

# Do Autonomous Vehicles Respond Faster than Human Driver?

Tanmay Das<sup>1</sup>, Shoaib Samandar<sup>1</sup>, Nagui Rouphail<sup>1</sup>, Billy Williams<sup>1</sup>

<sup>1</sup>Civil Construction and Environmental Engineering, North Carolina State University, Raleigh, NC



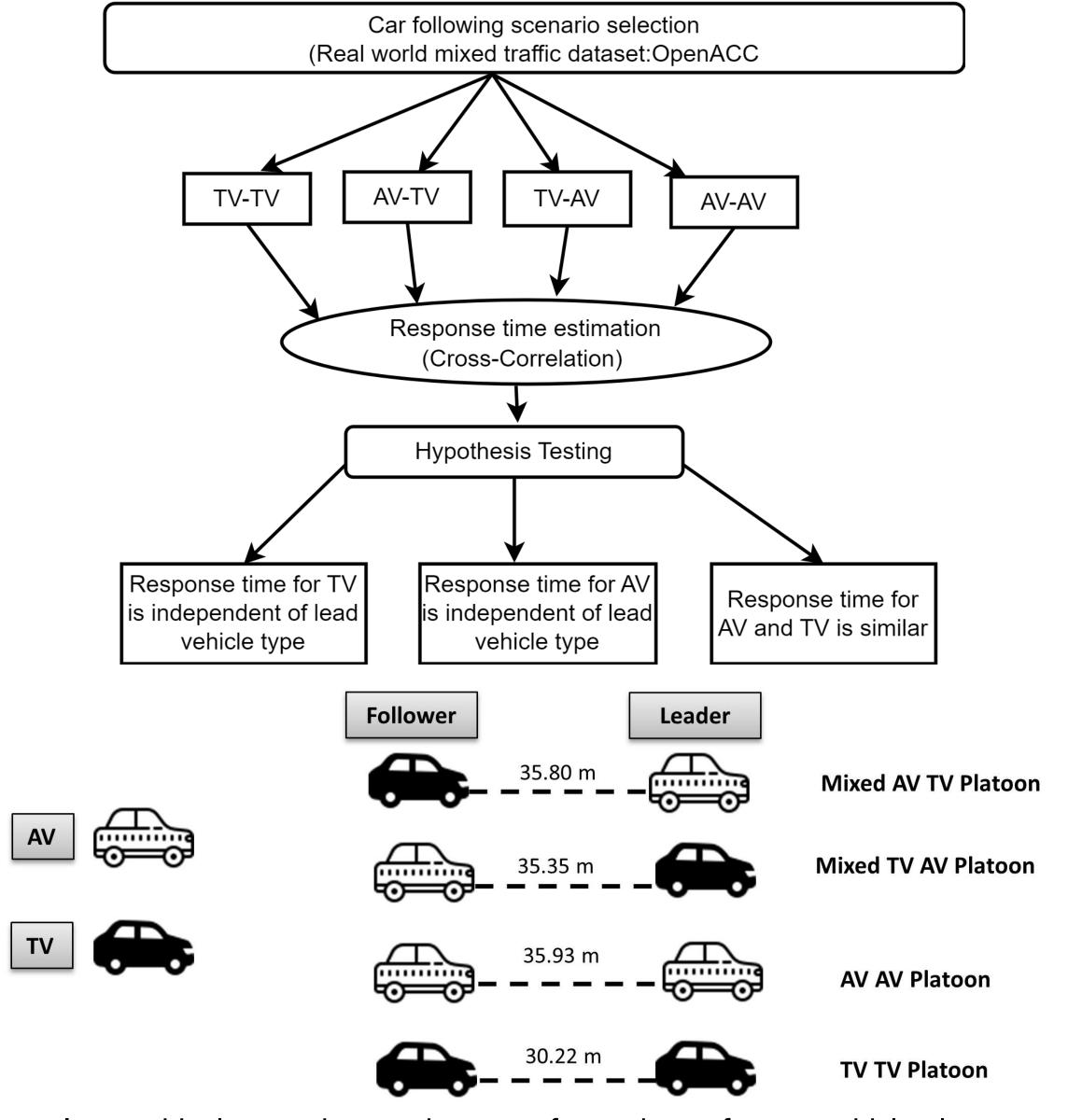
#### INTRODUCTION

- ❖ Response time (RT) shows how long it takes for a driver/vehicle to respond to a situation by accelerating, decelerating or doing nothing in response to the action of the leading vehicle.
- ❖ Literature suggests, RT affects safety and mobility of traffic stream significantly.
- ❖ Scarce literature available on estimating autonomous vehicles' (AVs) RT operating in mixed traffic with human driven vehicles (TVs).

### RESEARCH QUESTION

❖ Do Autonomous Vehicles Respond Faster than Human Drivers ?

## **WORKFLOW and DATA DESCIRPTION**

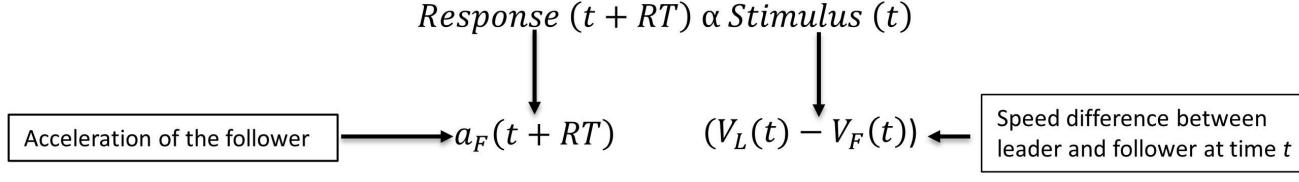


Inter vehicular spacings at the start of experiment for two-vehicle platoons

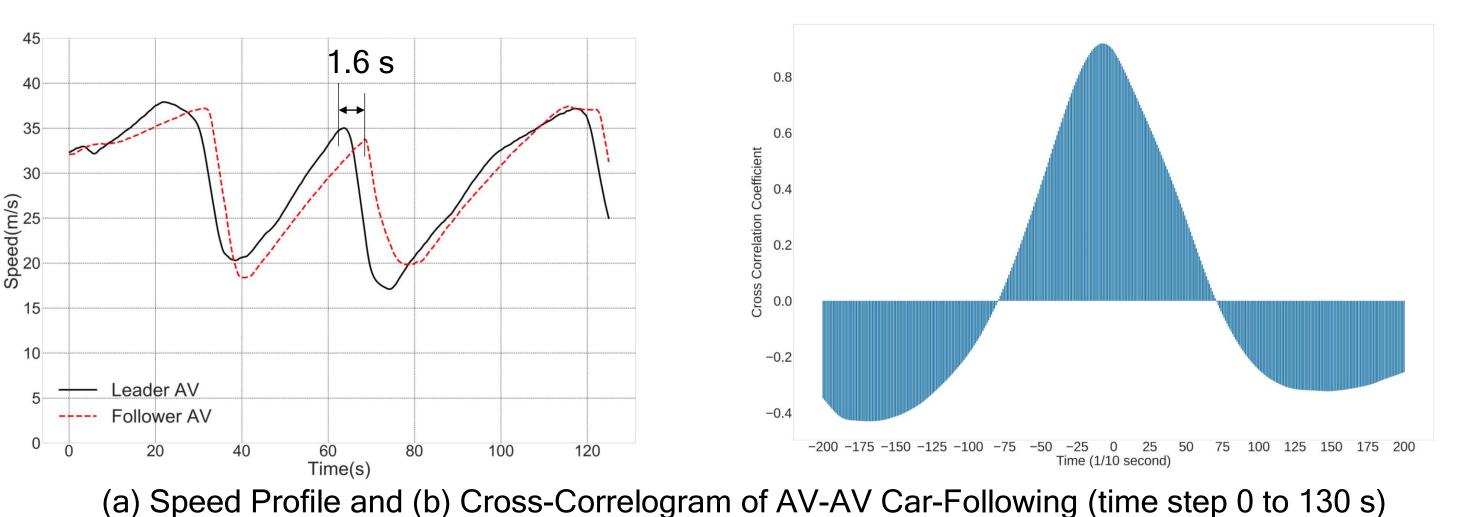
## RESEARCH METHODOLOGY (CROSS CORRELATION)

Consider, two time series x(t) = Stimulus(t) and  $y(t) = Response\ (t+RT)$  lag by a time interval RT, where  $t \in \{0,1,2,3,\ldots,n\}$ . The cross-correlation r at lag d, r(d) as follows:  $r(d) = \frac{\sum_t [(x(t) - \mu_x)*(y(t-d) - \mu_y)]}{\sqrt{\sum_t (x(t) - \mu_x)^2} \sqrt{\sum_t (y(t-d) - \mu_y)^2}}$ 

The value of the lag with the highest correlation coefficient represents the best fit between the two series therefore the RT.



#### RESULTS



- ❖Correlation coefficient between response of the following vehicle and the stimulus is highest (0.88) at -16(1/10)=-1.6 s.
- Similarly, we estimated response time for all other time steps for TV-AV, AV-TV and TV-TV scenarios.

3.5
3.0
(S) 2.5
(B) 2.5
(B) 2.0
(S) 2.5
(S) 2.

Sample 1 Follower's Response Time (s)	Sample 2 Follower's Response Time (s)	Null Hypothesis	t test p Value	At 95% CI
AV-TV (1.15 s*, 0.59 s**)	TV-TV (1.56 s*, 1.06 s**)	Response time for TV is independent of lead vehicle type	0.305	Cannot reject
TV-AV (2.36 s*, 0.58 s**)	AV-AV (1.99 s*, 0.61 s**)	Response time for AV is independent of lead vehicle type.	0.1829	Cannot reject
AV (2.15 s*, 0.59 s**)	TV (1.31 s*, 0.76 s**)	Response time for AV and TV is similar	0.0003	Reject

Estimated response times for different car-following scenarios

\*Mean; \*\*Standard deviation

### CONCLUSIONS

- ❖Response time for TVs or AVs was independent of lead vehicle type
  - ❖AV response time (2.15 s) was significantly higher than the TV response time of (1.31 s)