Haptic Feedback and Its Effect on Learning

Diedrich Swetlik
daswetlik19@coe.edu

Stephen Hughes
shughes@coe.edu

Coe College
Coe makes it possible. You make it happen.

Abstract

Our research explored the potential benefit of using haptic feedback systems in an attempt to train users to use novel control schemes with greater speed and accuracy. The participants raced through six trials in a simulated vehicle using a DualSense controller equipped with some navigation features found in modern cars: Lane Keep Assistance and Lane Departure Warnings. Our initial results suggest that there is a potential connection between haptic feedback and learning, as our groups that used haptic feedback generally performed better than the control group, but more research needs to be done to confirm this. Future research in this topic should include an analysis into participant experience and handedness, as well as including a penalty for collisions.

Concept

The idea for this project grew out of previous work on a mixed-initiative, three-dimensional exploration tool. This tool attempted to guide users toward a specific destination by forcefully taking control of itself when close to a point of interest. A discussion took place about how this method was not truly mixed-initiative, as either the operator or the tool could lock the other out of the controls. This led us to start looking into how haptic feedback systems could replace or enhance this method.

After reading a study from the U.S. Department of Transportation focused on analyzing the effects that haptic feedback integration in vehicles have on the speed and accuracy of motorists [1], we decided to see if haptic feedback had the potential to train an operator in the use of a novel control scheme to a greater degree of speed and accuracy than without the haptic feedback assistance.

Materials

Unity3D
Used to create the environment

DualSense Controller
Used to control the simulated vehicle

Dreamteck Splines
Creates an optimized route within the environment

UniSense
Allows for fine-tune adjustments to the controller

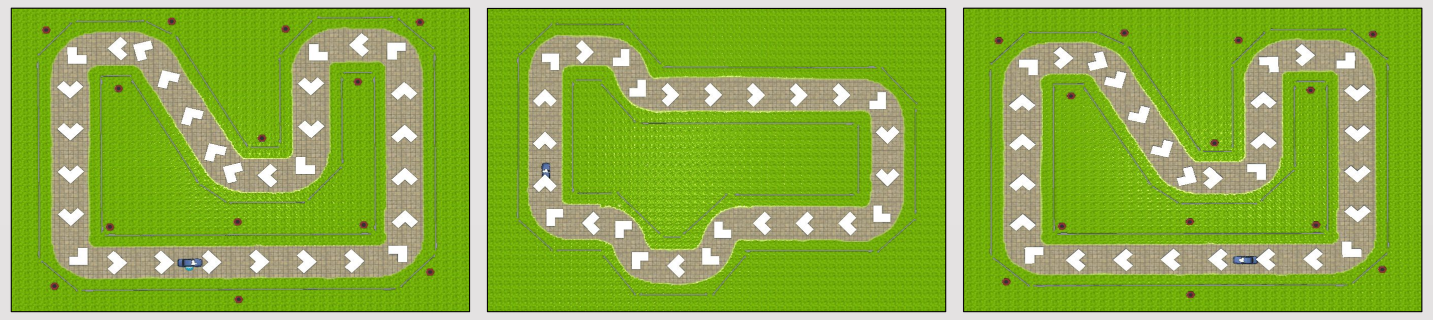
Lane Keep Assistance
Continuous assistance given to keep participants in the middle of the optimized path

Lane Departure Warning
Passive assistance given to redirect participants away from a collision event

Procedure

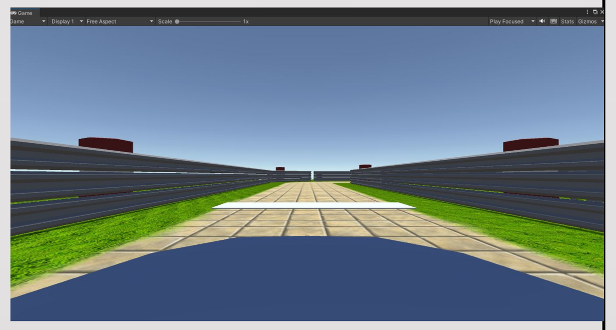
12 participants operated a simulation of a differential steering vehicle using a DualSense controller, utilizing the left and right shoulder triggers (L2 / R2) to move the corresponding side of the vehicle.

Participants used the controller and the simulated vehicle to navigate through three distinct tracks. We designed these tracks to focus on different aspects of using the system. Track A and C are left- and right-dominant, respectively. Track B, due to being more complex, requires finer trigger control overall.



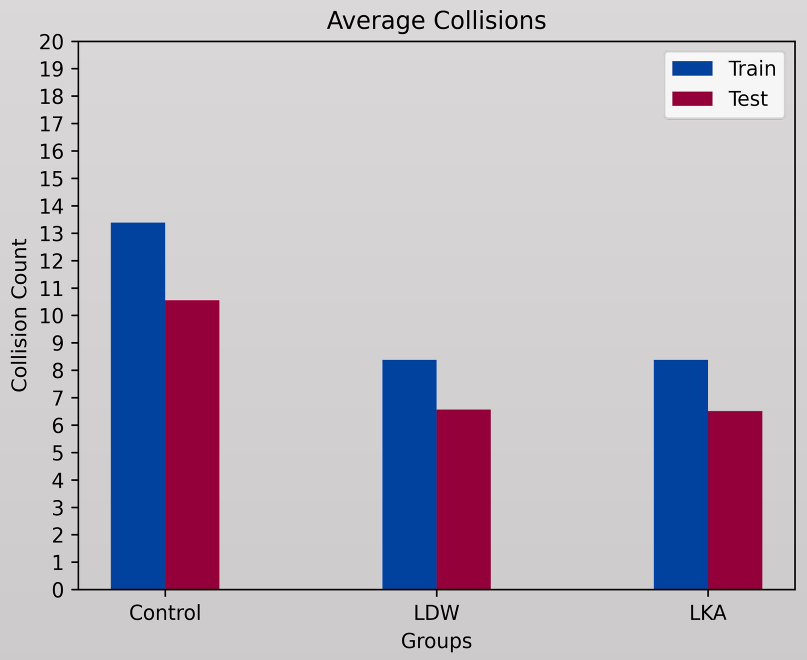
Overhead view of Track A, Track B, and Track C with directional arrows.

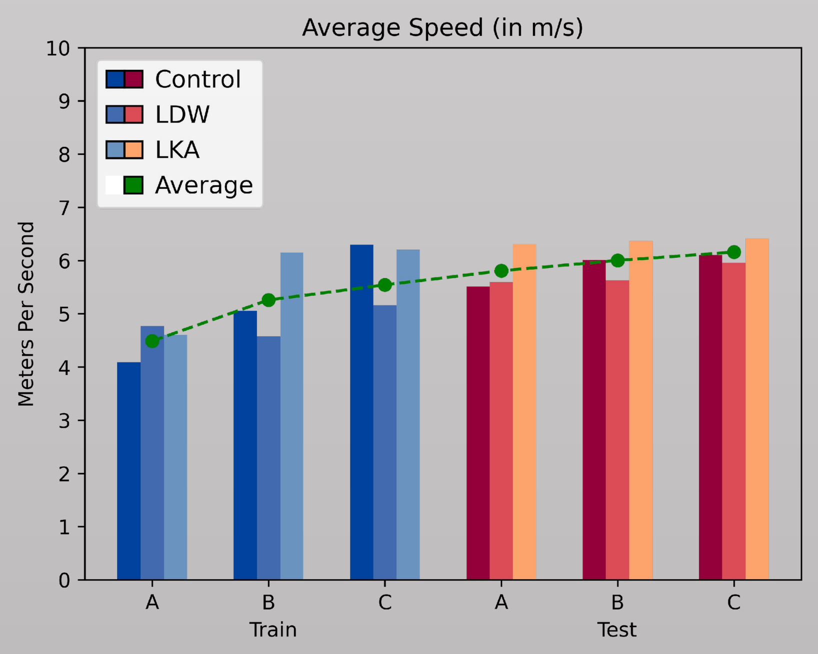
Participants were split into three even groups: Control, LDW, and LKA. All groups navigated through the three tracks for five laps each in two rounds. In the first round, groups LDW and LKA navigated with haptic feedback assistance in the form of either Lane Departure Warning or Lane Keep Assist. For round two, the three groups navigated without assistance.



Participant's view from the vehicle.

Results





Between the train and test phases, the average number of collisions fell. This suggests that there was improvement or learning taking place throughout the experiment from the participants. LDW and LKA have a lower rate of collisions in the training phase, which is to be expected with the haptic feedback assistance. What is promising, however, is that LDW and LKA maintain this lower collision rate throughout the test phase. This indicates potential learned behavior from the haptic feedback assistance that is not matched from the Control group.

The average speed trended upwards for all three groups as the experiment progressed, suggesting that participants began to be more comfortable with the control scheme.

Overall, LDW and LKA had about the same speed with fewer errors than the Control group.

Controller

A DualSense Controller

We used the DualSense (PlayStation 5) controller and its integrated haptic feedback system for this experiment. This system allows for variable tensile strength on the trigger buttons (L2/R2). This allowed us to either increase how much strength was required to depress the triggers, or even forcefully push the triggers back out. We used this to correct a participant's trigger pull to keep them in the road (Lane Keep Assist) or get them back onto the road (Lane Departure Warning). This was done to imitate modern car systems, which currently can vibrate or even jerk the steering wheel in a particular direction in an attempt to correct erroneous steering.

Conclusion

Our preliminary research suggests a few promising results:

1. Speed increased throughout the experiment.
2. Collisions decreased throughout the experiment, especially for LDW and LKA.
3. LDW and LKA performed better initially, particularly with reduced collisions.
4. LDW and LKA maintained their better performance even after the haptic feedback assistance was turned off.

More care needs to be taken in recruiting participants, as those who have previous experience with any controller tended to perform better than those who have not.

We discovered a few points of interest that may also be worth investigating or controlling for in subsequent research:

1. Participant Handedness
   i. Track C, which is right-dominant, seemed to have better performance overall than the left-dominant A.
2. Collision Event Penalties
   i. Participants actively caused collisions to increase speed, since there was no penalty in doing so.

References

[1] Philips, B., Weaver, S., & Gonzalez, T. (2020). *To Alert or Assist: Comparing Effects of Different Lateral Support Systems on Lane-Keeping (FHWA-HRT-20-068).* U.S. Department of Transportation - Federal Highway Administration.