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Optimising the energy efficiency of rail vehicles by a novel application of integrated adaptive control method for vehicle traction and active steering systems

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Active wheelsets steering control for railway vehicles travelling around curves

Market requirements

- Facilitate highly efficient movement of passenger and freight.
- Continuous improvement of rolling stock energy and carbon efficiency.
- Reliable, energy efficient, low whole life cost rolling stock.
- Energy efficient drive systems which produce less pollution.
- Reduction of tractive energy, peak power demand and the unit costs.

Proposed adaptive integrated control for traction and active wheelset systems

Controller

\[ u(t) = u_a(t) + u_r(t) \]
\[ u_a(t) \in \mathbb{R}^m \text{ is the control input} \]
\[ u_r(t) \in \mathbb{R}^m \text{ is the nominal feedback control} \]
\[ u_a(t) = K_1 x(t) + K_2 c(t) \]
\[ K_1 \in \mathbb{R}^{m\times m}; \text{ feedback gain, } K_2 \in \mathbb{R}^{m\times m}; \text{ feedforward gain} \]
\[ u_a(t) \in \mathbb{R}^m \text{ is the adaptive feedback control} \]

Adaptive mechanism

\[ u_a(t) = -W_{d1}^T \sigma(x(t)) - W_{u1}^T u_a(x(t)) \]
\[ W_{d1}(t) \in \mathbb{R}^{m\times m} \text{ & } W_{u1}(t) \in \mathbb{R}^{m\times m} \text{ are the estimates weight matrix} \]
\[ \sigma : \mathbb{R}^n \rightarrow \mathbb{R} \text{ is a known basis function of the form } \sigma(x) = [\sigma_1(x), \sigma_2(x), ..., \sigma_l(x)]^T \]
\[ x(t) \in \mathbb{R}^n \text{ is the state vector available for feedback} \]

Traction control systems in railway vehicles

Novelty: advantages of the proposed method

- Novel controller which enables significant reduction of creep forces within wheel-rail interface and reduction of motor current.
- Energy efficient integrated adaptive control method for vehicle traction and active steering systems.
- Significant improvements to vehicle dynamic performance.
- Easy integration with intelligent condition monitoring systems.

Adaptive control method – uses a controller which must adapt the commands depending on variable parameters or uncertainties.

Reference