Look-ahead Control

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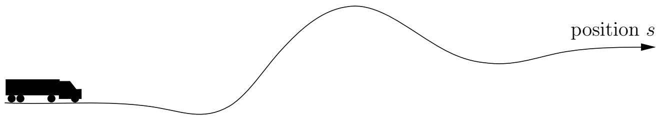


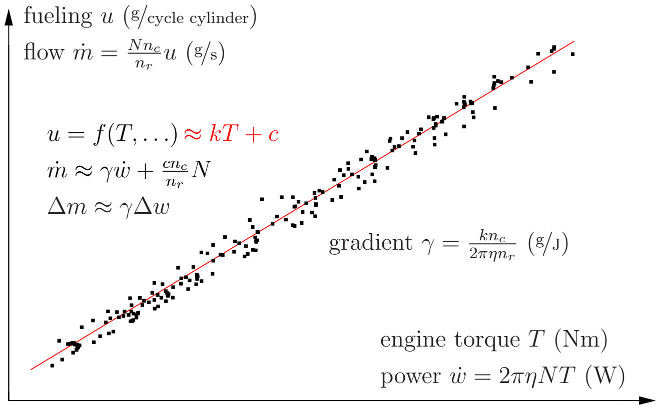
The objective is to minimize the fuel use M on a drive mission $s \in [0, s_f]$ with a given trip time $T = T_0$. The problem is solved by adjoining the trip time to the criterion,

$$\underset{T=T_0}{\text{minimize}}\, M \quad \curvearrowright \quad \text{minimize}\, M + \beta T$$

and, on board, computing solutions for a truncated horizon $s \in [0, s_h]$,

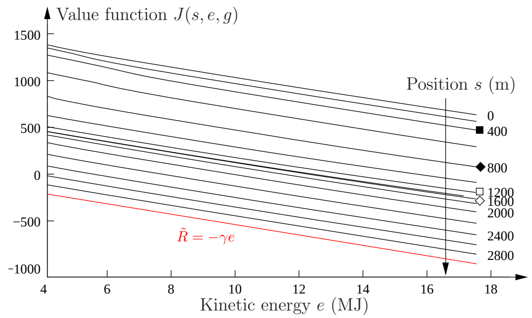
$$J = \min M(s_f) + \beta T(s_f)$$
$$\approx \min M(s_h) + \beta T(s_h) + \tilde{R}$$

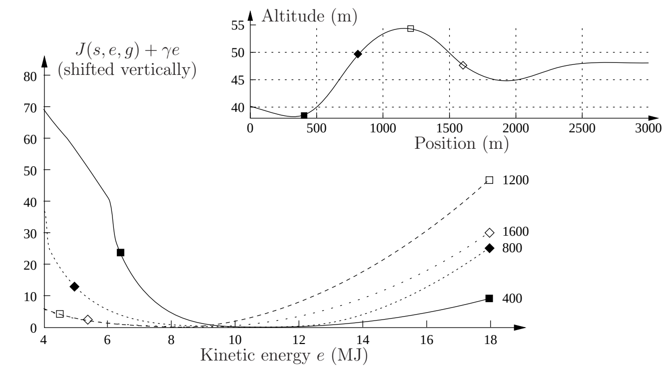
where $\tilde{R}$ is an approximation of the residual cost.



Energy Formulation

The variation of the criterion is $\delta J = \delta M + \beta \delta T$. A perturbation in the initial kinetic energy δe for $s = 0$ gives, approximately, $\delta J = -\gamma \delta e$. In this way, the kinetic energy e can be calculated to an equivalent fuel energy and conversely. Based on this, the residual cost $\tilde{R} = -\gamma e$ is proposed. It is also observed that the value function is dominated by this linear function with gradient γ, and this allows interpolation on a coarse grid.





Results

A prototype demonstration has been implemented and tested in a heavy duty truck. The project milestone has been achieved. [1]

An algorithm for fuel-optimal control has been developed where the framework allows a proper physical model of gear shifts. It was shown that reformulating the problem in terms of energy allows simple integration and coarse grids. Furthermore, it is demonstrated that a linear function in energy, derived from engine and driveline characteristics, can be used as a residual cost. [2]

[1] Hellström, E., Ivarsson, M., Åslund, J., and Nielsen, L. (2009a). Look-ahead control for heavy trucks to minimize trip time and fuel consumption. *Control Engineering Practice*, 17(2):245–254.

[2] Hellström, E., Åslund, J., and Nielsen, L. (2009b). Design of an efficient algorithm for on-board look-ahead control. *Solicited for Control Engineering Practice*.