Event coordinators:

Lauryna Šidlauskaitė   Justas Kažys   Jonas Kaminskas

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THE DECREASING IMPORTANCE OF ROAD WEATHER FORECASTS

Lee Chapman
University of Birmingham, Birmingham, B15 2TT, UK
l.chapman@bham.ac.uk, ORCID: 0000-0002-2837-8334

Summary

Road Weather Information Systems (RWIS) have seen little *rapid* fundamental change since their original implementation in the 1980's – it is often a case of evolution rather than revolution. Significant technological advances leading to a step-change are uncommon, with the adoption of geographical information systems and global positioning systems bringing arguably the first significant change in practice some twenty years later after the first generation of RWIS. However, a range of technologies now exist that have the potential to cause a paradigm shift in the way society deals with winter resilience on transport networks, signalling the end of road weather forecasts and RWIS as currently known.

Background: Road Weather Information Systems pre-2000

The original road weather forecasts were very crude with treatment decisions being made on the most basic of text forecasts [1]. For example:

"*Road surface temperatures are expected to fall below zero at 2 a.m. and ice is expected to form on most of the roads in the region."*

This was transformed in the 1980's which saw a widespread increase in the use of Road Weather Information Systems (RWIS). The earliest from of RWIS was an *ice detection* system consisting of embedded sensors in the road to monitor road surface temperature and relay real-time road condition information back to the highway engineer. Using this approach, action could be taken if temperatures changed suddenly. However, the ice detection approach also paved the way for *ice prediction* systems which embedded the forecasting component into the system. The availability of road weather data enabled an increased level of sophistication to forecasts allowing dedicated teams of forecasters to produce 24 hour forecast graphs from simple models. These which were issued daily at noon to guide improved decision making: a midday forecast provided ample time to deploy people and vehicles, whilst complying with legal demands such as working time directives.

Advances since 2000

The system remained broadly unchanged for the next 20 years, but increased computing power meant forecasts could now be run at a scale previously impossible opening the door to high spatial resolution weather forecasts such as route-based forecasting [2]. New technologies were also starting to become embedded such as geographical information systems, global positioning systems and decision support systems meaning that treatments could be increasingly targeted and optimised [3]. It represented a step-change in RWIS for highway engineers brave enough to have confidence in the new technology. Fast forward another 20 years and it is becoming evident that a new wave of technological advances are rapidly emerging. A number of disruptive technologies are already being implemented that have the potential to radically change the way that the industry thinks about RWIS. These include:

More sophisticated sensors: Options are now far more numerous than ever with a range of vehicle mounted and in-situ non-invasive and embedded sensors now available on the market. The non-invasive market has particularly increased, offering ease of installation and measurements of surface state as well as road surface temperature.

The Internet of Things: At the other end of the scale, IoT devices provide less sophistication, but at a vastly lower cost allowing unprecedented densification of measurements [4]. The self-contained nature of the technology is attractive meaning that devices are un-reliant on mains power and are therefore 'semi-mobile' (Figure 1).

Connected & Autonomous Vehicles: The industry has long embraced the potential of collecting weather data from cars [5]. However, with the rise of the connected vehicle, opportunistic sensing provides a means to provide observations at an unparalleled scale. Forecasting solutions are already commercially available in this space taking advantage of high-resolution road condition data [6].

Artificial Intelligence (AI): AI is not new, but is enjoying a renaissance and plays a role in all three of the afore-mentioned technologies. This can take a variety of forms ranging from image processing / object recognition on sophisticated sensors to provide real-time insights of the 'big data' generated from the IoT and opportunistically sensed data from cars.

Fig. 1. The latest generation Wintersense IoT road temperature sensor.

Increasing Automation: The end of road weather forecasts?

AI is synomonous with automation and it stands to reason that a key disruption in the sector will be increasingly autonomous decision making. This is a significant topic of debate and one which is problematic. decision has to be made somewhere, by someone (or even *something* - but the responsibility still has to reside with an individual, or organisation). Hence, even if the technologies exist to automate decision making (it could be argued that this has been the case for a decade or more), the disruption is likely to take the form of a more nuanced (or even radical) approach.

For example, at a basic level, the automation of road weather forecasts is relatively simple. There is very little reason why a human weather forecaster is going to be required in the sector in the medium term – AI is already vastly more capable of producing the simple text forecasts introduced at the start of this paper. Whereas a paucity of high resolution data has limited our capabilities here previously, the IoT and opportunistic sensing means that this is no longer the case and the industry is amassing large datasets from a range of sources (e.g. [4,6]) which provide sufficient training data to fully automate the forecast process. Much of this can be readily done in the cloud, but there will be an increasing role for edge computing to deliver the processing on the sensor itself, especially when combined with federated learning approaches [7]. With this in mind, it is clear that nowcasting will play an increasingly important role in the winter road maintenance sector.

However, there is scope to take this a stage further by considering how automation may eliminate the need for weather forecasts entirely. Indeed, an increasing fleet of autonomous vehicles could render the entire RWIS ecosystem obsolete by marking a return to *ice detection*. Consider the following scenario:

1. The vehicle fleet of 2030 will have bespoke in-built sensing capabilities as standard (e.g. [6]). Given the scale, this means that deployments of in-situ sensors are no longer required.
2. Treatment vehicles will be autonomous. As unmanned vehicles, there will be no need to comply with working time directives, so no longer will decisions be required to be taken in advance.
3. Treatment will be performed on a 'just-in-time' basis. Sensor data from the autonomous vehicle fleet will be constantly relayed back to treatment vehicles meaning that sites becoming at increased risk of ice will be treated before the problem manifests (i.e. *ice detection*)
4. Actions will be stored in the cloud allowing for real-time updates on both road condition and temperature. Autonomous treatment vehicles will continue to 'patrol' the network, analysing data in real-time, keeping the roads secure as required.

Although much of this seems far-distant, the building blocks are already in place. There is a question mark on exactly when society will be ready to make the switch to autonomous vehicles, but at the time of writing, it does appear to be a case of 'when' and not 'if'. However, it is the unmanned vehicle which is pivotal to the success of the approach. It is useful to bear in mind how rapid this can be – the transition from horse-drawn carriages to motor vehicle happened in less than a decade.

Conclusion

It is counter-intuitive to think that the disruptive technologies emerging today will take the winter road maintenance sector back to *ice detection* approaches that essentially pre-date modern RWIS, but it is certainly a plausible scenario. AI will increasingly automate many aspects of the winter road maintenance sector, as has already started with road weather forecasts, but that has the potential to be only the start of a rapid journey towards an active system to manage winter road maintenance. Such active systems have been a luxury only previously afforded to high risk, high traffic areas (e.g. airport, bridge decks), but the move to autonomous vehicles affords a new paradigm – one where road weather forecasts (and indeed RWIS as currently known) are no longer required.

References

[1] Thornes, J.E. & Chapman, L. **2008** XRWIS: A new paradigm for road and rail severe weather prediction in the United Kingdom. *Geography Compass* 2, 1012-1026

[2] Chapman, L. & Thornes, J.E. **2006** A geomatics based road surface temperature prediction model. *Science of the Total Environment* 360, 68-80

[3] Handa, H., Chapman L. & Yao X. **2006** Robust route optimisation for gritting/salting trucks: A CERCIA experience. *IEEE Computational Intelligence Magazine* 1(1), 6-9

[4] Chapman, L & Bell, S.J. **2018** High-Resolution Monitoring of Weather Impacts on Infrastructure Networks using the Internet of Things. *Bulletin of the American Meteorological Society* 99, 1187-1154

[5] Siems-Anderson, A., Lee, J.A., Brown, B., Wiener, G. and Linden, S., **2020**. Impacts of assimilating observations from connected vehicles into a numerical weather prediction model. *Transportation Research Interdisciplinary Perspectives*, 8, 100253.

[6] Magnusson, P., Frank, H., Gustavsson, T. and Almkvist, E., **2019**. *Real-time high-resolution road condition map for the EU. In 9th International*

Munich Chassis Symposium 2018 (pp. 851-875). Springer Vieweg, Wiesbaden.

[7] Fowdur, T.P., Beeharry, Y., Hurbungs, V., Bassoo, V., Ramnarain-Seetohul, V. and Lun, E.C.M., **2018**. Performance analysis and implementation of an adaptive real-time weather forecasting system. *Internet of Things*, 3, 12-33.