Assessment of Connected Vehicle Friction Measurement Data on DOT Winter Maintenance Use Cases

tech transfer summary

Friction measurement data from connected vehicle fleets can help departments of transportation make decisions regarding variable speed limits, chain laws, and winter maintenance operations.

Background

Reliable road friction measurement is critical for monitoring the accessibility and safety of road networks and the effectiveness of winter maintenance operations.

Connected vehicle friction measurement (CVFM) provides continuous information from connected vehicles (CVs) traversing a given road network. These data, in combination with weather parameters, form the basis of a key performance indicator (KPI) for winter maintenance. Friction data are also valuable, for instance, when deciding whether to impose a variable speed limit (VSL) or require snow chains within a jurisdiction.

NIRA Dynamics provides real-time friction data through a fleet of CVs in which integrated software uses the vehicles' existing sensor arrays to calculate a wide range of values, including friction. CVFM data are aggregated every 10 minutes for 75 ft long sections of a road called subsegments, which are classified as high- or low-friction subsegments.

Problem Statement

Departments of transportation (DOTs) have a critical need for friction data during winter storms but are sometimes uncertain about how to incorporate CVFM data in specific use cases.

Goal and Objectives

This project aimed to demonstrate the uses and value of CVFM data by addressing three research questions:

1. Can CVFM data be used to activate and deactivate VSLs?
2. Can CVFM data be used to inform chain laws?
3. How can CVFM be used in forensic scenarios, for example, in understanding the effects of a storm and its aftermath on road conditions?

Research Description

Over the 2023–2024 winter season, analyses were carried out in three states—Colorado, Utah, and Pennsylvania—to demonstrate the role of CVFM data in the states' use cases and the value drawn from the data. Three use cases for CVFM data were evaluated.

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RESEARCH PROJECT TITLE
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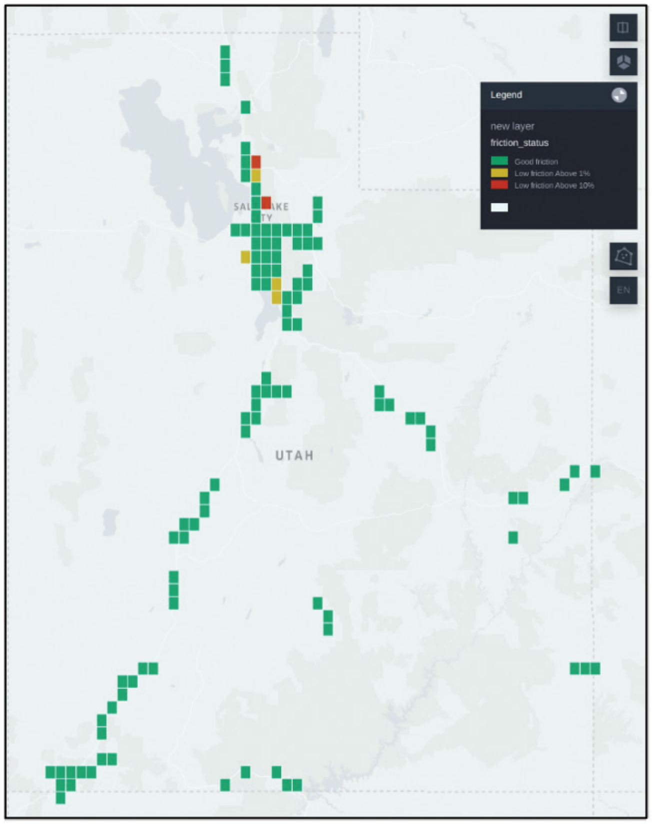


Friction measurements over a 30-minute period in Utah

The first use case evaluated how friction data from NIRA's CV fleet could support VSL decision-making. A proof-of-concept friction signal indicating different levels of road slipperiness was developed using data from VSL corridors in Pennsylvania and Utah. The friction signals generated during winter storm events were compared to historical DOT data on speed restrictions to assess how the friction signal would have impacted VSL decisions.

The second use case evaluated how NIRA's CVFM data could be used as a basis for issuing chain requirements. The friction signal described above was applied to data from Colorado corridors subject to chain laws. A similar comparison was made between friction signals and historical DOT data to assess how the friction signal would have affected chain requirements.

The third used case explored three methods for using NIRA's CVFM data to assess winter maintenance operations in Colorado. Two of these used CVFM and DOT maintenance data to calculate KPIs for winter storm mitigation on individual roads. The KPIs were based on road regain, the time from when a road exceeds a certain percentage of low friction measurements to when it returns to an acceptable state. The third method evaluated the effectiveness of winter maintenance during different snowfall intensities for a complete road network.

Key Findings

First Use Case

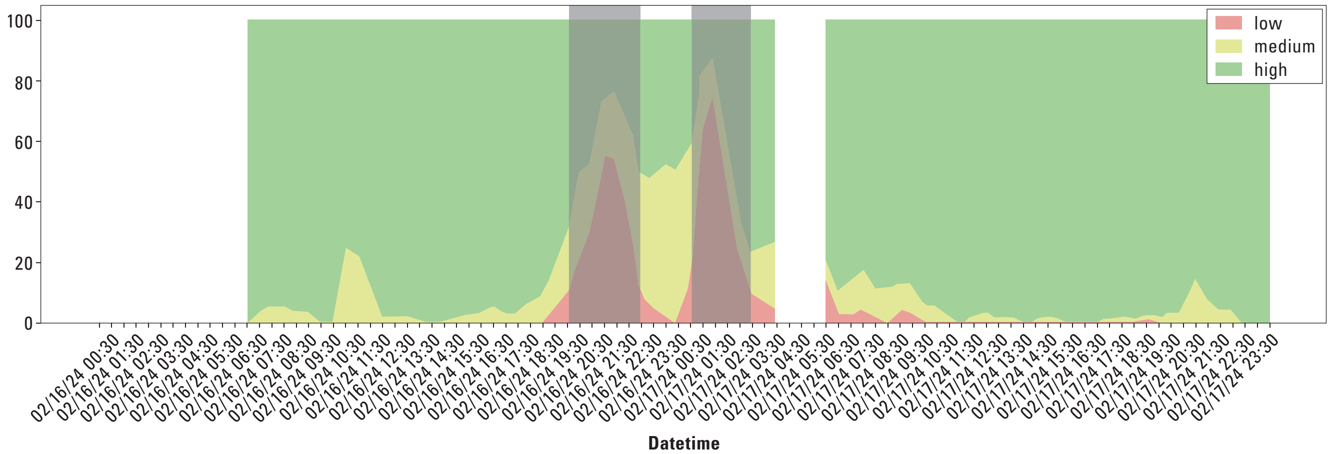
- The friction signal successfully indicated slipperiness on the chosen VSL corridors. A comparison with historical VSL data demonstrated the value in using a friction signal as an additional parameter for VSL decision-making.
- On VSL corridors with high CV coverage, a friction signal can be used as an additional parameter in removing speed restrictions. On corridors with sparser CV coverage, a friction signal can provide benefits but should not the sole criterion for removing speed restrictions.
- When combining the use of the friction signal with existing methods such as the use of road weather information systems (RWIS), weather forecasts, and live observations, dedicated thresholds should be finetuned for the characteristics of each VSL corridor.

Second Use Case

- The friction signal developed for the first use case showed reliable performance when applied to chain law decisions on the chosen corridors. The friction signal reflected the impacts of snowstorms during the winter of 2024.
- Applying chain restrictions based on the friction signal alone can be challenging because it does not distinguish snowy from icy roads. If chain restrictions are to be activated only during snowfall, the friction signal could be used with existing weather data to identify snowy roads.

Third Use Case

- Analysis of winter maintenance operations on an individual road results in a road regain graph, which provides an overview of a winter season's impact. A desired regain threshold can be set to calculate a KPI, which can be used to quantify maintenance performance.
- For each regain occurrence on a road segment, changes in CV friction measurements can be studied in detail alongside DOT maintenance data to evaluate how maintenance work mitigates low friction.
- The winter maintenance KPI provides a reliable measure of how snowfall affects roads and how the work of maintenance crews mitigates these effects. The resulting KPI and illustrative graphs can be used for post-season evaluation of maintenance work.



Example road regain graph for a corridor, with regain time shaded grey

- Consistently monitoring the winter maintenance KPI throughout a season can help agencies reallocate resources between different road networks in order to reach the desired KPI.
- An upper snowfall precipitation limit can be set to consider the precipitation intensity at which maintenance work stops having an effect. This limit prevents the KPI from being negatively affected in scenarios that cannot be mitigated.

Implementation Readiness and Benefits

Various vendors, including NIRA Dynamics, currently offer CVFM data to DOTs.

Friction measurement data from CV fleets can help DOTs make decisions regarding variable speed limits and chain laws and can inform assessments of winter maintenance operations.