Towards version 2.0 of intelligent systems to support decision making in the management of winter maintenance.

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ABSTRACT

Intelligent systems, one of the best examples is the MDSS, have been a remarkable progress in improving the management of winter maintenance.

However needs to cover necessarily imply the need to move towards new and expanded versions of these intelligent systems.

The presentation will describe the two areas in which technological advances should focus.

The first one is the need to get to predict the existence of adverse weather conditions ad hoc basis in radius curve of xx,xx a certain road, and the shady area of PK xx, xx another road, or the input or output of the PK bridge xx,xx of that other…Beyond current technology that allowed for determining what will be
The second development must focus on to evaluate the best treatment to be performed, not only based on the prediction, the experience gained by the system itself, but what is much more important for the real knowledge of the degree of salinity of the road just before preventive treatment, point to point, and based on this, the estimated prediction of precipitation, experience and the system itself and theoretical appropriations set by the administration for each situation, make the treatment more effectively provide.

1.- Introduction

The winter road maintenance is one of the routine maintenance activities, with affection on users.

The widespread use of mobile phones has led users to contact the media, real-time, to voice their complaints about the lack of service that the presence of snow or ice generated at a given point in the road network of a country.

This social pressure makes the owner administrations of the road networks have significantly increased the mechanical and human resources to attend the winter road maintenance.

However, this increase in resources have a limit, especially when the economy is imposing restrictions on government investments.

So the next step is reasonably advance towards the optimization and improvement of the efficiency and effectiveness of these stable resources.

Over the last two decades has increased the application of systems to aid decision making for winter maintenance operations, based on predictions of weather road networks in various countries in Europe and North America, that are resulting an extraordinary help for winter maintenance operations.

Most of these systems are composed of:

- Station networks of continuous observation of the weather and the pavement in many points, isolated, on the roads.

- Evaluation of alternative models to predict in advanced adverse weather conditions on the road network and its status after completing either preventive treatment.

- Mechanisms to inform staff of road maintenance relevant information to enable the operation to allow implementation of appropriate preventive operations in principle, and curative if they need snow removal on the roadway.

The experience accumulated over the period in which these systems have been operating has provide sufficient evidence of its importance, both from the point of view of safety, environmental efficiency and cost savings from its use carries with it.

It has also been able to gauge the importance of the economic benefits from the timely implementation of preventive treatments to avoid icing and commissioning of devices for removing snow on the carriageway of roads, apart from the consequent reduction in the number of accidents.

Thus, it has been proved that the cost of setting up such systems to support decision making it is broadly compensate with only the savings from a more optimized operatives spread salt or brine with snow ploughs.

Furthermore, unnecessary operations or excessive spread salt on the roads should be avoided not only for economic reasons, but also for environmental impacts that may result.

Optimizing preventive treatment winter maintenance operations can only be achieved by providing a good information on the expected evolution of weather affecting the road network. Being fundamental geographic concreteness weather forecasts.

That is to say the search of efficacy leads us to seek both the prediction of possible snow and to determine the geographical area of potential high risk snowfall. Therefore, we must have adequate forecasts for temperature, humidity and precipitation to infer the risk of icing or snow accumulation on the road surface as well as the geographical limits of the high-risk areas.

It can be applied to two strategies:

- The manual work of a meteorologist weather prediction expert that develop road maintenance reports based on various weather tools (observations, forecasts of weather, knowledge of the local climate, etc..)

- An automated operations based on numerical results of deterministic mathematical models or statistical analysis.

In the case of Spain extensive road network, where climate variability is also very remarkable, if opted for the first approach would require the continued participation of a team of experts working in shifts. Therefore, it is clearly more advantageous the second procedure, which in fact is being applied in most European countries and North America.

Systems to aid decision making currently used are of two types: purely statistical generally based on "fuzzy logic" (eg Hertl and Schaffar, 1998) and numerical models using purely physical (eg MDSS , 2004; Sass & Petersen, 2004 Crevier & Delage, 2001).

Although the statistical methods been shown to provide useful predictions of the temperature on the road network, it is generally considered models representing the physical process give better results, especially in the event of transition between weather situations.

So there has been progress in the use of so-called intelligent systems to aid decision making for winter road maintenance. One of the best examples is the MDSS of AASHTO (Maintenance Decision Support Systems).

They based on weather forecasts which progress will occur and depending on the various treatment options to perform on the road, from doing nothing, to make preventive treatment with different endowments, or with different types of fluxes...Generating a temporal prediction of the situation which can be obtained in each of the cases analyzed.

This facilitates the technician making the decision more efficiently with enough time to maximize efficiency of the treatment, under two aspects main scanning from one side the possibility of optimizing flux endowments produce an improvement in the environment and other by the improvement that occurs in traffic safety by realizing the best possible treatment to prevent or at least minimize, the existence of a dangerous situation for the circulation of vehicles.

In addition these systems feed back with their experiences, which means that its continued use creates a continuous improvement in the quality of service provided to users of the road.

The question to ask is whether this type of intelligent systems to support effective decision making are efficient and generate an improvement on the management that has been done by traditional means, based on experience.

No doubt the answer is yes. Manage winter road maintenance protocols through traditional means generates stiffness and shortage of alternatives, while intelligent systems of decision making present alternatives that can jointly evaluate and facilitate different approaches of action, as appropriate, allow take decisions which have been considered many more variables and thus, a priori, should be more effective.

However, these systems can not give closed. They have areas for improvement and in this document we present two aspects that significantly improve these systems.

Besides efficiency demands requested from the various administrations own the road networks are becoming larger, which implies the need to move even further to new and expanded versions of such management schemes. That is, it has to move forward in the improvement of intelligent decision making in the management of winter maintenance, the current version has to be improve and move towards a version 2.0.

2.- First thing to approach in the 2.0 version

A first aspect that we consider critical in the current level of development of intelligent decision-making for managing winter road maintenance is in the accuracy and reliability of weather forecasts in terms of both the amount of rainfall snow will occur as temporary, when that will happen, as the place in which it will happen.

In fact, whether these kind of intelligent decision-making systems are used or a traditional management is performed, based on the experience and protocols, truthfulness and accuracy of weather forecasting are essential to adequately address the preventive activity.

But progress in improving winter maintenance management can, or rather should be, adjust this type of decision-making models to reality and not in each area, and each road, but progress should be made to establish the weather forecast for each kilometre of road, of each slope, curve, shady area ...

Obviously, the questions is, and is this possible? or making a more accurate question, is it possible at a reasonable cost?.

In the high-capacity network of the Central Administration, you can set a quantification of the presence of meteorological stations would be around a station every 40 kilometres (24.85 miles) of road, approximately. While in conventional network this same administration the presence of weather stations could be established in the vicinity of one every 150 kilometres (93.20 miles). Proportion would happen to a station every 350 kilometres (217.47 miles), on average, for road networks of the autonomous communities and even lower density for the rest of the other government networks.

This gives us a picture that, even in the best of cases, high-capacity network of the Central Administration clearly demonstrates insufficient to establish a weather forecast for a particular area of the network. Since each single meteorological stations measured at a point, so that it automatically sets extrapolation areas around the station, comprising each 40 kilometres. As the levels of reliability of prediction we can get is a function of variables such as changes in the topography, the shady or of the location of the weather station, in areas such as wind speed and direction.

The approach that we do is to create a wireless network of "micro" stations of high performance and low cost, so that each will communicate with those around you (at least two of them) creating a network wireless data transport to a "node" that allows long-distance communication through a modem or wireless GPRS link.

Then we would have customized an entire geographical area characterized by specific climatic conditions, which could be compared with broader information that a meteorological station provides throughout the area, and thus could be obtained not only an extrapolation of a single figure but, on the contrary, supplementation of the actual data of the "micro" stations throughout the area with those provided by the weather station basis, which would lead establishing a local prediction with high reliability.

The real power of the network is in the large number of samples provided, thus generating strong statistical support to absorb the noise, bugs and "background noise" in the measurement process, achieving stability and reliability in the supply of data, which would be unreachable from the perspective of using isolated weather stations, and all at a reasonable cost.

The approach is to place the "micro" stations on the pavement of the road surface, a distance between them that, according to the ground, would fall between 500 meters and 1000 meters, this distance may decrease in areas of terrain complicated or shady to 100 or 150 meters.

Once obtaining specific data from “micro” stations, they must be transmitted to a control centre, which will also receive wider data that fixed weather stations provides. In the control centre we will have to apply thorough computational intelligence techniques and using a meteorological model, and by comparison with more extensive data obtained from weather station, the fixed point of precipitation forecasting weather to 36 hours.

The Spanish Association of Maintenance and Exploitation of Infrastructures (ACEX) is working on developing a research project that validate the approach and economic viability of implementation and maintenance of the proposed solution.

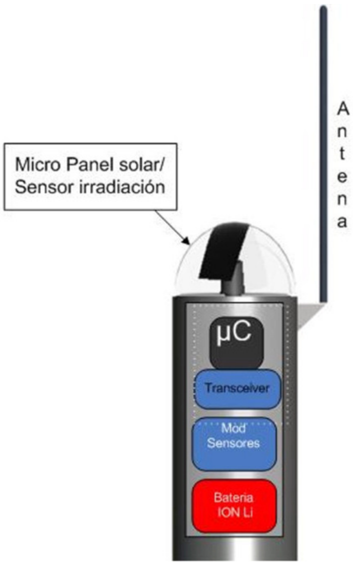


Figure 1. - Generic design micro station

In this sense it has raised the integration of the system within the roads through various alternatives:

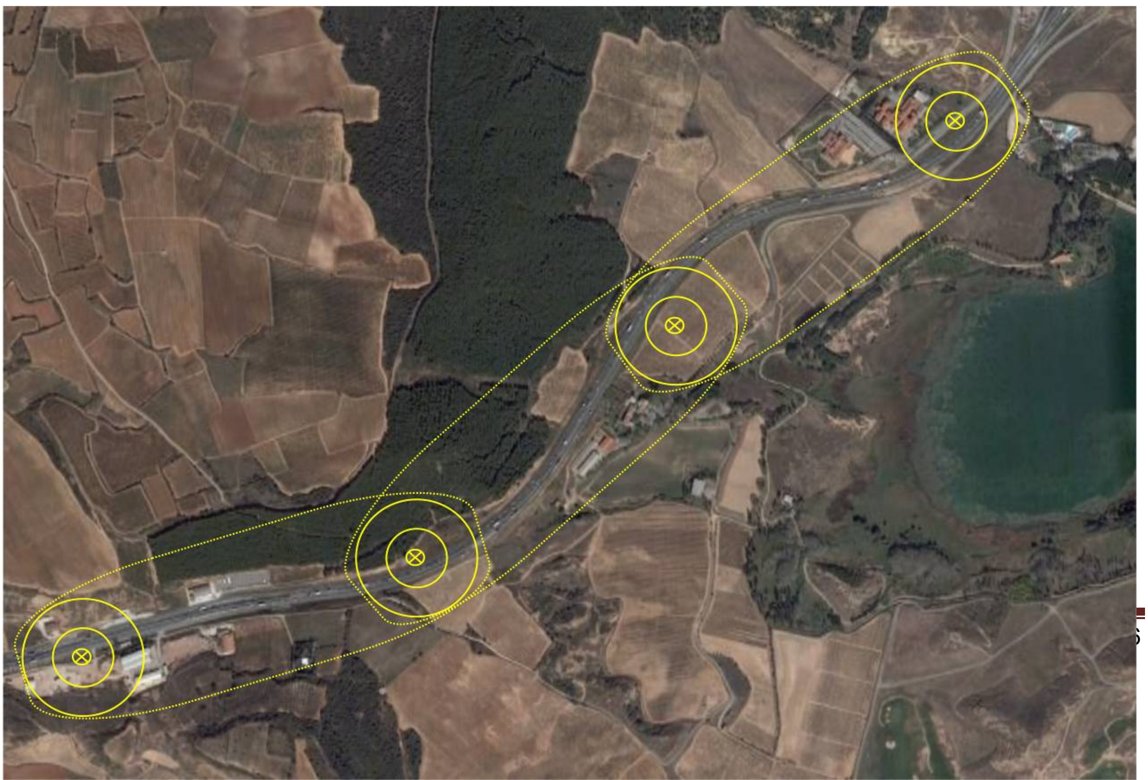
- Edges of the road
- Systems buried in the road shoulders
- Hidden Systems in marking or signaling systems.

This project will validate tangentially the costs of implementing each of the options. Since during the development / testing will be thoroughly documenting the results of each test batteries performed well as installation procedures and all relevant data for a possible massive deployment.

The solution chosen will reach a correct compromise between cost and reliability.

The approach is to perform the placing of 30 micro stations along a pilot section to be determined, for which it is established that:

- must have a important IMD, but not critical
- variable climatic conditions, with different gradients and significant shady areas
- must also possess the property of being a frequent snowfall area, in order to validate the findings into a short period

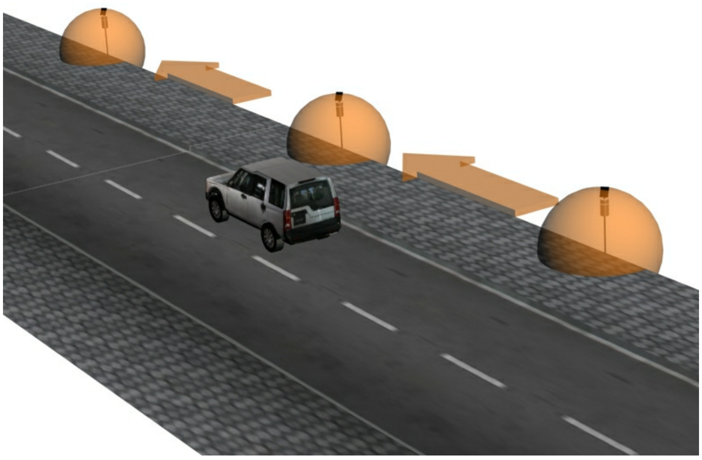


The draft states that the data to be collected by micro weather stations are:

- Ambient temperature.
- Temperature of the road.
- Rainfall.
- Pressure.
- % H2O.
- Solar Radiation

A significant aspect of the project is communication between micro stations. After analyzing various technical solutions project has opted for the use of Zigbee technology. The reasons for this are:

- ZigBEE is a wireless standard created for this type of devices.
- It is a wireless technology with speeds between 20kB/s and 250kB/s and ranges from 10 m 75 m. You can use the free ISM band of 2.4 GHz, 868 MHz (Europe) and 915 MHz (USA).
- A ZigBee network can consist of up to 65,000 nodes which are most of the time asleep ZigBee transceiver in order to consume less than other wireless technologies.
- La ZigBEE Alliance is a group of companies (nowadays over 180) link of different ways to the electronic sector, telecommunications and control systems that work together to ensure the interoperability of systems certified by them.



Micro stations will be controlled by a microchip ZigBee technology that will allow an automatic setting up of a wireless network communications between all micro stations belonging to the same stretch of road.

This network allows free mesh topology, which involves a spatial distribution of the nodes very flexible. Enough that each node is in radio range of at least one of them to close the network and the routing protocol carry data to the master node to send to the control station.

The network will be self-managed, allowing redirect the communications traffic to one or another path in case of failure of one of the micro stations or consumption requirements.

After its sensors capturing all the variables in the local environment of the stations, they will be put into communication with each other by establishing a network (based on ZigBee technology) to move all the data to a collector node to act as head of each section.

Once the data reaches the collector node, they are routed through GPRS technology to a control centre using the transport services of a communications manager.

Finally, we plan to carry out an implementation of a system for receiving and storing data in a control centre. In this role we will monitor the stations micro data.

No doubt this project is posing with a useful and significant improvement of zonal weather forecasts that have been used right now.

3.- A second aspecto to tackle in 2.0 version

Once known locally weather prediction raises a new possibility to improve the technology currently used, based on the fundamental idea that any preventive treatment should begin with the actual knowledge of the state of the road and supplement it until a situation defined as desirable at the time of start of the snowfall.

That is, the starting point of any preventive treatment must take into account the existing salinity level in the driveway. Therefore it is absolutely necessary to know, exactly, the salinity level of the floor in a timely manner.

You might think of placing a number of sensors in the road that leveraging established communications network for sensors and meteorological information would referring salinity, or better than the meteorological sensors should measure, besides salinity. However sensors that currently are being used to determine the degree of salinity have the limitation, not small, require the presence of moisture on the road. So it is necessary to consider other technical solution.

It therefore poses the existente of a vehicule that travel along the road and refers salinity data to the operation centre, where tipping as input for the system helps the road. The problem arises of what is the optimal technology that allows us to quickly and effectively, take a shot of salinity data in driveway.

A first possibility is to place on a vehicle, equipped with a tank of water prior wetting of the measurement zone, perform measuring salinity, a along the stretch of road subject to processing. This solution via laser is sufficiently developed, and therefore a vehicle travelling along the stretch of road can send real time pavement salinity to the conservation centre to incorporate these data as a starting point of the system of aid to decision of optimal preventive treatment. This is a simple solution but whose effectiveness is clearly demonstrated.

There are some studies that have advanced in obtaining the degree of salinity on photogrammetric analysis of the pavement. There are several variables that influence, type of asphalt mix, more or less open nature of the aggregates that compose it... But on the other hand has the advantage of their autonomy and not rely on a water tank attached to the measuring sensor.

And as the nature of the pavement is a fixed starting data for the stretch of road, the identification is homogeneous.

In the research project, previously mentioned, is incised in the photogrammetric solution as the optimum for the degree of salinity of the road as a starting point the study of preventive treatment to be performed.

No doubt the two issues mentioned generate a significant technical improvement, better utilization, optimization and result of the use of systems to aid decision making preventive treatments in winter maintenance.

Also in times when the economic optimization of maintenance activities is leading to various administrations, it is required to adapt the treatment to each of the specific areas of the road and take as its starting point the real situation of salinity found in each point of the road. So as to optimize the consumption and maximize the efficacy of preventative treatments adapting them to each point instead of carrying out a specific treatment throughout a stretch of road.