# TED UNIVERSITY

Faculty of Engineering

Department of Computer Engineering

**Analysis Report**

**CMPE 491 – Senior Design Project I**

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# Analysis Report

## 1. Introduction

The Figion project addresses domestic companies exporting food safety. A particular problem faced by companies exporting dried figs is the inability to quickly and accurately detect aflatoxin-containing products. Figs that remain undetected during the preliminary detection phase are discarded if laboratory tests show levels exceeding the required levels, negatively impacting both the producer and the national economy. As a solution to these problems, the Figion project aims to reduce error rates and speed up the process by using image processing during the preliminary detection phase. It aims to create a safe and well-organized environment by optimizing traditional methods and using an innovative approach supported by artificial intelligence.

Access to the system will be provided by units responsible for the company's quality assurance processes, such as food engineers, production line managers, and quality managers. These users will be able to review product images, view information such as aflatoxin levels, session information, and more via the dashboard. This project will enable faster, more reliable, and more traceable control processes. Furthermore, our project is aligned with the "Food Security" (3.2.2.1. Agriculture and Food) and "Artificial Intelligence Applications" (3.2.3.6. Information and Communication Technologies) objectives of the 12th Development Plan, as well as the "Agricultural Technologies" (Article 513) and Artificial Intelligence (Article 557) areas of the 2030 Industrial and Technology Strategy. Consequently, the dataset generated through this project will not only provide a scientific basis for academic researchers but will also contribute to the national economy by accelerating industrial processes and developing aflatoxin control systems.Ultimately, the analysis report delves into the Figion project, detailing the proposed functions, requirements, and design patterns.

We begin with a general overview of the system, then delve into the functional and non-functional requirements in detail, and discuss the pseudo-requirements that shape the system's constraints. We also present various system models, including scenarios, use cases, object and class models, and dynamic models. This structured analysis systematically identifies the needs of the Figion project, enabling both data collection processes and user access structures to operate more efficiently.

# 2. Current system

There is currently no automated or digital system in place for the detection of aflatoxin in dried figs. The project is being designed to replace an outdated, purely manual workflow. Currently, the quality control process relies entirely on human inspection performed in "dark rooms" under UV light. Workers visually scan the figs on conveyor belts to spot fluorescence, a method that is subjective, slow, and prone to high error rates due to eye strain and fatigue. While definitive chemical analysis (HPLC) exists, it is a destructive laboratory procedure applied only to random samples, not the entire production line. Therefore, there is no existing machine or software solution capable of performing real-time, non-destructive screening on the production line, necessitating the development of this project from scratch.

# 3. Proposed system

To address the operational bottlenecks and reliability issues of the current manual inspection workflow, the Figion project introduces a fully automated, AI-driven solution. By shifting from subjective human observation to objective, data-driven analysis, the proposed system aims to ensure high precision in aflatoxin detection while maintaining the speed required for industrial operations.

## 3.1 Overview

Building upon the strategic objectives aimed at food safety and operational efficiency, the Figion system is engineered as a unified hardware-software integration rather than a simple software tool. The system architecture is specifically designed to function within a controlled dark environment, utilizing high-intensity UV illumination to expose fluorescent contamination on dried figs.

Unlike generic image processing applications, Figion is optimized for edge computing constraints. The platform performs real-time Deep Learning inference directly on standard laptop CPUs (or integrated GPUs), purposely avoiding reliance on cloud-based services or expensive external hardware. This design choice ensures high portability and allows the system to be deployed seamlessly on existing conveyor lines, meeting the critical latency requirement of under one second per fig to match the manual processing throughput of approximately 175 kg/hour.

Functionally, the system operates as a comprehensive traceability hub. Beyond making a binary "Healthy/Contaminated(Contain Aflatoxin)" decision, it manages inspection sessions by automatically archiving the UV image of every scanned product alongside its classification data in CSV format. This creates a verifiable audit trail for quality managers and provides a structured dataset for future model retraining, thereby transforming a transient inspection process into a recorded data pipeline.

## 3.2 Functional Requirements

**Scan Start / Stop:** The scanning process should be started and stopped with a single button on the system interface. The color or icon of the button should clearly indicate to the user whether the system is active or paused.

**Live Counters and Status Indicator:**
The following information should be displayed in real time on the application screen:
• Total number of scanned figs

• Number of figs containing aflatoxin
• Number of healthy figs
• Percentage of figs containing aflatoxin (%)

**Report Generation and Export:** All screening results must be exportable in CSV format based on date and batch. Report columns: Date, Time, Band_ID, Fig_ID, Decision

**Image Recording and Archiving:** The UV image of each scanned fig should be automatically recorded along with the decision tag.

**Session Management and Counter Reset:** When a user starts a new session, counters should be reset, and the system should create a new CSV file and image folder.

**Session Log:** The system should display a list of the last figs scanned in the current session (since the scan was started) and their results ("Aflatoxin" / "Healthy") in a simple table/list format on the interface.

**Hardware Status Notification:** The system should check the camera and UV light source (if controllable) connections at startup. If the camera connection is missing, the system should not crash; instead, it should clearly warn the user, "Camera not found. Please check the USB connection."

**Real-Time Visual Feedback:** The system should display the live image (or the last scanned frame) from the camera on the interface. When the model makes a decision ("Healty" or "Aflatoxin"), that decision should be instantly overlaid on the image (with a green/red frame or text). This allows the user to monitor the system in real time.

## 3.3 Nonfunctional Requirements

**Classification Performance:** The system's key success metric is to ensure that figs containing aflatoxin are not missed (Public Health Obligation 1.3.1). Therefore, in the test dataset: Recall (for Aflatoxin Class): Must be at least 95%. (That is, at least 95 out of 100 figs containing aflatoxin must be correctly labeled as "Aflatoxin"). Precision (for Aflatoxin Class): Must be as high as possible to avoid financial loss (False Positive), aiming for a minimum of 85%. (That is, at least 85 out of 100 figs labeled "Aflatoxin" must actually be aflatoxin).

**Environmental Robustness:**The system should be designed to operate within a closed test box (prototype conveyor belt), isolated from external ambient light and under a constant UV light source.

**Usability:**The interface should be simple and understandable, and the user should be able to learn the scanning process with a short (under 30 minutes) training.

**Maintainability:**The software's code structure must be modular; the model, camera driver, and user interface components must be able to be updated independently.

**Portability:**The developed application must be able to run on a standard computer or a server (with an external USB camera and UV light source).

**Latency:** The time it takes to capture an image of a fig, make a decision for the model, and display the result in the interface should not exceed 1 second. The system should match the speed of a manual processing pipeline (approximately 175 kg/hour). This performance should be provided on a standard laptop CPU (or integrated GPU), without Google Colab or an external GPU, for inference, not training.

**Data Integrity:**The system must consistently save an image of a scanned fig (e.g., fig_105.jpg) and its CSV entry (fig_105, Contains Aflatoxin). There must be no duplicates or missing labels (image present, CSV missing).

**Reliability:**The system must be able to operate without errors during long-term operations (e.g., 2 hours of uninterrupted scanning).

## 3.4 Pseudo requirements

**Data Structure:**

Each fig record must contain the following information:

- Fig_ID
- Batch_ID
- Image (photograph taken under UV light)
- Aflatoxin label (Aflatoxin/Healthy)
- Scan time (date-time)

**Data Quality:** The dataset must be free of identical image records (exact duplicates) or visually indistinguishable near-duplicates. All images must meet a minimum resolution, be in sharp focus, and use a consistent, high-quality format (e.g., .PNG or high-quality .JPEG). Images must be checked for uniform exposure, correct color depth (24-bit RGB), and accurate labeling consistency ('Contaminated' or 'Healthy') according to the established strategy.

The following strategies will be followed for labeling:

• Samples with "ground truth" confirmation of aflatoxin presence through HPLC or similar laboratory analysis are used.

• Labeling is based on visual confirmation by an expert.

• Labeling is divided into two categories based on fluorescence observed under UV light: 'Contaminated' and 'Healthy.' The 'Contaminated' group includes any specimen exhibiting even the slightest fluorescent spot or trace, while the 'Healthy' group is reserved exclusively for those specimens showing absolutely zero signs of fluorescence.

**Dataset Extensibility:** To overcome the limited data situation and increase the small number of examples in the "Aflatoxin" class, data augmentation (translation, rotation, brightness/contrast adjustment) techniques will be applied during the training phase.

**Target Data Set Size:** For the prototype model to undergo robust and effective training, a total of 10,000 unique fig images should be collected, ideally consisting of at least 5,000 'Contaminated' (Aflatoxin) and 5,000 'Healthy' images.

## 3.5 System models

## 3.5.1 Scenarios

**Scenario 1: Routine Scanning and Real-Time Monitoring**

The operator initiates a new session for a batch of dried figs. After the session is initiated, the system activates the camera and captures real-time images. The captured images are classified using the AI model. Based on the classification, the images are labeled on-screen as "healthy" or "aflatoxin." The collected data is then displayed on the dashboard, displaying information such as the number of healthy figs, aflatoxin levels, and session information.

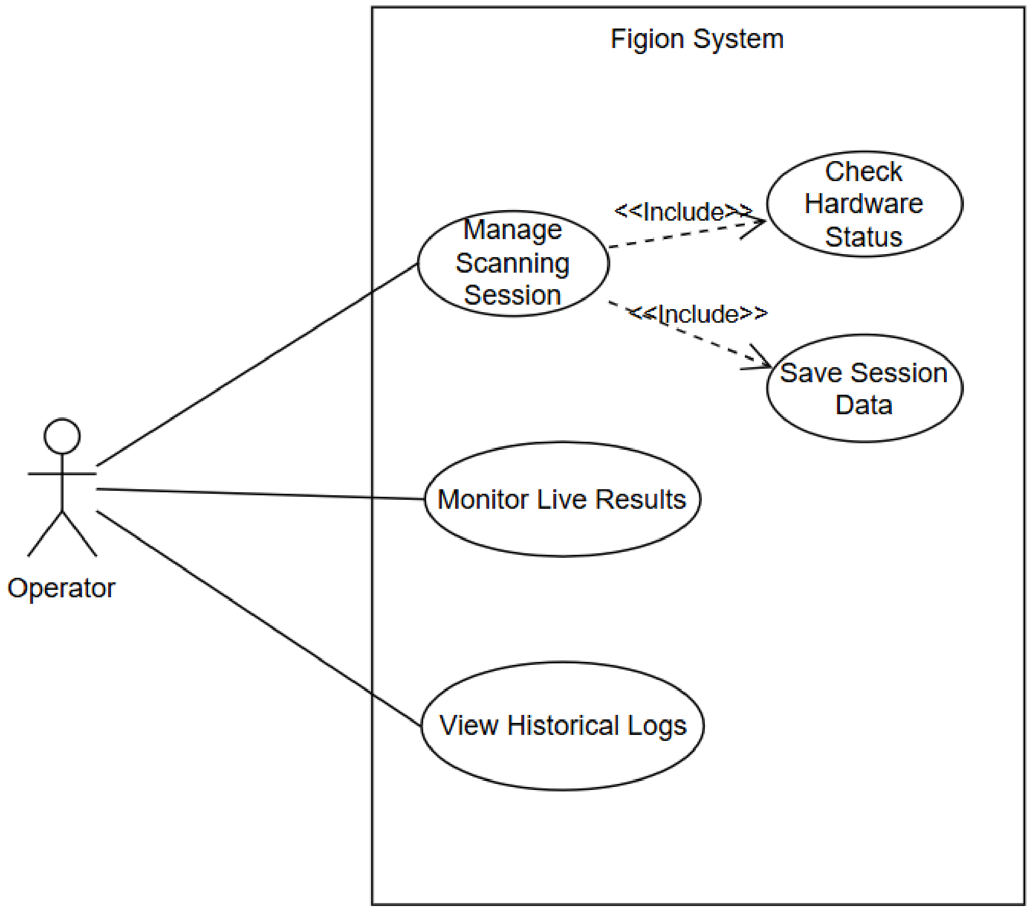
**Scenario 2: Hardware Initialization Failure**

The system automatically performs a hardware check. If the camera connection is not detected, a warning message appears saying, "Camera not found. Please check the connection." Scanning operations remain inactive until the operator establishes the connection.

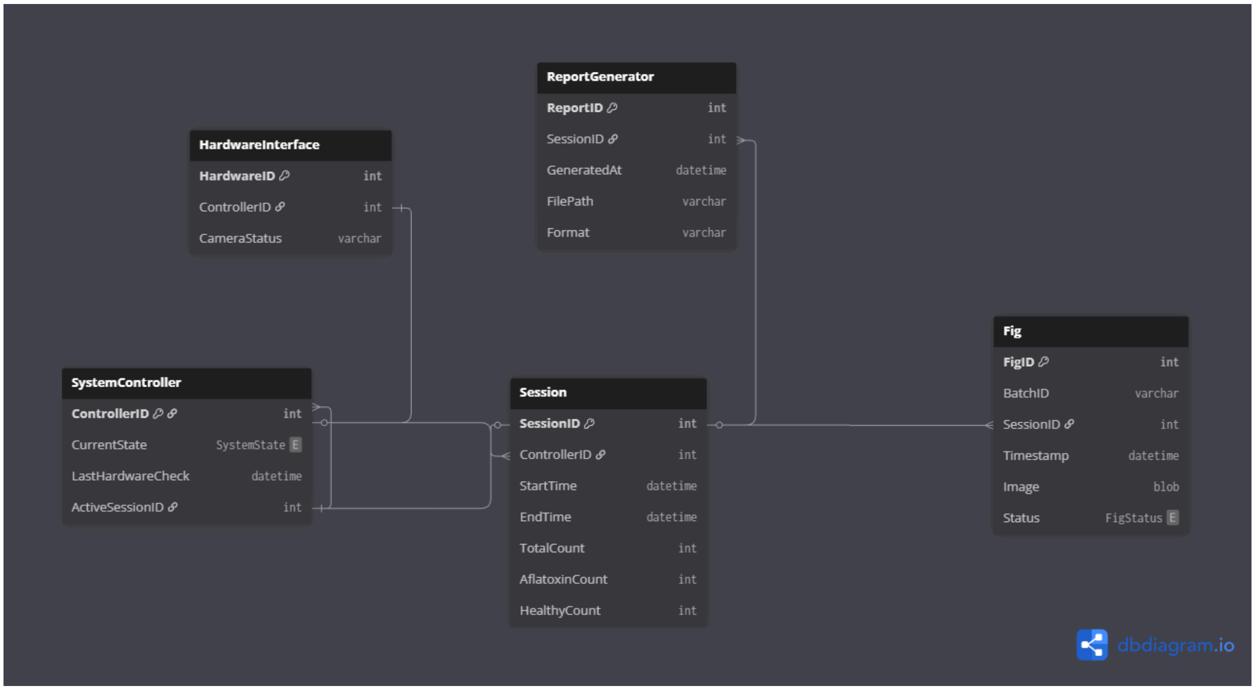
**Scenario 3: Session Completion and Data Export**

After scanning is completed via the interface, the operator exports the results. The system saves the captured images in the session folder. The report for the requested current batch is exported as a csv file containing the date, time, Fig_ID, and decision information. The counters are then reset for the next session.

## 3.5.2 Use Case Model

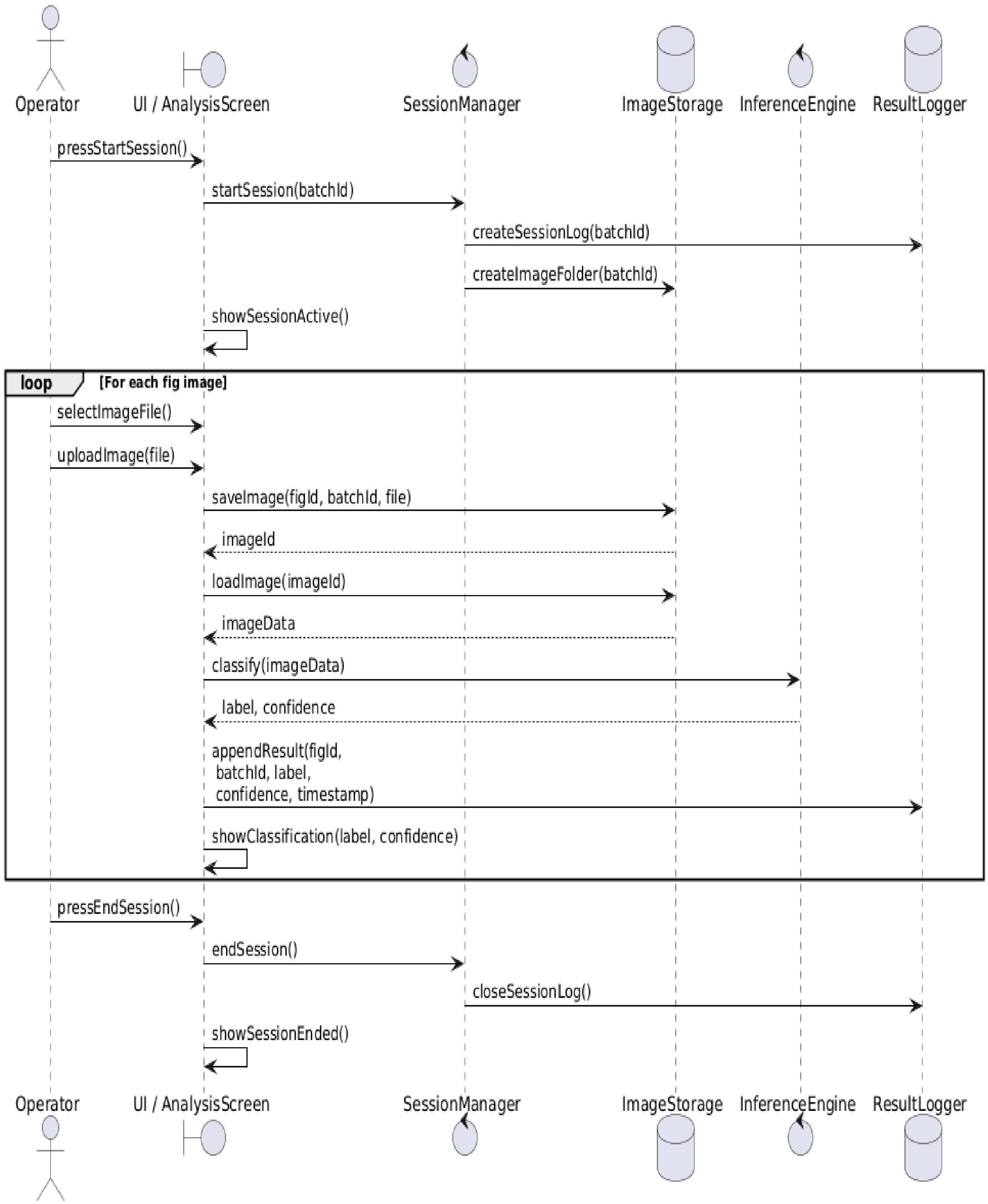


### 3.5.3 Object and class model

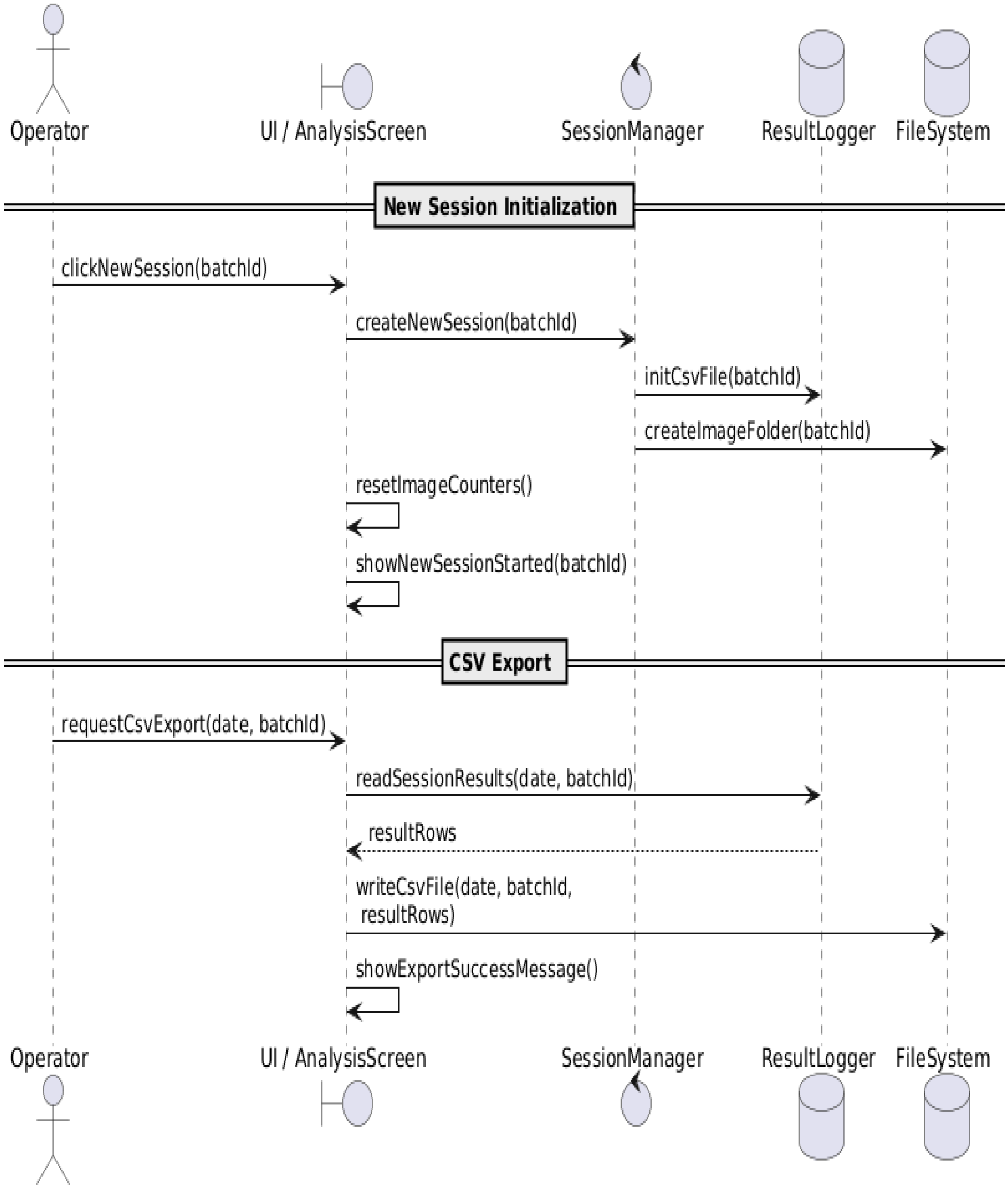


## 3.5.4 Dynamic models

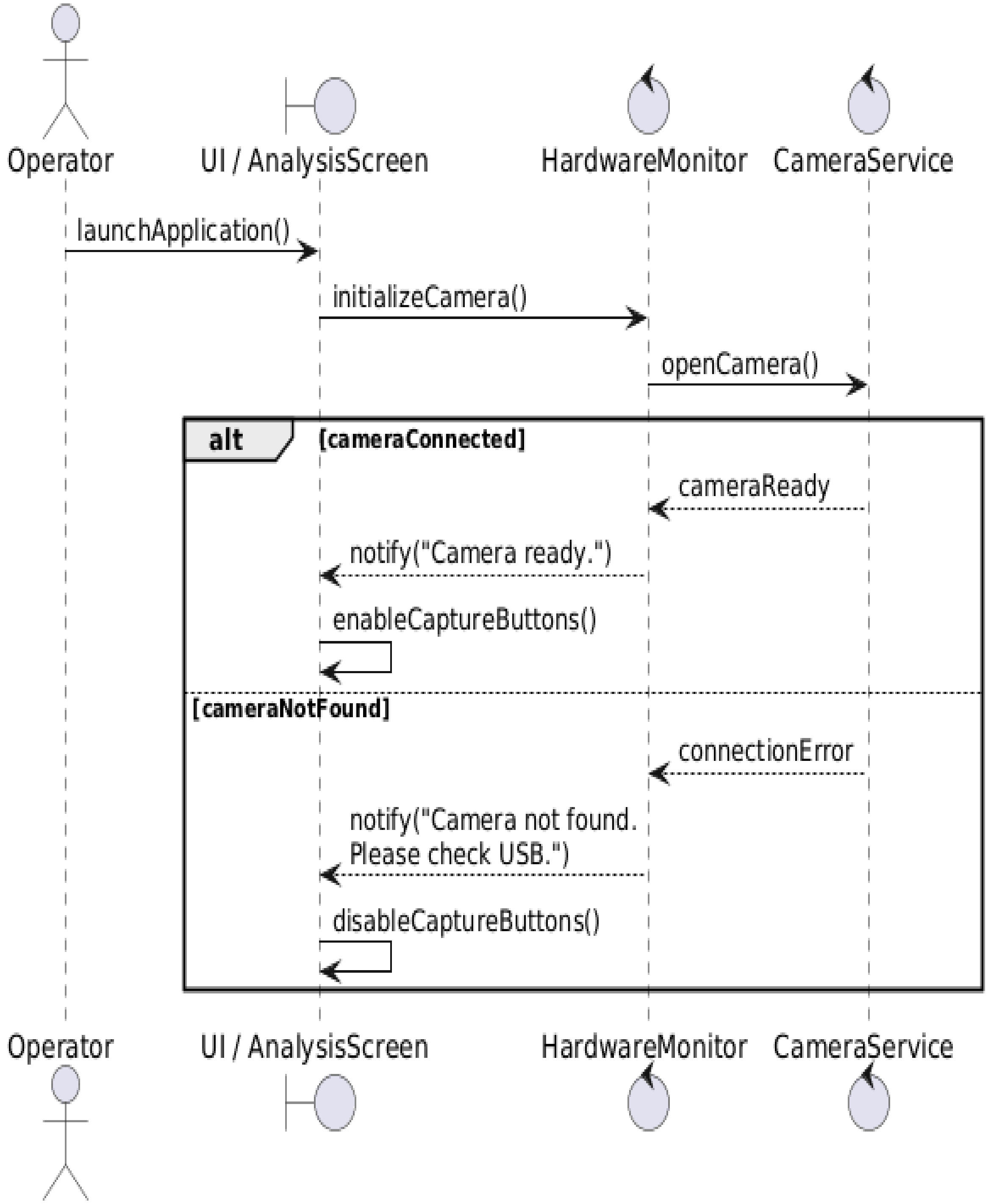
### 3.5.4.1 Fig Scanning and Classification



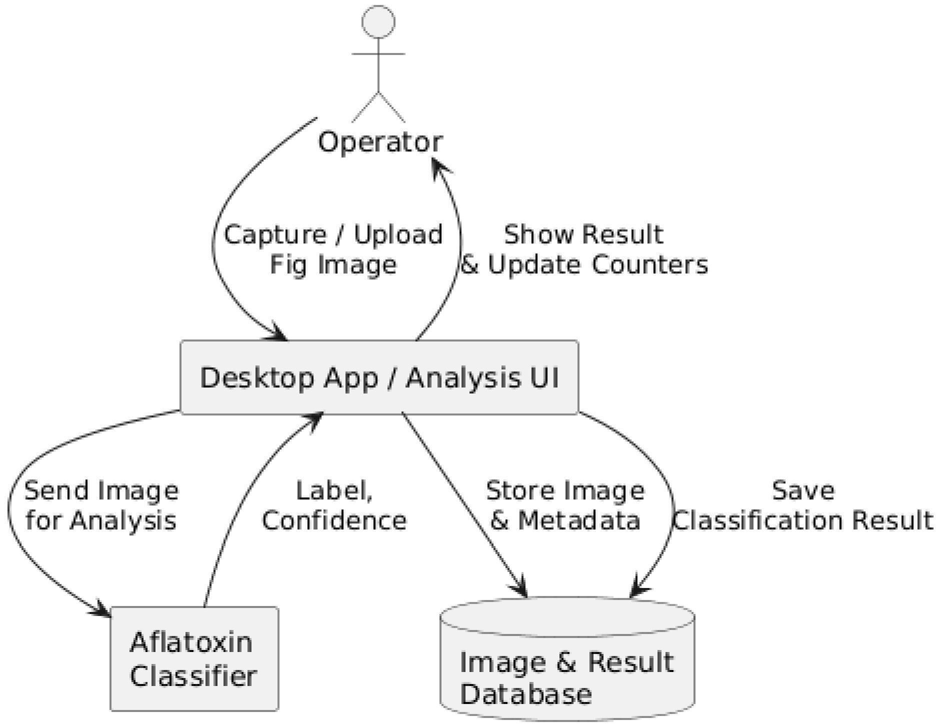
### 3.5.4.2 Session Start, Reset and CSV Export



### 3.5.4.3 Hardware Initialization and Error Handling



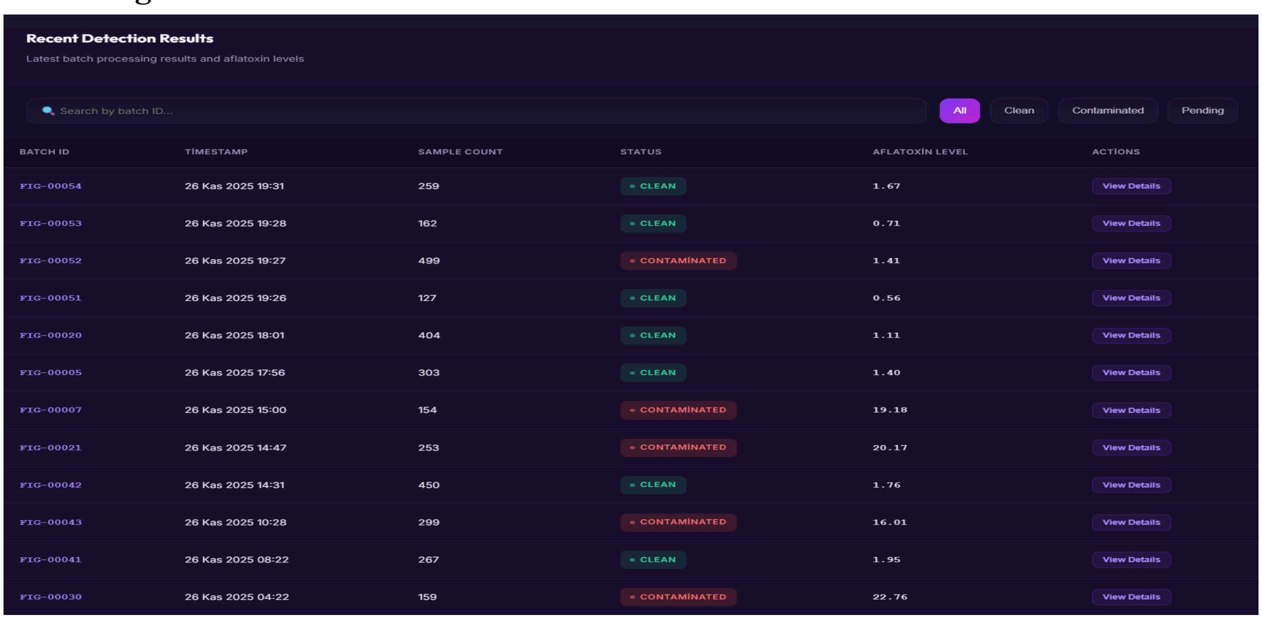
#### 3.5.4.4 Overall Fig Image Analysis Workflow



## 3.5.5 User interface - navigational paths and screen mock-ups

### 3.5.5.1 Figion Dashboard


### 3.5.5.2 Figion Dashboard Recent Detection Results




| BATCH ID | TİMESTAMP | SAMPLE COUNT | STATUS | AFLATOXİN LEVEL | ACTİONS |
|---|---|---|---|---|---|
| FIG-00054 | 26 Kas 2025 19:31 | 259 | CLEAN | 1.67 | View Details |
| FIG-00053 | 26 Kas 2025 19:28 | 162 | CLEAN | 0.71 | View Details |
| FIG-00052 | 26 Kas 2025 19:27 | 499 | CONTAMİNATED | 1.41 | View Details |
| FIG-00051 | 26 Kas 2025 19:26 | 127 | CLEAN | 0.56 | View Details |
| FIG-00020 | 26 Kas 2025 18:01 | 404 | CLEAN | 1.11 | View Details |
| FIG-00005 | 26 Kas 2025 17:56 | 303 | CLEAN | 1.40 | View Details |
| FIG-00007 | 26 Kas 2025 15:00 | 154 | CONTAMİNATED | 19.18 | View Details |
| FIG-00021 | 26 Kas 2025 14:47 | 253 | CONTAMİNATED | 20.17 | View Details |
| FIG-00042 | 26 Kas 2025 14:31 | 450 | CLEAN | 1.76 | View Details |
| FIG-00043 | 26 Kas 2025 10:28 | 299 | CONTAMİNATED | 16.01 | View Details |
| FIG-00041 | 26 Kas 2025 08:22 | 267 | CLEAN | 1.95 | View Details |
| FIG-00030 | 26 Kas 2025 04:22 | 159 | CONTAMİNATED | 22.76 | View Details |

# 4. Glossary

Aflatoxin: A family of toxins produced by certain fungi that are found on agricultural crops such as maize (corn), peanuts, cottonseed, and tree nuts.

HPLC : HPLC is an advanced laboratory analysis method used to separate, identify, and quantify the components in a mixture. A liquid sample is forced through a column filled with very fine particles at high pressure. Each substance passes through the column at different speeds, allowing for separation.

# 5. References

1. Kuru incirlerde AFLATOKSİN ve okratoksin a bulaşisinin önlenmesi. (n.d.). https://www.tarimorman.gov.tr/GKGM/Belgeler/Uretici_Bilgi_Kosesi/Egitim/Hijyen_Kilavuz/kuru_incir_aflatoksin_okratoksin_a_onleme_azaltma.pdf

2. Ömer Barış Özlüoymak. (2014). Development of an UV-Based Imaging System for Real-Time Aflatoxin Contaminated Dried Fig Detection and Separation. Tarım Bilimleri Dergisi/Ankara Üniversitesi Ziraat Fakültesi Tarım Bilimleri Dergisi, 20(3), 302–302. https://doi.org/10.15832/tbd.87873

3. Kılıç, C., Özer, H., & İnner, B. (2024). Real-time detection of aflatoxin-contaminated dried figs using lights of different wavelengths by feature extraction with deep learning. Food Control, 156, 110150. https://doi.org/10.1016/j.foodcont.2023.11015