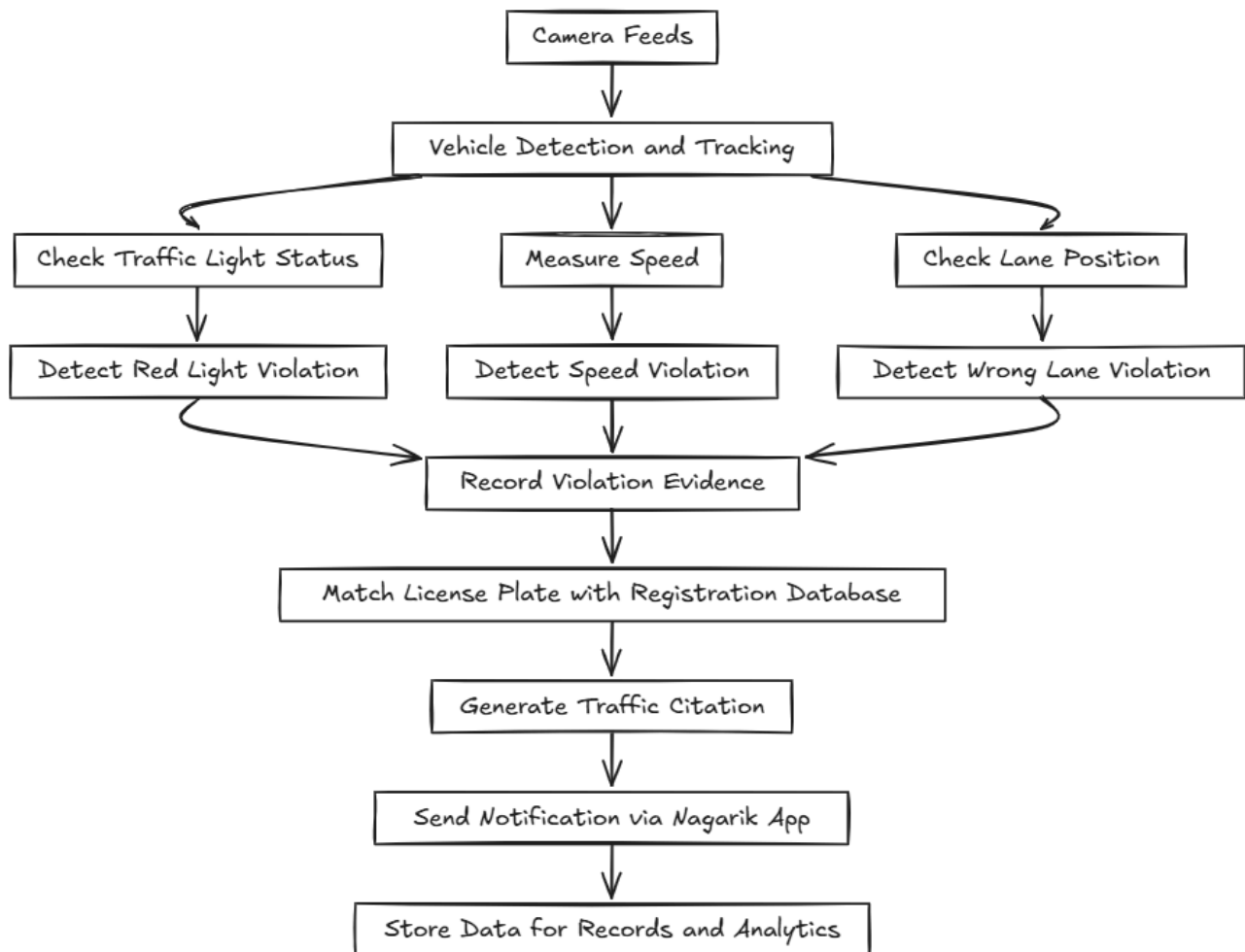Name: Sejal Panta
Email: sejalpanta@gmail.com

Traffic Violation Detection System

1. System Diagram or Flowchart:

2. Explanation

A. Design Decisions for Major Components

1. Camera Feeds & Vehicle Detection
Each road connected to the intersection has a camera watching the vehicles. The live video is analyzed using a simple object detection model (for example, YOLOv5/YOLOv8) to find moving vehicles. Each detected vehicle is tracked in the video so that we can follow its movement and know when it crosses lines or changes lanes. The camera view is also used for license plate recognition using a simple OCR-based ALPR (Automatic License Plate Recognition) system like Tesseract.

2. Traffic Light Monitoring
The system receives real-time information about traffic light status (Red, Yellow, or Green) for each lane. When the traffic light is red and a vehicle crosses the stop line, the system marks it as a red light violation. This is done by comparing the vehicle's position and the traffic light state at the same time.

3. Speed Detection
The system calculates vehicle speed using the distance a vehicle moves between two camera frames. If the cameras are calibrated (we know real distance in meters), and we can thus use the formula:

$$\text{Speed} = \text{Distance} / \text{Time}$$

If the speed is higher than the set limit, the system flags it as a speeding violation.

4. Lane Detection
Each lane is drawn or marked in the camera's view during setup. If a vehicle moves outside its correct lane or drives in the wrong direction, the system identifies it as a wrong lane violation. This helps catch cases like driving in bus-only lanes or entering from the wrong side.

5. Violation Logic Engine
This is the main logical part of the system that combines all data i.e. camera tracking, speed, and traffic light information. It decides what kind of violation has happened and records details like:

- Type of violation (red light, wrong lane, speeding)
- Vehicle number (from license plate)
- Time and camera location
- Captured image or short video clip

6. Citation Generation & Notification
The recognized plate number is matched with the vehicle registration database to find the owner. A digital fine is automatically created and sent to the citizen's Nagarik App through an API. A short video or image proof is also included for fairness and transparency.

B. Key Assumptions

1. All cameras are time-synchronized with the traffic lights.
2. Each camera view clearly shows the vehicle's license plate.
3. Lane maps and speed limits for that intersection are already known.
4. There is enough internet and computing power for real-time processing.

C. Potential Challenges & Simple Solutions

1. Crowded or Blocked Views
Sometimes vehicles block each other, especially during office hours (9-11 AM or 4-6 PM).
Solution: Use more than one camera angle or check multiple frames before confirming a traffic violation so that fairness can be maintained and no one is inconvenienced.

2. Bad Weather or Low Light
Rain, fog, or low light can make detection harder i.e. during monsoon, winters, evening and night time respectively.
Solution: Use cameras with infrared or night vision, and apply image enhancement filters.

3. Blurry or Dirty License Plates
Sometimes OCR can misread plates due to dirt or motion blur.
Solution: Take multiple frames and choose the clearest one for recognition.

4. False Detections
The system might make mistakes due to shadows or sudden movements.
Solution: Confirm a violation using at least 2 to 3 continuous frames before sending a fine. In case the frames are unrecognizable, consider human intervention, e.g. traffic police officers.

5. Data Privacy & Security
The system uses sensitive personal data so a level of privacy must be ensured.
Solution: Encrypt data, allow only authorized access, and delete old footage after a fixed time or after the problem has been tackled.

D. Alternative Approaches Considered

1. Radar sensors can be used to measure speed more accurately. But since they are expensive and harder to install and maintain, we can consider using these only in more cluttered and busy main roads in the context of Nepal.

2. Manual review options can be considered for unclear cases where the system can send suspected violations to traffic officers for final checking before issuing fines, which is also mentioned earlier. For example, if a violation has been detected in some area but we aren't able to clearly record the license plate number, then the problem must be immediately forwarded to the traffic officer patrolling the nearby area.