



Team 24

Traffic Flow Optimization Using Deep Reinforcement Learning Enabled Traffic Lights Network

TEAM Design | Term 232

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Problem statement

Urban traffic congestion increases delays, fuel use, and emissions due to outdated traffic management systems that cannot adapt to real-time conditions. This inefficiency underscores the urgent need for an intelligent traffic light system that dynamically optimizes flow and reduces congestion.

Constraints

- Infrastructure Compatibility:** Must integrate with existing traffic systems.
- Green Time Duration:** Limited to a maximum of 60 seconds.
- Regulatory Compliance:** SBC, SASO, IEEE, etc.
- Time and Budget:** 15 weeks with a budget cap of 6000 SAR.

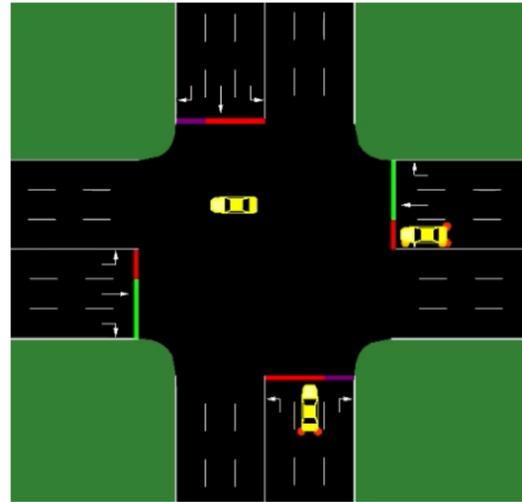
Target Specifications

- 1 Set-up Time < 2 Weeks
- 2 Rapid Real-time Decision < 5 Seconds
- 3 Idle Time ~ 10% Reduction
- 4 Area Coverage > 80% Coverage per Intersection
- 5 Cars Throughput ~ 10% Increase per Day
- 6 Hardware Costs < \$3000 per Junction
- 7 Life Span > 10 Years

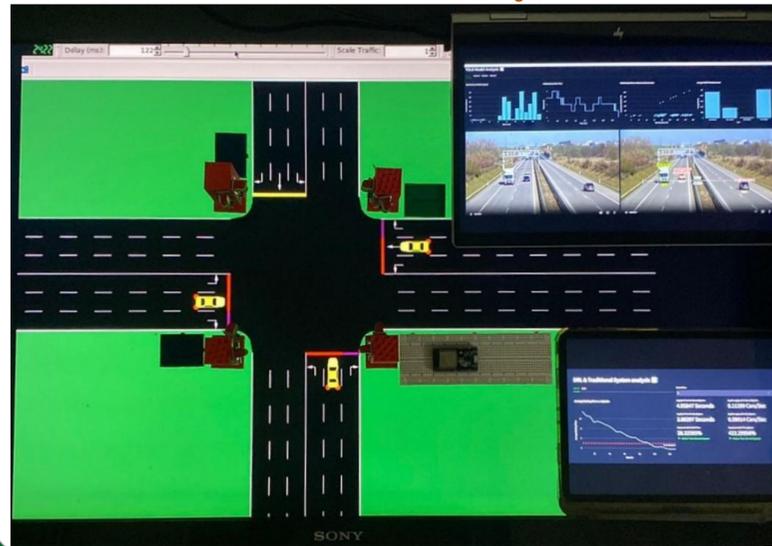
Project Impact

- Economic:** Reduces congestion-related costs and spurs traffic management innovations.
- Societal:** Improves commute times, enhances public safety, and supports equitable access.
- Environmental:** Decreases emissions by optimizing traffic flow, promoting cleaner air.

SUMO Simulation & Environment



Final Assembly



Computer Vision

- YOLO Model:** is a fast, real-time object detection system that has been effectively utilized to detect and recognize vehicles in various traffic systems, acting as inputs for the DRL model.
- OpenCV:** is a comprehensive library aimed at real-time computer vision applications that has been used for frame manipulations, drawing annotations, and enhancing the visualization of detection results.
- Supervision:** a platform designed to optimize computer vision projects by managing and enhancing datasets, extracting key features for improved model training.

Backup System

In case of DRL failure, our backup system seamlessly integrates computer vision and traditional traffic light control to ensure uninterrupted traffic management. This equation dynamically adjusts traffic light durations per lane based on real-time vehicular weight, maintaining flow better than traditional systems.

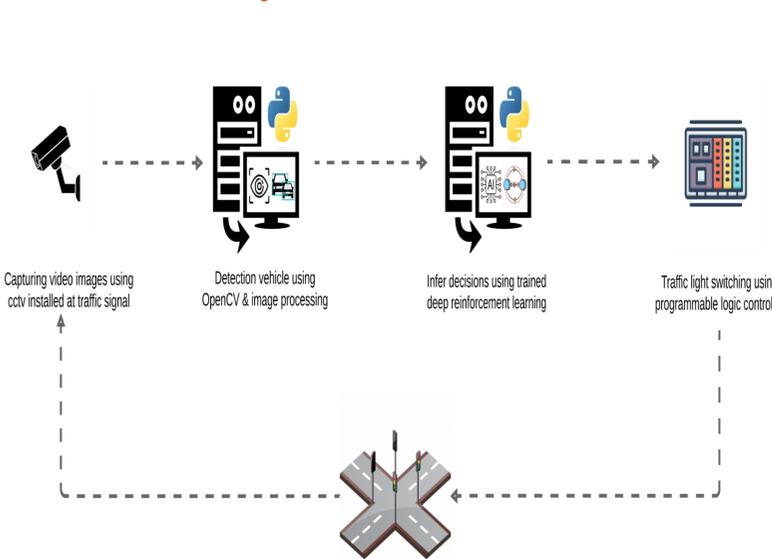
$$\text{Time} = 60 \times \left(\frac{(cars \times car_weight) + (trucks \times truck_weight) + (busses \times bus_weight) + (motorcycles \times motorcycle_weight)}{\text{Total_capacity}} \right)$$

Total_capacity = 30, Car_weight = 1
 Truck_weight = 1.5, Bus_weight = 3
 Motorcycle_weight = 0.5

DRL Model

Our Deep Reinforcement Learning (DRL) model employs advanced algorithms to optimize traffic light timings, significantly reducing delays and maximizing vehicle throughput using real-time traffic data. It dynamically adjusts traffic signals to minimize vehicle wait times and idle periods, constrained by a 60-second green time limit and ensuring sequential light changes for safety. This model is designed to outperform traditional traffic systems by at least 40% reduction in idle time, aiming for a 10% increase in vehicle throughput. Integrated seamlessly with existing traffic infrastructure, the DRL model not only promises enhanced traffic flow and safety but also supports urban mobility with a scalable solution that adapts to varying traffic patterns, demonstrating a substantial improvement over conventional traffic management approaches.

System Overview

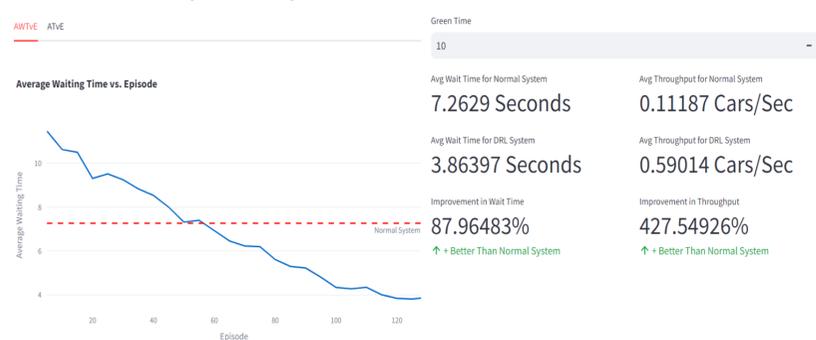


Conclusions & Future Work

Our project demonstrates a smart traffic light system powered by deep reinforcement learning that effectively improves traffic flow and reduces congestion. The prototype's success in simulated environments indicates strong potential for real-world application. Future enhancements will focus on diverse traffic scenarios and emergency vehicle prioritization, aiming to significantly impact urban traffic management, public safety, and environmental quality.

DRL Validation Dashboard

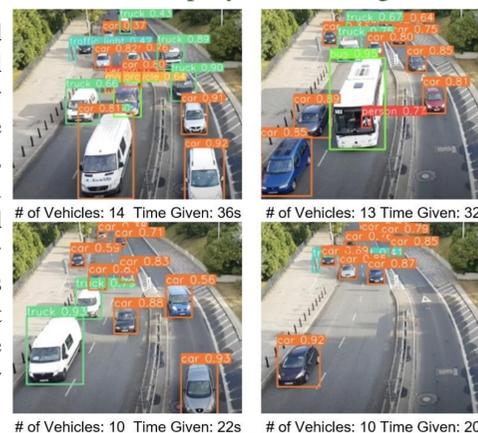
DRL & Traditional System analysis



Testing and Validations

Our prototype rigorously met and exceeded designated specifications in a simulated environment with 16 intersections. Key achievements include a 40% reduction in idle time and a dramatic 400% increase in vehicle throughput, reflecting significant improvements over traditional systems. Decisions are made within a rapid 5-second timeframe, demonstrating the prototype's efficiency in dynamic traffic management. Cost-effectiveness was also validated, with implementation costs kept under \$3000 per junction. These results affirm the prototype's effectiveness and its potential scalability for real-world traffic systems.

Backup System Testing



YOLO Validation Dashboard

