Review of control strategies used in modern railway vehicles

Student - Roy W. Ngigi Supervisors - Dr C. Pislaru, Prof A. Ball, Dr F. Gu

The Centre for Diagnostic Engineering, Computing and Engineering

University of HUDDERSFIELD

ABSTRACT

Control systems are being developed in the railway industry to maintain good steering, stability and comfort. Although, these systems are in operational, there are prospects of fully implementing mechatronic principles through an integrated control system. This poster is intended to provide various aspects of control system technology that are incorporated in modern railway vehicles and to give illustrative examples of where particular control objectives have been met. Its main contribution is to identify opportunities for further research in this field.

INTRODUCTION

The use of railway vehicles worldwide has increased and thus, more and more trains are being produced. This trend is unlikely to change anytime soon. Therefore, there is a need to develop trains that provide safe and comfortable transportation, and at the same time have minimal impact on the environment. The challenge is to develop vehicles that can satisfy these conflicting requirements. One of the steps in achieving this is the use of mechatronic subsystems that employ sensors, actuators and control systems. There are several control strategies which have been developed to automate various operations within the railway vehicle. Only the ones that are well established will be reviewed.

CONTROL STRATEGIES

Tilt control concept:

- ❑ Enables trains to curve at higher speeds.

Tilting technology on a pendolino train (Source: Virgin website)

Secondary suspension control concept:

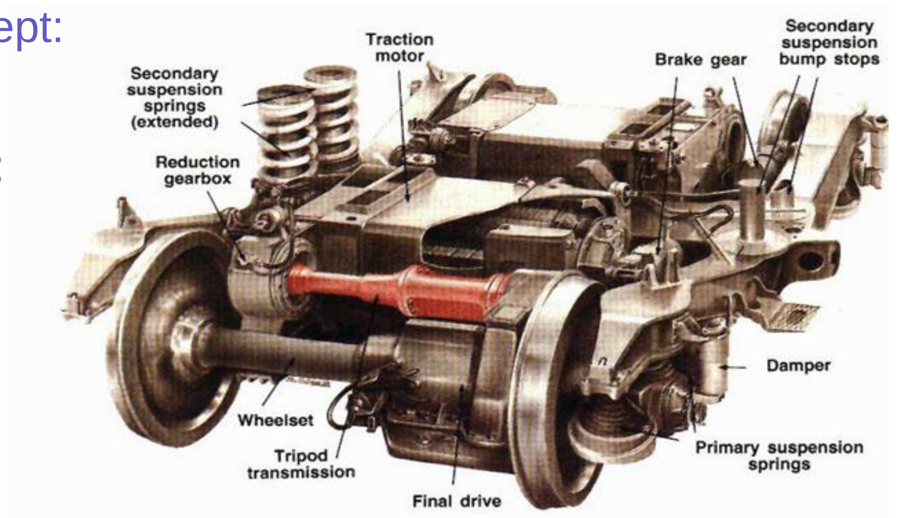
- ❑ Improves the ride quality.

Primary suspension control concept:

- ❑ Stability at high speeds.
- ❑ Improve curving abilities and wheel-rail wear reduction.

Adhesion control concept:

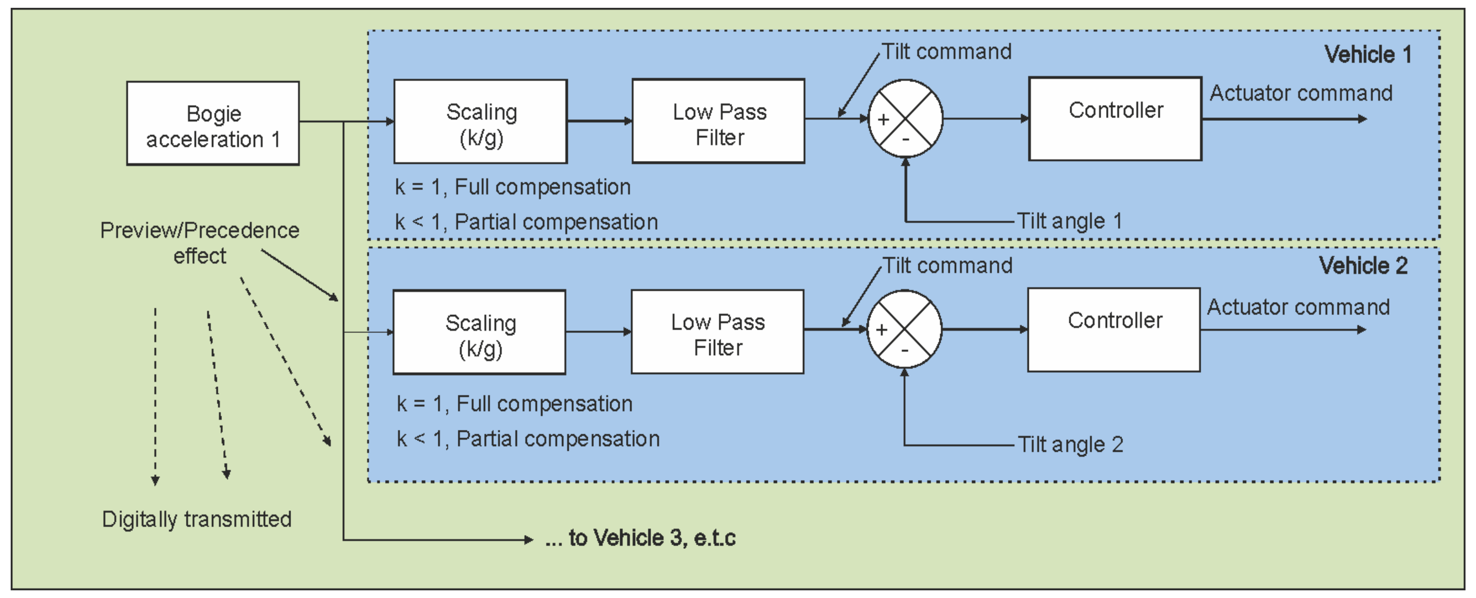
- ❑ Maximizes the use of poor running conditions.



Bogie configuration for a high speed train

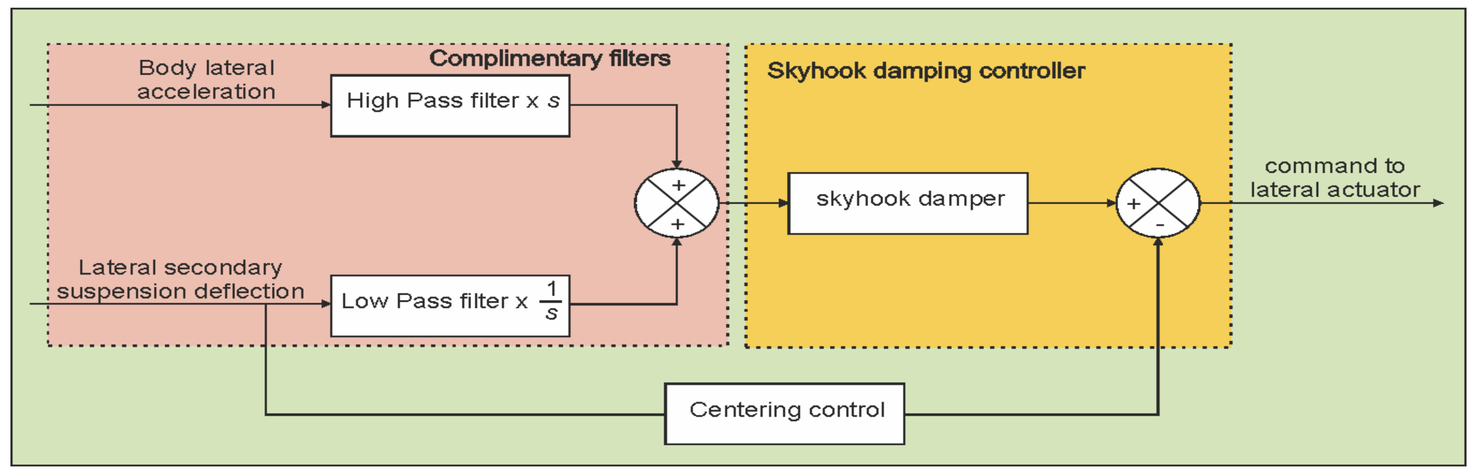
CONTROL SCHEMES USED IN RAILWAY VEHICLES

1. Tilt control



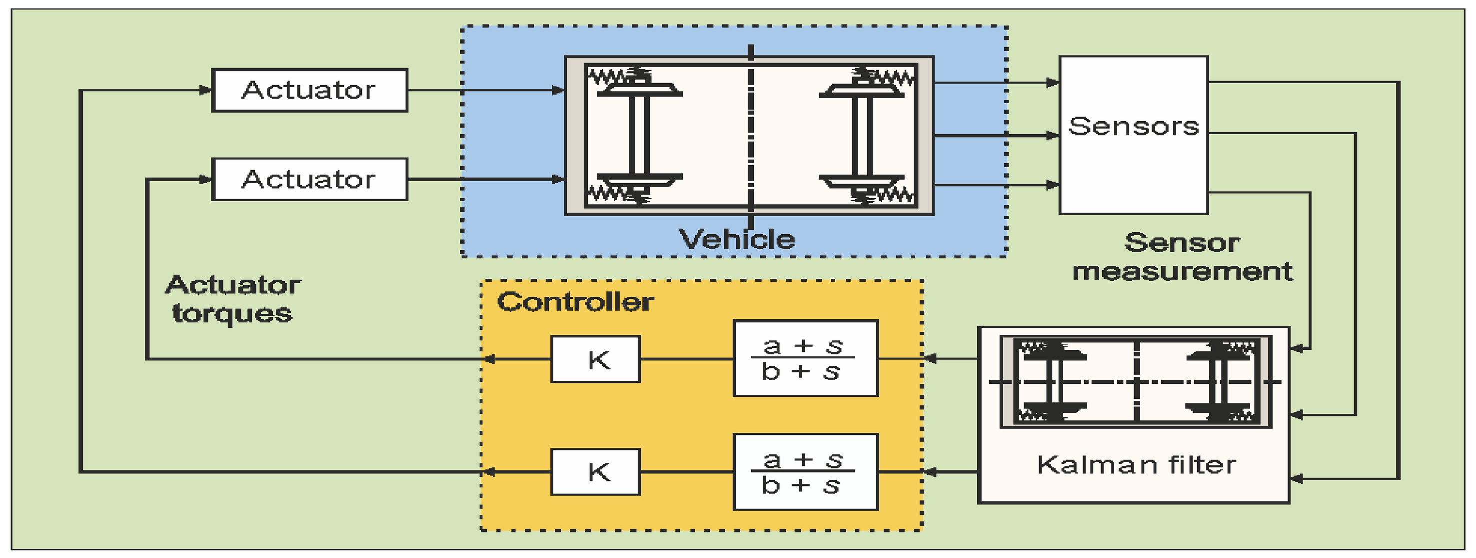
Precedence control [1]

2. Active lateral suspension control



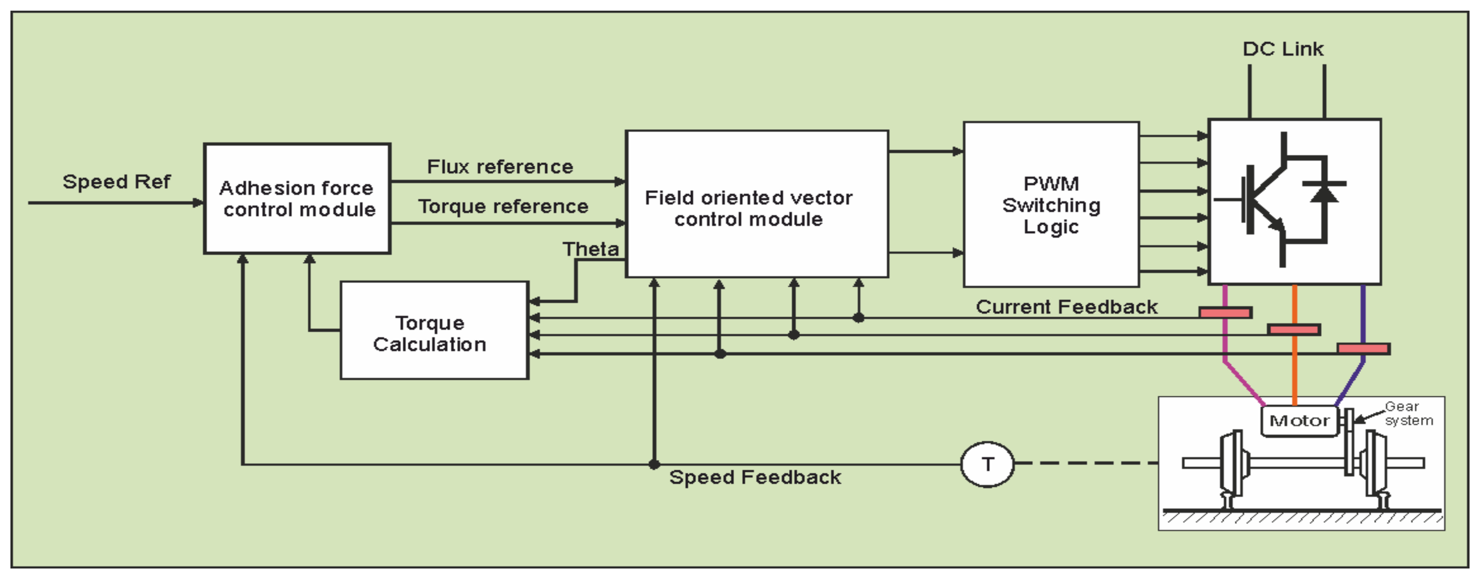
Skyhook damping control [1]

3. Active primary suspension control



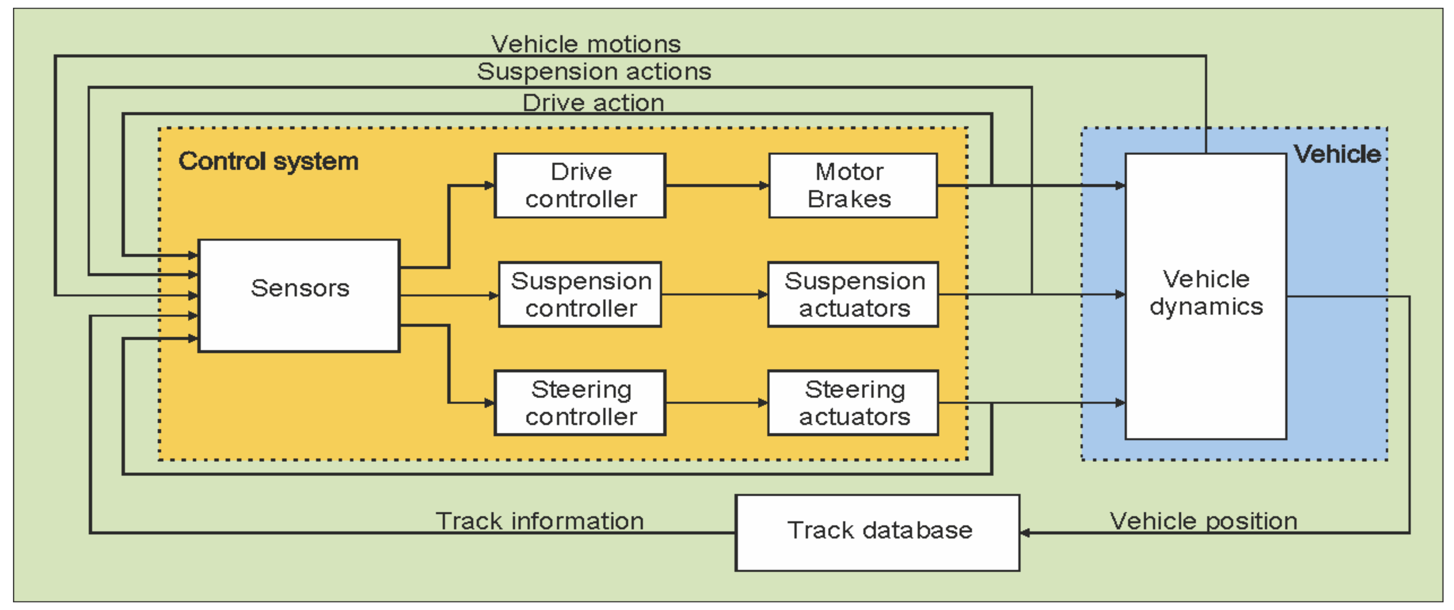
Active stability and steering control of wheelset [2]

4. Wheel slip control



Adhesion force control based on field oriented vector control [4]

CHALLENGES



Integrated control scheme [3]

- ❑ The level of integration of various aspects (traction, braking, suspension) is high, thereby more sophistication in designing a controller.
- ❑ The use of the contact patch between the wheel and rail for the designing of an integrated control scheme.
- ❑ The difficulty in accommodating all of the dynamical features.

CONCLUSIONS

- ❑ The benefits of incorporating such systems in an 'asset' (railway vehicles) has been remarkable. One of the key contributions is the increased dynamic performance which was scarce when trains had only passive elements.
- ❑ It is clear that the electromechanical control systems within the railway industry is well developed and will continue to do so as more opportunities arises especially in the field of mechatronic systems.
- ❑ Most of these control systems are designed individually but there is a possibility of an optimal controller.
- ❑ Suspension, braking, propulsion and guidance force acting on the railway vehicle are related by the wheel and rail contact point. This is one of the avenues for further research in establishing if it is feasible.

REFERENCES

[1] R. Zhou, A. Zolotas, and R. Goodall, "Integrated tilt with active lateral secondary suspension control for high speed railway vehicles," *Mechatronics*, vol. 21, no. 6, pp. 1108-1122, Sep. 2011.

[2] J.T. Pearson et al, "Kalman filter design for a high speed bogie active stability system," *Control,* University of Bath, UK, Sep 2004

[3] R. M. Goodall and W. Kortüm, "Mechatronic developments for railway vehicles of the future," *Control Engineering Practice*, vol. 10, pp. 887-898, Aug. 2002.

[4] Wenli Lin, Lijun Diao, Gang Zhang, Dan Chen, and Zhefeng Li, "Maximum Adhesion Force Control Simulated Model of Electric Locomotive," in *2007 IEEE International Conference on Automation and Logistics*, 2007, pp. 1704-1708.