Identifying Driver Behaviour in Steering: Effects of Preview Distance

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Operator identification methods have been used extensively to identify pilot models while controlling aircraft dynamics [1,4]. The current state of the art allows us to simultaneously identify the separate contributions of the pilot's visual system, the vestibular system and the neuromuscular system [1,2,3]. System identification was also used successfully to observe changes in the estimated pilot model parameters due to changes in the simulator motion cueing algorithm [5].

In this paper, the first steps are taken to bring identification in driver steering tasks up to the same level as identification in aircraft piloting tasks. A study was performed to provide measurement data, to allow identification of the driving behaviour in a curve negotiation task. The study aimed to separate two essential driver control components, being:

1. preview (feedforward) control using visual information regarding the upcoming road curvature, and
2. compensatory (feedback) control to minimise lateral position and heading error.

Figure 1 shows a model adapted from [6] which shows two compensatory control loops, responding to a heading error (ψ) and a lateral error (y). Also a feedforward loop is shown, responding directly to the commanded heading ψ_c.

In a fixed base driving simulator, drivers were instructed to drive as they would normally do over a winding road. Two separate stimuli, commonly called forcing functions, were simultaneously applied being 1) the commanded road heading ψ_c, and 2) a steering wheel disturbance δ_{sd}, representing disturbances due to wind and

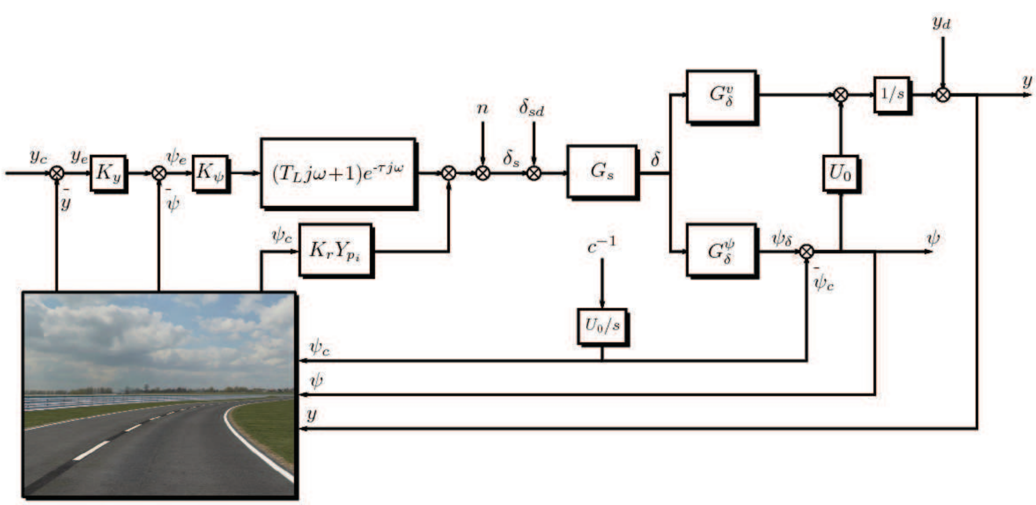

Figure 1. Driver-Vehicle Model adapted from [6].

100m preview 15m preview 5m preview

Figure 2. Three different preview distances.

road irregularities. The application of the forcing functions allows the simultaneous identification of preview and compensatory driver control loops. The forcing functions were defined in the frequency domain and ranged between 0.02 and 1 Hz. To further investigate the use of preview information, the distance of the path preview that was visible to the driver was varied. Figure 2 illustrates the three different preview conditions.

Figure 3 shows the resulting driver steering action magnitude relative to the road curvature. The feedforward system shows an increasing gain with higher frequencies, and this behaviour almost perfectly compensates for the vehicle characteristics which have a reduced gain for higher frequencies. The feedback system shows a more complex behaviour resulting from combined position and heading compensation.

Results with varying preview distance show that drivers rely more on preview with increasing preview distance and that compensatory behaviour is reduced. Although not all results were statistically significant, several measures show that the highest performance was not reached at the maximum preview distance used in this study (100m) but at a shorter distance of 15m. This indicates that with preview above a certain point, drivers no longer minimize lateral error, but use the additional preview to obtain a smooth path.

The presentation will further illustrate methods and results as an example of driver (and pilot) model identification.

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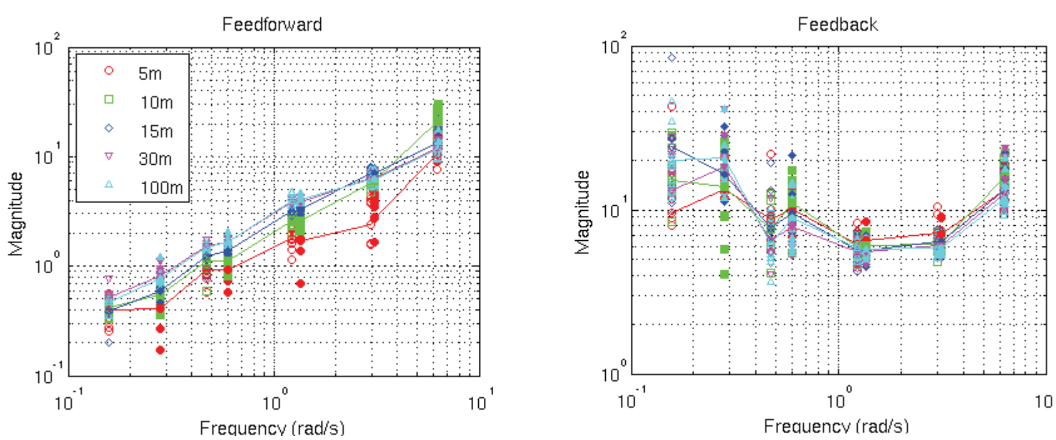

Feedforward system Feedback system

Figure 3. Identified driving behavior. The open symbols represent the commanded road heading, the close symbols represent the steering wheel disturbance.

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