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Distributed Acoustic Sensing: Explanation of Signal Anomalously Responsive to Traffic Noise

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Summary

Distributed acoustic sensing (DAS) measures the strain in optical fibres caused by incident acoustic energy. The City of Calgary has DAS set up with fibre optics installed along its Light Rail Transit system. Train and car traffic produce sufficient acoustic energy to strain the fibre, allowing general interpretations of speed and position of these vehicles to be made. There exists a 300-metre length of fibre where road traffic causes anomalously high strains (Figure 1). This investigation identifies the physical location of this portion of fibre and attributes the high amplitude response to a meander in the fibre's path that moves it closer to an adjacent expressway. This is an important discovery because these fibre installation conditions can be mimicked in future projects to allow for a more versatile traffic monitoring system. Further knowledge of traffic patterns could plausibly lead to increased efficiency and safety on public roads.

Theory / Method / Workflow

A useful way to view DAS measurements are in waterfall plots showing the amplitude of vibrational energy experienced, by position along the fibre, in time (refer to Figure 1 (Lower)). The amplitude is reported from channels along the fibre, where the DAS intensity is dependent on the angle of incidence of acoustic energy Willis et al. (2016). DAS intensities between 8400 and 8725 m in Figure 1 (Lower) show anomalously high values.

Results, Observations, Conclusions

We find that DAS intensities corresponding to westbound vehicles are approximately 80% greater than their surroundings with peak intensities of 90% greater. Intensity from eastbound traffic is largely absent, both inside and outside the area of interest, but it is less often seen in the area of interest. These observations alone point to the cause of the anomalous signal being due to the fibre installation path. Since signal does not increase in both traffic directions, this eliminates the cause being different installation methods that affect the coupling of the fibre to the ground.

Novel/Additive Information

The cause of the anomalous signal between University Station and Brentwood Station was previously unknown. This investigation proves that the fibre path is moved from midway between the two sides of Crowchild Trail to run much closer to the westbound lanes. The change in fibre path causes the anomalous signal because the effect of geometric spreading from westbound traffic is greatly reduced when the fibre is closer. DAS was used with geographic information systems to identify the location of this region. This informed coordinates used to retrieve installation drawings from the City of Calgary. The drawings prove that the path

of the fibre is the same as the path proposed through the interpretation of DAS. The motivation behind the installation geometry in this region is unknown, but it turned out to be beneficial in that it provides DAS data that can be used for traffic monitoring.

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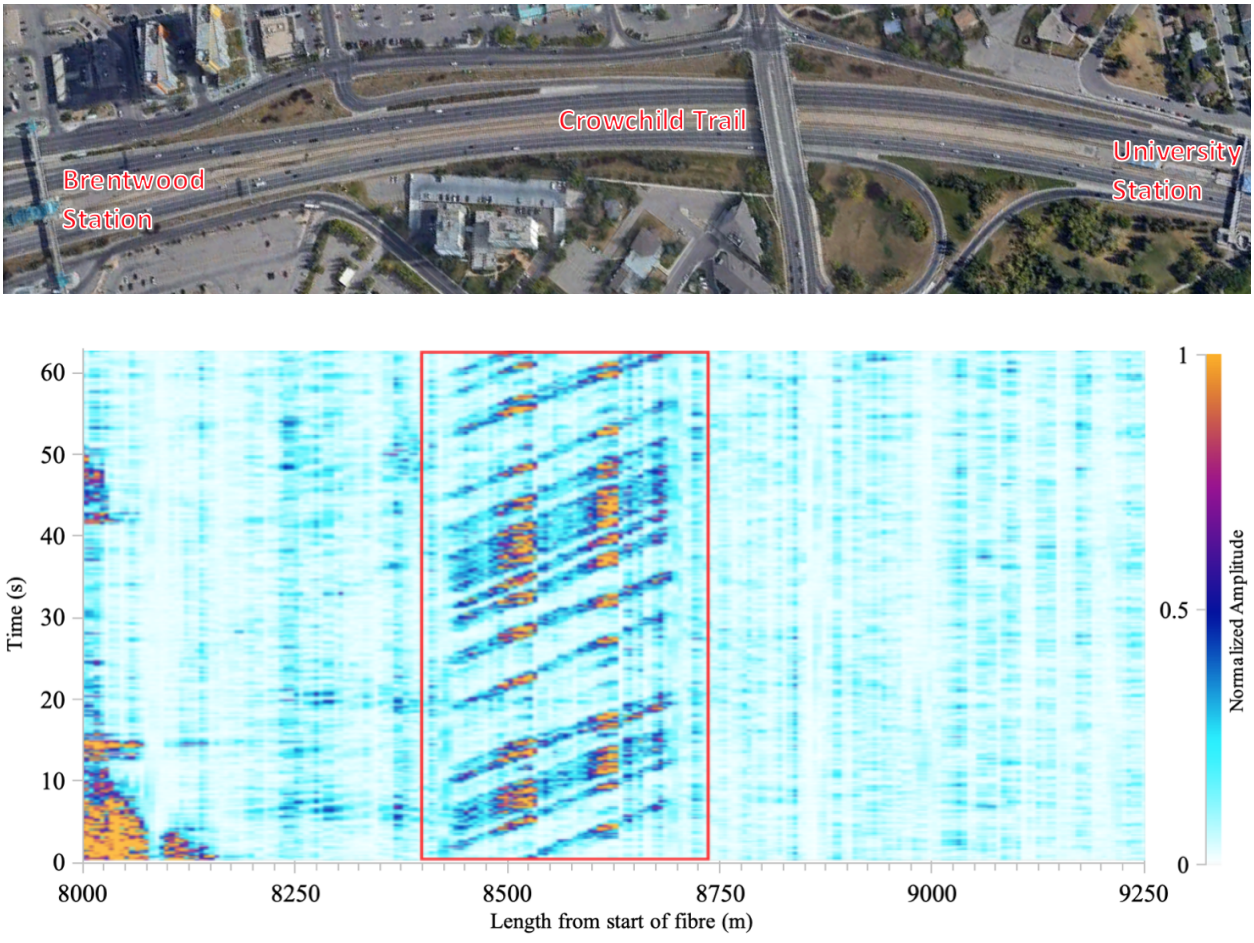

Figure 1: DAS image of a fibre meander close to the City of Calgary Red Line. Upper: survey area between Brentwood and University stations (Google Earth Pro). Lower: DAS intensity data - the red box indicates anomalous DAS intensities due to vehicle traffic.

References

Willis, M. E., Barfoot, D., Ellmauthaler, A., Wu, X., Barrios, O., Erdemir, C., Shaw, S., and Quinn, D. (2016). Quantitative quality of distributed acoustic sensing vertical seismic profile data. Leading Edge (Tulsa, OK), 35(7):605–609.