Development of Smart Prognostics Agents (WATCHDOG AGENT®)

Introduction

For different industries or sectors, the performance of machines or processes degrades due to aging and wear, which decreases their reliability and increases the potential of failure and downtime. On the other hand, highest possible quality of products and services is indispensable for attaining or retaining market domination. Therefore, to achieve near-zero downtime and optimal quality of products and services, prognostics is increasingly needed to predict future failures. And the proactive Predict and Prevent (PAP) maintenance paradigm will consequently replace the currently prevalent Fail and Fix (FAF) paradigm, which reactively addresses and fixes failures once they occur. [1-4]

Technical Progress

To accomplish the paradigm transition, a toolbox approach for degradation assessment and failure prediction has been proposed and studied. Watchdog Agent® Toolbox contains four categories of analytical tools that assess and predict performance or failures of machines or processes, by extracting performance-related features from inputs of sensor data, controller signals, expert knowledge etc and modeling the historical feature sets with selective expert knowledge to derive prediction results. Eventually the output of prediction is utilized to support maintenance decision making and related infrastructure operation. After near ten years of development, the entire toolbox includes over 20 types of algorithms (Table 1) and a preliminary designed approach for tool selection depending on systems and datasets characteristics. Figure 1 illustrates the systematic approach to apply tools to achieve Prognostics and Health Management objectives.

Table 1. Watchdog Agent® Toolbox Algorithms

Signal Processing & Feature Extraction	Health Assessment
Time Domain Analysis	Logistic Regression
Frequency Domain Analysis	Statistical Pattern Recognition
Time-Frequency Analysis	Gaussian Mixture Model (GMM)
Wavelet/Wavelet Packet Analysis	Feature Map Pattern Matching (Self-Organizing Maps)
Expert Extracted Features	Neural Network Pattern Matching
Autoregressive (AR) Model/AR Model Roots	Adaptive Filtering
Principle Component Analysis (PCA)	Hidden Markov Model (HMM)
Performance Prediction	**Health Diagnosis**
Autoregressive Moving Average (ARMA)	Feature Map Pattern Matching (Self-Organizing Maps)
Elman Recurrent Neural Network	Support Vector Machine (SVM)
Match Matrix	Bayesian Belief Network (BBN)
Trajectory Similarity Based Prediction	Hidden Markov Model (HMM)
Stochastic Filtering	
Fuzzy Logic	

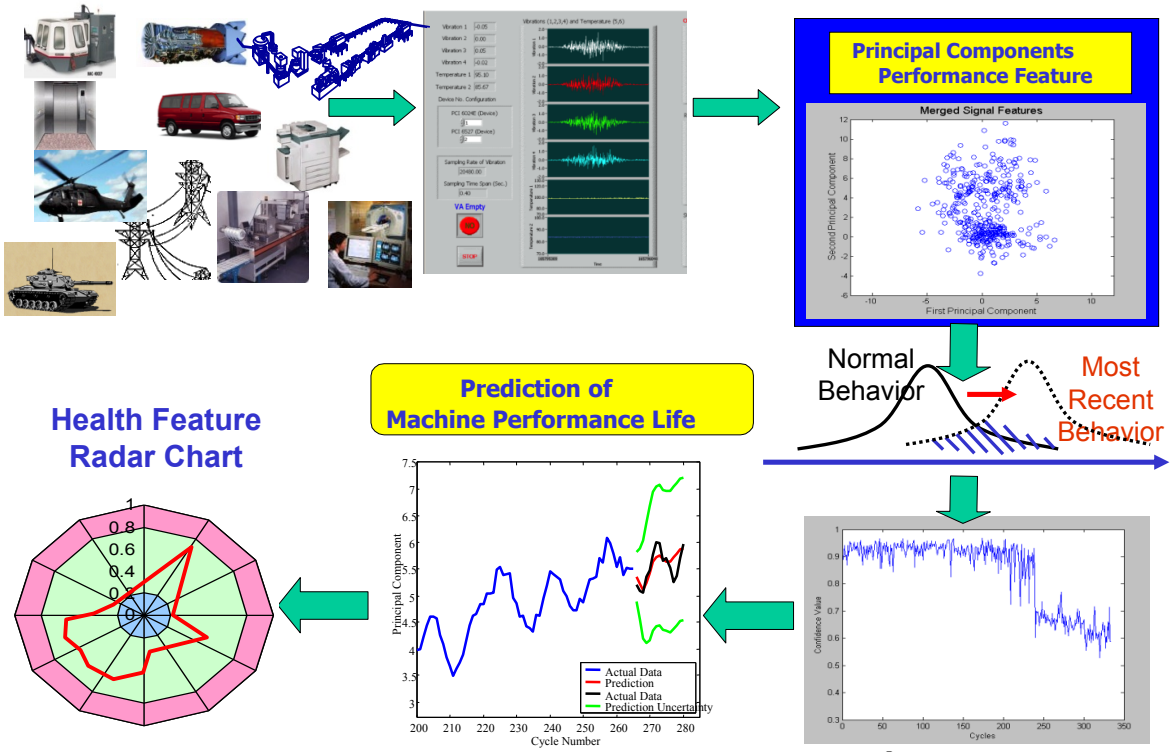

Figure 1. Systematic Approach to Apply Watchdog Agent® Tools

Applications

The Watchdog Agent® Toolbox has been developed and packaged on different hardware and software platforms. The tools are employed and validated using real-world data supplied by different company test-beds from various industries to achieve different diagnostics and prognostics tasks. A portfolio of selected IMS projects is listed in Table 2. The results are delivered in different forms such as technical reports, software & hardware platforms, paper publications or patents.

Table 2. Selected IMS Project Portfolio

COMPANY	PROJECT
General Motors	Prognostics of Vehicle Components
Harley Davidson	Spindle Bearing Monitoring
Toyota	Assembly Robot Monitoring
Caterpillar	Machine Tool Health Monitoring
PMC	Fixed Cycle Feature Test
Proctor and Gamble	Quality-centric Process Health Management
Omron	Precision Energy Management Systems
Semiconductor	Predictive & Preventive Maintenance
Techsolve	Smart Machine Platform Initiative (SMPI)
Siemens	Reconfigurable Plug-n-Prognose Watchdog Agent®

Future Work

- To expand the toolbox by including more advanced algorithms from most recent research and applications.
- To develop hardware and software platform for rapid deployment of validated tools in new applications.
- To improve tool-selection method by defining applicability of different algorithms for different application scenarios.

References

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