Development of dynamic traffic signal control based on Monte Carlo simulation approach

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Computational Statics Physics
UNAM

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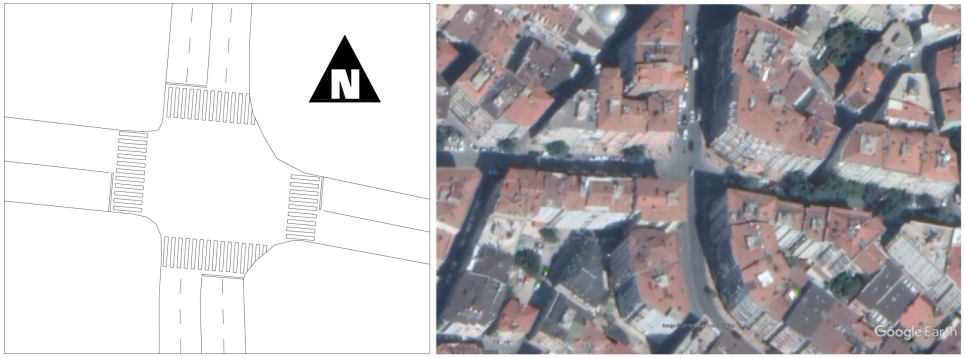
Outline

Context



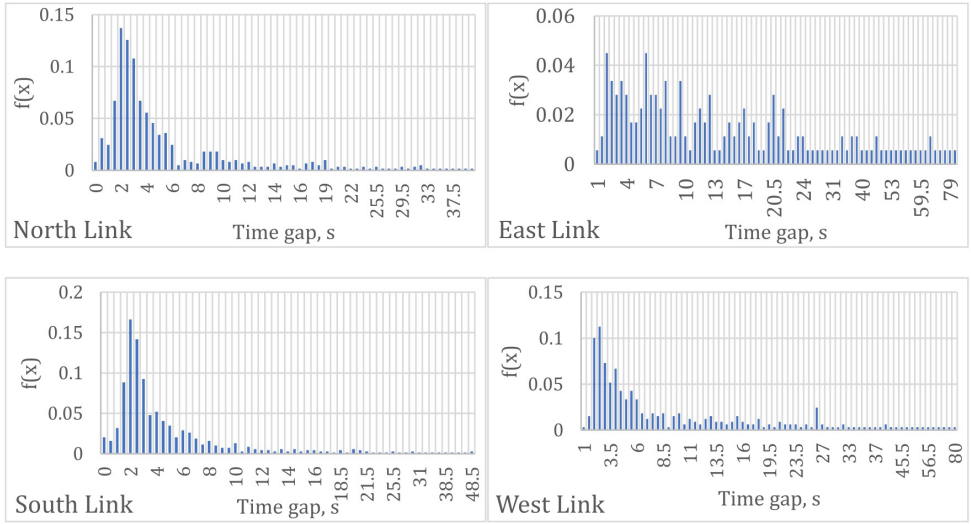
Intersection for the study. Aegean, Turkey.

Why is traffic signal control important?

- Optimizing signal timings allow more fluent traffic flow and less delay.
- Avoid queuing.
- Minimized fuel consumption and emissions.

[Eriskin et al., 2022]

The queue length and vehicle arrived time are they key parameters.



Frequency analysis of the intersection

Best fit distribution for each link:

- **North**: Generalized Extreme Values (R 92.5%)
- **East**: Birnbaum-Saunders (R 75.8%)
- **South**: Generalized Extreme Values (R 90.9%)
- **West**: Generalized Extreme Values (R 92.9%)

[Eriskin et al., 2022]

Queue Formation and Vehicle Delay

For queue formation:

$$Q_{total} = Q_{first} + V_{rend}$$

$$Q_{first} = \begin{cases} 0 & \text{if}(Q_0 + V_{rfirst} + V_g - S_g) \leq 0 \\ (Q_0 + V_{rfirst} + V_g - S_g) & \text{if}(Q_0 + V_{rfirst} + V_g - S_g) > 0 \end{cases}$$

$$S_g = t_g * \frac{s}{3600}$$

Where:

- Q_{total}: Total queue length.
- Q_{first}: Initial queue.
- Q_0: Residue queue.
- V_{rfirst}: Arrival flow at the first red time.
- V_g: Arrival flow at green time.
- t_g: Green time.
- S: Saturated flow rate.

[Eriskin et al., 2022]

Delays:

$$D_r = Q * t_r + \left(\sum_{i=1}^{n} \left(t_r - \sum_{k=1}^{n} \Delta t_i \right) \right)$$

$$D_g = \begin{cases} \left(\sum_{i=1}^{k} \frac{i}{\frac{s}{3600}} \right) & \text{if} \quad k = Q_o + V_g \\ \left(\sum_{i=1}^{k} \frac{i}{\frac{s}{3600}} \right) + (Q_0 + V_g - k) * t_g & \text{if} \quad k = \frac{t_g * s}{3600} \end{cases}$$

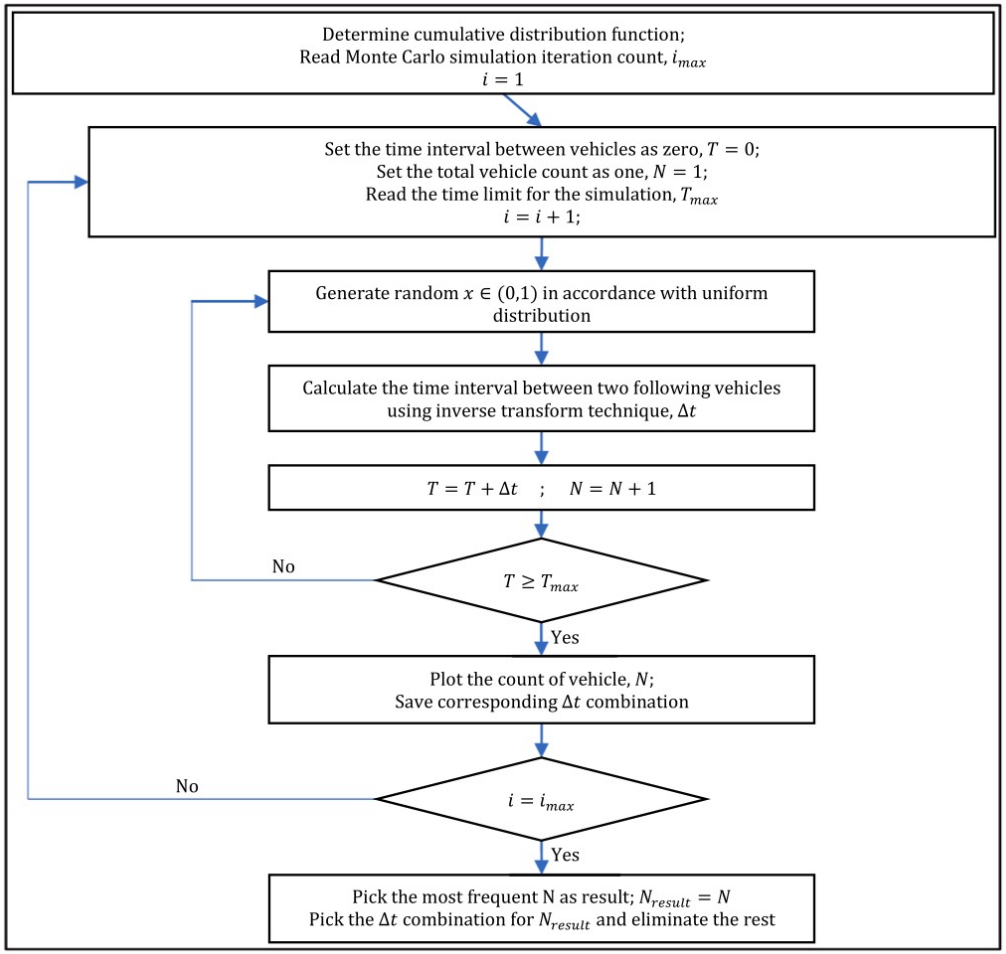
$$k = min \left(\frac{t_g * s}{3600}, Q_0 + V_g \right)$$

Where:

- D_r: Delay occurred on the red time.
- D_g: Delay occurred on the green time.

[Eriskin et al., 2022]

Monte Carlo Algorithm



[Eriskin et al., 2022]

Table 4
Statistical parameters calculated for the Monte Carlo simulated flow's time intervals for the one hour and comparison with the real field data.

Parameters	North		East		South		West	
	S*	R*	S*	R*	S*	R*	S*	R*
Count of Data (vehicle)	614	614	179	179	692	692	330	330
Peak Value (s)	2.5	2	7.5	6	2	2	2.5	2.5
Median Value (s)	4	3	13	11.5	3.5	3	5	5.5
Aritmetic Mean (s)	5.27	5.86	16.30	20.04	4.72	5.16	10.21	10.88
Standard Deviation	4.14	6.98	12.82	22.55	3.57	6.26	12.05	13.56
Variance	17.12	48.72	164.25	508.31	12.78	39.24	145.13	183.97
Skew Coefficient	1.56	2.97	1.33	2.10	1.37	3.53	2.10	2.65

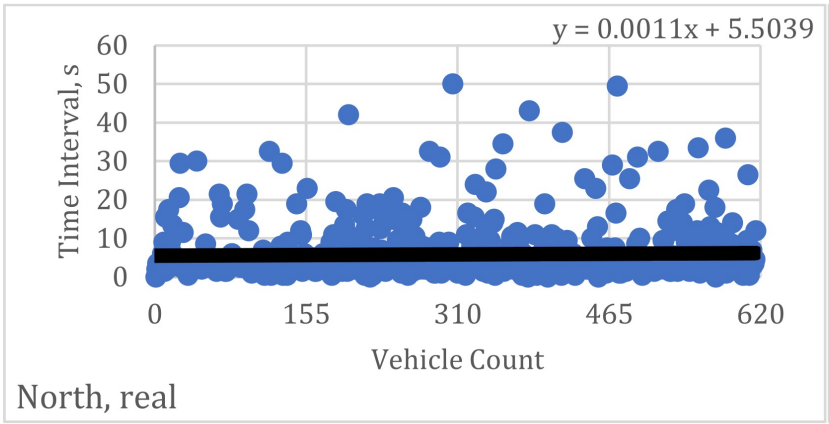
*S – simulated data; R – real data.

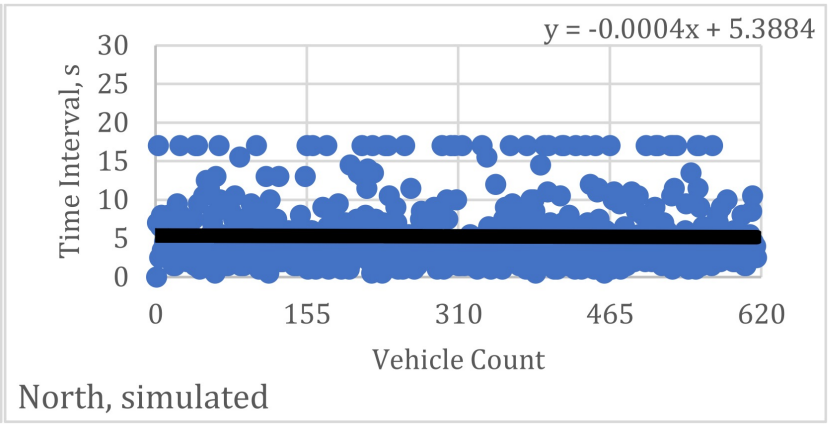
Parameters	North	East	South	West
Count Of Data (Vehicle)	616	181	686	324
Median Value (s)	3.46	19.83	3.57	5.67
Arithmetic Mean (s)	5.85	20.06	5.26	11.15
Standard Desviation	7.93	6.76	6.18	15.9
Skew Coefficient	3.46	0.309	5.85	3.9

[Eriskin et al., 2022]

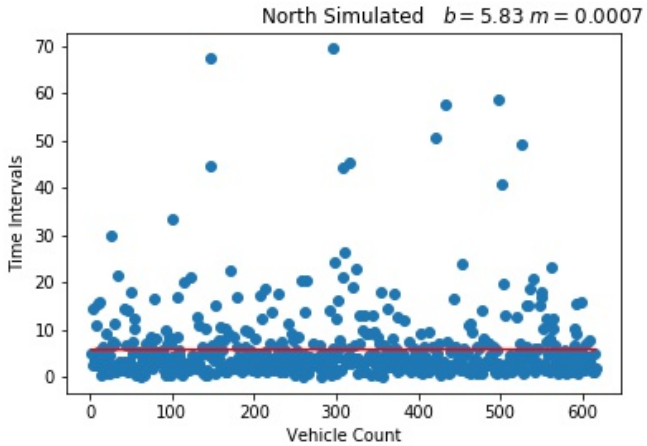
Tendency Analysis

North





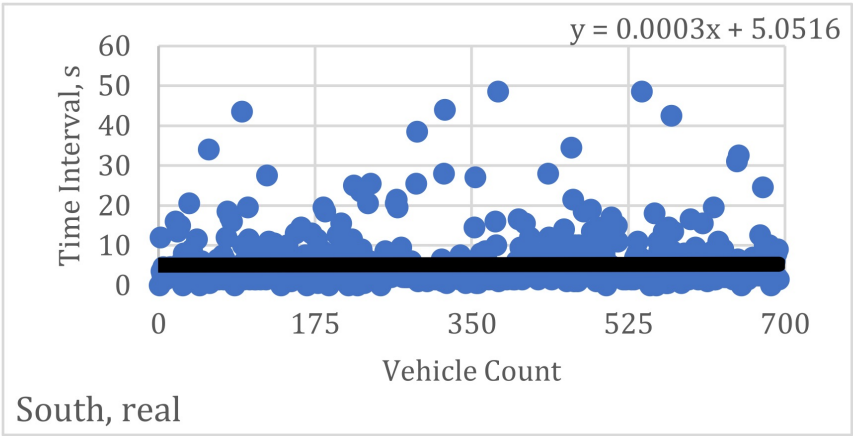
Original Research

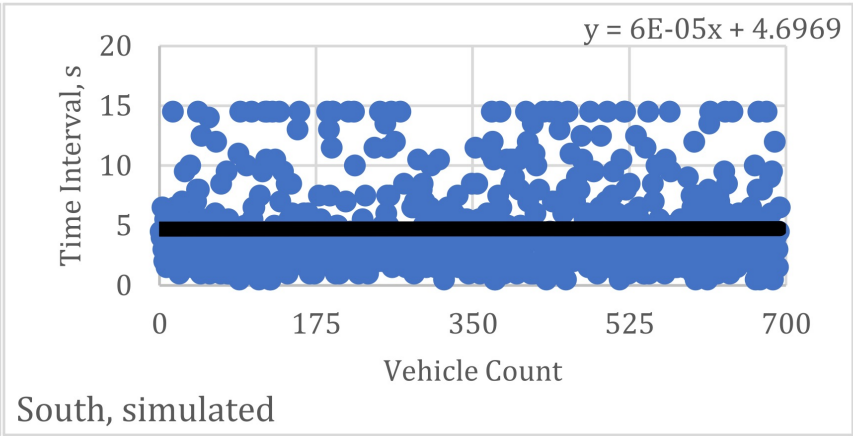


Simulated

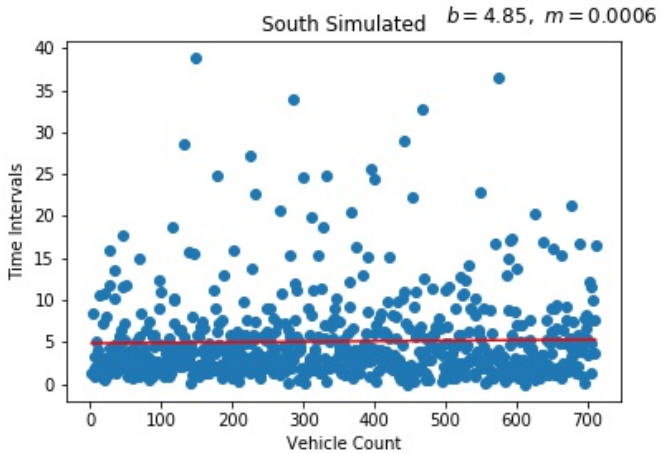
Tendency Analysis

South





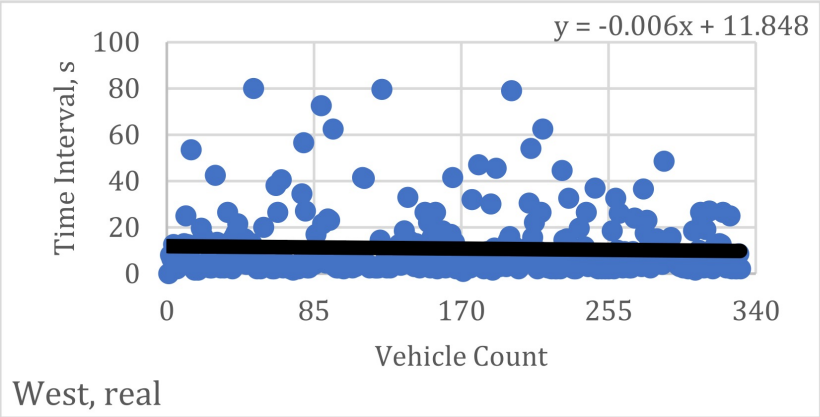
Original Research

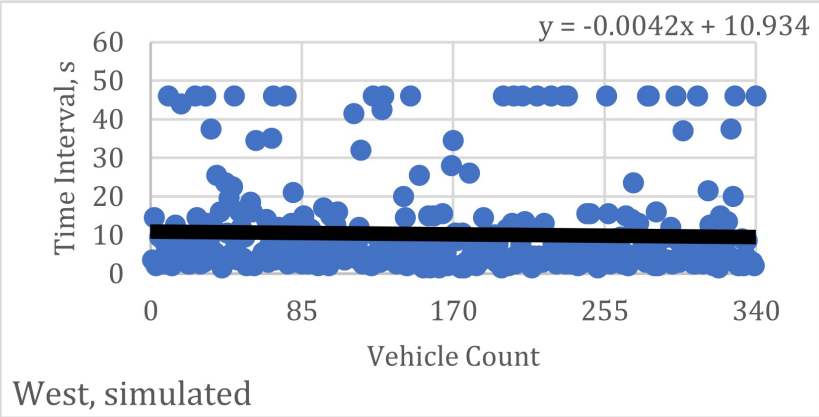


Simulated

Tendency Analysis

West





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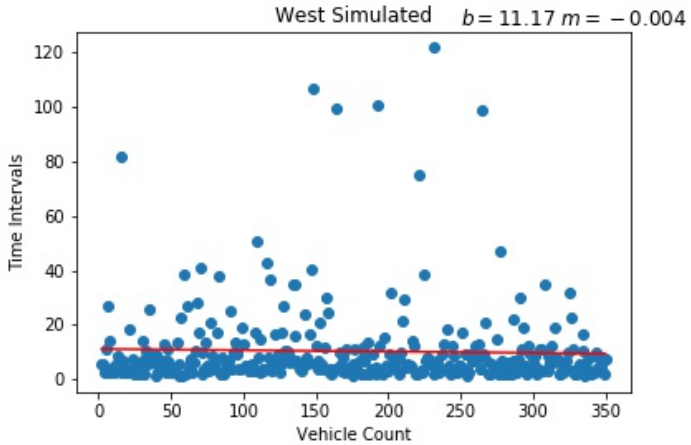
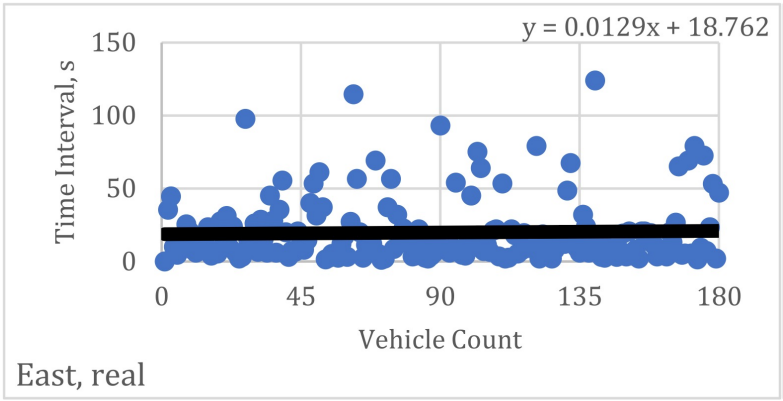
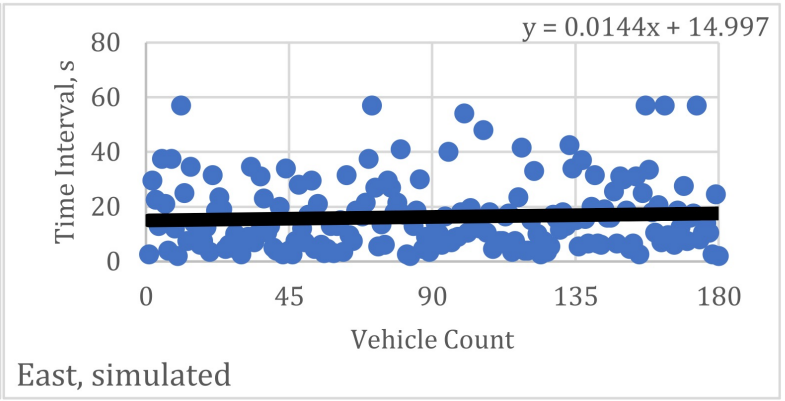


Simulated

Tendency Analysis

East





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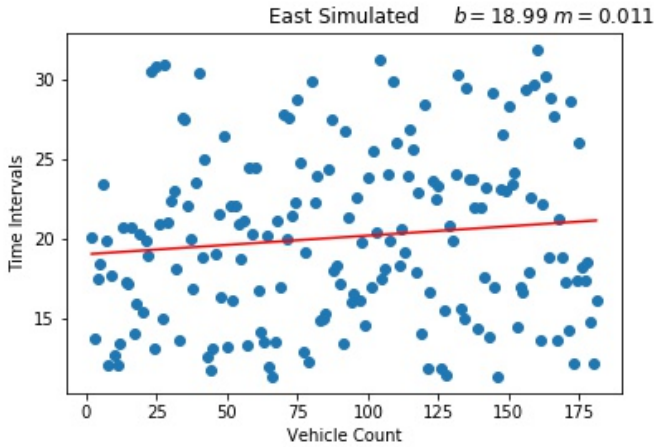
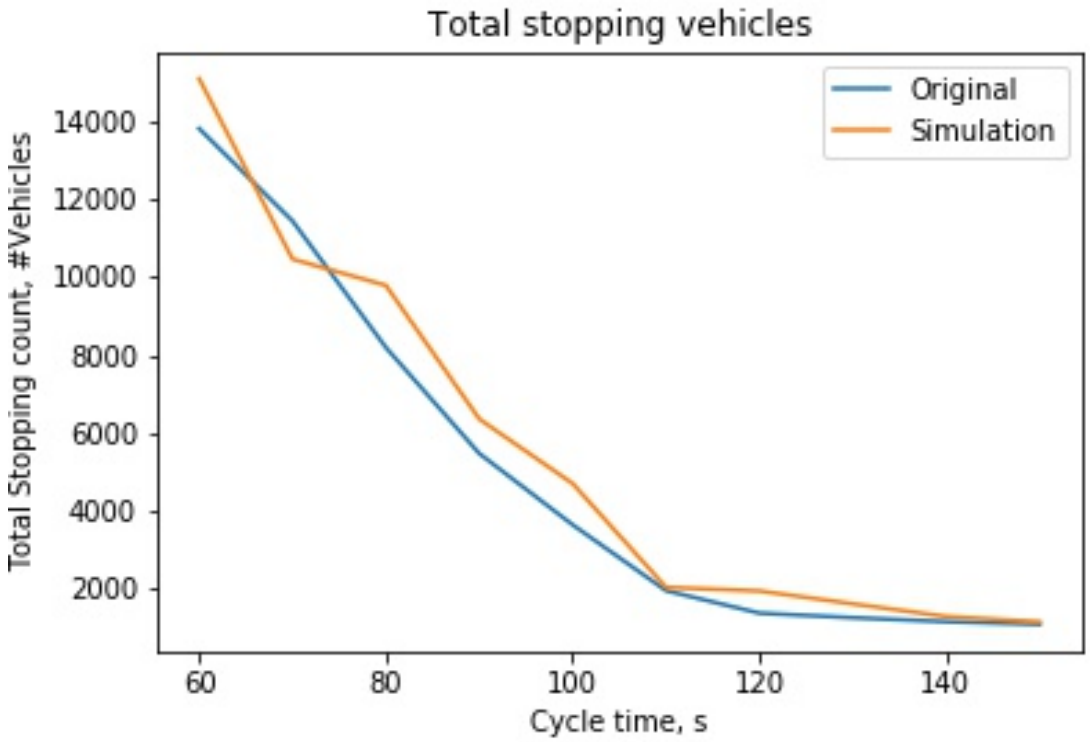
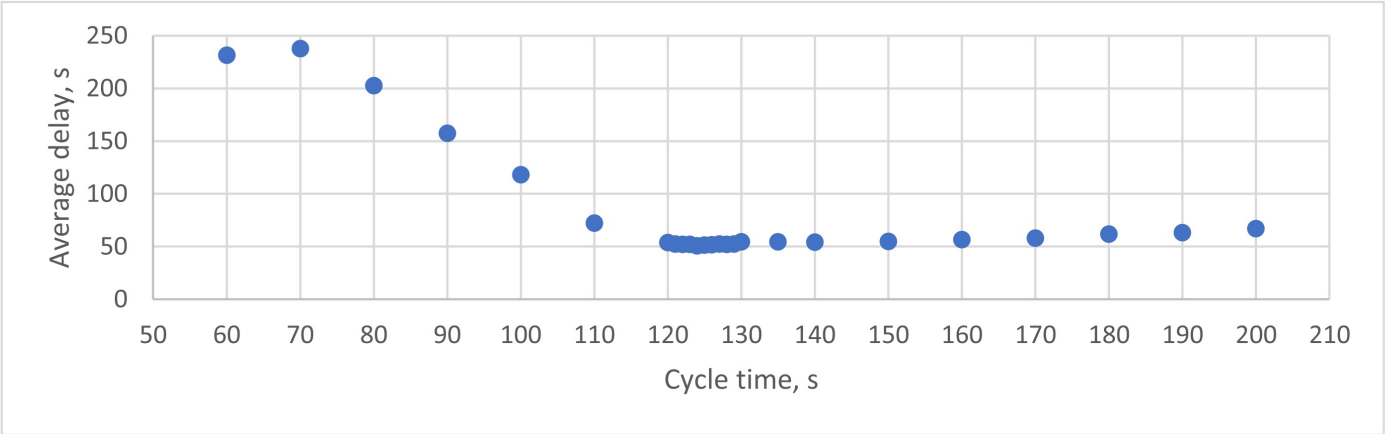


Simulated

Vehicle Stopping



Delays



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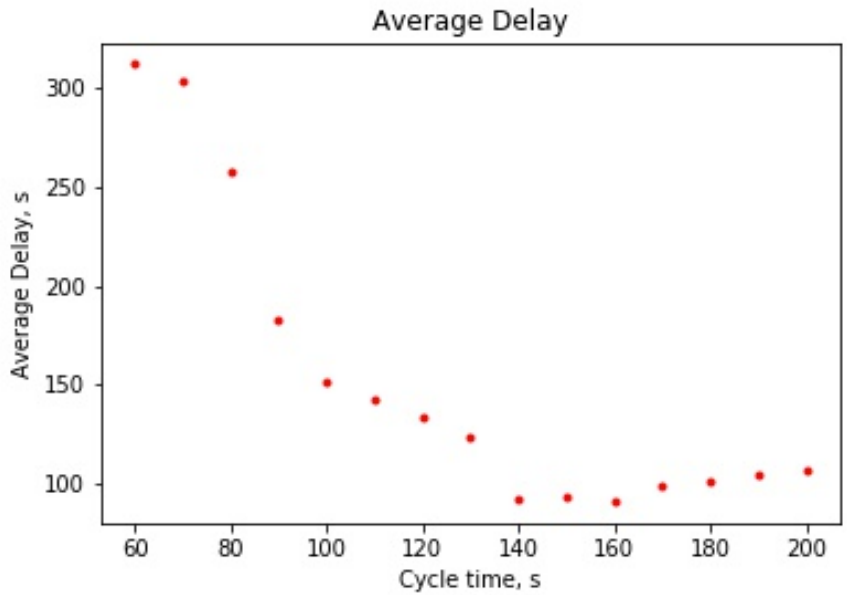

Thank You.

Code at:

https://github.com/Mahonry/ProjectStatiscalPhysics/

References I

[Eriskin et al., 2022] Eriskin, E., Terzi, S., and Ceylan, H. (2022).
Development of dynamic traffic signal control based on monte carlo simulation approach.
Measurement, 188:110591.