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UE22CS320A – Capstone Project Phase 2

Smart Reconnaissance System

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Outline

- Abstract and scope.
- Design Approach
- Design constraints, Assumptions and Dependencies
- Architecture
- Proposed methodology and Approach
- Design Description
- Datasets and Preprocessing
- Base Model Implementation
- Project Progress Plan for Phase 3 and Phase 4

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ABSTRACT AND SCOPE

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Problem Statement

The SRS is proposed to autonomously conduct camera status checks, detect anomalous behaviour, minimize false positives, generate per-camera reports and alerts thus,raise alerts ensuring uninterrupted operation by harnessing advanced machine learning algorithms for real time data processing.

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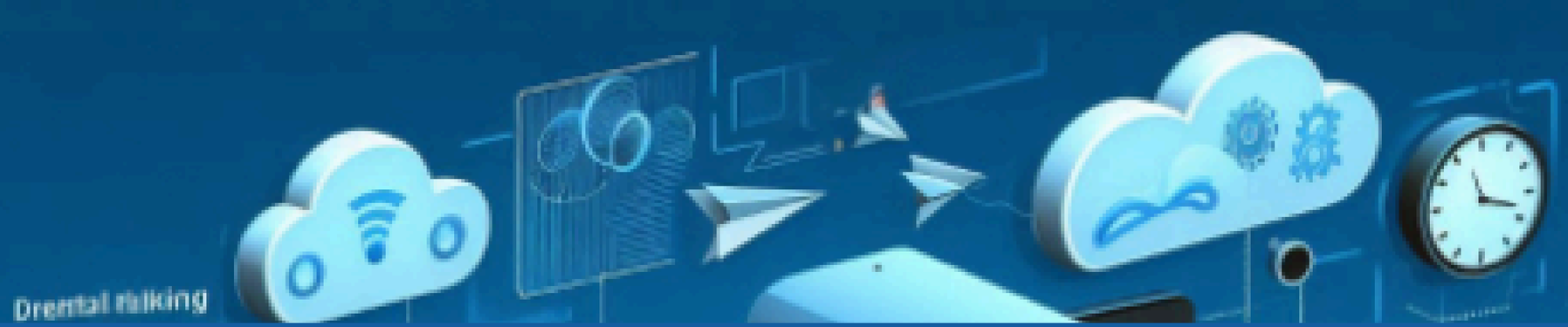
Introduction

- The **S**mart **R**econnaissance **S**ystem a.k.a **SRS** is a cutting-edge solution aimed at automating surveillance and enhancing security through real-time monitoring.
- By utilising machine learning and video analysis, the **SRS** ensures that cameras are fully operational and detects abnormal behaviour.
- This reduces the reliance on manual oversight and improves response times in critical situations.



Overview of the Scope

The scope of the **SRS** encompasses a diverse array of surveillance enhancements, like automated camera status verification, real-time video analysis, and the detection of objects and anomalies.

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DESIGN APPROACH

Methodology & Philosophy

Modular & Scalable Design

- Independent hardware, network, and software modules.
- Ensures scalability

01

Event-Driven & Real-Time Processing

- Event-driven approach, where camera pings, failures, and anomalies trigger immediate actions

02

Hybrid Monitoring Strategy

- IP pings for connectivity checks
- Video-based detection for anomaly recognition

03

Automated Alerting & Feedback Loop

- Alerts are triggered based on connectivity failures or suspicious activity

04

User-Centric & Data-Driven Interface

- Dashboard provides real-time alerts, camera logs, and flagged anomalies

05

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IMPLEMENTATION AND COMPONENT WORKFLOWS

1. **CAMERA REGISTRATION AND MONITORING**
   - Cameras are registered with a unique IP address and location
   - Cameras are pinged and video footage retrieved.
2. **FAILURE DETECTION AND CATEGORIZATION**
   - Non Responsive to 2 consecutive pings - camera marked
   - Anomalies in video footage identified
   - Camera Failure categorized
3. **AUTOMATED ALERTING AND WORKFLOW**
   - SMS alerts triggered for offline cameras or anomalies detected.
   - If unresolved, escalation to higher authorities
4. **ISSUE RESOLUTION AND FEEDBACK LOOP**
   - Personnel respond to alerts
   - Once resolved, the camera's status is updated.
   - System logs the resolution time and personnel performance
5. **REPORT GENERATION & ANALYSIS**
   - Periodic reports generated
   - Reports include resolution times, cause of issues, and security alerts

BENEFITS

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AUTOMATED ALERTS & ESCALATION

- SMS alerts ensure prompt attention to issues.
- Escalation workflow ensures unresolved problems reach higher authorities without delays.

DETAILED ANALYTICS

- Periodic reports provide insights into recurring issues, aiding in preventive maintenance and improved system design.

ENHANCED SECURITY ASSURANCE

- Quick issue resolution and data analysis improve surveillance reliability, reducing blind spots and potential security breaches.

DRAWBACKS

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DEPENDENCE ON NETWORK STABILITY

- Frequent pinging and video streaming require a stable network; poor connectivity may cause false positives or delays.

HIGH MAINTENANCE OVERHEAD

- Continuous monitoring, alerting, and reporting may demand significant infrastructure, increasing operational costs.

ESCALATION BOTTLENECKS

- If the escalation process is inefficient, unresolved issues may accumulate, affecting system reliability.

DESIGN CONSTRAINTS, DEPENDENCIES AND ASSUMPTIONS

DESIGN CONSTRAINTS

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Hardware Constraints	Software Constraints	Network Constraints	User Interface Constraints
Cameras must support high resolution & low latency. Storage efficiency needed for continuous recording	Real-time video processing with low delay. Efficient anomaly detection using AI.	High bandwidth required for video streams. Low-latency asynchronous communication for realtime alerts.	Fast, intuitive UI for real-time monitoring. Scalable dashboard supporting multiple camera feeds.

DEPENDENCIES

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Legal Implications	Usage Limitations	Software & Hardware Requirements	Integration and Maintenance
Compliance with data privacy laws and local surveillance regulations.	Impact of environmental factors on accuracy and high computational requirements limit scalability.	Requires AI frameworks , IP enabled cameras, GPUs and large-scale storage solutions.	Needs seamless integration with existing security systems and regular updates to models, hardware, and compliance policies.

ASSUMPTIONS

Adequate Infrastructure

Sufficient access to computational resources, like high-performance GPUs, large-scale storage, and stable network connectivity.

Legal Compliance

All the necessary legal permissions for surveillance have been obtained, and compliance with privacy regulations is maintained.

Adaptability to Diverse Environments

The AI models are assumed to adapt well to different environments and varying conditions.

ARCHITECTURE

ARCHITECTURE

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Client-Server Model

- Client-Server Model – IP-enabled CCTV cameras stream data and respond to periodic pings.
- The central monitoring system processes both ping responses and video feeds for anomaly detection.

Network Communication Layer

- Ping Setup: Cameras are pinged at intervals (e.g., 180 sec) to check connectivity.
- Video Processing: Selected footage is analyzed using machine learning models to detect unusual activity.

Database Layer

- Stores camera metadata, failure logs, flagged anomalies, and personnel details.

Automated Alerting System

- Alerts triggered based on ping failures or detected anomalies in video feeds.
- Escalation Path ensures unresolved issues are escalated to higher authorities.

Dashboard & Issue Resolution Module

- Real-time UI: Displays camera statuses, logs, and flagged anomaly events for administrators.
- Status Updates: Allows personnel to mark cameras as operational after issue resolution.

ARCHITECTURE

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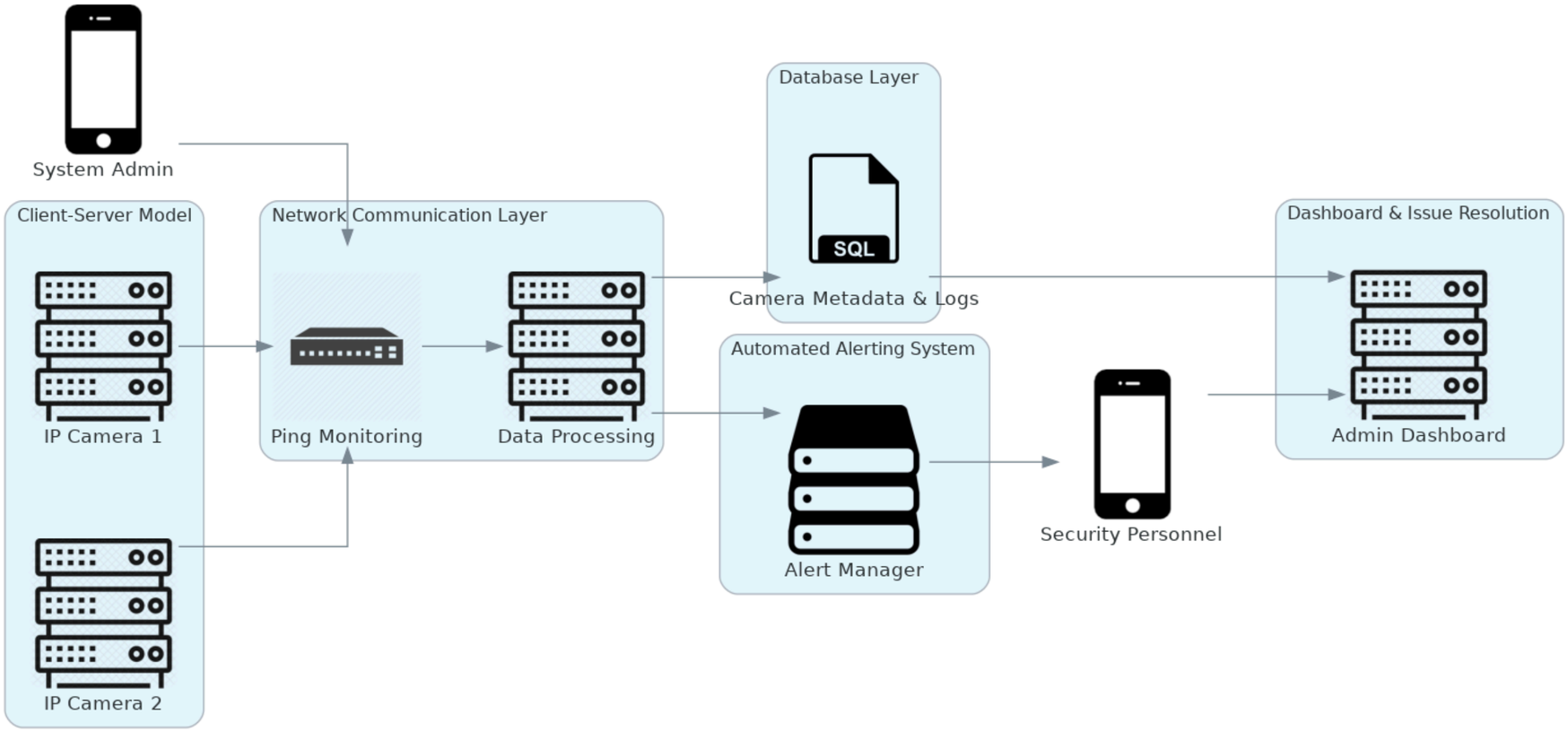

Smart Reconnaissance System

PROPOSED METHODOLOGY AND APPROACH

Proposed Methodology and Approach

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Planning & Requirement Analysis

- Define system requirements, workflow, and technology stack.
- Design a scalable client-server architecture for camera monitoring.

System Design & Development

- Ping-based monitoring for camera connectivity.
- Failure detection (offline, network, power issue).
- Automated alerts via SMS & escalation.
- Video anomaly detection using ML.
- Real-time dashboard for monitoring.

Testing & Performance Optimization

- Conduct unit testing, load testing, and performance tuning.
- Fix issues to ensure efficient real-time processing.

Deployment & Maintenance

- Deploy system in a real-world surveillance environment.
- Monitor performance, collect feedback, and update system as needed.

DESIGN DESCRIPTION

MASTER CLASS DIAGRAM

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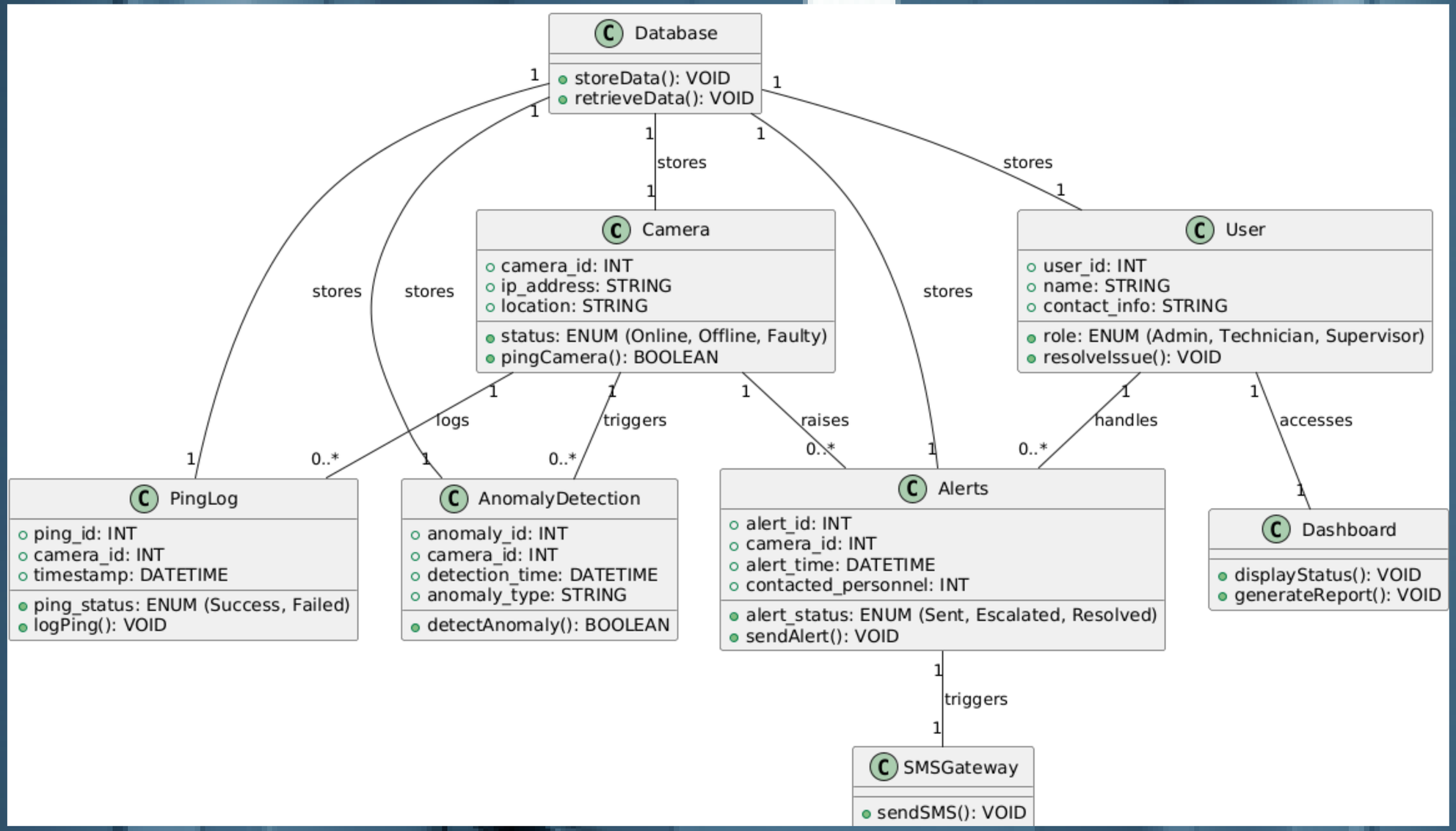
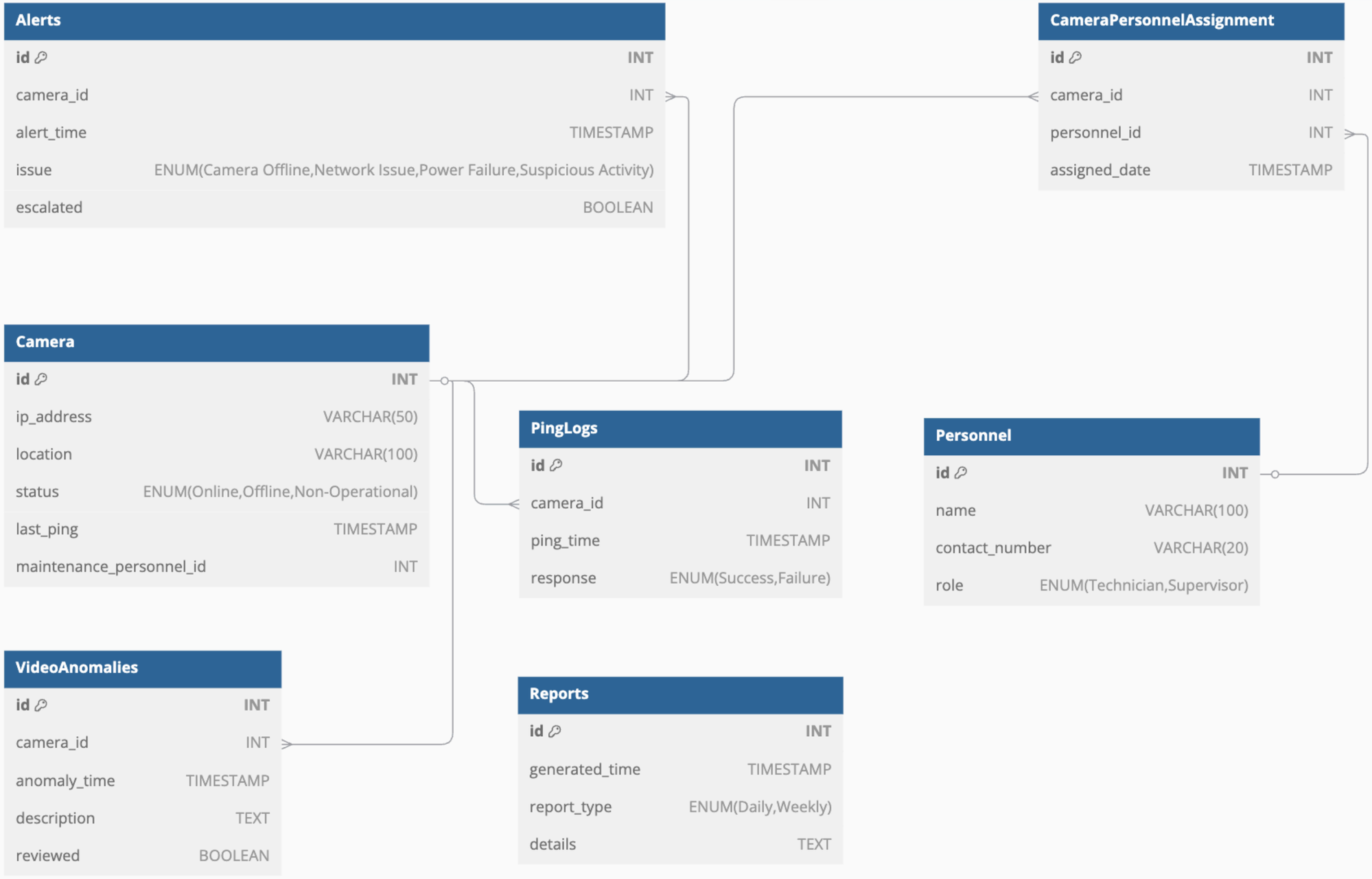


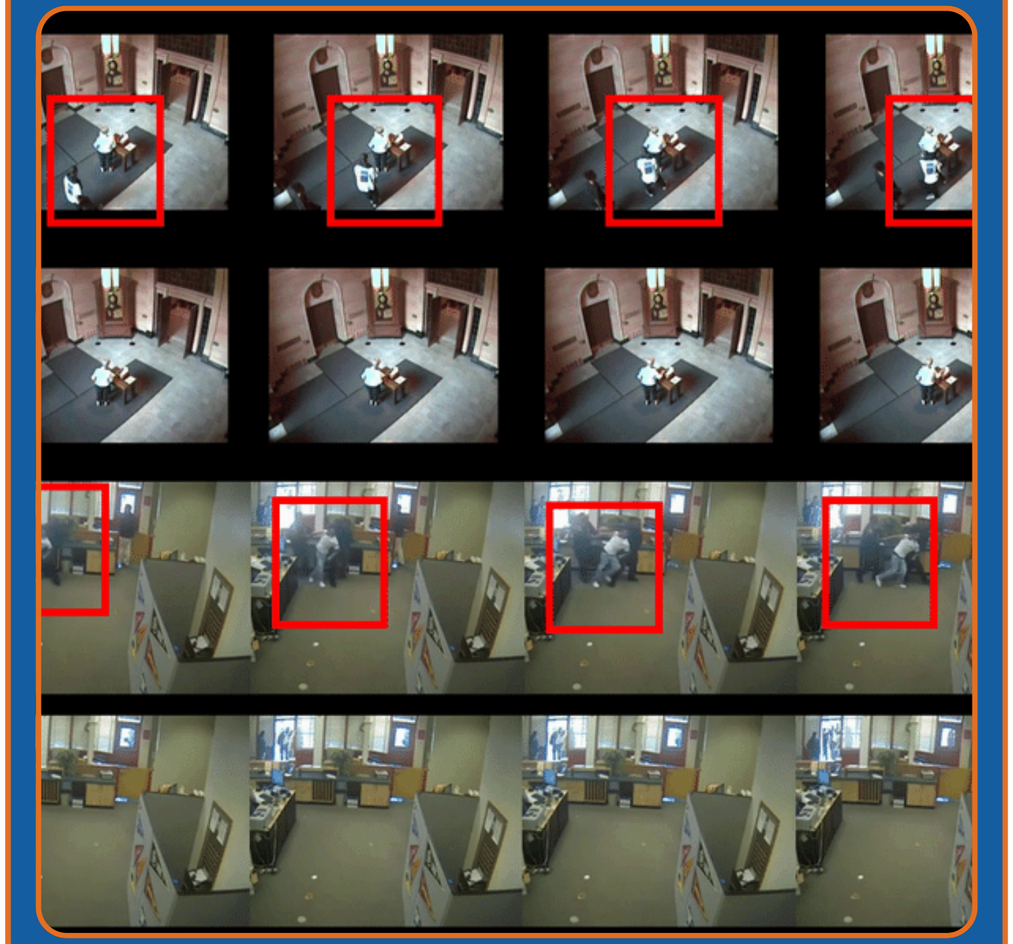
RELATIONAL SCHEMA



DATASET EXPLORATION

UCF Crime

- **Videos:** MP4/AVI
- **Annotations:** CSV/TXT (video-level labels)
- **Metadata:** File name, timestamp, crime type
- **Preprocessing:** Frame extraction and Resizing
- **Models:** CNN + LSTM



UCF Crime Dataset

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1,900+ real-world videos

Large-Scale Dataset

Anomaly Diversity

Covers fights and vandalism

Captured from CCTV cameras.

Real Surveillance Footage

Long Video Duration

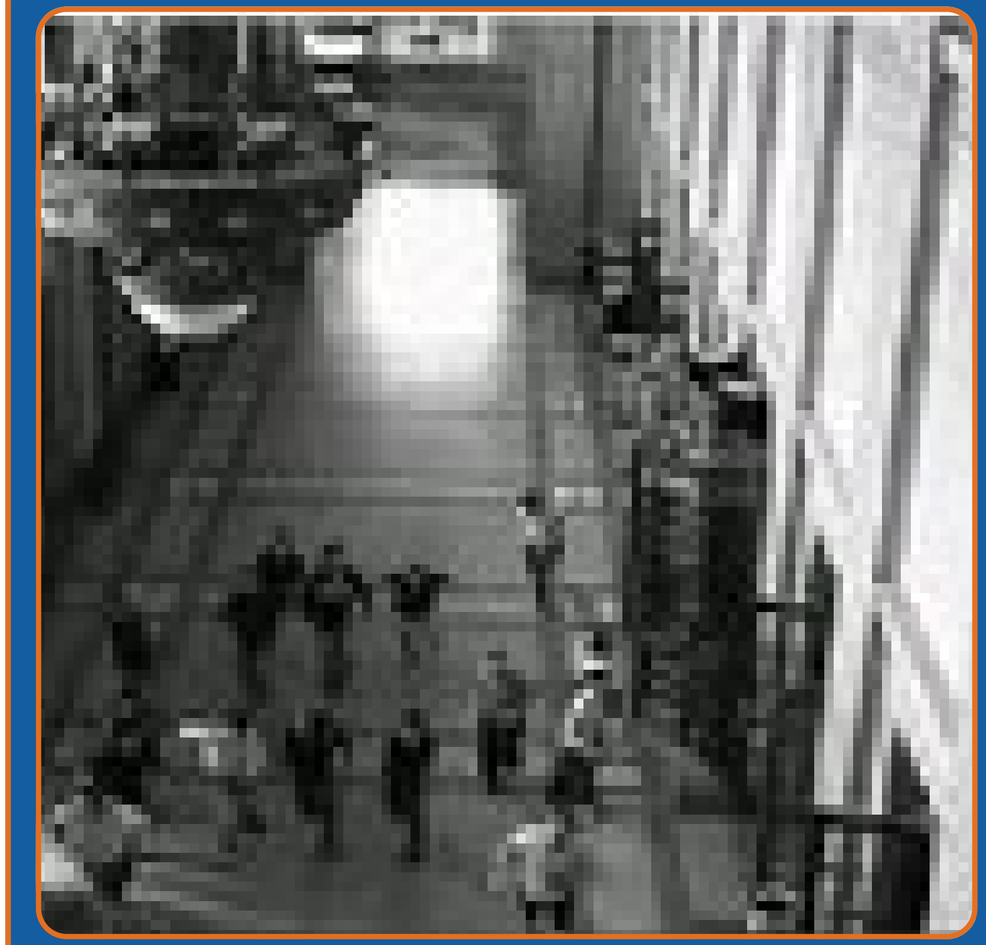
Enables temporal anomaly analysis.

Supports binary & specific crime classification

Multi-Class Labels

UMN

- **Videos:** MP4
- **Annotations:** TXT (frame-level labels)
- **Metadata:** Scene ID, timestamps, activity type
- **Preprocessing:** Frame extraction, resizing, motion analysis
- **Models:** **CNN** + Optical Flows



UMN Dataset

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Crowd Panic Detection

Captures sudden dispersals and unusual movement patterns.

Indoor & Outdoor Footage

Suitable for cafeterias and public space surveillance.

Frame-Level Labels

Provides precise timestamps for normal-to-abnormal transitions.

Realistic Anomaly Progression

Shows gradual shifts from normal to abnormal behavior.

Multi-Scene Dataset

Covers hallways, grassy fields, and walkways for diversity.

ShanghaiTech

- **Videos:** MP4
- **Annotations:** MAT (pixel-level masks)
- **Metadata:** Scene ID, frame number, anomaly type
- **Preprocessing:** Frame extraction, normalization
- **Models:** CNN + Transformer models

ShanghaiTech Dataset

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Ideal for loitering, movement anomalies

Crowd Anomaly Detection

Normal & Abnormal Data

Trains balanced anomaly detection models.

Provides pixel-wise annotations for precision

Pixel-Level Labels

Early Threat Detection

Helps identify issues before escalation

Covers 13 urban environments

Multi-Scene Dataset

BASE MODEL IMPLEMENTATION

Camera Health Monitoring

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Three-Layered Health Check

- Pings IP, fetches snapshot, and measures latency to assess camera status.

Rule-Based Classification

- Classifies issues as Operational, Not Streaming, Disconnected, or Intermittent..

Temporal Analysis

Uses fixed-length deque queues to track recent ping, feed, and latency history.

Dual Logging System

Logs all events and failures separately for better diagnostics and traceability.

Automated Alerts

Sends email notifications to admins after 5 consecutive failures, enabling proactive maintenance.

Camera Health Monitoring

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```
    Minimum = 4ms, Maximum = 4ms, Average = 4ms
[Check 8] Ping: ✔ | Feed: 📷 | Latency: 3 ms → ✅ Operational
2025-04-24 11:24:08,890 — INFO — 192.168.147.154 - Ping: True - Feed: True - Latency: 3 - ✅ Operational

Pinging 192.168.147.154 with 32 bytes of data:
Reply from 192.168.147.154: bytes=32 time=4ms TTL=64

Ping statistics for 192.168.147.154:
    Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 4ms, Maximum = 4ms, Average = 4ms
[Check 9] Ping: ✔ | Feed: 📷 | Latency: 4 ms → ✅ Operational
2025-04-24 11:24:14,122 — INFO — 192.168.147.154 - Ping: True - Feed: True - Latency: 4 - ✅ Operational
```

When camera is working

Camera Health Monitoring

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```
Ping statistics for 192.168.147.154:
    Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 122ms, Maximum = 122ms, Average = 122ms
[Check 5] Ping: ✔| Feed: 🚫 | Latency: 6 ms → 📷 Camera reachable but not streaming
2025-04-24 11:26:58,193 — INFO — 192.168.147.154 - Ping: True - Feed: False - Latency: 6 - 📷 Camera reachable but not streaming
2025-04-24 11:26:58,193 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 6 - 📷 Camera reachable but not streaming

Pinging 192.168.147.154 with 32 bytes of data:
Reply from 192.168.147.154: bytes=32 time=14ms TTL=64

Ping statistics for 192.168.147.154:
    Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 14ms, Maximum = 14ms, Average = 14ms
[Check 6] Ping: ✔| Feed: 🚫 | Latency: 7 ms → 📷 Camera reachable but not streaming
2025-04-24 11:27:05,507 — INFO — 192.168.147.154 - Ping: True - Feed: False - Latency: 7 - 📷 Camera reachable but not streaming
2025-04-24 11:27:05,507 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 7 - 📷 Camera reachable but not streaming
Email sent successfully!
```

When Camera is not Streaming

Camera Health Monitoring

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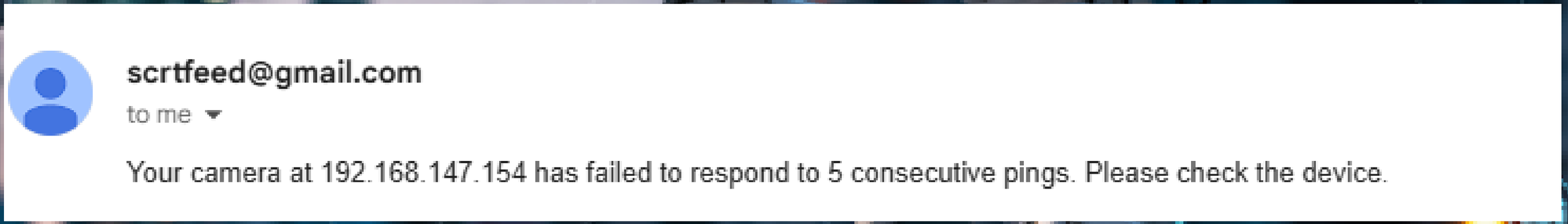

Alert when camera is not working

Camera Health Monitoring

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```
2025-04-24 11:42:02,257 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 5 - 📷 Camera reachable but not streaming
2025-04-24 11:42:09,444 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 6 - 📷 Camera reachable but not streaming
2025-04-24 11:42:16,613 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 6 - 📷 Camera reachable but not streaming
2025-04-24 11:42:23,813 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 7 - 📷 Camera reachable but not streaming
2025-04-24 11:42:30,983 — WARNING — 192.168.147.154 - FAILURE - Ping: True - Feed: False - Latency: 6 - 📷 Camera reachable but not streaming
2025-04-24 11:43:35,072 — WARNING — 192.168.147.154 - FAILURE - Ping: False - Feed: False - Latency: None - ⚠️ Power failure or disconnected
```

Log file for failure

MODEL ARCHITECTURE

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CNN LAYER

- **Spatial Feature extractor** for each video frame using **ResNet18 as a backbone.**
- Processes the frames to **produce 512 dimension visual embeddings.**
- **Fully connected layer is removed** retaining only the **convolutional base**

LSTM LAYER

- **Captures temporal dependencies** by taking in input of the **form [B,T,512]**
- Consists of a **single layer with 256 hidden units** to **model motion dynamics.**
- Last hidden state is passed to **fully connected layer for classification**

CLASSIFICATION LAYER

- **Final hidden state from LSTM taken as a summary** of the entire video sequence.
- Passed through a fully connected layer to **produce logits.**
- The class with the **highest probability** is selected

Accuracies Achieved

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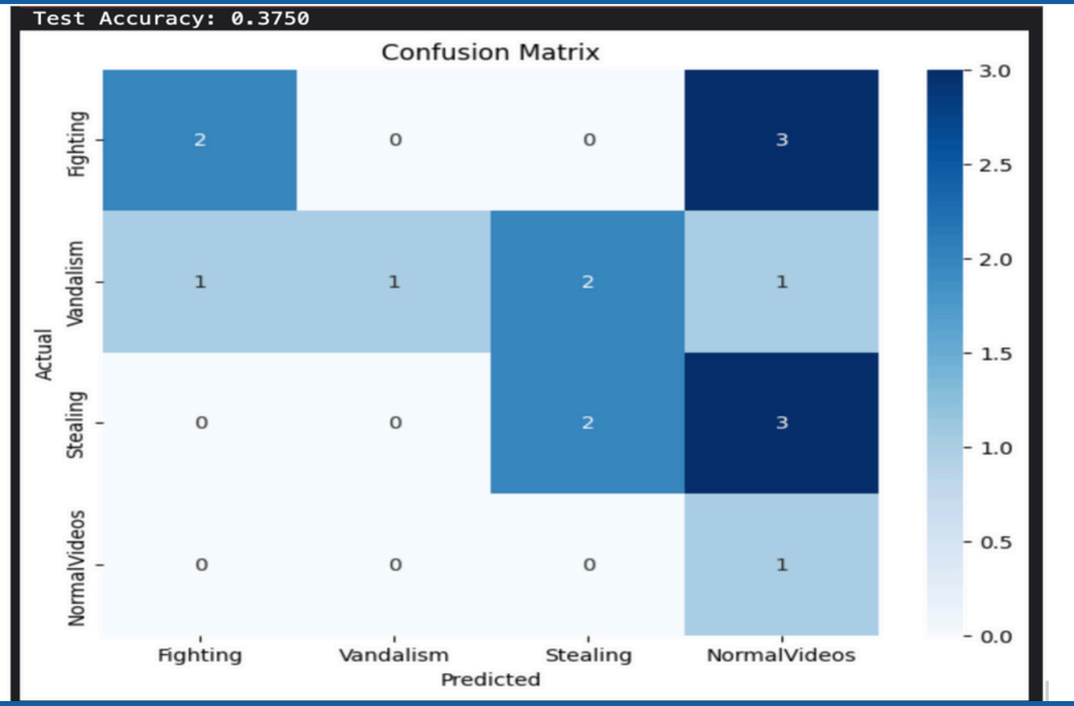
Training and Validation Accuracy

```
Epoch 1/30  | Loss: 132.2351 | Train Acc: 0.8033 | Val Acc: 0.8325
Epoch 2/30  | Loss: 119.9663 | Train Acc: 0.8160 | Val Acc: 0.8426
Epoch 3/30  | Loss: 118.7247 | Train Acc: 0.8173 | Val Acc: 0.8579
Epoch 4/30  | Loss: 112.1483 | Train Acc: 0.8261 | Val Acc: 0.8426
Epoch 5/30  | Loss: 110.2511 | Train Acc: 0.8261 | Val Acc: 0.8376
Epoch 6/30  | Loss: 105.9946 | Train Acc: 0.8287 | Val Acc: 0.8477
Epoch 7/30  | Loss: 104.5661 | Train Acc: 0.8287 | Val Acc: 0.8426
Epoch 8/30  | Loss: 100.6136 | Train Acc: 0.8363 | Val Acc: 0.8325
Epoch 9/30  | Loss: 102.6999 | Train Acc: 0.8401 | Val Acc: 0.8528
Epoch 10/30 | Loss: 100.1822 | Train Acc: 0.8401 | Val Acc: 0.8426
Epoch 11/30 | Loss: 103.3291 | Train Acc: 0.8350 | Val Acc: 0.8325
Epoch 12/30 | Loss: 100.8316 | Train Acc: 0.8439 | Val Acc: 0.8426
Epoch 13/30 | Loss: 94.0540  | Train Acc: 0.8515 | Val Acc: 0.8325
Epoch 14/30 | Loss: 98.6906  | Train Acc: 0.8388 | Val Acc: 0.8325
Epoch 15/30 | Loss: 93.2442  | Train Acc: 0.8452 | Val Acc: 0.8071
Epoch 16/30 | Loss: 90.0073  | Train Acc: 0.8503 | Val Acc: 0.8020
Epoch 17/30 | Loss: 95.2784  | Train Acc: 0.8503 | Val Acc: 0.8071
Epoch 18/30 | Loss: 93.4852  | Train Acc: 0.8528 | Val Acc: 0.8376
Epoch 19/30 | Loss: 85.3285  | Train Acc: 0.8566 | Val Acc: 0.8173
Epoch 20/30 | Loss: 95.1797  | Train Acc: 0.8464 | Val Acc: 0.8274
Epoch 21/30 | Loss: 92.5294  | Train Acc: 0.8426 | Val Acc: 0.8426
Epoch 22/30 | Loss: 88.5743  | Train Acc: 0.8477 | Val Acc: 0.8223
Epoch 23/30 | Loss: 87.6615  | Train Acc: 0.8541 | Val Acc: 0.8020
Epoch 24/30 | Loss: 83.3415  | Train Acc: 0.8655 | Val Acc: 0.8376
Epoch 25/30 | Loss: 83.7287  | Train Acc: 0.8655 | Val Acc: 0.8579
Epoch 26/30 | Loss: 91.1190  | Train Acc: 0.8566 | Val Acc: 0.8071
Epoch 27/30 | Loss: 86.3830  | Train Acc: 0.8464 | Val Acc: 0.8376
Epoch 28/30 | Loss: 88.0168  | Train Acc: 0.8604 | Val Acc: 0.7868
Epoch 29/30 | Loss: 85.1084  | Train Acc: 0.8604 | Val Acc: 0.8173
Epoch 30/30 | Loss: 85.9057  | Train Acc: 0.8566 | Val Acc: 0.8223
✅ Model training complete and saved!
```

Testing Accuracy



PROGRESS PLAN FOR PHASE 3 AND PHASE 4

PROGRESS PLAN FOR PHASE 3 AND PHASE 4
GANTT CHART

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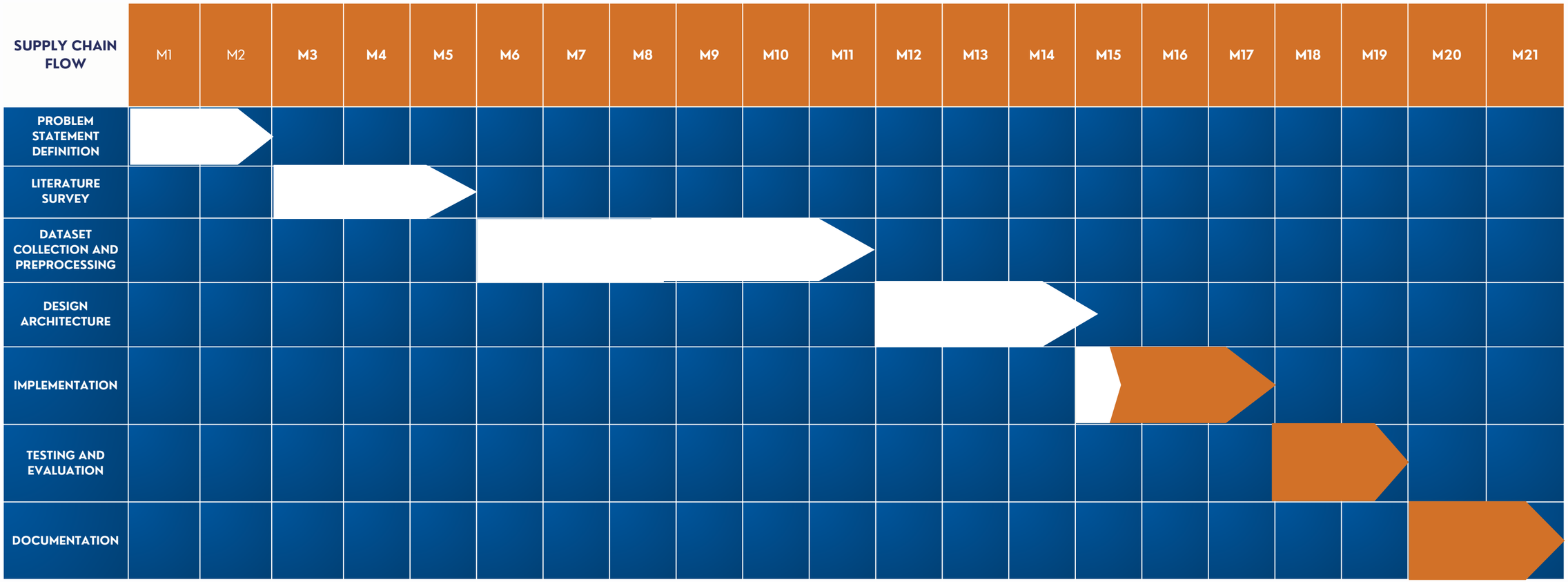

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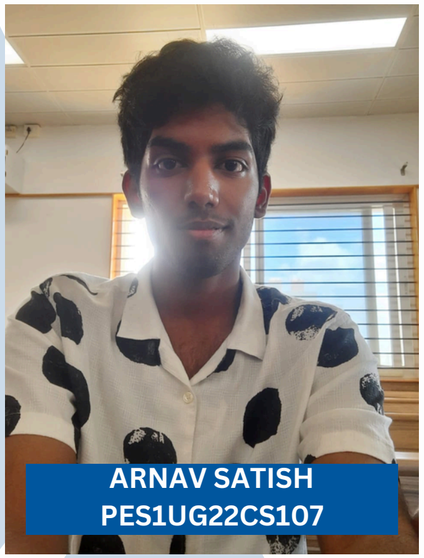
THANK YOU!



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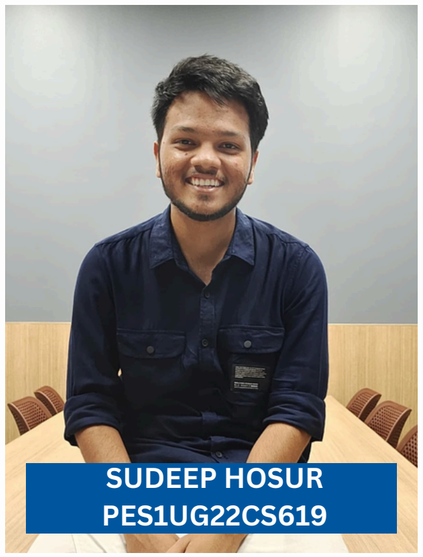

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