HapticSense

Design of Vibrotactile Signals for Assisted-to-Manual Driving

Henry Li   Matthew Chun

The University of British Columbia

Introduction

In recent years, the prospect of autonomous vehicles has provoked the development of remarkable technologies. Effort has been made to study the affordances and acceptance of autonomous vehicles in the presence of traditional manually operated cars. In one study, Gouy et al. focused on issues stemming from experience of manual operators driving amongst 'platoons' of autonmous vehicles. Chiefly, they focused on the issue of 'time headway' (THW); the amount of following distance admitted given a certain speed. They studied the acclimation effects where manual drivers briefly experienced platoon driving. Subsequently, drivers found safe/conventional THW to be over-generous, suggesting adapation to shorter platoon-style following distances. In situations where automated driving is not possible, dirvers must be able to adapt back to larger THW and manual driving behaviour. We find ways to regulate these lapses in relative distance judgement by using haptic cues to trigger appropriate affective states to allow drivers used to automated driving to behave more like manual drivers.

Objectives

Our goals focused on designing haptic signals which outputted to the vibrotactile chair. Our requirements involved the following:

1) The driver should not be impeded or irritated to the degree they would opt to deactivate the haptic feedback system
2) The signals should be parameterizable in some fashion in order to convey increasing or decreasing levels of urgency determined primarily by proximity
3) The signals should be comprehensible in terms of intended emotional conveyance and driving behavior eg. calm, alert, drive normally, driver faster

Approach

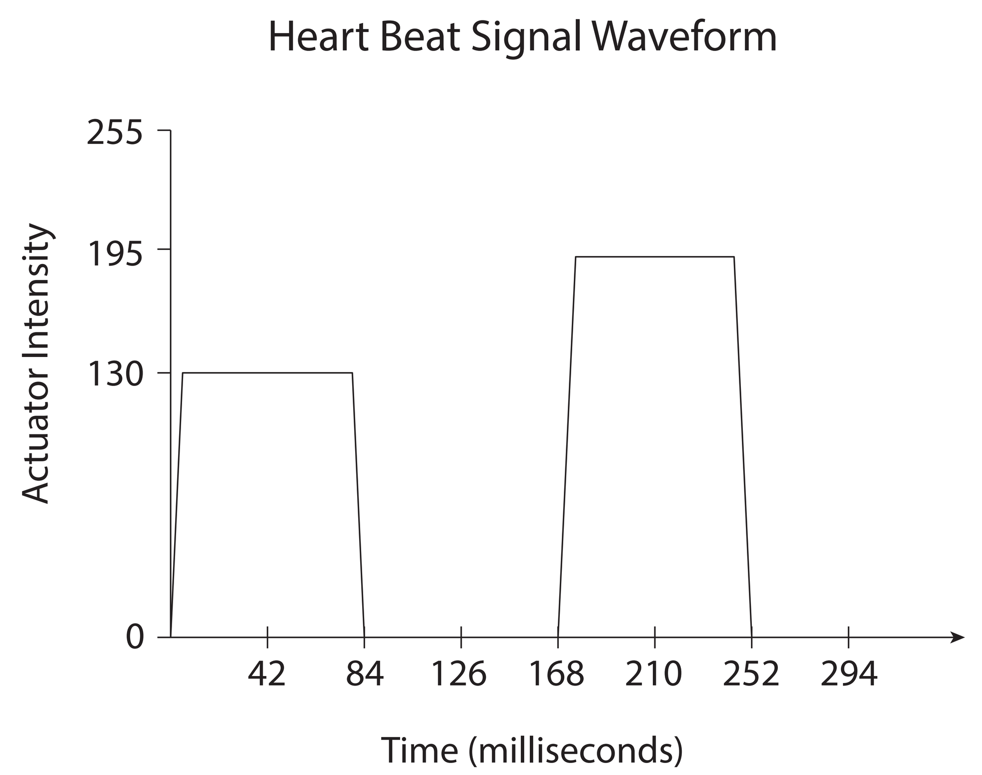
We chose to use a video with timed haptic cues to demonstrate a proof of concept of our system. The script written is dependent on the frame period of the video. Since we used a video with a framerate of 23.976 FPS, we used a loop that

• Send intensity information to each of the active vibro-actuators
• Sustain the intensity for 42 milliseconds

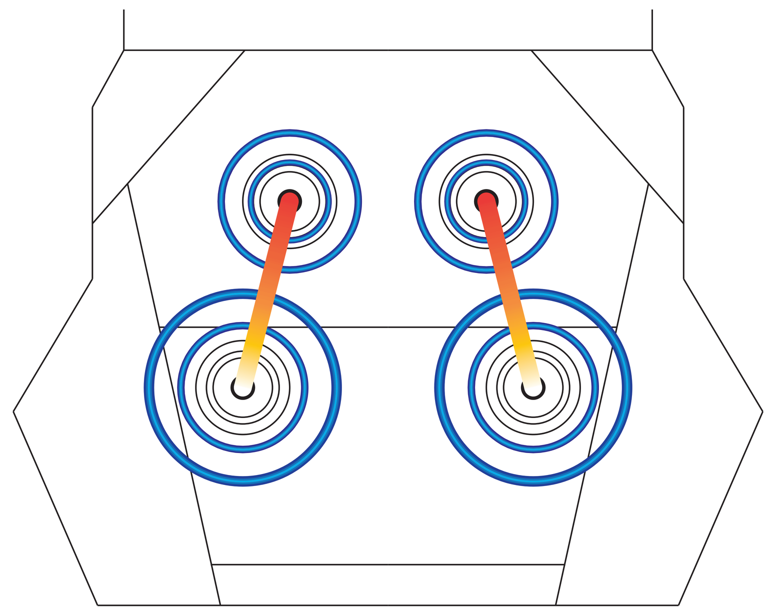
The intensity information was read from an array that was developed to match the action in the video. We defined these arrays programmatically to control the

• beat-rest duration — for the heartbeat signal
• interpolation parameter — for the linear interpolation signal

Results



We developed a pleasing "heartbeat" signal to convey a *rest state* that could easily be ramped as the situation necessitated. We found that the resting heart rate (~ 35.29 beats per min) was not too irritating and conveyed a calm mood as desired.



Additionally, a ramping "wave-like" signal was developed to convey an alert state to further augment the perceived urgency of a situation. We found that using an interpolation parameter was helpful in conveying the intended signal urgency at the precise time for specific driving cases.

The ramping up and down of the urgency parameter for both signals when synchronized with the video was found to be coherent and understandable among team members and external sources.

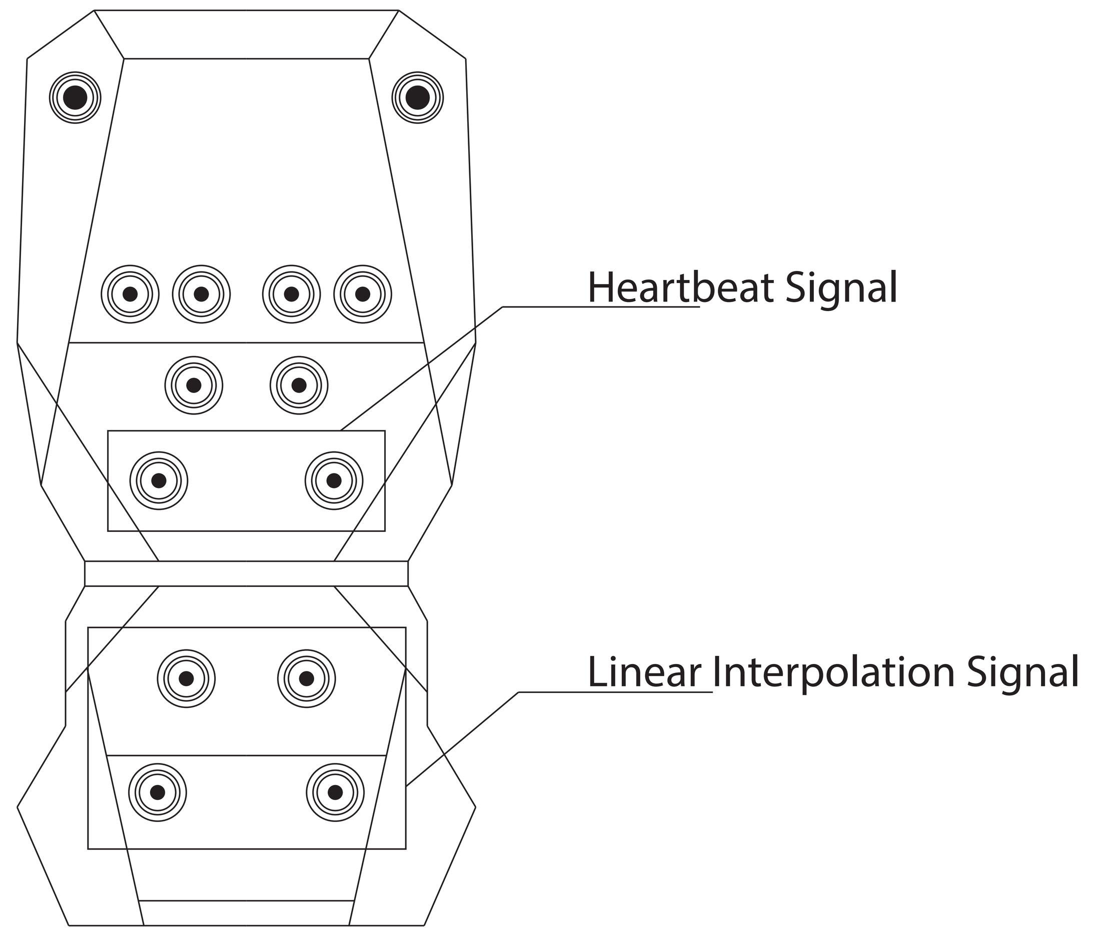
Discussion and Future Work

Qualitatively, the voice-coil type actuators found in the top of the chair were "noisy" in actuation definition. Additionaly these were too weak to acceptably discern relative to the motor actuators. As a result, our signals lost some of their intended urgency/affect. The bottom set of vibro-actuators were found to be more precise in controlling acutuation quality, and conveyed a "sharper" actuation quality needed for our signals.

External feedback indicated that our approach in testing our signals using video somewhat detracted the realism of our intended emotional and driving behaviour expression.

It was suggested that future work should test an interactive "closed" loop system where signals would be based directly on participant information (eg. physiological state, current driving style, etc).

If we were to next consider the design of the actuator layout for this particular application the voice coils could be spaced further apart, so that the spatial content of the signals could be more convincing. This would allow a less distracting display of the increasing amount of sensors (such as blind spot awareness and curb-to-tire proximity sensors) equipped on cars.



Acknowledgements and References

Magali Gouy, Katharina Wiedemann, Alan Stevens, Gary Brunett, Nick Reed, Driving next to automated vehicle platoons: How do short time headways influence non-platoon drivers' longitudinal control?, Transportation Research Part F: Traffic Psychology and Behaviour, Volume 27, Part B, November 2014, Pages 264-273, ISSN 1369-8478, http://dx.doi.org/10.1016/j.trf.2014.03.003. (http://www.sciencedirect.com/science/article/pii/S1369847814000345)