Università del Salento
DIPARTIMENTO DI INGEGNERIA DELL'INNOVAZIONE

A Real-Time Condition Monitoring System by using Seasonal ARIMA Model and Control Charting

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The basic problem

- Advanced methods of supervision become increasingly important for many technical processes and systems.
- In the case of a dangerous process state, three main supervisory methods can be distinguished (Isermann, 2005)
  - Monitoring
  - Automatic Protection
  - Fault Diagnosis

The basic problem

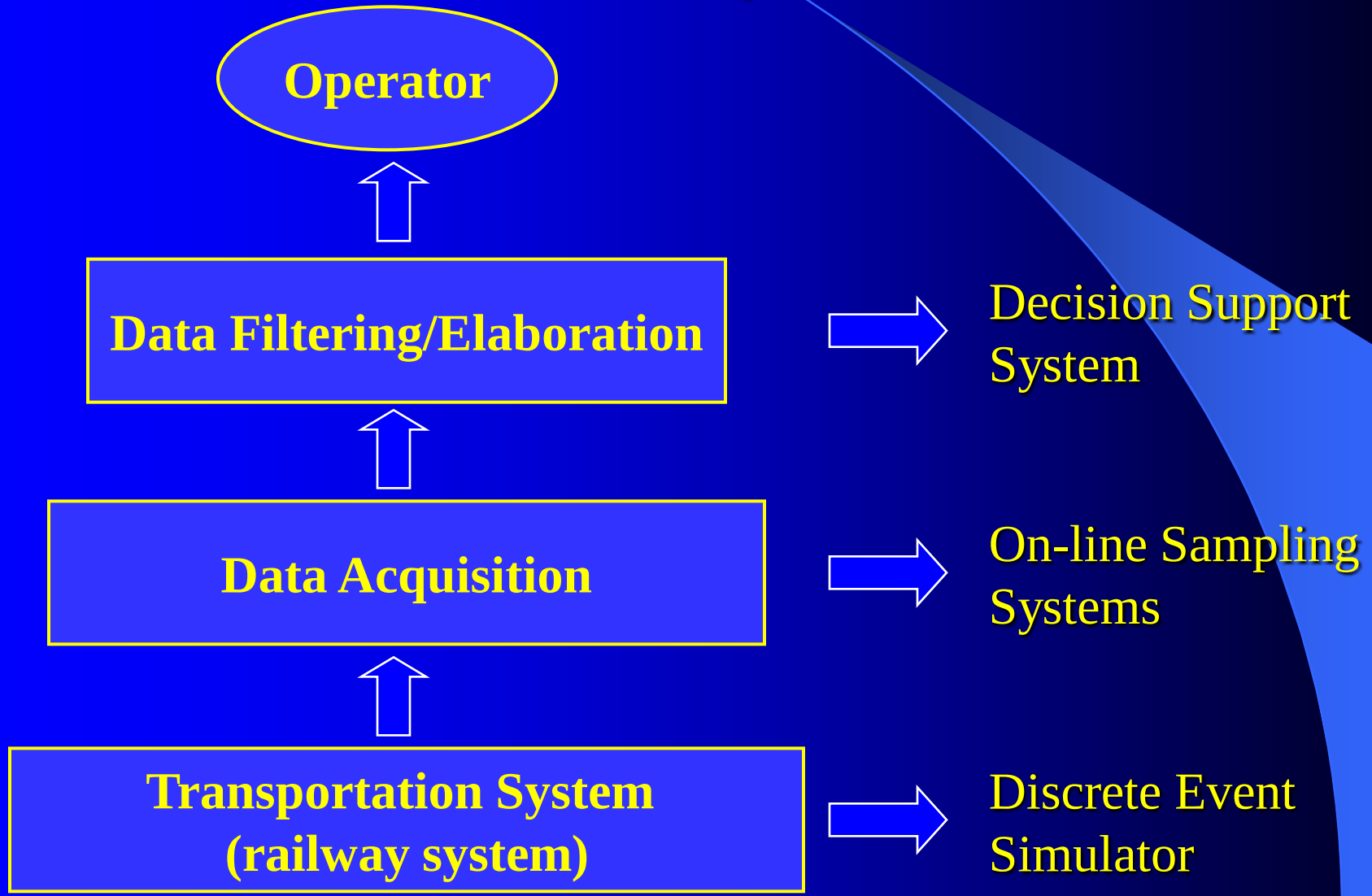
- This paper presents the application of a SPC method that uses time-series filters and control charting for on-line condition monitoring of railway equipment.
- A SPC tool of car brakes temperature, which can provide advanced warning to train operator of an overheated bearing condition, is discussed.

The basic problem

Traditional Railcar Systems

Driverless Railcar Systems

The basic problem



Main Issue: ON-LINE MONITORING → Readings exhibit autocorrelation

Three general charting techniques can be identified to handle autocorrelation.

1. Use time series models to fit the data, and then apply standard control charts (Alwan and Roberts, 1988).
2. Apply control charts with adjusted control limits, which account for the correlation structure of the data (Wardell *et al.* 1994).
3. Monitoring specialized statistics of the original observations (Zhang 1997).

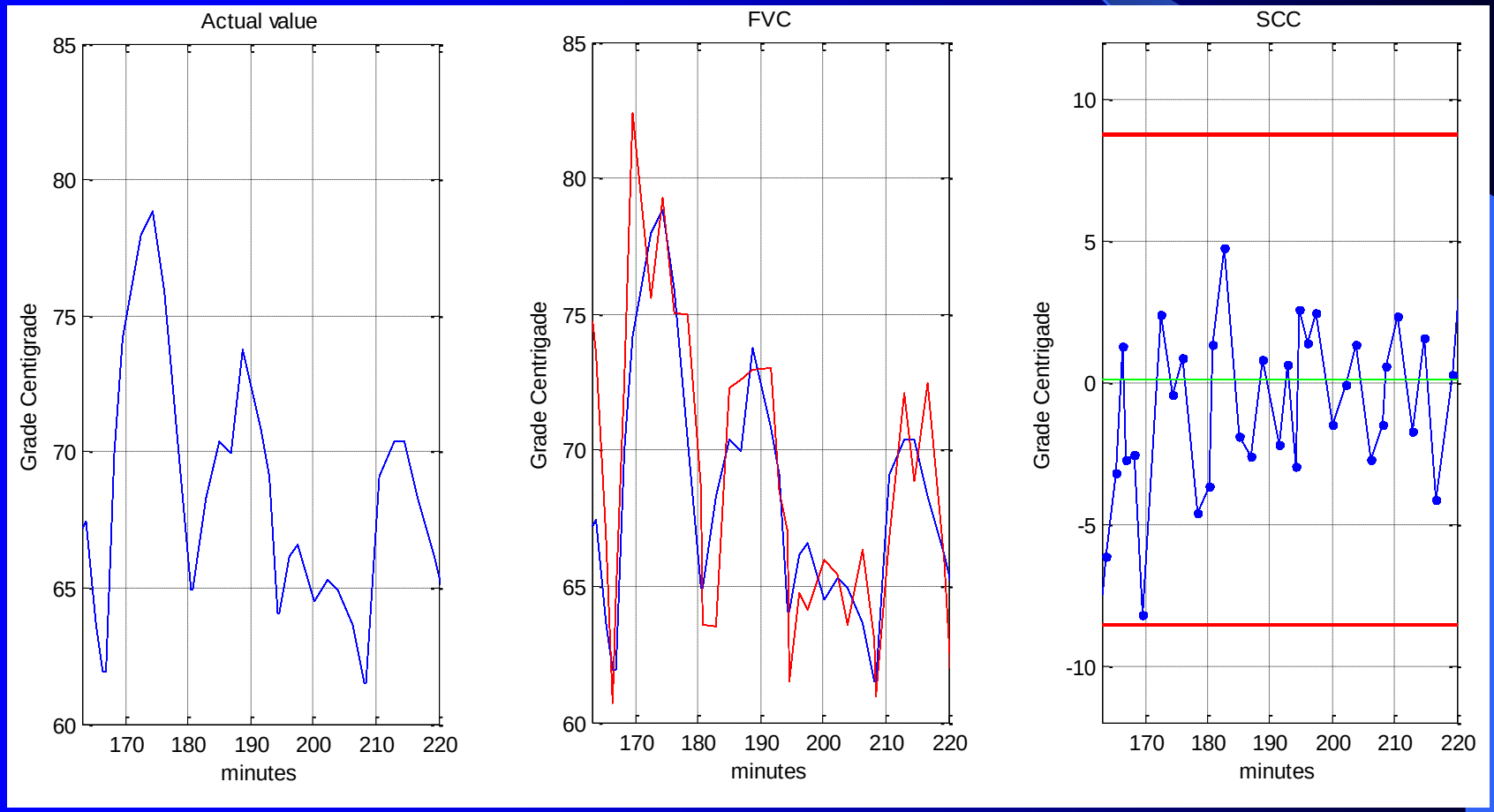
Method Implemented Techniques of Box et al. → Seasonal ARIMA model $(p,d,q) * (P,D,Q)_f$

$$\phi(B)\Phi(B^f)(1-B^d)(1-B)^D y_t = \vartheta(B)\Theta(B^f)\varepsilon_t$$

The real-time SPC scheme takes temperature sensor data and feeds them into an appropriate time-series filter.

Seasonal ARIMA produce independent and identically distributed residuals. A control chart is then applied on the residual sequence.

The model ARIMA $(p,d,q) * (P,D,Q)_f$ is $(2,2,0) * (3,2,4)_{16}$



Implementation of the Method

The statistical software MINITAB® was exploited in order to:

1. Estimate model parameters.
2. Check the adequacy of the model.
3. Estimate the variance of the residuals.

Eventually, a Special Cause Control chart (SCC) was designed on the residuals.

Implementation of the Method

A software package was developed to implement the real-time monitoring scheme. It includes four modules:

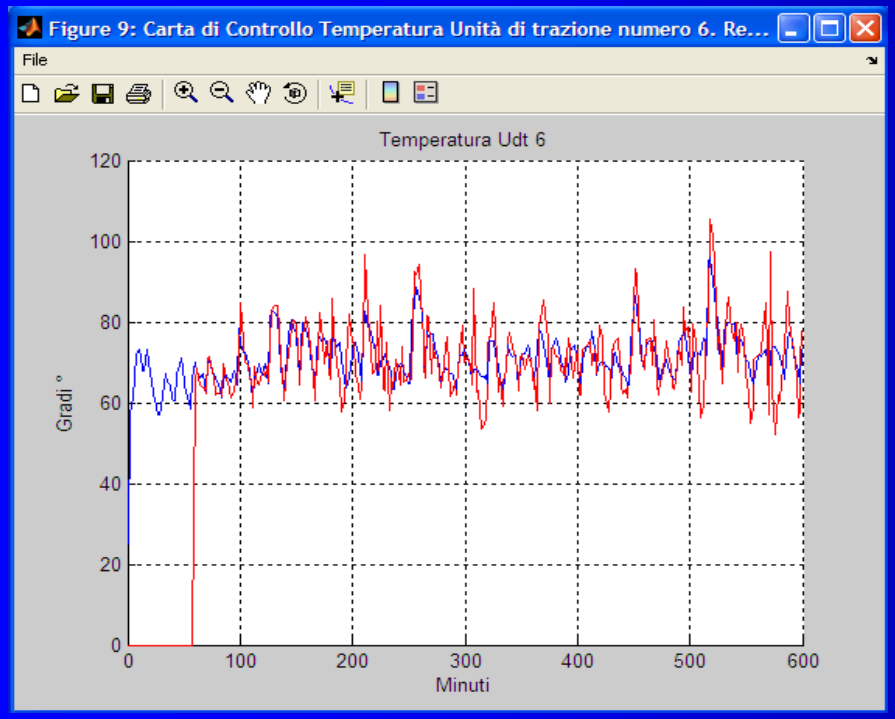
1. Data manipulation.
2. Seasonal ARIMA filtering.
3. Control charting and graphical display.
4. Alarm generation.

These operations were implemented in MATLAB®.

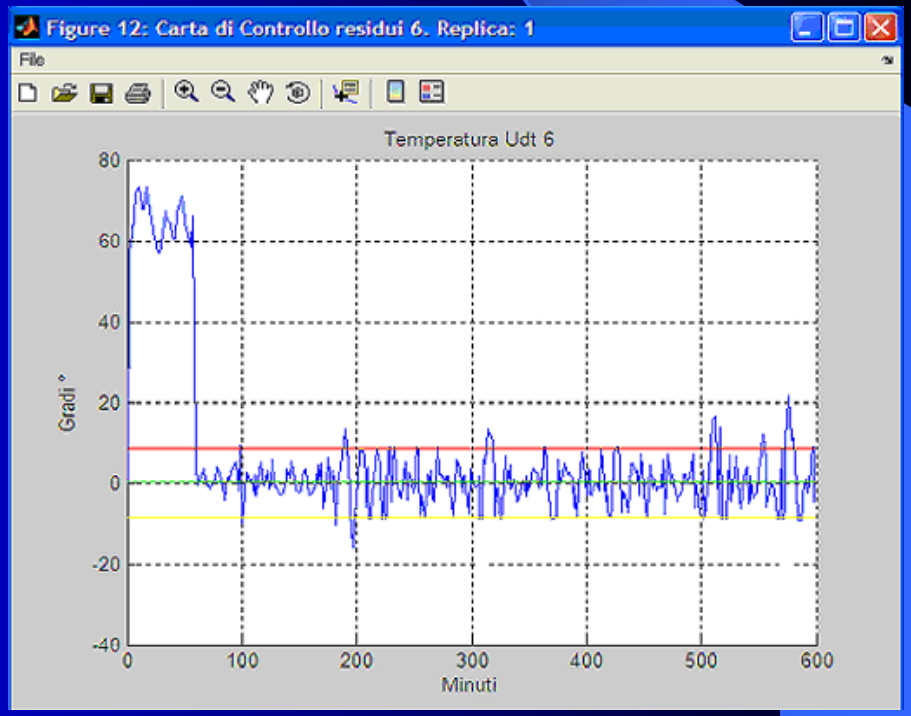
The Fitted Value Chart (FVC) is a graph of the actual time series along with the fitted values.

The Special Cause Control chart (SCC) is the Shewhart's control chart of residual errors between actual data and predicted values.

Fitted Value Chart (FVC)



Special Cause Control (SCC) chart



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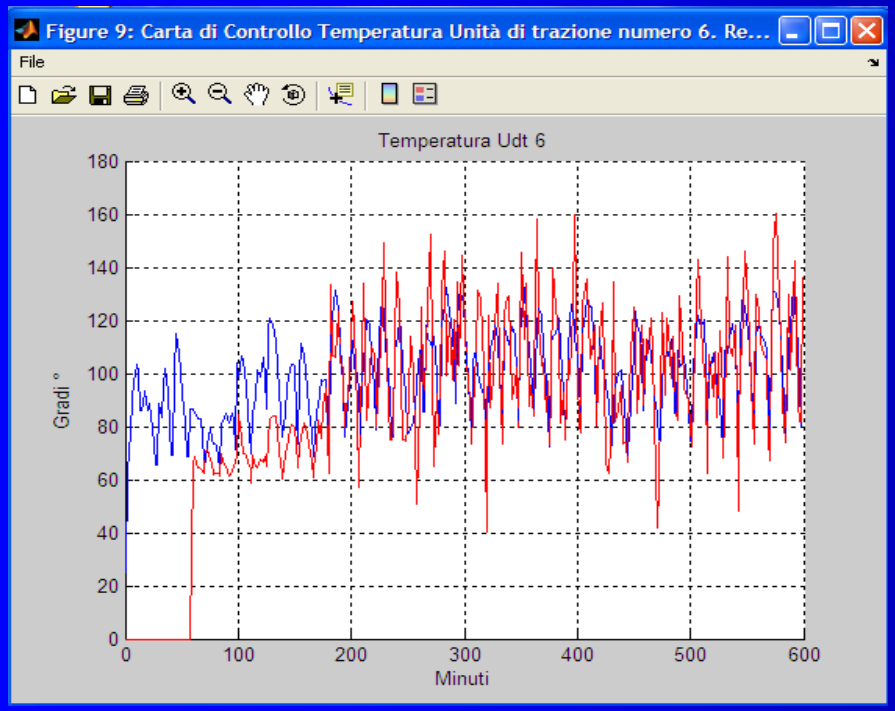
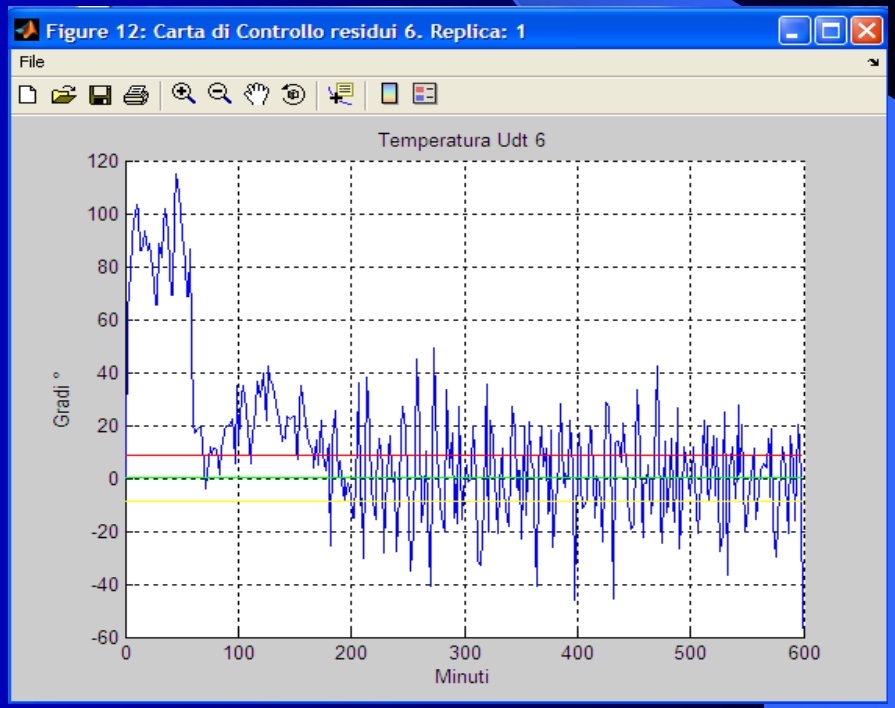
Fitted Value Chart (FVC)



Special Cause Control (SCC) chart



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