Software Requirements Specification

for

"GATISHEEL" – A Next Gen. Smart Navigation System

Version 1.0

Prepared by: Ankit Vohra

Shrey Jasuja

Indian Institute of Information Technology, Nagpur

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1. Introduction

This section gives a scope description and overview of everything included in this SRS document. Also, the purpose for this document is described and a list of abbreviations and definitions is provided.

1.1 Purpose

The purpose of this document is to give a detailed description of the requirements for the "GATISHEEL" Smart Navigation software. It will explain the purpose and features of the system, the interfaces of the system, what the system will do, the constraints under which it must operate and how the system will react to external stimuli. It will illustrate the purpose and complete declaration for the development of system. It will also explain system constraints, interface and interactions with other external applications. This document is intended for both the stakeholders and the developers of the system.

1.2 Document Conventions

This document follows MLA Format. Bold-faced text has been used to emphasize section and sub-section headings. Highlighting is to point out words in the glossary and italicized text is used to label and recognize diagrams.

1.3 Intended Audience and Reading Suggestions

This document is to be read by the development team, the project managers, testers and documentation writers. Our stakeholders, company manufacturing associated hardware,

company providing embedded operating system, government agencies, road construction companies and distributors who markets the finished product, may review the document to learn about the project and to understand the requirements. The SRS has been organized approximately in order of increasing specificity. The developers and project managers need to become intimately familiar with the SRS.

Others involved need to review the document as such:
Overall Description – Marketing staff have to become accustomed to the various product features in order to effectively advertise the product.
System features – Testers need an understanding of the system features to develop meaningful
test cases and give useful feedback to the developers.
External Interface Requirements – The hardware developers need to know the requirements of the device they need to build. The marketing staff also needs to understand the external interface requirements to sell the product by describing the user-friendly features of the GATISHEEL.
Nonfunctional and Functional Requirements – The hardware developers.

1.4 Product Scope

Traffic control is one of the major problems faced by modern cities. With increasing no. of vehicles, there is a need to find innovative and efficient solution for this problem. This system uses this solution by making use of the modern technology of machine learning, game theory, GPS and reinforcement learning.

Emergency service providers will be a major stakeholder in this project as their vehicles will be provided the main priority in minimizing their delay by tracking them with GPS and

clearing path for them even before they reach the CCTV (traffic light) range. Traffic Violations are also detected using image recognition and violators are penalized.

Also, road conditions will be taken into account if it is rough or smooth by using a crowdsourced data using smartphone sensors such as accelerometers, gyroscopic sensors etc. These sensors on having variations in their reading outputs will detect potholes and speed breakers and will mark them on the map using GPS of the phone. This will lead to the mapping of unsafe roads. This data will be sent to government organizations to carry out maintenance work on such roads. This data can be sent to daily travellers, cab aggregators and transport agencies.

Thus, this system let us control traffic at intersections, penalize violators, provide priority access to emergency vehicles and also map road conditions.

1.5 References

i. El-Tantawy, Samah & Abdulhai, Baher. (2012). Multi-Agent Reinforcement Learning for Integrated Network of Adaptive Traffic Signal Controllers (MARLIN-ATSC). Conference Record - IEEE Conference on Intelligent Transportation Systems. 319-326. 10.1109/ITSC.2012.6338707.

ii. Bhatt, Umang & Mani, Shouvik & Xi, Edgar & Zico Kolter, J. (2017). Intelligent Pothole Detection and Road Condition Assessment.

iii. R. Z. G. K. A. Mednis, G. Strazdins and L. Selavo.Real time pothole detection using android smartphoneswith accelerometers. International Conference onDistributed Computing in Sensor Systems and Workshops (DCOSS), pages 1–6, 2011

iv. IEEE. IEEE Std. 830-1998 IEEE Recommended Practice for Software Requirements Specifications. IEEE Computer Society, 1998.

2. Overall Description

2.1 Product Perspective

This system will consist of two parts: one mobile application and one CS. The mobile application will be used to display the roads which are affected or are not in a good condition, it will also be used to read the details of the gyroscope and the accelerometer sensor. The CS will be used to store the video coming from all the CCTV cameras and to detect the number of vehicles and accordingly take the decision of traffic light. It will also be used to manage the database of traffic violators and to share the details to respective department.

The decision making is the main part of the GATISHEEL project which will be using various models of ML, GT, RML, and many more from which a particular signal will be able to decide a particular algorithm which can be used to ensure that minimum delay is observed.

The mobile application will need to communicate to a GPS application within the mobile phone, which in turn communicates with a physical GPS device to find the location of the user. The GPS will be used whenever the accelerometer and gyroscope sensors reading will be more than the threshold reading which will represent that the vehicle found a pothole at that particular location.
Then the particular location will be marked in the app if the same location is marked regularly by other users also.

Refer to the attached use case diagram for further information.

2.2 Product Functions

- It will be used by daily travelers to reduce their travelling time and also to find safer and smooth roads.
- It will save large amount of fuel of the nation.
- It can detect all the traffic rules violators without the need of a traffic policeman standing at the intersection. Thus, saving lot of human efforts at adverse conditions.
- The traffic violator's vehicle number can be detected using RCNN and other mechanism through which they will be getting the penalty bill at their house directly.
- GATISHEEL can also be used to find all the potholes of the city which are left open and needs attention of the Government Agencies.
- Emergency vehicles are stuck in traffic at times, but due to the implementation of smart traffic system, they will be given priority and the route on which they are traveling will get a Green signal whenever possible.
- This can save lives of thousands of people whose health gets affected due to the delay while travelling to the hospital.
- Roads which are damaged can be mapped on maps which will be displayed to users as well as different government agencies who will be passing tenders to maintain those roads.
- Vehicle repairing cost will also be reduced if someone avoids such roads.
- Give bribe and go culture will be reduced if the penalty directly comes to vehicle owner's house.

2.3 User Classes and Characteristics

GATISHEEL system will be accessed by three kind of users:

1. General User: They will access the GATISHEEL app who can see the road conditions and can plan their trip accordingly.

2. Govt Agencies: They will have the access of all the road conditions of nearby areas and can create a tender for its repairing.

3. Traffic Authority: They will be having details of all the traffic violators

All the above users require normal user interface and need Internet access.

2.4 Operating Environment

The complete system will require different environment to operate. It will require a hardware platform to implement the signals like Raspberry Pie or Arduino. It will use Python as the main programming languages to implement the ML models. It will also use JAVA and other languages to make the android app and to read details of its sensors. Multiple API's will be used such as Google Maps to map the potholes.

2.5 Design and Implementation Constraints

There are a few constraints which were coming while designing the entire system as the project is beyond the scope of 2nd year under graduates. The testing phase is one probable issue which is going to arrive as well as the collection of past data.

Training a ML model which is so complex is not possible in a personal computer due to which cloud system like Google Colab will be used to train the model. The use of cloud server and getting all the real time videos of all the CCTV Camera videos requires huge amount of hardware setup and professionals.

Access to the signals of the city will not be given directly unless a miniature working model is ready.

2.6 Assumptions and Dependencies

- It is assumed that CCTV Cameras at the intersection are clear and have a wide view which will help to detect cars easily and thus helping in decision making.
- The past data will be available for calculating the number of vehicles at any time initially.
- Cloud Server will be fast and sufficient enough to perform object detection on a real time basis.
- Dataset for bikers with and without helmet as well as dataset of cars and other vehicles will be required which will help in object detection.
- Database management system will be required to save and manage all the details.
- Access to signals should be provided from a central server to manage their working.
- Database of RTO will be required to find the vehicle owner of the traffic violator.
- Money spent in previous repairing should be given so that a trained model can be prepared.
- Dataset of sensors which are used for pothole mapping will be required to classify whether the vibration which was aroused was because of a pothole or not.
- Google Maps API will be used for plotting potholes and other roads which are not in a good condition.

3. External Interface Requirements

3.1 User Interfaces

The user will see the google map of his/her area which will be marked with different colors depicting the road condition of that particular area.

The govt. agency will be able to view the same as well as will be allowed to generate a complete report on the condition of the roads.

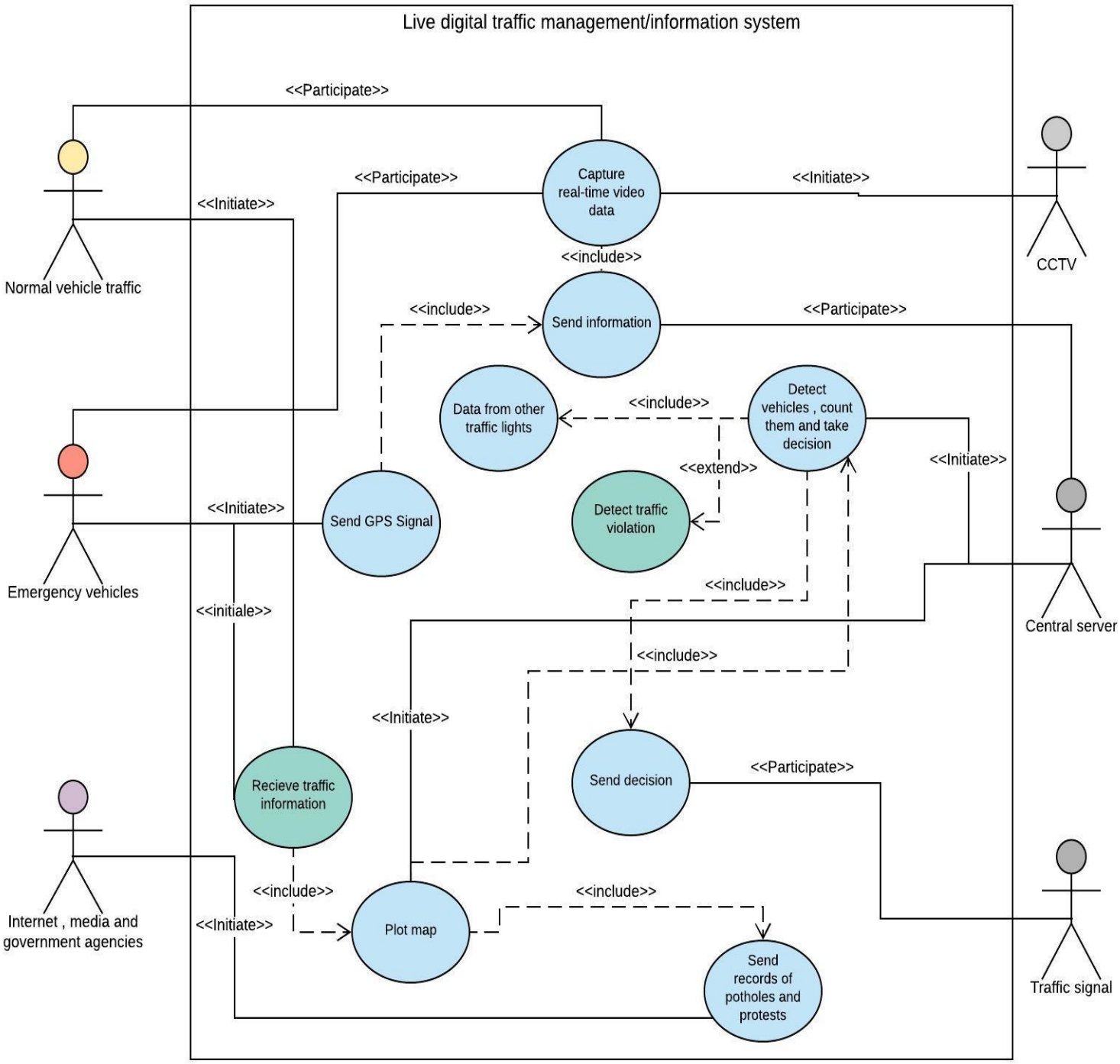
The remaining things will be worked on the CS which will not be accessed by the user.

3.2 Hardware Interfaces

There is a heavy Hardware requirement on this system. Sensors of mobile phone of travelers will be used to find the potholes and the CCTV cameras will be used to find the number of vehicles at any intersection and accordingly set the timer of each side of intersection.

4. System Features

4.1 Complete System

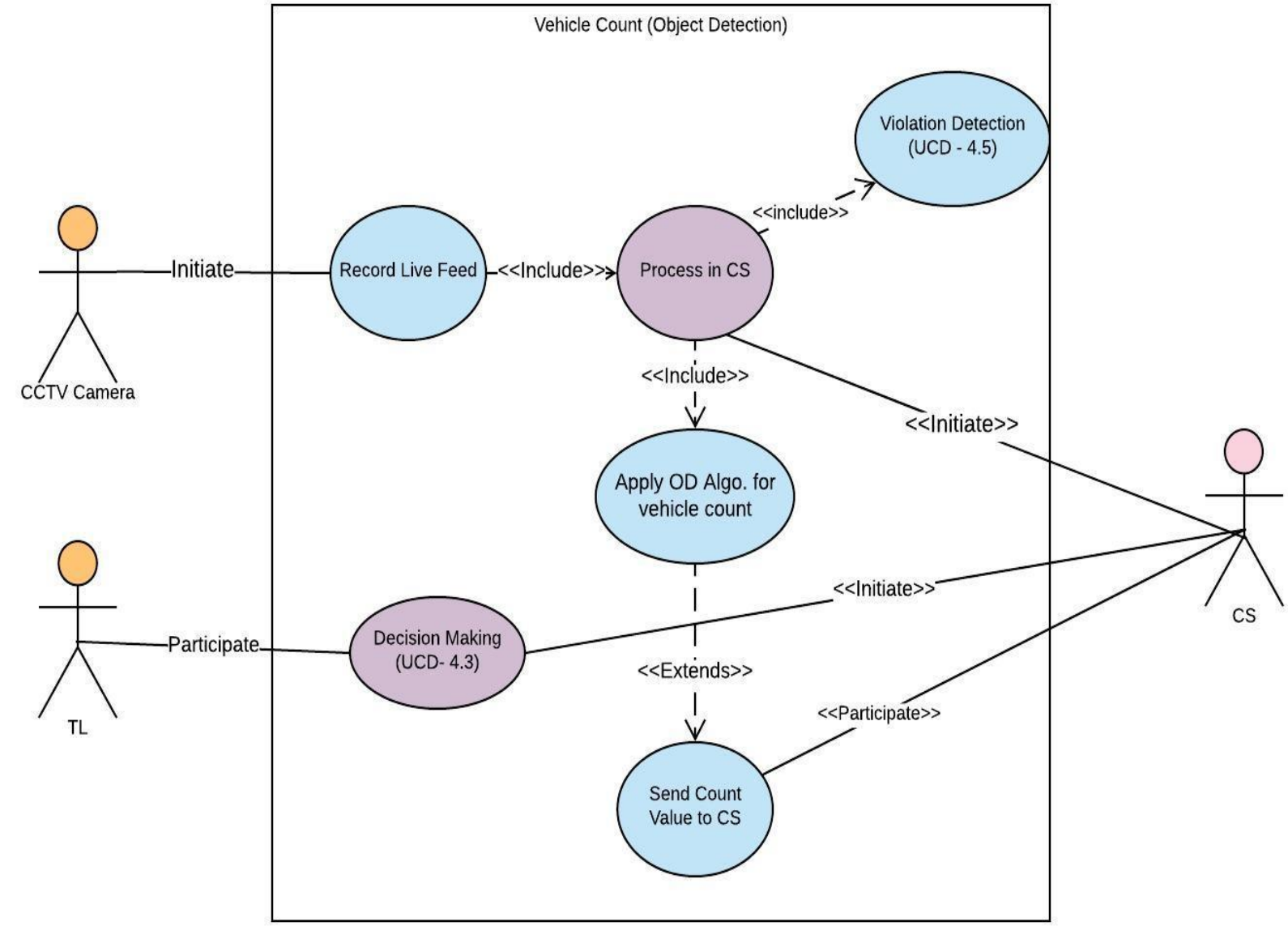


The main factors determining the switching of traffic lights are:

1) Density of vehicles.
2) Historic record of the traffic at that signal.
3) Incoming traffic information from the CCTVs at signals that direct traffic to the concerned signal.
4) Game theory algorithms will be used to decide the strategies of the decision of switching traffic lights with the aim of minimizing traffic delay.
5) Reinforcement learning with neural networks can be used on the decisions with reduced time delay in traffic as the positive reward and time delay as negative reward, which will help in automatically going towards the best decision.
6) The co-ordination of all the traffic lights will take place from a central server, which will calculate the optimal strategies using the game theory, reinforcement learning as mentioned above as well as using the data from the previous CCTV in the same path of traffic. The database will be stored in a central server as well with a backup in cloud in case of technical problems in the server.

- Emergency vehicles will be provided the main priority in minimizing their delay by tracking them with GPS and clearing path for them even before they reach the CCTV (traffic light) range.
- The data from the GPS and internet regarding the traffic, accidents, protests, etc. can also be taken into account in the decision making.
- Also, through CCTV Video traffic rules violators can be detected and be penalised using deep learning algorithm by reading the number plates.
- Road conditions will be taken into account if it is rough or smooth by using crowd sourced data using smartphone sensors such as accelerometers, gyroscopic sensors etc. These sensors on having variations in their reading outputs will detect potholes and speed breakers and will mark them on map using GPS of the phone. This will lead to mapping of unsafe roads. This data will also be sent to government organizations to carry out maintenance work on such roads.

4.2 Object Detection Module



The above use case diagram is a part of the main system which describes details about Object Detection.

The functions which it operates are:

- Record Live feed
- Process the live feed at CS.

- Apply object detection module on real time live feed.
- Increment Counter
- Send the final count value to the CS.
- Check violation.

Record Live Feed: This function will take the live feed from the CCTV camera at an intersection and will pass it to the CS.

Process the live feed at CS: The live feed which arrives at the CS goes through some processing which will help to increase the accuracy of object detection and it will be passed to next step.

Apply object detection module on real time live feed: Fastest object detection algorithm will be applied on the live feed which will help in counting the number of vehicles on each side of a particular intersection which will play a vital role in decision making.

Increment Counter: Once a vehicle is detected it will increment the counter by 1 and thus by this fashion, we will be able to gather the information of all the vehicles on a particular side at intersection.

Send the final count value to the CS: The final count will be stored in the CS and will be passed to the decision-making module.

Check violation: Checking of violation is an integral part of our system, it is used to detect violations like over speeding, checking of helmets and breaking of signal during Red light.

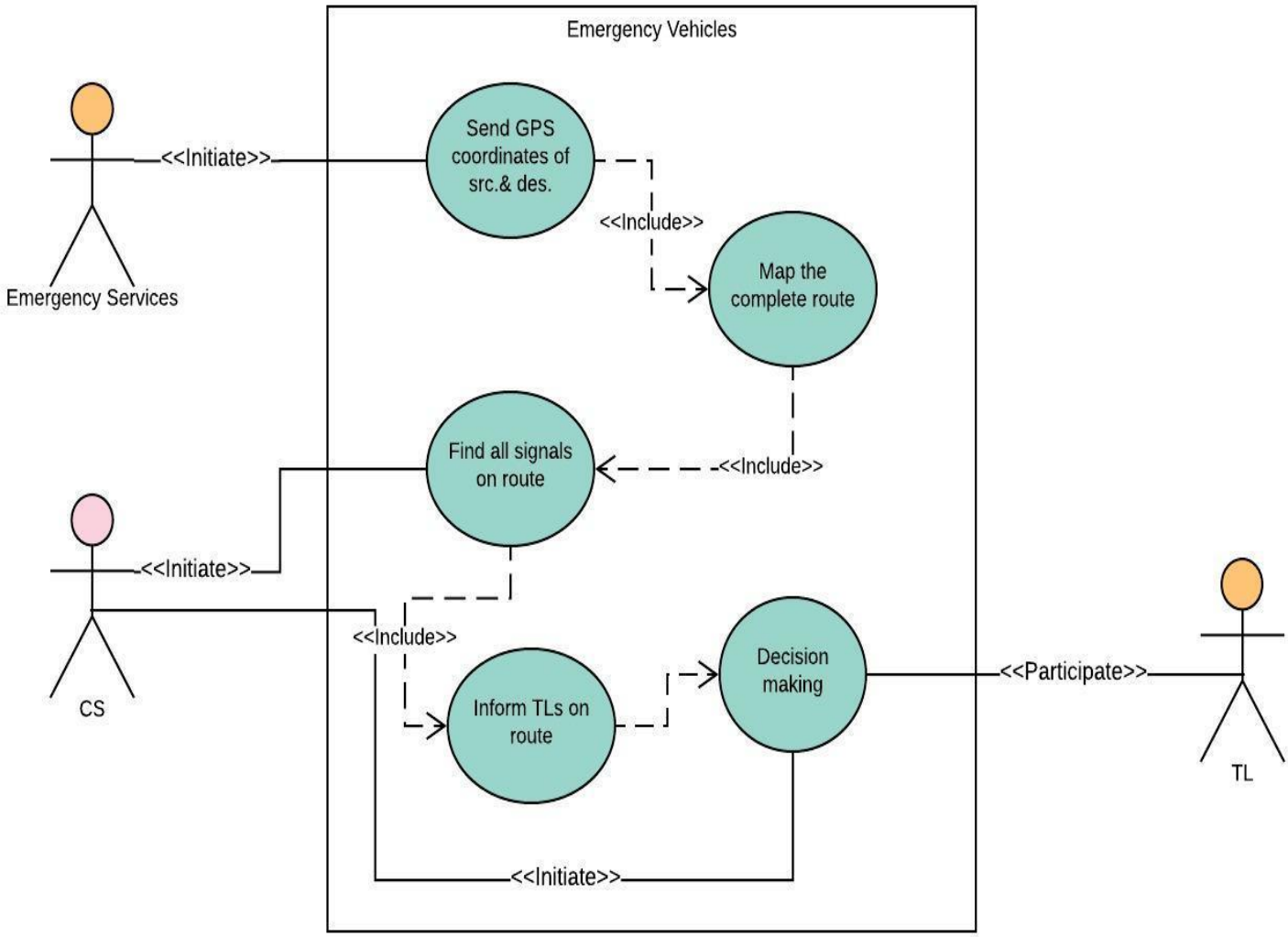
ACTORS:

CCTV Camera: CCTV cameras are those which are installed at intersections to keep an eye on the people who are travelling which will come handy when a violation or a crime takes place.

CS: Centralized Cloud Server is an eternal part of the system as it will be used to keep all the data and to perform the various operations on the live feed.

TL: Traffic Lights are the systems which are connected at intersections. They will be controlled by the CS according to the Decision-making module.

4.3 Emergency Vehicle



The above use case diagram is a part of the main system which describes details about Emergency Vehicles.

The functions which it operates are:

- Send GPS coordinates of source & destination.
- Map the complete route
- Find all signals on route
- Inform TLs on route
- Decision Making

Send GPS coordinates: This function will take the GPS coordinate of the source and the destination of the vehicle

Map the entire route: From the source and the destination the entire path will be mapped and we can find tall the TL on the route.

Find all signals on route: The TLs of the route will be marked which are to be kept Green when the emergency vehicle arrives at the destination to ensure that it can pass without any interruption.

Decision Making: Decision making model will be called and would make sure that the emergency vehicle is given preference.

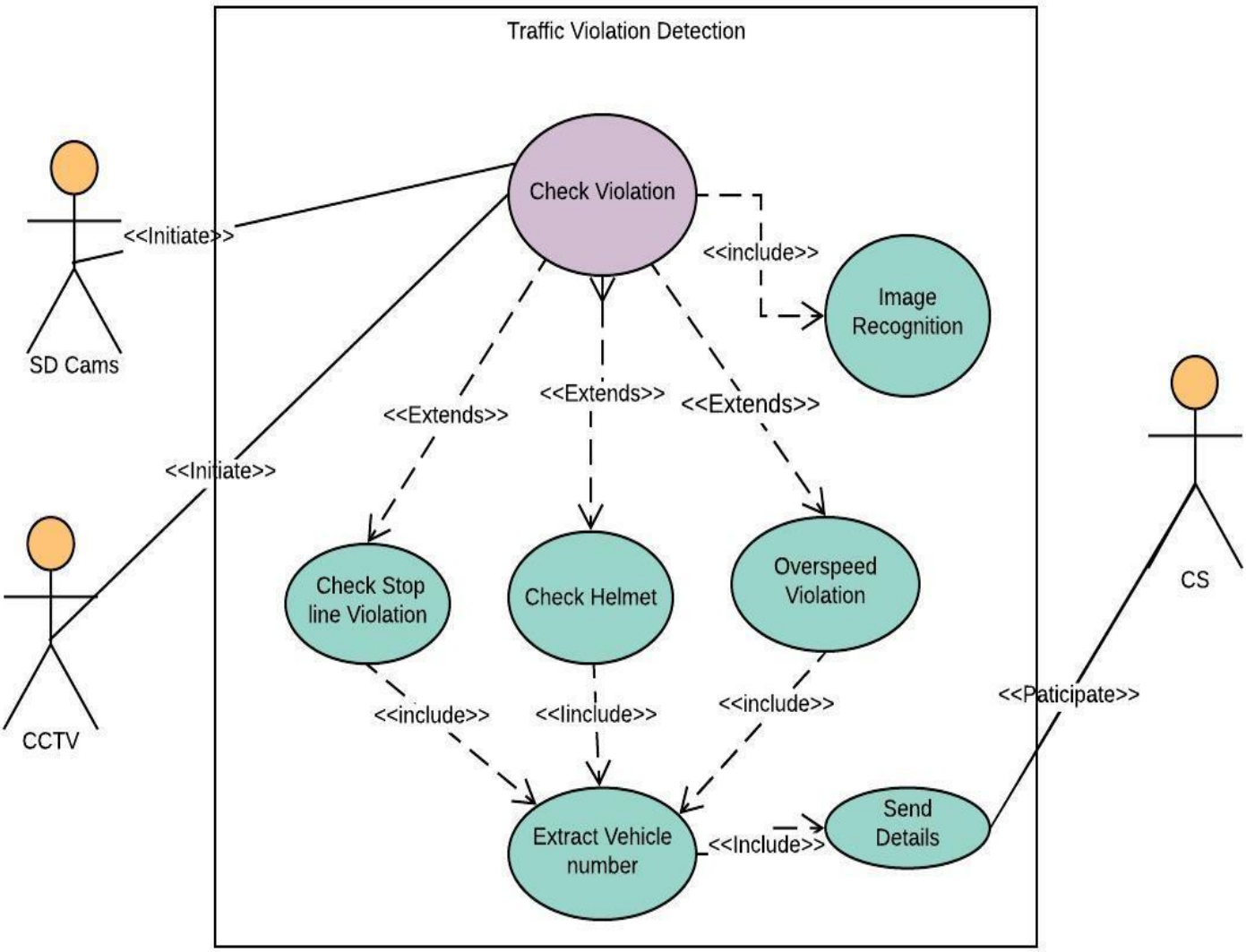
ACTORS:

Emergency Services: Emergency Services like Ambulance, Police etc. needs special access so they can send their GPS coordinates from which they will be provided a green corridor.

CS: Centralized Cloud Server is an eternal part of the system as it will be used to keep all the data and to perform the various operations on the live feed.

SD: SD cameras will read the speed of the running vehicles which will help to find the over speeding vehicles.

4.4 Violation Detection Module



The above use case diagram is a part of the main system which describes details about Traffic Violation Detection.

The functions which it operates are:

- Check Violation
  - ❖ Check Stop Line violation
  - ❖ Check Helmet

- ❖ Overspeed Violation
- Extract Vehicle Number
- Send details to CS.

Check Violation: This function will check if there is any particular type of violation taking place and accordingly invoke the corresponding function. This will take place through already trained dataset of bikers with and without helmet, a virtual stop line will be present and a threshold speed will be set for each intersection.

Extract Vehicle Number: If a violator is caught, then his/her vehicle number must be recorded and should be passed to the concerned authority. So this module will be handling the role of reading the number plate.

Send details to CS: The details will be stored in the CS which will be further passed to the concerned authority for penalizing the culprit.

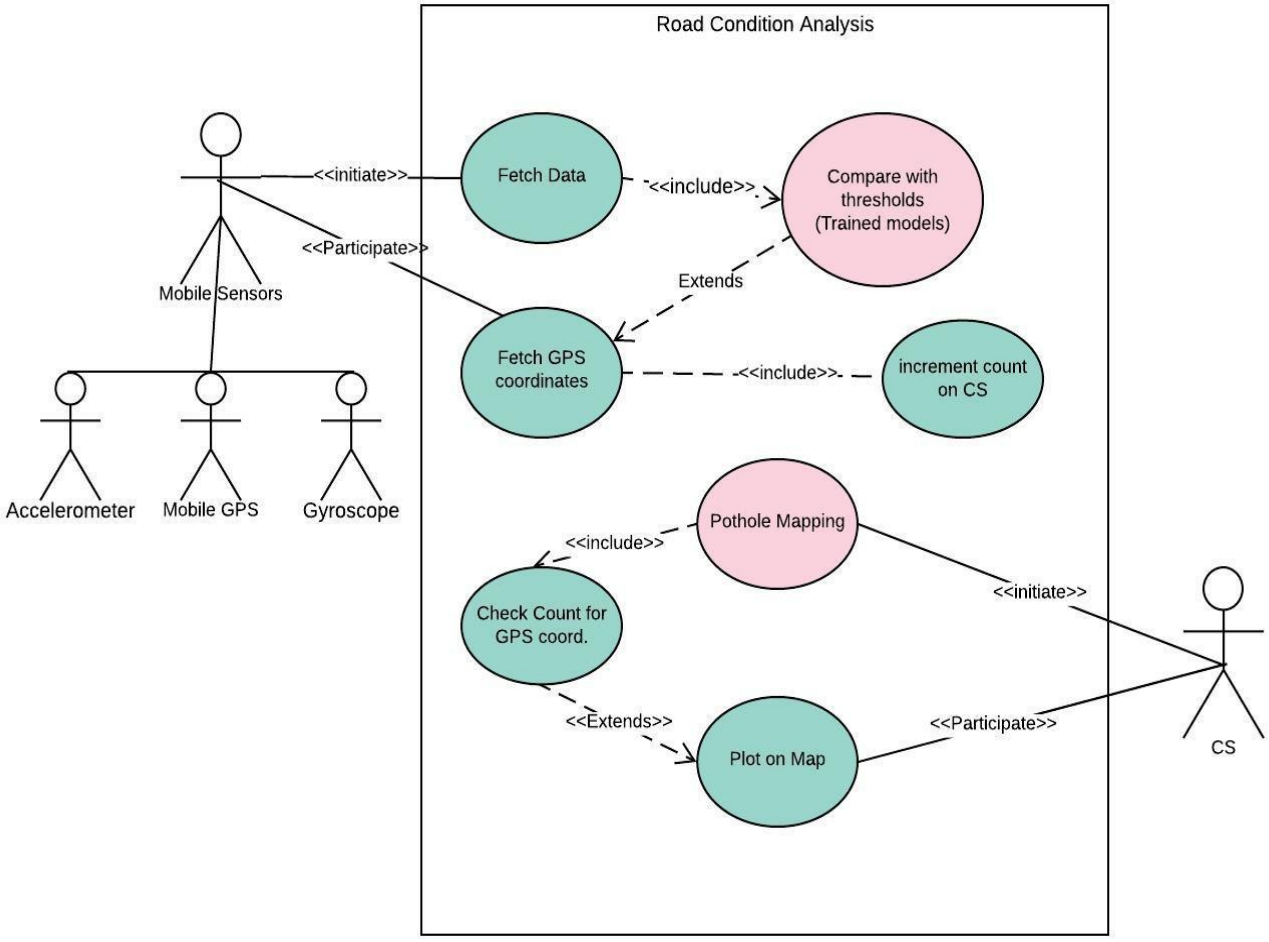
ACTORS:

CCTV Camera: CCTV cameras are those which are installed at intersections to keep an eye on the people who are travelling which will come handy when a violation or a crime takes place.

CS: Centralized Cloud Server is an eternal part of the system as it will be used to keep all the data and to perform the various operations on the live feed.

SD: SD cameras will read the speed of the running vehicles which will help to find the over speeding vehicles.

4.5 Road Analysis Module



The above use case diagram is a part of the main system which describes details about Road Condition analysis. The functions which it operates are:

- Fetch data
- Compare threshold
- Fetch GPS coordinates
- Increment count on CS
- Pothole Mapping
- Plot on Map
- Check count for GPS coordinate

Fetch Data: Data which was recorded from mobile phones sensors like accelerometer, gyroscope sensor and GPS sensor is fetched and regularly observed.

Compare threshold: The data which is been recorded by the mobile sensors is continuously observed and measured with threshold.

Fetch GPS coordinate: Once the reading says that there is a pothole or road is affected then the GPS location is marked.

Increment Count on CS: The counter of the particular GPS location is incremented.

Pothole Mapping: If a location has been marked with a pothole then it has to be mapped on the google maps for which its API will be used.

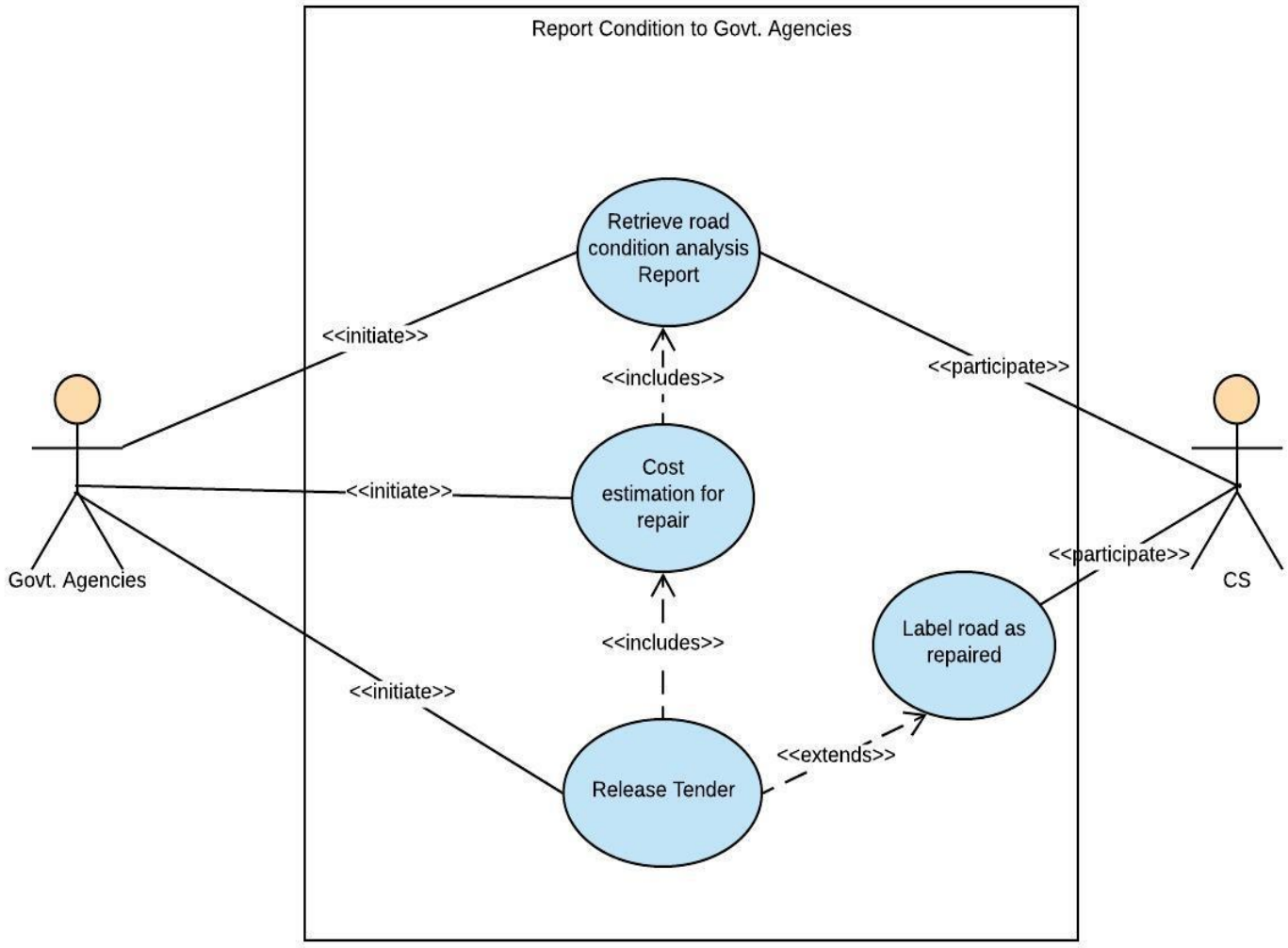
Check count for GPS coordinate: This model is to check whether the same GPS coordinate has been already marked by the other passengers. If it is marked by more than 10 passengers then only that particular location will be marked on the map.

ACTORS:

Mobile Sensors: Sensors of mobiles will be used to mark down the road condition. Gyroscope and accelerometer will be used so that whenever a heavy vibration comes on the vehicle it will help to detect the pothole by changing its observation. A model will be trained according to the past trends of these sensors.

CS: Centralized Cloud Server is an eternal part of the system as it will be used to keep all the data and to perform the various operations on the live feed.

4.6 Report Conditions for repair work



The above use case diagram is a part of the main system which describes details about Report Conditions of road to Govt. Agencies.

The functions which it operates are:

- Retrieve road condition report
- Cost estimation for repair
- Release Tender
- Mark road as repaired.

Retrieve road condition report: Data which was recorded from mobile phones sensors like accelerometer, gyroscope sensor and GPS sensor is used to mark the potholes and accordingly road condition report is generated.

Cost estimation for repair: Previous cost required for similar repair will be saved accordingly the cost estimate for the particular repair will be calculated which will help in generation and selection of tender.

Release Tender: Once the cost has been estimated, the tender for the project must be released and the most suitable tender should be selected seeing all the constraints.

Mark road as repaired: After the completion of the repair work the area should be marked as repaired so that users can again start going from that particular road.

ACTORS:

Govt. Agencies: Agencies which are responsible for the maintenance of roads will be given the detailed reports on the road conditions of the entire region which will help them to select the type of repair work required and to maintain the road as soon as possible.

CS: Centralized Cloud Server is an eternal part of the system as it will be used to keep all the data and to perform the various operations on the live feed.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

The system objective is to achieve a least delay in navigation by implementing strategies of ML, RML and GT in TLs. The delay will be calculated by randomly picking up a vehicle and monitoring the delay during the entire journey. The delay thus obtained will be used for performance evaluation of the system.

In pothole mapping the location accuracy will play a major role. ±5% of error in position will be tolerance limit in mapping.
In object detection system should try to achieve 95% accuracy in terms of vehicle count and 92% in case of violation detection.

5.2 Safety Requirements

The traffic violation detection system might lead to detection of some false positives which might result in problem. This can be prevented by manually analyzing violations detected by the system and thereafter penalizing them. Sometimes, any technical snag can lead to collapse of the system, this can be dealt with providing an option to turn to manual controls.

5.3 Security Requirements

The cloud server is to be made a secure one with only possible access by traffic department and other govt. agencies. For violators, to be penalized authentication will be needed. Initiating procedures like cost estimation and issuing tender will also require authorization. Emergency services will pe provided a secure login to the server for getting priority access.

Appendix A: Glossary

Abbreviations Used:

CS: Cloud Server

Govt: Government

TL: Traffic Lights

ML: Machine Learning

RML: Reinforcement ML

GT: Game Theory

SD: Speed Detection camera

&: and

Appendix B: Analysis Models

Data flow diagrams, class diagrams etc. are under process for this software.