# Platooning Trajectory Optimization for Connected Automated Vehicles in Coordinated-Arterials

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## Objective

To develop a heuristic framework to optimize Connected-Automated-Vehicles (CAVs) trajectories.

## Motivation

- In the U.S current signal control strategies account for 295 million vehicle-hours of delay on major roadways alone [1].
- Simulation results suggest that it is possible to reduce delays by exploiting CAVs capabilities [2]
- Most of the existing optimization frameworks are limited by the complexity of their formulation making their implementation challenging [2]

## Methodology

A heuristic framework was developed to adjust CAVs trajectories using the kinematics equations (variable acceleration case).

$$x(t)_{l,n} = x(t_0) + \int_{t_0}^{t} v(t)dt$$
$$v(t)_{l,n} = v(t_0) + \int_{t_0}^{t} \alpha(t)dt$$
$$\alpha(t)_{l,n} = y - zt$$

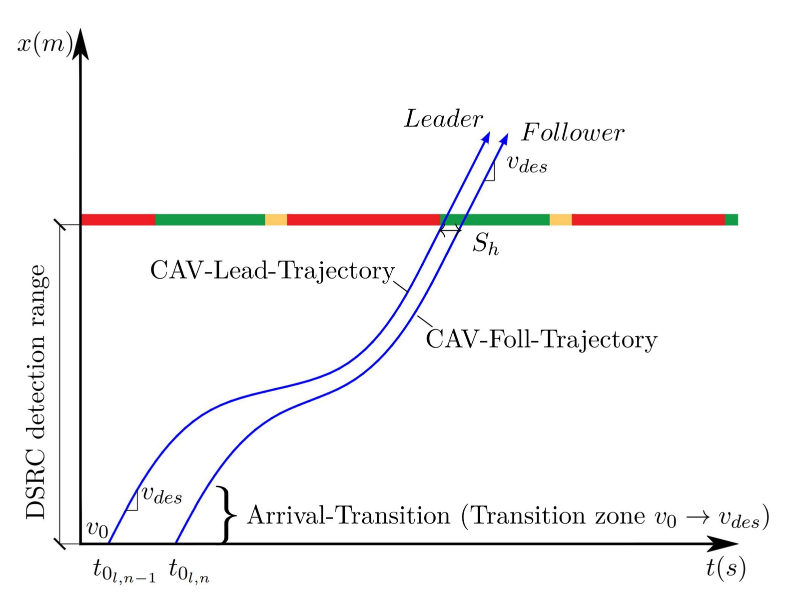


Fig. 1: Concept of trajectory optimization algorithms.

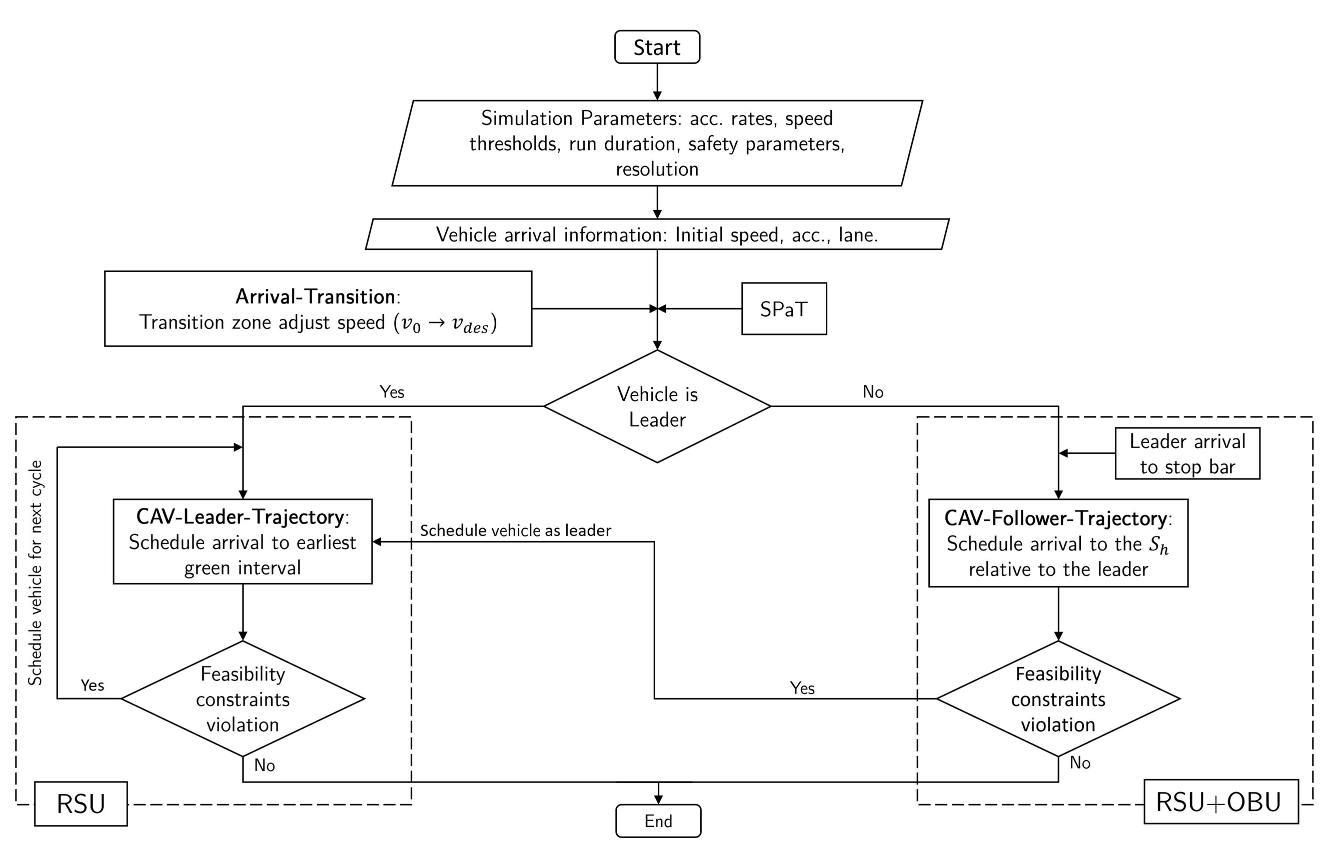


Fig. 2: Algorithms integration.

## Simulation Experiments

An arterial with two intersections was used to evaluate the efficiency of the proposed heuristic. Demand from Eastbound (EB), and Southbound for both intersections were considered (SB-1), (SB-2).

| Demand (vph) | Scenarios | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII |
| Eastbound (EB) | 150 | 250 | 350 | 475 | 600 | 725 | 750 |
| Southbound Intersection 1, (SB-1) | 130 | 190 | 280 | 350 | 470 | 580 | 625 |
| Southbound Intersection 2, (SB-2) | 120 | 210 | 270 | 380 | 450 | 550 | 625 |
| Network (EB + SB-1 + SB-2) | 400 | 650 | 900 | 1205 | 1520 | 1855 | 2000 |

Fig. 3: Demand Scenarios.

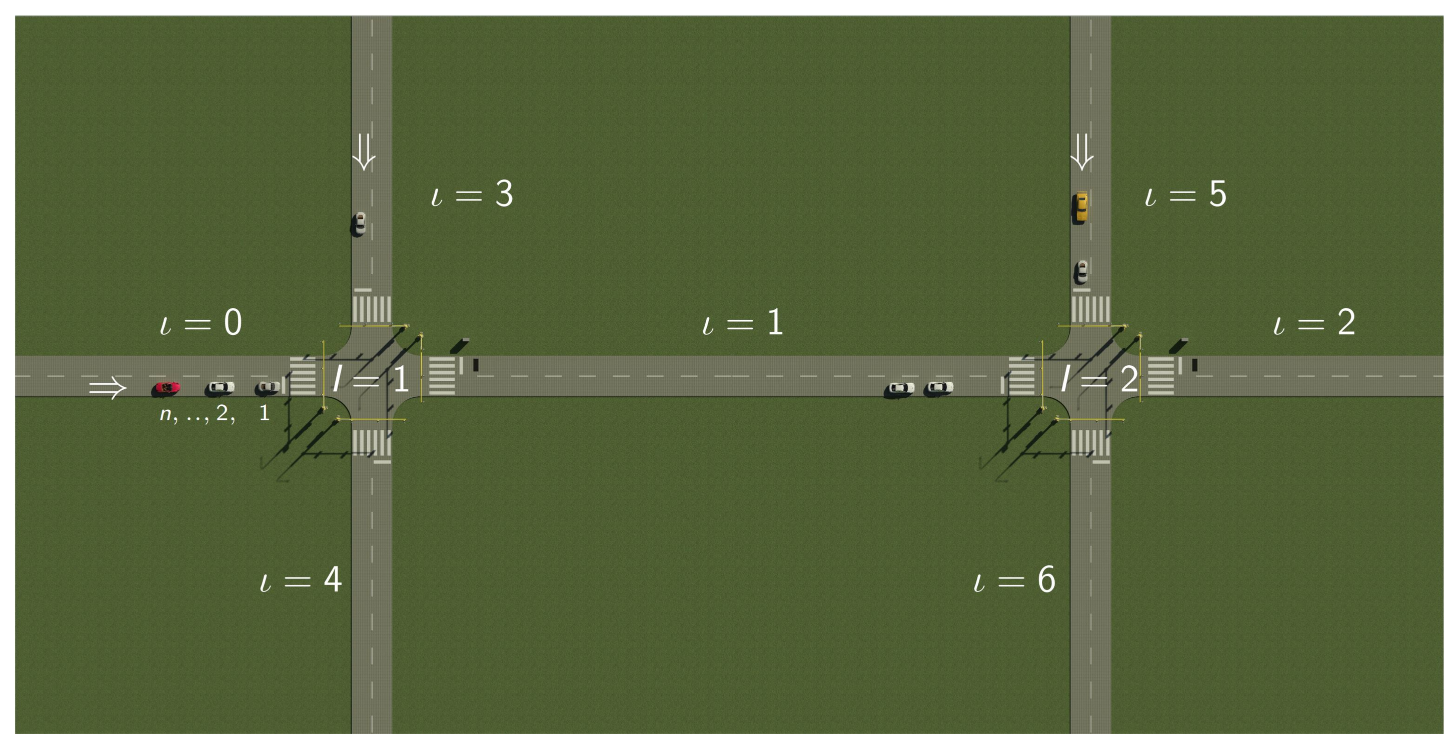


Fig. 4: Study arterial for simulation experiments.

## I. Results

Simulation results showed that the trajectory optimization framework successfully form collision-free platoons at the saturation headway.

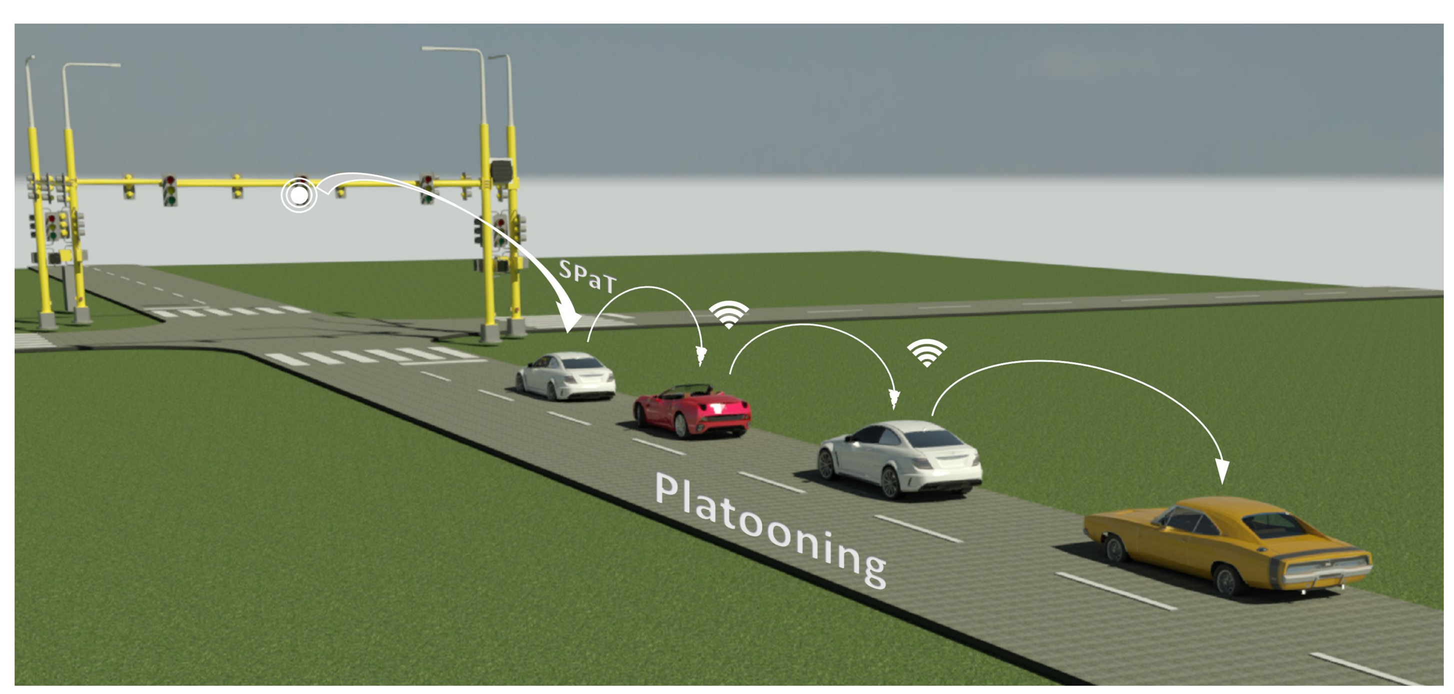


Fig. 5: Conceptual of Platooning.

## II. Results

The results showed that travel time and delay are reduced by (8-22%) and (11-23%), respectively.

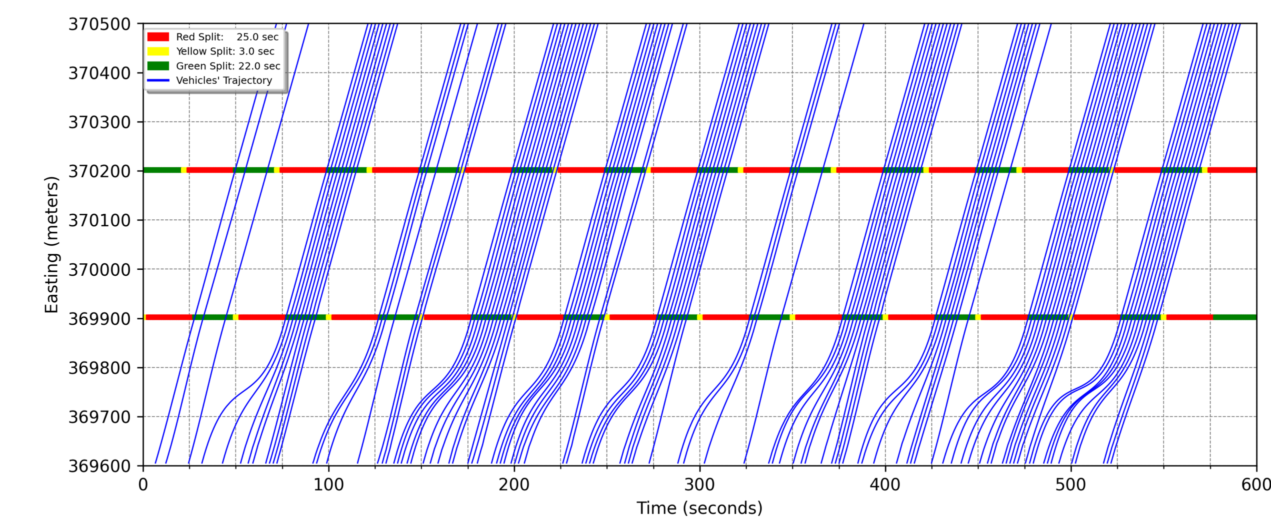


Fig. 6: Time-Space Diagram.

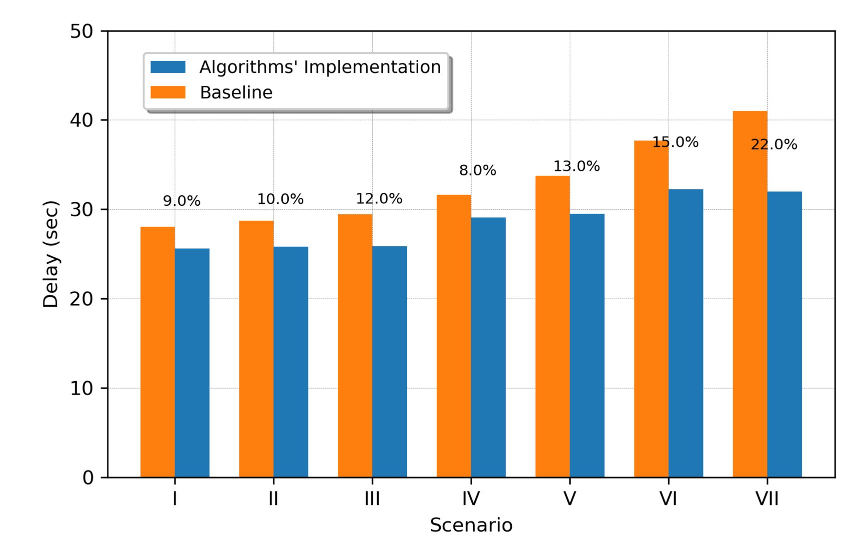


Fig. 7: Average Network Travel Time Improvements.

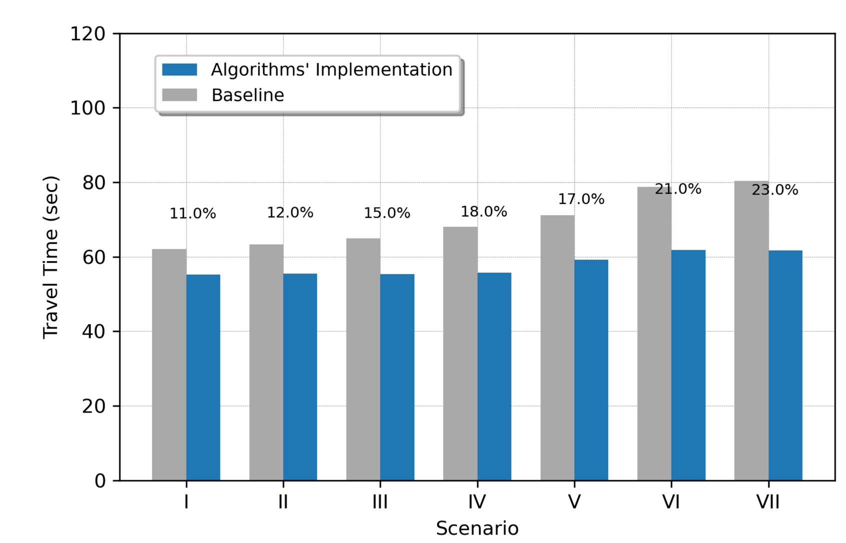


Fig. 8: Average Network Delay Improvements.

## Remarks

This work is an extension of previous studies for an isolated intersection that has been tested in a real intersection. The time complexity of the algorithms is quadratic $O(n^2)$. However, empirical results showed $O(n)$, we believe this framework is suitable for real-world implementation. Although we only considered CAVs, this methodology can be extended to Connected-Vehicles (CVs).

## References

[1] Zhuofei. Li et al. In: (2014). DOI: https://doi.org/10.1016/j.trc.2014.10.001.

[2] Aschkan Omidvar et al. In: (2018). DOI: 10.1177/0361198118782798.