THE USE OF ADVANCED ROAD WEATHER INFORMATION SYSTEM IN REPUBLIC OF CROATIA

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Abstract

An overview of the Road Weather Information System (RWIS-HC) in Croatia is presented in the paper. The basic features of the system architecture, components configuration, application software, as well as some machine-human interface solutions are described. Road weather monitoring is the basis for successful road traffic with respects to the weather condition that significantly affect to the safety, functionality and efficiency of road traffic. To support the work, better use of winter service resources, and to increase traffic safety in winter conditions, The network of road weather stations to measure the local weather conditions on the main road routes are installed. This project develops a flexible RWIS model that can seamlessly integrate with the existing systems and can gradually expand to a larger system. The project also focuses on new ways of utilizing the massive amount of weather sensor data collected from RWIS-HC. Traditional ways of using Road Weather Information Systems have been to forecast road icing before its formation for proactive winter-road maintenance. The algorithm of applying artificial neural networks for short-term forecast of surface temperature road is presented in the paper.

1. INTRODUCTION

Road weather monitoring is essential for traffic because ambient conditions have considerable influence on safety, functionality and efficiency of road traffic. Therefore, the monitoring system has to be set-up on the elements that enable fast exchange of information and good response [1]. There are many scientific papers with examples that prove the importance of meteorological information in the traffic, [2, 3, 4]. Road Weather Information Systems are also very important part of Intelligent Transportation Systems, [5].

The Croatian roadways agency *Hrvatske caste Ltd.* installed a series of road weather monitoring stations in the arterial road routes and in the Croatian regions that have challenging winter conditions, Fig.1. Data on specific ambient conditions measured at the stations is used to support scheduling and optimizing winter maintenance activities and to enhance road safety. The road network covered by road weather monitoring includes the region of Lika, the littoral region along the Velebit mountain range, and the region south of Karlovac town. There are 20 main road weather monitoring stations and 27 auxiliary stations that are combined with variable message signs. All weather data is automatically collected at the Information Center of HC and is distributed to headquarters and regional winter maintenance centers. The information on weather conditions on a specific road route enables scheduling of maintenance actions to be taken to ensure road safety and mobilization of winter maintenance operative forces, but also to enable timely clearing of snow and de-icing chemicals spreading, issuing alert information to the travelling public etc. [6]. Also RWIS-HC helps in actions planning to maintain the necessary level of traffic safety, winter services preparedness, timely clearance of snow, sprinkling by chemicals against freezing, issuing warnings and others. Due to rapidly changing technologies and associated increasing costs, implementation of RWIS-HC has been complex. Project team finds that it is important to start with an architecture that allows easy integration of new and build-in technologies, and then gradual expanding to a larger system. The primary objective and purpose of the project is to assist in winter maintenance operations. This implies the use of pavement sensors at main and auxiliary weather monitoring stations, the collecting of ambient data from the pavement, the development of prognostic software, the interpretation adequate for the field-use and the incorporation of weather information system in standard procedures of winter maintenance providers [7].

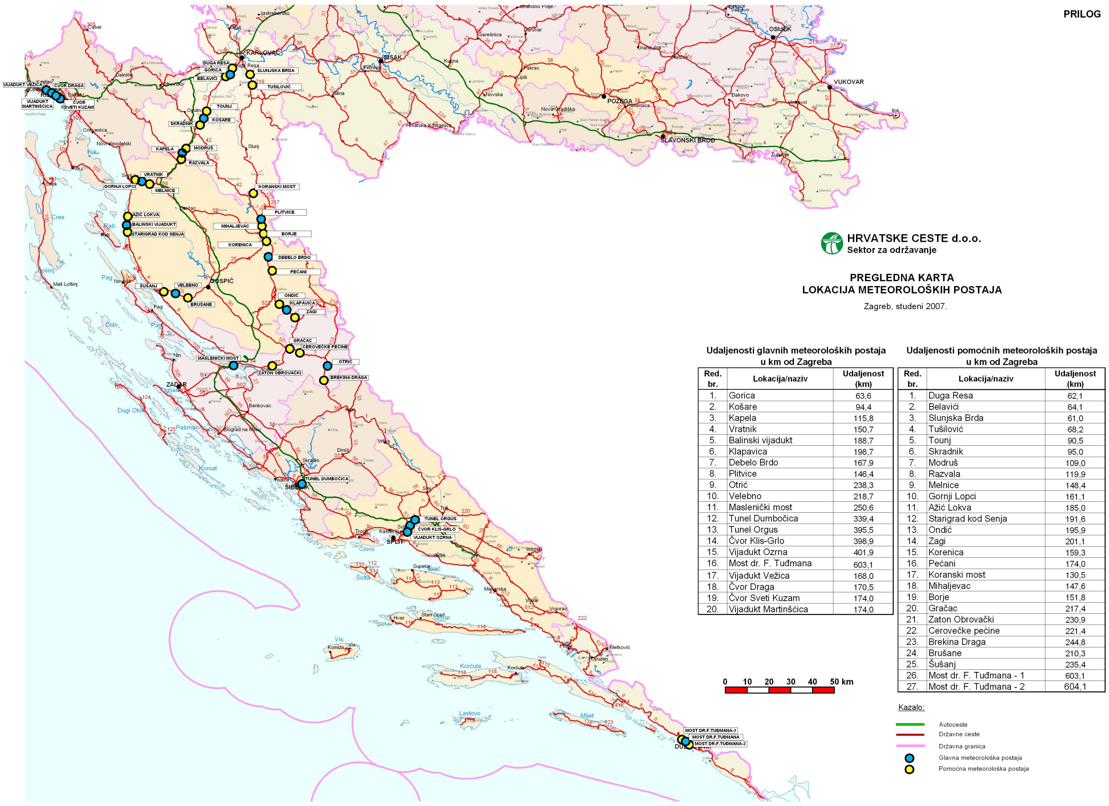

Fig. 1. Map of Road Weather Station in Croatia

The stations measure all relevant data required for evaluation of weather conditions and pavement conditions. Type of precipitation, visibility, wind speed and direction, air temperature and pressure, relative humidity and dew point are detected. Special pavement sensors enable accurate information on pavement condition that may be wet, slippery, covered by black ice, snow or ice. The sensors also detect presence and concentration of de-icing chemicals in the pavement. Data collected are used by road weather information system to calculate the quantities of deicing chemicals to be spread per road surface unit to prevent the forming of ice and to give recommendation for decision making in winter service operations. Depending on the evaluation of weather and pavement conditions (slippery and wet pavement, participation, visibility, side wind gust strength), the purpose is to provide real-time roadway condition information on variable message signs encountered by travelling public. The ultimate aim is to make a general image of the weather conditions along the arterial routes of the state road network, based on the collected precise data and surveys taken at the weather monitoring stations and on the regional forecasts provided by the Croatian National Meteorological and Hydrological Service (CNMHS).

Noting the need for modern solutions in the field of road meteorological system in the Republic of Croatia has initiated the innovation project *Intelligent traffic telematics*. Development of some special intelligent road telematics device refers to the development of advanced versions of the following devices: Mini road meteorological station (CMP), in fixed and mobile performance, Automatic traffic counter (ABP), Variable Message Sign (SPZ), etc. Some preliminary results are presented in this paper.

Configuration and architecture of the system are described in the second section. The description of system software and its organization is given in the third section. In development of the system special attention was paid to solutions of the operator interface, which is described in the fourth section. The fifth section gives a description of possible application of artificial neural networks for short range forecasts of pavement surface temperature. In the conclusion, we emphasize the need to cooperate with winter service providers in all future endeavors to enhance the efficiency of the system.

2. SYSTEM CONFIGURATION AND ARCHITECTURE

The project of development and set-up the road weather information system of Croatian roadways agency identified all details on technical features, locations of the main and auxiliary weather monitoring stations, locations of variable message signs, communication and software functions, the system architecture and auxiliary equipment requirements [6, 7].

Main road weather monitoring station collects general data on weather and pavement condition continually. The data measured at selected micro-locations is as follows: temperature, relative humidity of air and dew point temperature; wind speed and direction; air pressure; quantity, intensity and type of precipitation; visibility; pavement temperature; pavement condition, residual salt, ice point temperature etc.

Auxiliary road weather monitoring stations collects additional weather data continually and reports them to variable message signs that display advisory messages on challenging driving conditions to travelling public. The data measured at any micro-location is as follows: air temperature; dew point temperature; relative humidity of air; pavement surface temperature.

Central control centre consists of communication and application servers with an Oracle data base, connected through the local Ethernet network. The application server is in the network together with operator workstations – clients that use installed user software to retrieve data from the Oracle database. Data on the application server may be accessed by

1. Local computer network, or
2. modem / ISDN/web

Configuration of the system has been designed at the dual interface of data and communication servers with the large data quantities long-term storing system, as shown in Fig. 2.

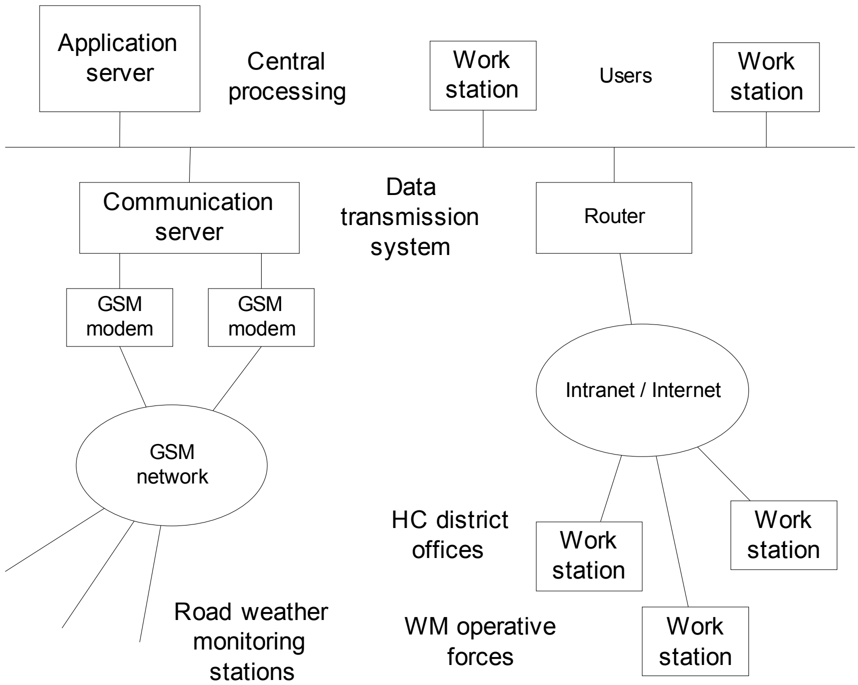

Fig. 2. The system configuration

3. SYSTEM SOFTWARE

The system software of the central information system includes a series of software modules for processing of data collected from road weather monitoring stations, meteorological data base with data surveyed, prognostic models, reports and display of collected information to road users. The main components of the system software are:

a) Software for data collection and data display:

1. communication drive software
2. software for polling of stations (universal polling for main and auxiliary stations, VMS and additional panels) and collecting of real-time data in the process base with transmission to Oracle base
3. data display software – browsers (clients) for unlimited number of users in the local network and remote users

b) Control algorithms and decision models for control of variable message signs and additional panels

c) Analysis of data obtained, incorporation of other sources of data (CNMHS) and prognostic models for short-range forecasts (1-2 hours) of the road weather conditions. The structure of system software is shown in Figure 3.

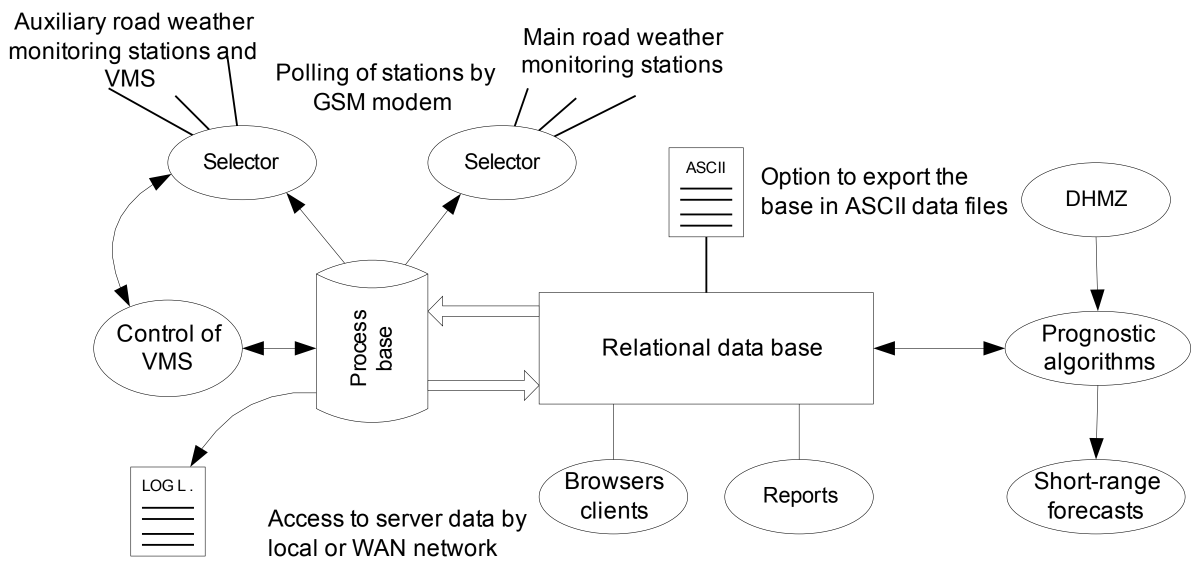

Fig. 3. System Software Structure

4. USER INTERFACE

Efficient user interface is an essential component of the system. The interface has to be tailored to the specific user needs and it has to take into account actual possibilities to interpret the weather data collected. Accordingly, the interpretation of the data on roadway conditions and recommendations for activities to be taken are quite simple in order to serve the needs of winter maintenance staff. The common questions used in routine winter maintenance operations are summarize as:

1. Is there any ice on the pavement?
2. When will the ice formation start on the pavement?
3. Where has the ice been detected, at which sections?

4. What to do, which activities to take?

Road weather information system uses warnings and alerts and thermal maps of the region to give response and information to assist the winter maintenance operations, as follows:

Precipitation – warning:

- There was precipitation (rain, snow), ice formation possible - pavement temperature close to or under 0ºC!

Frost – warning:

- Frost on pavement present or may appear!

Ice – warning:

- Ice will be formed in 1 to 2 hours!

Ice – alert

- Pavement temperature is under 0ºC, ice has begun to form!

Thermal maps of the area:

- Presentation of thermal colder and warmer sections, condition evaluation, recommendations for decisions on salt spreading

This segment of system development has to be upgraded with artificial intelligence methods.

5. ARTIFICIAL NEURAL NETWORK APPROACH FOR SHORT RANGE FORECASTS

The development of prognostic models for road meteorology has been described by substantial indeterminacy in initial and marginal conditions and difficulties in complex topography for specific areas. Additional problems in prognostic models of pavement surface temperature are seen in the complex and unknown mechanisms of impacts created by traffic characteristics, in the frequency of snow cover, on the previous spreads of salt and other spreading materials [8]. This is a typical situation to be approached by artificial intelligence methods, in particular techniques based on the application of artificial neural networks (ANN). The technology has already become mature and is now widely applied in commercial systems. Significant results have been achieved in traffic and transport applications [9].

The main idea behind the use of the technology is to correct a prognostic system based on deterministic forecast resulting from thermodynamic modeling of pavement (energy balance). The correction is based on artificial neural network (usually three layers) that has been learned in previous measurements of pavement surface temperature. The artificial neural network that has acquired the knowledge in a proper manner is capable of identifying the size and form of an error in basic prognostic system for specific weather conditions. In such a way the forecasts of ice formation on pavement may be enhanced [8]. Figure 4. shows the structure of correction algorithm of short-range forecast for pavement surface.

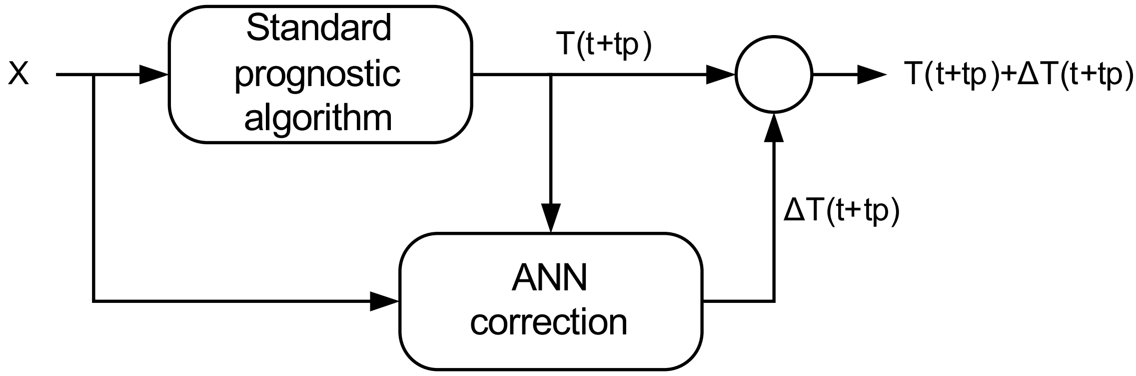

Fig. 4. Structure of correction algorithm for short range forecast

It has to be mentioned that good knowledge of background of physical processes is a precondition for the selection of neural network structure, the procedure of learning and the interpretation of results. Some experiences have indicated that the increase in accuracy depends on a specific location and on a time interval segment (time of day). The main problem in neural network learning is local optimum traps.

6. CONCLUSION

The accuracy of all conclusions on pavement condition relies on the accuracy of measurements. It is assumed that measuring methods used in the main and auxiliary weather monitoring stations are correct and that measuring that are conducted are accurate. Therefore, it is important to establish good cooperation with meteorology experts, especially in the identification of optimal micro-locations for stations and any future upgrading of the system. Functions and algorithms of the system have to be monitored and improved over a long period to improve safety and quality of data obtained and conclusions made. Besides, in future research and development advances special attention will be paid to those parts of algorithms that are related to short-range prognosis of pavement surface temperature. This is of particular relevance for contemporary use of Advanced Optimization Methods for Winter Services Organization.

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