Automatic transmission

This model is a simplified 3-gear automatic transmission system [2]. The efficiency of a system which delivers mechanical power varies with respect to load and rotation speed. To guarantee an efficient use of the transmission, the gears are switched to change the system's dynamic. In an automatic transmission, the occurrence of this commutation between states is automatically computed. Thus, an hybrid automaton is an appropriated model. The values of rotation speed used as threshold for switching between gears have been tuned with respect to transmission efficiency and speed [1].

Physical system. The load is imposed by the vehicle dynamic. Therefore, the state of the system is given by the rotation speed of the output shaft ω as well as the distance travelled by the vehicle. The latter is proportional to the angular position of the shaft θ.

The ability of the transmission to accelerate the vehicle depends on the efficiency of the current gear ratio. In a real system, this function is computed in real time and is influenced by the load. However, to simplify the study, the efficiency is assumed known via an analytic expression (see 1). a_i depends on the actual gear. The aim of this model is to provide a simple expression that matches the aspect of a real efficiency function (see figure 1). The coefficients bear no physical meaning.

$$\eta_i = 0.01 + 0.99 \exp((\omega - a_i)^2/64) \tag{1}$$

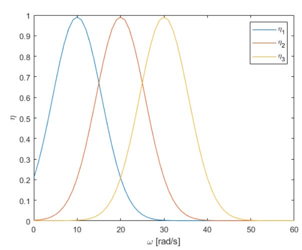

Figure 1: Efficiency function

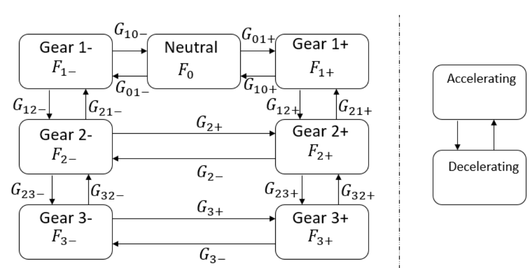

Figure 2: simplified view of the automaton

The automaton. The overall automaton structure is the same as in the original paper. However, the aim here is no longer to find the optimal guard parameters with respect to a driving scenario. The automaton has to simulate the kinematic behaviour of the vehicle when it is solicited by the driver. The driver interaction is represented by an input time-serie. If the input is greater than 0, then the driver is accelerating, else he is decelerating.

The flow F in Gear i is :

$$(F) \begin{cases} \dot{\theta} = \omega \\ \dot{\omega} = \alpha \eta_i \end{cases} \quad \text{where } \alpha \in \{-1; 1\} \text{ represents the direction of rotation}$$

The guards are the same as in the original paper, with the addition of a time limitation of 5 seconds via the $after()$ function so that the transmission will not immediately switch gears. The influence of the driver is also included in the guards, as it determines if the system is able to switch between + states and − states.

References

[1] Susmit Jha, Sumit Gulwani, Sanjit A. Seshia, and Ashish Tiwari. Synthesizing switching logic for safety and dwell-time requirements. In *Proceedings of the 1st ACM/IEEE International Conference on Cyber-Physical Systems*, ICCPS '10, pages 22–31, New York, NY, USA, April 2010. Association for Computing Machinery.

[2] John Lygeros. Lecture notes on hybrid systems. In *Notes for an ENSIETA workshop*, 2004.