T4.1-P1

Advances in State of Health Analysis forInternational Monitoring Systems

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Analysis of state of health (SOH) data from international monitoring system (IMS) stations can provide valuable information about the station performance and aid in failure diagnostics. SOH research is currently being conducted to aid in the identification of current and potential future system failures. A software framework was developed that uses model-based analysis techniques. The current version of this tool is designed to analyze data from the Swedish Automated Unattended Noble gas Analyzer (SAUNA). Models of normal operation were implemented using both a basic mean and an alternate, exponential smoothing approach. Deviations from the models are then used to provide alerts and identify trends.

Goals and Objectives

Challenge

Data availability from IMS stations is required to be at 95% or better (no more than 15 days of downtime per year). This can be a challenge when systems have failures that require unscheduled maintenance visits. Analysis of SOH data can provide a better understanding of current and future potential failures.

Research Goals

Analysis of SOH data verifies that systems are running within specification and aids in post-run diagnostics.

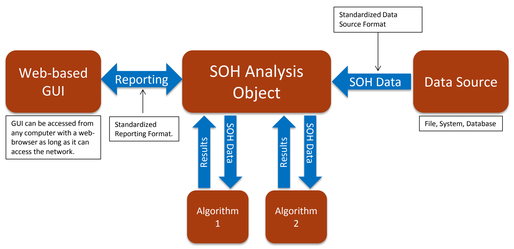
- Identify current and potential future failures through SOH analysis
- Increase system uptime
- Increase data availability
- Recognize and fix problems early
- Reduce false-positives
- Identify sensor trends

Methods

Implementation

A modular software analysis framework was designed and implemented.

- Standard interface for analysis algorithms
- Standard interface for data sources
- Web-based graphical user interface
- All software developed in C++ under the Linux operating system



Algorithms

Two simple algorithms were implemented for testing.

- Standard Deviation Algorithm
  - Uses a training set to develop mean and standard deviation
  - Alerts based on the number of sigmas from the mean

$$\delta_{i,R} = \begin{cases} \left(\frac{|m_{i,R} - \mu_{i,T}|}{\sigma_{i,T}}\right), if\, \sigma_{i,T} \neq 0 \\ 0 \quad , if\, \sigma_{i,T} = 0 \end{cases}$$

δ = sigma delta from the mean
m = measured value
μ = mean value (data model)
σ = standard deviation
i = time (minute in 1440 time in the case of SAUNA)
T = training set designation
R = current measured value designation (value being analyzed)

- Exponential Weighted Moving Average
  - Does not require a training set
  - The model is less influenced by data that is further removed in time
  - Comes from exponential smoothing (weights decrease as observations get older)
  - Alerts based on a percentage of the sensor range

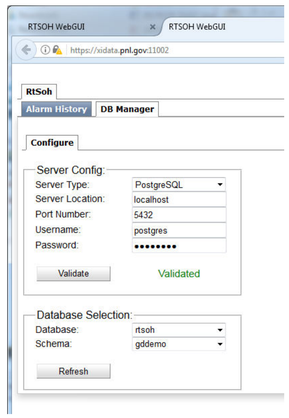
$$Z_t = \lambda Y_t + (1-\lambda) Z_{t-1}, \quad 0 < \lambda \leq 1$$

Z_t = new model value
Z_{t-1} = previous model value
Y_t = new observation
λ = weighting factor
t = time (minute in 1440 time in the case of SAUNA)

User Interface and Data Visualization

A web-based graphical user interface was developed to perform analysis and visualize the data

- Independent operating system
- Multiple interfaces can be opened simultaneously

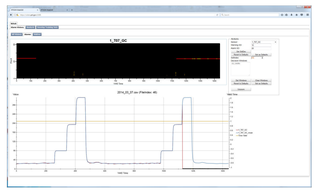


Data Interface

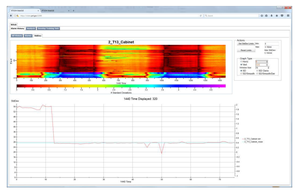
Current interface is text based comma separated files, but a data base interface is currently being added.

Outputs

Historical Alert Summary -- Shows whether any sensor over a period of days have alerted.



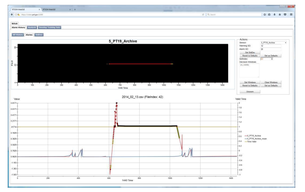
Sensor Alert Summary -- Shows the alerts for a particular sensor over a period of time.



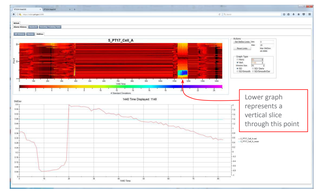
Raw Deviation Summary – Shows the raw deviation from the model for a particular sensor over a time period. This can be used to identify trends in sensors.

Analysis Results

Station logs for SE_X_63 indicate a cell failure in May of 2015 represented in the historical alert summary



Station logs for SE_X_63 indicate an archive pressure anomaly in February of 2015 represented in sensor alert summary



Trend example for pressure in detector Cell A for USX75

Conclusion

A SOH framework was designed and implemented for analyzing data from SAUNA systems using one minute sampling intervals. The tool provides a simple way to visualize alerts over large periods of time, identify individual sensors that fail, and look at raw deviations over time to identify trends. It also provides the ability to look at multiple sensors for a single processing run.

Next Steps

- A demonstration version of this software was delivered to the Provisional Technical Secretariat and General Dynamics for feedback that will be incorporated into the tool.
- A database interface and automated trend analysis will be added.
- Analysis will be extended to other types of systems in the IMS network.

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