

## Chapter 8.11

# Application of Machine Learning Techniques for Railway Health Monitoring

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### ABSTRACT

Emerging wireless sensor networking (WSN) and modern machine learning techniques have encouraged interest in the development of vehicle health monitoring (VHM) systems that ensure secure and reliable operation of the rail vehicle. The performance of rail vehicles running on railway tracks is governed by the dynamic behaviours of railway bogies especially in the cases of lateral instability and track irregularities. In order to ensure safety and reliability of railway in this chapter, a forecasting model has been developed to investigate vertical acceleration behaviour of railway wagons attached to a moving locomotive using modern machine learning techniques. Ini-

tially, an energy-efficient data acquisition model has been proposed for WSN applications using popular learning algorithms. Later, a prediction model has been developed to investigate both front and rear body vertical acceleration behaviour. Different types of models can be built using a uniform platform to evaluate their performances and estimate different attributes' correlation coefficient (CC), root mean square error (RMSE), mean absolute error (MAE), root relative squared error (RRSE), relative absolute error (RAE) and computation complexity for each of the algorithm. Finally, spectral analysis of front and rear body vertical condition is produced from the predicted data using Fast Fourier Transform (FFT) and used to generate precautionary signals and system status which can be used by the locomotive driver for deciding upon necessary actions.

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## INTRODUCTION

Recent advances in wireless communications and machine learning techniques have jointly encouraged interest in the development of VHM systems to reduce the maintenance and inspection requirements of railway systems while maintaining safety and reliability. In this chapter, the design and possible deployment of an energy-efficient railway health condition monitoring systems has been investigated that monitor's typical dynamic behaviour of railway wagons. If a security-related incident has occurred, this system may support the operator in taking the appropriate action, communicating to the right authorities, checking the availability of rescue teams and providing all necessary information (Shafiullah, Gyasi-Agyei & Wolfs, 2007), (Smith, Russel & Looi, 2003).

Typical dynamic behaviours of railway wagons are responsible for the safe and reliable operation of freight railways. The dynamic performance is determined by the characteristics of the wagon and the irregularities in the track. Railway track irregularities need to be kept within safe operating margins by undertaking appropriate maintenance programs. Railway wagons are intended to guide the load along the track safely with minimal damage to the track and the load. Railway track is designed to interface with railway vehicles to support the load while providing a permanent path of travel. It is identified that the performance of rail vehicles running on a track is limited by 1) the lateral instability inherent to the design of the steering of a railway wagon, and 2) the response of the railway wagon to individual or combined track irregularities.

Collection of acceleration signals from the track and sending meaningful signals to the locomotive is the challenging research area. In this chapter, an energy-efficient data acquisition model has been investigated for railway applications using modern machine learning techniques. A team of Engineers from CQUniversity, Australia developed a Health Card (Bleakley, 2006), (Wolfs, Bleakley, Senini &

Thomas, 2006a) system to monitor every wagon in fleet using low cost intelligent device. Bleakley (Bleakley, 2006) collected necessary field data by using dual axis accelerometers fitted to each corner of the wagon body and to the bogie side frame. Same data were collected in this study by placing three sensor nodes in each wagon body and three sensor nodes in wagon side frame. Average weighted performance measure and rule-based learning approach were used to select a suitable algorithm for this application (Garg & Dukkupati, 1984), (Wolfs, Bleakley, Senini & Thomas, 2006a), (Bleakley, 2006), (Shafiullah, Thompson, Wolfs & Ali, 2008).

To monitor lateral instability and track irregularities in this study, train wagon body acceleration signals, i.e., six degrees of freedom (DOF) or six modes of vehicle body motion: *roll*, *pitch*, *yaw*, *lateral*, *vertical* and *longitudinal* are investigated using machine learning techniques. Ten popular regression algorithms are used to predict vehicle vertical acceleration motion of the wagon body. The performance of different models are assessed and the most suitable algorithm for forecasting vertical displacement behaviour of railway wagons proposed based on the selected performance attributes. Finally, instead of sending or storing the collected or predicted data, only necessary events those cross the safety limits are transmitted to the driver for necessary actions in coded format using the FFT approximation technique as used in Reference (Bleakley, 2006), (Shafiullah, Simson, Thompson, Wolfs & Ali, 2008). This chapter is organized as follows: Section II discusses the existing literature. Section III presents an overview of the regression algorithms. The development of the data acquisition model is discussed in Section IV. Forecasting of vertical acceleration of railway wagons is presented in Section V. Section VI concludes the article with future directions.

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