3.7 Speed Control Notes

As your GPS navigation improves and you begin to consider obstacle avoidance, you will want to take control of vehicle speed. Throttle control involves a variation of the PID function, as used for steering. It is less clear how to control the brakes, which in general are a highly non-linear phenomenon. The brakes on ERTS are inefficient, so an analytic control function may work well enough. However, in the notes below an experimental approach to brake control is recommended.

3.7.1 Throttle

The ERTS throttle is mechanically connected to a solenoid (a coil of wire wrapped around a metalic core). The pedal moves the core, whose position is translated to the original-equipped motor controller. In `auto` mode, the VCM bypasses this solenoid to simulate the throttle action.

Throttle control is a variation of the steering control method. For steering the next-state equation is

$$s' = P \cdot \epsilon_s\text{''}$$

where ϵ_s is the current heading error, in degrees; s' is the next steering command, as an inverse turning radius; and P is an experimentally determined proportionality constant. The recommended next state equation for throttle control is

$$t' = t + P \cdot \epsilon_t + D \cdot \Delta\epsilon_t$$

where t' (%) is the next throttle setting; t (%) is the current throttle setting; ϵ_t (m/sec) is the current speed error $\Delta\epsilon_t$ (m/sec) is *change in speed error* since the last cycle; and P, D are experimentally determined constants.

So throttle control is based on a “PD function, a PID with $I = 0$. Unlike the steering function, the term $P \cdot \epsilon_t + D \cdot \Delta\epsilon_t$ computes a *throttle increment*, to be added to the current throttle setting. The reason computing an increment rather than a next state value is the command representation. In the case of steering, an error of zero maps to an inverse-radius of zero, to keep the vehicle going straight. If the vehicle is going the correct speed, $\epsilon_t = 0$, we *do not* want to set the throttle to 0%, we want to keep it where it is.

The D-term, $D \cdot \Delta\epsilon_t$, is needed because the vehicle has substantial inertia. If there is a sudden change in desired speed, such as when a traffic light turns from red to green, we need extra throttle “boost” to bring the vehicle quickly up to speed. This happens only in the cycle where the error changes significantly; thereafter, $\Delta\epsilon_t$ will be small, so only minor throttle adjustments will be needed.

Notes

1. It has been observed that a throttle setting of 0.50 (50%) will barely get ERTS moving on level ground.

2. I do not have good testing records for my implementation of throttle control, but the last setting I used to initialize the throttle PD function are $P = 0.\overline{370}$ and $D = 5.0$. You might try these as a starting point for experimentation.

Braking

The brake pedal is connected by a cable to the brake shoes, which apply friction to the slow the rotation of the rear axel. Both ends of a linear actuator are connected to this cable. Under computer control, the actuator shortens, shortening the cable to apply the brakes. The actuator is driven by a channel of the main Roboteq AX2850E Amplifier, externally controlled by the VCM.

Although it may be reasonable to control the braking with a PID loop, the recommended approach is using an experimentally determined look-up table. This table is three dimensional, mapping the current speed, target speed, and distance to a braking percentage. There has been preliminary work to construct this table, but it remains an open project.

As a starting point, one might use a simple $3 \times 3 \times 3$ table,

current-speed: $\{$*slow*, *medium*, *fast*$\}$

target-speed: $\{$*slow*, *medium*, *fast*$\}$

distance: $\{$*close*, *near*, *far*$\}$

and entries

percentage_braking: $\{$*none*, *gentle*, *hard*$\}$

The table indicies are speed and distance ranges. For example, $\mathit{slow} \in [0, 1.5)$ m/sec, $\mathit{near} \in [10 - 20, 1.5)$ m, $\mathit{hard} = 0.75$ m, and so on.

It seems obvious that when one is applying the breaks, the throttle percentage should be zero, and conversely, when one is accelerating, the braking percentage should be zero. This is a safe thing to do, but the **Notes** suggest that something more aggressive would be more responsive.

Notes

1. It has been observed that a the breaks start to engage at a braking percentage of around 45%. Anything less results in free-running wheels.

2. The braking actuator is connected to the brake cable with a metal pin that is thin enough to break before the cable does. *A breaking percentage above 80% causes this pin to shear!* For safety (of the mechanics) never set the braking percentage above 80%. ← **CAUTION!**