SECJ3553: Artificial Intelligence

Project Proposal - Progress 3

System Name: Smart Traffic Management

Prepared by: **4MG**

Member Name	**Matric Number**
AHMAD JALKHAN MUJAHID BIN AHMAD JAHIDDIN	A21MJ5007
AIRIL HAZIQ BIN AIRIL YASREEN	A21MJ5034
AHMAD HAFIZ ALI BIN HASSAN ALI	A21MJ5012
ADAM ISKANDAR BIN SHARUDIN	A21MJ5041

1. AI Solution

This AI-driven Traffic Management and Optimization solution leverages real-time traffic data, predictive models, and Reinforcement Learning (RL) to create an efficient and adaptive traffic control system. It optimises traffic flow by dynamically adjusting traffic signals, offers commuters a mobile app for real-time route suggestions, employs AI-based incident detection to enhance safety, and optimises public transportation services. User feedback and collaboration with stakeholders ensure continuous improvement. The system mitigates traffic congestion, reduces commuting times, and enhances the overall transportation experience, addressing the needs of both commuters and traffic authorities in the smart city..

2. Goal of AI Solution

I. To reduce traffic congestion, by allowing the traffic lights to adapt to situations, such as heavy rains, traffic accidents and rush hours.
II. Improve traffic safety, by identifying potential hazards, traffic accidents, presence of any emergencies such as ambulances and potential crimes.
III. Provide and receive real-time traffic updates from main cameras and especially third party companies such as Maps and Waze.
IV. Provide comprehensive traffic predictions for the future and apply it on a daily basis.
V. Provide data driven suggestions for future developments, such as potential new routes, lanes and building zones.

3. Process of Emphasise in DT

In the realm of AI-driven traffic management, the key stakeholders include daily commuters, emergency responders, city authorities, and business owners/logistics companies. Their primary goals revolve around reaching their destinations safely, on time, and swiftly, all while ensuring road safety, efficiency, and smooth traffic flow. These stakeholders often encounter traffic congestion, road accidents, and road hazards, leading to frustrations about constant traffic congestion, inaccessibility during emergencies, and dissatisfaction with existing traffic systems, which results in unpredictable delays and inefficiencies. In response, they employ various strategies like carpooling, using public transport, altering plans, or taking alternative routes. They're bombarded with constant complaints and concerns and actively engage in discussions about traffic problems and potential solutions. Emotionally, they grapple with fear of accidents and hazards, frustration, stress, and pressure related to work and travel, while also seeking potential solutions and answers to alleviate these challenges

a. Summary

Who are they?	● Daily commuters ● Emergency responders ● City authorities ● Business owners and logistics
What do they do?	● Reaching their destination safely ● Reaching their destination on time ● Reaching their destination swiftly ● Ensure roads to be safe, efficient and flows smoothly
What do they see?	● Traffic congestions ● Road accidents ● Road hazards
What do they say?	● Frustration on the constant traffic congestions ● Inaccessibility during emergencies ● Subpar traffic systems ● Unpredictable delays and inefficiencies
What do they do?	● Carpooling ● Using public transport ● Delay, alter or cancelling of plans ● Using alternative longer routes
What do they hear?	● Constant complaints and concerns ● Traffic problems and potential solutions
What do they think and feel?	● Fear of accidents and hazards ● Frustration and stress from traffic congestions ● Pressure from work and travelling ● Potential solutions and answers

4. Process of Defined in DT

Commuters and Traffic Authorities share a common challenge of addressing traffic-related issues, albeit from different perspectives. Commuters aim to navigate the roadways efficiently, seeking a safe and expedient journey while minimising delays and stress. Their primary concerns revolve around unpredictable road conditions, accidents, and congestion. On the other hand, Traffic Authorities strive to maintain overall road safety, promptly respond to incidents, and optimise traffic flow during rush hours. Their focus lies in reducing congestion, minimising accidents, and efficiently managing traffic systems. Despite distinct roles, both user groups share a fundamental interest in creating a smoother, safer, and more streamlined commuting experience.

a. Summary

Users	Problem	Pains	Goals	What Matters to Them
Commuters	● Deal with traffic congestion ● Delays ● Accidents ● Unpredictable road conditions.	● Being late ● Dealing with erratic traffic conditions ● Going through stressful delays all happen during the commute.	Travel safely, with as little traffic as possible, and to get to their destinations quickly and on schedule.	Minimal delays, stress-free commute, and reaching destinations faster.
Traffic Authorities	● Control traffic during rush hour ● React quickly to collisions ● Maintain general road safety.	● Managing traffic congestion ● Responding quickly to incidents ● Optimising traffic flow.	Maintain efficient traffic flow, react quickly to problems, and successfully operate traffic lights.	Reducing traffic congestion, minimising accidents, and optimising traffic management.

5. Knowledge Representation (KR)

a. Current Problem

1. Traffic Congestion:
    i. Constant traffic congestion causes frustration for travellers on a daily basis since it results in unpredictable delays and inefficiency.
2. Road Safety Concerns
    i. Road accidents, dangers, and difficulties in effectively regulating traffic flow are encountered by commuters and law enforcement, which have an effect on overall road safety.
3. Inefficient Traffic Management
    i. Stakeholder dissatisfaction originates from the perception that the current transportation systems are inadequate.

b. Proposed Solution

In order to achieve our goal, we have determined the two key aspects that will assist our AI in determining the steps to be taken. First is the use of sensors that will detect the presence of cars on the lanes of the traffic light and the amount of cars that are waiting, in order to determine whether it is congested or not. Second is the use of cameras, to gauge the vision constraint of the area that shall determine if it is raining or foggy, scan for any hazards such as accidents, unsafe objects or crime and lastly the presence of any emergency responders such as the ambulance or police.

From these data, the AI shall analyse and predict the possible effects of such events and give real time updates to the traffic authorities & third party apps and determine which settings of the traffic light to be used. The relevant authorities shall also be contacted whenever a presence of hazards are detected by the camera.

In regards to the settings of the traffic light, the traffic light shall shorten the time of green if there are not more cars detected, or lengthen the time if congestion are detected, depending on the other affecting lanes and traffic lights. Similarly, in case of vision constraint, the traffic light shall be longer when green, with regards to the other affecting lanes and traffic lights, due to the nature of driving during such an event.

Additionally, the traffic lights shall be green when emergency responders are on route. Lastly, the traffic lights timer will take necessary action depending on the type of hazards detected, always prioritising the safety of commuters.

c. KR of the system

Congestion_ Detection (Sensor), S	Vision_Detection (Camera), V			Actions	
S = Empty or Congested (X)	V = Vision Constraint (A)	V = Hazards (B)	V = Emergency Responders (C)	Real_Time_ Update_And _Predictions, UP	Contact_Aut horities, CA
1	1	1	1	1	1
1	1	1	0	1	1
1	1	0	1	1	0
1	1	0	0	1	0
1	0	1	1	1	1
1	0	1	0	1	1
1	0	0	1	1	0
1	0	0	0	1	0
0	1	1	1	1	1
0	1	1	0	1	1
0	1	0	1	1	0
0	1	0	0	1	0
0	0	1	1	1	1
0	0	1	0	1	1
0	0	0	1	1	0
0	0	0	0	0	0

KR 1:

IF (S=X) = TRUE AND (V=A) = TRUE AND (B=A) = TRUE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 2:

IF (S=X) = TRUE AND (V=A) = TRUE AND (B=A) = TRUE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 3:

IF (S=X) = TRUE AND (V=A) = TRUE AND (B=A) = FALSE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 4:

IF (S=X) = TRUE AND (V=A) = TRUE AND (B=A) = FALSE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 5:

IF (S=X) = TRUE AND (V=A) = FALSE AND (B=A) = TRUE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 6:

IF (S=X) = TRUE AND (V=A) = FALSE AND (B=A) = TRUE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 7:

IF (S=X) = TRUE AND (V=A) = FALSE AND (B=A) = FALSE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 8:

IF (S=X) = TRUE AND (V=A) = FALSE AND (B=A) = FALSE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = FALSE.

KR 9:

IF (S=X) = FALSE AND (V=A) = TRUE AND (B=A) = TRUE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 10:

IF (S=X) = FALSE AND (V=A) = TRUE AND (B=A) = TRUE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 11:

IF (S=X) = FALSE AND (V=A) = TRUE AND (B=A) = FALSE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 12:

IF (S=X) = FALSE AND (V=A) = TRUE AND (B=A) = FALSE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 13:

IF (S=X) = FALSE AND (V=A) = FALSE AND (B=A) = TRUE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = TRUE.

KR 14:

IF (S=X) = FALSE AND (V=A) = TRUE AND (B=A) = FALSE AND (C=A) = FALSE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 15:

IF (S=X) = FALSE AND (V=A) = FALSE AND (B=A) = FALSE AND (C=A) = TRUE THEN (UP=A) = TRUE, (CA=A) = FALSE .

KR 16:

IF (S=X) = FALSE AND (V=A) = FALSE AND (B=A) = FALSE AND (C=A) = FALSE THEN (UP=A) = FALSE , (CA=A) = FALSE .

d. Explanation KR

KR 1:

If the sensors detect that the lanes are empty or are congested and the camera detects a vision constraint, presence of hazards and the presence of emergency responders, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 2:

If the sensors detect that the lanes are empty or are congested and the camera detects a vision constraint and presence of hazards, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 3:

If the sensors detect that the lanes are empty or are congested and the camera detects a vision constraint and the presence of emergency responders, the system will make new predictions and give real time updates & change the traffic light settings.

KR 4:

If the sensors detect that the lanes are empty or are congested and the camera detects a vision constraint, the system will make new predictions and give real time updates & change the traffic light settings.

KR 5:

If the sensors detect that the lanes are empty or are congested and the camera detects the presence of hazards and the presence of emergency responders, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 6:

If the sensors detect that the lanes are empty or are congested and the camera detects a presence of hazard, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 7:

If the sensors detect that the lanes are empty or are congested and the camera detects the presence of emergency responders, the system will make new predictions and give real time updates & change the traffic light settings.

KR 8:

If the sensors detect that the lanes are empty, the system will make new predictions and give real time updates & change the traffic light settings.

KR 9:

If the camera detects a vision constraint, presence of hazards and the presence of emergency responders, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 10:

If the camera detects a vision constraint and presence of hazards, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 11:

If the camera detects a vision constraint and the presence of emergency responders, the system will make new predictions and give real time updates & change the traffic light settings.

KR 12:

If the camera detects a vision constraint, the system will make new predictions, give real time updates & change the traffic light setting.

KR 13:

If the camera detects the presence of hazards and the presence of emergency responders, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 14:

If the camera detects a presence of hazards, the system will make new predictions, give real time updates & change the traffic light settings, and contact the authorities.

KR 15:

If the camera detects the presence of emergency responders, the system will make new predictions, give real time updates & change the traffic light settings.

KR 16:

If the sensors and cameras do not detect anything, the traffic light will use the default setting..

e. First Order Logic (FOL)

- CarPresence(x, lane): Predicate indicating the presence of a car x in lane lane.
- WaitingCarsCount(lane, count): Predicate indicating the count of waiting cars in lane lane.
- Congested(lane): Predicate indicating that the lane lane is congested.
- VisionConstraint: Predicate indicating a vision constraint due to rain or fog.
- HazardDetected: Predicate indicating the presence of hazards such as accidents or unsafe objects.
- EmergencyRespondersPresent: Predicate indicating the presence of emergency responders.
- TrafficLightSettings(lane, colour, duration): Predicate indicating the settings of the traffic light for lane lane, with colour (red, green, yellow) and duration.
- ContactAuthorities: Predicate indicating the need to contact relevant authorities.

I. Car Detection and Congestion:

A. (CarPresence(x, lane) =>WaitingCarsCount(lane, count)

B. (WaitingCarsCount(lane, count) ^ count > threshold =>Congested(lane)

II. Vision Constraint and Hazard Detection:

A. (VisionConstraint => HazardDetected)

III. Emergency Responders:

A. (EmergencyRespondersPresent => TrafficLightSettings(lane, green, duration)

IV. Traffic Light Settings:

A. (Congested(lane) => TrafficLightSettings(lane, red, duration)

B. (VisionConstraint => TrafficLightSettings(lane, green, longer_duration)

C. (HazardDetected => (TrafficLightSettings(lane, red, duration) ^ ContactAuthorities)

V. Real-time Updates:

A. (Congested(lane) => RealTimeUpdate(TrafficAuthorities, ThirdPartyApps)

B. (HazardDetected => RealTimeUpdate(TrafficAuthorities, ThirdPartyApps)

f. How KR solves the goal

1) Solving Traffic Congestion

KR rules (KR 1 to KR 8) address situations where the sensors detect congestion or emptiness in the lanes. In response, the system forecasts future events, provides real-time information, and modifies traffic light settings as necessary. This is in line with the objective of minimising traffic jams by dynamically adjusting traffic light timings in response to actual traffic situations.

2) Ensuring Safety and Hazard Detection

KR rules (KR 1, KR 2, KR 5, KR 6, KR 13, KR 14) incorporate camera data (Vision_Detection) to identify hazards, accidents, and emergency responders. The technology not only modifies traffic signals to accommodate emergency responders or hazards, but it also notifies authorities to ensure prompt action. This is in line with the objective of enhancing traffic safety through the rapid resolution of possible dangers.

3) Vision Constraints and Weather Conditions

KR rules (KR 1 to KR 4, KR 9 to KR 12) consider vision constraints (such as rain or fog) detected by cameras. Based on these circumstances, the system modifies the traffic light settings to make sure that the lights are adapted to account for decreased visibility. This is in line with the objective of offering a complete solution that takes the weather into account for the best possible traffic management.

4) Real-time Updates and Predictions

The Real_Time_Update_And_Predictions action (UP) is triggered in various KR rules, making certain that traffic authorities and other apps receive constant real-time updates and forecasts from the system. This is in line with the objective of improving overall situational awareness by sending and receiving real-time traffic updates.

5) Contacting Authorities

The Contact_Authorities action (CA) is triggered in specific KR rules (e.g., KR 1, KR 5, KR 13) when hazards or emergencies are detected. This helps achieve the objectives of increased safety and prompt incident response by ensuring that pertinent authorities are notified as soon as possible.

6) Adaptive Traffic Light Settings

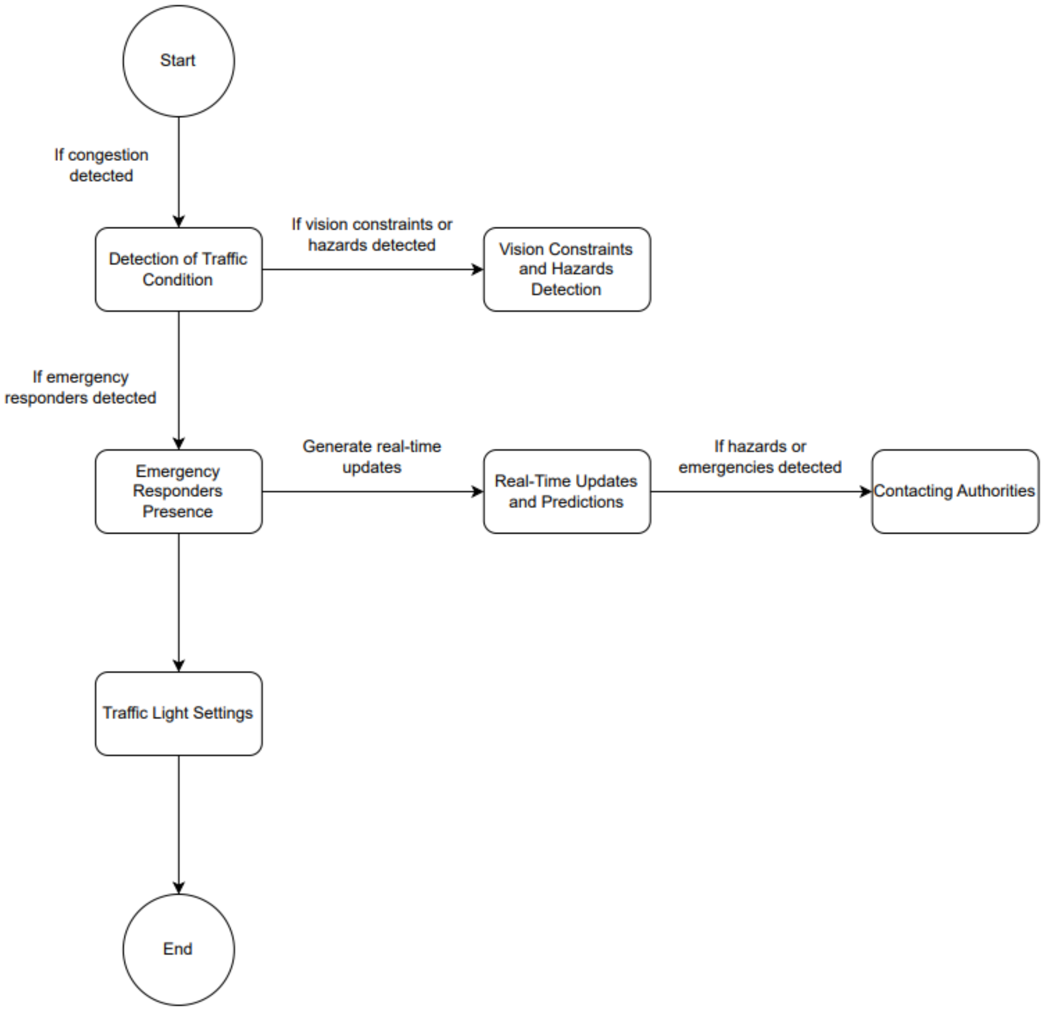
The KR rules specify how sensor and camera data should be used to modify the traffic signal settings. For instance, the green light duration could be shortened if congestion is found (KR 1). In the event of dangers, the system may respond differently according to the particular circumstances (KR 5, KR 13). This is consistent with the objective of optimising traffic flow through dynamic adaptation of traffic light timings.

6. Process of Emphasise in DT

a. States and Actions

States No.	State Name	Description	Action
1	Detection of Traffic Conditions	The system detects the presence of traffic congestion through the use of sensors.	If it is detected, the system proceeds to the next state. If there is no congestion, traffic settings remain as usual.
2	Vision Constraints and Hazard Detection	The system checks for vision constraints due to rain, fog, etc., and the presence of any hazards, through the use of cameras.	If vision constraints or hazards are detected, the system proceeds to the next state. If not, traffic settings remain as usual.
3	Emergency Responders Presence	The system checks for any presence of emergency responders, using cameras.	If emergency responders are detected, the system proceeds to the next state. If otherwise, traffic settings remain as usual.
4	Real-Time Updates and Predictions	The system generates real-time updates and predictions, based on the detected conditions in the previous states.	The system proceeds to the next state.
5	Contacting Authorities	The system determines whether authorities need to be contacted.	If hazards or emergencies are detected, the system contacts the relevant authorities. If not, the system proceeds to the next state.
6	Traffic Light Settings	The system adjusts traffic light settings based on the detected conditions.	The traffic light settings are modified according to the analysis of the current conditions.

b. Graph Representation



c. Problem Formulation

Components/Facets	Issue	Problem Formulation
Traffic Congestion	Congestion causes inefficient traffic flow, which causes delays and annoyance for commuters.	How can the system effectively detect and manage traffic congestion to optimum traffic flow?
Road Safety and Hazard Management	In order to guarantee road safety, the system must identify potential threats and adjust to visual impairments brought on by inclement weather.	How can the system quickly detect dangers, like collisions or weather-related vision impairments, to improve commuter road safety?
Emergency Response Coordination	Effective handling of emergencies requires quick reaction times and good communication with emergency responders, such as police and ambulances.	What is the fastest way for the system to recognise and react to emergency responders in order to maintain safety and efficient traffic flow during an outbreak?

d. Solution of Problem

Component	Problem Formulation	Relation with KR
Traffic Congestion	How can the system effectively detect and manage traffic congestion to optimise traffic flow?	States 1 (Detection of Traffic Conditions) and 6 (Traffic Light Settings) correspond to this problem formulation. The KR focuses on detecting congestion through sensors (State 1) and adjusting traffic light settings based on detected conditions to alleviate congestion (State 6).
Road Safety and Hazard Management	How can the system quickly detect dangers, like collisions or weather-related vision impairments, to improve commuter road safety?	States 2 (Vision Constraints and Hazard Detection) and 6 (Traffic Light Settings) correspond to this problem formulation. The KR involves checking for vision constraints and hazards using cameras (State 2) and adjusting traffic light settings to accommodate these conditions (State 6) for enhanced road safety.
Emergency Response Coordination	What is the fastest way for the system to recognize and react to emergency responders to maintain safety and efficient traffic flow during an outbreak?	States 3 (Emergency Responders Presence), 4 (Real-Time Updates and Predictions), and 5 (Contacting Authorities) correspond to this problem formulation. The KR involves detecting emergency responders using cameras (State 3), generating real-time updates based on detected conditions (State 4), and contacting authorities if hazards or emergencies are detected (State 5) to ensure efficient traffic flow and safety.

e. How the problem is formulated to support the proposed KR

- **Traffic Congestion**: The KR involves using sensors to detect congestion as shown in State 1 and adjusting traffic light settings based on detected conditions to alleviate congestion as shown in State 6.
- **Road Safety and Hazard Management**: The KR includes checking for vision constraints and hazards using cameras as shown in State 2 and adjusting traffic light settings to accommodate these conditions for enhanced road safety as shown in State 6.
- **Emergency Response Coordination**: The KR involves detecting emergency responders using cameras as shown in State 3, generating real-time updates based on detected conditions as shown in State 4, and contacting authorities if hazards or emergencies are detected as shown in State 5 to ensure efficient traffic flow and safety.

7. Intelligent Agent - PEAS Model

a. Comparisons

PEAS Model	Before	After
P: Performance Measure	● Frequent traffic congestion resulting in delays and frustration among road users. ● Inefficient response to road safety issues and hazards ● Lack of cohesion among emergency responders during emergencies.	● A smoother flow of traffic due to better management of traffic ● An improved road safety by quickly identifying and responding to traffic hazards. ● An enhanced coordination mechanism among emergency responders for a better accidents handling processes
E: Environment	● Unpredictable traffic conditions, hazards and accidents ● Lack of adaptive traffic light based on outside conditions, especially weather.	● Real-time monitoring and adaptation of traffic lights ● Specific responses to vision constraints, hazards and emergencies ● Enhanced coordination with third parties
A: Actuators	● Lack of adjustment to traffic lights based on outside conditions	● Automated adjustment of traffic lights based on real-time data ● Coordinated response to

	● Inefficient mechanism to identify emergency situations	emergencies with the adaptive traffic lights
S: Sensors	● Lack of real-time data on traffic conditions and surrounding conditions ● Limited awareness on the situations on the ground	● Cameras detecting traffic congestions ● Cameras identifying vision constraints, hazards and the presence of emergency responders ● Continuous monitoring and feedback for real-time decision making and third party use

b. PEAS Model

Agent: AI-Driven Traffic Management and Optimization System

I. <u>Performance</u>

- Minimise traffic congestion and delays.
- Enhanced road safety through quick hazard detection.
- Efficient coordination with emergency responders.
- Improved overall transportation experience.

II. <u>Environment</u>

- Real-time monitoring of traffic conditions.
- Adaptive response to changing weather conditions, incidents, and emergencies.
- Collaboration with daily emergency responders, city authorities and third parties.

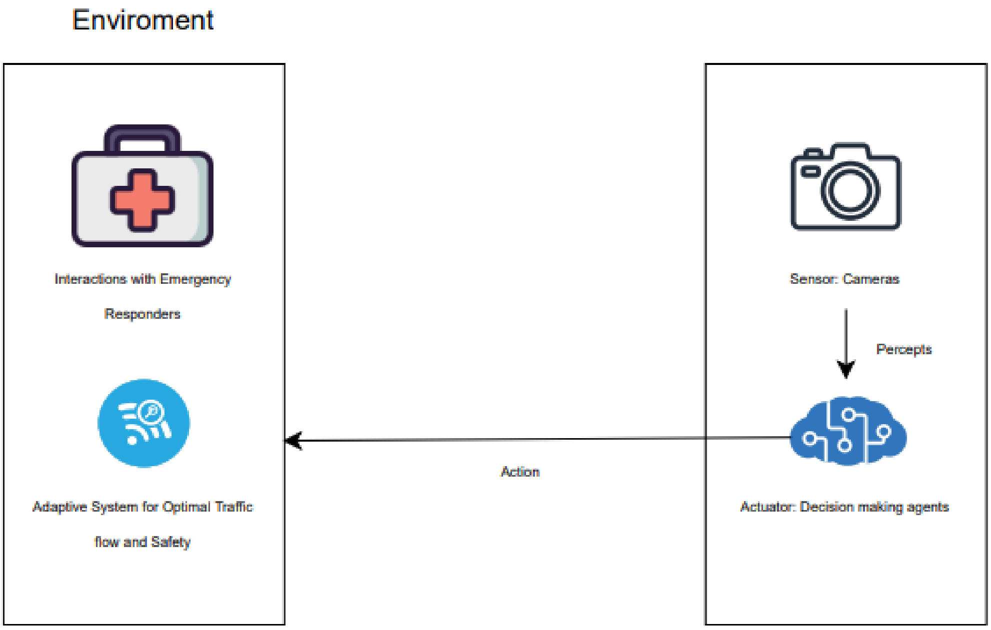
III. <u>Actuator</u>

- Automated adjustment of traffic lights based on real-time data.
- Coordinated communication systems for real-time updates.

IV. <u>Sensors</u>

- Cameras detecting traffic conditions, congestion, and waiting counts.
- Cameras identifying vision constraints, hazards, and emergency responders.
- Communication systems providing real-time updates to third parties and authorities..

c. PEAS Model Diagram



d. Representation in Proof of Concept (POC)

A Proof of Concept (POC) depiction, based on the PEAS (Performance, Environment, Actuator, Sensors) model, describes the actions of the AI-driven Traffic Management and Optimization System agents.

- **Performance**

  a. <u>Data Analysis and Prediction</u>

     i. Real-time data from cameras and sensors is accurately analysed by AI agents.

     ii. Based on the situations that have been observed, make forecasts (traffic congestion, risks, crises).

     iii. Predictive models can be used to anticipate possible traffic problems and make necessary adjustments.

  b. <u>Traffic Light Settings Adjustment</u>

     i. Make decisions by adjusting traffic lights dynamically in response to data analysis.

   ii. Give priority to adjusting traffic lights in order to reduce gridlock and improve traffic flow.

c. <u>Enhancing Safety during Adverse Conditions</u>
   i. Ensure the system can adjust to different situations, particularly bad weather.
   ii. Increase safety by modifying traffic light settings accordingly when visibility is limited due to precipitation or fog.

d. <u>Prioritising Emergency Response</u>
   i. Give emergency vehicles priority in traffic and change the lights to make it easier for them to pass.

- **Environment**
  a. <u>Interactions with Emergency Responders</u>
     i. Create systems for coordination and communication with emergency responders.
     ii. Make sure the traffic management system adjusts to the circumstances in order to respond effectively during emergencies.

  b. <u>Adaptive System for Optimal Traffic Flow and Safety</u>
     i. To provide the best possible traffic flow and safety, let the system adjust to changing environmental conditions.

- **Actuator**
  a. <u>Decision-Making Agents</u>
     i. AI agents make decisions based on forecasts and data analysis.
     ii. Adjust traffic signal settings dynamically to deal with traffic jams or safety issues.

- **Sensors**
  a. <u>Data Collection and Analysis</u>

i. Sensors evaluate wait times, spot possible dangers, and detect the presence of cars.
ii. The decision-making processes of AI agents are informed by collected sensor data, which enables them to dynamically modify traffic signal settings for the best possible traffic management.

b. Camera Contributions
   i. Cameras help by monitoring the presence of emergency responders, detecting threats, and analysing vision restrictions (such as rain or fog).
   ii. Camera data enhances the system's responsiveness by offering perceptions of the surroundings and any threats.

This proof of concept shows how the AI agents act in the system, using information from cameras and sensors to make judgments in real time, dynamically modify traffic signals, and give safety and traffic flow issues top priority in response to shifting environmental circumstances.

e. How agents in AI behave in the proposed system?

i. Performance

- Analyse data from sensors and cameras accurately.
- Make real-time predictions.
- Adjust traffic light settings accordingly.

ii. Environment

- Interactions with emergency responders.
- Ensuring that the traffic management system adapts to varying scenarios to maintain optimal traffic flow and safety.

iii. Actuator

- Act as decision-makers.
- Dynamically modifying traffic signals to alleviate congestion.
- Enhance safety during adverse weather conditions.
- Prioritise emergency response vehicles.

iv. Sensors

- Detect the presence of cars, measure waiting times, and identify potential hazards.
- The data collected from sensors inform the AI agents' decision-making process, allowing them to dynamically adjust traffic light settings.
- Cameras contribute to vision constraints analysis, hazard detection, and monitoring emergency responder presence, further enhancing the system's responsiveness.