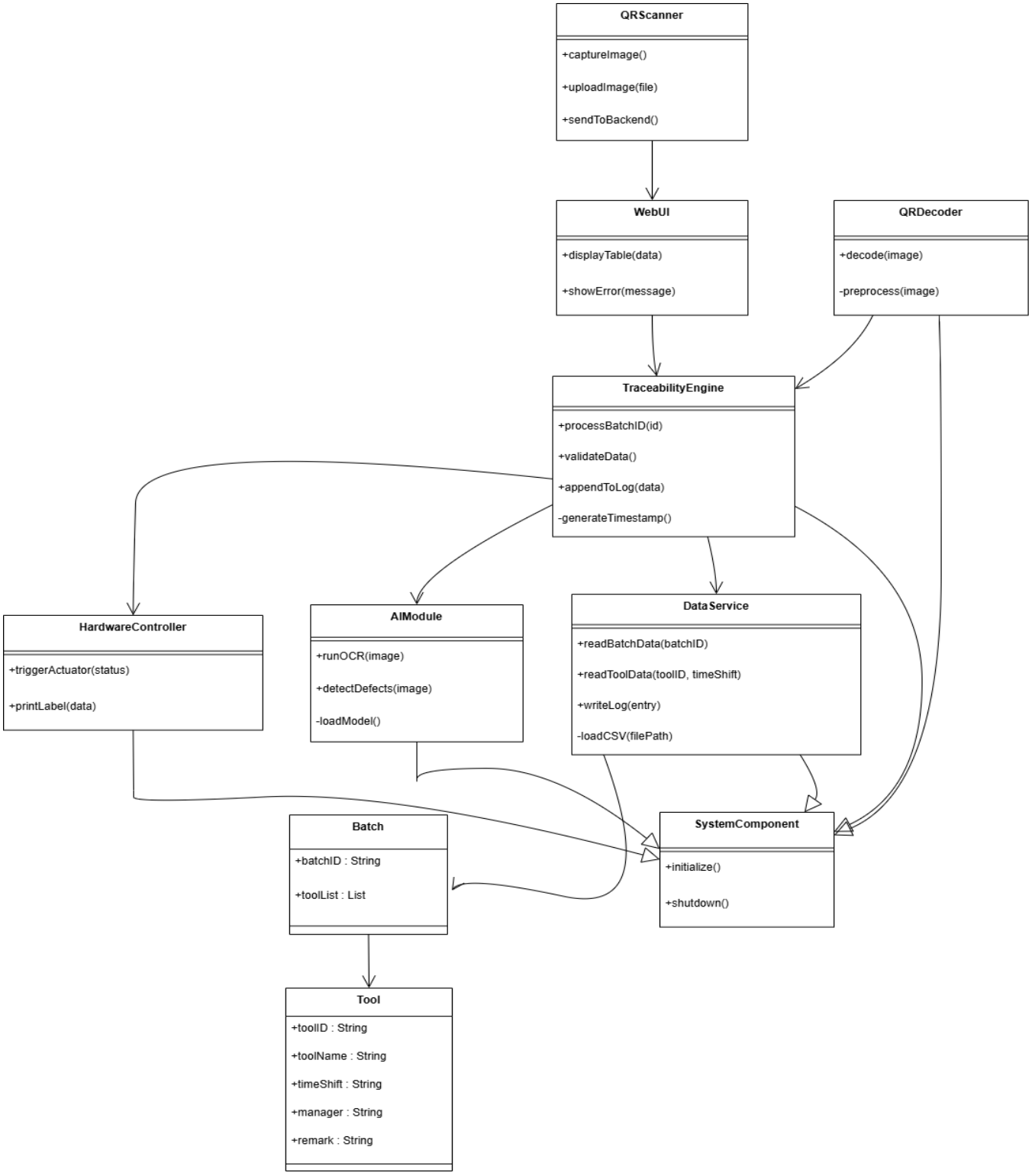
USE CASE DIAGRAM

Smart Product Labeling and Traceability System - Flow Diagram



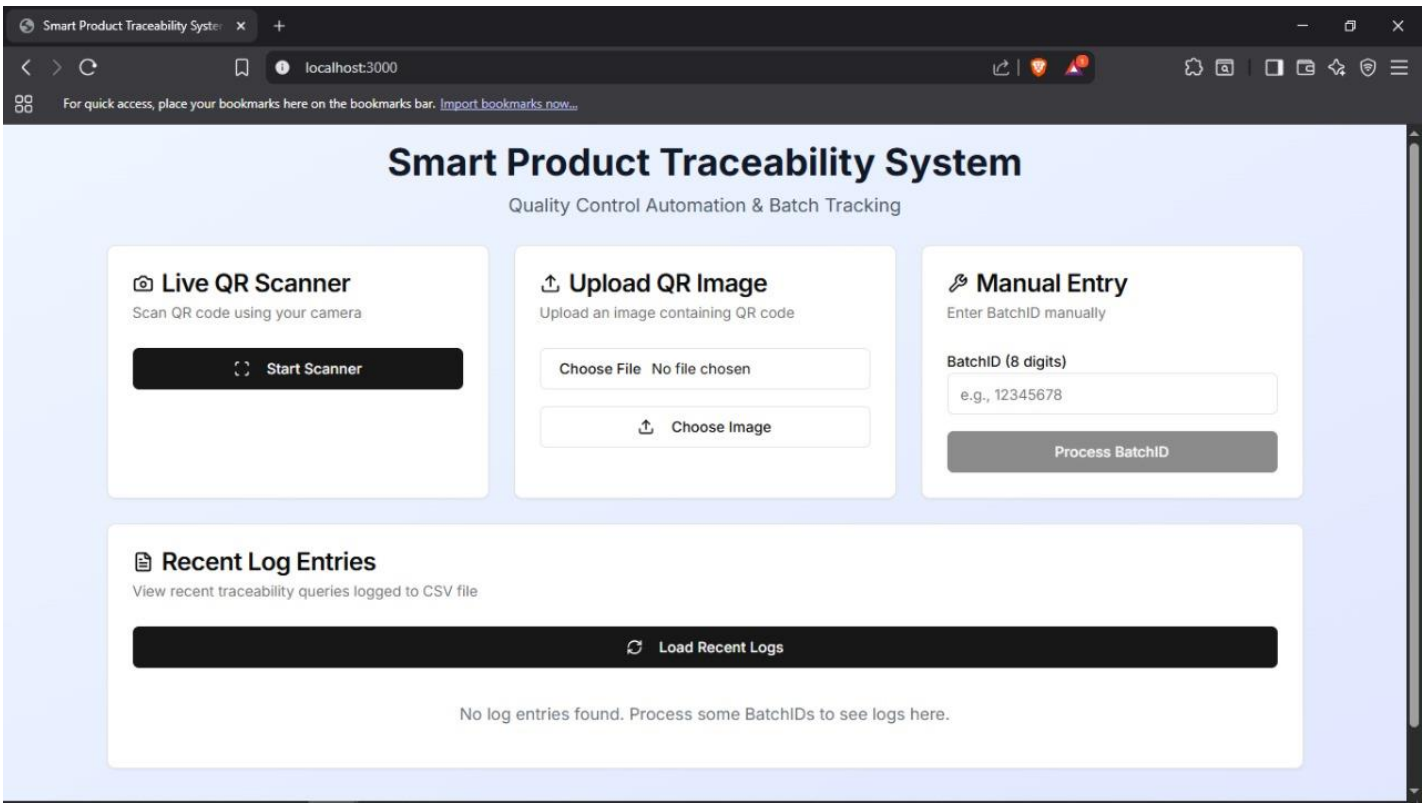

Sequence Diagram - Smart Product Labeling and Traceability System
Operator
Web UI (HTML/JS)
QR Decoder (OpenCV/Pyzbar)
Traceability Engine (Python Backend)
Data Service (Pandas CSV)
AI Module (OCR/ML)
batch_dataset.csv
tools_dataset.csv
traceability_log.csv
(Optional Hardware)
QR Code Input
Scan or Upload QR Code
Send Image for Decoding
Decode QR to BatchID
Return BatchID
Data Retrieval
Get Batch Details
Read Rows by BatchID
Return Batch Records
Get Tool Metadata
Read Tool Info by ToolID + TimeShift
Return Joined Data
Optional AI Label Validation
Validate Label Image / Defect Detection
Return Validation Result
Logging
Append Result with Timestamp
Append Record
Response
Return Tool Info Table
Optional Actions
Trigger Print or Reject Action
Label Printer / Actuators (Optional Hardware)

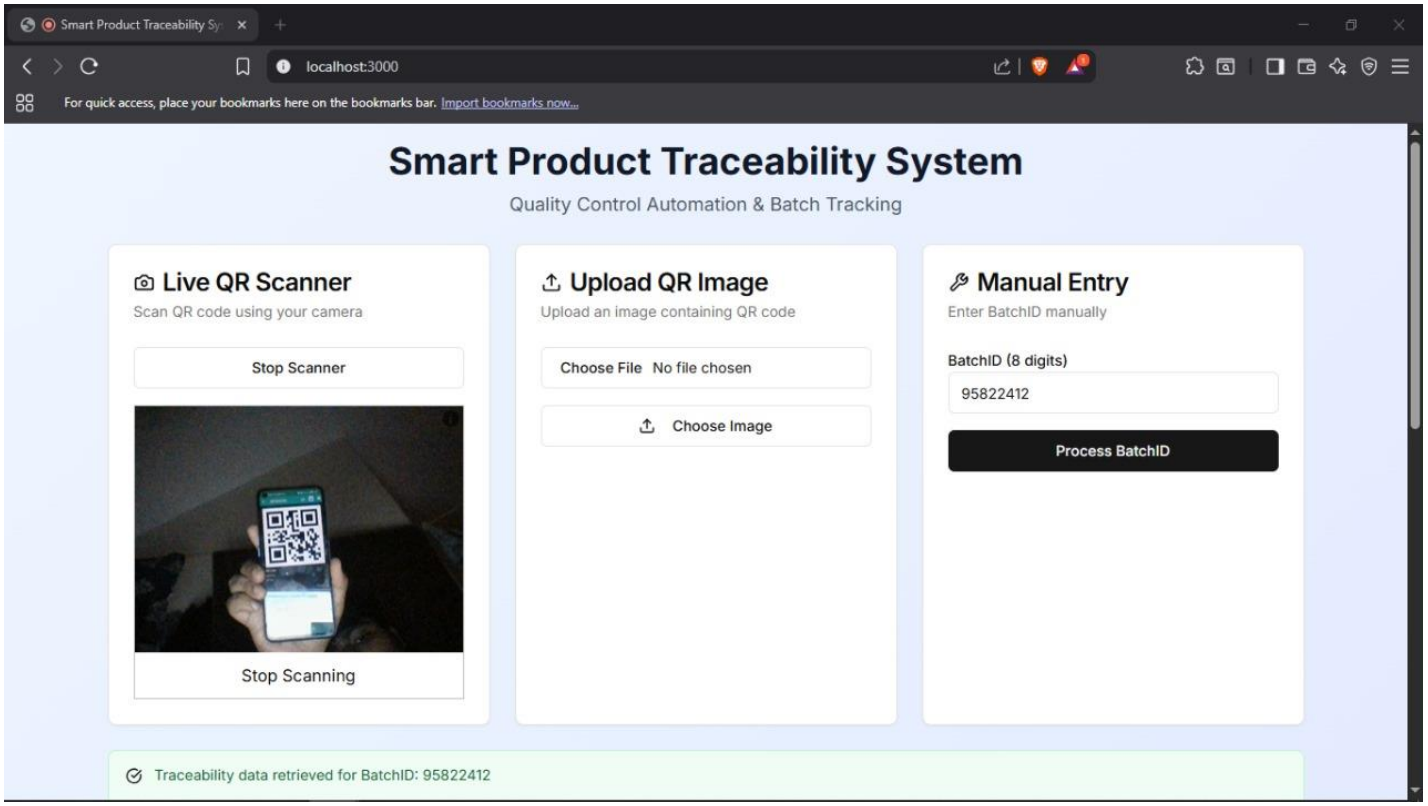
Class Diagram

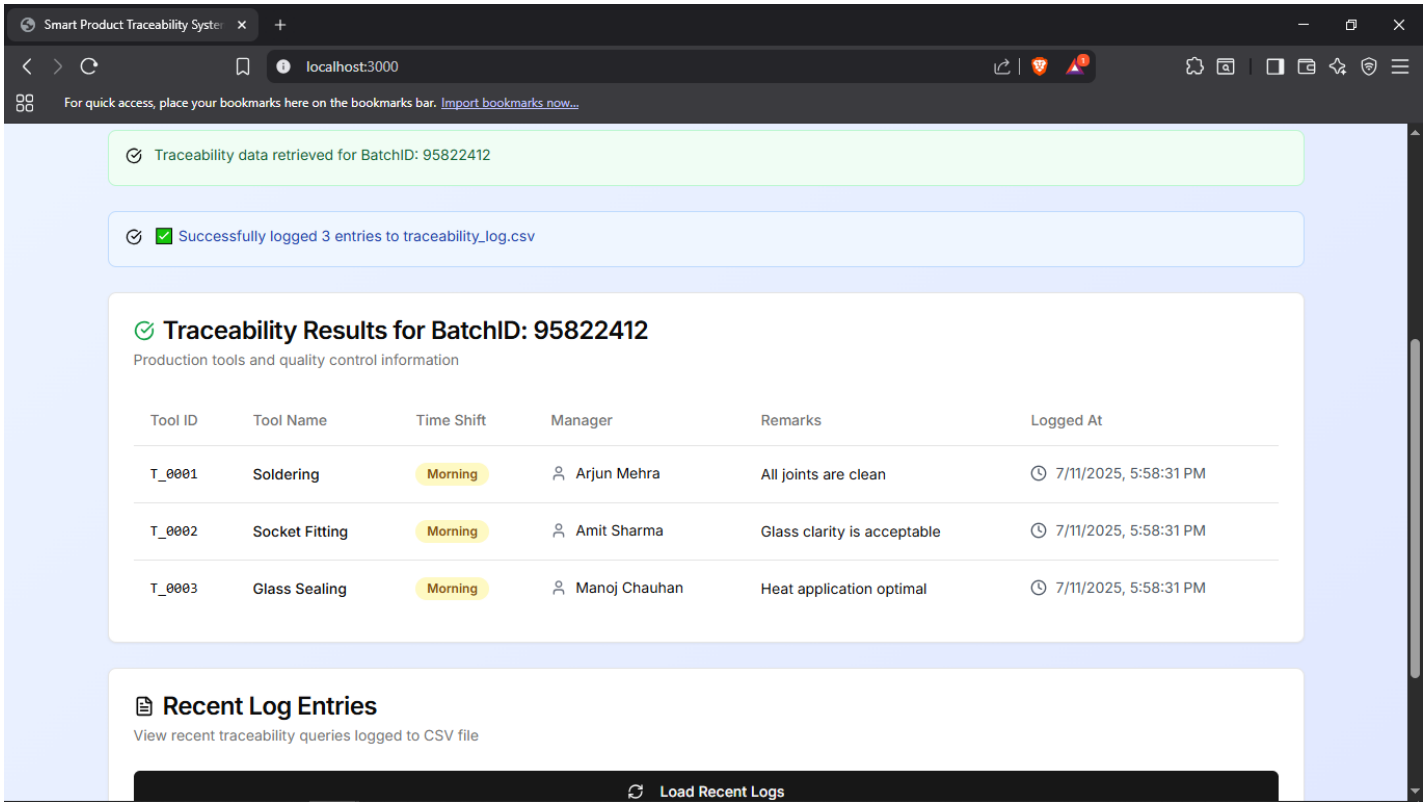


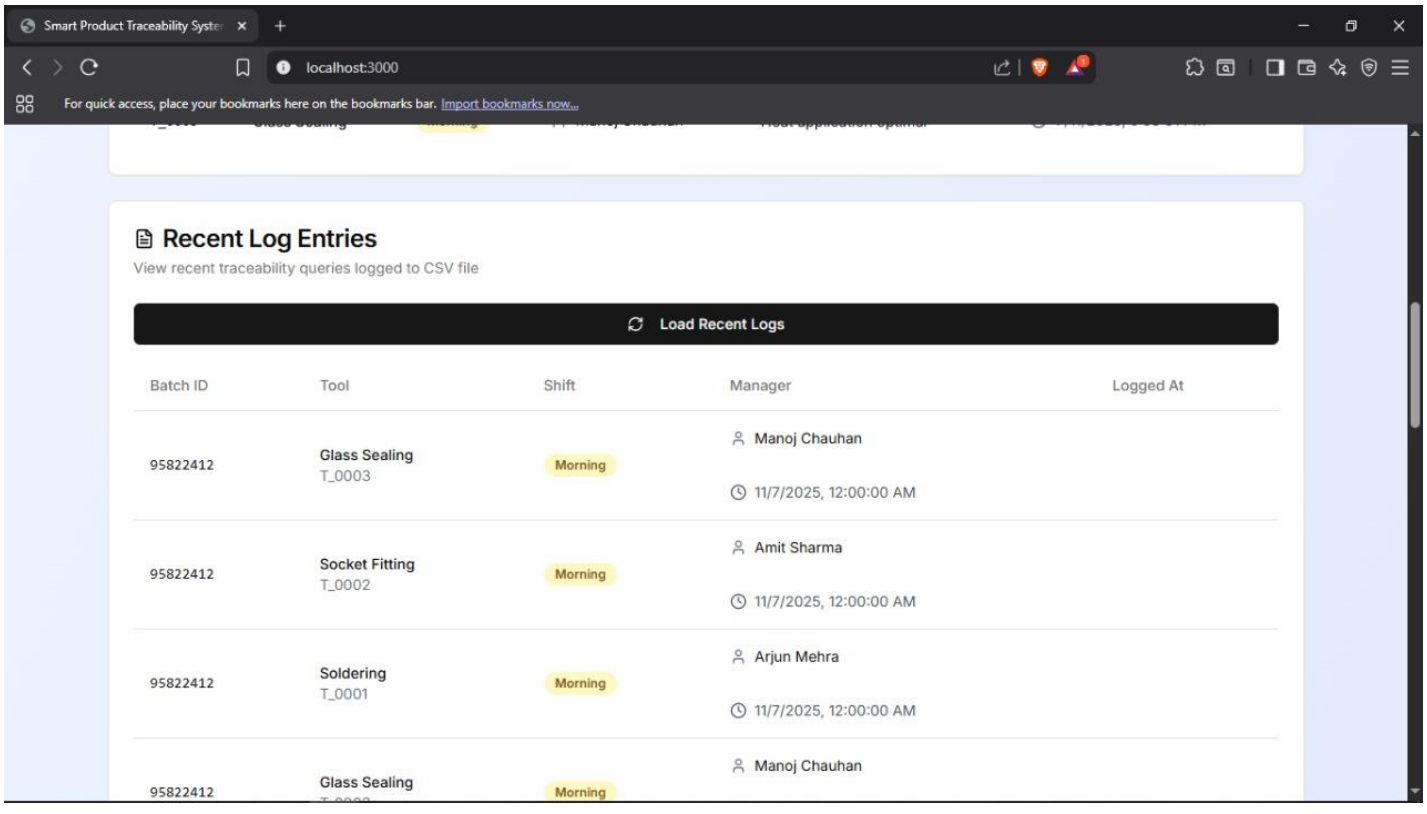
4. IMPLEMENTATION

4.1. Output screens






Smart Product Traceability Syste
localhost:3000
For quick access, place your bookmarks here on the bookmarks bar. Import bookmarks now...
Traceability data retrieved for BatchID: 95822412
Successfully logged 3 entries to traceability_log.csv
Traceability Results for BatchID: 95822412
Production tools and quality control information
Tool ID
Tool Name
Time Shift
Manager
Remarks
Logged At
T_0001
Soldering
Morning
Arjun Mehra
All joints are clean
7/11/2025, 5:58:31 PM
T_0002
Socket Fitting
Morning
Amit Sharma
Glass clarity is acceptable
7/11/2025, 5:58:31 PM
T_0003
Glass Sealing
Morning
Manoj Chauhan
Heat application optimal
7/11/2025, 5:58:31 PM
Recent Log Entries
View recent traceability queries logged to CSV file
Load Recent Logs


Smart Product Traceability Syste
localhost:3000
For quick access, place your bookmarks here on the bookmarks bar. Import bookmarks now...
Recent Log Entries
View recent traceability queries logged to CSV file
Load Recent Logs
Batch ID
Tool
Shift
Manager
Logged At
95822412
Glass Sealing
T_0003
Morning
Manoj Chauhan
11/7/2025, 12:00:00 AM
95822412
Socket Fitting
T_0002
Morning
Amit Sharma
11/7/2025, 12:00:00 AM
95822412
Soldering
T_0001
Morning
Arjun Mehra
11/7/2025, 12:00:00 AM
95822412
Glass Sealing
Morning
Manoj Chauhan

5. CONCLUSION

The *Smart Product Labeling and Traceability System for Quality Control Automation* successfully demonstrates how intelligent technologies can streamline manufacturing processes by automating the identification, labeling, and validation of product batches. By integrating QR code scanning, structured data retrieval, and AI-based label inspection, the system ensures that each product meets quality and compliance standards while minimizing human error. Through a user-friendly web interface and a robust Python-based backend, the system enables operators to trace production history, log inspection results, and simulate real-time hardware responses like label printing and unit rejection

This project serves as a scalable prototype that aligns with the goals of Industry 4.0, offering a practical solution for smart manufacturing. Its modular design allows for future expansion to include cloud integration, real-time analytics, and physical IoT hardware. Overall, the system not only enhances operational efficiency and traceability but also provides a valuable learning model for combining computer vision, machine learning, and industrial automation in a cohesive environment.

Future scope:

The *Smart Product Labeling and Traceability System* has been developed as a modular and scalable prototype, and it offers significant potential for future enhancements. One major direction is the integration of cloud-based data storage and monitoring dashboards, allowing centralized access to traceability logs, quality control reports, and system analytics in real time. This would enable production managers and quality auditors to access information remotely, improving decision-making and operational efficiency .

In addition, the system can be expanded to support **real-time IoT device integration**, using microcontrollers such as Arduino or Raspberry Pi to control physical sensors, label printers, and actuators. This would make the solution deployable on actual production lines. Other possible enhancements include the use of **deep learning models** for more accurate defect classification, multi-language OCR support for global product labeling, and integration with ERP systems for full end-to-end digital manufacturing workflows. With these improvements, the system can evolve into a complete industrial-grade platform for intelligent quality control and compliance management.