IT314: Software Engineering
Lab 6
Speed Detection Project

Domain Analysis Model:

A domain analysis model for a speed detection system is representation of the system's domain, inputs, outputs and its components.It defines the key concepts, relationships and behaviour within the domain and it helps to identify the requirements and constraints that the system must satisfy
Below is our system's current domain analysis model

1. Inputs: Currently, the system requires the following inputs:
    - A video file from the local system or a video feed from the webcam
    - The frame rate of the video
    - A reference line to be made over the video feed to indicate the starting line to detect the moving objects
    - A box over the object whose speed is to be calculated

2. Processing: Currently, the system processes the video file/feed using the following steps
    - Detects the object in each frame of the video
    - Tracks the position of the object across frames
    - The above 2 points are done by using various .xml files which are obtained from training the object detector model with images of objects like car, human etc
    - Calculates the speed of the object on the basis of the distance travelled and time it took to travel that distance

3. Outputs: Currently, the system outputs the following
    - A .csv file containing the speed over different frames of the video

4. Constraints and Assumptions: Currently, the system operates under the following constraints and assumptions
    - The camera is stationary and its position and orientationdo not change during the video feed
    - The object is clearly visible in the video feed and is not obstructed by any other objects
    - The frame rate and resolution of the camera are sufficient to capture the movement of the object accurately

5. Actors: Currently, the system has following actors
    - Traffic officer
    - Analyst
    - Speed detection system(primarily including a camera to capture the video feed)
    - System admin

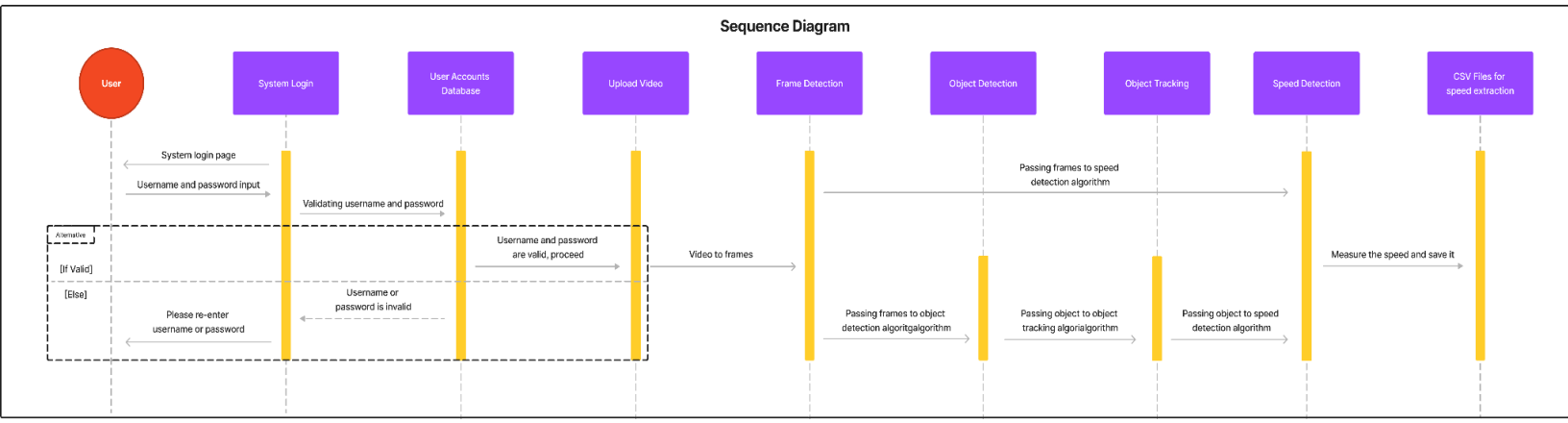
Identify Boundary, Entity and Control Object:

Boundary: VideoInputBoundary (interfaces with external video source), SpeedOutputBoundary (interfaces with external data storage or display)

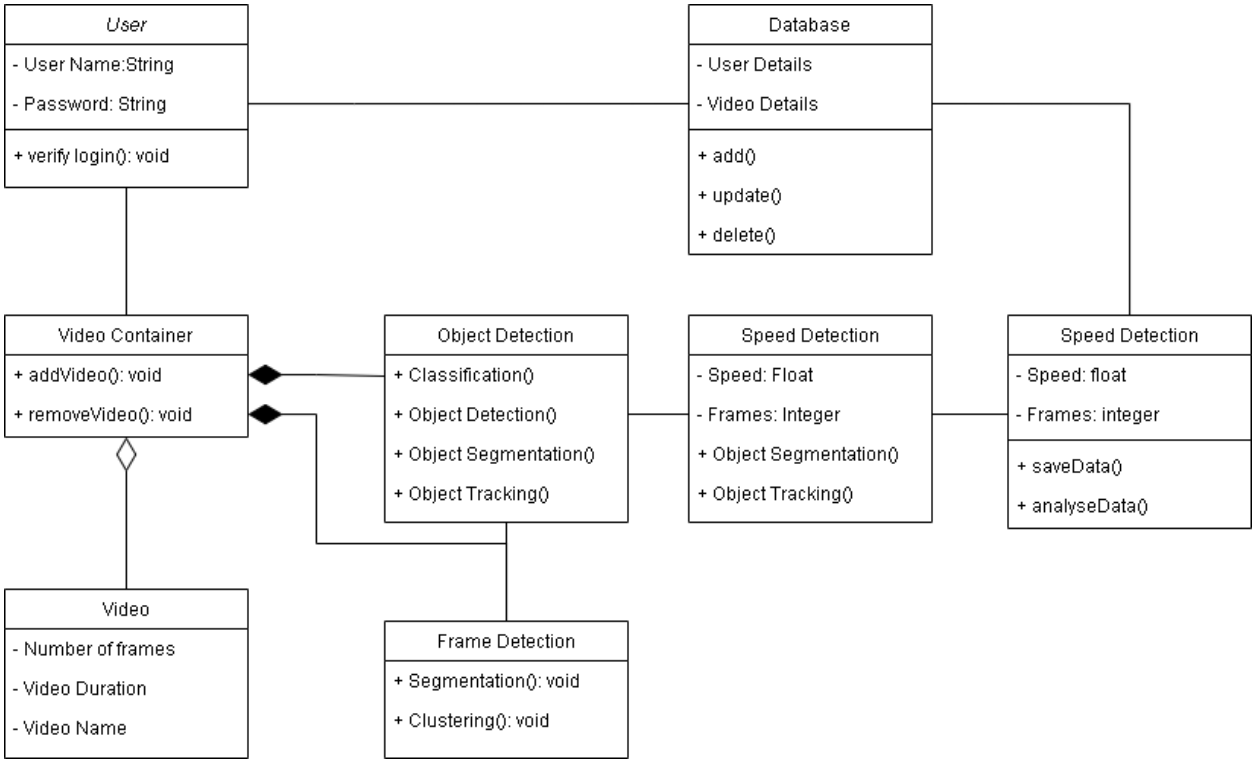
Entity: Frame (represents a single image captured from the video), Speed (represents the calculated speed of a moving object)

Control Object: FrameExtractor (controls the process of separating frames from the video input), SpeedCalculator (controls the process of applying ML algorithms to estimate speed from frames)

Sequence Diagram:



Class Diagram:



Design goals:

- **Functionality:** The system should provide all the expected services and features to its users such as detecting and calculating speed from video input, storing or displaying speed data etc
- **Reliability:** The system should perform consistently and accurately under different conditions and scenarios, such as varying lighting, camera angle and distance. The system should also handle errors and exceptions gracefully and recover quickly from failures
- **Usability:** The system should be easy to use and understand by its intended users, such as traffic police officers or road safety analysts. The system should have a clear and intuitive user interface that provides feedback, guidance and help. The system should also meet the user's needs and preferences in terms of functionality, performance and aesthetics

- **Efficiency:** The system should use resources such as memory, CPU, bandwidth and battery optimally without compromising quality or functionality. The system should also minimize latency and maximize throughput when processing video input and outputting speed data. The system should also be scalable to handle increasing demand or workload
- **Accuracy:** The system should produce correct and precise speed estimates for each moving object in the video input. The system should also minimize false positives (detecting non-moving objects as moving) or false negatives (missing moving objects). The system should also be able to calibrate itself based on the camera parameters or user input.
- **Scalability:** The system should be able to handle increasing amounts of video input or speed data without degrading performance or quality. The system should also be able to support multiple cameras or devices simultaneously or distributed across different locations. The system should also be modular and extensible to allow adding new features or functionalities easily.

High level system design, its architecture and subsystems:

High level system design:

Following is the high level system design of the speed detection system

1. Input: The system will need one or more hardware components to detect the object. In our system, we use the camera of devices like mobile, laptop etc to detect the moving object.

2. Data acquisition: The camera will record the video feed, and then the video feed is converted into frames and fed to this module for further processing.

3. Data processing: This module will take raw data we got from the data acquisition module and convert it into meaningful information. In our system, after detecting the object this module tracks the object over various frames, and sends the frame data to the speed detection module

4. Speed detection: This module analyzes the frame data sent by the data processing module, and calculates the speed of the object by finding how much distance the object moves over different frames.

5. Output display: This module displays the detected speed. In out system, the speed output is given in the form a .csv file. Various things like the average speed, graph of the speed of the object, notifying if a vehicle above speed limit can also be accessed by the web application on which this system runs.

6. Data storage: The system also stores data about the detected speed of the object and other related information for future reference or analysis.

Architecture:

1. **Physical layer:** This layer includes the hardware components of the system such as the camera used for object detection and the system(hardware device like phone, laptop) for processing and calculating the object speed. The physical layer is responsible for collecting data from the environment and processing it into a format that can be understood by the upper layers.

2. **Data processing layer:** This layer includes the data processing unit. It is responsible for processing the data received from the physical layer. In our system, this layer receives the video feed from the physical layer and converts it into frames, detects the object, tracks the object over various frames of the feed, calculates its speed and outputs/stores the data into a .csv format.

3. **Application layer:** This layer includes the software that runs on top of the data processing layer. The application layer is responsible for providing the user the interface for the system. In our system, the data obtained from data processing layer is passed to the speed database which can be accessed through an web application(application layer). This web app could have features like calculating average speed, graph of the speed of the object, notifying if a vehicle above speed limit etc.

Subsystems:

Subsystem 1: Object detection

This subsystem will be responsible for detecting objects like vehicles, humans etc as they pass through the detection zone. This is currently done by a camera ; to accurately identify and track the object. The detection subsystem will need to be fast and accurate to ensure all the objects are correctly identified.

Subsystem 2: Speed calculation

Once an object is detected, this will be responsible for measuring its speed. This could be done by using a camera, capturing the video feed, converting the feed into frames, tracking the identified object over different and finally calculating the speed by dividing the distance travelled by the object by the time it took for those frames to move. The speed calculation subsystem will need to be accurate and precise, with low error rates.

Subsystem 3: Data analysis, storing and reporting

The final subsystem will be responsible for analyzing the speed data collected by the system, and generating meaningful output (eg average speed of the object; reporting any speed limit violations if the object is a vehicle; graph of the speed of the object). This subsystem will need to be reliable(and fast and low false positive rates in case of speed limit tracking of the vehicles)