Motion Profiles XGV Control Mode Performance

We have examined the motion profiles XGV control mode performance with several stimulus patterns. Lets first describe the results we have obtained with motion profile speed (car velocity) control.

Car Speed Control

The graph of Figure 1 presents the motion profiles speed control performance for acceleration equal to 2.0 m/s^2.

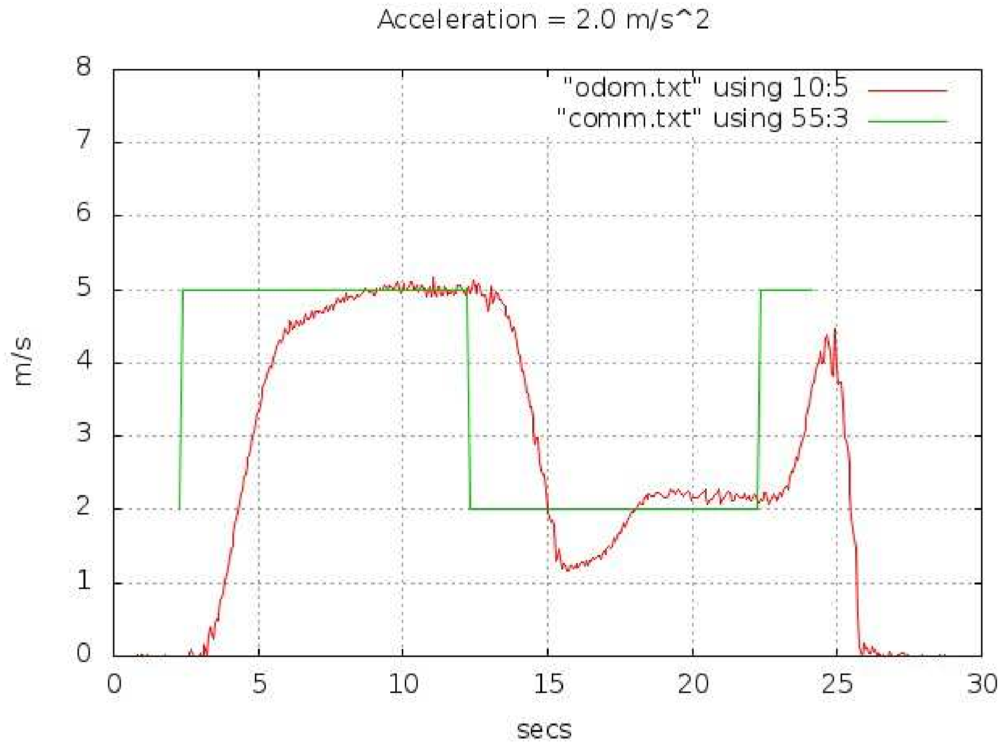

Figure 1: Motion profiles speed control performance with acceleration equal to 2.0 m/s^2.

In the graph of Figure 1, the x axis is time, in seconds, while the y axis is the car speed in m/s. The green curve is the velocity stimulus applied to the car using the motion profiles XGV control mode, and the red curve is the car speed measured using the proper Jaus message.

To produce the graph of Figure 1 we have used an extended version of the code we have developed in the visit we have made to Torc headquarters, in the beginning of this year (we have made this code available to Torc via e-mail). Our code sends motion profiles at a rate equal to 10 Hz, with a single motion profile of 0.2 s duration. Therefore, motion profiles are continuously overwritten by new ones at a rate of 10 Hz. We have made experiments with a duration equal to 0.1 s and obtained equivalent results.

As the graph of Figure 1 shows, there is a significant latency (delay) between the stimulus and the car response. This latency can be better examined in Figure 2.

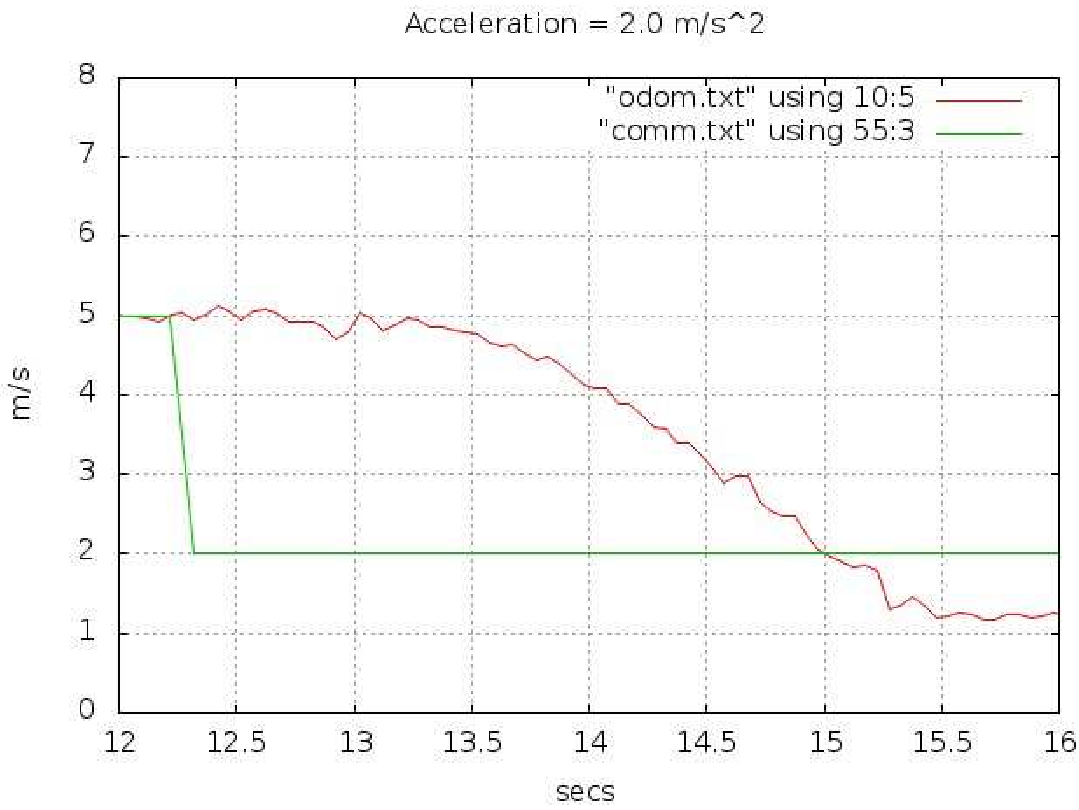

Figure 2: Motion profiles speed control performance with acceleration equal to 2.0 m/s^2 - detail.

As in Figure 1, in Figure 2 the x axis is time in seconds, the y axis is the car speed in m/s, the green curve is the stimulus applied to the car using the motion profiles XGV control mode, and the red curve is the car speed. By examining the difference in time between the velocity stimulus reduction from 5 m/s to 2 m/s to the beginning of the car velocity reduction one can see that the latency of the motion profiles velocity control is more than 1 second. We are concern with this latency because our current maximum operation velocity target is 10 m/s. At this speed, if we decide to stop de car, it will start to reduce its velocity only after traversing more than 10 meters (about 15 meters, actually).

If we increase the acceleration used by the motion profiles command, the latency stays about the same, as a comparison between Figure 3 and Figure 1 shows. In addition, the car speed starts to oscillate.

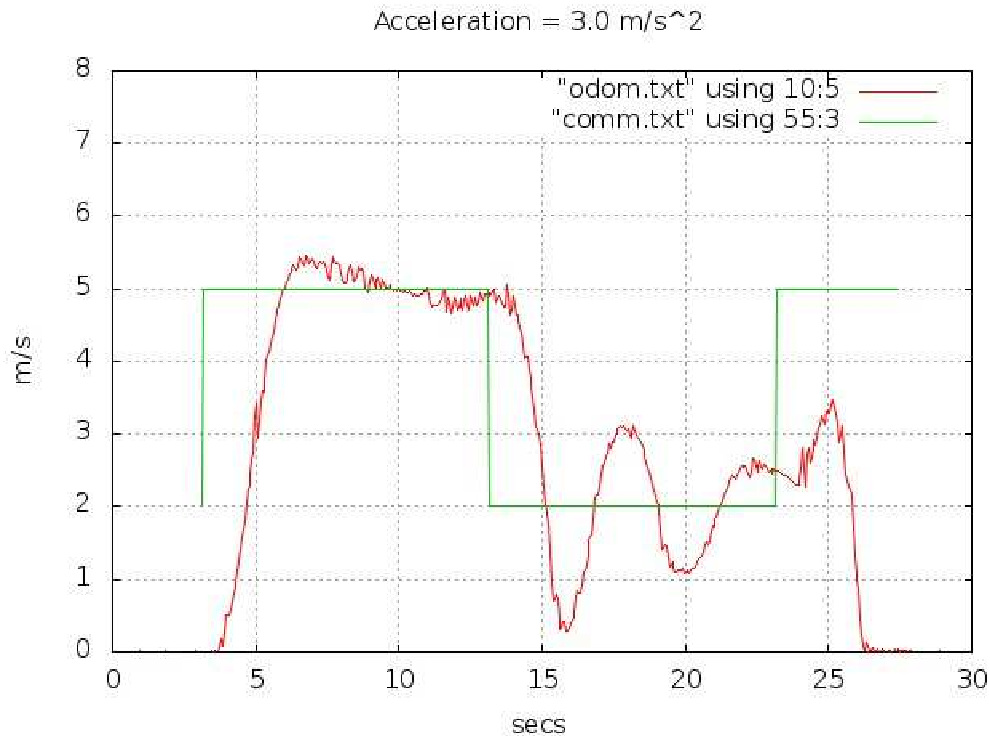

Figure 3: Motion profiles speed control performance with acceleration equal to $3.0\ m/s^2$.

Car Steering Control

The graph of Figure 4 presents the motion profiles curvature control performance for acceleration equal to 0.115 $1/m\ s^2$. Similarly to previous figures, in Figure 4 the x axis is time in seconds, the y axis is curvature in 1/m (please forgive the fact that the graph is current with the wrong unit (m/s)), the green curve is the stimulus applied to the car using the motion profiles XGV control mode, and the red curve is the car curvature. To produce the graph of Figure 4 we have used the same code described previously and in the same conditions.

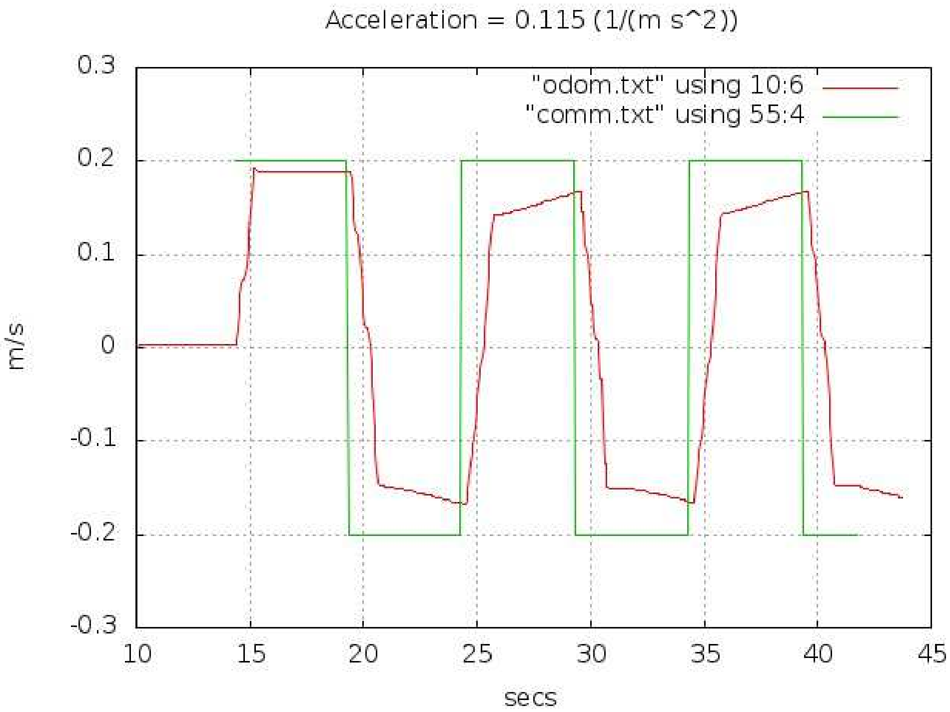

Figure 4: Motion profiles steering control performance with acceleration equal to 0.115 1/m s^2.

Again, as the graph of Figure 4 shows, there is a significant latency (delay) between the stimulus and the car response. This latency can be better examined in Figure 5.

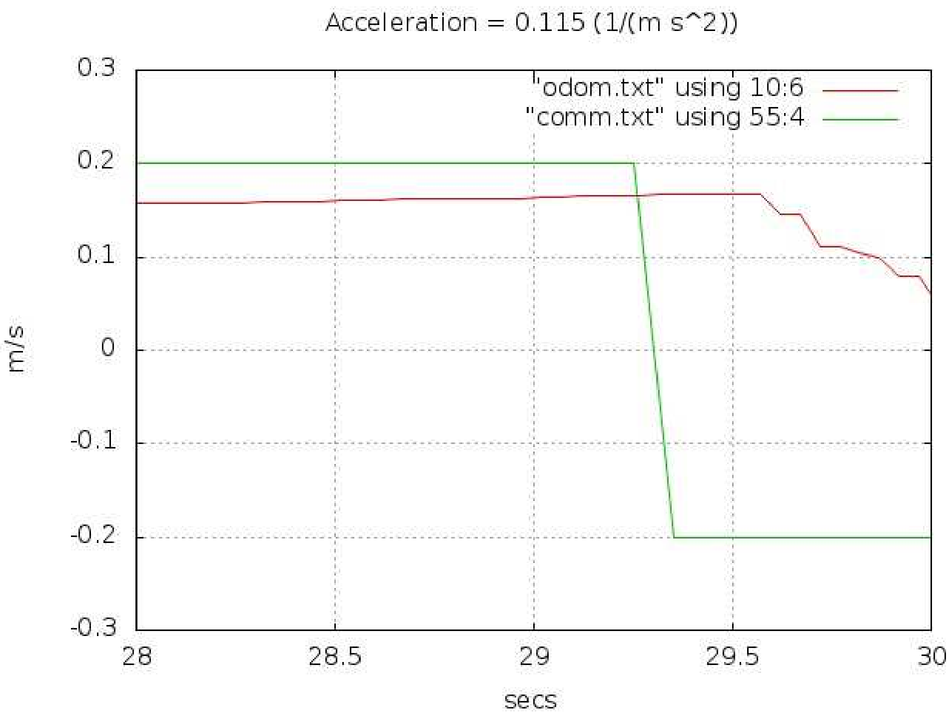

Figure 5: Motion profiles steering control performance with acceleration equal to 0.115 1/m s^2 - detail.

By examining the difference in time between the curvature stimulus reduction from 0.2 1/m to -0.2 1/m to the beginning of the car curvature reduction one can see that the latency of the motion profiles curvature control is more than 0.25 second.

If we increase the acceleration to 0.235 1/m s^2, the latency does not change much, as a comparison between the graphs of Figure 6 and Figure 4 shows. It is important to mention that evolution of the curvature from a set point to another is not smooth, as the graphs of these figures shows.

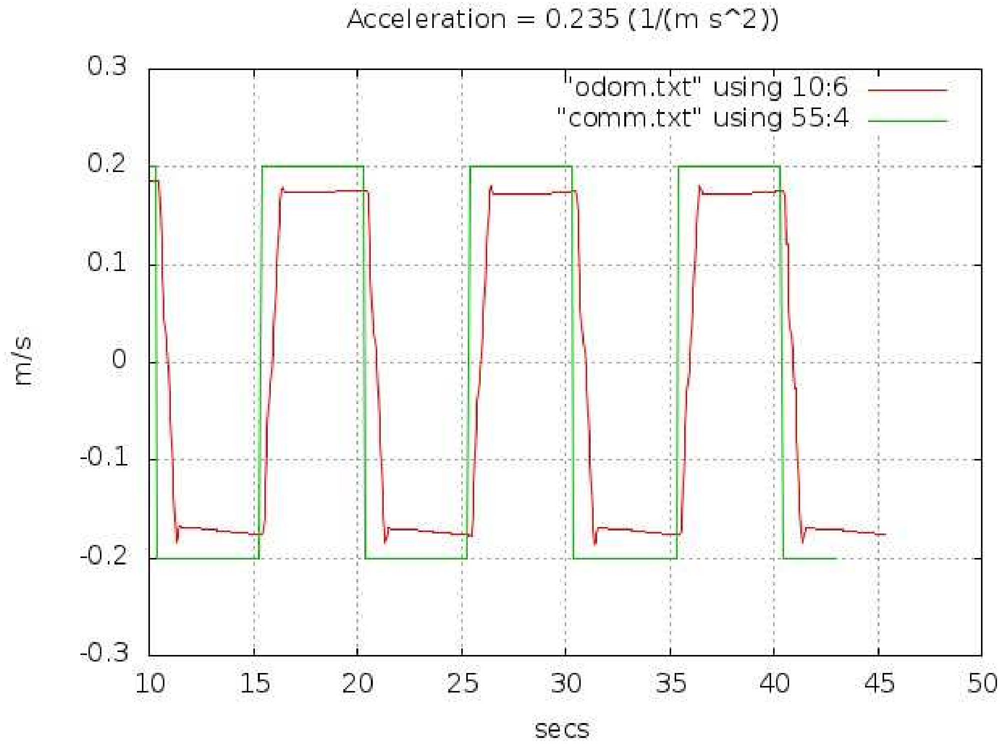

Figure 6: Motion profiles steering control performance with acceleration equal to 0.235 1/m s^2.

Discussion and Conclusions

The experiments described above shows that the motion profiles control mode of the XGV presents some shortcomings, i.e., significant latency and instability. We believe that the main problem - latency - could be improved because, in tests we performed with the joystick, we could experience the latency in motion profiles, but it was hard to notice it in wrench efforts. This suggests that the latency is associated with the motion profiles implementation.

Regarding the instabilities, we believe that they are associated with parameters of the motion profiles controller. So, perhaps some tuning may improve this aspect of it too.

One alternative for us would be implementing a control system equivalent to motion profiles (to preserve our code base) using the wrench efforts XGV control mode. But this would take some time and effort; so, we ask you if we missed something or if there is any firmware update that may improve the motion profiles performance.

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