CRASH IMMINENT SAFETY:
A TIER 1 UNIVERSITY TRANSPORTATION CENTER

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The full name of our Center:

“Human Factors for Crash Imminent Safety in Intelligent Vehicles”
Each Project has a Lead Investigator and researchers from multiple Universities.
PROJECT #1: NETWORKED DRIVING SIMULATORS

- All are simulators from the same company, although some are “table-top” models. All are running the same software.
- OSU-1 has moveable base, back rear screen etc.
- Some connections established and still under test.
- Research also underway on synchronization issues
MOTIVATION FOR BEHAVIOR CLASSIFICATION

Project #2:

In congested traffic, a vehicle needs to change into the left/right turn only lane.

A vehicle is changing lane without checking the blind spot.

The driver has to change lane to deal with emergencies.

A vehicle needs to change to a certain lane to exit the highway.

In all these situations, the lane change behavior of the cut-in vehicle can be different from the common estimation estimated by the driver or auto-pilot controller of the overtaken (host) vehicle.

- Necessary to recognize behavior difference of lane change and cut-in maneuvers.
- In this work, we classify a driver’s lane change behaviors into two classes: Normal driving and dangerous driving.
- Dangerous driving is defined as driving behavior with unexpected manners involved during lane changing, e.g. fatigue or aggressive driving, emergency obstacle avoidance, etc.
MOTIVATION FOR BEHAVIOR CLASSIFICATION

Try to estimate and classify driver’s behavior of the cut-in (target) vehicle using vehicle state emissions from the beginning stage of a lane change process.
Input: \( \{x_1, \ldots, x_K\}, \quad x \in \mathbf{X} \subset \mathbb{R}^M \) \hspace{1cm} (State measurements of the target vehicle)

Maneuver prediction: \( \{x_1, \ldots, x_K\} \times m \in \mathcal{M} \) \hspace{1cm} (\( \mathcal{M} \) is the maneuver candidate set)

Behavior classification: \( \{x_1, \ldots, x_K\} \times m \times b \in \mathcal{B} \)

\[ \mathcal{B} := \{b_i, i \in \{0,1\} : b_0 = \text{normal}, b_1 = \text{dangerous}\} \] (1)
An Hidden Markov model consists of a set of $N$ discrete hidden states and a set of observations of each state.

$$\lambda = \{N, M, \pi, T, e\}$$  \hspace{1cm} (2)

The model has $N$ unobservable (discrete) states and a probability matrix $T$ shows the hidden state transition, and $e$ is the emission matrix connecting the hidden states to their output $x$.

The observations are dependent on the hidden states, and each state has a probability distribution over each possible output.
Model-based re-engagement and control coordination

- Algorithms assess anomalies and risk at multiple temporal and spatial scales
- Re-engagement at multiple timescales
  - Alerting/warning
  - Redirecting driver attention to developing risk
  - Directing the driver to take charge of some control functions
  - Reconfiguring automated subsystems
  - Communicating authority and capacity—clearly demarking intended use
- Concept development and evaluation in the simulator
- Driver model development in parallel to complement Project 2
Project 3: COGNITIVE ATTENTION MODELING

- Understand how drivers respond to vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) information cues in pre-crash scenarios.

- Understand driver engagement over a range of human physiological and behavioral factors, including age and drowsiness.

- Consider how to re-engage a driver who may be partially or completely disengaged from key attention elements while operating a semi-autonomous vehicle.
Semi-autonomous Vehicles: Two cases

Case 1: Alternating glances inside and outside vehicle

Case 2: Transfer of control
How long does it take drivers to achieve situation awareness in a semi-autonomous Level 3 environment?

Experienced drivers were quicker to achieve the same level of situation awareness (i.e., latent hazard anticipation; LHA) as the manual driving control group.

*Informative of the not only personalized take-over times, but more importantly the validity of LHA as a measure of situation awareness in a semi-autonomous environment.*
The purpose of this project is to initiate foundational experimental research, based upon enabling technologies for automated operation and V2X communications, in the areas of:

- Lane Change and Merging freeway lateral maneuvers, with the purpose of increasing roadway throughput and safety.
- Optimizing and executing the lane change, merging and demerging tasks into/out of highways in longitudinal automation. This could involve V2X sensors and communications at fixed locations in the highway network.

Gap opening/closing merging in to convoy scenario illustration & demonstration with test vehicles on the road.
• Proposed SCENARIOS For Next Phases

- Weaving (Coverleaf Enter/Exit Lane)
- Zipper Merge & Construction Zone
- Integration of real cars (blue) and virtual cars (red)
- RSU Vehicle Tracking with V2I
- Infrastructure Support Vehicle Tracking in Mixed Traffic Environment
- Freeway Entrance with Infrastructure Support
ON DEMAND AUTOMATED SHUTTLES

- On demand automated shuttles can be used for the first or last mile of mobility or for mobility within a selected zone.
- Connected Vehicle technology (intersection safety, cooperative driving) has to be utilized for optimum results. Some Road-Side Units for communication may need to be installed.
- The shuttles are slow but move among dense pedestrian environments and present many “Crash Imminent” situations.
ON DEMAND AUTOMATED SHUTTLES

Shared Routes: Bikes & Pedestrians

Road types:
- Driveway
- Bike trail
- Parking lot
- Parking lot driveway

Control and Intelligent Transportation Research Lab