ECS427U Professional and Research Practice

Assignment 3 – Group Technical Thinking & Writing Task

Group - 2.13

MEMBERS:
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ROLES TAKEN ON IN LAB ACTIVITIES:

Member	**Lab 5**	**Lab 6**	**Lab 7**	**Lab 8**
1 Mohammed Mahdi Ahmed	*Questioner*	*Scribe*	*Questioner*	*Scribe*
2 Rilwan Adeniji	Manager	Scribe	Questioner	Manager
3 Kieran Barber	Scribe	Manager	Recorder	Questioner
4 Dennis Singh	Questioner	Scribe	Manager	Scribe
5 Emmanuel Olabanji	Manager	Questioner	Recorder	Questioner
6 Emmanuel Learmount	Scribe	Manager	Questioner	Scribe

TEAM CONTRIBUTION STATEMENT

For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1 to 4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column.

Evaluation criteria	**1**	**2**	**3**	**4**	**5**	**6**

Attends group meetings regularly and arrives on time.	2	3	4	2	4	1
Contributes meaningfully to group discussions.	2	4	4	3	3	2
Completes group assignments on time.	3	4	4	3	4	2
Prepares work in a quality manner.	3	4	4	4	4	2
Demonstrates a cooperative and supportive attitude.	3	4	3	4	4	2
Contributes significantly to the success of the project.	3	4	4	4	4	3
TOTAL	16	23	23	20	23	12

Feedback on team dynamics:

How effectively did your group work? When our team met together, we worked well as a group and made sure our work was done each week. I think we can all agree that our communication could have been better during this assignment but in the end we always made sure our work was completed. Taking up different roles during the labs was also useful, as someone could focus on writing while others focused on managing our work.
Were the behaviors of any of the team members particularly valuable or detrimental to the team? Please explain. Members that took up a planning role were useful, making sure people knew what work they had to complete each week so that the group did not fall behind . Some people produced more work than others however everyone was useful in the completion of the assignment.
What did you learn about working in a group from this project that you will carry into your next group experience? The groundwork for how the group is going to work needs to be set out early in order to be the most successful throughout the course of working together, for example laying out a schedule of when work needs to be completed to avoid rushing and compromising the quality of our work.

PART A: PROBLEM DEFINITION:

A1. Problem Statement & Project Aims:

The system must measure the density of traffic at intersections using motion sensors in conjunction with image recognition software to provide data to calculate the amount of road users at the intersection. The image recognition software will classify the road users by types of transport that it has been trained to recognise, such as distinguishing between emergency vehicles and regular commuters. The system must make data informed intelligent decisions to direct users between intersection points to reduce the number of users at certain points of the road network. The data is communicated between the nodes on the traffic network (each intersection) in the form and an activity level measurement that is calculated by applying a vector to the base activity level of an intersection. The vector is calculated using the integer provided by the motion sensors and multiplying it by the base activity level of each intersection.

- The intelligent traffic lights will change to red after 1 minute when a pedestrian has pushed the button at the side of the traffic light post.[1]
- The intelligent traffic light system will have motion sensors on top of existing traffic lights.
- The motion sensors in the intelligent Traffic light system must be able to detect the number of vehicles, bikes and pedestrians in the roads and intersection.[2]
- The motion sensors in the Traffic light system must be able to detect whether the vehicles passing by the traffic lights or stop at it are emergency vehicles (fire trucks, ambulances and police cars) from ordinary vehicles to change time cycles to make them green sooner to allow those vehicles to not get stuck in traffic jams too long, all done with image recognition software.
- The intelligent traffic light system will need an algorithm that changes traffic lights to green at best times to allow lots of vehicles through especially emergency vehicles.[3]
- The intelligent traffic light system must be able calculate the speed of pedestrians and approaching vehicles by taking pictures at a fixed time.
- The intelligent traffic light system must be able to change traffic lights to green to reduce the amount of congestion in the intersection, road where the sensors and traffic lights are located.[4]
- The intelligent traffic light system must change traffic lights to green when the traffic jam gets very big (around 1km).
- There must be a backup system of a regular traffic light system to take place of the intelligent traffic light system in the case the sensors stop functioning within their intended purpose, to prevent traffic jams across the whole city.
- The traffic light system must be able to communicate with each other within a 1.5km radius using infrared emitters and deation to change traffic lights to green more frequently if the areas where traffic lights that carry traffic inform are stationed have lots of vehicles passing by. [5]

- The intelligent traffic light system must make the traffic light change to red when multiple very fast vehicles (around 90mph) are going to collide in an intersection or on a road.

A2. User Requirements

- Priority management ie to buses and emergency vehicles.
    - The work is designed to develop a density based dynamic traffic signal system. The signal timing changes automatically on sensing the traffic density at the junction. The whole system, when installed on road, provides a way for easy traffic clearance for emergency vehicles without a need for manual detection. [7]
- Safety standards met.
    - Intelligent traffic lights when implemented are created around the safety of the user ensuring traffic is safer as the flow of traffic is improved, the environmental impact is reduced and the facilitate accessibility and livability of cities. traffic lights to emergency vehicles with blue lights.[8]
- Accessible for people that cannot see the colour of the light.
    - Lights set out in a way that is understandable, for example stop at the top and go at the bottom, regardless of their colour.
- Priority for bikes and pedestrians.
    - For example if a high number of idle/waiting pedestrians is recognised, then turn lights to red and allow them to cross. And if there is a high volume of cyclists, then allow them to progress through the traffic by having the cyclist lights turn green and the regular lights remaining red.
    - Numbers of cyclists and pedestrians will be ascertained by combining data from image recognition software and motion sensors.
- Bike lane lights.
    - Fitted on the traffic lights but in view of the eyeline of cyclists that indicate the traffic signals but only for the cyclists and not other vehicles to allow separate control over bikes and others.
- Mitigate traffic jams.
    - For example if there are backed up traffic jams along the main road, then the data gathered by our sensors and image recognition software will recognise this and the decision will be made to direct traffic another route using the traffic signals turning from green to red at certain points along the roads. [9]
- Ensure vehicles are operated at their maximally efficient speed and separation distance.
    - Through the use of of the motion detection technology the flow of traffic is impacted ensuring that traffic is controlled and all road users safety in driving is not compromised in any way whilst ensuring that certain road users are prioritised including emergency services, cyclists and pedestrians.

A3. Constraints

- New and updated traffic management systems could encourage more people to use the roads and be counterproductive, disincentives people to use other types of transport such as bikes and walking as the experience of travelling by car is improved.
- Can only be as efficient as the road layouts and population allow as more complex road layouts may hinder the systems performance.
  - The performance of the system is bottlenecked by the current infrastructure of the street. Installing new systems may be costly or not be possible in certain cases.
  - Where older roads or infrastructure exist, performance of the traffic light system may not be improved by installing newer traffic lights.
- Higher complexity means a higher risk of failure
  - Whilst human error is removed from the use of AI the complexity of the system needed for intelligent traffic lights makes it more prone to dysfunctioning and failure.
- Expensive to maintain and update as you will need to hire lots of trained workers and technicians to do the tasks.
- Adjustment - the implementation of intelligent traffic lights will be a long process especially when implemented on a whole city, consequently this will potentially lead to roads being closed for certain times and so forth generating a lot of traffic.

What tasks the system need to perform:

- Control the flow of traffic
  - Based on user activity and current congestion, directs users around a network of traffic signals to reduce time spent waiting on roads.
  - Adaptable to abnormal weather conditions like harsh rain and snow could cause significant traffic slowdowns.
  - prioritise emergency vehicles and bikes over cars.
  - Gather and analyse data from cameras.
  - Detect cars and trigger individual traffic lights.

- Made of traffic lights (output), cameras and sensors (input).
- Needs to successfully manage the flow of traffic around a large network of intersections and traffic lights to reduce congestion.
- The system will be implemented in urban areas where traffic is a prime issue to road users in their commute and general journeys therefore the application of intelligent traffic lights will face this issue head on and provide an eco friendly solution.
- The system is made of technology set up by specialist engineers which makes use of AI technology, motion censoring etc to provide a system that removes the use of an outdated manual trafficking system.
- The system is used regularly by commuters and road users as normal traffic management infrastructure. The traffic lights have a number of features to direct traffic and ensure further safety and performance enhancements.

User requirements: how the system will be used, plus constraints:

User requirements:
- Priority management eg to busses and emergency vehicles
- Safety standards met
- Accessible for people that cannot see colour of light
- Priority for bikes and pedestrians
- Bike lane lights
- Mitigate traffic jams
- Ensure vehicles are operated at their maximally efficient speed and separation distance

Tasks of the system: various functions of the system or its parts:

What tasks will the system need to perform:
- Control the flow of traffic
  - Based on user activity and current congestion, directs users around a network of traffic signals to reduce time spent waiting on roads
  - Adaptable to abnormal weather conditions like harsh rain and snow could cause significant traffic slowdowns
  - prioritise emergency vehicles and bikes over cars
  - Gather and analyse data from cameras
  - Detect cars and trigger individual traffic lights

Entities, i.e. parts (of the system architecture): focus on logical subsystems first - i.e. their purpose and function - then consider how they can be physically divided (if applicable) - i.e. do these functions reside in physically separate parts of the system?

- traffic lights (output)
- cameras and sensors (handle input)
- Users (input)

PART B: SYSTEM REQUIREMENTS:

B1. Input/Output Requirements:

System inputs:

- Pedestrian push button
    - A button at the pedestrian waiting zones that when pressed will indicate there are pedestrians waiting to cross.
    - Works almost as a fail safe incase the pedestrians are out of view by the image recognition software input cameras or it is malfunctioning
- Inputs to the system are provided by motion detection sensors
    - Detects the and measures the activity of certain areas that would supplement the calculation of traffic density to inform the decisions to redirect traffic.
    - Density encoded as a percentage that is applied to the base level measured at each intersection point to work out the overall activity of the location.
    - The sensor has an ultrasonic sender/receiver that measures the sound waves it receives back after emitting them to detect objects in its field of view.
- Image recognition software provides data to the system such as types of vehicles waiting, this data combined with the data gained from the motion sensors would give a more accurate reading of the density of the traffic
    - The data provided will be in the form of an integer simply stating the number of each vehicle recognised. This will be done by classifying the vehicle by its type i.e. emergency, truck, car or bus, and collecting the number of each of them currently in view.

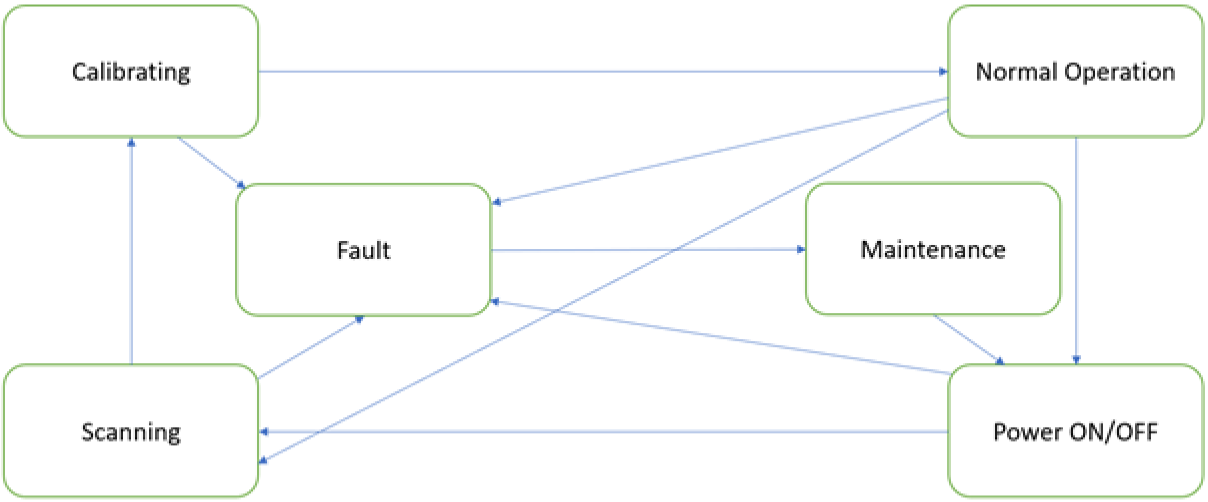
System outputs:

- Light bulbs in the traffic lights
    - Change the schedule of when the light bulbs change in traffic lights according to the current activity in the area from sensors.
    - Change to red light when the pedestrian has pressed the button to cross the road.
- Data produced as an output:
    - Electrical signal sent to the bulb to tell switches in the circuitry whether it needs to be turned on or off.
    - Data gathered from motion detectors and image recognition software (that is previously stated).

B2. Operational requirements:

- There are 6 operation modes: Power On/Off, Scanning, Processing, Normal Operation, Fault and Maintenance.
- Power On/Off: The traffic light system boots up all the sensors
- and traffic lights.
- Scanning: The sensors start taking images of incoming/outgoing vehicles, pedestrians and emergency vehicles specifically.

- Processing: The system will process taken images to classify vehicles and measure the activity in the area and change traffic light time cycles to better regulate traffic flow, especially for emergency vehicles.
- Normal Operation: The system will have traffic lights change on their new time cycles to regulate traffic flow.
- Fault: There's any electrical faults or software glitch in any of the 4 states of the system.
- Maintenance: To fix any electrical faults or software glitch in any of the 4 states of the system.



B3. Functional Requirements:

How does the sensor:

- Change light colour.
  - Send an electronic signal to indicate which light colour to light up.
- Measure pedestrian volume.
  - Image recognition software that recognises which objects in the photo are pedestrians, and which of those pedestrians are waiting to cross at the intersection observing their idle wait time.
- Measure cyclist volume.
  - Motion detection sensors at cyclist waiting points.
  - Image recognition software with a large field of view on the traffic light to distinguish between cyclists, cars, emergency vehicles.
- Measure volume of cars.
  - Motion sensors.
  - Image recognition software.
- Communicate information with other sensors.
  - Sends data that includes information about the area where the traffic light is, and the data gained from the motion sensors and image detection software.
  - The overall density factors are communicated with each sensor to decide whether to direct traffic to that intersection, for example if a location has an extremely low density vector then an intersection with a high one can direct traffic towards it to ease up the flow of traffic.
- Image detection data is stored as an integer number of the vehicle types and the data gathered from the motion sensor is stored a vector that is applied to the

calculation to work out the density of traffic at that intersection. For example if the intersection has a base rating of 1 and the sensor calculated a traffic density vector of 2, then the overall density at that intersection would be 2 (base x vector).

B4. Non functional requirements:

- In order to make the traffic lights as sustainable as possible, the lights and circuitry themselves will be powered by solar panels fitted to the top of each light structure, with mains connected backups.
- We will also be using LEDs to power our traffic lights as they are reliable in cold and hot temperatures, and although more expensive than other bulbs such as halogen lights for example, they are less power hungry and more cost effective to run in the long run.[10]
    - Lights must be bright enough to be seen in harsh weather conditions, but not excessively bright to contribute as little as possible to light pollution.
    - Must be set out in such a way that colourblind people are able to distinguish between signals.
- As these systems are designed to replace the current traffic management solutions presently implemented, they would be maintained by the council responsible for that area, with support from staff that have expertise in our systems also.
- Data that is transferred between intersection points must be compressed in order to make the sending and receiving cycles as efficient as possible, the data must also be securely encrypted upon transfer across our networks.
- The systems must also be fully accessible. For example a sound being played to indicate that it is safe to cross for a blind person, or multiple visual cues for someone that is hard of hearing. It must also be accessible for wheelchair users, making sure the pedestrian buttons are low down enough to be reached by them.
- Network must be reliable, running off of servers that are 24/7 maintained by a team of our technical professionals that will work in conjunction with local authorities.
- A backup solution must also be implemented in case the network does go offline. The lights should still be able to carry out enough functions to keep road users safe, even on a temporary network failure. If the sensors detect that they have disconnected from the network, the lights will move to being controlled by its internal software (lights changing from red to green and then back to red every minute, and in turns to make sure that traffic is still regulated without causing any accidents.).

Part C: Key design challenges

C1

Addressing fault Tolerance and Error Handling by:

- providing additional requirements on how the system will respond to expected, probabilistic, or catastrophic errors or events.
    - The requirements presented in the current project are a mere subset of those that would be imposed on a system integrated into a greater roadway and traffic system.

- For a fully deployed system, this section would be integrated with the safety requirements to ensure that great care has been taken to address error handling that could prevent or minimize safety hazards.

C2

Long term design life versus immediate implementation is a design challenge, as the Multi-way intelligent traffic-lights system development matures from a research prototype to a deployable system, design life requirements need to be developed, matured, and supported in order to accommodate future communication between autonomous vehicles and sensors with that retrospect our system will have a time horizon of approximately 10 years.

C3

Trade-off between problem solving and problem framing as the image recognition software will process the image and match it with previous data to provide information to influence changing the state of the traffic lights as opposed to solving the problem in real time.

C4

- Environmental Compatibility can be increased with the use of materials such as recycled aluminium.
  - Using recycled aluminium instead of new requires very little energy. This leads to less greenhouse gas emission which is beneficial to the environment. Casting the aluminium can make it much stronger but still weigh very little.
  - This is useful because the less our components weigh, the less material is required to support them up in the air (for traffic lights) therefore less energy required to source and manufacture this material, hence a positive environmental impact.

- For the lighting for the traffic lights, we will be using LEDs.
  - Besides their decreased response time compared to halogen bulbs, they also require much less energy to function while providing the same light intensity compared to halogens.
  - Typically use 25-85% less energy than traditional incandescent bulbs.[11]
  - This of course has a positive impact on the environment as well.

Bibliography:

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[2] Albagul, A and Hrairi , M , ResearchGate. 2020. (PDF) Design And Development Of Sensor Based Traffic Light System. [online] Available at: <https://www.researchgate.net/publication/26439807_Design_and_Development_of_Sensor_Based_Traffic_Light_System> [Accessed 6 December 2020].

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[10] Energy.gov. 2020. Lighting Choices To Save You Money. [online] Available at: <https://www.energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money#:~:text=The%20most%20popular%20light%20bulbs,because%20they%20use%20less%20energy.> [Accessed 1 December 2020].

[11] Energy.gov. 2020. Lighting Choices To Save You Money. [online] Available at: <https://www.energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money#:~:text=The%20most%20popular%20light%20bulbs,because%20they%20use%20less%20energy.> [Accessed 1 December 2020].

ASSESSMENT CRITERIA

Criteria and parts they refer to	**YES (4-5)**	**PARTLY (1-3)**	**NO (0)**
A1. Problem Statement & Project Aims: High-level aims clearly define the **project context** (**user(s), purpose, gap or need)**. Problem statement is clear and succinct. **Objectives** are comprehensive and demonstrate some **in-depth thinking about the development process**. Language is **succinct**, to the point.			
A2. User Requirements The language is **clear, succinct, and precise**. Show how the system will be used and interacted with by the user(s).			
A3. Constraints Consider **physical**, **power, technological** and **cost** limitations in **specific and concrete situations** relevant arising from the project/system under considerations as well as from ethical and sustainability considerations.			
B1. Input/Output Requirements - Logically derive from user requirements and constraints; - Are **quantifiable** (i.e. **testable**); - Are **unambiguous.**			
B2. Operational Requirements - Consider high-level operation of the system; - Use **technically precise language.**			
B3. Functional Requirements - Show **some technical depth**, i.e. an attempt to “unpick” and open-up what high-level functionality entails technically, in terms of design; - Follow on from problem statement, user requirements, and constraints; - Demonstrate **background reading** on relevant technology; - The language is **technically precise.**			
B4. Non-functional Requirements At least some aspects of reliability, power efficiency and sustainability requirements are **given** but in a **very specific and concrete context of the project** (i.e. they are not generic broad-brush statements but broad issues interpreted specifically in the project context).			

C. Key Design Challenges **Trade-offs are systematically considered** for the specific problem at hand. General issues common to engineered systems are interpreted i**n the context of the project** chosen.			
	MARK: /40 *		

*** This scheme offers 5 bonus points.** For example, say you get 4 marks for each criterion. This adds to 8*4 = 32 marks out of 35 which is the maximum for this assignment. If you get 5 marks for each criterion, then you will still receive 35 marks for the assignment.*