Countermeasures to Detect and Combat Inattention While Driving Partially Automated Systems

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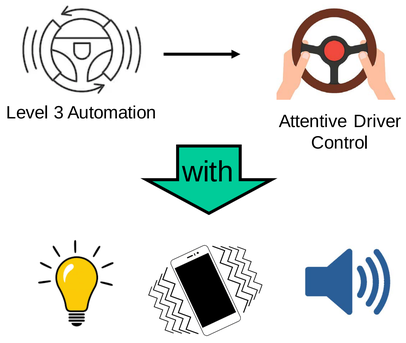
Introduction

- Problem: Inattention leads to accidents
- Solution: Direct attention back with cues when there are faults with automation
- Find best cue that shortens time between autonomous driving and human control

Objective



Background

Problems with highly automated vehicles

- Lack of education on how to use autonomous vehicles
- Automated systems could potentially fail
- Requirements for takeover are unclear

Scenarios Where Automation Fails

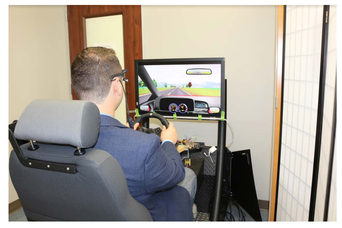
- Extreme weather conditions
- Speed traps situations
- Closed Roadways

Experiment

- ~30-50 participants from ages 18 up
- Designed to encourage inattentiveness to test the displays
- Using behind the scenes “Wizard of Oz” method to run displays
- Vigilance article used to determine time between events (roughly 5 minutes between start and first event and total scenario time of 20 minutes)
- Baseline vitals taken a few minutes beforehand using the empatica for physiological baseline measures such as heartrate.
- Scenarios created after accidents where autonomous vehicles failed in reported accidents
- Test subjects will be given a practice driving scenario, then a baseline driving test before the display testing scenario.
- During the testing scenario, test subjects will be asked to notify the proctors when the display cues the driver then the driver will be prompted to put their hands on the steering wheel
- The test will have the test subjects take over the steering wheel around 6 times (with 4 cued takeovers and 2 not cued) with 3 steering and 3 petal failures.

Devices Used

- Empatica E4: measures Blood Volume Pulse, Skin Conductance
- Pupil: eye tracking and pupil diameter



Methods

Scenarios

- To create the scenarios which the displays will be tested, STISIM drive was used
- Either a auditory, tactile, or light display will be used to cue the driver to direct their attention back to the steering wheel
- The scenario will test how long it will take the test subject to react to the display and the physiological measures of pupil diameter and heart rate at the times of transition.

STISIM Drive

- PC based simulator
- Programmed by text file then uploaded
- Wide variety of premade scenarios
- Detailed manual
- Easy to use
- Variety of models and variations of road

Limitations of STISIM Drive

- Glitch when used for over 10000 feet
- Occasional slow lag when loading

Summary of Scenario

Scenario time (approximate)	Distance (feet)	Event	Simulator	Experimenter-triggered
0:00:00	0	Start: Surburbia	x	x
0:01:20	4800	Highway Starts (70 mph)		x
0:05:10	29000	Severe Weather (Fog)	x	
0:05:53	31000	Petal Automation Fail-Signal-Parked Car in Road with Fog	x	
0:10:08	52700	Steering Automation Fail- Signal- No Obstruction		x
0:10:25	54970	Steering Automation Resumes		x
0:12:02	71200	Steering Autkomation Fail- NO SIGNAL -boxes in road		x
0:14:43	87200	Petal Automation Fail -Signal- No Obstruction	x	
0:15:06	89000	Petal Automation Fail Ends	x	
0:18:17	107900	Steering Automation Fail -Signal-Barrels in Road		x
0:19:26	119000	Petal Automation Fail-NO SIGNAL- boxes in road	x	
0:20:45	127100	End Scenario	x	

Example of STISIM Code

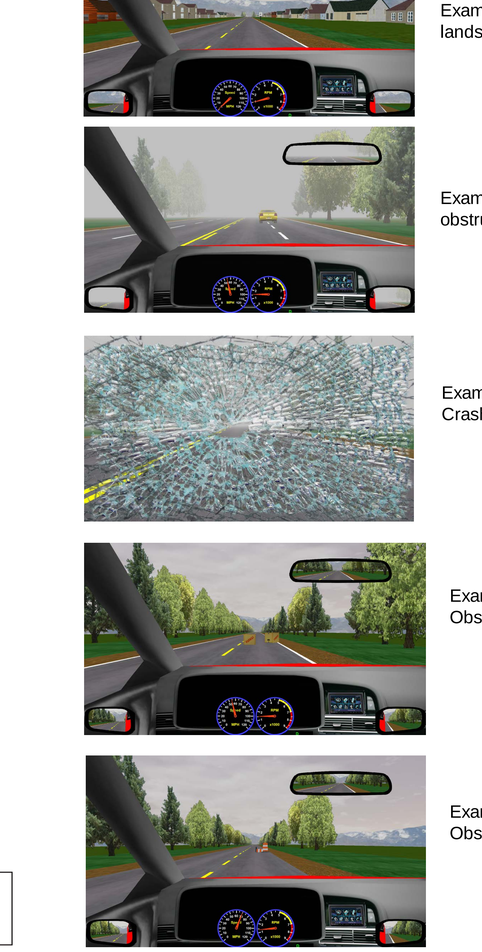
```
1200, Sign, 7, 1000, 4, 0, 0

- initially apears at 1200
- object will be a sign
- 7 = Stop Sign
- 1000 feet from where it initially appears
- 4 way stop
- 0 = U.S Road Sign (1 is European)
- 0 = Drivers Side (1 is opposite side of the road)
```

Event Parameters:

Parameter 1:	**Sign Model Index Number.** Model index numbers for the signs are defined in the *Model Library Manual*. **100** = Specifies a non-standard sign model. If 100 is entered, specify the sign model filename and path in Parameter 3.
Parameter 2:	**Appear Distance (feet or meters).** Longitudinal distance that the sign is away from the driver when the sign event initially appears. See the *SDL Basics – Introduction* for further information about ways to set the Appear Distance. **Automatic Intersection Stop Sign Placement:** If Parameter 1 is specified for a Stop Sign Model (7), a negative sign (–) placed in front of the Appear Distance will place the signs automatically in the intersection. If no negative sign is used, the sign models will act as specified. If you are using this option, make sure that the stop sign event lines up with the intersection event, otherwise the signs will be mis-aligned. For example if you have an intersection that is 1200 feet away, you want the stop sign event to have the same On Distance as the intersection event and its Appear Distance to be -1200 feet away.
Parameter 3:	Specialty parameters for any signs that require them. If not using a stop sign or non-standard sign model, this parameter is ignored. **Stop Sign (Parameter 1 = 7):** 1 = Single stop sign in driver's direction 2 = Two way stop in the driver's direction 3 = Single stop sign in cross traffic's direction on right 4 = 4 way stop 5 = Two way cross traffic stop 6 = Single stop sign in cross traffic's direction on left 7 = 4 way stop with a "4-Way" placard underneath the sign 8 = 4 way stop with an "All-Way" placard underneath the sign **Non-Standard Sign Model** (If Parameter 1 = 100): Specifies the file name and path of the sign model that will be displayed.
Parameter 4:	**Sign Source.** 0 = United States road signs 1 = Generic European road signs
Parameter 5:	**Side of Road to Display.** Specifies if the sign should be displayed on the opposite side of the road. 0 = Sign displayed on driver's side of road 1 = Sign displayed on opposite side of road
Parameter 6:	**Heading Rotation Value (degrees).** This allows you to display road signs whose faces are rotated relative to the roadway. For example a sign on the other side of the road facing in the other direction.

Timing Prompts

- Deer sign = start display
- Plain White Rectangle Sign= end display



Example of landscape

Example of obstruction

Example of Crash

Example of Box Obstruction

Example of Barrel Obstruction

Future Work

- VTTI has the second phase of this project by developing and refining a Driver Monitoring System (DMS). This will be used to estimate the level of attentiveness the driver has when completing driving tasks that require human input or taking over driving from automation control.
- Later we will combine our efforts with VTTI(Virginia Tech Transportation Institute) and use all the advancements in an actual autonomous vehicle and test displays and the DMS.
- The study will be completed on a test track with the experimenters as drivers instead of participants. This event will be open to the general public and also the media.