DESCRIPTION

Title of Invention

DISPLAY DEVICE, DISPLAY METHOD, CONTROL DEVICE, AND COMPUTER PROGRAM

Technical Field

[0001]

The present invention relates to a display device, a display method, a control device, and a computer program.

Background Art

[0002]

In the related art, a sensor has been provided in a target to be monitored such as a plant to monitor an operating status of target equipment to be monitored based on data acquired by the sensor.

[0003]

PTL 1 discloses an online monitoring device that can reduce labor in a screen operation work for checking a state of a target to be monitored. The online monitoring device includes image display information generation means for determining a screen to be displayed from a plurality of screen candidates.

Citation List

Patent Literature

[0004]

[PTL 1] Japanese Unexamined Patent Publication No. 2018-106432

Summary of Invention

Technical Problem

[0005]

In a case where abnormality has occurred in the target to be monitored, a warning is issued. In order to examine validity of the warning, an operator views a graph generated based on the data acquired from the sensor.

[0006]

However, since the online monitoring device disclosed in PTL 1 displays information required for implementation of an "equivalent measure to a skilled person by an inexperienced operator" on a screen by "automatically selecting" the information ([Technical Problem]), a long time is required to check graphs in a case where there is a large number of graphs to be displayed. For example, even a skilled operator has to view the same graph as the inexperienced operator.

[0007]

In order to reduce the number of graphs to be displayed, setting a representative graph to be displayed for each warning in advance may be considered. However, in a case where a graph to be displayed for each warning is confirmed, a graph that is supposed to be checked may be excluded from a target to be checked. For example, the inexperienced operator may overlook a graph that has to be checked.

[0008]

Therefore, an object of the present invention is to provide a display device, a display method, a control device, and a computer program that enable efficient checking of a graph to be checked.

Solution to Problem

[0009]

The present disclosure provides a display device configured to, based on a history of a graph viewed at a time of a warning generated in the past, display selection options of a graph to be viewed at a time of a warning, and display the selected graph.

[0010]

The selection options may be displayed together with a description of at least one graph associated with the warning.

[0011]

The selection options may be displayed based on the number of times the graph viewed at the time of the warning generated in the past is displayed.

[0012]

Furthermore, the selection options may be displayed based on a learning model that is generated using the warning generated in the past and the history of the graph viewed at the time of the warning as training data.

[0013]

The present disclosure provides a display method including a step of displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning, and a step of displaying the selected graph.

[0014]

In addition, the present disclosure provides a control device including means for displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning on a display device, and means for displaying the selected graph on the display device.

[0015]

In addition, the present disclosure provides a computer program causing a computer to execute a step of

displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning on a display device, and a step of displaying the selected graph on the display device.

[0016]

The computer program is executed by a computer including a processor, such as the control device illustrated in the present embodiment. The computer program may be recorded on a recording medium such as a non-volatile semiconductor memory in a non-transitory form.

Brief Description of Drawings

[0017]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant according to an embodiment of the present invention.

Fig. 2 is a functional block diagram of an operation support system.

Fig. 3A is an example of information stored in an alarm setting DB.

Fig. 3B is an example of information stored in a graph setting DB.

Fig. 3C is an example of information stored in a graph viewing history DB.

Fig. 3D is an example of guide information.

Fig. 4 is an example of a graph recommendation list.

Fig. 5 is an example of a display screen of a display device.

Fig. 6 is an example of a physical configuration of the operation support system.

Fig. 7 is an example of a flowchart of a display method.

Description of Embodiments

[0018]

Hereinafter, an embodiment of the present invention will be described using the drawings. The following embodiment is an illustration for describing the present invention, and the present invention is not intended to be limited to only the embodiment.

A target to be monitored to which the present invention is applied includes a plant. For example, a plant such as a power generation plant including a boiler, an incineration plant, a chemical plant, or a wastewater treatment plant in which process data can be acquired is targeted. In addition to the illustration of the process data in the power generation plant described in the following embodiment, the process data in the incineration plant of a waste or the like includes, for example, an

input air amount and an input air temperature of an incineration furnace, a gas temperature and composition factors of a furnace outlet, and measurement data such as a temperature, a pressure, a flow rate, and a combustion state of each part measured by a sensor or the like. The process data in the chemical plant includes, for example, a difference in temperature between processes or between two or more thermocouples, an operation pressure, a product flow parameter (a velocity, density, or the like), a flow rate of cooling water, an output measurement value, and valve sensor data. The process data in the wastewater treatment plant includes, for example, raw water input and output flow rates of a tank, a water level, processed water quality, and manipulated variables of device operation of various pumps and the like output from each sensor and from each electricity meter.

[0019]

[Description of Plant]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant 1 that is an example of the target to be monitored to which the present invention is applied. For example, the plant 1 according to the present embodiment is a power generation plant including a circulating fluidized bed boiler (circulating fluidized bed type) that generates vapor by combusting fuel while

circulating a circulation material such as silica sand that is fluidized at a high temperature. As the fuel of the plant 1, not only fossil fuel such as coal but also, for example, non-fossil fuel (woody biomass, waste tires, waste plastic, sludge, or the like) can be used. The vapor generated in the plant 1 is used for driving a turbine 100.

[0020]

The plant 1 is configured to combust the fuel in a furnace 2, separate the circulation material from exhaust gas via a cyclone 3 that functions as a solid-gas separation device, and return the separated circulation material to the furnace 2 to be circulated. The separated circulation material is sent back to a lower part of the furnace 2 via a circulation material recovery pipe 4 connected to a part below the cyclone 3. A lower part of the circulation material recovery pipe 4 and the lower part of the furnace 2 are connected through a loop seal part 4a in which a flow path is narrowed. Accordingly, the lower part of the circulation material recovery pipe 4 is in a state where a predetermined amount of the circulation material is stored. The exhaust gas in which the circulation material is removed by the cyclone 3 is supplied to a rear flue 5 via an exhaust gas flow path 3a.

[0021]

The boiler includes the furnace 2 for combusting the fuel and a heat exchanger for generating water vapor or the like using heat obtained by combustion. A fuel feed port 2a through which the fuel is supplied is provided in a middle part of the furnace 2. A gas outlet 2b through which combustion gas is exhausted is provided in an upper part of the furnace 2. The fuel that is supplied to the furnace 2 from a fuel supply device, not illustrated, is supplied to the inside of the furnace 2 through the fuel feed port 2a. In addition, a furnace wall pipe 6 for heating boiler feedwater is provided in a furnace wall of the furnace 2. The boiler feedwater that flows through the furnace wall pipe 6 is heated by combustion in the furnace 2.

[0022]

In the furnace 2, a solid matter including the fuel supplied from the fuel feed port 2a is fluidized by air for combustion and fluidization introduced from an air supply line 2c in the lower part, and the fuel is combusted at, for example, approximately 800°C to 900°C while being fluidized. The combustion gas generated in the furnace 2 is introduced into the cyclone 3 with the circulation material. The cyclone 3 separates the circulation material and gas from each other based on a centrifugal effect, returns the separated circulation material to the furnace 2 through the circulation material recovery pipe 4, and sends

the combustion gas in which the circulation material is removed to the rear flue 5 from the exhaust gas flow path 3a.

[0023]

In the furnace 2, a part of the circulation material called an in-furnace bed material remains in a bottom part. The bed material may include a bed material or an exhaust impurity having a coarse particle size not suitable for circulation and fluidization. These bed materials not suitable as the circulation material may cause a fluidization failure. Thus, in order to suppress the fluidization failure, the in-furnace bed material is continuously or intermittently exhausted to the outside from an exhaust port 2d in the bottom part in the furnace 2. Metal or an unsuitable material having a coarse large particle size or the like is removed from the exhausted bed material on a circulation line, not illustrated. Then, the bed material is either supplied to the furnace 2 again or discarded. The circulation material of the furnace 2 circulates in a circulation system configured with the furnace 2, the cyclone 3, and the circulation material recovery pipe 4.

[0024]

The rear flue 5 has a flow path through which the gas exhausted from the cyclone 3 flows to a rear stage. The

rear flue 5 includes, as an exhaust heat collection unit that collects heat of the exhaust gas, a superheater 10 that generates superheated vapor, and a coal economizer 12 that preheats the boiler feedwater. The exhaust gas flowing through the rear flue 5 is cooled by exchanging heat with the vapor or the boiler feedwater flowing through the superheater 10 and the coal economizer 12. In addition, a steam drum 8 in which the boiler feedwater that has passed through the coal economizer 12 is stored is provided. The steam drum 8 is also connected to the furnace wall pipe 6.

[0025]

The coal economizer 12 preheats the boiler feedwater by transferring the heat of the exhaust gas to the boiler feedwater. The coal economizer 12 is connected to a pump 7 by a pipe 21 and is connected to the steam drum 8 by a pipe 22. The boiler feedwater that is supplied to the coal economizer 12 from the pump 7 via the pipe 21 and that is preheated by the coal economizer 12 is supplied to the steam drum 8 via the pipe 22.

[0026]

A downcast pipe 8a and the furnace wall pipe 6 are connected to the steam drum 8. The boiler feedwater in the steam drum 8 moves down through the downcast pipe 8a to be introduced into the furnace wall pipe 6 on a lower part side of the furnace 2 and then, flows toward the steam drum

8. The boiler feedwater in the furnace wall pipe 6 is heated by combustion heat generated in the furnace 2 and evaporates into vapor in the steam drum 8.

[0027]

A saturated vapor pipe 8b through which the vapor inside the steam drum 8 is exhausted is connected to the steam drum 8. The saturated vapor pipe 8b connects the steam drum 8 to the superheater 10. The vapor in the steam drum 8 is supplied to the superheater 10 via the saturated vapor pipe 8b. The superheater 10 generates the superheated vapor by superheating the vapor using the heat of the exhaust gas. The superheated vapor is supplied to the turbine 100 outside the plant 1 through a pipe 10a and is used for power generation.

[0028]

A pressure and a temperature of the vapor exhausted from the turbine 100 are lower than a pressure and a temperature of the vapor exhausted from the superheater 10. The pressure and the temperature of the vapor supplied to the turbine 100 are not particularly limited and are approximately 10 to 17 MPa and approximately 530°C to 570°C, respectively. The pressure and the temperature of the vapor exhausted from the turbine 100 are approximately 3 to 5 MPa and approximately 350°C to 400°C, respectively.

[0029]

A condenser 102 is provided downstream of the turbine 100. The vapor exhausted from the turbine 100 is supplied to the condenser 102 to be condensed into saturated water in the condenser 102 and then, is supplied to the pump 7. A generator that converts kinetic energy obtained by rotation of the turbine 100 into electrical energy is connected to the turbine 100.

[0030]

A pump 7a supplies makeup water in order to constantly maintain a water level of the condenser 102. In Fig. 1, a makeup water flow rate u1 (an example of "process data") supplied by the pump 7a is illustrated.

[0031]

The process data handled in the present embodiment may be arbitrary data related to the plant 1. For example, the process data may be data (an example of the "process data") obtained by measuring a state of the plant 1 via a sensor and, more specifically, may include a measurement value such as a temperature, a pressure, and a flow rate of the plant 1. In Fig. 1, a boiler feedwater flow rate u2 (an example of the "process data") supplied to the coal economizer 12 from the pump 7 is illustrated. Furthermore, in Fig. 1, a boiler outlet vapor flow rate u3 (an example of the "process data") supplied to the turbine 100 from the superheater 10 is illustrated, and a saturated vapor flow

rate u4 (an example of the "process data") supplied to the superheater 10 from the steam drum 8 is illustrated. The makeup water flow rate u1 may be controlled in accordance with the saturated vapor flow rate u4. In addition, the boiler feedwater flow rate u2 may be controlled to be adjusted while both of the boiler outlet vapor flow rate u3 (or a superheated vapor flow rate) and a liquid surface level of the steam drum 8 are monitored.

[0032]

In a case where a hole has occurred in a pipe system constituting the plant 1, the makeup water flow rate u1 rises, or a difference in flow rate between the boiler feedwater flow rate u2 and the boiler outlet vapor flow rate u3 is increased. A distributed control system (DCS; Fig. 2) 20 receives the process data of the plant 1 such as the makeup water flow rate u1, the boiler feedwater flow rate u2, the boiler outlet vapor flow rate u3, and the saturated vapor flow rate u4 from the plant 1 to monitor an operating status of the plant 1 and to monitor whether or not abnormality has occurred in the plant 1. As will be described later, a monitoring device 40 evaluates the process data based on an alarm determination logic set for each type of abnormality and, in a case where it is determined that abnormality has occurred, causes a display device 40 to issue an alarm.

[0033]

While the makeup water flow rate u1, the boiler feedwater flow rate u2, the boiler outlet vapor flow rate u3, and the saturated vapor flow rate u4 are illustrated as the process data, the process data related to the plant 1 may be other data. The process data related to the plant 1 may be other data such as a temperature and a pressure or data calculated based on a plurality of pieces of the process data, or may be data that is acquired from the sensor or the like and that is not obtained by calculation processing.

[0034]

Fig. 2 is a functional block diagram of the plant 1, the DCS 20, and an operation support system 30 according to the present embodiment.

[0035]

The DCS 20 is a distributed control system for controlling the plant 1. The DCS 20 acquires the process data from the sensor or the like installed in the plant 1 and supplies a control signal for controlling the plant 1 based on the process data to the plant 1.

[0036]

The operation support system 30 includes an edge/cloud computing unit 32 that acquires the process data from the DCS 20, the monitoring device 40 that acquires the process

data from the edge/cloud computing unit 32 and that monitors the plant 1 based on the process data, and the display device 50 that displays the operating status of the plant 1 for an operator. The monitoring device 40 (an example of a "control device") also functions as a control device that controls the display device 50. Specifically, the monitoring device 40 acquires the process data, determines whether or not abnormality is present based on the process data, and in a case where it is determined that abnormality has occurred, causes the display device 50 to issue an alarm (an example of a "warning"). In issuing the alarm, the monitoring device 40 acquires information such as guide information (described later) to be displayed in issuing the alarm from a database, described later, and displays the information on a display screen of the display device 50.

[0037]

The edge/cloud computing unit 32 includes a plurality of edge servers that are distributedly disposed in an edge part of a network, and a cloud data server that collects the process data from the plurality of edge servers and that provides the process data to the monitoring device 40. By including the edge/cloud computing unit 32, the process data can be suitably collected from a large-scale monitoring device or from a plurality of distributed

monitoring devices. However, the operation support system 30 may not include the edge/cloud computing unit 32. In this case, the operation support system 30 acquires the process data from the DCS 20 through the network.

[0038]

The monitoring device 40 includes an alarm display control unit 42 and a storage unit 44.

The alarm display control unit 42 includes a process data acquisition unit 42A that acquires the process data from the edge/cloud computing unit 32, an alarm determination unit 42B that determines whether or not it is required to issue an alarm based on the process data acquired by the process data acquisition unit 42A, a graph recommendation order calculation unit 42C that, in a case where the alarm determination unit 42B determines that it is required to issue an alarm, generates a graph recommendation list (an example of "selection options of a graph") based on a history of a graph viewed at a time of the alarm generated in the past, an alarm checking display unit 42D that, in a case where the alarm determination unit 42B determines that it is required to issue an alarm, displays information related to the alarm on the display device 50, and a graph display actual result collection unit 42E that collects a display of a graph selected by the

operator on the display screen of the display device 50 as a graph display actual result.

[0039]

The storage unit 44 of the monitoring device includes an alarm setting DB 44A, an alarm generation history DB 44B, a graph setting DB 44C, a graph viewing history DB 44D, and a guide information DB 44E. First, each database of the storage unit 44 will be described.

[0040]

The alarm setting DB 44A stores an alarm determination logic (determination reference) for determining whether or not an alarm indicating abnormality or the like of the plant 1 is generated based on the process data. Fig. 3A illustrates an example of information stored in the alarm setting DB 44A. In the drawing, identification information (ID) of the alarm, classification information ("large category", "intermediate category", and "small category") of the alarm, and an evaluation item name related to the alarm are shown for each row. The alarm determination logic is recorded in association with the evaluation item name. The alarm determination logic may be based on the process data acquired from a single sensor or may be based on the process data acquired from a plurality of types of sensors in accordance with a predetermined algorithm (including an algorithm based on a predetermined trained model generated

by machine learning and an algorithm based on a formula or a mathematical model derived by performing multivariate analysis or the like on the process data of a plurality of sensors).

[0041]

The alarm generation history DB 44B stores information related to the alarm issued in the past. Specifically, information related to the alarm issued in the past and a generation date and time and the like of the alarm are recorded.

[0042]

The graph setting DB 44C stores information related to a graph that can be generated based on the process data. Fig. 3B illustrates an example of information stored in the graph setting DB 44C. In the drawing, a registration name and a type of graph are shown for each row. The registration name (an example of a "description of a graph") is set to describe an evaluation item displayed as the graph and thus, corresponds to information for describing the graph. In addition, a signal name of the process data that is a basis of the evaluation item is also recorded in the graph setting DB 44C. For example, in a case where the operator double-clicks (selects) one graph, a corresponding signal name of the process data is shown. The operator can access the graph setting DB 44C and edit

content of the graph recorded in the database. In addition, it is also possible to register a new graph in the database.

[0043]

The graph viewing history DB 44D stores history information of the graph viewed at a time of issuing the alarm in the past. Fig. 3C illustrates an example of information stored in the graph viewing history DB 44D. In the present embodiment, the graph viewing history DB 44D stores, as a score value, the number of times the graph is displayed at the time of issuing the alarm in the past for each graph (described as "chart 1" and the like). In the drawing, as an example, it is shown that recording indicating that a graph having a name "chart 1" (in actuality, the registration name of the graph in Fig. 3B) is displayed 30 times, a graph having a name "chart 2" is displayed 21 times, and a graph having a name "chart 3" is displayed five times in the past at a time of issuing an alarm related to "agglomeration detection" is performed.

[0044]

The guide information DB 44E stores information for a guide as to a method of a countermeasure at the time of issuing the alarm. For example, in the guide information DB 44E, a sentence describing a method titled "1. Monitoring Point (How to Read Graph)" for perceiving an event from the

graph and a sentence describing a method titled "2. Method of Countermeasure" for adjusting a state of the process data are recorded for each alarm. The method for adjusting the state of the process data is a method for adjusting a state where the process data of interest exceeds a threshold to set the process data within the threshold.

[0045]

Fig. 3D illustrates an example of the guide information displayed on the display screen of the display device 50 in a case where the issued alarm is "circulation system temperature difference 1". A definition of a difference in temperature in the furnace and a calculation formula are described in "1. Monitoring Point (How to Read Graph)". The method of perceiving an event from the graph can be checked from the description, and it is easy to understand what kind of event has occurred. An item to be checked by the operator in accordance with a magnitude of the difference in temperature in the furnace is listed in "2. Method of Countermeasure". The method for adjusting the state of the process data can be checked from the description. The guide information may include not only text information, a formula, and the like but also an image, a graph with legends, and the like. Furthermore, a function of displaying a time at which the same alarm is issued in the past may be provided.

[0046]

Next, each functional block of the alarm display control unit 42 will be described.

The process data acquisition unit 42A acquires the process data from the edge/cloud computing unit 32.

[0047]

The alarm determination unit 42B determines whether or not abnormality or the like has occurred in the plant 1 based on the process data and, in a case where it is determined that abnormality has occurred, causes the display device 50 to issue an alarm. Specifically, the alarm determination unit 42B reads out the alarm determination logic (determination reference) recorded in the alarm setting DB 44A and evaluates the process data in accordance with the alarm determination logic. For example, the alarm determination unit 42B determines whether or not abnormality such as a burst (a state such as a boiler tube leakage where a metal material such as a tube and a pipe constituting the boiler is damaged to form a hole and where the vapor inside the boiler leaks to the outside, including a state where there is a strong possibility of occurrence of the burst in the future; the same applies below) that may occur in the plant 1 has occurred by evaluating predetermined process data based on the alarm determination logic.

[0048]

Furthermore, in a case where it is determined that abnormality has occurred, the alarm determination unit 42B records information related to the alarm (specifically, information about a name, the generation date and time, and the like of the alarm) in the alarm generation history DB 44B. In addition, information related to the alarm in the past is read out from the alarm generation history DB 44B and is provided to the alarm checking display unit 42D together with information related to the alarm to be issued.

[0049]

The graph recommendation order calculation unit 42C generates the graph recommendation list based on the history of the graph viewed at the time of the alarm issued in the past and provides the graph recommendation list to the alarm checking display unit 42D. Specifically, in a case where the alarm determination unit 42B determines that it is required to issue an alarm, the graph recommendation order calculation unit 42C accesses the graph viewing history DB 44D and acquires a plurality of graphs associated with the alarm and the score value of each graph. In addition, the graph recommendation order calculation unit 42C accesses the graph setting DB 44C and acquires the signal name of the process data corresponding

to each graph. Then, the graph recommendation order calculation unit 42C generates the graph recommendation list.

[0050]

Fig. 4 illustrates an example of the graph recommendation list. As illustrated in the drawing, it is shown that in a case where the alarm is "circulation system temperature difference 1", a graph that has a graph name "circulation system temperature difference 1 (for detecting coarse graining) - by condition" and that has an X axis denoting "boiler load (based on heat output) (%)" and a Y axis denoting "difference in temperature in furnace (upper part of furnace - bottom of furnace) in the corresponding process data has a score value of 90. The graph recommendation order calculation unit 42C provides the generated graph recommendation list to the alarm checking display unit 42D.

[0051]

In a case where the alarm determination unit 42B determines that it is required to issue an alarm, the alarm checking display unit 42D displays information for the operator to check the alarm on the display device 50. Fig. 5 illustrates an example of information displayed on the display screen of the display device 50 at the time of issuing the alarm. In a first region AR1 of the display

screen, information related to the alarm in the past and in the present acquired from the alarm determination unit 42B is displayed in a list form.

[0052]

In addition, in a case where the operator double-clicks (selects) a predetermined alarm AL1, the alarm checking display unit 42D acquires a graph recommendation list GL1 corresponding to the alarm AL1 from the graph recommendation order calculation unit 42C. The graph recommendation list GL1 is displayed in a second region AR2 of the same display screen. Furthermore, the alarm checking display unit 42D may access the guide information DB 44E to read out the guide information corresponding to the alarm and display the guide information in a different region of the display screen.

[0053]

Furthermore, in a case where the operator double-clicks (selects) a predetermined graph GR1 displayed on the graph recommendation list GL1, the alarm checking display unit 42D accesses the graph setting DB 44C to acquire the process data and displays the graph. The graph (for example, "circulation system temperature difference 1") selected by the operator is displayed in a third region AR3 of the same display screen.

[0054]

In a case where the operator double-clicks (selects) another graph displayed on the graph recommendation list GL1, a different graph (for example, "circulation system pressure difference 1") selected by the operator is displayed in the third region AR3 of the same display screen. The third region AR3 may be configured to display a plurality of graphs at the same time.

[0055]

Each time the operator selects a graph displayed on the graph recommendation list GL1, the graph display actual result collection unit 42E (an example of "recording means") records, in the graph viewing history DB 44D, information indicating that the graph is viewed at the time of issuing the alarm. In the present embodiment, the number of times the graph is viewed is counted up in association with the alarm.

[0056]

Fig. 6 is a diagram illustrating a physical configuration for implementing the operation support system 30 according to the present embodiment. The edge/cloud computing unit 32 can employ a known physical configuration and thus, will not be described. Hereinafter, a physical configuration of the operation support system 30 excluding the edge/cloud computing unit 32 will be described.

[0057]

The operation support system 30 includes a central processing unit (CPU) 30A corresponding to a calculation unit, a random access memory (RAM) 30B and a read only memory (ROM) 30C corresponding to a storage unit, a communication unit 30D, an input unit 30E, and a display unit 30F. These configurations are connected to each other to be capable of transmitting and receiving data through a bus. While a case where the operation support system 30 is configured with one computer will be described in the present example, the operation support system 30 may be configured with a plurality of computers. For example, the display unit 30F may be configured with a plurality of displays. In addition, the configurations illustrated in Fig. 6 are merely an example, and a part of the configurations may not be provided. Furthermore, a part of the configurations may be provided at a remote location. For example, a part of the ROM 30C may be provided at a remote location and may be configured to communicate through a communication network.

[0058]

The CPU 30A is a calculation unit that performs control processing, calculation processing, and the like included in the present disclosure by executing a computer program or the like recorded in the ROM 30C or the like. The CPU 30A includes a processor. The CPU 30A receives

various types of information (including the process data) from the RAM 30B, the ROM 30C, the communication unit 30D, the input unit 30E, and the like, and displays a calculation processing result and the like on the display unit 30F or stores the calculation processing result and the like in the RAM 30B or in the ROM 30C.

[0059]

The RAM 30B functions as a cache memory in the storage unit and may be configured with, for example, a volatile semiconductor storage element such as an SRAM and a DRAM.

[0060]

The ROM 30C functions as a main memory in the storage unit and may be configured with, for example, a non-volatile semiconductor storage element such as a flash memory in which information can be electrically rewritten, or with an HDD in which information can be magnetically rewritten. For example, the ROM 30C may store the computer program and data for executing processing including each control and each calculation processing illustrated in the present disclosure.

[0061]

The communication unit 30D is an interface for connecting the operation support system 30 to other devices such as the DCS 20. The communication unit 30D may be connected to a communication network such as the Internet.

[0062]

The input unit 30E receives input of data, the selection of the graph, and the like from the operator and may include, for example, a keyboard and a touch panel.

[0063]

The display unit 30F visually displays a calculation result of the CPU 30A and may be configured with, for example, a liquid crystal display (LCD).

[0064]

In the physical configurations, each function constituting the alarm display control unit 42 of the monitoring device 40 can be implemented by executing the computer program mainly via the CPU 30A. Each database constituting the storage unit 44 can be implemented mainly by the ROM 30C. The display device 50 can be implemented mainly by the display unit 30F.

[0065]

[Display Method]

Hereinafter, a display method of information for the operator to trace validity of the alarm to be issued using the operation support system 30 will be described. Fig. 7 is a flowchart including the display method.

[0066]

First, the alarm determination unit 42B evaluates the process data acquired by the process data acquisition unit

42A based on the alarm determination logic and determines whether or not abnormality has occurred in the plant 1. In a case where the alarm determination unit 42B determines that predetermined abnormality has occurred in the plant 1, an alarm is issued (step S71). Specifically, the monitoring device 40 displays, in the first region AR1 of the display screen, information related to the alarm in the past and in the present acquired from the alarm determination unit 42B in a list form. The monitoring device 40 may display the graph recommendation list corresponding to the latest alarm in the second region AR2 of the display screen, display a plurality of graphs having the highest score value in the graph recommendation list in the third region AR3, and furthermore, display the guide information corresponding to the latest alarm in a different region.

[0067]

In a case where the alarm is issued, the operator starts a work of checking the validity of the alarm. Specifically, the operator selects a graph to be checked while examining the graph name, the signal name, and the score value (Fig. 4) listed on the graph recommendation list (step S72). In a case where the operator selects another alarm displayed in the first region AR1, the monitoring device 40 displays the graph recommendation list corresponding to the alarm in the second region AR2 of the

display screen, displays a corresponding graph in the third region AR3, and furthermore, displays the guide information in a different region.

[0068]

Here, the graph recommendation list includes the score value. Thus, the operator can identify a graph of high priority to be checked. In addition, the score value is information that is not set in advance and that reflects a fact actually viewed by the operator during operation of the plant 1. The graph recommendation list according to the present embodiment may vary for the same alarm in a case where the plant varies. Accordingly, the operator can identify a graph of high priority to be checked based on a model-specific viewpoint implemented in the plant 1.

[0069]

Furthermore, the graph recommendation list reflects the fact actually viewed by the operator during the operation of the plant 1. Thus, even in the same plant, the graph recommendation list may vary for the same alarm in accordance with a time-dependent change or the like. Accordingly, the operator can identify a graph of high priority to be checked based on a viewpoint in which a time-dependent change or the like of the plant 1 is taken into consideration.

[0070]

In a case where the operator selects one graph from the selection options of the graph displayed as the graph recommendation list, the monitoring device 40 displays the selected graph in the third region AR2 of the display screen (step S73).

[0071]

The operator can select graphs in an order that is considered to be appropriate, as required depending on a situation. For example, it is possible to select and display a graph having a low score value first and then, select and display a graph having a high score value. By doing so, a graph having a high score can be viewed based on a viewing result of a graph having a low score value.

[0072]

Each time the operator selects a graph displayed on the graph recommendation list, the monitoring device 40 records, in the graph viewing history DB 44D, information indicating that the graph is viewed at the time of issuing the alarm (step S74).

[0073]

After the operator displays all graphs to be checked and ascertains the validity of the issue of the alarm, the operator performs a countermeasure in accordance with the guide information.

[0074]

As described above, according to the display device and the display method illustrated in the present embodiment, a graph to be checked can be efficiently checked.

[0075]

[Modification Example]

Various modifications can be made to the present invention without departing from the concept thereof. For example, it may be configured to learn about similarity between graphs using the known collaborative filtering algorithm based on a viewing history of the graph that is selected by the operator and displayed on the display screen, and to calculate the score value based on the similarity. In this case, the graph recommendation order calculation unit 42C performs machine learning of the similarity between graphs based on the viewing history of all graphs of the operator, calculates the score value based on the similarity, and records the score value in the graph viewing history DB. For example, the similarity may be calculated using the Euclidean distance, a weighted average, or the Pearson coefficient. In addition, the graph recommendation list may be updated based on the graph being displayed. In addition, the graph recommendation order calculation unit 42C may calculate the score value based on a learning model that is generated using the warning

generated in the past and the history of the graph viewed at the time of the warning as training data. The machine learning model includes machine learning models that use a neural network such as a convolutional neural network (CNN), a regression model such as Gaussian process regression, and a tree algorithm such as a decision tree. The edge/cloud computing unit 32 can be used for collecting information for machine learning.

[0076]

In addition, in the graph recommendation list, only a graph having a high score value may be displayed, or all graphs having a score value may be displayed. It may be required to view a graph having a low score value under a special circumstance.

[0077]

In addition, various modifications can be made to the present invention without departing from the concept thereof. For example, a part of components in an embodiment can be added to another embodiment within the scope of ordinary creativity of those skilled in the art. In addition, a part of components in an embodiment can be substituted with a corresponding component of another embodiment.

Reference Signs List

[0078]

1 Plant

2 Furnace

3 Cyclone

4 Circulation material recovery pipe

5 Rear flue

6 Furnace wall pipe

7 Pump

8 Steam drum

10 Superheater

12 Coal economizer

30 Operation support system

32 Edge/cloud computing unit

40 Monitoring device

42 Alarm display control unit

44 Storage

50 Display device

100 Turbine

102 Condenser

CLAIMS

1. A display device configured to:

based on a history of a graph viewed at a time of a warning generated in the past, display selection options of a graph to be viewed at a time of a warning; and

display the selected graph.

2. The display device according to claim 1,

wherein the selection options are displayed together with a description of at least one graph associated with the warning.

3. The display device according to claim 1 or 2,

wherein the selection options are displayed based on the number of times the graph viewed at the time of the warning generated in the past is displayed.

4. The display device according to any one of claims 1 to 3,

wherein the selection options are displayed based on a learning model that is generated using the warning generated in the past and the history of the graph viewed at the time of the warning as training data.

5. The display device according to any one of claims 1 to 4, further comprising:

recording means for performing recording indicating that the graph is displayed.

6. A display method comprising:

a step of displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning; and

a step of displaying the selected graph.

7. A control device comprising:

means for displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning on a display device; and

means for displaying the selected graph on the display device.

8. A computer program causing a computer to execute:

a step of displaying, based on a history of a graph viewed at a time of a warning generated in the past, selection options of a graph to be viewed at a time of a warning on a display device; and

a step of displaying the selected graph on the display device.