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(54) **APPARATUS FOR ALARM INFORMATION DETERMINATION**

VORRICHTUNG ZUR ALARMINFORMATIONSBESTIMMUNG

APPAREIL DE DÉTERMINATION D'INFORMATIONS D'ALARME

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus for alarm information determination, a method for alarm information determination, and to a computer program element and computer readable medium.

BACKGROUND OF THE INVENTION

[0002] A process plant can have many process control systems, for example those used in chemical, petroleum and other industrial processes. One or more process controllers are communicatively coupled to various field devices such as valves, valve positioners, relays, switches, various sensors that monitor temperature, pressure, position, flow rates etc. The process controllers receive data signals indicative of process measurements made by the field devices, which can be used to generate control signals to implement control routines.

[0003] US2015/0186608A1 describes a method and system for assessing alarm events generated in a physiological monitoring system. The method identifies one or more qualitative measures associated with the generation of the alarm event. The one or more qualitative measures can include a calculated trajectory of the monitored physiological parameter, the calculated time between alarm events and the duration of the current alarm event. Based upon the qualitative measures, the method calculates a clinical relevancy score for the alarm event. The alarm event, each of the qualitative measures and the clinical relevancy score are presented on a display panel. The method and system can generate an urgent alarm based on the calculated relevancy score. The system includes a processor that calculates the clinical relevancy score based on qualitative measures and algorithms entered into the processor.

[0004] Users or operators in control rooms have access to information from the field devices and process controllers, and running appropriate software on computer systems are able to perform a variety of tasks, such viewing the current state of the process, changing an operating state, changing settings of a process control routine, modifying the operation of the process controllers and/or the field devices.

[0005] Furthermore, such process plants have numerous alarm systems that monitor the field devices and process controllers. Alarm data is also provided to the users and operators, and this forms an important aid identifying installation or process states that require immediate action. Since both individual components and subsystems of a control system are designed to generate alarms. Thus tens of thousands of data signals and alarm data can occur. However, if too many alarms are generated during serious situations, the user/operator may possibly be confused, and alarms which are actually important may remain unidentified or ignored in the flood of alarms. This is particularly problematic when an unusual alarm or event has just occurred or is occurring. There is a need to address this situation.

SUMMARY OF THE INVENTION

[0006] Therefore, it would be advantageous to have an improved technology for alarm information determination.

[0007] The object of the present invention is solved with the subject matter of the independent claims, wherein further embodiments are defined in the dependent claims. It should be noted that the following described aspects of the invention apply also for the apparatus for alarm information determination, the method for alarm information determination, as well as for the computer program element and storage medium.

[0008] In a first aspect, there is provided an apparatus for alarm information determination as defined in appended claim 1.

[0009] In a second aspect, there is provided a method for alarm information determination as defined in appended claim 7.

[0010] In a first example, there is provided an apparatus for alarm information determination, comprising:

- an input unit;
- a processing unit; and
- an output unit.

[0011] The input unit is configured to provide the processing unit with historical process control data. The process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest. The processing unit is configured to determine a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data. a correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score. The processing unit is configured to identify at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest. The processing unit is utilized to identify at least one first data signal from the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least first one alarm data paired with the plurality of data signals. The output unit is configured to output the at least one first data signal.

[0012] In other words, an apparatus is provided for determining and visualizing related alarms, events and signal for an industrial process plant that enables the root cause of an unusual alarm or event to be determined. This enables a best course of action to remedy the situation to be determined.

[0013] Process plants can have many thousands of time varying data signals, with many alarms and events occurring, often coming in floods of events. However,

only a few of these signals, alarms and events are relevant to a specific problem in the plant. Thus, the relevant alarm data associated with an event are displayed along with the relevant data signals, enabling a user to quickly identify the root cause of the problem, from which remedial action can be implemented, without an exhaustive and time-consuming search through the many data to determine an appropriate course of action being required.

[0014] In an example, identification of the at least one first data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one alarm data.

[0015] In an example, the processing unit is configured to determine a plurality of correlation scores for pairs of data signals of the plurality of data signals. A correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score. The processing unit is utilized to identify at least one second data signal of the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least one first data signal paired with the plurality of data signals. The output unit is configured to output the at least one second data.

[0016] In other words, an event of interest is used to determine relevant alarm indications, which are then used to indicate associated data signals. These data signals, are then used to determine other data signals that are correlated with these data signals, thereby providing a user with a simplified overview of what could be the root cause of the event of interest.

[0017] In an example, identification of the at least one second data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one first data signal.

[0018] In an example, the output unit is configured to output the one or more data signals. The input unit is configured to enable a user to select at least one data signal of the one or more data signals. The identified at least one second data signal can then be the at least one data signal selected by the user.

[0019] In this manner, a user is provided with a down-selection of data signals relating to an event of interest such as an unusual alarm or event, and the user can select the most relevant using their experience.

[0020] In an example, the processing unit is utilized to identify at least one second alarm data from the plurality of alarm data, the identification comprising utilization of the correlation scores for the identified at least one second data signal paired with the plurality of alarm data. The output unit is configured to output the at least one second alarm data.

[0021] In an example, identification of the at least one second alarm data comprises a determination of one or more alarm data of the plurality of alarm data that have the highest correlation scores when paired with the identified at least one second data signal.

[0022] In an example, the output unit is configured to output the one or more alarm data. The input unit is configured to enable a user to select at least one alarm data of the one or more alarm data, and wherein the identified at least one second alarm data can be the at least one alarm data selected by the user.

[0023] In this manner, information relating to an event, such as an unusual alarm, leads to a relevant data signals being presented to a user, which can be further refined by the user if necessary, and these data signal are used to provide information relating to the associated alarms to the user. With this information, the user can determine what the root cause of the unusual alarm is, and determine what remedial action is required.

[0024] In an example, the data relating to the event of interest comprises a user input query term. The processing unit is configured to utilize the query term to identify the at least one first alarm data.

[0025] In an example, the plurality of alarm data are stored in a database, and wherein the query term is utilized to identify the at least one first alarm data.

[0026] In other words, a user input query is parsed and translated into a query targeting an alarm database (for example, a historian, or a general-purpose data storage product such as a relational database, a NoSql document store etc), and the relevant alarms are identified corresponding to the query term input by the user. This is then used to identify relevant data signals.

[0027] In a second example, there is provided a method for alarm information determination, comprising:

a) providing a processing unit with historical process control data from an input unit, wherein the process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest;

b) determining by the processing unit a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data, wherein a correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score;

c) identifying by the processing unit at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest;

d) identifying at least one first data signal from the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least first one alarm data paired with the plurality of data signals; and

h) outputting by an output unit the at least one first data signal.

[0028] In an example, the method comprises step e) determining by the processing a plurality of correlation

scores for pairs of data signals of the plurality of data signals, wherein a correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score; and wherein the method comprises step f) identifying at least one second data signal of the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least one first data signal paired with the plurality of data signals; and wherein step h) comprises outputting the at least one second data.

[0029] In an example, the method comprises step g) identifying at least one second alarm data from the plurality of alarm data, the identification comprising the processing utilizing the correlation scores for the identified at least one second data signal paired with the plurality of alarm data; and wherein step h) comprises outputting the at least one second alarm data.

[0030] In an example, in step a) the data relating to the event of interest comprises a user input query term, and wherein step c) comprises utilizing the query term to identify the at least one first alarm data.

[0031] According to another aspect, there is provided a computer program product as defined in appended claim 10.

[0032] Advantageously, the benefits provided by any of the above aspects equally apply to all of the other aspects and vice versa.

[0033] The above aspects and examples will become apparent from and be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Exemplary embodiments will be described in the following with reference to the following drawings:

Fig. 1 shows a schematic representation of an example of an apparatus for alarm information determination;

Fig. 2 shows a method for alarm information determination;

Fig. 3 shows an example of user input queries relating to an unusual event or alarm;

Fig. 4 shows a schematic representation of an example of sorting of alarms;

Fig. 5 shows an example of data signals in clustered and expanded forms; and

Fig. 6 shows an example of alarm occurrences arranged by similarity.

DETAILED DESCRIPTION OF EMBODIMENTS

[0035] Fig. 1 shows an example of an apparatus 10 for alarm information determination. The apparatus 10 comprises an input unit 20, a processing unit 30, and an output unit 40. The input unit 20 is configured to provide the processing unit 30 with historical process control data. The process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest. The processing unit 30 is configured to determine a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data. A correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score. The processing unit 30 is configured also to identify at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest. The processing unit 30 is utilized to identify at least one first data signal from the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least first one alarm data paired with the plurality of data signals. The output unit 40 is configured to output the at least one first data signal.

[0036] In an example, the process control data comprises engineering data, for example operator display information.

[0037] In an example, the data signals are temporal data.

[0038] In an example, the alarm data comprises temporal data.

[0039] According to an example, identification of the at least one first data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one alarm data.

[0040] According to an example, the processing unit is configured to determine a plurality of correlation scores for pairs of data signals of the plurality of data signals. A correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score. The processing unit is utilized to identify at least one second data signal of the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least one first data signal paired with the plurality of data signals. The output unit is configured to output the at least one second data.

[0041] According to an example, identification of the at least one second data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one first data signal.

[0042] According to an example, the output unit is configured to output the one or more data signals. The input unit is configured to enable a user to select at least one data signal of the one or more data signals. The identified at least one second data signal can then be the at least one data signal selected by the user.

[0043] According to an example, the processing unit is utilized to identify at least one second alarm data from the plurality of alarm data, the identification comprising utilization of the correlation scores for the identified at least one second data signal paired with the plurality of

alarm data. The output unit is configured to output the at least one second alarm data.

[0044] According to an example, identification of the at least one second alarm data comprises a determination of one or more alarm data of the plurality of alarm data that have the highest correlation scores when paired with the identified at least one second data signal.

[0045] According to an example, the output unit is configured to output the one or more alarm data. The input unit is configured to enable a user to select at least one alarm data of the one or more alarm data, and wherein the identified at least one second alarm data can then be the at least one alarm data selected by the user.

[0046] According to an example, the data relating to the event of interest comprises a user input query term. The processing unit is configured to utilize the query term to identify the at least one first alarm data.

[0047] According to an example, the plurality of alarm data are stored in a database, and wherein the query term is utilized to identify the at least one first alarm data.

[0048] Fig. 2 shows a method 100 for alarm information determination in its basic steps where dashed boxes indicate optional method steps. The method 100 comprises:

in a providing step 110, also referred to as step a), providing a processing unit with historical process control data from an input unit, wherein the process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest;

in a determining step 120, also referred to as step b), determining by the processing unit a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data, wherein a correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score;

in an identifying step 130, also referred to as step c), identifying by the processing unit at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest;

in an identifying step 140, also referred to as step d), identifying at least one first data signal from the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least first one alarm data paired with the plurality of data signals; and

in an outputting step 150, also referred to as step h), outputting by an output unit the at least one first data signal.

[0049] In an example, the data signals are temporal data.

[0050] In an example, the alarm data comprises temporal data.

[0051] In an example, step d) comprises determining one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one alarm data.

[0052] According to an example, the method comprises step e) determining 160 by the processing a plurality of correlation scores for pairs of data signals of the plurality of data signals. A correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score. The method then comprises step f) identifying 170 at least one second data signal of the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least one first data signal paired with the plurality of data signals. Step h) then comprises outputting the at least one second data.

[0053] In an example, step f) comprises determining one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one first data signal.

[0054] In an example, step f) comprises outputting by the output unit the one or more data signals, wherein the input unit enables a user to select at least one data signal of the one or more data signals, and wherein the identified at least one second data signal is the at least one data signal selected by the user.

[0055] According to an example, the method comprises step g) identifying 180 at least one second alarm data from the plurality of alarm data, the identification comprising the processing utilizing the correlation scores for the identified at least one second data signal paired with the plurality of alarm data. Step h) then comprises outputting the at least one second alarm data.

[0056] In an example, step g) comprises determining one or more alarm data of the plurality of alarm data that have the highest correlation scores when paired with the identified at least one second data signal.

[0057] In an example, step g) comprises outputting the one or more alarm data, wherein the input unit enables a user to select at least one alarm data of the one or more alarm data, and wherein the identified at least one second alarm data is the at least one alarm data selected by the user.

[0058] According to an example, in step a) the data relating to the event of interest comprises a user input query term, and wherein step c) comprises utilizing the query term to identify the at least one first alarm data.

[0059] In an example, the plurality of alarm data are stored in a database, and wherein the query term is utilized to identify the at least one first alarm data.

[0060] The apparatus and method as described above with respect to Figs. 1-2 are explained in specific detail with respect to Figs. 3-6.

[0061] Finding the root cause and deciding on the best course of action to remedy an unusual alarm or event in industrial process plants is a challenging problem. But only does a process plant contain potentially tens of thousands of time varying signals, it also emits many alarms

and events often in floods. However only very few of the signals, alarms, and events are relevant to a specific problem in the plant. This can lead to an exhaustive and time-consuming search for an appropriate course of action. The apparatus and method for alarm information determination addresses this situation, as described above with respect to Figs. 1 and 2 and as now described in more detail with respect to a specific mode of operation.

[0062] In overview, a method/apparatus is provided to help the user find the root cause of an unusual event or occurrence in a plant, or find similar unusual events which occurred in the past through offering guided/contextual information, and by presenting the user with contextual information on similar/related signals to an alarm or event. A user can then iteratively explore and pinpoint a root cause or course of action.

Detailed Operational Structure

[0063]

1. Historical signal data, alarm and event data, and optionally engineering data (for example, operator display information) are made available to the apparatus;
2. Scores are computed between pairs / groups of signals. These scores can be based on several factors, which include both generic information and domain-knowledge. Such factors may include (note: this calculation can either be done in a bulk fashion or ad-hoc as a result of exploration from the user):

    a. (generic) similarities of the shapes of the time series data over specified intervals of time;
    b. (generic) other time-series clustering properties. This can make use of the techniques described in the paper by T. Warren Liao "Clustering of time series data - a survey", Pattern Recognition 38 (2005) 1857-1874;
    c. (generic) the history of previous explorations from all users in a user interface (previous investigations of signal X commonly led to queries on signal Y);
    d. (generic / domain-knowledge) similarity in identifiers, in particular with regard to semantic identifiers (including those defined in KKS (Kraftwerk-Kennzeichensystem)). For more information see IEC 6135-1 Classification and designation of documents for plants, systems and equipment, Fan Yang, et al, "Improved correlation analysis and visualization of industrial alarm data", ISA transactions 51.4 (2012) 499-506;
    e. (domain-knowledge) co-occurrence of signals on operator graphics (if available). These can potentially be prioritized by those entities displayed physically closer to each other on operator displays);
    f. (domain-knowledge) signals which have been manually tagged by an expert user as being related;

3. Scores are computed between alarms and events and signals. There are several methods for doing this. This calculation can either be done in a bulk fashion or ad-hoc as a result of exploration from the user:

    a. (generic) similarities of the alarm activations / return-to-normal and signal changes of interest (step changes, first- or second-order rise or decays, etc.);
    b. (domain-knowledge) co-occurrence of signals and alarms on operator graphics or other engineering information;
    c. (domain-knowledge) the definition of alarm;
    d. (combination) combining the other methods in bullet point 3 with those in bullet point 2. For example, if it is known from the engineering system that a signal (SignalA) is used in the definition of when to activate a certain alarm (AlarmA), other signals which are considered highly related to SignalA;
    e. Pairwise correlation coefficient can be calculated between each of the signals and/or time-shifted variants thereof. The pair getting the highest correlation will be shown first. Next comes the remaining signal with the highest correlation to the second signal and so on;
    f. Each alarm can be translated into a binary vector by slicing it into time intervals (e.g. 1 hour intervals) If the alarm was active during the interval, the vector gets a "1" and "0" otherwise. Then each vector is compared with each other vector. If both components contain a "1" the score is increased. If one contains a "0" and the other a "1" the score is decreased;

4. These scores can be used for clustering similar / related entities together (using any / multiple of the above-mentioned factors, or other factors). An example visualization for clustering similar signals is shown in Fig. 5;
5. Related entities are stored and can be either queried or triggered to be calculated in an ad-hoc fashion;
6. An end user has access to tools which allow him or her to:

    a. View alarms, events, and signals;
    b. Query alarms, events, and signals with descriptive queries, including but not limited to:

        i. Type of entity (Alarm, Event, Setpoint Change, etc);
        ii. Alarm duration;

iii. Alarms which were active at a certain time (or started or ended before or after a time of interest);

c. Sort alarms and events by several criteria in order to visually see patterns and pinpoint further areas to interactively explore. These criteria might include:

i. First / last occurrence in a flood of events;
ii. Similarity of occurrence patterns;

[0064] An example visualization of alarms sorted by a similarity metric is shown in Fig. 6.

[0065] From a given event, explore potentially-relevant signals occurring at the same time (these are calculated in main bullet point 3).

Mode of Use

[0066] A user starts from either a time period they are troubleshooting, or a particular (unusual) alarm or event which occurred. From there, the user can navigate through related alarms, events, and signals (which are sorted on relevant criteria) or are recommended to the user as a result of the calculations described in "Detailed Operational Structure".

[0067] A typical workflow is shown below:
A person is interested in knowing which set point changes made in a plant have led to increased or decreased alarms of a particular type. Using the described apparatus, the user could then:

1. Execute a query which returns back all setpoint changes and all alarms meeting their criteria of interest;
2. The apparatus shows these on a shared time axis, allowing patterns to be seen by visual inspection and / or by computing similarity measures between the alarms and events.

Detailed Example

[0068] A detailed specific example is described in the following bullet points.

1. A user is interested in times when a manual setpoint change (done by an operator) may have led to new alarms and critical events occurring, possibly only in a portion of a plant (as designated by a KKS or other identifier);
2. The user uses the apparatus described herein, and enters one or more queries, as shown in Fig. 3;
3. These queries are parsed and translated into a query targeting the underlying alarm database (for example, a historian, or a general-purpose data storage product such as a relational database, a NoSql document store, etc);
4. The system displays the alarms and events for each query on a shared, synchronized view. In an industrial plant, tens of thousands of individual alarm occurrences could be present in the period of a few days, which could be overwhelming to find individual relationships of interest;
5. With this view, the alarms can be sorted by several criteria (example: similarity of occurrences - see bullet point 3 under "Detailed Operational Structure"). Such a view can guide the user to find potential causal relationships. This is shown in Fig. 4;
6. Once this is found, additional investigation into the associated signals can be done (see bullet point 2 under "Detailed Operational Structure").

[0069] Fig. 5 shows a clustered view of signal trends. Signals are automatically clustered based on similarity. These clusters can be shown to the user for diagnosis/drill down purposes or for anomaly detection, when a signal no longer exhibits similarity with the others for example.

[0070] Thus, the user or operator is guided to possibly interesting artefacts with the displaying recommendation of contextually relevant alarms, events and signals; uses given tools to quickly and further pinpoint their problem in an ad hoc fashion. In this manner, contextually relevant alarms, events and signals are determined and can be visualised by user, facilitating the implementation of remedial action to address an unusual event or alarm.

[0071] In another exemplary embodiment, a computer program or computer program element is provided that is characterized by being configured to execute the method steps of the method according to one of the preceding embodiments, on an appropriate system.

[0072] The computer program element might therefore be stored on a computer unit, which might also be part of an embodiment. This computing unit may be configured to perform or induce performing of the steps of the method described above. Moreover, it may be configured to operate the components of the above described apparatus and/or system. The computing unit can be configured to operate automatically and/or to execute the orders of a user. A computer program may be loaded into a working memory of a data processor. The data processor may thus be equipped to carry out the method according to one of the preceding embodiments.

[0073] It has to be noted that embodiments of the invention are described with reference to different subject matters. In particular, some embodiments are described with reference to method type claims whereas other embodiments are described with reference to the device type claims.

[0074] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive.

[0075] In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article

"a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items re-cited in the claims. The mere fact that certain measures are re-cited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. An apparatus (10) for alarm information determination, comprising:

   - an input unit (20);
   - a processing unit (30); and
   - an output unit (40);

   characterised in that the input unit is configured to provide the processing unit with historical process control data, wherein the process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest, wherein the data relating to the event of interest comprises a user input query term;
   wherein, the processing unit is configured to determine a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data, wherein a correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score;
   wherein, the processing unit is configured to identify at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest, wherein the processing unit is configured to utilize the query term to identify the at least one first alarm data;
   wherein, the processing unit is adapted to identify at least one first data signal from the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least one first alarm data paired with the plurality of data signals, wherein identification of the at least one first data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one alarm data; and
   wherein, the output unit is configured to output the at least one first data signal.

2. Apparatus according to claim 1, wherein, the processing unit is configured to determine a plurality of correlation scores for pairs of data signals of the plurality of data signals, wherein a correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score; wherein the processing unit is utilized to identify at least one second data signal of the plurality of data signals, the identification comprising utilization of the correlation scores for the identified at least one first data signal paired with the plurality of data signals, wherein identification of the at least one second data signal comprises a determination of one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one first data signal; and wherein the output unit is configured to output the at least one second data.

3. Apparatus according to claim 2, wherein the output unit is configured to output the one or more data signals, wherein the input unit is configured to enable a user to select at least one data signal of the one or more data signals, and wherein the identified at least one second data signal is the at least one data signal selected by the user.

4. Apparatus according to any of claims 2-3, wherein the processing unit is utilized to identify at least one second alarm data from the plurality of alarm data, the identification comprising utilization of the correlation scores for the identified at least one second data signal paired with the plurality of alarm data, wherein identification of the at least one second alarm data comprises a determination of one or more alarm data of the plurality of alarm data that have the highest correlation scores when paired with the identified at least one second data signal; and wherein the output unit is configured to output the at least one second alarm data.

5. Apparatus according to claim 4, wherein the output unit is configured to output the one or more alarm data, wherein the input unit is configured to enable a user to select at least one alarm data of the one or more alarm data, and wherein the identified at least one second alarm data is the at least one alarm data selected by the user.

6. Apparatus according to any of claims 1-5, wherein the plurality of alarm data are stored in a database, and wherein the query term is utilized to identify the at least one first alarm data.

7. A method (100) for alarm information determination, comprising:

   a) providing (110) a processing unit with historical process control data from an input unit,

wherein the process control data comprises a plurality of data signals, a plurality of alarm data and data relating to an event of interest, wherein the data relating to the event of interest comprises a user input query term;

b) determining (120) by the processing unit a plurality of correlation scores for the plurality of data signals paired with the plurality of alarm data, wherein a correlation score is determined for a data signal paired with an alarm data and wherein a high score indicates a higher degree of correlation than a low score;

c) identifying (130) by the processing unit at least one first alarm data from the plurality of alarm data, the identification comprising utilization of the data relating to the event of interest, wherein the identification comprises utilization of the query term;

d) identifying (140) at least one first data signal from the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least one first alarm data paired with the plurality of data signals, wherein the identifying comprises determining one or more data signals of the plurality of data signals that have the highest correlation scores when paired with the at least one alarm data; and

h) outputting (150) by an output unit the at least one first data signal.

8. Method according to claim 7, wherein the method further comprises step e) determining (160) by the processing a plurality of correlation scores for pairs of data signals of the plurality of data signals, wherein a correlation score is determined for different pairs of data signals, wherein a high score indicates a higher degree of correlation between a pair of data signals than a low score; and wherein the method comprises step f) identifying (170) at least one second data signal of the plurality of data signals, the identification comprising the processing unit utilizing the correlation scores for the identified at least one first data signal paired with the plurality of data signals; and wherein step h) comprises outputting the at least one second data.

9. Method according to any of claims 7-8, wherein the method further comprises step g) identifying (180) at least one second alarm data from the plurality of alarm data, the identification comprising the processing utilizing the correlation scores for the identified at least one second data signal paired with the plurality of alarm data; and wherein step h) comprises outputting the at least one second alarm data.

10. A computer program product for controlling an apparatus according to any one of claims 1 to 6, the computer program product comprising instructions that when executed by the apparatus allows it to carry out the method of any of claims 7-9.

Patentansprüche

1. Vorrichtung (10) zum Bestimmen von Alarminformationen, Folgendes umfassend:

- eine Eingabeeinheit (20);
- eine Verarbeitungseinheit (30); und
- eine Ausgabeeinheit (40);

dadurch gekennzeichnet, dass

die Eingabeeinheit dazu ausgebildet ist, der Verarbeitungseinheit historische Prozesssteuerungsdaten bereitzustellen, wobei die Prozesssteuerungsdaten eine Vielzahl von Datensignalen, eine Vielzahl von Alarmdaten und Daten bezüglich eines Ereignisses von Interesse aufweisen, wobei die Daten, die sich auf das Ereignis von Interesse beziehen, einen vom Benutzer eingegebenen Abfragebegriff aufweisen;

wobei die Verarbeitungseinheit dazu ausgebildet ist, eine Vielzahl von Korrelationswerten für die Vielzahl von Datensignalen, die mit der Vielzahl von Alarmdaten gepaart sind, zu bestimmen, wobei ein Korrelationswert für ein Datensignal bestimmt wird, das mit einem Alarmdatensatz gepaart ist, und wobei ein hoher Wert ein höheres Maß an Korrelation angibt als ein niedriger Wert;

wobei die Verarbeitungseinheit dazu ausgebildet ist, mindestens einen ersten Alarmdatensatz aus der Vielzahl von Alarmdaten zu identifizieren, wobei die Identifizierung die Verwendung der Daten bezüglich des Ereignisses von Interesse beinhaltet, wobei die Verarbeitungseinheit dazu ausgebildet ist, den Abfragebegriff zu verwenden, um den mindestens einen ersten Alarmdatensatz zu identifizieren;

wobei die Verarbeitungseinheit eingerichtet ist, um mindestens ein erstes Datensignal aus der Vielzahl von Datensignalen zu identifizieren, wobei die Identifizierung die Verwendung der Korrelationswerte für den identifizierten mindestens einen ersten Alarmdatensatz beinhaltet, der mit der Vielzahl von Datensignalen gepaart ist, wobei die Identifizierung des mindestens einen ersten Datensignals eine Bestimmung eines oder mehrerer Datensignale aus der Vielzahl von Datensignalen umfasst, die die höchsten Korrelationswerte aufweisen, wenn sie mit dem mindestens einen Alarm-

datensatz gepaart sind; und
wobei die Ausgabeeinheit dazu ausgebildet ist, das mindestens eine erste Datensignal auszugeben.

2. Vorrichtung gemäß Anspruch 1, wobei die Verarbeitungseinheit dazu ausgebildet ist, eine Vielzahl von Korrelationswerten für Paare von Datensignalen der Vielzahl von Datensignalen zu bestimmen, wobei ein Korrelationswert für verschiedene Paare von Datensignalen bestimmt wird, wobei ein hoher Wert ein höheres Maß an Korrelation zwischen einem Paar von Datensignalen angibt als ein niedriger Wert; wobei die Verarbeitungseinheit verwendet wird, um mindestens ein zweites Datensignal der Vielzahl von Datensignalen zu identifizieren, wobei die Identifizierung die Verwendung der Korrelationswerte für das identifizierte mindestens eine erste Datensignal beinhaltet, das mit der Vielzahl von Datensignalen gepaart ist, wobei die Identifizierung des mindestens einen zweiten Datensignals eine Bestimmung eines oder mehrerer Datensignale aus der Vielzahl von Datensignalen umfasst, die die höchsten Korrelationswerte aufweisen, wenn sie mit dem mindestens einen ersten Datensignal gepaart sind; und wobei die Ausgabeeinheit dazu ausgebildet ist, den mindestens einen zweiten Datensatz auszugeben.

3. Vorrichtung gemäß Anspruch 2, wobei die Ausgabeeinheit dazu ausgebildet ist, die ein oder mehreren Datensignale auszugeben, wobei die Eingabeeinheit so ausgebildet ist, dass sie es einem Benutzer ermöglicht, mindestens ein Datensignal aus den ein oder mehreren Datensignalen auszuwählen, und wobei das identifizierte mindestens eine zweite Datensignal das von dem Benutzer ausgewählte mindestens eine Datensignal ist.

4. Vorrichtung gemäß einem der Ansprüche 2-3, wobei die Verarbeitungseinheit verwendet wird, um mindestens einen zweiten Alarmdatensatz aus der Vielzahl von Alarmdaten zu identifizieren, wobei die Identifizierung die Verwendung der Korrelationswerte für das identifizierte mindestens eine zweite Datensignal beinhaltet, das mit der Vielzahl von Alarmdaten gepaart ist, wobei die Identifizierung des mindestens einen zweiten Alarmdatensatzes eine Bestimmung eines oder mehrerer Alarmdatensätze aus der Vielzahl von Alarmdatensätzen beinhaltet, die die höchsten Korrelationswerte aufweisen, wenn sie mit dem identifizierten mindestens einen zweiten Datensignal gepaart sind; und wobei die Ausgabeeinheit dazu ausgebildet ist, den mindestens einen zweiten Alarmdatensatz auszugeben.

5. Vorrichtung gemäß Anspruch 4, wobei die Ausgabeeinheit dazu ausgebildet ist, die ein oder mehreren Alarmdatensätze auszugeben, wobei die Eingabeeinheit so ausgebildet ist, dass sie es einem Benutzer ermöglicht, mindestens einen Alarmdatensatz der ein oder mehreren Alarmdatensätze auszuwählen, und wobei der identifizierte mindestens eine zweite Alarmdatensatz der von dem Benutzer ausgewählte mindestens eine Alarmdatensatz ist.

6. Vorrichtung gemäß einem der Ansprüche 1-5, wobei die Vielzahl von Alarmdaten in einer Datenbank gespeichert ist, und wobei der Abfragebegriff verwendet wird, um den mindestens einen ersten Alarmdatensatz zu identifizieren.

7. Verfahren (100) zur Bestimmung von Alarminformationen, Folgendes umfassend:

a) Bereitstellen (110) von historischen Prozesssteuerungsdaten von einer Eingabeeinheit an eine Verarbeitungseinheit, wobei die Prozesssteuerungsdaten eine Vielzahl von Datensignalen, eine Vielzahl von Alarmdaten und Daten bezüglich eines Ereignisses von Interesse aufweisen, wobei die Daten, die sich auf das Ereignis von Interesse beziehen, einen vom Benutzer eingegebenen Abfragebegriff aufweisen;
b) Bestimmen (120), durch die Verarbeitungseinheit, einer Vielzahl von Korrelationswerten für die Vielzahl von Datensignalen, die mit der Vielzahl von Alarmdaten gepaart sind, wobei ein Korrelationswert für ein Datensignal bestimmt wird, das mit einem Alarmdatensatz gepaart ist, und wobei ein hoher Wert ein höheres Maß an Korrelation angibt als ein niedriger Wert;
c) Identifizieren (130), durch die Verarbeitungseinheit, von mindestens einem ersten Alarmdatensatz aus der Vielzahl von Alarmdatensätzen, wobei die Identifizierung die Verwendung der Daten bezüglich des Ereignisses von Interesse beinhaltet, wobei die Identifizierung die Verwendung des Abfragebegriffs beinhaltet;
d) Identifizieren (140) mindestens eines ersten Datensignals aus der Vielzahl von Datensignalen, wobei die Identifizierung beinhaltet, dass die Verarbeitungseinheit die Korrelationswerte für den identifizierten mindestens einen ersten Alarmdatensatz, der mit der Vielzahl von Datensignalen gepaart ist, verwendet,
wobei das Identifizieren das Bestimmen eines oder mehrerer Datensignale aus der Vielzahl der Datensignale beinhaltet, die die höchsten Korrelationswerte aufweisen, wenn sie mit dem mindestens einen Alarmdatensatz gepaart sind; und
h) Ausgeben (150), durch eine Ausgabeeinheit, des mindestens einen ersten Datensignals.

8. Verfahren gemäß Anspruch 7, wobei das Verfahren ferner Schritt e) umfasst:

Bestimmen (160), durch die Verarbeitung, einer Vielzahl von Korrelationswerten für Paare von Datensignalen der Vielzahl von Datensignalen, wobei ein Korrelationswert für verschiedene Paare von Datensignalen bestimmt wird, wobei ein hoher Wert ein höheres Maß an Korrelation zwischen einem Paar von Datensignalen angibt als ein niedriger Wert; und wobei das Verfahren Schritt f) umfasst: Identifizieren (170) mindestens eines zweiten Datensignals aus der Vielzahl von Datensignalen, wobei die Identifizierung beinhaltet, dass die Verarbeitungseinheit die Korrelationswerte für das identifizierte mindestens eine erste Datensignal, das mit der Vielzahl von Datensignalen gepaart ist, verwendet; und wobei Schritt h) das Ausgeben des mindestens einen zweiten Datensatzes beinhaltet.

9. Verfahren gemäß einem der Ansprüche 7-8, wobei das Verfahren ferner Schritt g) umfasst:
Identifizieren (180) mindestens eines zweiten Alarmdatensatzes aus der Vielzahl von Alarmdatensätzen, wobei die Identifizierung die Verarbeitung unter Verwendung der Korrelationswerte für das identifizierte mindestens eine zweite Datensignal, das mit der Vielzahl von Alarmdatensätzen gepaart ist, beinhaltet; und wobei Schritt h) das Ausgeben des mindestens einen zweiten Alarmdatensatzes beinhaltet.

10. Computerprogrammprodukt zum Steuern einer Vorrichtung gemäß einem der Ansprüche 1 bis 6, wobei das Computerprogrammprodukt Anweisungen aufweist, die, wenn sie von der Vorrichtung ausgeführt werden, es ihr ermöglichen, das Verfahren nach einem der Ansprüche 7 bis 9 auszuführen.

Revendications

1. Appareil (10) de détermination d'informations d'alarme, comprenant :

une unité d'entrée (20) ;
une unité de traitement (30) ; et
une unité de sortie (40) ;
caractérisé en ce que
l'unité d'entrée est configurée pour fournir à l'unité de traitement des données de commande de traitement historiques, dans lequel les données de commande de traitement comprennent une pluralité de signaux de données, une pluralité de données d'alarme et des données relatives à un événement d'intérêt, dans lequel les données relatives à l'événement d'intérêt comprennent un terme d'interrogation fourni en entrée par l'utilisateur ; dans lequel l'unité de traitement est configurée pour déterminer une pluralité de notes de corrélation pour la pluralité de signaux de données appariés avec la pluralité de données d'alarme, dans lequel une note de corrélation est déterminée pour un signal de données apparié avec une donnée d'alarme et dans lequel une note élevée indique un degré de corrélation plus élevé qu'une note faible ;
dans lequel l'unité de traitement est configurée pour identifier au moins une première donnée d'alarme parmi la pluralité de données d'alarme, l'identification comprenant l'utilisation des données relatives à l'événement d'intérêt, dans lequel l'unité de traitement est configurée pour utiliser le terme d'interrogation pour identifier ladite au moins une première donnée d'alarme ;
dans lequel l'unité de traitement est conçue pour identifier au moins un premier signal de données parmi la pluralité de signaux de données, l'identification comprenant l'utilisation des notes de corrélation pour ladite au moins une première donnée d'alarme identifiée appariée avec la pluralité de signaux de données, dans lequel l'identification dudit au moins un premier signal de données comprend une détermination d'un ou plusieurs signaux de données de la pluralité de signaux de données qui ont les notes de corrélation les plus élevées lorsqu'ils sont appariés avec ladite au moins une donnée d'alarme ; et
dans lequel l'unité de sortie est configurée pour fournir en sortie ledit au moins un premier signal de données.

2. Appareil selon la revendication 1, dans lequel l'unité de traitement est configurée pour déterminer une pluralité de notes de corrélation pour des paires de signaux de données de la pluralité de signaux de données, dans lequel une note de corrélation est déterminée pour différentes paires de signaux de données, dans lequel une note élevée indique un degré plus élevé de corrélation entre une paire de signaux de données qu'une note faible ; dans lequel l'unité de traitement est utilisée pour identifier au moins un second signal de données de la pluralité de signaux de données, l'identification comprenant l'utilisation des notes de corrélation pour ledit au moins un premier signal de données identifié apparié avec la pluralité de signaux de données, dans lequel l'identification dudit au moins un second signal de données comprend une détermination d'un ou plusieurs signaux de données de la pluralité de signaux de données qui ont les notes de corrélation les plus élevées lorsqu'ils sont appariés avec ledit au moins un premier signal de données ; et dans lequel l'unité de sortie est configurée pour fournir en sortie ledit au moins un second signal de données.

3. Appareil selon la revendication 2, dans lequel l'unité de sortie est configurée pour fournir en sortie lesdits un ou plusieurs signaux de données, dans lequel l'unité d'entrée est configurée pour permettre à un

utilisateur de sélectionner au moins un signal de données parmi lesdits un ou plusieurs signaux de données, et dans lequel ledit au moins un second signal de données identifié est ledit au moins un signal de données sélectionné par l'utilisateur.

4. Appareil selon l'une quelconque des revendications 2-3, dans lequel l'unité de traitement est utilisée pour identifier au moins une seconde donnée d'alarme parmi la pluralité de données d'alarme, l'identification comprenant l'utilisation des notes de corrélation pour ledit au moins un second signal de données identifié apparié avec la pluralité de données d'alarme, dans lequel l'identification de ladite au moins une seconde donnée d'alarme comprend une détermination d'une ou plusieurs données d'alarme de la pluralité de données d'alarme qui ont les notes de corrélation les plus élevées lorsqu'elles sont appariées avec ledit au moins un second signal de données identifié ; et dans lequel l'unité de sortie est configurée pour fournir en sortie ledit au moins un second signal d'alarme.

5. Appareil selon la revendication 4, dans lequel l'unité de sortie est configurée pour fournir en sortie lesdites une ou plusieurs données d'alarme, dans lequel l'unité d'entrée est configurée pour permettre à un utilisateur de sélectionner au moins une donnée d'alarme parmi lesdites une ou plusieurs données d'alarme, et dans lequel ladite au moins une seconde donnée d'alarme identifiée est ladite au moins une donnée d'alarme sélectionnée par l'utilisateur.

6. Appareil selon l'une quelconque des revendications 1-5, dans lequel la pluralité de données d'alarme est stockée dans une base de données, et dans lequel le terme d'interrogation est utilisé pour identifier ladite au moins une première donnée d'alarme.

7. Procédé (100) de détermination d'informations d'alarme, comprenant :

a) la fourniture (110) à une unité de traitement de données de commande de traitement historiques provenant d'une unité d'entrée, dans lequel les données de commande de traitement comprennent une pluralité de signaux de données, une pluralité de données d'alarme et des données relatives à un événement d'intérêt, dans lequel les données relatives à l'événement d'intérêt comprennent un terme d'interrogation fourni en entrée par l'utilisateur ;

b) la détermination (120) par l'unité de traitement d'une pluralité de notes de corrélation pour la pluralité de signaux de données appariés avec la pluralité de données d'alarme, dans lequel une note de corrélation est déterminée pour un signal de données apparié avec une donnée d'alarme et dans lequel une note élevée indique un degré de corrélation plus élevé qu'une note faible ;

c) l'identification (130) par l'unité de traitement d'au moins une première donnée d'alarme parmi la pluralité de données d'alarme, l'identification comprenant l'utilisation des données relatives à l'événement d'intérêt, dans lequel l'identification comprend l'utilisation du terme d'interrogation ;

d) l'identification (140) d'au moins un premier signal de données parmi la pluralité de signaux de données, l'identification comprenant l'utilisation par l'unité de traitement des notes de corrélation pour ladite au moins une première donnée d'alarme identifiée appariée avec la pluralité de signaux de données,

dans lequel l'identification comprend la détermination d'un ou plusieurs signaux de données de la pluralité de signaux de données qui ont les notes de corrélation les plus élevées lorsqu'ils sont appariés avec ladite au moins une donnée d'alarme ; et

h) la fourniture en sortie (150) par une unité de sortie dudit au moins un premier signal de données.

8. Procédé selon la revendication 7, dans lequel le procédé comprend en outre l'étape e)

de détermination (160) par le traitement d'une pluralité de notes de corrélation pour des paires de signaux de données de la pluralité de signaux de données, dans lequel une note de corrélation est déterminée pour différentes paires de signaux de données, dans lequel une note élevée indique un degré plus élevé de corrélation entre une paire de signaux de données qu'une note faible ; et dans lequel le procédé comprend l'étape f) d'identification (170) d'au moins un second signal de données de la pluralité de signaux de données, l'identification comprenant l'utilisation par l'unité de traitement des notes de corrélation pour ledit au moins un premier signal de données identifié apparié avec la pluralité de signaux de données ; et dans lequel l'étape h) comprend la fourniture en sortie dudit au moins un second signal de données.

9. Procédé selon l'une quelconque des revendications 7-8, dans lequel le procédé comprend en outre l'étape g) d'identification (180) d'au moins une seconde donnée d'alarme parmi la pluralité de données d'alarme, l'identification comprenant le traitement utilisant les notes de corrélation pour ledit au moins un second signal de données identifié apparié avec la pluralité de données d'alarme ; et dans lequel l'étape h) comprend la fourniture en sortie de ladite au moins une seconde donnée d'alarme.

10. Produit de programme informatique destiné à commander un appareil selon l'une quelconque des revendications 1 à 6, le produit de programme informatique comprenant des instructions qui, lorsqu'elles sont exécutées par l'appareil, lui permettent de mettre en œuvre le procédé selon l'une quelconque des revendications 7-9.

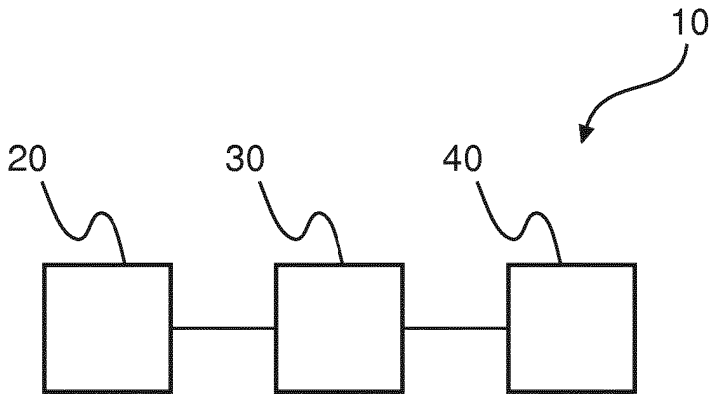


Fig. 1

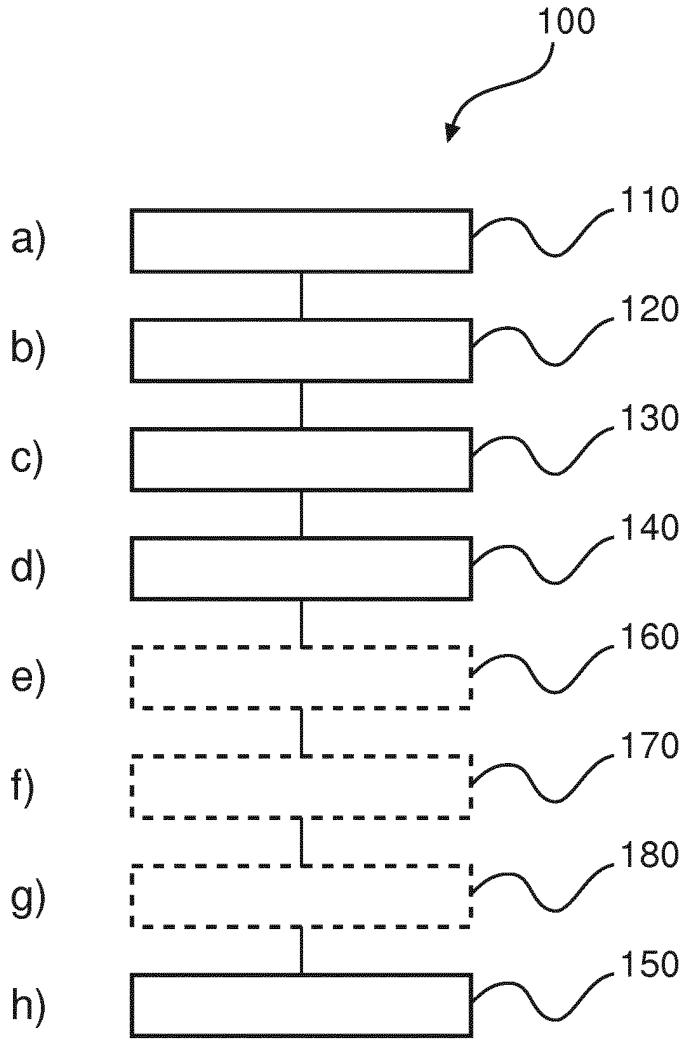


Fig. 2

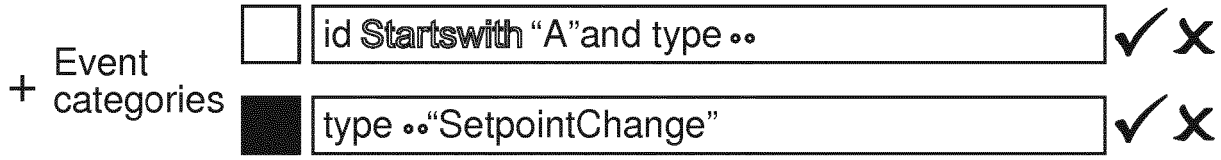

+ Event categories
id Startswith "A"and type ••
type ••"SetpointChange"

Fig. 3

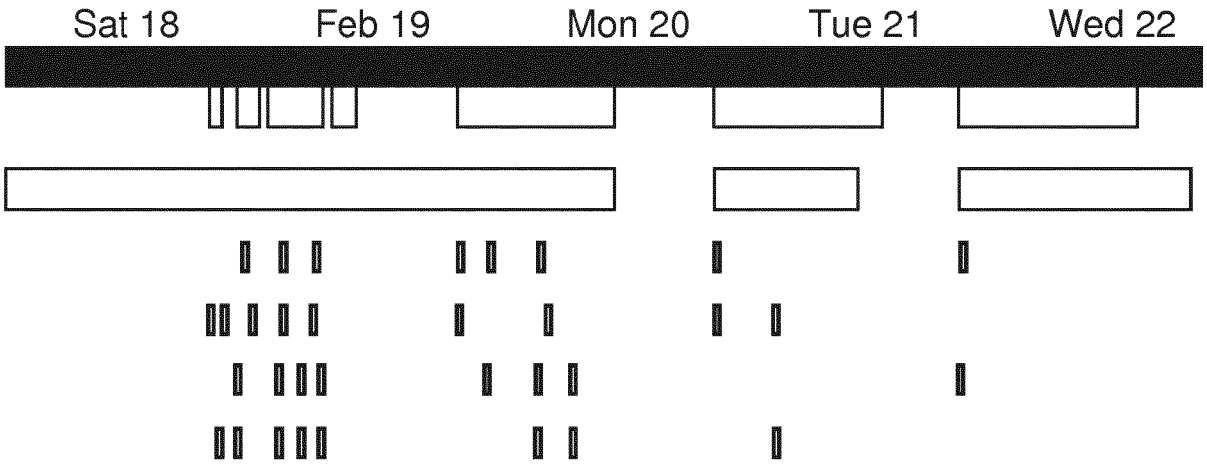
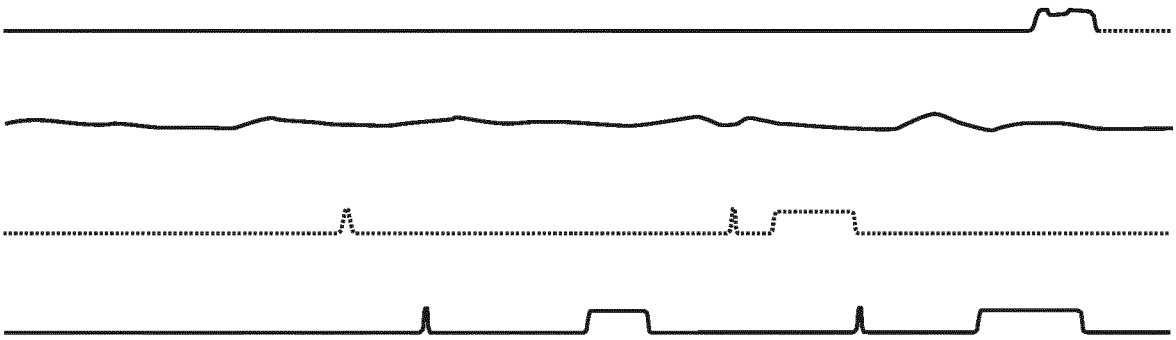

Sat 18
Feb 19
Mon 20
Tue 21
Wed 22

Fig. 4

Diagrams
Signal trends of interest (clustered)



Signal trends of interest (expanded)

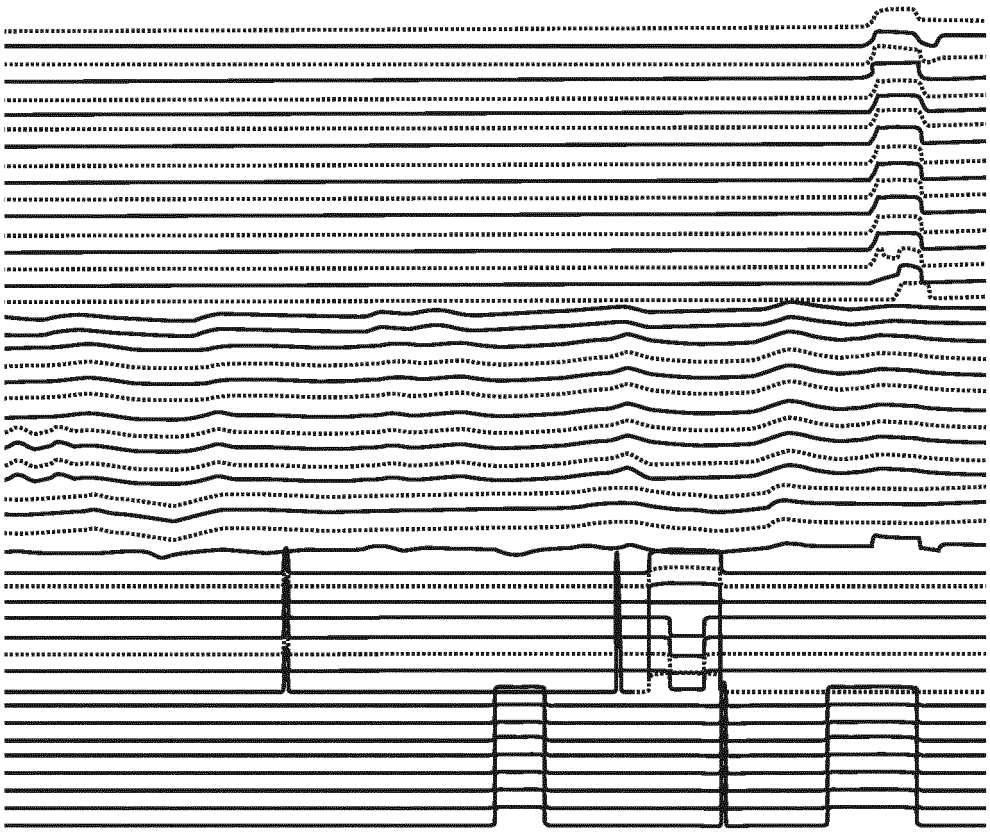


Fig. 5

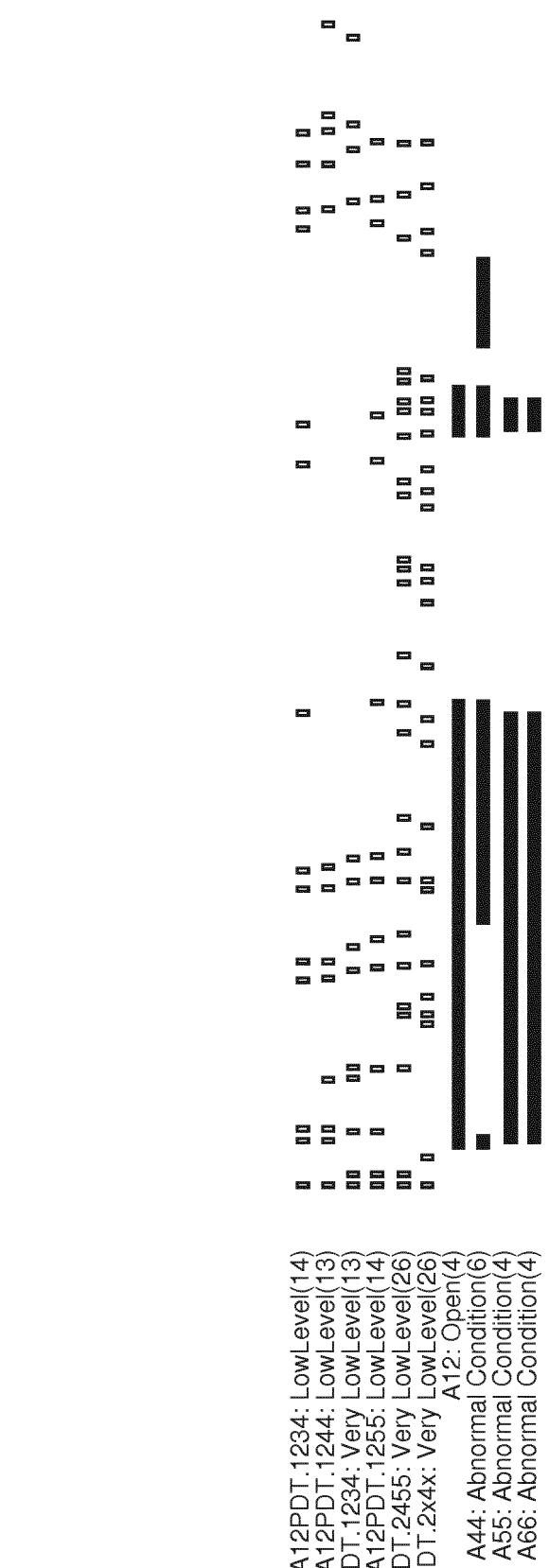

A12PDT.1234: LowLevel(14)
A12PDT.1244: LowLevel(13)
A12PDT.1234: Very LowLevel(13)
A12PDT.1255: LowLevel(14)
A12PDT.2455: Very LowLevel(26)
A12PDT.2x4x: Very LowLevel(26)
A12: Open(4)
A44: Abnormal Condition(6)
A55: Abnormal Condition(4)
A66: Abnormal Condition(4)

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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- **FAN YANG et al.** Improved correlation analysis and visualization of industrial alarm data. *ISA transactions,* 2012, vol. 51.4, 499-506 **[0063]**