On-line review of existing US patents in the area of water quality event detection and real-time anomaly detection

Sean A. McKenna and Laura Cutler
Sandia National Laboratories
June 2008

This document contains brief summaries of existing patents that were determined to have some relation to on-line water quality event detection. This relationship could be in the form of a patent that was created specifically to measure water quality in some manner, or it could also be in the area of detecting anomalous readings from a sensor or mechanical or industrial device. The summaries are organized in this document with those that are specifically related to water quality at the front of the document and those that are more related to signal processing and anomaly or outlier detection, no matter what the field of application, arranged at the back of the document. The latter group of patents comprises the bulk of this document. For each summary an "Evaluation" is provided that is a few sentences highlighting relevant information of the patent or adding information concerning the approach documented in the patent that was not clear from the summary information.

All of the information contained in this report was obtained through web searches of publicly available sites. Sites that were accessed include: www.freepatentsonline.com and www.patentstorm.us and several others. In most cases, the full text or a pdf version of the patent is available at these web sites.

The final three pages of this document contain a description of a report of a wastewater monitoring approach that has not been patented as well as the Multivaraite State Estimation Technique (MSET) that has generated a number of patents as listed in the final table of this document.

No guarantee is made as to the completeness of the information provided in this document.

Title: Method and apparatus for detecting and classifying contaminants in water

Patent Number: 5646863
Inventor: Stephen G. Morton
Application Number: 08/541952
Publication Date: 07/08/1997
Filing Date: 10/10/1995

Abstract

A method and the apparatus (hereinafter referred to as the environmental monitoring system or EMS") designed to sample, detect, measure, and report, in real time, the presence of contaminants and thereby provide users with the ability to continually monitor conformance of water with established health and safety standards. When integrated with a user operated process control system, the EMS enables users to control the monitored process and to thereby ensure that the sampled water complies with established health and safety standards.

Evaluation: This patent appears to comprise both the hardware and software to measure concentrations of heavy metal and organic contaminants and detect deviations from reference samples. It employs a neural network to try and classify the contaminant measurements.

Title: System for Detection and Prediction of Water Quality Events

Abstract

A method of evaluating a water sample for the presence or possible future presence of nitrification comprises obtaining data values of a number of parameters, processing the data values to determine correlation coefficients, to identify any linear dependencies, to standardize the scales, evaluating the data values over a plurality of proliferation time periods and neuron numbers, calculating MSEs and R2's from the evaluations, and estimating a valid likelihood of nitrification of the water sample. A method of evaluating a water sample for the presence or possible future presence of nitrification, comprises obtaining data values of a number of parameters, statistically pre-processing the data values and supplying the pre-processed data values to a neural network. Apparatus, media and processors which are used in performing such methods.

Evaluation: Patent has not yet been granted. Approach uses a neural network including neural network architecture development to model a single target parameter from values of the other parameters through linear regression.

Title: Classification of deviations in a process

Patent Number: 6999898
Inventors: Karl L. King, Ziyi Wang, Dan J. Kroll
Application Number: 10/751168
Publication Date: 02/14/2006
Filing Date: 12/31/2003

Abstract

A process analysis system includes sensors and a processing system. The sensors monitor the process to generate sensor signals. The processing system processes the sensor signals to detect a deviation from a baseline for the process. The processing system generates a process vector for the deviation in response to detecting the deviation. The processing system compares the process vector to a plurality of library vectors to classify the deviation. In some examples, the process comprises a system that supplies water.

Evaluation: This patent is the basis for the Hach event detection system. The patent is not specific on the actual techniques used.

Title: System for monitoring quality of water system

Patent Number: 7391333
Inventors: Terrance P. Madden, Christopher Campbell, Cornelius Murphy, Michael R. Brower
Application Number: 11/236088
Publication Date: 06/24/2008
Filing Date: 09/27/2005

Abstract
        A monitoring, detection and alarm for water systems includes a plurality of sensing components for detecting the presence of target contaminants in water and for measuring the overall quality of the water. The apparatus contains water sensing components, a database for storing sensor data and processors for data analysis using artificial intelligence. The apparatus provides control logic to take responsive action based on the results of the detection of the target contaminants. Responsive action includes, but is not limited to, generation of reports and alarm signals that are delivered in near real-time to users of the system.

Evaluation: A broad description of sensors, data transmission, signal processing (neural network and artificial intelligence using Bayesian statistics) and a user interface to monitor and detect contamination in water systems. This system provides real-time analysis of a particular contaminant being present and this part of the system appears to be focused on biological contaminants.

Title: System and method for the on-demand on-line treatment of water

Patent Number: 20050199483
Inventor: Dan J. Kroll
Application Number: 10/946762
Publication Date: 09/15/2005
Filing Date: 09/22/2004

Abstract

A system and method for the on-demand on-line treatment of water is disclosed. The system uses ultra high energy UV light coupled with the introduction of a strong oxidant to induce photo-catalytic degradation of chemical compounds and biocidal activity. When an agent or substance is detected in the water the treatment system would be activated.

Evaluation: On demand, real time treatment of water using ultra-high energy UV light.

Title: Systems and Methods for fluid quality monitoring using portable sensors in connection with supply and service entities

Inventors: Malcolm R. Kahn, Uwe Michalak
Application Number: 11/201,325
Publication Number: US 2006/0020427 A1
Filing Date: 08/09/2005

Abstract

A method of monitoring fluid quality is described. At least one of raw fluid quality data and processed fluid quality data is communicated from one or more portable sensor units configured for wireless communication to one or more wireless transceivers, the raw fluid quality data and processed fluid quality data having been generated based upon measurements made using the portable sensor unit(s) at different locations corresponding to different points of fluid delivery. The locations are controlled by separate entities. At least one of the raw fluid quality data and the processed fluid quality data is communicated from the wireless transceiver(s) to a data collection system. At least one of the raw fluid quality data, the processed fluid quality data, and fluid quality measures derived therefrom is communicated to additional entities other than the separate entities.

Evaluation:

The focus of this patent is in the portability of the sensors and the network used to transmit data between different sensors

Title: Predicting sample quality real time

Patent number: 6799117
Inventors: Mark A. Proett, Jianghui Wu, James M. Fogal, Madan Mohan Manohar
Application number: 10/446,366
Issue Date: 9/28/2004
Filing Date: 5/28/2003

Abstract

Systems and methods for estimating properties of fluid samples pumped from a formation through a well are described. Based upon input properties, an artificial neural network (ANN) may predict a plurality of data points, and each data point may correspond to a predicted time sample of the property of the fluid sample. Properties predicted by the ANN include sample quality or pumping pressure differential.

Evaluation: Appears to be an oil industry application and makes heavy use of a neural network.

Title: Monitoring, diagnostic, and reporting system and process

Patent number: 6356205
Inventors: Joseph James Salvo, Patricia Denise Mackenzie
Application number: 9/201,385
Issue Date: 3/12/2002
Filing Date: 11/30/1998

Abstract

A monitoring system determines characteristics of a fluid in a well. The system comprises a well module adapted to be disposed in a well, where the module comprises a probe and at least one sensor that senses characteristics of the fluid. The well module is capable of transmitting information concerning fluid characteristics. The system further comprises a data collection center, which is capable of receiving well information from the well module and generating information concerning characteristics of the fluid, a monitoring site, and a communication link that enables a user at the monitoring site to obtain information such as, but not limited to, real-time, historical, and a combination of real-time and historical concerning the characteristics.

Evaluation: Appears to be an oil industry application for downhole use in wells

Title: Automated groundwater monitoring system and method

Patent number: 6021664
Inventors: Gregory E. Granato, Kirk P. Smith
Issue Date: 02/08/2000
Filing Date: 01/29/1998

Abstract

A method of monitoring the quality of water at a ground water sampling site without human intervention. Water at the sampling site is purged until at least one preselected purge criterion is satisfied. At least one water quality attribute is automatically measured at the sampling site, and the quality of water at the site is determined based on the measured water quality attribute. The method is performed by a system including a control unit which, in accordance with a computer program, controls the taking of water quality attribute measurements at the sampling site. The control unit may be equipped with a port for downloading data to a technician on site and with a transceiver for communicating data to a base station via a communications network.

Evaluation: This is a ground water application and has an automatic control for collecting samples

Title: System, method and computer program product for subsurface contamination detection and analysis

Patent number: 7058509
Inventors: John H. Sohl III, James Edward Tillman
Issue Date: 06/06/2006
Filing Date: 09/22/2003

Abstract

A system, method and computer program product for source area contamination data acquisition, analysis and processing. The present invention leverages and expands direct sensing technology, knowledge and experience to provide detailed, real-time images of subsurface conditions. The latest technologies in sensors, digital processing, computation and 3D visualization are used to enable clients to work with a single contractor who can perform data acquisition, processing and analysis necessary to produce quantifiable, user-friendly 3D maps on a daily basis which can be delivered via the Internet and/or to mobile devices. This allows the owner and site project manager to make timely decisions as they guide investigation, remediation and monitoring efforts.

Evaluation: Ground water tool to aggregate data into 3-D plumes depicting the location and concentration of subsurface ground water contamination.

Title: System and methods for fluid quality sensing, data sharing and data visualization

Patent Number: 20070219728
Inventors: Dimitris S. Papageorgiou, Uwe Michalak, Malcolm R. Kahn
Application number: 11/601,404
Publication number: US 2007/0219728 A1
Filing Date: 11/16/2006

Abstract
        A service provider receives fluid test data generated from multiple different entities and permits authorized users affiliated with the different entities, as well as others, to visualize information associated with that data to via the Internet using graphical computer interfaces at respective computers. The fluid test data can be gathered using portable sensor units equipped with GPS and wireless communication to transmit the fluid test data and geographical information to the service provider.

Evaluation: This patent is focused on a system for the visualization of water quality data in space and time and would most likely involve the use of a GIS

Title: Well monitoring, controlling and data reducing system

Patent Number: 4461172
Inventors: Charles B. McKee, Duane B. McKee, H. Kent Wainwright
Issue Date: 07/24/1984
Filing Date: 05/24/1982

Abstract

An apparatus is provided for gathering monitored data from one or more selected wells of a number of wells and reducing the monitored data in a real time manner to a useful form for analysis by one skilled in ground water evaluation. The apparatus can also be used to control the discharge rate of well water to further assist in the analysis of the characteristics of the selected wells. The apparatus is an integrated system which includes a computer, a number of inter-communicating modules, probes inserted in the wells for sensing water level, and a flow meter for use in measuring water flow rate. A control module directly interfaces with the computer and controls the sending of control and data information to and from the computer. A pump/flow module communicates with the control module and is used in controlling the discharge rate of water from a selected well operatively joined to a pump. An A/D module also communicates with the control module and is used to convert data from a selected well into digital form for use by the computer. Input modules interface between the probes and the A/D module to provide a compatible input to the A/D module.

Evaluation: This is a ground water application that has capabilities for both collection and transmission of water quality data as well as control of sampling mechanisms to collect such data

Title: Water monitoring, data collection, and transmission module

Patent Number: 6536272
Inventors: Thomas Houston, Rod G. Zika, Geoffrey K. Morrison, Richard Wood, Arthur M. Barbeito
Issue Date: 03/25/2003
Filing Date: 08/04/2000

Abstract

A water sampling apparatus is disclosed having a water inlet and a water collecting scoop. A pump, in fluid communication with the water inlet, draws a water sample from a body of water through the water inlet. A plurality of testing units, in fluid communication with the pump and the water inlet, determine characteristics of the water sample. The plurality of testing units are contained within an instrument module. A plurality of electrical components, in communication at least with some of the plurality of testing units, generates data signals concerning the characteristics of the water sample. The plurality of electrical components are contained within a computer module. A computer, in communication at least with some of the plurality of electrical components, collects the data signals generated by the plurality of electrical components and provides the data signals both to a local database and also by satellite transmission to a remote central data base. An automated anti-bio...

Evaluation: This is principally a patent for hardware to collect samples, characterize them and transmit data on that characterization to a central location

Title: Modular water quality apparatus and method

Patent Number: 5821405
Inventors: Terry Lee Dickey, Michael Albert Alkier
Issue Date: 10/13/1998
Filing Date: 08/14/1997

Abstract

A modular water quality measurement apparatus and method includes a sealed or unsealed housing with a universal sensor interface cap (12) and mechanical and electrical sensor connections (14) for receiving removably attachable sensors (16 or 16'). Each of the mechanical and electrical sensor connections (14) are individually electrically connected to a programmable motherboard (20) within the housing. Sensor daughterboards (22) are removably attached to the motherboard (20) corresponding to individual sensors (16 or 16') connected to the universal sensor interface cap (12). Further, removably attachable input/output daughterboards (24) are electrically connected to the motherboard (20) for accommodating various serial interface types and software is provided for collecting information from the sensors (16 or 16') and transmitting the information through the input/output daughterboards (24) for manipulation by a user. Additionally,...

Evaluation: Hardware components for measuring water quality with focus on electrical components and connections

Patents from this point to the end of the document are not specific to water quality and are generally focus on detection of anomalous data or outliers from digital data and from mechanical tools.

Title: Signal detection system with dynamically adjustable detection threshold

Patent Number: 5084696
Inventors: John K. Guscott, Gerard G. Stelmack
Application Number: 07/645236
Publication Date: 01/28/1992
Filing Date: 01/24/1991

Abstract

A signal detection system with dynamically adjustable detection threshold includes a signal detection comparator having a dynamically adjustable threshold which adjusts the detection sensitivity of the comparator from a quiescent value to a value which is dependent upon the value of an event trigger signal, thus anticipating the amplitude of a second, confirming event trigger signal. Additionally, an alarm window timer activated by an event signal which exceeds the quiescent signal detection comparator threshold, assures that an alarm activator will be enabled only after a second, confirming event trigger signal exceeds the adjusted detector threshold, and which occurs during the active period of the alarm window timer.

Evaluation: This could be considered a signal processing patent and does not mention application to water quality, although this process could be used for event detection

Title: **Device for generating an alarm signal**

Patent Number: 4725821
Inventors: Tetsuo Kimura, Akihiro Kobayashi
Application Number: 07/001978
Publication Date: 02/16/1988
Filing Date: 01/09/1987

Abstract

A device for generating an alarm signal in the event of an abnormality in the environment of a detector includes a pair of signal/power supply lines, a number of detectors for detecting an abnormality, e.g., fire, gas leakage, or burglary, and an alarm receiver including a signal processing circuit for receiving a signal from a detector indicating the presence of an abnormality. The signal process circuit includes a signal storage circuit, and a converting circuit for changing one or a combination of at least two of a polarity, voltage, current, or impedance of a power source if the abnormality persists for a predetermined time. The change in the power source parameter is supplied via the supply lines to a signal holding circuit in the vicinity of the detector. The signal holding circuit is responsive to the changed parameter and changes state, thus providing an indication at the detector that the abnormality has persisted for the predetermined time.

Evaluation: This could be considered a signal processing patent and does not mention application to water quality, although this process could be used for event detection. The patent is focused on electrical (analog) means of signal processing

Title: **Event detection apparatus**

Patent Number: 4528553
Inventors: Ray D. Hastings, Ernest W. Boyer
Application Number: 06/524015
Publication Date: 07/09/1985
Filing Date: 08/16/1983

Abstract

Circuitry for qualifying a series of randomly occurring alarm events to avoid erroneous indications. Alarm events occurring in a surveillance system or the like are counted over a selected time interval, and final alarm output is effected only if a selected 1+n number of events has been counted within the interval. Both the repetitive time intervals and the event number are variable in accordance with the exigencies of the alarm application.

Evaluation: This patent is hardware/electronic apparatus for to perform the specific function of improving the integrity of an unattended, remote intrusion detection system by eliminating statistical random or false event indications.

Title: Event detection system with centralized signal processing and dynamically adjustable detection threshold

Patent number: 5471194
Inventor: John K. Guscott
Issue Date: 11/28/1995
Filing Date: 03/23/1993

Abstract

An event detection system with centralized signal processing and dynamically adjustable detection threshold includes a number of remotely located event detection units coupled to a single centralized signal processing unit. Each event detection unit provides an event detection signal to the centralized signal processing unit. At least one signal processor in the centralized signal processing unit compares the value of the event detection signal with a dynamically adjustable threshold value, and provides a first detection signal when the event detection signal exceeds the value of the dynamically adjustable threshold. A threshold generator compares the event detection signal and a predetermined offset value, and adjusts the value of the dynamically adjustable threshold as the event detection signal exceeds the offset value. The signal processor then provides a second event detection signal when the event detection signal exceeds the adjusted threshold value. The invention further includes a mutual event verifier located in the centralized signal processing unit, for establishing at least one of the event detection units as a mutual verification event detection unit, and for activating an alarm only upon the concurrence of a detection signal from the designated mutual verification event detection unit, and a second confirming detection signal from any other event detection unit coupled to the system.

Evaluation: Event detection post processor

Title: Real time status monitoring system

Patent number: 5161103
Inventors: Michitaka Kosaka, Toshiro Sasaki, Kuniaki Matsumoto, Kichizo Akashi, Satoru Suemitsu
Issue Date: 11/03/1992
Filing Date: 07/05/1989

Abstract

A real time status monitoring method for inputting randomly varying data relating to a plurality of objects, processing a plurality of functions having some of the data as variables and monitoring an overall status including the objects on a real time basis, and an apparatus therefore are disclosed. A table indicating the presence or absence of data change in the objects and the presence or absence of variables related to the data change in the functions is prepared. In processing the functions, the table is referenced and only those functions which include the variables related to the data change are processed.

Evaluation: Developed as a trading support system in the financial and security field

Title: Adaptive pattern recognition based control system and method

Patent Number: 6400996
Inventors: Steven M. Hoffberg, Linda I. Hoffberg-borghesani
Application Number: 09/241135
Publication Date: 06/04/2002
Filing Date: 02/01/1999

Abstract

An adaptive interface for a programmable system, for predicting a desired user function, based on user history, as well as machine internal status and context. The apparatus receives an input from the user and other data. A predicted input is presented for confirmation by the user, and the predictive mechanism is updated based on this feedback. Also provided is a pattern recognition system for a multimedia device, wherein a user input is matched to a video stream on a conceptual basis, allowing inexact programming of a multimedia device. The system analyzes a data stream for correspondence with a data pattern for processing and storage. The data stream is subjected to adaptive pattern recognition to extract features of interest to provide a highly compressed representation that may be efficiently processed to determine correspondence. Applications of the interface and system include a video cassette recorder (VCR), medical device, vehicle control system, audio device, environmental control system, securities trading terminal, and smart house. The system optionally includes an actuator for effecting the environment of operation, allowing closed-loop feedback operation and automated learning.

Evaluation: Multimedia (e.g., video) adaptive pattern recognition that takes user interface. Applications in areas of data compression

Title: Inductive monitoring system constructed from nominal system data and its use in real-time system monitoring

Patent Number: 7383238
Inventor: David L. Iverson
Application Number: 10/789029
Publication Date: 06/03/2008
Filing Date: 02/24/2004

Abstract

The present invention relates to an Inductive Monitoring System (IMS), its software implementations, hardware embodiments and applications. Training data is received, typically nominal system data acquired from sensors in normally operating systems or from detailed system simulations. The training data is formed into vectors that are used to generate a knowledge database having clusters of nominal operating regions therein. IMS monitors a system's performance or health by comparing cluster parameters in the knowledge database with incoming sensor data from a monitored-system formed into vectors. Nominal performance is concluded when a monitored-system vector is determined to lie within a nominal operating region cluster or lies sufficiently close to a such a cluster as determined by a threshold value and a distance metric. Some embodiments of IMS include cluster indexing and retrieval methods that increase the execution speed of IMS.

Evaluation: Use of clustering of nominal condition data to determine range of normal operating conditions. Abnormal conditions are those that do not fit the normal conditions as identified by a distance from an existing cluster. Clustering algorithms are not specified.

Title: Change-point detection apparatus, method and program therefore

Patent number: 7016797
Inventors: Jun-ichi Takeuchi, Kenji Yamanishi
Issue Date: 03/21/2006
Filing Date: 06/09/2004

Abstract

A time-series model learning unit reads in time-series data sequentially, learns the parameters of a time-series model and stores the parameters in a storage device. A loss function calculating unit reads in sequentially from storage each item of the input time-series data one at a time and calculates values of a loss function. A complexity calculating unit sums the loss values to sequentially calculate complexity as fitting error resulting when a time-series model is fit to the input data. Complexity is stored. A change-point searching unit reads in complexity regarding time-series data before and after change-point candidates from storage with respect to all change-point candidates, compares the sum of the complexities with complexity regarding all time-series data in a case where a change point is assumed to be absent, calculates the change-point score based upon the difference between the compared values, and detects and outputs the change point.

Evaluation: This appears to be an offline approach to change-point detection that requires all data to be collected prior to determining the locations of the change points. If this is the case, there would be no application to on-line event detection
See paper: Takeuchi, J.-I. and Yamanishi, K., 2006, A Unifying Framework for Detecting Outliers and Change Points from Time Series, *IEEE Transactions on Knowledge and Data Engineering*, Vol. 18, No. 4, pp. 482-492

Title: Detection of deviations in monitored patterns

Patent number: 5659593
Inventor: Dvora Tzvieli
Issue Date: 08/19/1997
Filing Date: 11/30/994

Abstract

A system and method for detecting significant deviations in a pattern in near real time by making forecasts about the pattern and determining if the actual pattern is within a threshold of the forecast. The preferred embodiment is a method for detecting recording errors in a telephone network that provides services to a plurality of customers, the method comprising: recording information output by the telephone network relating to a service that was provided to the customers in a first time period; forecasting, based on the recorded information, information that will be output by the network in a second time period that has not yet occurred; recording information output by the telephone network relating to the provision of the service to the customers in the second time period; and comparing the result of the forecasting step with the information recorded during the second time period to generate a deviation.

Evaluation The general approach described is well-known and often used in a number of fields including signal processing and surface water hydrology (linear filters) and astronautics (Kalman filters) among others including tsunami detection

Title: Parametric outlier detection

Patent Number: 7062415
Inventors: Bruce J. Whitefield, David A. Abrcrombie, David R. Turner, James N. McNames
Application number: 10/928,292
Publication number: US 2006/0047485 A1
Issue Date: 06/13/2006
Filing Date: 08/27/ 2004

Abstract

  A method for determining outlier data points in an ordered dataset of values. a) A subset of dataset patterns is selected from a set of mathematical dataset patterns, and b) the subset of dataset patterns is combined into a composite dataset. c) The composite dataset is compared to the ordered dataset of values, and d) a degree of correlation between the composite dataset and the ordered dataset of values is determined. e) Data points within the composite dataset are selectively weighted to improve the degree of correlation, and f) steps a through e are selectively iteratively repeated until the degree of correlation is at least a desired value. g) Residuals for the data points within the composite dataset are selectively determined. h) At least one of (1) the weighted data points within the composite dataset that are weighted within a first specified range, and (2) data points within the composite dataset that have a residual within a second specified range, are selectively output as outlier data points.

Evaluation: Correlation-based approach to outlier detection

Title: Method and device for event detection utilizing data from a multiplicity of sensor sources

Patent number: 6525658
Inventors: Steven S. Streetman, Matthew W. McGarvey
Issue Date: 02/25/2003
Filing Date: 06/11/2001

Abstract

A method and apparatus for event detection utilizing data from a multiplicity of sensors is provided. In a first step, actual detections from a plurality of sensors identified with predetermined sensor sequences, each indicative of an event, are compared with the predetermined sensor sequence to determine whether the times between the actual detections match the times allocated between detections for any predetermined sensor sequence. If a match occurs, the event indicated by the matching predetermined sensor sequence is provided. If no match occurs, a second step is initiated wherein the actual detections are compared to a predetermined script file which defines criteria for a plurality of events. If this criteria is matched, the event for which the criteria is provided is indicated.

Evaluation: Multivariate sensor fusion and event detection. Details of algorithms do not appear to be provided.

Title: Signal Processing Fault Detection System

Author: Derke R. Hughes (Department of the Navy).
Filing Date: 07/13/2007
Media Count: 28 Pages(s)
Report Number(s):
     PAT-APPL-11 777 564 *(PATAPPL11777564)*
     XBNUWC-NPT *(XBNUWCNPT)*

Abstract

A fault detection system designed to evaluate the structural integrity of a material employs an array of sensors disposed over the material being evaluated. The sensors detect vibrations in the material and the sensor signals are fed to a data processor. The processor employs a method to analyze the linear and nonlinear characteristics of the sensor signals and then determines whether to proceed with a linear signal processing analysis or a nonlinear signal processing analysis of the sensor signals. Once the analysis is completed, the results are compared to baseline results to determine what if any divergence exists between the results and the baseline results. A significant divergence indicates a potential material failure. The fault detection system will indicate such a potential failure through a visual alarm on a graphical user interface.

<http://www.science.gov/scigov/resultNavFrameset.html?ssid=-
    71c3e75d%3A11a736dcf66%3A3a13&requestType=USER&displayMode=RANK
    &startPosition=0&resultItem=2&resultCount=826&resultId=390580614&ranked=tr
    ue&index=2&mode=RESULT>

Evaluation: Application is strengths and failure modes of materials. The use of vibration frequency data and the decision point between linear and non-linear processing of the signals appear to be novel aspects

Title: Method and apparatus for knowledge-based signal monitoring and analysis

Abstract

A method and apparatus for monitoring and analysing signal data which uses a network model describing the system under investigation and a runtime agent for acquiring the signal data and accessing the model if an anomaly in the signal data is indicated. The network model describes events of interests and how the events relate to phenomena in the system. The network model is constructed using an object-oriented approach with: observations of the events of interests in the system; situations which describe possible underlying causes of the observations; and relations which specify the logical relationship between the observations and situations. The runtime agent is constructed with an object-oriented approach using observers which monitor the signal data and compute whether an anomaly in the incoming signal data exists. If an anomaly is identified, an "observation" is generated and the network model entered to analyse the observation and estimate a cause of the observation. The method and apparatus are applicable for interpreting phenomena in a wide variety of physical systems and have been exemplarily applied to monitoring the quality of oil well logging and laboratory material test sensor configurations.

Evaluation: Unique aspects appear to be anomaly detection and connection to network model to provide some estimate of the cause of the anomaly.

Title: Diagnostic system and method

Patent Number: 4517468
Inventors: Christian T. Kemper, Robert L. Osborne, James C. Bellows
Application Number: 06/605703
Publication Date: 05/14/1985
Filing Date: 04/30/1984

Abstract

A diagnostic system wherein a central diagnostic center receives sensor data relative to the operating condition of a plurality of remote plants. Each plant records just certain sensor signals and transmits them at respective prescheduled transmission times. If certain activation limits are exceeded, a data link with the diagnostic center is immediately established so that the data may be transmitted ahead of its normally scheduled transmission time in order that an immediate diagnostic analysis be made on the plant. A communication link between the plant and diagnostic center is kept open for a predetermined period of time in which more data may be sent from the plant to the diagnostic center, and results and instructions, sent from the diagnostic center back to the plant. Such instructions may include the changing of certain parameters in the examination of the sensor signals.

Evaluation: Focus on facilitating adaptive communications between the plants (sensors) and a central receiving processor

Title: Rule based diagnostic system with dynamic alteration capability

Patent Number: 4642782
Inventors: Christian T. Kemper, Simon Lowenfeld, Mark S. Fox
Application Number: 06/636196
Publication Date: 02/10/1987
Filing Date: 07/31/1984

Abstract

Sensor based diagnostic apparatus for performing on-line realtime monitoring of an industrial or other operating system. The diagnostic apparatus has a rule network for propagation of belief leading to one or more possible malfunctions of equipment in the operating system. The propagation of belief is dynamically altered as a function of the operating conditions of the sensors themselves.

Evaluation: Focus on propagation of belief (fuzzy logic?)

Title: Diagnostic apparatus

Patent Number: 4644479
Inventors: Christian T. Kemper, James C. Bellows, Pamela J. Kleinosky
Application Number: 06/636195
Publication Date: 02/17/1987
Filing Date: 07/31/1984

Abstract

Diagnostic apparatus utilized to monitor a steam turbine-generator power plant. A plurality of sensors around the plant provide data to the diagnostic apparatus which utilizes a digital computer to come to some conclusion relative to actual or impending malfunctions in the plant components. The computer utilizes an expert system diagnosis which establishes a plurality of subsystems which are generic and can be applied to any sensor to obtain indications of (a) sensor output movement, (b) validated sensor readings and (c) malfunction indications based on conclusions reached in (a) and (b).

Evaluation: Multivariate sensing into an expert system to identify or predict malfunction of the process.

Title: Method and apparatus for real-time control

Patent Number: 4975865
Inventors: George J. Carrette, James E. Clancy, Gregory H. Fossheim
Application Number: 07/359871
Publication Date: 12/04/1990
Filing Date: 05/31/1989

Abstract

Digital processing methods and apparatus for monitoring, controlling, and simulating industrial processes operate on data signals representative of process parameter values and generate response values representative of desired or requested process parameter values. A knowledge base stores knowledge of the industrial process in the form of rules, and an inference engine applied the rules to calculate the response values. A time-stamp value is assigned to each data signal, representing the time of receipt of each signal. Currency evaluation elements, responsive to user-selected currency range values and the time-stamp signals, assign an expiration-time value to the data signals and disregard data signals having an expiration-time value outside a corresponding user-selected currency range value.

Evaluation Focus is real-time monitoring, control and simulation of processes. Unique feature seems to be the temporal expiration of the data.

Title: Process diagnostics

Patent Number: 7290450
Inventors: Gregory C. Brown, Marcos Peluso, Robert J. Karschnia
Application Number: 10/893144
Publication Date: 11/06/2007
Filing Date: 07/16/2004

Abstract

A diagnostic device for use in a industrial process includes monitoring electronics or diagnostic circuitry configured to diagnose or identify a condition or other occurrence in the industrial process. The system can be implemented in a process device such as a flowmeter, and in one example an acoustic flowmeter. A transducer can also be used and a frequency response, such as resonant frequency, can be observed.

Evaluation: Application is focused on detection of fouling and corrosion in industrial processes. Use of mechanical and electronic components including flowmeters and acoustic sensors.

Title: Real time method for processing alarms generated within a predetermined system

Patent Number: 4977390
Inventors: Charles H. M. Saylor, Kamal Jabbour
Application Number: 07/423872
Publication Date: 12/11/1990
Filing Date: 10/19/1989

Abstract

A methodology for processing alarms generated within a predetermined system embodies a forward chaining approach to the analysis of alarms. Before an alarm set can be diagnosed, the method includes the steps of: providing a computer database representative of all components of the system capable of faulting and the interconnections between the components; providing rules that relate component faults to generated alarms and to propagation of component faults within the system; determining individual alarm patterns generated by separate faulting of each component of the system; and storing in a computer database individual alarm patterns determined for each component of the system. Thereafter, the method includes preparing each stored alarm pattern with a generated set of alarms and ascertaining those components whose individual alarm patterns are a subset of this set of alarms. A practical real time implementation of the method is obtained by including the steps of: hashing the individual alarm patterns determined for each system component to a binary pattern corresponding to a unique integer number; hashing the set of alarms to be analyzed to a binary representation; and comparing the alarm set binary representation with all binary patterns stored for the system components and ascertaining therefrom all potentially faulted components of the system.

Evaluation: Appears to be a systems engineering approach to defining the system as a network of connected nodes with rules governing those connections.

Title: Event Detection

Patent number: 6347374
Inventors: David L. Drake, David J. Webster
Issue Date: Feb 12, 2002
Filing Date: Jun 5, 1998

Abstract

A system for event detection employs a collector that collects raw audit data made up of raw audit data records at an audit source; a database; an inserter at a downstream processing location that inserts Virtual Records into the database, including both a first type of Virtual Record generated in response to a raw audit data record, and a second type of Virtual Record generated in response to a detected audit event; the inserter; a parser; coupled to the collector, that converts raw audit data records in the raw audit data into Virtual Records; a detector that detects audit events in response to the Virtual Records generated by the parser, and generates the second type of Virtual Record in the event an audit event is detected.

Evaluation: This work is aimed at intrusion detection for security of physical structures. It is not clear if this approach works in real time or is an offline detection capability. The focus on using audit data suggest that it is offline.

Title: Method and apparatus for diagnosing difficult to diagnose faults in a complex system

Patent Number: 7100084
Inventors: Richard C. Unkle, Nicholas Edward Roddy
Application Number: 10/649513
Publication Date: 08/29/2006
Filing Date: 08/26/2003

Abstract

A method and apparatus for determining the root cause of no trouble found events in a machine is disclosed. The actual faults occurring during a predetermined time interval prior to the no trouble found event are analyzed and correlated with the no trouble found events in an effort to identify those actual faults that have a high correlation with each no trouble found event. If a high correlation is not found, then the no trouble found event is analyzed off-line to determine the root cause.

Evaluation: Focus is on machines (hardware) and the diagnoses of faults within those machines. This approach allows for offline determination of the cause of the fault

Title: Method and apparatus for monitoring and recording computer system performance parameters

Patent number: 7020802
Inventors: Kenny C. Gross, Larry G. Votta, Jr.
Issue date: 03/28/2006
Filing date: 10/17/2002

Abstract

One embodiment of the present invention provides a system that systematically monitors and records performance parameters for a computer system. During operation, the system periodically measures values for a set of performance parameters associated with the computer system while the computer system continues operating. The system then records the values on a data storage device, wherein the recording process keeps track of temporal relationships between events in different performance parameters. The system subsequently allows the recorded values for the set of performance parameters to be analyzed.

Evaluation:

This system is designed to monitor and record performance parameters within a computer system. Anomaly detection is part of this system using one or more previously developed methods. Anomaly detection uses a threshold limit test on one or more performance parameters, an automated data mining and pattern recognition agent, a soft error rate discriminator (SERD), a sequential probability ratio test (SPRT), a multivariate state estimation technique (MSET), a signature analysis mechanism for intrusion detection, and a neural network.

Title: Online Instrumentation to Protect Wastewater Facilities from Toxic Chemicals

Authors: Andrew Shaw, Andrew Fairey, Jake Earle, Nancy Love, Ed Roehl, Ruby Daamen, Gustaf Olsson and John Watts.
Courtesy of WEFTEC 2008
Originally published Oct. 2006

Abstract
     Security concerns are driving current research to develop means of detecting toxic chemicals in wastewater influents as few online instruments are currently available for this purpose. Online respirometers such as the STIPTox are the obvious choice using existing, established technology. One of these units was recently used successfully in the WERF project 03-CTS-7S "Feasibility Testing of Support Systems to Prevent Upsets" to detect 5 out of 6 known toxins.
     In the same project a decision support system (DSS) was developed that used three simple sensors – pH, ORP and conductivity – to detect known toxins. The main difficulty in getting the DSS to work was in dealing with the noisy data caused by filter blockages and sensor fouling. With very good sensor maintenance the DSS based on simple sensors could work well, as proven by testing the DSS with "cleaned up" data which had much of the noise removed.
     Future advances in sensor technology will add more sensors to the suite that can be used in a DSS.

<http://www.environmental-expert.com/resultEachArticle.aspx?cid=5306&codi=12163&idproducttype=6&level=0>

Evaluation: This is a report, not a patent. Focus is on monitoring of wastewater. Report is both testing of commercial sensor tools and development of a decision support system.

Title: MSET, or Multivariate State Estimation Technique, was developed by SmartSignal Corporation of Lisle, Ill., Argonne National Laboratory in 1999

Features continuous signals, few false alarms, fault annunciation, improved dynamic feedback/control algorithms. It is non-linear, non-parametric, kernel regression.
Uses the Sequential Probability Ratio Test (SPRT)

From http://www.ne.anl.gov/codes/mset/patents/index.html, the Argonne National Laboratory site: The Multivariate State Estimation Technique (MSET) is a software system for real-time process monitoring. It provides system operators with timely and reliable information regarding the conformance of process behavior, as inferred from sensor readings, with the expected behavior based on past observation. It employs highly effective, patented techniques to: (1) generate an *analytical estimate* of sensor signals on the basis of actual sensor readings and previously learned correlations among them, and (2) analyze the statistical characteristics of the time series obtained by taking the difference between each measured signal and its numerically generated counterpart to determine, at the earliest possible time, whether the process is behaving as expected or anomalously. The reliability, sensitivity and efficiency of MSET have been demonstrated for a wide variety of process monitoring, signal validation, and sensor operability surveillance applications.

(Kenneth C. Gross was listed as one of the inventors for each patent)

Number Title	Abstract
5,223,207 Expert system for online surveillance of nuclear reactor coolant pumps	An expert system for online surveillance of nuclear reactor coolant pumps. This system provides a means for early detection of pump or sensor degradation. Degradation is determined through the use of a statistical analysis technique, sequential probability ratio test, applied to information from several sensors which are responsive to differing physical parameters. The results of sequential testing of the data provide the operator with an early warning of possible sensor or pump failure.
5,761,090 Expert system for testing industrial processes and determining sensor status	A method and system for monitoring both an industrial process and a sensor. The method and system include determining a minimum number of sensor pairs needed to test the industrial process as well as the sensor for evaluating the state of operation of both. The technique further includes generating a first and second signal characteristic of an industrial process variable. After obtaining two signals associated with one physical variable, a difference function is obtained by determining the arithmetic difference between the pair of signals over time. A frequency domain transformation is made of the difference function to obtain Fourier modes describing a composite function. A residual function is obtained by subtracting the composite function from the difference function and the residual function (free of nonwhite noise) is analyzed by a statistical probability ratio test.
5,629,872 System for monitoring an industrial process and determining sensor status	A method and system for monitoring an industrial process and a sensor. The method and system include generating a first and second signal characteristic of an industrial process variable. One of the signals can be an artificial signal generated by an auto regressive moving average technique. After obtaining two signals associated with one physical variable, a difference function is obtained

40

	by determining the arithmetic difference between the two pairs of signals over time. A frequency domain transformation is made of the difference function to obtain Fourier modes describing a composite function. A residual function is obtained by subtracting the composite function from the difference function and the residual function (free of nonwhite noise) is analyzed by a statistical probability ratio test.
6,131,076 Self tuning system for industrial surveillance	A method and system for automatically establishing operational parameters of a statistical surveillance system. The method and system performs a frequency domain transition on time dependent data, a first Fourier composite is formed, serial correlation is removed, a series of Gaussian whiteness tests are performed along with an autocorrelation test, Fourier coefficients are stored and a second Fourier composite is formed. Pseudorandom noise is added, a Monte Carlo simulation is performed to establish SPRT missed alarm probabilities and tested with a synthesized signal. A false alarm test is then emperically evaluated and if less than a desired target value, then SPRT probabilities are used for performing surveillance.
5,745,382 Neural network based system for equipment surveillance	A method and system for performing surveillance of transient signals of an industrial device to ascertain the operating state. The method and system involves the steps of reading into a memory training data, determining neural network weighting values until achieving target outputs close to the neural network output. If the target outputs are inadequate, wavelet parameters are determined to yield neural network outputs close to the desired set of target outputs and then providing signals characteristic of an industrial process and comparing the neural network output to the industrial process signals to evaluate the operating state of the industrial process.
5,586,066 Surveillance of industrial processes with correlated parameters	A system and method for surveillance of an industrial process. The system and method includes a plurality of sensors monitoring industrial process parameters, devices to convert the sensed data to computer compatible information and a computer which executes computer software directed to analyzing the sensor data to discern statistically reliable alarm conditions. The computer software is executed to remove serial correlation information and then calculate Mahalanobis distribution data to carry out a probability ratio test to determine alarm conditions.
5,764,509 Industrial process surveillance system	A system and method for monitoring an industrial process and/or industrial data source. The system includes generating time varying data from industrial data sources, processing the data to obtain time correlation of the data, determining the range of data, determining learned states of normal operation and using these states to generate expected values, comparing the expected values to current actual values to identify a current state of the process closest to a learned, normal state; generating a set of modeled data, and processing the modeled data to identify a data pattern and generating an alarm upon detecting a deviation from normalcy.
6,119,111 Neuro-parity pattern recognition system and method	A method and system for monitoring a process and determining its condition. Initial data is sensed, a first set of virtual data is produced by applying a system state analyzation to the initial data, a second set of virtual data is produced by applying a neural network analyzation to the initial data and a parity space analyzation is applied to the first and second set of virtual data and also to the initial data to provide a parity space decision about the condition of the process. A logic test can further be applied to produce a further system decision about the state of the process.