The Approach Velocity Controller (AVC)

The Approach Velocity Controller (AVC) We consider two cars, a leading car c_l and a following car c_f. While c_l drives at nearly constant velocity, the acceleration of c_f is controlled by its *Approach Velocity Controller* (AVC). The goal of the AVC is to approach the leading car until a desired distance *dist* is established and to maintain this distance afterward.

Dynamics of the AVC The AVC has three modes, the *Normal* mode, where the acceleration $\dot{v}_f$ is computed by a linear differential equation, and two border modes, namely *HighAcceleration* and *LowAcceleration*, which are introduced to avoid extreme accelerations or decelerations.

Let v_l the velocity of the leading car c_l and d the measured distance from c_f to c_l. In the *Normal* mode the AVC computes the acceleration $\dot{v}_f$ by

$$\dot{v}_f = a(v_l - v_f) + b(d - dist),$$

where a and b are parameters with $a > 0$, $b > 0$ and $\frac{a^2}{4} \geq b$.[1]

If the computed acceleration $\dot{v}_f$ exceeds the upper limit a_{max} the controller switch to the *HighAcceleration* mode, where $\dot{v}_f = a_{max}$ is set. The analogous behavior holds if the computed acceleration falls below the minimal allowed acceleration a_{min}. The controller switches back to *Normal* mode, as soon as the computed acceleration is within the allowed values.

The model For the model we have chosen the parameter $a = 0.29$ and $b = 0.01$. The initial velocity of the following car is between $v_{min} = 0\frac{\mathrm{m}}{\mathrm{s}}$ and $v_{max} = 40\frac{\mathrm{m}}{\mathrm{s}}$ and the initial distance between both cars is between 450m and

[1]The right choice for these parameters can be read of the homogeneous solution of this linear differential equation. Only for positive values of a and b a stable behavior can be guaranteed, which is approaching the desired distance *dist*. If the discriminant $\frac{a^2}{4} - b$ is chosen negatively the AVC would oscillate around *dist*.

500m. The desired distance is $dist = 50$m. We restricted the considered time to the interval $t \in [0\text{s},\ 500\text{s}]$.

We proved a combined safety property depending on the initial velocity v_l of the leading car

a) collision freedom, for $v_l \in [v_{min},\ v_{max}]$ the distance d is always greater than 0m,

b) reaching the desired distance, for $v_l \in [v_{min},\ 0.8v_{max}]$ we can ensure that the desired distance $dist \pm 5$m is reached after 160s and kept afterward. The velocity of the following car stays within the bounds $v_f \in [v_{min} - 1\frac{\text{m}}{\text{s}},\ v_{max} + 5\frac{\text{m}}{sr}]$.

In addition we allow small disturbances on the acceleration of the leading car, $\dot{v}_l = 0 + u$, with $|u(t)| \leq disturb$.

Results On an Intel Core 2 Duo T7500, 2.2 GHz, 2 GB RAM using one processor we measured a running time of 57sec for the undisturbed model. For the disturbed we measured a running time of 77sec for the safe version ($disturb = 0.1$) and 37sec for the unsafe version ($disturb = 0.25$).