TU Delft | Transport & Planning

Cyclist priority at traffic lights through the “eyes” of CAVs

Connected automated vehicles (CAVs) must continuously sense the environment to be able to function safely. Yet, the collected information could also be used for other purposes. This work highlights the potential of using cyclist observations by CAVs to augment the situational awareness of traffic signal controllers. The approach is implemented in a simulation study and quantifies the benefits of prioritizing cyclists and reducing lost times in the control cycle.

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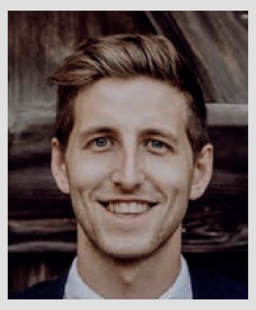

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MOTIVATION

WHY PRIORITIZE CYCLISTS?

- Cycling is an environmentally friendly means of transport.
- It encourages cycling by making it more convenient for cyclists at intersections.
- Less stops at traffic signals and reduced delays of cyclists.

STATE-OF-THE-ART

- In Rotterdam, in the Netherlands, cyclists are prioritised during rainfall, using loop detectors in combination with rain sensors.
- In Hengelo, in the Netherlands, smart cameras are used to detect and prioritize bicycle platoons of three or more cyclists.

WHY CAV OBSERVATIONS?

- Using more loop detectors or cameras to detect cyclists is expensive.
- Mobile apps have their disadvantages as well: privacy, battery drainage, forget to activate app.
- CAVs must continuously sense the environment to function safely. This sensor information also can be used for advanced traffic monitoring and control applications.
- CAV observations: a new available source of information. (1)

APPROACH

Observations from CAVs are used in an intelligent traffic signal controller. (2)

Traffic demand: Input demand for cyclists, cars, and penetration rate of CAVs.
Signal state: Color of the signals.
Sensing: When a cyclist enters the field of view of a CAV an observation may be generated. Each observation originates from a single cyclist or is a false detection. Note that observations may be noisy, include clutter or miss a cyclist because of occlusion.
Tracking: Let us assume an unknown and varying number of indistinguishable cyclists. A multiple-target tracking approach is used to infer the number of cyclists present on the cycle path and estimate their dynamic state at each time instant.
VAT: Vehicle Actuated control by Tracking, a revised controller based on traditional VA control that prioritises cyclists using tracking.

- **Handle priority:** Conditional for individual cyclists, platoons not considered.
- **Phase truncation:** Reduce lost time by ending unused timing (remaining minimum green, yellow, clearance time) of cyclists.

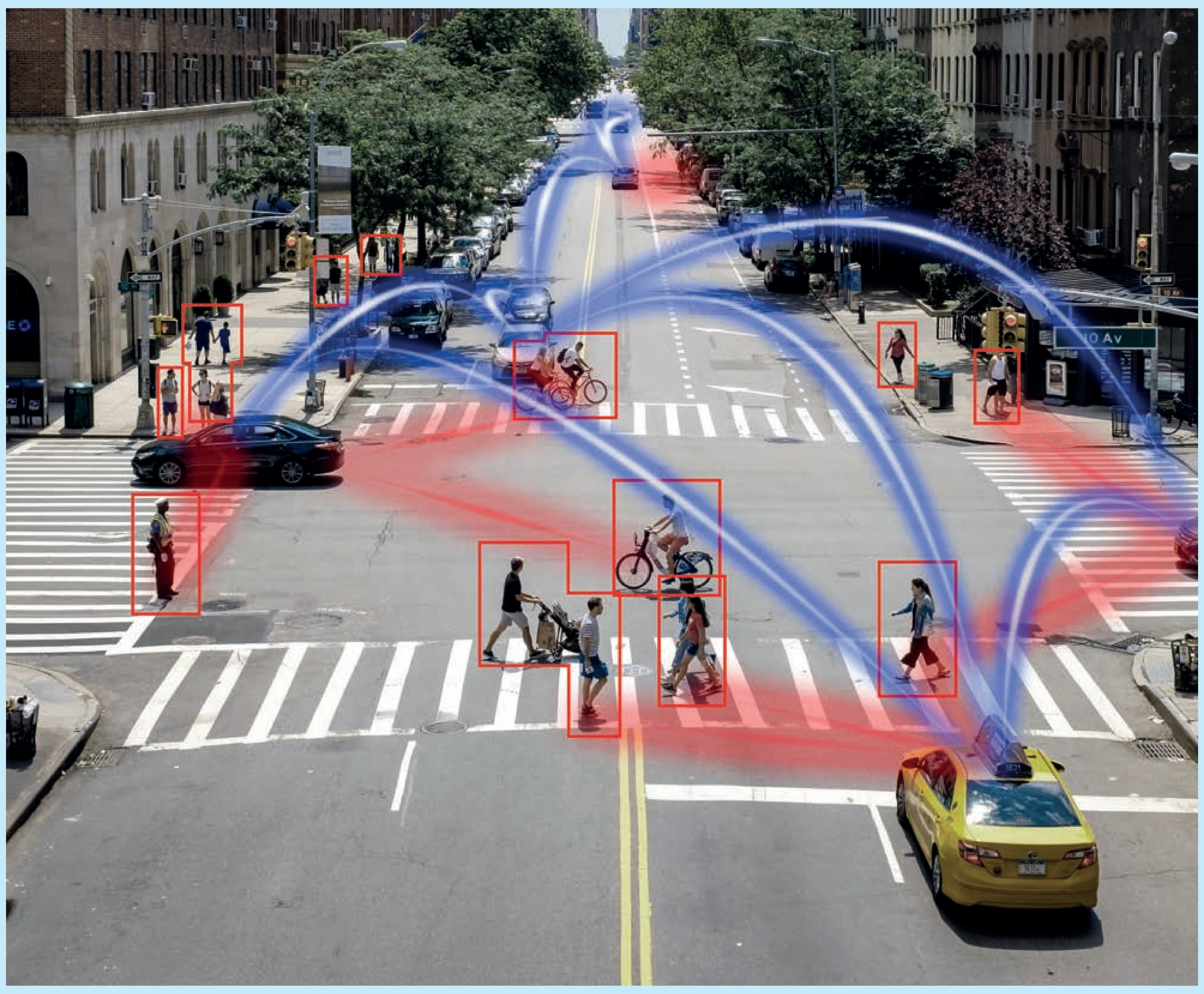
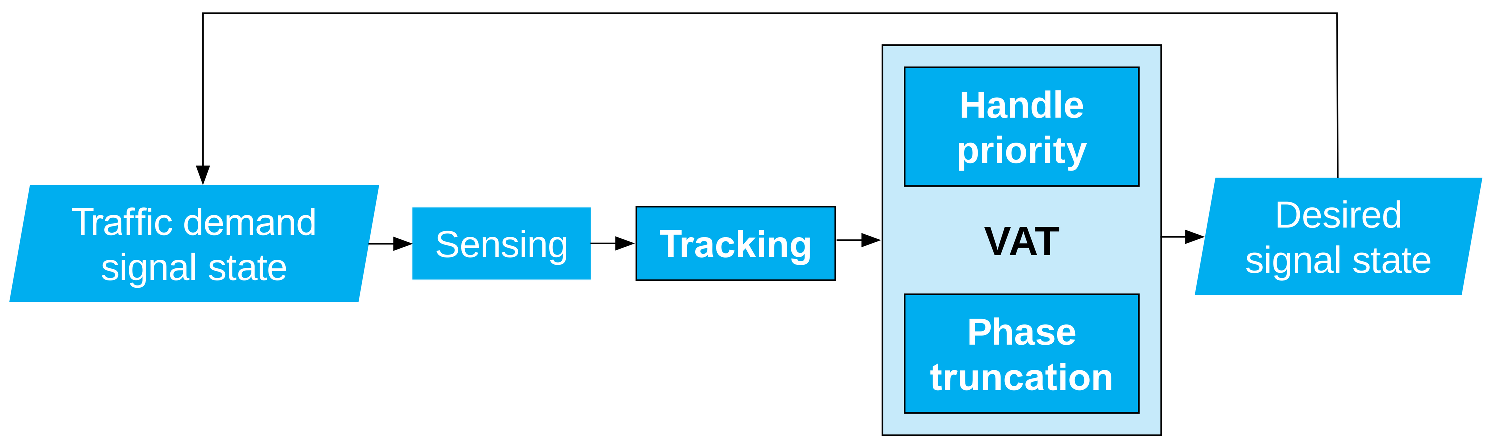


Photo: Mj, Unsplash

(1) Observation of location and speed of cyclists.



(2) Proposed VAT (Vehicle Actuated control by Tracking) approach.

RESEARCH QUESTIONS

Q1: How does the proposed approach compare to state-of-the-art traffic signal controllers* in terms of car and bicycle delay and stops, for different levels of car and bicycle demands?

Q2: What is the effect of using VAT on the efficient use of green for cyclists?

Q3: How does the penetration rate and the field of view of CAVs affect the cyclist delay?

Q4: What is the value of observing the absence of cyclists?

* ***VA:*** Vehicle Actuated control, phase-based control using loop detection. Green is extended until the queue is solved. ***VAP:*** using VA, cyclists are prioritized based on the bicycle detector near the stop line.

Photo: Aditya Chinchure, Unsplash

RESULTS AND DISCUSSION

The proposed approach is quantified using micro-simulation. (3)

VAT provides reduction of the delay for cyclists or avoids stops considering *i)* low penetration rate of CAVs, *ii)* occlusion events, and *iii)* a small field of view. (4) (5)

However, average car delay increases much when the number of cyclists increases, while the average bicycle delay does not show much variation. (6)

The green allotted per cyclist reduces as the cyclist demand increases, green time is thus used more effectively with increasing demand. (7)

False observations can start unwanted green. (8)

Highly occluded areas (e.g. at intersections) can have negative impact on the information available to the tracker and thus lead to less priority requests. (9) (10)

Results indicate that observational confirmation that cyclists are not present is beneficial for all traffic, leading to less lost time in the cycle. (9) (10)

CONCLUSION AND OUTLOOK

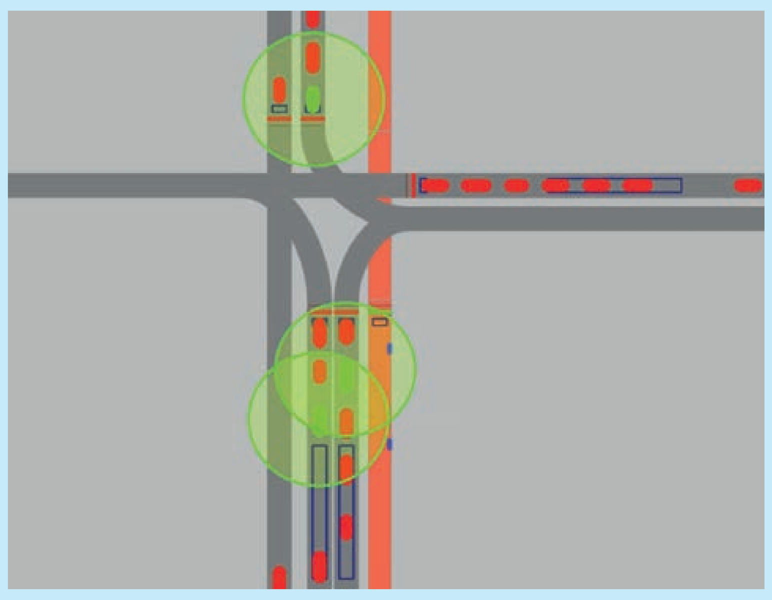
Cyclists prioritization should be assessed with respect to safety:

1. Cyclists might be inclined to run red if there are control cycles where, due to a low penetration rate of CAVs, few observations are available and the expected priority is not given.
2. When a saturated car queue moves over the stop line, ending green can be unexpected by the car drivers. This is less credible and can lead to red light running by car drivers.

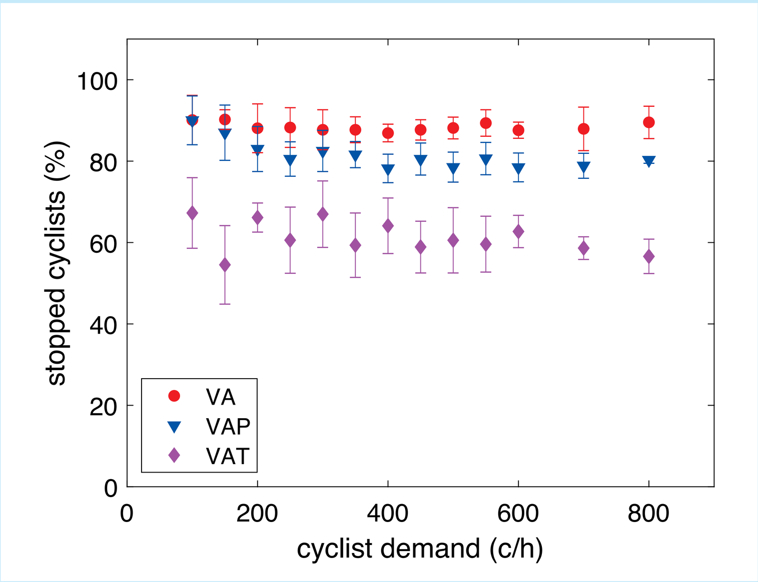
When cyclists are prioritized, it is beneficial for the throughput of the intersection that the cyclists are close together, so the green extension can be shorter.

Next step is to optimize the control that balances the delay and stops of cyclists and cars.

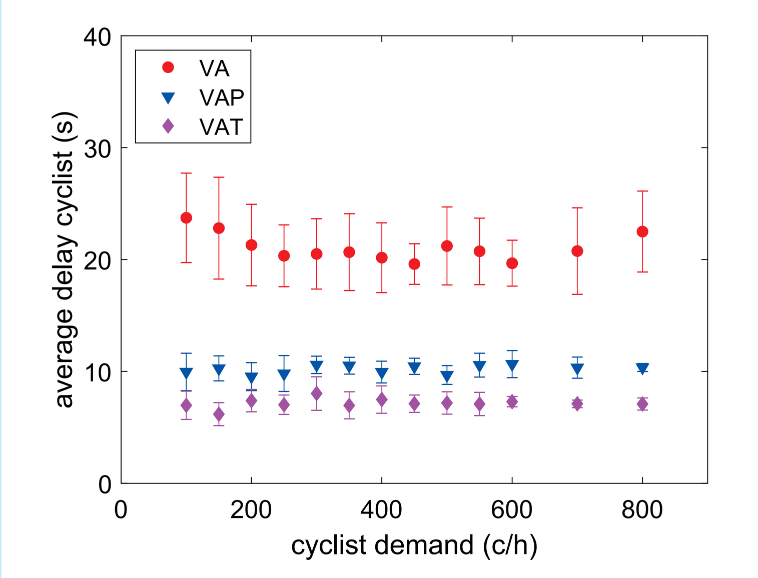
A combination of speed advice for cyclists and prioritization is an interesting direction for future research.



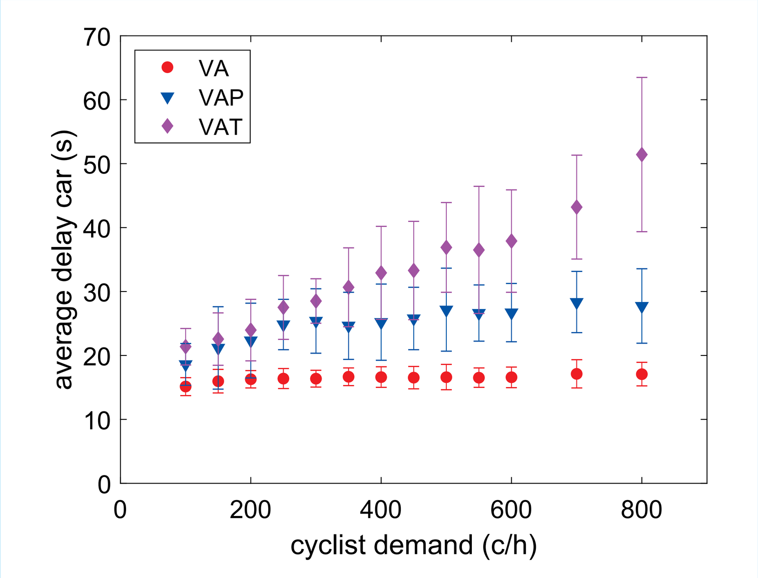
(3) Observation in the simulation.



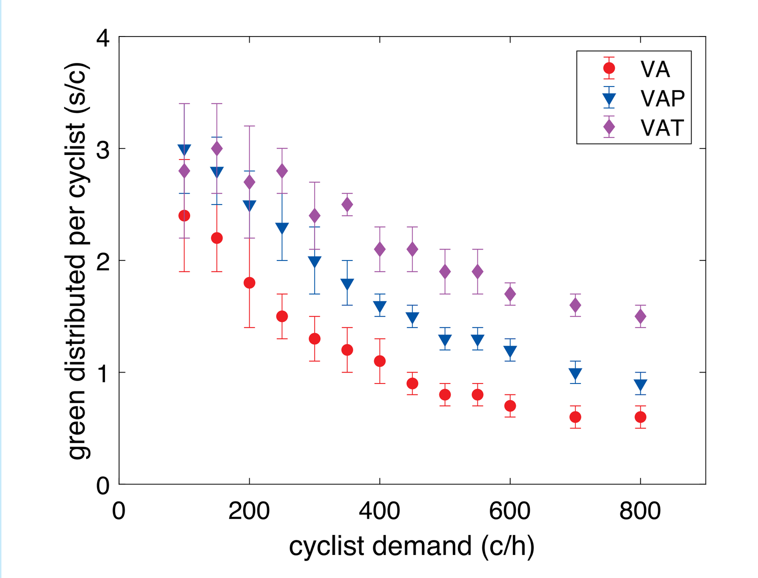
(4) Percentage of stopped cyclists. Proposed control (VAT) compared to state-of-the-art control (VA, VAP).



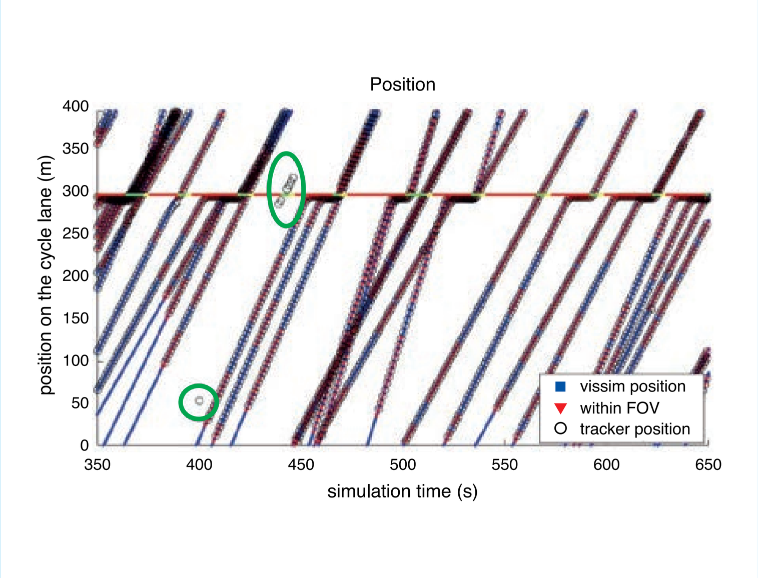
(5) Average delay of cyclists. Proposed control (VAT) compared to state-of-the-art control (VA, VAP).



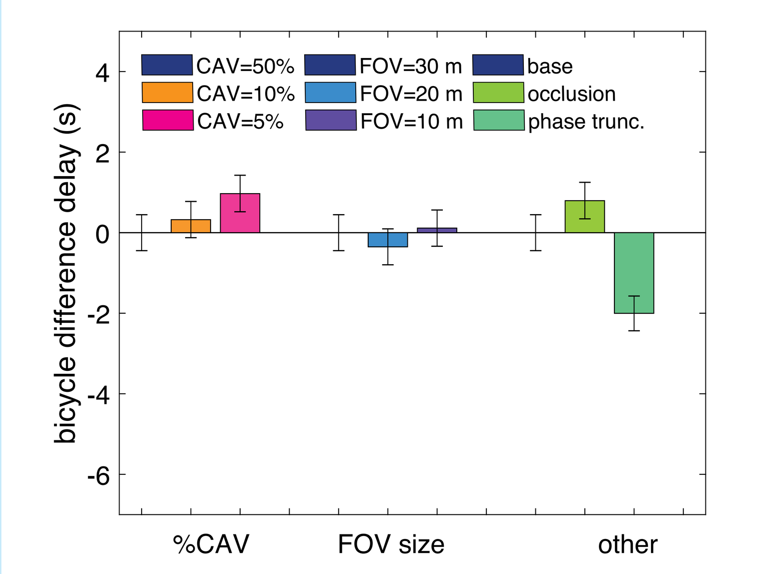
(6) Average delay of cars. Proposed control (VAT) compared to state-of-the-art control (VA, VAP).

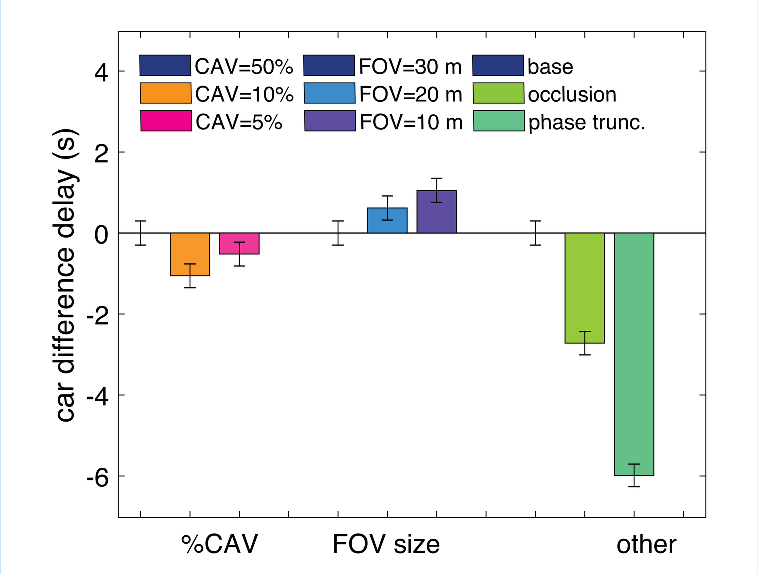


(7) Average green time allotted per cyclist. Proposed control (VAT) compared to state-of-the-art control (VA, VAP).



(8) Example of inferred bicycle trajectories using the tracker.





(9) Bicycle delay difference (figure left). (10) Car delay difference (figure right). Difference with base case (CAV 50%, field of view (FOV) = 30 m, no occlusion or phase truncation).

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