Presentation 2.1

NETWORK DESIGN CONSIDERATIONS FOR A NEW GENERATION OF HIGH RESOLUTION ROAD WEATHER INFORMATION SYSTEMS

Lee Chapman[a], Simon J. Bell[a]

[a]*School of Geography, Earth & Environmental Science,*
University of Birmingham, Birmingham, B15 2TT, UK.
l.chapman@bham.ac.uk

Introduction

Route based forecasting (RBF) is now a standard technique used by highway authorities to make daily winter road maintenance decisions. RBF takes into account the interaction of the regional climate with the local geography to produce a high resolution forecast (e.g. 100m) of road conditions (1). The approach was motivated by the concept of selective salting, where highway engineers identify which routes need treatment on a nightly basis, or control in-route treatments by turning the spreader on or off depending on local road conditions (2). However, whilst the approach has been available for over a decade, selective salting is still not happening with practitioners nervous about making decisions based on largely unverified forecasts (3). Previous research has investigated the clustering of road stretches to better locate the limited RWIS instrumentation available, but concluded that instrumentation was too expensive to be deployed in the quantity required (4). However, technology has since moved on and via the Internet of Things, high resolution weather monitoring of road networks to complement RBF is now a reality (3). A discussion is now required to understand how best to use this new technology.

An Internet of Things Road Surface Temperature Sensor

A low-cost road surface temperature sensor has been developed at the University of Birmingham (3). The sensor is based on a thermopile, powered by lithium (or alkaline) batteries and uses the latest generation of Internet of Things communication networks. It is self-contained and simply mounts on a lighting column or gantry in minutes (Fig. 1a). The combination of technologies means that sensors can be produced and deployed at an order of magnitude cheaper than traditional alternatives that require slot cutting, external power, dataloggers, or GSM communications.

Deployment Strategies

Traditionally, the road network is subdivided into distinct climatic domains (e.g. coastal, urban, high altitude etc) each of which would receive a dedicated forecast. It was logical to then provide a means of initialisation and verification for each forecast and hence it was common (and generally affordable) to install a RWIS outstation for each domain. This strategy has remained relatively unchanged over the last 30 years and the move to high resolution RBF has not significantly changed thinking. This is surprising as the number of routes treated by highway authorities significantly outnumbers outstations leading to a paucity of observations (routes may also traverse several domains). Hence, the existing strategy is far from ideal for RBF, but outstations remain too expensive to deploy on every route (the larger local authorities in the UK can have upwards of 40 routes). Hence, an extension of existing RWIS can easily be achieved by locating low-cost sensors on routes where there is presently no instrumentation (Fig. 1b). This step could probably be achieved for most highway authorities at a cost of less than a single traditional outstation yet would in itself provide a step-change in available information.

The traditional climate domain approach also favours locating outstations in 'representative' locations (in most countries). Whilst this maximises value from the limited number of sites, the disadvantage is that information is not then available about conditions on the most problematic road sections. The low-cost approach also provides an opportunity to rethink this and design a strategy particularly suitable for use with RBF. Sensors could be placed at the COLDEST location(s) of every salting route providing a snapshot of the present worst case scenario. Locations would be identified by thermal mapping, RBF ensembles, or tacit knowledge. This step only requires a modest investment in a small number of additional sensors, but the financial benefits (especially on marginal nights) could be significant.

Whilst the one sensor per route strategy is ideally suited to maximise the benefits of RBF (i.e. treat the route or not), it would be insufficient for use in genuine selective salting practices where a much denser network would be required. Indeed, the complexity greatly increases when multi-laned roads are considered, where cross-profile differences (up to 3°C between lanes) would also need to be resolved (5). At current costs, this would be too expensive, but there is no need to saturate the entire network with sensors. Unlike traditional outstations, sensors are portable and so blanket coverage (i.e. every 100m) could be obtained on a single route at a time, moving the sensors once confidence in forecasts had been achieved.

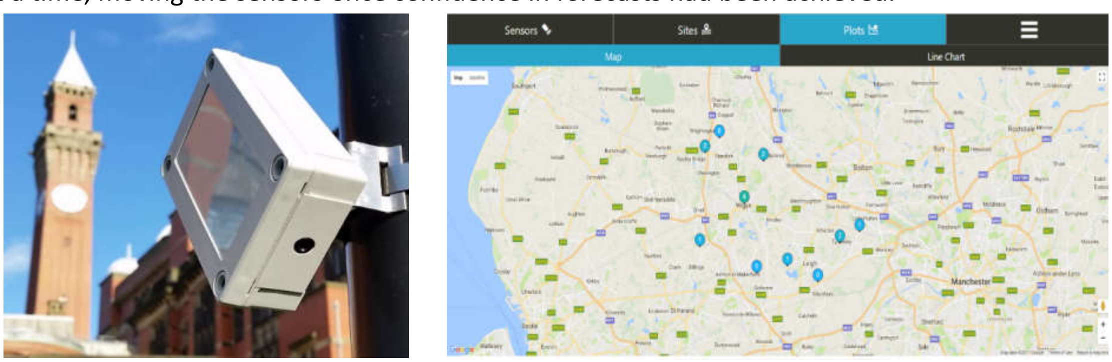

Fig 1. a) Prototype road surface temperature sensor and b) An example deployment in a UK Highway Authority. Each salting route has its own dedicated road surface temperature sensor.

Conclusions

Given the rapid emergence of low-cost sensing, there are many opportunities and options to rethink RWIS: i) Continue with traditional outstations deployed on a climate domain basis; ii) Supplement traditional outstations with representatively located sensors on a route by route basis; iii) Locate sensors at cold locations; iv) High resolution coverage (say every 100m) to also include the cross-profile. Option 3 is the recommended way forward as not only being cheap to implement, it should also provide easy returns from RBF and have the potential to reduce the number of traditional sites. However, option 4 should still be explored as costs continue to fall.

References

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