Behavioral Model of Railway Turnouts

WP2 Signal-based Condition Monitoring

Contributors: Pegah Barkhordari (PhD student), Roberto Galeazzi (WP leader)

Railway turnouts are complex systems whose dynamical behavior changes spatially (along and across the turnout) and temporally. A complete and cohesive description of how the overall system responds to train excitations usually demands models of high complexity in order to capture the interactions among the individual constituent components (rails, rail pads, sleepers, ballast, sub-ballast, subgrade). These high-fidelity models have several shortcomings in connection with the health monitoring of the turnout as lack of portability (the models are fine-tuned to one specific turnout), lack of scalability (inclusion of additional components is laborious) and lack of adaptiveness (the large number of parameters makes it challenging to properly accommodate changes in the components due to wear & tear or environmental conditions).

INTELLISWITCH innovates by proposing low-complexity behavioral models, i.e. models capturing the dominant dynamics of the turnout when excited by train passages. By combining advanced signal processing (Empirical Mode Decomposition) with system identification (N4SID subspace identification), a fourth order model is continuously estimated exploiting measured track vertical accelerations at a given location of the turnout. The model is then used to compute the first and second track resonance frequencies, describing the stiffness due to the ballast and the rail pad. To account for intrinsic uncertainties due to variations in operational conditions (train type, train speed, train load) and environmental conditions (temperature, amount of precipitation, quality of the soil) statistical models are built for the two resonance frequencies.

Dividing the turnout into sections of interest and building such model for each section it is possible to monitor both temporal and spatial changes of the track resonance frequencies, which are indicative of degradation processes occurring to the ballast layer or to specific rail pads.

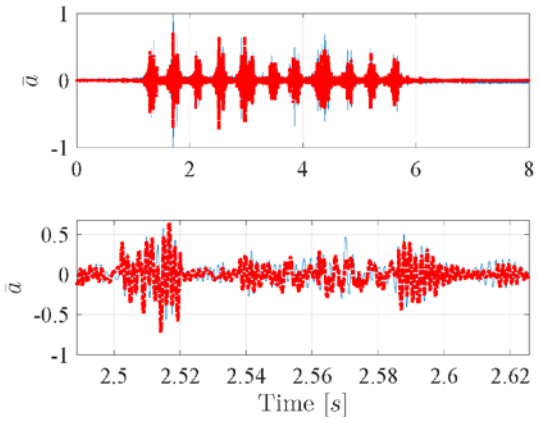

Fig.1 Comparison of measured track vertical acceleration (blue solid line) with estimated one (red dashed line).

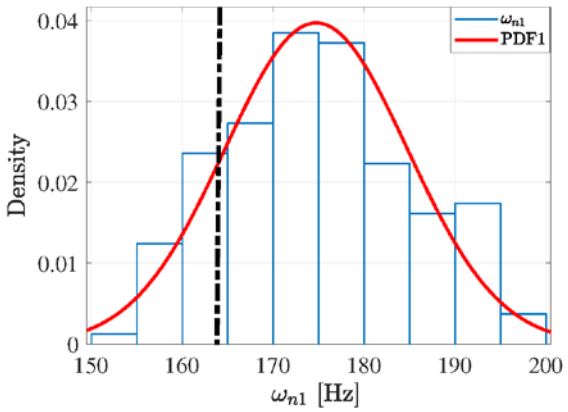

Fig. 2 Statistical model of the first track resonance frequency (ballast layer). The black dash-dotted line refers to the frequency estimated through the receptance test.

References

Barkhordari, P., Galeazzi, R., de Miguel Tejada, A., and Santos, I.F., “Low-complexity Behavioral Model for Predictive Maintenance of Railway Turnouts”. *In Proceedings of the 8th Annual Conference of the Prognostics and Health Management Society*. Florida (USA), 2017.

Barkhordari, P. and Galeazzi, R., “Statistical Model of Railway's Turnout based on Train Induced Vibrations”. *In Proceedings of the 10th IFAC Symposium on Fault Detection, Supervision and Safety of Technical Processes*. Warsaw (Poland), 2018.