Application of time-frequency representations for the detection of railway track singularities

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Nowadays, stakeholders are betting on railways as a rapid, massive and energy-efficient transport mode, leading to a higher number of track kilometres to maintain. In this context, Railway Engineers must find a compromise between ride quality and track performance (speed, comfort), and maintenance costs. In order to achieve this main goal, this work presents a methodology for assisting track condition-based procedures. By means of a proper time-frequency analysis, performed to the accelerations signal recorded at wheelset axleboxes, it is possible to identify and classify a whole set of track defects and singularities.

The suitability of using axlebox accelerations as an indicator of condition based monitoring has already been proven by some authors [1], [2]. By means of the analysis of axlebox accelerations, a large set of track defects can be identified, e.g. short wavelength defects occurring at discrete track locations, such as squats [3], insulated joints [4] or spalling. They can also detect rail corrugation growth [5], railway turnouts deterioration [6] and the vibration modes associated to the different track elements [7]. For this purpose, a proper time-frequency signal decomposition such as the short time Fourier Transform [8], the Wavelet Transform [9] or the Hilbert Transform [10] must be set up.

Previous works carried out by the same Research Group [7] in metropolitan railways show the feasibility of this procedure. In the present work, this procedure is extended to conventional secondary railways, whose tracks consist of wooden sleepers and short bar rails linked by means of fish plated joints. Furthermore, lateral axlebox accelerations are included as well. For this purpose, a DMU series 592 covering the regional services between Xàtiva and Alcoi (Spain) was monitored, and data were recorded during regular commercial services. The analysis tool is based on the conventional short time Fourier transform (STFT) rather than the Wavelet transform. In this particular case, STFT, represented by means of consecutive spectrograms, is preferred since it homogeneously covers a given frequency band, thus allowing the identification of a wide variety of track singularities occurring at different frequency ranges (e.g. loose sleepers, misaligned joints, worn turnouts). In these terms, and with a proper values of the defining parameters of the spectrograms, the results shown in Fig. 1 are obtained for the case of vertical axlebox accelerations.

In this figure, the lower part shows the accelerations in the time domain as they were registered, whereas the upper part shows the spectrogram relative to the STFT representation of that signal period. Amplitudes associated to each frequency are depicted in logarithmic scale following the colour scale at the right. Whereas the location and degree of severity of every track defect is determined by performing the analysis in the time domain following the criteria stablished by the Spanish Railway Administrator, the developed algorithm is able to automatically detect the cause of each defect. At the moment, detection of worn and misaligned fish-plated joints, worn turnouts and loose sleeper is achieved. Thus, the defects found are labelled in a box showing its location along the track and its main cause. The text boxes are coloured upon the degree of severity of their respective defects.

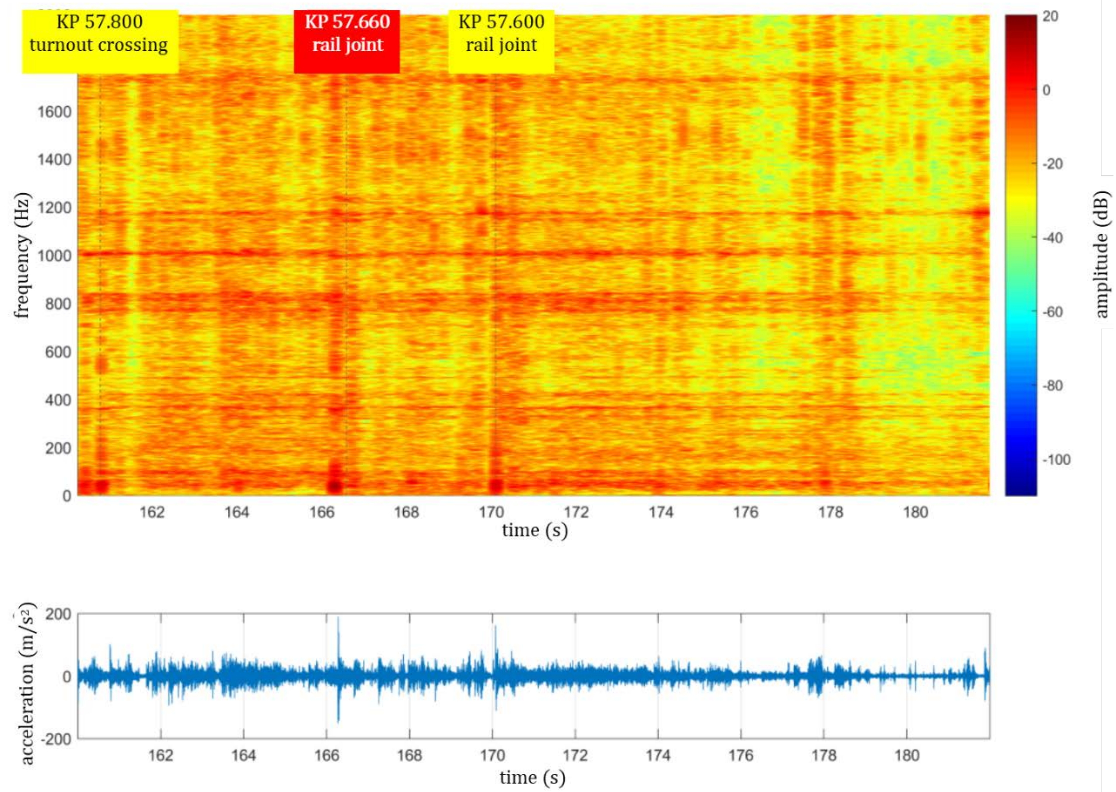

Fig. 1: Spectrogram corresponding to the vertical axlebox accelerations

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