AWIS: an Airport Winter Information System

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Outline

- Road Winter Information System -> Airport Winter Information System
- Generale system overview
- Nowcasting: local short term weather forecast
- Special Sensors: Ice and Snow
- Torino Caselle International airport: a real study case
AWIS genesis

SIRWEC 2006 Torino:

• can RWIS be adapted to an airport?

• Yes. AWIS:

  • I Goal: to build a prototype platform where to implement different strategies to increase winter safety in airports

  • II Goal: to set up a complete “package” which can be used by every airport
AWIS partners (2 MEuros in 36 months)

- SAGAT: International Torino Airport
- Giletta-Bucher: salt spreaders
- Brillada: bitumen
- N-Lab: electronic sensors
- EST: radar
- Politecnico di Torino
- Regione Piemonte
**AWIS items**

- user safety
- runway accessibility (delays, closure)
- corrosion of maintenance vehicles, aircrafts and runway surfaces due to treatment with de-icing substances
- forecast of the surface conditions in order to organize maintenance activities just in time
- higher reliability of the control process of the surface of the runway
- higher trust of users in the control authorities
Research topics

• Comparison of road surface sensors under various conditions such as snow, ice, wet and low temperature;
• Analysis of different methods for microclimate weather and road surface conditions nowcasting based on these sensorial data, especially for critical event forecasting;
• Optimization of preventive maintenance strategies, such as spreading of de-icing substances;
• Distribution of these data to the airport administration and clients by means of modern communication networks.
• Optimization of the utilization of resources such as human resources and maintenance vehicles.
AWIS activities for next 36 months

1. Weather stations
2. Surface condition sensors on the runway.
3. Nowcasting system (microclimate short-term weather forecasting)
4. Radar monitoring system
5. Intelligent Electronic spreader controls (ESC)
6. Slippery control on board of the de-icing spreaders
7. Runway database
8. Optimized materials (anti-icing chemical and wearing course mixture)
9. Pavement thermal model
10. Information System
Meteorological forecast

• Traditional weather forecasting systems (large areas and long term) assisted by a nowcasting system (limited to the airport neighborhood next three hours)

• Artificial Neural Networks to “nowcast” airport conditions in next few hours
Why Neural Networks?

Mathematical models

- Real situation!
Winter events forecast

• Fog, rain and snow in the airport area
  – Local data must be enforced by the thermodynamic state and the stability of the atmosphere:
    small surveillance X-band radar

• Ice on the runway
  – Special sensors for ice detection and thermic characterization of the pavement
Ice formation?

- **Analytical model based on:**
  - air, ground and subsoil temperature
  - relative humidity
  - pressure
  - solar radiation
  - wind
  - rain

Ice thickness: analytical model
Special electronic sensors

D-ICE. Dielectric constant of the surface can identify ice

A low cost, simple sensor able to detect ice on the roads.
Water dielectric constant is function of temperature and measurement frequency

D-ICE

1 GHz

Water

1 kHz

Ice
Mobile sensors on the maintenance vehicles of the airports to characterize the thermal pavement condition without fixed systems

NIR: T infrared contactless measurement
NEMEFO: NEural Meteo FOrecast

- Short term meteo forecast:
  - Situation monitoring (T, H, P etc)
  - Forecast in next 1, 2, 3 hours
  - Forecast of meteo events (fog, rain, snow, ice etc.)

- Time numerical series forecast
Forecast algorithm

2 cascaded systems:
1) “Feature Selection” algorithm
2) Artificial Neural Network

Complete set of Features → Features Selection Algorithm → Optimal Subset of Features

Parzen → Relative Entropy → Output estimate
Feature Selection

- We have a huge amount of sampled meteo data (years)
- How to evaluate the correlation among these data to forecast their evolution in time?
- To find mutual information among variables.
Multi Layer Perceptron

- 1 MLP for each parameter to forecast
- 32 inputs
- 5 hidden neurons
- 1 output neuron
- Extended Kalman filter training procedure

Best Features

T @ t+1, t+2, t+3
Previsioni a breve termine per il Politecnico di Torino

<table>
<thead>
<tr>
<th>Ora</th>
<th>Stato</th>
<th>T.Aria</th>
<th>T.Suolo</th>
<th>U.Relativa</th>
<th>Pressione</th>
<th>Radiazione</th>
<th>Pioggia</th>
<th>Nebbia</th>
<th>Ghiaccio</th>
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<td>Attuale</td>
<td></td>
<td>10.4 °C</td>
<td>18.1 °C</td>
<td>64 %</td>
<td>1019 mBar</td>
<td>169 W/m²</td>
<td>0.0 mm</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>+1 ora</td>
<td></td>
<td>12 °C</td>
<td>18 °C</td>
<td>63 %</td>
<td>1019 mBar</td>
<td>88 W/m²</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>+2 ore</td>
<td></td>
<td>11 °C</td>
<td>17 °C</td>
<td>64 %</td>
<td>1018 mBar</td>
<td>27 W/m²</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>+3 ore</td>
<td></td>
<td>11 °C</td>
<td>17 °C</td>
<td>64 %</td>
<td>1018 mBar</td>
<td>0 W/m²</td>
<td>-</td>
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</tbody>
</table>

Sun, 02-Dec-2007 14:30
06/2006 – 10/2007 T e H

<table>
<thead>
<tr>
<th></th>
<th>1 hour forecast</th>
<th>2 hours forecast</th>
<th>3 hours forecast</th>
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</thead>
<tbody>
<tr>
<td>(°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average error</td>
<td>0.9</td>
<td>0.97</td>
<td>1.1</td>
</tr>
<tr>
<td>standard deviation (σ)</td>
<td>0.71</td>
<td>0.89</td>
<td>1.1</td>
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Table 1: Air temperature : Average error and standard deviation.

<table>
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<tr>
<th></th>
<th>1 hour forecast</th>
<th>2 hours forecast</th>
<th>3 hours forecast</th>
</tr>
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<tbody>
<tr>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average error</td>
<td>2.7</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>standard deviation (σ)</td>
<td>5.4</td>
<td>5.7</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Table 2: relative humidity : Average error and standard deviation.
Torino – Caselle international airport: winter 2008/2009

- Fixed and mobile sensors will monitor the runway status.
- Low power (and cost) meteo radar will give information about atmosphere status within 30 km area
- NEMEFO will give fog, rain, snow and ice alerts
- A first winter data base will be available
Torino – Caselle international airport: winter 2008/2009

- An Electronic Spreader Control (ESC) system for the de-icing spreader, able to gather information from the sensors installed on the vehicle and the surface condition sensors.
- New anti-icing treatment techniques, innovative solutions for the construction of wearing courses.
CONCLUSIONS

• Airport Winter Information System and Road Winter Information System have several key points in common
• Both systems can exchange useful experiences to improve respective performances
• In next Sirwec 2010 I hope to present the AWIS package “ready to go”