Machine Learning Techniques Deliver Railway Application Improvements

OptaSense's latest generation QuantX Distributed Acoustic Sensing (DAS) interrogator unit delivers long-range quantitative data performance with high-fidelity and sensitivity – enabling the potential for numerous advanced railway applications to be delivered.

QuantX interrogates the fibre with a sequence of launch pulses that unwrap higher fidelity phase and amplitude locked information from the Rayleigh backscatter. QuantX has an operational rage of up to 50 km and is capable of transforming long fiber optic cable lengths into a dense sensor array - producing in real-time a spatially and temporally rich dataset required for many railway applications.

However, with this increased dataset, challenges are presented in the form of high-volume data handling, processing and classifying signals of interest (such as rolling stock, track features or intrusions) efficiently.

The OptaSense QuantX Distributed Fiber Sensing Interrogator Unit.

To harness this power whilst addressing the challenges posed by the increase in data volumes, OptaSense is utilising a number of Machine Learning (ML) techniques to maximise the value from the improved data fidelity and reduce QuantX commissioning times. A key area of focus for our Transportation team has been using supervised ML techniques to deliver a step-change improvement in the detection of rolling stock movements which enables a performance improvement across the rail solution portfolio. In addition to supervised ML techniques, another focus area is to employ adaptive classification algorithms which utilise goal seeking methods to dynamically and continuously tune every channel along the fibre according to assessments of background noise levels – all day, every day.

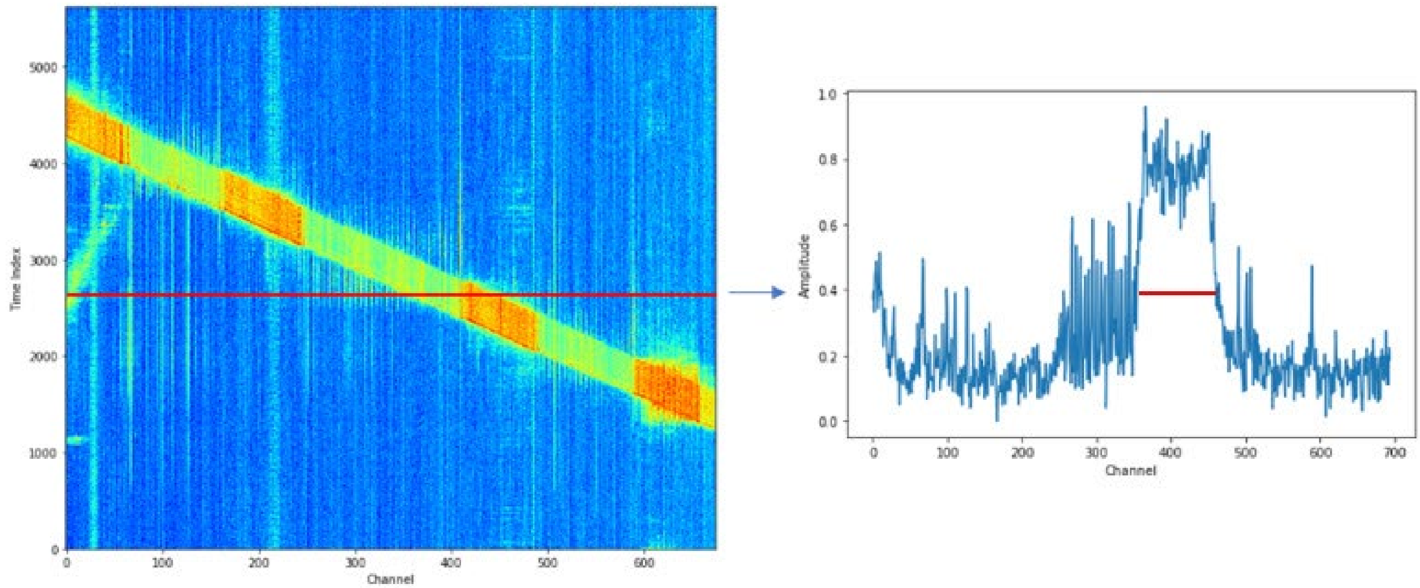

Figure 1 - (left) Fibre Sensing frequency band extracted data showing a train moving at constant speed. The higher-level red sections are where the train travels through a tunnel. The red line indicates the time index of the data (right). On the right hand chart the red line shows the train length.

Figure 1 shows a typical response for a moving train from a distributed fiber sensing system. Identification of the moving train can be seen visually and generally a time slice of the data at any point shows a distinctive square profile. The exception is near the tunnel sections (as shown on the right-hand graph) where the signals get noisier as the train enters, travels through and leaves the tunnels. Prior experience has demonstrated however, that there are limitations in using only this raw acoustic signal for applications which require accurate train position, length and speed information as a customer output or for disabling certain detectors while trains are present.

Figure 2 shows the front and back of the train being accurately detected with Quant X data and the application of ML supervised learning techniques.

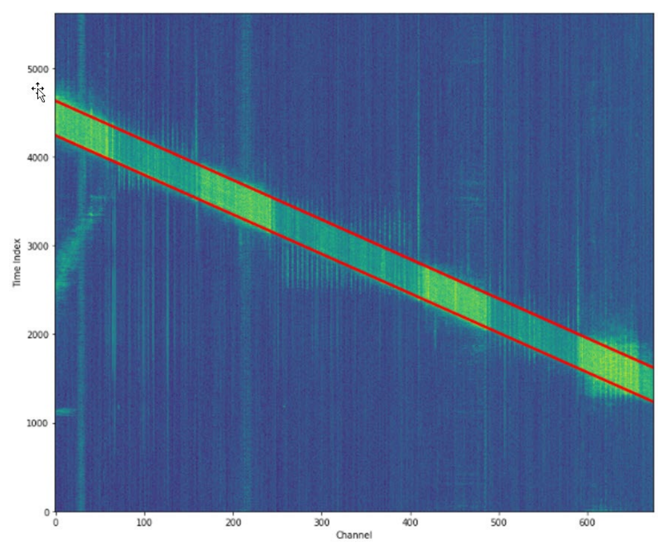

Figure 2 - Red lines indicate the front and back of the train to provide the ground truth information for the identified machine learning method.

Fibre sensing data (including mixed passenger and freight train movements) from a number of different fibre sensing installations was marked up with truth labels showing the actual train position. The ML model was then trained using the ground truth labels as a target signal.

The results show many improvements over the previous detection methods including improved probablility of detection combined with a reduced nuisance alarm rate.

The ML supervised learning tehnique was also evaluated against existing commissioning methods that required an experienced engineer to configure the algorithm settings to optimise the system. This exercise revealed that an inherent advantage of the ML technique is a reduction in the commissioning time as the ML model can be trained on train movements from other fibre sensing installations leading to a reduced commissioning period. The ongoing goal is to create a modular system where these methods can be employed to build new algorithm quickly, leading to reduced developent timescales of new applications.