AWIS: an Airport Winter Information System

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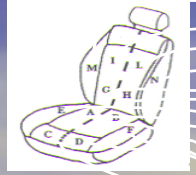
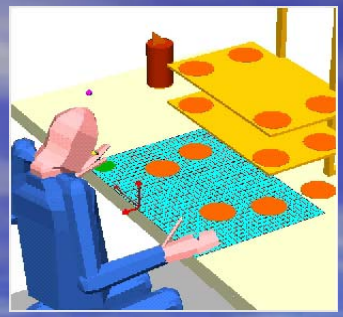
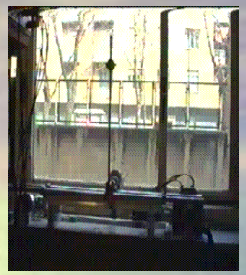
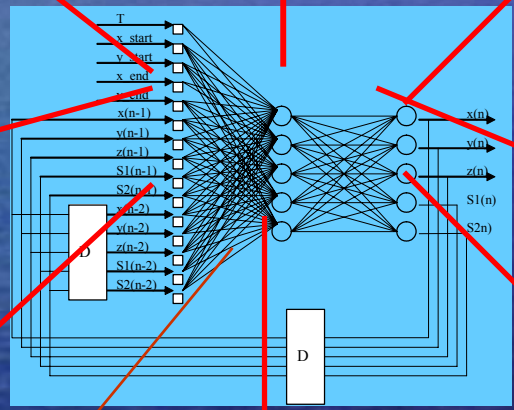
NL N-LAB
SISTEMI DI INTELLIGENZA ARTIFICIALE





126
133
75



T
x_start
y_start
x_end
y_end
x(n-1)
y(n-1)
z(n-1)
S1(n-1)
S2(n-1)
x(n-2)
y(n-2)
z(n-2)
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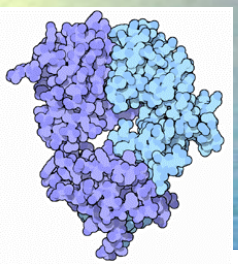
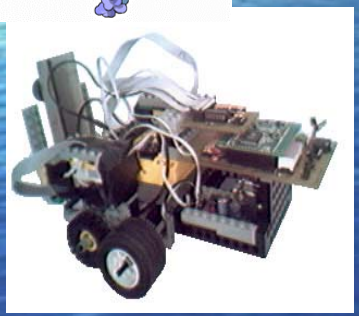
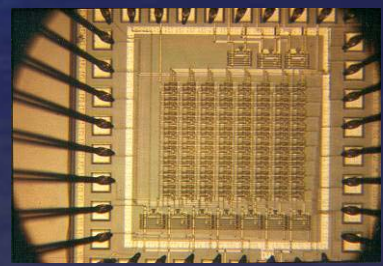



T
26.9 °C
H
41.3 %
P
999.6 MBAR
17.55.00 22/03/04


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

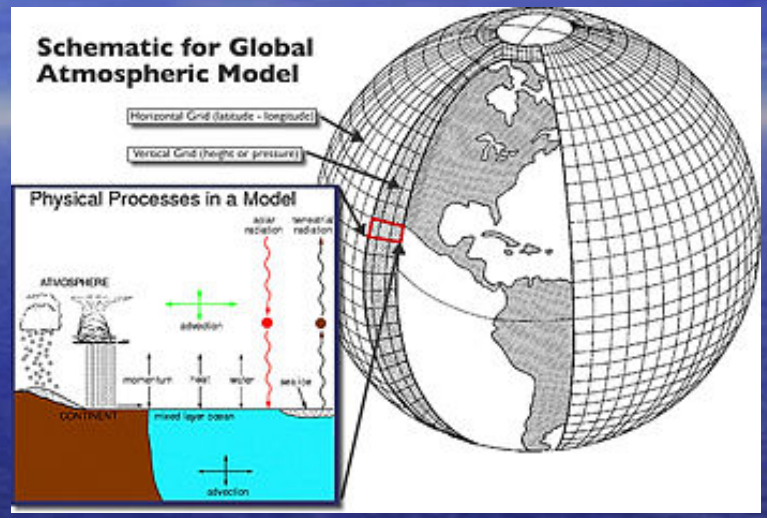
- Comparison of road surface sensors under various conditions such as snow, ice, wet and low temperature;
- Analysis of different methods for microclimate weather and road surface conditions nowcasting based on these sensorial data, especially for critical event forecasting;
- Optimization of preventive 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.

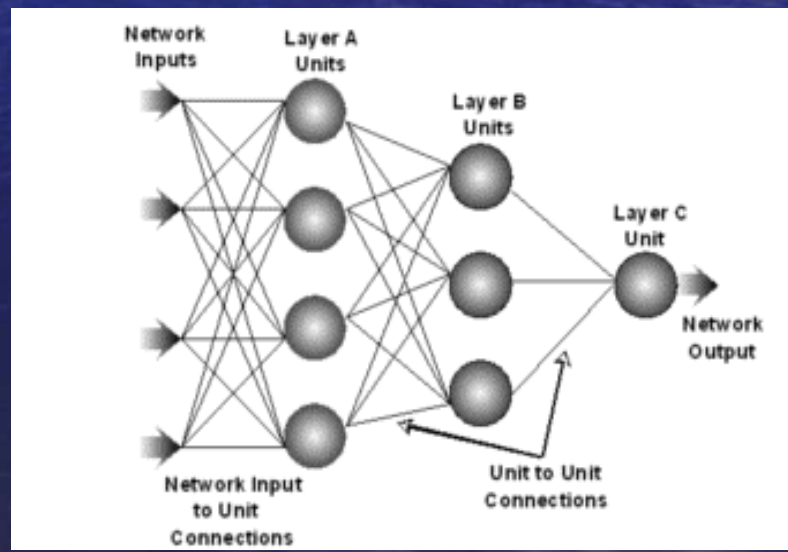
AWIS activities for next 36 months

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***

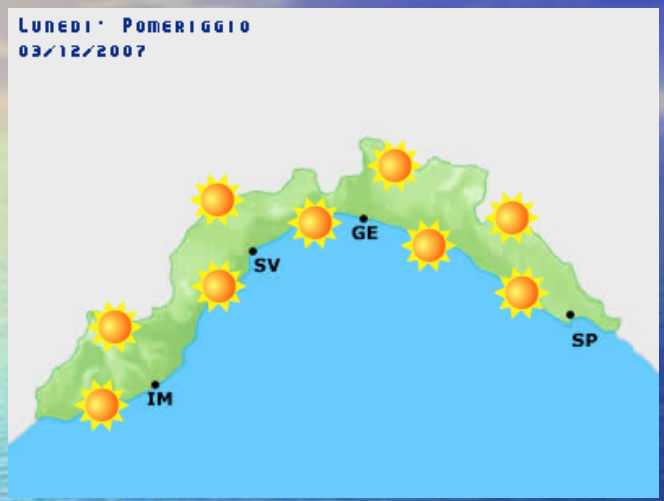
Meteorological forecast

- Traditional weather forecasting systems (large areas and long term) assited 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

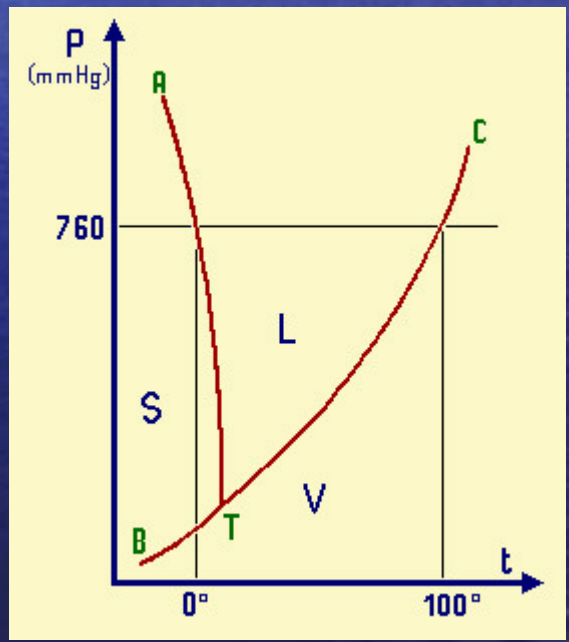
- Real situation!

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

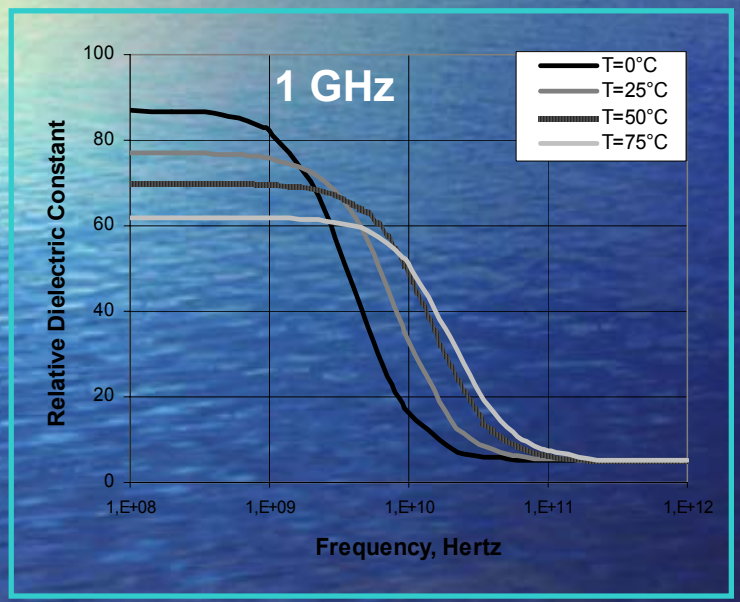
Special electronic sensors

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

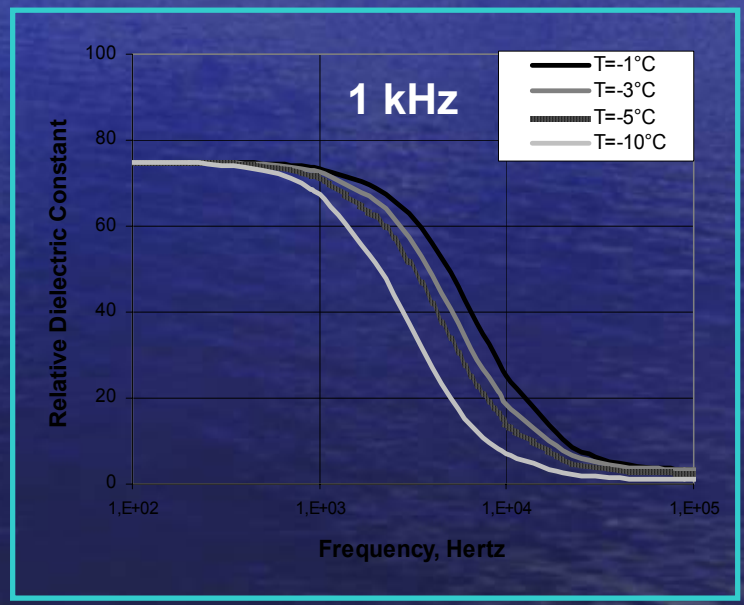
A low cost, simple sensor able to detect ice on the roads.

D-ICE

Water dielectric constant is function of temperature and measurement frequency



Water



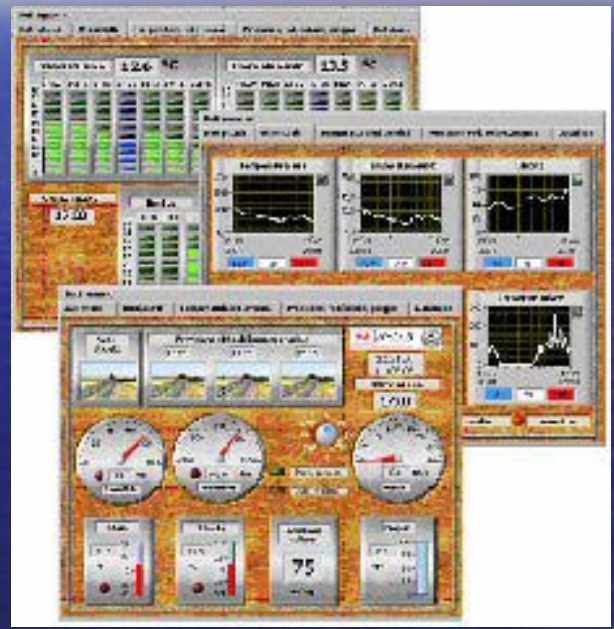
Ice

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

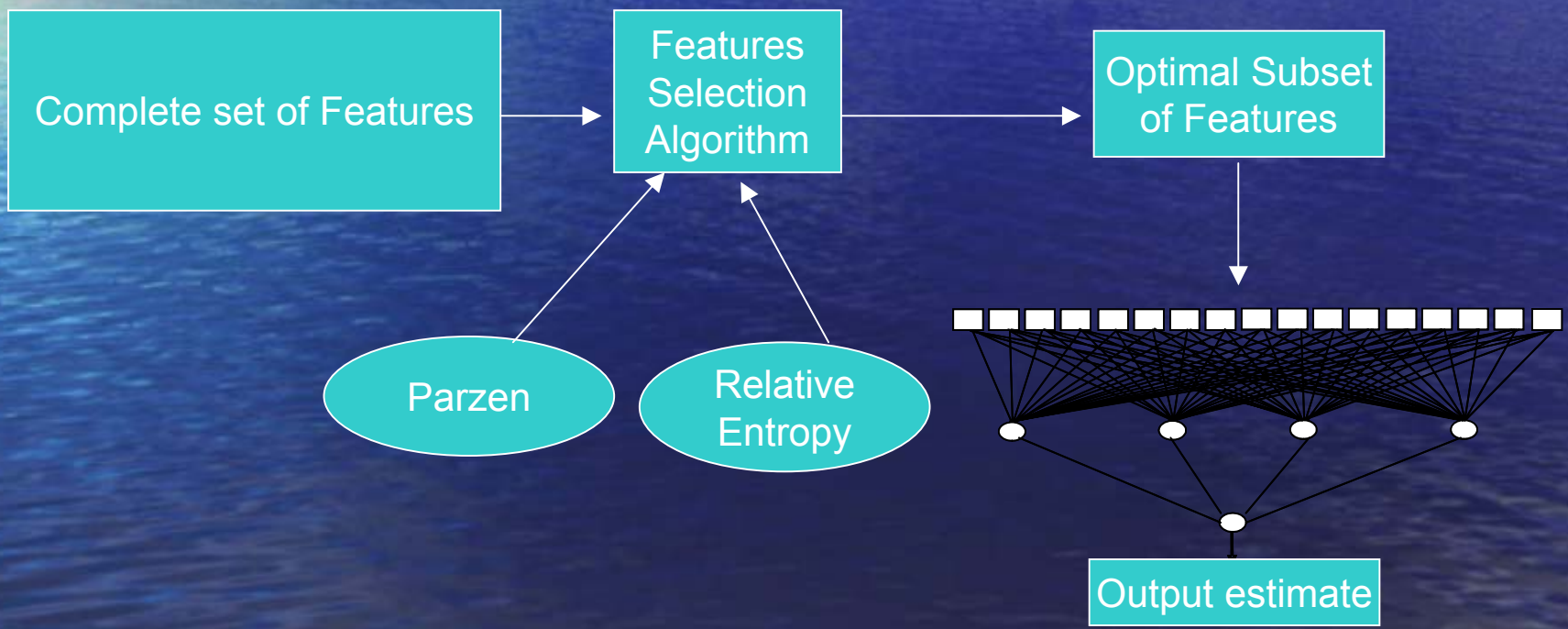
- Short term meteo forecast:
  - Situation monitoring (T, H, P etc)
  - Forecast in next 1, 2, 3 hours
  - Forecast of meteo events (fog, rain, snow, ice etc.)
- Time numerical series forecast



Forecast algorithm

2 cascaded systems:

1) "Feature Selection" algorythm
2) Artificial Neural Network

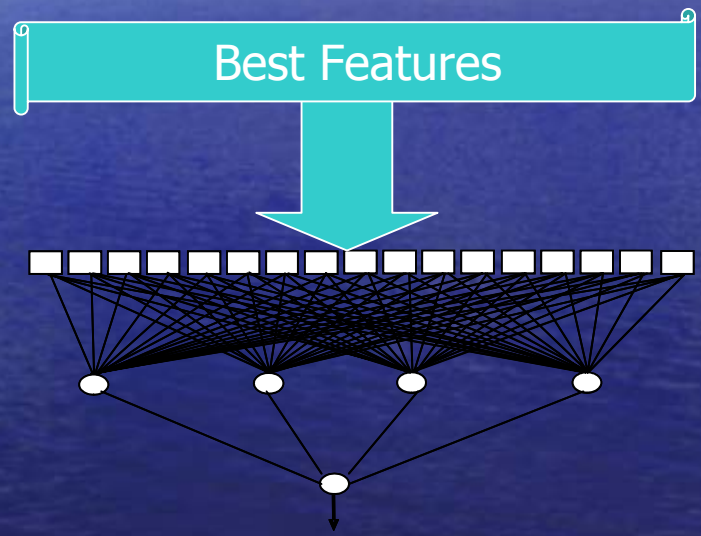


Feature Selection

- 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



T @ t+1, t+2, t+3

NEMEFO - POLITO

Previsioni a breve termine per il Politecnico di Torino

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

Sun, 02-Dec-2007 14:30

06/2006 – 10/2007 T e H

(°C)	1 hour forecast	2 hours forecast	3 hours forecast
Average error	0.9	0.97	1.1
standard deviation (σ)	0.71	0.89	1.1

Table 1: Air temperature : Average error and standard deviation.

(%)	1 hour forecast	2 hours forecast	3 hours forecast
Average error	2.7	4	5
standard deviation (σ)	5.4	5.7	6.2

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”