How Does CAV Improve the Traffic in Diverse Weather? Results Based on VISSIM Simulation

CEE 678 Advanced Traffic Modeling and Computer Simulation

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Project Background

Where?
Along the Beltline, south of campus

How?
Using VISSIM software, create a traffic system that analyzes the inclusion of Connected Autonomous Vehicles (CAVs) and the effects it has on adverse weather conditions

Why?
Adding CAVs to the road can allow for less congestion and lower travel times [1] that may otherwise occur with adverse conditions

[1] M. Guériau and I. Dusparic, "Quantifying the impact of connected and autonomous vehicles on traffic efficiency and safety in mixed traffic," 2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC)

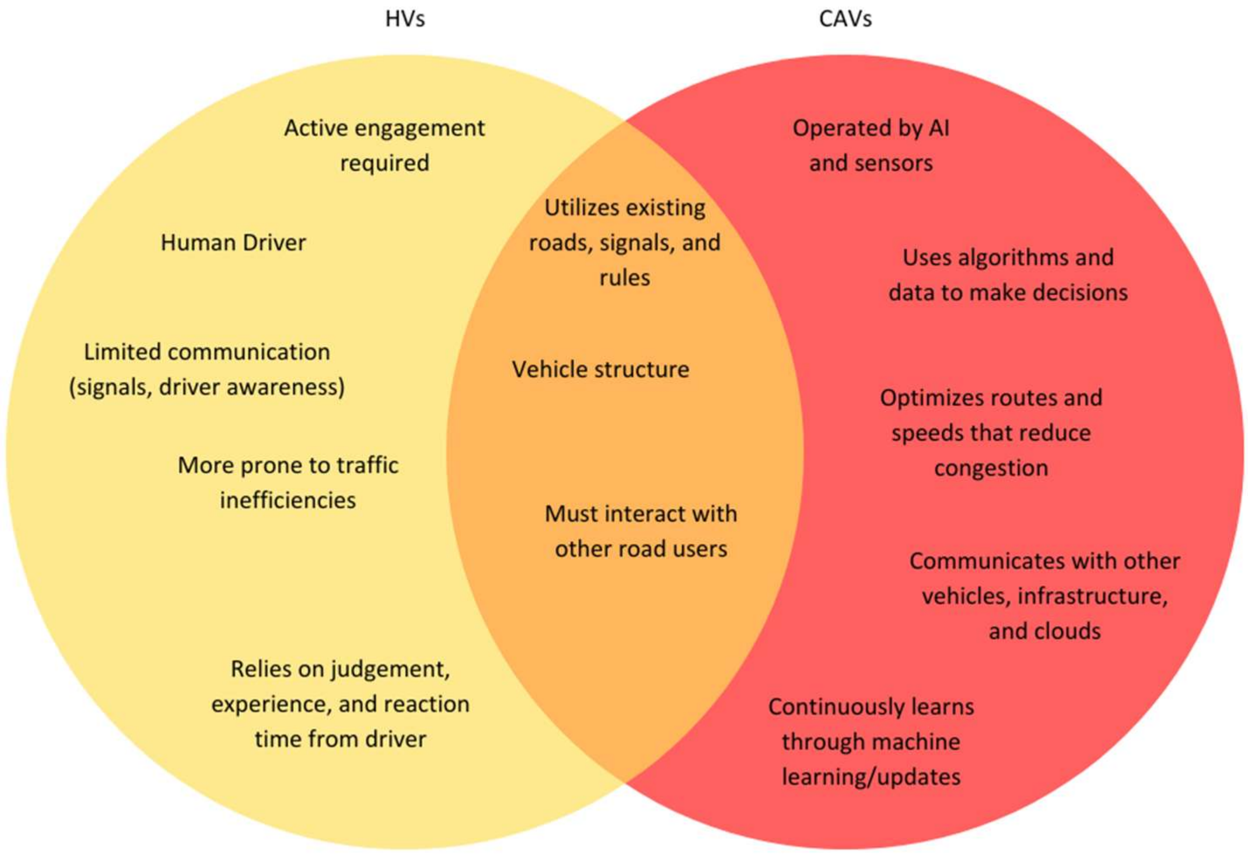
Background

Adverse Conditions:
- Reduce visibility
- Cause slower speeds
- Increase the risk of accidents
- Increase delay and congestion on the road

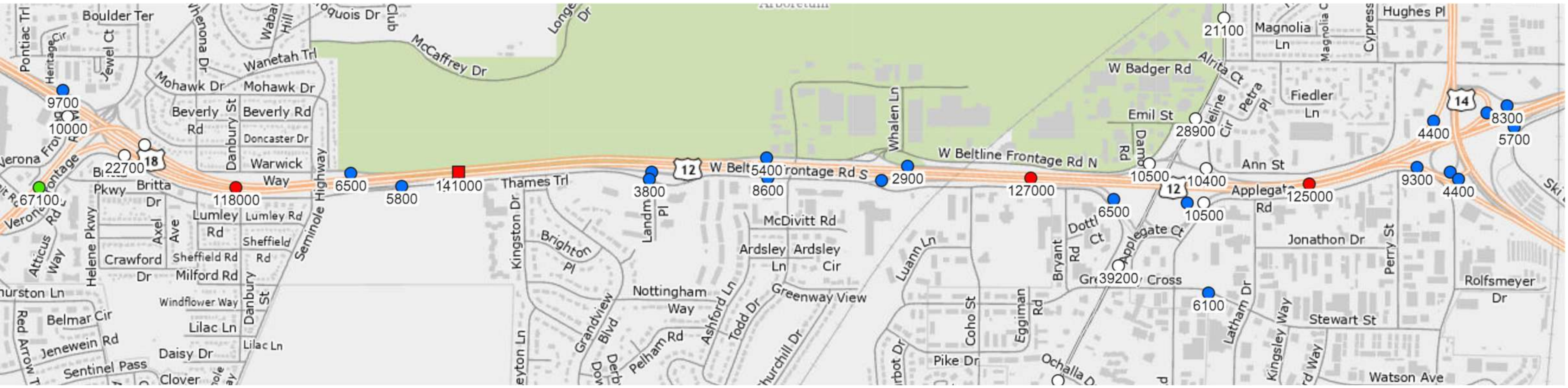
How do things change with Connected Autonomous Vehicles (CAVs)?
- CAVs can communicate with other vehicles, and allows data analysis for a more efficient path of travel
- According to literature [2], CAVs are safer and reduce traffic conflicts
- CAVs can react to road hazards by reducing speed, adjusting braking distance, or changing lane positioning after analyzing real-time data

[2] Papadoulis, A., Quddus, M., & Imprialou, M. (2019, January 2). *Evaluating the safety impact of connected and autonomous vehicles on motorways*. Accident Analysis & Prevention.

Background


HVs
CAVs
Active engagement required
Human Driver
Limited communication (signals, driver awareness)
More prone to traffic inefficiencies
Relies on judgement, experience, and reaction time from driver
Utilizes existing roads, signals, and rules
Vehicle structure
Must interact with other road users
Operated by AI and sensors
Uses algorithms and data to make decisions
Optimizes routes and speeds that reduce congestion
Communicates with other vehicles, infrastructure, and clouds
Continuously learns through machine learning/updates

Simulation Setting: Location



Traffic volume data (AADT) are captured from [WisDOT Traffic Counts](#) updated in Oct. 2022.

Simulation Setting: Scenario

Our study consider three weather conditions: **normal**, **fog**, and **rain**.

According to the literature [3], the impacts of the above two special environments on traffic flow can be translated into effects on the **speed**. Based on literature [4], we have set specific speeds as follows:

Weather	Normal	Fog	Rain
Speed Reduction	0%	7.4%	10.2%
Car Speed	90 km/h	83 km/h	81 km/h

[3] Nasim Khan, Md, Anik Das, and Mohamed M. Ahmed. "Non-parametric association rules mining and parametric ordinal logistic regression for an in-depth investigation of driver speed selection behavior in adverse weather using SHRP2 naturalistic driving study data." *Transportation research record* 2674.11 (2020): 101-119.

[4] Das, Anik, and Mohamed M. Ahmed. "Adjustment of key lane change parameters to develop microsimulation models for representative assessment of safety and operational impacts of adverse weather using SHRP2 naturalistic driving data." *Journal of safety research* 81 (2022): 9-20.

Simulation Setting: Car Following

Our simulation compares the results for HV and ADS-equipped CAV. According to the literature [5], we use the Wiedemann 99 Car-Following model with the following parameters to simulate the HV and CAV:

Definition	HV	CAV
Stand still distance (m)	1.5	1
Headway time (s)	1.6	1
Following variation (m)	4	0
Threshold for entering following (s)	-8	-6
Negative following threshold (m/s)	-0.35	-0.1
Positive following threshold (m/s)	0.35	0.1
Speed dependency of oscillation (1/(m/s))	11.44	0
Oscillation acceleration (m/s^2)	0.25	0.1
Standstill acceleration (m/s^2)	3.5	4
Acceleration with 50 mph (m/s^2)	1.5	2

[5] Hajbabaie, Ali, Mehrdad Tajalli, and Eleni Bardaka. "Effects of connectivity and automation on saturation headway and capacity at signalized intersections." Transportation research record 2678.5 (2024
31-46.

Simulation Setting: Lane Changing

According to the literature [5], we use the Lane Changing model with the following parameters to simulate the HV and CAV:

1 Advanced Merging: A vehicle's ability to anticipate merging needs and adjust its speed to facilitate smoother merging maneuvers.
HV: Disabled (**Off**) **CAV:** Enabled (**On**)

2 Cooperative Lane Change: Allows vehicles to communicate and adjust their speeds to smoother lane-changing. Maneuvers.
HV: Disabled (**Off**) **CAV:** Enabled (**On**)

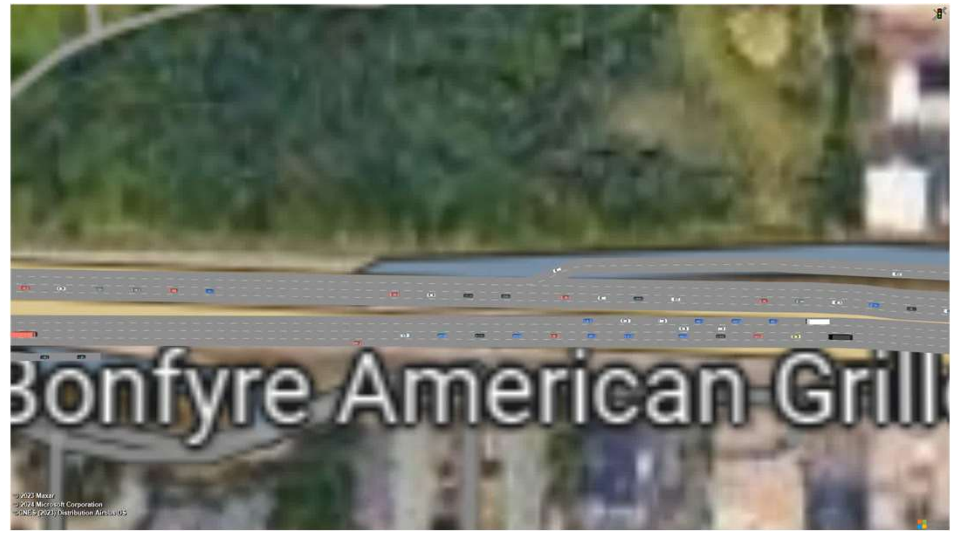
3 Safety Distance Reduction Factor: How much a vehicle can reduce its following distance while maintaining safe driving conditions
HV: 1.0 **CAV:** 0.6

4 Maximum Deceleration for Cooperative Braking: The maximum rate at which a vehicle can decelerate when participating in cooperative braking scenarios
HV: -2.5 m/s^2 **CAV:** -4.0 m/s^2

[5] Hajbabaie, Ali, Mehrdad Tajalli, and Eleni Bardaka. "Effects of connectivity and automation on saturation headway and capacity at signalized intersections." Transportation research record 2678.5 (2024): 31-46.

Simulation Demonstration

HV Normal

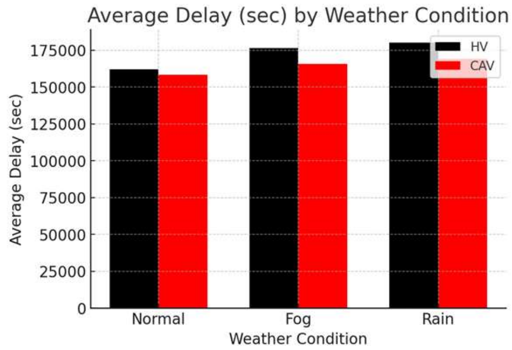


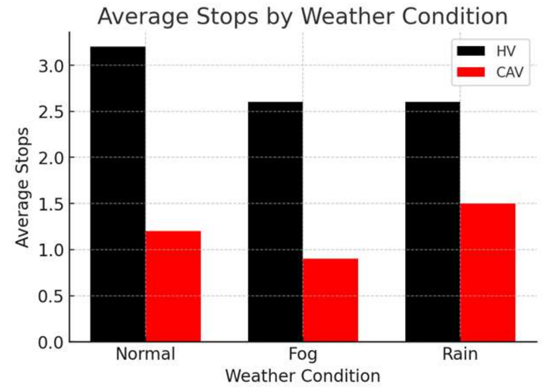
CAV Normal

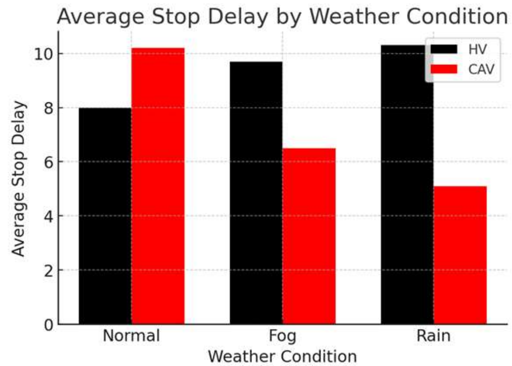
Other scenarios needed

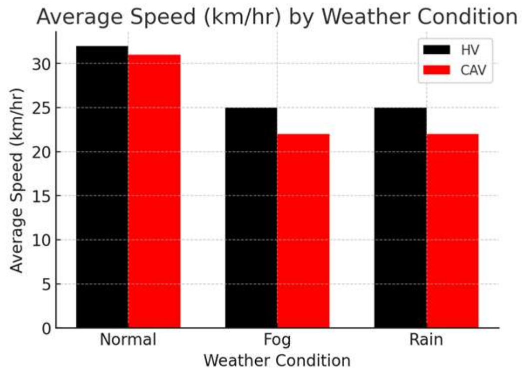
Performance Comparison

Simulation setups: for each model, we run simulation 5 times with each lasting 600 seconds and then take average for each metric over all runs.









Conclusion & Key Takeaways

- Using VISSIM, lane changing model and the Wiedemann 99 car-following Model, our study highlights the potential of Connected and Automated vehicles (CAVs) in improving roadway efficiency
- Heavy fog and rain notably affect human-driven vehicles (HVs), leading to increased delays and lower speeds
- CAVs show resilience in adverse weather conditions, maintaining smoother traffic flow and reducing congestions compared to HVs
- As CAVs technology evolves, integrating these insights can help reduce human error and design smarter and more efficient traffic systems for safer roads
- Real-world complexities (e.g., unexpected driver behavior, infrastructure variations) may not fully be captured and further research is needed to refine CAV models for diverse traffic environments

Thank you

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