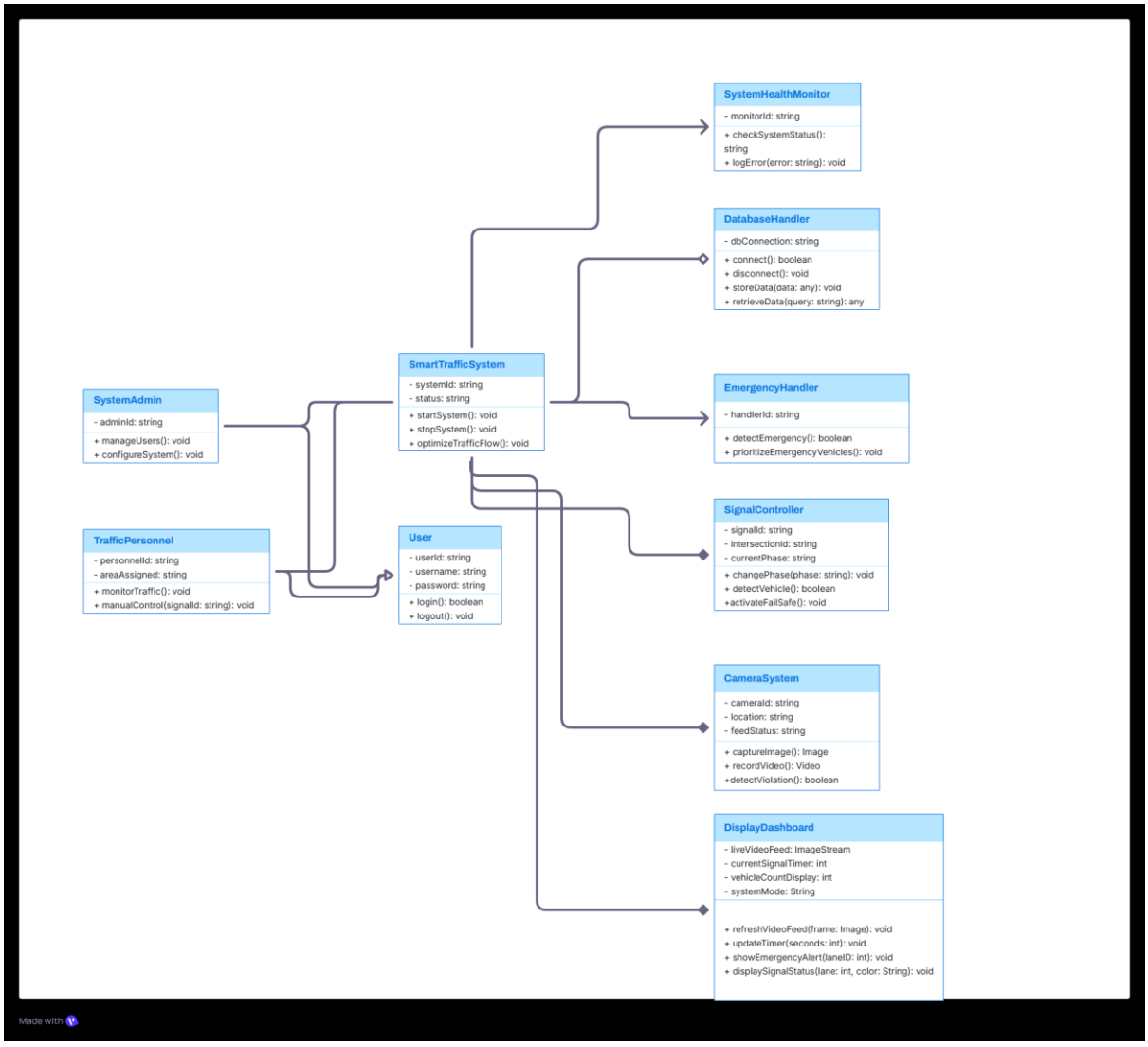
Q1. Key Classes, Attributes, and Functionalities

The system is architected around a central controller that manages specialized modules for vision, signaling, and data handling.

1. **SmartTrafficSystem (Central Controller)**
    - **Role:** The main orchestrator that initializes the system, manages state (Auto/Manual/Fail-Safe), and coordinates data flow between modules.
    - **Key Attributes:** systemId, status
    - **Key Methods:** optimizeTrafficFlow() (executes the core logic for timing adjustments), startSystem(), stopSystem().
2. **User (Base Class)**
    - **Role:** An abstract parent class handling common authentication data for all human actors.
    - **Key Attributes:** username, password (Encrypted), userId.
    - **Key Methods:** login(), logout().
3. **SystemAdmin (Inherits from User)**
    - **Role:** Handles configuration and administrative monitoring.
    - **Key Methods:** configureSystem() (updates global settings), manageUsers().
4. **TrafficPersonnel (Inherits from User)**
    - **Role:** Operational staff responsible for monitoring and manual intervention.
    - **Key Methods:** manualControl() (overrides signal timers), monitorTraffic().
5. **CameraSystem**
    - **Role:** Interfaces with hardware to capture and process video feeds.
    - **Key Attributes:** feedStatus, location.
    - **Key Methods:** captureImage(), detectViolation() (identifies wrong-way/overspeeding), recordVideo().
6. **SignalController**
    - **Role:** Directly manages the traffic light hardware logic.
    - **Key Attributes:** currentPhase (Red/Green/Yellow), intersectionId.
    - **Key Methods:** changePhase(), activateFailSafe() (reverts to fixed timers on error).
7. **EmergencyHandler**
    - **Role:** A dedicated module for high-priority event management.
    - **Key Methods:** detectEmergency() (identifies sirens/visuals), prioritizeEmergencyVehicles() (forces green lights).

8. **DisplayDashboard**
    - **Role:** Manages the user interface and simulation visualization.
    - **Key Attributes:** liveVideoFeed, currentSignalTimer, systemMode.
    - **Key Methods:** refreshVideoFeed(), updateTimer(), showEmergencyAlert().

Q2. Relationships and Class Diagram Description



1. Inheritance (Generalization)

- **Relationship:** SystemAdmin and TrafficPersonnel → User
- **Description:** Both the Admin and Traffic Personnel share common attributes (username, password) and behaviors (login). The User class acts as the parent, adhering to the **"Is-A"** relationship (e.g., A System Admin *is a* User), which reduces code redundancy.

2. Composition (Strong "Has-A" Relationship)

- **Relationship:** SmartTrafficSystem <>— CameraSystem, SignalController, SystemHealthMonitor
- **Description:** The system is composed of these critical modules. The SmartTrafficSystem acts as the owner; if the main system is destroyed, these components effectively cease to function in the context of the application.
    - **Cardinality:**
        - 1 SmartTrafficSystem manages 4 CameraSystem instances (one per road).
        - 1 SmartTrafficSystem manages 1 SignalController.

3. Association ("Uses" Relationship)

- **Relationship:** SmartTrafficSystem — DatabaseHandler
- **Description:** The system *uses* the database handler to persist data. This is a looser coupling where the database handler provides a service (storage) to the main system.
- **Relationship:** SmartTrafficSystem — DisplayDashboard
- **Description:** The system updates the dashboard with real-time data. This is a directed association where the flow of information goes from the Logic Controller to the Display.

4. Dependency

- **Relationship:** TrafficPersonnel --- > SmartTrafficSystem
- **Description:** The personnel *depend* on the system to perform manual overrides. They do not "own" the system, but interact with it temporarily to change its state.