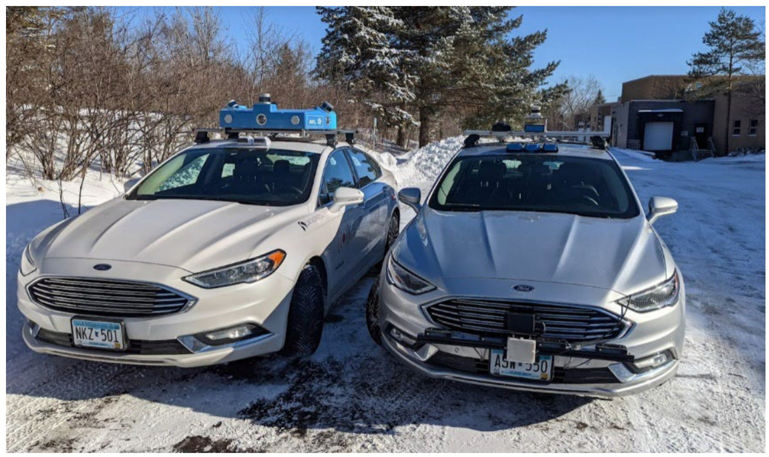
VSI Labs

Can Automated Driving Handle Minnesota Winters?

Active safety and automated driving systems rely on a variety of sensory inputs to make decisions about the environment the vehicle operates within. For ADAS, this generally includes one or more visible cameras plus radar. Together, they may enable Adaptive Cruise Control (ACC) and lane keep assist (LKA).



ACC and LKA are the basis of SAE Level 2 automated driving, what we consider to be the new ADAS. In fact, more than half of the cars sold today have a forward-facing camera and/or radar.

ACC and LKA are responsible for both longitudinal and latitudinal control, respectively. L2 systems typically operate within the context of a lane while "L2+" systems are more advanced and generally include high-definition maps (or *e-Horizon*) to augment the Operational Design Domain (ODD). Both L2 and L2+ require constant human supervision.

Though applications like ACC and LKA are advanced systems, they are still highly dependent on environmental factors, one of which is inclement weather.

Bring on the Weather!

Just as it is for humans, poor weather influences active safety and automated driving systems. If humans cannot see, the visible cameras cannot see either. This makes LKA and automated driving systems unavailable when the weather is bad. Radar systems work reasonably well in declining weather, but any accumulation of frozen matter will disable radar in no time.

While new sensor technologies are getting better at seeing in adverse conditions, they do not have the intelligence to adjust to changes in road grip caused by snow, ice or standing water. And while map-based lane keeping (as found in L2+ systems) is pretty good at understanding where it needs to be when vision systems are compromised, this only pertains to lateral vehicle control. Longitudinal control (speed) is pre-set by the data stored in the map database and is static.

Similarly, braking output in an AEB application, or acceleration in an ACC application, is pre-set by the algorithm and does not adjust to changes from slippery roads. What you need is a way to adjust the outputs to compensate for changes in surface friction.

Input Challenges

Sensors like radar and lidar work reasonably well in wintery conditions if the sensors don't become coated with frozen matter. Some sensors contain heating elements, but this is generally not enough to avoid the rapid accumulation of snow and ice in below-freezing temps. VSI Labs experiences this frequently because we are testing in wintery conditions for 3 or 4 months of the year.

Other sensors have less exposure to precipitation but are affected, nonetheless. For example, GNSS (global navigation satellite services) may fail in poor weather or other atmospheric conditions that affect satellite performance.

In snowy conditions where roads are covered, vision systems struggle at seeing lane markings. In these situations, you could augment the positioning with precision maps assuming your GNSS provides absolute positioning within 10 centimeters.

Coping with Slippery Conditions

ADAS and automated driving systems are no doubt challenged when operating in slippery conditions. When road grip becomes compromised, you must consider the system outputs as well as the inputs. This largely applies to longitudinal control in terms of braking and acceleration output. For example, AEB (automatic emergency braking) and ACC (active cruise control) are highly compromised in slippery conditions because braking will require greater distances.

The best way to cope with ADAS operation in wintery areas is through dynamic output that is calculated based on real time grip measurements. In other words, you need a "*low-grip algorithm*" that can adjust output based on the current conditions of the roadway. For ACC and AEB, this will enhance the safety of the systems. For automated driving, this will likely become a requirement!

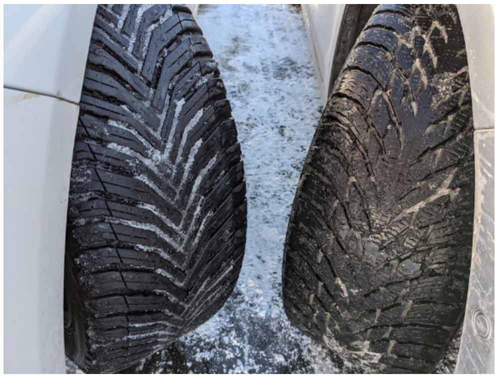
Before adjusting brake or acceleration outputs, you must first have a method of knowing (with confidence) that friction values have changed. To do this, you rely on intelligence primarily from the wheel speed sensors whereby relative wheel slip is measured and analyzed. This process is complicated and is based on numerous slip models that consider such things as tire type and road surface materials.

Traditional methods for coping with low grip in automotive is through closed-loop systems like ABS (anti-lock braking systems) or ESC (electronic stability control). Typically, these systems adjust to the loss of grip through brake modulation. While these systems are terrific at coping with transient situations, they are not suitable for ADAS or automated driving because they react after the fact when the vehicle's stability is already compromised.

ABS and ESC systems are largely binary in that they are either on or off. They do not have a means of discerning a gradual decline in road friction. This is not to say those systems are ineffective and go away. On the contrary, systems like these may remain in place because they provide additional safety coverage, especially under human driving situations.

Let's Talk Tires

Road grip is one of the most overlooked elements of ADAS and automated driving. And you cannot talk about road friction without a discussion about tires. Most drivers and passengers generally assume the tires on their vehicle will do the job, but this is far from the case.



Tires are one of the most overlooked components in ADAS and automated driving systems. Improper tire selection, especially for vehicles operating in northern climates, can have serious safety implications. VSI Labs outfits its vehicles with dedicated winter tires for at least four months out of the year. Dedicated winter tires are made with softer compounds with silica and tread block siping.

A three-peak mountain snowflake (3PMSF) symbol that is branded on a tire's sidewall indicates that the tire meets required performance criteria in snow testing and is considered severe snow service-rated. Originally used as a designation for winter tires, the 3PMSF symbol is now featured on some all-season and all-terrain tires with snow performance that meets the testing criteria.

Operation in inclement weather is equally challenged by the accumulation of precipitation on the roadway surface. The accumulation of water leads to aquaplaning that is often exacerbated by the presence of trucker ruts. Operation in inclement weather with poor tires and in the presence of "trucker ruts" is a terrible combination.

Conclusion:

The operation of both ADAS and automated driving systems in northern climates is often compromised by poor weather conditions. ACC systems, for example, may cause a loss of control if they encounter icy roads or black ice. For this reason, many western states warn to disable any form of cruise control under these conditions. Likewise, automatic emergency braking (AEB) systems may be less effective under slippery conditions for obvious reasons.

For ADAS and automated driving systems to operate safely when road grip is compromised, they need to adjust outputs when conditions warrant. This requires a real-time monitor of surface grip conditions. To do this, you need a method that can examine wheel speed sensors, steering angle, and throttle position and adapt outputs accordingly.

The goal is to monitor road grip in real-time and adjust output accordingly. For longitudinal control, both brake and throttle position would be adjusted based on the current levels of grip. For lateral control, you may have less of an impact on the premise that lateral grip will be determined by vehicle speed. Nevertheless, some steering output may be adjusted to maximize control or applied to counter-steer if the vehicle oversteers.

About VSI Labs

Established in 2014 by Phil Magney, VSI Labs is one of the industry's top advisors on AV technologies, supporting major automotive companies and suppliers worldwide. VSI's research and lab activities have fostered a comprehensive breakdown of the AV ecosystem through hands-on development of its own automated vehicle platform. VSI also conducts functional validation of critical enablers including sensors, domain controllers, and AV software development kits. Learn more about VSI Labs at https://vsi-labs.com/.

Conditions of this Report