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INFORMATICS INSTITUTE OF TECHNOLOGY

In Collaboration with

ROBERT GORDON UNIVERSITY ABERDEEN

Smart Traffic Light System Using Image Processing

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Submitted in partial fulfilment of the requirements for the BSc (Hons) in Artificial Intelligence and Data Science degree at the Robert Gordon University

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# Declaration

We hereby certify that this project proposal and all the artifacts associated with it is our own work and it has not been submitted before nor is currently being submitted for any degree program.

|  |  |  |
| --- | --- | --- |
| **Student Name** | **Student ID** | **Signature** |
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I have read the project proposal, and it is in accordance with the approved university project proposal outline.

Signature of the supervisor: Date:

# Introduction

The Smart Traffic light system is a system which uses image processing and sensors to detect road traffic as well as emergency vehicles and control the traffic lights at junctions and pedestrian crossings according to the traffic flow. This system will increase the efficiency of the usual timer-based system and make day-to-day life of all drivers and pedestrians way easier.

# Problem Domain

**Transportation Sector**

The Transportation sector will be the main Field this system will affect. As we all know, our cities are flooded with heavy traffic and that causes major inconvenience to many people every single day. With this system, we believe that it would result in better traffic control in comparison with the standard timer-based traffic lights and the basic police traffic control. And it would make day to day life of all drivers, pedestrians, and passengers so much more convenient. And it would also make driving as well as crossing roads so much safer.

**Health-care Sector**

A main feature of this system is it has the ability to detect emergency vehicles and control the traffic, clearing the way for these emergency vehicles to get to their desired destination. We see so many lives being lost just due to the factor that an emergency vehicle could not get to the patient or to the hospital in time. With this system, we believe that many lives could be helped which we think would be a huge win for everyone.

# Problem Definition

Extreme roadblocks and heavy traffic if a problem every single person faces every single day. As a driver or a passenger, we all face this problem every day. Not being able to get to the desired place at the desired place can be a crucial disadvantage to everyone. Also, being stranded at a red light when all the other roads are clear can also be a huge waste of time. This system will detect the traffic flow of all the relevant junctions and see which way has the most traffic and will prioritize that lane. Similarly, for a pedestrian, the system will scan and recognize all the traffic around and change the lights accordingly. Another main advantage this system has is the Emergency Vehicle detection. This is a huge aspect of our system which can positively affect the whole transportation system. We have seen so many lives which have been lost as a result of emergency vehicles not being able to arrive at the desired destination on time. This system will detect these emergency vehicles using sound sensors and will change the lights and clear the way for these emergency vehicles. With the help of this, we believe this will have a huge impact on the transportation as well as the medical fields.

# Problem Statement

The problem at hand is to reduce urban traffic congestion and improve overall quality of life by implementing intelligent traffic lighting systems based on imaging technologies, with the goal of reducing waiting times at intersections and improving traffic flow by adapting to real-time traffic conditions.

# Research Motivation

Thousands of people go through traffic lights every day. It is in fact one of the most crucial things both drivers and pedestrians face while travelling. Not paying attention to them can end up doing some serious harm to both people and vehicles. The entire purpose of traffic lights is to control the traffic flow smoothly and efficiently and prevent any traffic that may be caused. However, due to the regularly changing patterns in traffic flow, the currently existing system hasn’t been able to keep up adapting accordingly, hence the traffic congestion continues to rise during rush hours especially. In addition, it hasn’t been able to tackle the problem when external factors such as accidents or weather conditions affect traffic. By developing our traffic light sensor system, which uses image processing, our goal is to create a much more responsive and accurate system to control the traffic flow by considering several external factors that affect traffic, such as accidents, weather, closing of roads etc. This system can also provide added advantages such as prevention of accidents/injuries as well as a method to prevent theft and potential traffic violations.

# Existing work

|  |  |  |  |
| --- | --- | --- | --- |
| **Citation** | **Technology/ Algorithm** | **Advantages** | **Limitations** |
| de Charette, R. and Nashashibi, F. (2009) | * An image processing method based on spotlight detection and adaptive template matching. * cascade classifier training with AdaBoost and Haar features. | * Improved traffic safety * Efficient traffic flow * Smart city development | * Data quality and quantity * Cost of implementation and maintenance * Limited generalization |
| Jhonson and Smith (2019). | * Utilized computer vision techniques. * Integrated an intelligent traffic signal control system. | * Enhanced pedestrian safety * Reduced accidents * Improved traffic flow | * Crowded environments * Dependency on technology * Integration with existing infrastructure |
| Smith and Johnson (2021) | * machine learning model that used historical data and real-time observations | * Reduced traffic congestion * Shorter commute times * Smart city development | * Adaptation to unforeseen events * Dependency on infrastructure * Algorithm complexity |
| Lee and Brown (2020) | * Utilized deep reinforcement learning | * Adaptation to changing conditions * Safety enhancements * Resource efficiency | * Requires high quality data * Adversarial attacks * Implementation costs |
| Mitchell and Anderson (2018) | * An image processing and machine learning-based system * Utilized image analysis techniques and real-time tracking algorithms | * Improved emergency response times * Efficiency in healthcare * Community well-being | * False alarms * Data accuracy * Technical failures |
| Lee and Foster (2018) | * Machine learning algorithms to predict traffic patterns * navigation apps to provide dynamic routing suggestions | * Public transportation integration * Shorter commute times * Fuel and emission savings | * Community acceptance * Limited data coverage * Dependency on technology |

# Research Gap

The research gap that you will be addressing in your research.

There are different type research gaps,

1. Theoretical gap
2. Performance gap
3. Empirical gap

# Contribution to the Body of Knowledge

## Technological Contribution

## Domain Contribution

With the use of the above-mentioned technologies, we will be designing a system which can control traffic lights depending on the road traffic flow and will also detect emergency vehicles and control the traffic lights accordingly.

For example, when a car is stopped at a red light at a four-way junction, and there is no other traffic at the other three junctions, the lights will automatically change so the car can go. Also, when a pedestrian is at a crossing and is waiting for the light to change, the system will scan and change the lights accordingly. This system is different from the existing timer-based system and is way more efficient.

One main feature of this system is having the ability to detect emergency vehicles which we think can be a huge game changer for every single person. This will be able to control the traffic lights and clear the way for these vehicles.

We believe that this system will help the transportation as well as the medical fields in a huge way while also making the life of every single driver, passenger and the pedestrian way easier.

# Research Challenge

* + - 1. Data Collection and Annotation - Identifying a comprehensive and diverse dataset of traffic conditions at various intersections is an essential component. This dataset would require accurate annotation for vehicle types, pedestrian movement, weather conditions, and other relevant factors to train image processing algorithms effectively.
      2. Real-time Image Processing - The ability to accurately track objects such as vehicles, pedestrians, and cyclists in traffic scenes is of utmost importance. Therefore, designing and optimizing algorithms for this purpose is a key task. Achieving real-time performance requires efficient algorithms and hardware capable of handling the computational load.
      3. Traffic Pattern Recognition - Another challenge is developing machine learning models that are required to recognize complex traffic patterns, including congestion, unusual traffic events, and predict the traffic flow based on processed image data. Traffic patterns can be highly variable, and accurately modeling them using machine learning involves a comprehensive and diverse dataset, advanced pattern recognition techniques, and continuous model training to adapt to changing conditions.
      4. Traffic Light Control Strategies - Designing traffic light control strategies that dynamically adjust signal timings based on real-time data is also a significant challenge. These strategies need to balance traffic flow optimization with safety and compliance with traffic laws. Control strategies must consider the needs of all road users, adapt to evolving traffic conditions, and ensure that emergency vehicles are prioritized while maintaining overall traffic efficiency.
      5. Human Interaction and Safety - Another significant research challenge is to ensure the safety of pedestrians and drivers by designing the system to respond to emergency situations, such as ambulance or police vehicle prioritization and pedestrian safety.

# Research Questions

1. What are the possible ways where image processing techniques be used to optimize traffic light control at intersections, to reduce congestion and finally improve traffic flow?
2. List a few image processing techniques that can be used to recognize and distinguish between pedestrians and cars at junctions in order to improve signal control.
3. What are key factors that could be used to design and implement adaptive traffic light control systems and further elaborate how image processing could enhance their adaptability to change traffic conditions?
4. What are the ways image processing technologies could be used to identify and prioritize emergency vehicles efficiently at intersections, that would contribute to improved emergency response times?
5. Mention how real time traffic prediction models, encapsulate image processing and other data sources while providing an accurate traffic forecast for commuters and suggestion for efficient routes in urban environments.

# Research Aim

This system would Scan the road traffic and change the color lights depending on which route needs the most attention helping reduce major traffic jams and increase the safety of all pedestrians. This system would also detect emergency vehicles and would change the traffic lights, clearing the way for these vehicles.

# Research Objective

Elaborate the steps of atomic activities that you need to carryout to achieve the aim

|  |  |  |
| --- | --- | --- |
| Research Objectives | Explanation | Learning Outcome |
| Problem Identification |  | LO1 |
| Literature Review | RO1  RO2  RO3 | LO1 |
| Data Gathering and Analysis |  | LO2, LO3 |
| Research Design |  |  |
| Implementation |  |  |
| Testing and Evaluation |  |  |
|  |  |  |
|  |  |  |

# Project Scope

1. **In-scope**
2. **Out-scope**
3. **Diagram showing prototype feature**
   1. **Methodology**
4. **Research methodology**

|  |  |
| --- | --- |
| Research Philosophy | The author of the research has selected the positivism as the research philosophy |
| Research Approach | Deductive or inductive why? |
| Research Strategy | Experiment, survey => questionnaire (can be quantitative or qualitative) or interview (can be quantitative or qualitative), |
| Research Choice | Mono method => only one method can quantitative (Positivist) or qualitative (interpretivist), Multi method (More than one method but all belong to same paradigm (positivist or interpretivist)) or Mixed method (only pragmatist can mix the method => mixing the method from positivism and interpretivism) |
| Time zone | Cross-sectional or longitudinal |
|  |  |
|  |  |
|  |  |

1. **Development methodology**
   1. **What is the life cycle model and why?**
   2. **Design methodology => SSADM or OOAD or Anything else?**
   3. **Evaluation methodology => Evaluation metrics and/or benchmarking**
2. **Project management methodology**
   1. **Schedule using the Gantt Chart after doing a WBS (Do not have to provide the WBS)**
   2. **Deliverables, milestones, and dates of deliverables**
   3. **Resource requirements** 
      1. **Hardware requirements**
      2. **Software requirements**
      3. **Skills requirements**
      4. **Data Requirements**
   4. **Risk Management**

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk Item** | **Severity** | **Frequency** | **Mitigation Plan** |
|  | **5** | **5** |  |
|  | **5** | **4** |  |
|  | **5** | **1** |  |
|  |  |  |  |

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