Hybrid powertrain modeling for energy management design

This task deals with the modeling of a hybrid powertrain. The developed model will be used in a dynamic programming algorithm to find the fuel optimal control strategy for a given driving cycle. The task is to calculate the amount of fuel required to propel the vehicle during one time step, t_i to t_{i+1}. In this time step the velocity, gear ratio as well as the state of charge changes from $v(t_i)$, $gr(t_i)$, and $SoC(t_i)$ to $v(t_{i+1})$, $gr(t_{i+1})$, and $SoC(t_i)$.

Let us first consider a parallel hybrid vehicle (see Figure 1). Use the notation and models in the Vehicle Propulsion Systems book and the Hand-in assignments to find the fuel consumption during one time step.

1. How much work is required by the vehicle at the wheels (acceleration, rolling resistance, and air drag) during this period of time.

2. How much energy has to be provided to or recovered from the gearbox during this period of time? Note: You need to consider the direction of power transfer.

3. Following the change in SoC, how much energy does the battery require from or provide to the electric machine during this period of time? Note: You need to include the battery losses.

4. How much mechanical energy is required or provided by the electric machine during this period of time? Note: You need to consider the direction of power transfer.

5. How much energy is required from the engine during this period of time?

6. How much torque is required from the engine during this period of time?

7. How much fuel is needed from the tank to drive the engine during this period of time?

8. What component limits do you have to check when going through the calculations in the steps above?

9. How can the cost in the DDP algorithm be calculated from the data obtained in the steps above?

Let us next consider a serial hybrid vehicle (Figure 2) that drives in a drive cycle with prescribed velocity profile $v(t)$. This task will treat the behavior and fuel consumption over the time from t_i to t_{i+1}, where we have $v(t_i)$, $v(t_{i+1})$. During this time period the state of charge changes from $SoC(t_i)$ to $SoC(t_{i+1})$ and the engine speed also changes from $\omega(t_i)$ to $\omega(t_{i+1})$.

1. Go through the same sequence of steps as above and modify them for the serial hybrid. Give special considerations for engine start, stop, and idle.

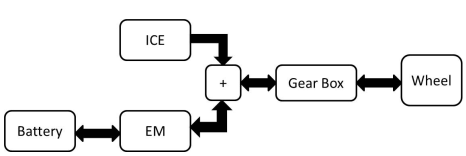

Figure 1: Parallel hybrid configuration

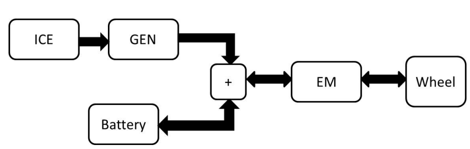

Figure 2: Series hybrid configuration