Scale Transform Signal Processing for Reducing the Effect of Rain on SSTDR Signals

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Spread spectrum time domain reflectometry (SSTDR) has proven to be effective in the detection and localization of intermittent faults on live electrical wiring. The location, shape, and magnitude of the peaks from the SSTDR signal give information about the location and type of wiring fault. To locate these faults, baseline subtraction is typically used. Unfortunately, varying weather conditions alter the SSTDR signal significantly and make baseline subtraction methods unreliable. Specifically, moisture from rain changes the relative permittivity of the cable and consequently leads to a change in the velocity of propagation (VOP) of the SSTDR signal. This change of VOP stretches the SSTDR signal and therefore shifts the peaks out of place, leading to inaccurate fault localization. Figure 1 (below) shows the described stretching effect rain has on SSTDR signals.

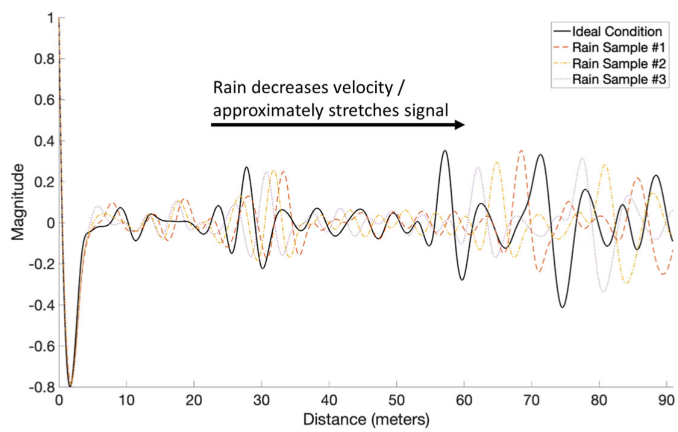

Figure 1. Effect of Rain on SSTDR Signals

In order to compensate for the stretch effect that occurs in rainy SSTDR signals, we make use of the scale transform, a variant of the Mellin transform with several stretch-invariant properties. This transform has already proved to be useful for tasks such as ultrasonic temperature compensation [1], where a temperature change is approximated by a time-stretch due to wave velocity changes. These results imply that the scale transform will similarly reduce the effects of rain in SSTDR data. Specifically, we use a computationally efficient approach known as the scale-invariant correlation/iterative scale transform (SIC/IST) where a scale factor estimate is produced by maximizing a scale cross-correlation function. We then compensate for the effects of moisture in our SSTDR signal by stretching our distorted rain signal by the inverse of our optimal scale factor estimate.

The average correlation coefficient for all rain samples compared to an ideal condition baseline was computed before and after applying our scale transform technique. The correlation coefficient was -0.0156 before applying our algorithm and 0.7828 afterwards. The positive increase in coefficient value after applying the transform implies that our approach is successfully mitigating the effects of rain in our signals, enabling us to use baseline subtraction to find faults.

Disclosure: Dr. C.M. Furse is a co-founder of LiveWire Innovation, Inc. which is commercializing SSTDR technology, and therefore has a financial conflict of interest with this company.

1. J.B. Harley, J.M.F. Moura, "Scale transform signal processing for optimal ultrasonic temperature compensation," *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, vol. 59, no. 10, October 2012.