## NC STATE

 UNIVERSITYDo Autonomous Vehicles Respond Faster than Human Driver?
Tanmay Das ${ }^{1}$, Shoaib Samandar¹, Nagui Rouphail1, Billy Williams ${ }^{1}$
${ }^{1}$ 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 $x(t)=\operatorname{Stimulus}(t)$ and $y(t)=$ Response $(t+R T)$ lag by a time interval $R T$, where $t \in\{0,1,2,3, \ldots \ldots \ldots . n\}$. The cross-correlation $r$ at lag $d, r(d)$ as follows: $r(d)=\frac{\sum_{t}\left[\left(x(t)-\mu_{x}\right) *\left(y(t-d)-\mu_{y}\right)\right]}{\sqrt{\sum_{t}\left(x(t)-\mu_{x}\right)^{2}} \sqrt{\sum_{t}\left(y(t-d)-\mu_{y}\right)^{2}}}$

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


## RESULTS

| Sample 1 Follower's <br> Response Time (s) | Sample 2 Follower's <br> Response Time (s) | Null Hypothesis | t test <br> p Value | At 95\% CI |
| :---: | :---: | :---: | :---: | :---: |
| AV-TV <br> $\left(1.15 \mathrm{~s}^{*}, 0.59 \mathrm{~s}^{* *}\right)$ | TV-TV <br> $\left(1.56 \mathrm{~s}^{*}, 1.06 \mathrm{~s}^{* *}\right)$ | Response time for TV <br> is independent of lead <br> vehicle type | 0.305 | Cannot <br> reject |
| TV-AV <br> $\left(2.36 \mathrm{~s}^{*}, 0.58 \mathrm{~s}^{* *)}\right.$ | AV-AV <br> $\left(1.99 \mathrm{~s}^{*}, 0.61 \mathrm{~s}^{* *}\right)$ | Response time for AV <br> is independent of lead <br> vehicle type. | 0.1829 | Cannot <br> reject |
| AV <br> $\left(2.15 \mathrm{~s}^{*}, 0.59 \mathrm{~s}^{* *}\right)$ | TV <br> $\left(1.31 \mathrm{~s}^{*}, 0.76 \mathrm{~s}^{* *}\right)$ | Response time for AV <br> and TV is similar | 0.0003 | Reject |

*Mean; **Standard deviation

Estimated response times for different car-following scenarios

## CONCLUSIONS

$\$$ Response time for TVs or AVs was independent of lead vehicle type
$\star \mathrm{AV}$ response time ( 2.15 s ) was significantly higher than the TV response time of ( 1.31 s )

