Fibre Bragg Grating Sensors for Smart Railway Monitoring

(Invited Talk)

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Abstract: A new approach for structural health and conditions monitoring of trains and railway tracks using fibre Bragg grating sensing networks will be described. Track-borne fibre Bragg grating sensing networks are used to monitor moving trains whereas fibre-Bragg grating sensing systems installed on passenger trains are used to monitor track condition as well as critical train components, including pantograph-catenary interactions. This approach minimizes capital investment to monitor extensive railway networks for safety and maintenance purposes.
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1. Introduction

The importance of railway transportation system has been increasing in the world. The improvement of safety, reliability and productivity of the railway systems will continue to be the most important directives for the transportation industry. The scale of investment in railways in Asia and particularly in China, where the high-speed rail links will reach 20,000 km by end of 2016, demands a more effective railway maintenance regime. Time-based maintenance performed based on a calendar schedule is being replaced by the more effective condition-based maintenance (CBM) systems where the health of components is monitored in real time, and maintenance decisions are based on current and forecasted component health to improve system availability, reliability, and safety. An effective CBM system requires a sensing network that is able to perform multi-parameter monitoring effectively and quickly over long distances without the concern of electromagnetic interference. This could be achieved using optical fibre monitoring networks based on fibre Bragg grating (FBG) sensors. Signals obtained from FBG sensors attached on a rail track are like taking patient pulses and have the ability to monitor many vital signs of railway systems. FBG sensing networks installed on railway system permits railway operators to record many critical information such as wheel flats, wheel cracks, train suspension problems, load unbalance, etc. Such system with the capability to measure multitudes of diverse physical and electrical parameters over wide area along many kilometers of optical fibers could provide a truly Smart Railway System that will herald a safer railway industry with reduced maintenance cost, optimized performance and capacity.

2. Smart Railway Monitoring Systems

Figure 1 illustrates the concept of the smart railway monitoring systems developed by the Photonics Research Centre of The Hong Kong Polytechnic University over the last decade using FBG sensors to measure the wheel-rail interactions at strategic locations to provide critical information related to various aspects of trains including axle counting, derailment detection, wheel defeats, etc. Therefore, all trains running along the railway line will be monitored by the track-based FBG sensing system.

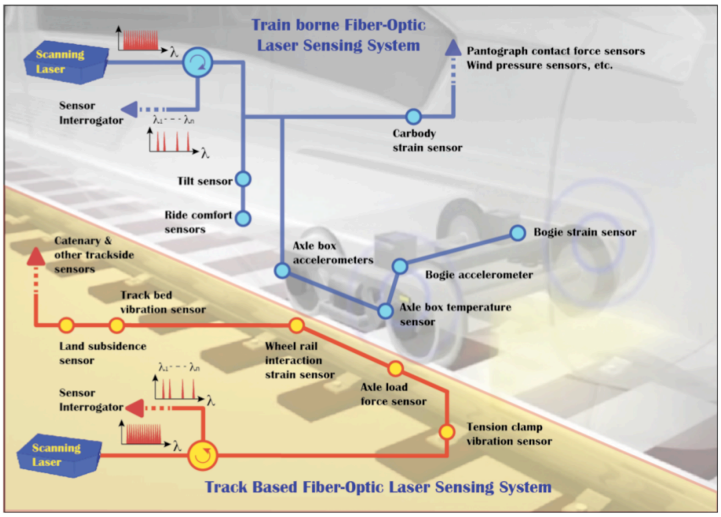

Fig. 1. Rail track-based and train-borne FBG sensing networks for condition and health monitoring of railway systems.

A train-borne FBG sensing system was also developed to monitor critical components of bogies, car bodies, pantograph-catenary interactions as well as the wheel-rail interactions to monitor the conditions of the overhead power lines and rail tracks of the entire railway links. Furthermore, the systems were installed on normal passenger trains, providing cost-effective solutions.

3. FBG Sensing Networks

Figure 2 shows a track-based FBG sensing network where FBG sensors attached on rail track to monitor the wheel-rail interactions during the passage of trains. Important information related to derailment, wheel defects, bearing seizure in axle box, etc. can be determined from the wheel-rail interactions using appropriate signal analysis. Similar system was installed in Hong Kong in 2011 to measure the weight of moving trains and accuracy of better 90% was achieved. The weight information is important for cargo trains as well as for derailment prevention.

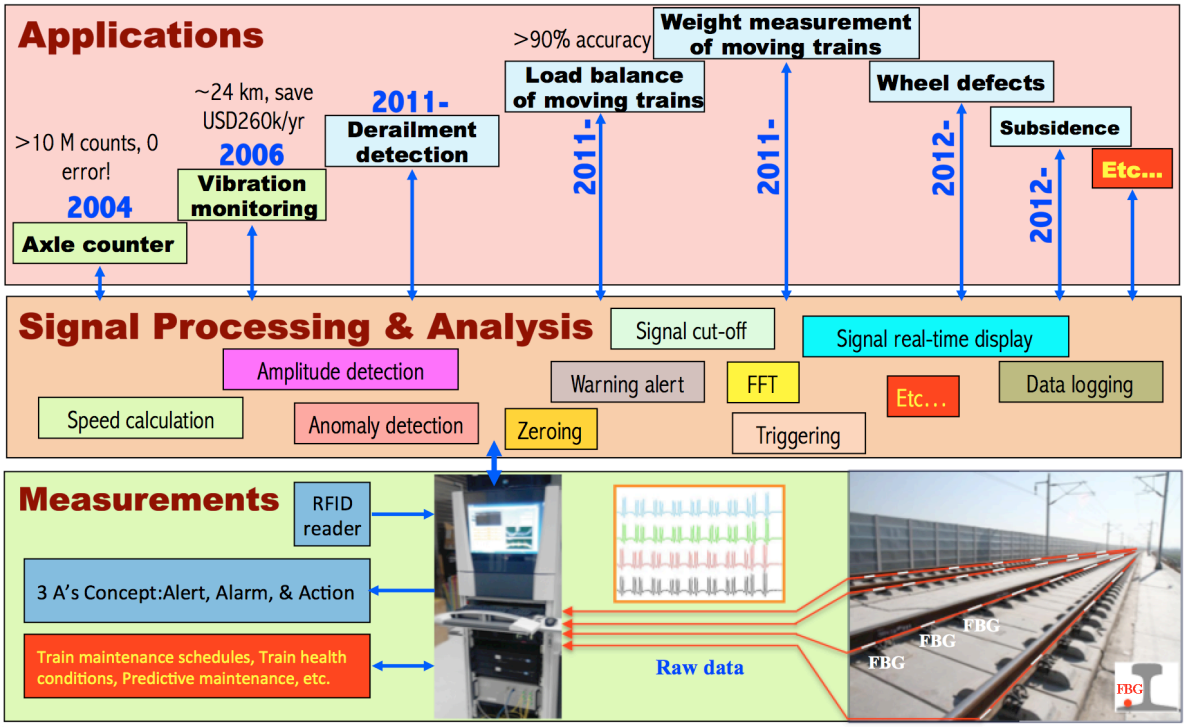

Fig. 2. Rail track-based FBG sensing network for monitoring of many critical condition of moving trains.

Train-borne systems using FBG sensors were also developed to monitor rail breaks, track corrugations, motor temperature, structural health of train bodies, passenger ride comfort, and pantograph-catenary interactions. This talk will focus on the applications of fibre Bragg grating technologies for assessing condition of overhead power line by measuring the pantograph-catenary interactions. Fibre Bragg grating sensing technology has proven to be extremely effective for railway monitoring. In 2014, an extensive city-wide fibre Bragg grating sensing network was installed in Hong Kong with the aim to monitor all the trains and metros running in the city to provide diagnostic and prognostic information.

4. References

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