Abobghala, Abdelmenem, Pislaru, Crinela and Iwnicki, S.

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

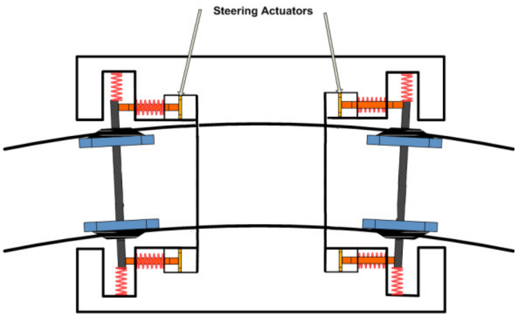
Optimising the energy efficiency of rail vehicles by a novel application of integrated adaptive control method for vehicle traction and active steering systems

Abdelmenem Abobghala, Crinela Pislaru, Simon Iwnicki

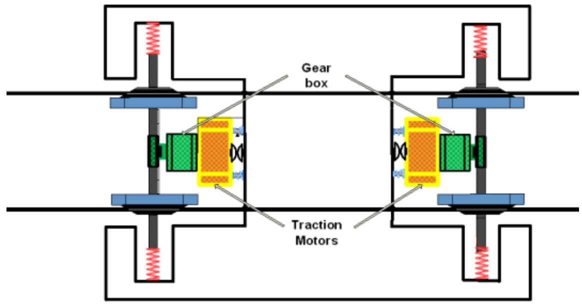
Institute of Railway Research

University of Huddersfield

Active wheelsets steering control for railway vehicles travelling around curves



Traction control systems in railway vehicles



Market requirements

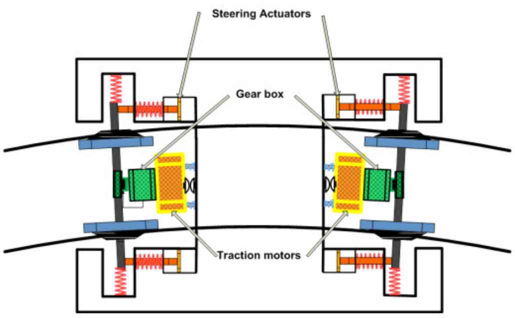
- Facilitate highly efficient movement of passenger and freight.
- Continuous improvement of rolling stock energy and carbon efficiency.
- Reliable, energy efficient, low whole life cost rolling stock.
- Energy efficient drive systems which produce less pollution
- Reduction of tractive energy, peak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

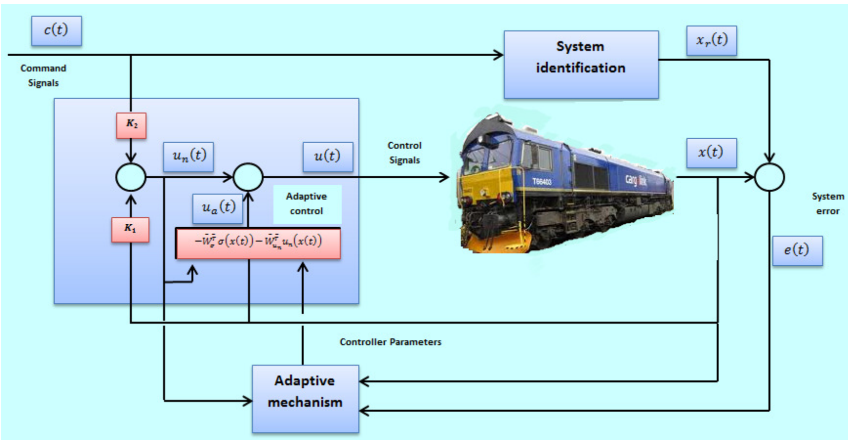
Novelty: advantages of the proposed method

- 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

Proposed adaptive integrated control for traction and active wheelset systems

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





Controller

$u(t) = u_n(t) + u_a(t)$,

$u(t) \in \mathbb{R}^m$ *is the control input*

$u_n(t) \in \mathbb{R}^m$ *is the nominal feedback control*

$u_n(t) = K_1 x(t) + K_2 c(t)$

$K_1 \in \mathbb{R}^{m\times n}$; *feedback gain*, $K_2 \in \mathbb{R}^{m\times m}$; *feedforward gain*

$u_a(t) \in \mathbb{R}^m$ *is the adaptive feedback control*

Adaptive mechanism

$u_a(t) = -\widehat{W}_\sigma^T\sigma(x(t)) - \widehat{W}_{u_n}^T u_n(x(t))$

$\widehat{W}_\sigma(t) \in \mathbb{R}^{s\times m}$ & $\widehat{W}_{u_n}(t) \in \mathbb{R}^{m\times m}$ *are the estimates weight matrix*

$\sigma: \mathbb{R}^n \to \mathbb{R}^s$ *is a known basis function of the form* $\sigma(x) = [\sigma_1(x), \sigma_2(x), \ldots\ldots, \sigma_s(x)]^T$

$x(t) \in \mathbb{R}^n$ *is the state vector available for feed back*

Controller: generates control signals based on command signals , feedback and signals generated by adaptive mechanism.

Adaptive mechanism: applies the proposed control method in order to optimise the operation of controller.

System identification: performs the processing of signals (such as v, θ, ω, T, …) which are directly measured form the rail vehicle.

Reference Tansel Yucelen*,† and Eric Johnson, (2012) A new command governor architecture for transient response shaping , *Int. J. Adapt. Control Signal Process*