

DESCRIPTION

Title of Invention

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

Technical Field

[0001]

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

Background Art

[0002]

In the related art, various technologies for monitoring an operation state of a plant have been suggested. For example, a plant monitoring device that compares a process value acquired in time series from a target point to be monitored in a plant with a corresponding constraint value to determine a time at which the process value exceeds the constraint value, and that displays the process value within a time range set based on the time and the corresponding constraint value on a display device in time series is suggested (refer to PTL 1).

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Publication No.
2016-115195

Summary of Invention

Technical Problem

[0004]

In the technology disclosed in PTL 1, while the process value can be displayed in a time-series graph, determining whether the operation state of the plant is normal or abnormal may be difficult with only a single type of graph.

[0005]

The present invention is conceived in view of such circumstances, and an object thereof is to provide a display device, a display method, a control device, a control method, and a computer program that can display an operation state of a plant using a plurality of graphs and that can contribute to analysis of the operation state from various viewpoints.

Solution to Problem

[0006]

A first aspect of the present invention is a display device that displays an operation state of a plant, in which a plurality of types of graphs representing the operation state of the plant are displayed in a first region as selection options, and the operation state of the plant is displayed in a second region using the graphs. In the display device, in a case where a specific graph is selected from the plurality of types of graphs displayed in the first region, the operation state of the plant may be displayed in the second region using the specific graph.

[0007]

A second aspect of the present invention is a display method of displaying an operation state of a plant, the display method including a selection option display step of displaying a plurality of types of graphs representing the operation state of the plant in a first region of a predetermined screen as selection options, and an operation state display step of displaying the operation state of the plant in a second region using any graph among the plurality of types of graphs displayed in the selection option display step. In the operation state display step of the display method, in a case where a specific graph is selected from the plurality of types of graphs displayed in the selection option display step, the operation state of

the plant may be displayed in the second region using the specific graph.

[0008]

A third aspect of the present invention is a control device that controls a display device that displays an operation state of a plant, the control device including an acquisition unit that acquires process data of the plant, a generation unit that generates a plurality of types of graphs representing the operation state of the plant based on the process data acquired by the acquisition unit, and a display control unit that displays the plurality of types of graphs in a first region of the display device as selection options and that displays the operation state of the plant in a second region of the display device using the graphs. The control device may further include a reception unit that receives a selection of a graph, in which in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received by the reception unit, the display control unit displays the operation state of the plant in the second region using the specific graph.

[0009]

A fourth aspect of the present invention is a control method of controlling a display device that displays an operation state of a plant, the control method including an

acquisition step of acquiring process data of the plant, a generation step of generating a plurality of types of graphs representing the operation state of the plant based on the process data acquired in the acquisition step, and a display control step of displaying the plurality of types of graphs in a first region of the display device as selection options and of displaying the operation state of the plant in a second region of the display device using the graphs. The control method may further include a reception step of receiving a selection of a graph, in which in the display control step, in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received in the reception step, the operation state of the plant is displayed in the second region using the specific graph.

[0010]

A fifth aspect of the present invention is a computer program causing a computer to execute a control method of controlling a display device that displays an operation state of a plant, in which the control method includes an acquisition step of acquiring process data of the plant, a generation step of generating a plurality of types of graphs representing the operation state of the plant based on the process data acquired in the acquisition step, and a display control step of displaying the plurality of types

of graphs in a first region of the display device as selection options and of displaying the operation state of the plant in a second region of the display device using the graphs. The control method executed by the computer program may further include a reception step of receiving a selection of a graph, in which in the display control step, in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received in the reception step, the operation state of the plant is displayed in the second region using the specific graph.

[0011]

In a case where such configurations and methods are employed, the plurality of types of graphs representing the operation state of the plant can be displayed in the first region of the display device as selection options. Accordingly, an operator can select any graph from the plurality of types of graphs displayed in the first region of the display device and can display the operation state of the plant in the second region of the display device using the selected graph. Accordingly, since the operation state of the plant can be displayed using the plurality of graphs, it is possible to contribute to analysis of the operation state from various viewpoints.

[0012]

As the plurality of types of graphs in each aspect of the present invention, a plurality of types of graphs representing a history of process data indicating the operation state of the plant may be employed. In addition, as the plurality of types of graphs, a plurality of types of graphs representing the common process data in different aspects (for example, a plurality of types of graphs including both of a graph showing the history of the process data in time series and a graph showing the history of the process data in non-time series) may be employed.

[0013]

By doing so, the operation state of the plant that cannot be found using only a time-series graph (for example, an operation state having a strong possibility of gradually transitioning to an abnormal state) can be specified using a non-time-series graph, and proactive measures can be performed by identifying a cause of abnormality in the plant early. It is possible to contribute to continuation of stable operation of the plant.

[0014]

The display control unit in the third aspect of the present invention may store the graphs generated by the generation unit in a storage unit. In the display control step in the fourth and fifth aspects of the present

invention, the graphs generated in the generation unit may be stored in a storage unit.

[0015]

In a case where such a configuration and a method are employed, a graph that is generated in the past and used can be stored. Accordingly, for example, by storing an operator and a graph used by the operator in association with each other, it is possible to refer to a graph used by a skilled operator in the past.

[0016]

The display control unit in the third aspect of the present invention may read the graphs stored in the storage unit and display the graphs in the second region of the display device. In the display control step in the fourth and fifth aspects of the present invention, the graphs stored in the storage unit may be read and displayed in the second region of the display device.

[0017]

In a case where such a configuration and a method are employed, for example, a graph (a graph for which various items are set) used by a specific skilled operator in the past can be read, and the graph can be displayed in the second region of the display device. Accordingly, even a relatively inexperienced operator can perceive which graph is used in which arrangement (item setting) by a skilled

operator in the past. Accordingly, it is possible to learn about a monitoring point, and it is possible to easily improve an operation skill level.

Advantageous Effects of Invention

[0018]

According to the present invention, it is possible to provide a display device, a display method, a control device, a control method, and a computer program that can display an operation state of a plant using a plurality of graphs and that can contribute to analysis of the operation state from various viewpoints.

Brief Description of Drawings

[0019]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant as a target to be monitored in an embodiment of the present invention.

Fig. 2 is a diagram illustrating a functional configuration of an operation support system in the embodiment of the present invention.

Fig. 3 is a diagram illustrating an example of a graph selection setting screen displayed on a display device according to the embodiment of the present invention.

Fig. 4 is a diagram illustrating an example of a time-series graph screen displayed on the display device according to the embodiment of the present invention.

Fig. 5 is a diagram illustrating an example of a non-time-series graph screen displayed on the display device according to the embodiment of the present invention.

Fig. 6 is a diagram illustrating a physical configuration of the operation support system in the embodiment of the present invention.

Fig. 7 is a flowchart illustrating an example of a control method according to the embodiment of the present invention.

Description of Embodiments

[0020]

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.

[0021]

Fig. 1 is a schematic diagram illustrating an overall configuration of a plant 1 that is an example of the target to be monitored in the embodiment of the present invention. 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.

[0022]

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.

[0023]

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.

[0024]

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.

[0025]

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 have a coarse particle size not suitable for circulation and fluidization or include an exhaust impurity. Such a bed material or the like not suitable as the circulation material may cause a fluidization failure. In order to suppress such a 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.

[0026]

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 in the plant 1. The steam drum 8 is also connected to the furnace wall pipe 6 of the furnace 2.

[0027]

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.

[0028]

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.

[0029]

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.

[0030]

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.

[0031]

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.

[0032]

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 u_1 (an example of "process data") supplied by the pump 7a is illustrated.

[0033]

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 an operation 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 u_2 (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 u_3 (an example of the "process data") supplied to the turbine 100 from the superheater 10 is illustrated, and a saturated vapor flow rate u_4 (an example of the "process data") supplied to the superheater 10 from the steam drum 8 is illustrated. The makeup water flow rate u_1 may be controlled in accordance with the saturated vapor flow rate u_4 . In addition, the boiler feedwater flow rate u_2 may be controlled to be adjusted while both of the boiler outlet vapor flow rate u_3 (or a superheated vapor flow rate) and a liquid surface level of the steam drum 8 are monitored.

[0034]

In a case where a hole has occurred in a pipe system constituting the plant 1, the makeup water flow rate u_1 rises, or a difference in flow rate between the boiler feedwater flow rate u_2 and the boiler outlet vapor flow rate u_3 is increased. A distributed control system (DCS; refer to Fig. 2) 20, described later, receives the process data of the plant 1 such as the makeup water flow rate u_1 , the boiler feedwater flow rate u_2 , the boiler outlet vapor flow rate u_3 , and the saturated vapor flow rate u_4 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.

[0035]

While the makeup water flow rate u_1 , the boiler feedwater flow rate u_2 , the boiler outlet vapor flow rate u_3 , and the saturated vapor flow rate u_4 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.

[0036]

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.

[0037]

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.

[0038]

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 of the plant 1, generates a plurality of types of graphs representing the operation state of the plant 1 based on the process data, displays the generated plurality of types of graphs in a first region of the display device 50 as selection options, and displays the operation state of the plant 1 in a second region of the display device 50 using the graphs. Accordingly, the operation state can be analyzed from various viewpoints.

[0039]

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.

[0040]

The monitoring device 40 includes a control unit 42 and a storage unit 44. The control unit 42 includes a process data acquisition unit 42A that acquires the process data from the edge/cloud computing unit 32, a graph selection reception unit 42B that receives a selection of a graph, a graph generation unit 42C that generates the plurality of types of graphs representing the operation state of the plant 1 based on the process data acquired by the process data acquisition unit 42A, and a display control unit 42D that displays the plurality of types of graphs generated by the graph generation unit 42C in a selection region (an example of the "first region") A1 of the display device 50 as selection options and that, in a case where the graph selection reception unit 42B receives a selection of a specific graph from the plurality of types of graphs displayed in the selection region A1, displays the operation state of the plant 1 in display regions (an example of the "second region") B1, C1, and the like of the display device 50 using the specific graph.

[0041]

The storage unit 44 of the monitoring device includes a graph setting DB 44A and a graph history DB 44B. First, each database of the storage unit 44 will be described.

[0042]

The graph setting DB 44A stores process data acquired in the past. Particularly, the graph setting unit DB 44A stores the process data in association with a time of acquisition so that the process data acquired in a target period can be output in a case where a period (target period) as a target to be monitored is designated by the operator.

[0043]

In addition, the graph setting DB 44A stores template information of each graph for representing the acquired process data using the plurality of types of graphs (for example, graphs such as a trend chart, a box plot chart, a scatter plot, and a cumulative frequency distribution chart). For example, in a case where a group of process data is input through the process data acquisition unit 42A and where the specific graph is selected through the graph selection reception unit 42B, the template information for displaying the input process data using the specific graph is read from the graph setting DB 44 and is used for generating the graph in the graph generation unit 42C. The

information stored in the graph setting DB 44A can be updated as appropriate.

[0044]

In addition, the graph setting DB 44 stores information for setting details of each graph. For example, in generating the graph of the scatter plot illustrated in Fig. 5, the process data is classified and stored for each parameter so that a parameter on a vertical axis (Y axis) can be selected and set from "air flow rate", "damper opening degree", and "air pressure".

[0045]

The graph history DB 44B stores history information of a graph used in the past. Particularly, by storing the operator and a graph used by the operator in the graph history DB 44B in association with each other, it is possible to refer to a graph used by a skilled operator in the past.

[0046]

Next, each functional block of the control unit 42 of the monitoring device 40 will be described.

[0047]

The process data acquisition unit 42A acquires the process data from the edge/cloud computing unit 32. The graph selection reception unit 42B receives a selection of

a graph from the operator through a user interface (a keyboard, a mouse, or the like), not illustrated.

[0048]

The graph generation unit 42C generates the plurality of types of graphs representing the operation state of the plant 1 based on the process data acquired by the process data acquisition unit 42A. Specifically, in a case where a group of process data is input through the process data acquisition unit 42A and where a period (target period) as a target to be monitored is designated by the operator, the graph generation unit 42C reads the process data acquired in the target period from the graph setting DB 44A, reads the template information for displaying the input process data using the plurality of types of graphs from the graph setting DB 44, and generates the plurality of types of graphs based on the information. For example, the graph generation unit 42C can generate a graph (a graph with a vertical axis denoting an air flow rate and with a horizontal axis denoting time) of a trend chart showing an air flow rate of a wind box 2c (Fig. 1) as the process data in time series as illustrated in Fig. 4 or generate a graph (a graph with a vertical axis denoting the air flow rate and with a horizontal axis denoting a boiler load) of a scatter plot of the air flow rate as illustrated in Fig. 5. The graph of the trend chart and the graph of the scatter

plot represent the common process data "air flow rate" in different aspects (one is a time-series aspect, and the other is a non-time-series aspect).

[0049]

The display control unit 42D displays the plurality of types of graphs generated by the graph generation unit 42C in the selection region (an example of the "first region") A1 of the display device 50 as selection options.

Specifically, as illustrated in Fig. 3, in the selection region A1 included in a graph setting screen S1 displayed on the display device 50, the display control unit 42D displays icons of the plurality of types of graphs (for example, graphs such as a trend chart, a box plot chart, a scatter plot, and a cumulative frequency distribution chart) generated by the graph generation unit 42C in the selection region A1 as selection options. The operator can select the specific graph (for example, an icon I_T of the trend chart or an icon I_S of the scatter plot) from the graphs of the displayed icons by a double-click operation or the like.

[0050]

In addition, the display control unit 42D displays information for setting details of each graph. For example, as illustrated in Fig. 3, the display control unit 42D performs display for selecting a period (target period) as

a target to be monitored in a period setting region A2 included in the graph setting screen S1. The operator can appropriately select a date and time from selection options displayed in the period setting region A2. In addition, as illustrated in Fig. 3, the display control unit 42D displays selection options for setting parameters of the vertical axis and the horizontal axis in generating the specific graph (for example, the scatter plot in Fig. 5) or performs display for adjusting lengths of the vertical axis and the horizontal axis in item setting regions A3 and A4 included in the graph setting screen S1. The operator can select the parameters of the vertical axis and the horizontal axis from the selection options in the item setting region A3 displayed by the display control unit 42D or adjust the lengths of the vertical axis and the horizontal axis by appropriately changing values displayed in the item setting region A4 by the display control unit 42D. In addition, as illustrated in Fig. 3, the display control unit 42D displays the lengths (adjusted values) of the vertical axis and the horizontal axis of the specific graph (for example, the scatter plot in Fig. 5) and the maximum value, the minimum value, an average value, and the like of the parameters of the vertical axis and the horizontal axis in a specific value display region A5 included in the graph setting screen S1.

[0051]

In a case where the graph reception unit 42C receives a selection of the specific graph by, for example, a double-click operation from the plurality of types of graphs displayed in the selection region A1, the display control unit 42D displays the operation state of the plant 1 in the display regions (an example of the "second region") B1 and C1 of the display device 50 using the selected specific graph. Specifically, in a case where the trend chart (icon I_T) is selected from the graphs of the icons displayed in the selection region A1, the display control unit 42D, as illustrated in Fig. 4, displays the graph of the trend chart in the display region B1 included in a first graph display screen S2 displayed on the display device 50. Accordingly, the operation state of the plant 1 is displayed using the graph of the trend chart.

[0052]

In the graph of the trend chart illustrated in Fig. 4, the vertical axis and the horizontal axis denote the air flow rate and time, respectively, and a time history of the air flow rate within a target period (21:45 on June 12, 2020 to 21:45 on June 19, 2020) is shown. A state where the air flow rate is increased or decreased in accordance with an elapse of time is identified from the graph of the trend chart. However, whether the time history indicates an

abnormal state or a normal state of the plant 1 may not be determinable depending on a skill level of the operator.

[0053]

Therefore, the operator selects a non-time-series graph (for example, the scatter plot) from the graphs of the icons displayed in the selection region A1 of the display device 50. In a case where the scatter plot (icon I_s) is selected from the graphs of the icons displayed in the selection region A1, the display control unit 42D, as illustrated in Fig. 5, displays the graph of the scatter plot in the display region C1 included in a second graph display screen S3 displayed on the display device 50. Accordingly, the operation state of the plant 1 is displayed using the graph of the scatter plot.

[0054]

In the graph of the scatter plot illustrated in Fig. 5, the vertical axis and the horizontal axis denote the air flow rate and the boiler load, respectively, and a correlation between the air flow rate and the boiler load within the same period as the target period (21:45 on June 12, 2020 to 21:45 on June 19, 2020) of the graph of the trend chart is shown. A gentle increase in the air flow rate in accordance with an increase in the boiler load is identified from the graph of the scatter plot. Since this correlation is typically seen in a case where the plant 1

is in a normal state, it is inferred that there is no particular abnormality in the plant 1.

[0055]

In addition, the display control unit 42D can also register and display the history information of the graph used in the past. That is, the display control unit 42D can store (register) the graph generated through the above procedure in the graph history DB 44B together with peripheral information of the graph (a name of the operator who has created the graph, the used process data, and the type, axes, adjusted values, and the like of the graph) by, for example, inputting predetermined information in a registration region A6 in Fig. 3. For example, the display control unit 42D can read a graph (a graph for which various items are set) used by a specific skilled operator in the past from the graph history DB 44B and display the graph in the display region B1 (C1) included in the graph display screen S2 (S3). Accordingly, even a relatively inexperienced operator can perceive which graph is used in which arrangement (item setting) by a skilled operator in the past. Accordingly, it is possible to learn about a monitoring point, and it is possible to easily improve an operation skill level.

[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 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]

The operation support system 30 may be configured with a tablet terminal. By configuring the operation support system 30 with a tablet terminal, it is possible to carry the operation support system 30. For example, it is possible to use the operation support system 30 while moving around in the plant 1.

[0066]

Next, a method (control method) of controlling the display device 50 that displays the operation state of the plant 1, using the operation support system 30 in the present embodiment will be described. Fig. 7 is a flowchart including such a display method. A method of displaying the operation state of the plant 1 using the control method according to the present embodiment is an example of a display method in the present invention.

[0067]

First, the process data acquisition unit 42A of the control unit 42 of the monitoring device 40 of the operation support system 30 acquires the process data of the plant 1 through the edge/cloud computing unit 32 or through the DCS 20 (data acquisition step: S71). Next, the graph generation unit 42C of the control unit 42 of the monitoring device 40 of the operation support system 30 generates the plurality of types of graphs representing the operation state of the plant 1 based on the process data

acquired in the data acquisition step S71 (graph generation step: S72). The display control unit 42D of the control unit 42 of the monitoring device 40 of the operation support system 30 displays the icons of the plurality of types of graphs generated in the graph generation step S72 in the selection region A1 of the display device 50 as selection options (selection option display control step: S73). The step of displaying the icons of the plurality of types of graphs in the selection region A1 as selection options in the selection option display control step S73 corresponds to a selection option display step of the display method in the present invention.

[0068]

Next, in a case where the operator selects any of the plurality of types of graphs of the icons displayed in the selection region A1 of the display device 50 by a double-click operation or the like, the graph reception unit 42B of the control unit 42 of the monitoring device 40 of the operation support system 30 receives the selection of the graph from the operator (graph selection reception step: S74). Then, the display control unit 42D of the control unit 42 of the monitoring device 40 of the operation support system 30 displays the specific graph (for example, the graphs of the trend chart and the scatter plot) received in the graph selection reception step S74 in the

display regions B1 and C1 of the display device 50 (graph display control step: S75). Accordingly, the operation state of the plant 1 is displayed using the specific graph (for example, the graphs of the trend chart and the scatter plot). The step of displaying the operation state of the plant 1 in the display regions B1 and C1 using the specific graph in the graph display control step S75 corresponds to an operation state display step of the display method in the present invention.

[0069]

According to the above embodiment, the plurality of types of graphs representing the operation state of the plant 1 can be displayed in the selection region A1 of the display device 50 as selection options. Accordingly, the operator can select any graph from the plurality of types of graphs displayed in the selection region A1 of the display device 50 and can display the operation state of the plant 1 in the display regions B1 and C1 of the display device 50 using the selected graph. Accordingly, since the operation state of the plant 1 can be displayed using the plurality of graphs, it is possible to contribute to analysis of the operation state from various viewpoints.

[0070]

In addition, according to the above embodiment, graphs that display the common process data in different aspects

(that is, both of a graph such as the trend chart showing a history of the process data in time series and a graph such as the scatter plot showing the history of the process data in non-time series) are employed as the plurality of types of graphs. Thus, the operation state of the plant 1 that cannot be found using only a time-series graph (for example, an operation state having a strong possibility of gradually transitioning to an abnormal state) can be specified using a non-time-series graph, and proactive measures can be performed by identifying a cause of abnormality in the plant 1 early. It is possible to contribute to continuation of stable operation of the plant 1.

[0071]

Various modifications can be made to the present invention without departing from the concept thereof. For example, the embodiment illustrates an example in which the display control unit 42D enables a relatively inexperienced operator to learn about a graph of a skilled operator in the past by reading a graph (a graph for which various items are set) used by a specific skilled operator in the past from the graph history DB 44B and by displaying the graph in the display region B1 (C1). The display control unit 42D can further automatically display a sample of an optimal graph in accordance with a status.

[0072]

In this case, the display control unit 42D can perform machine learning of a correlation between a specific status (for example, a status in which a warning is generated) and a graph used by a skilled operator in the status, record a learning result in the graph history DB, and in a case where it is determined that the specific status has occurred based on the process data, automatically read the graph related to the status from the graph history DB and display the graph in the display region B1 (C1). A 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.

[0073]

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

[0074]

1 Plant

40 Monitoring device (control device)

42A Process data acquisition unit (acquisition unit)

42B Graph selection reception unit (reception unit)

42C Graph generation unit (generation unit)

42D Display control unit

50 Display device

A1 Selection region (first region)

B1 Display region (second region)

C1 Display region (second region)

S71 Data acquisition step (acquisition step)

S72 Graph generation step (generation step)

S73 Selection option display control step (display
control step)

S74 Graph selection reception step (reception step)

S75 Graph display control step (display control step)

CLAIMS

1. A display device that displays an operation state of a plant,

wherein a plurality of types of graphs representing the operation state of the plant are displayed in a first region as selection options, and the operation state of the plant is displayed in a second region using the graphs.

2. The display device according to claim 1,

wherein the plurality of types of graphs represent a history of process data indicating the operation state of the plant.

3. The display device according to claim 2,

wherein the plurality of types of graphs represent the common process data in different aspects.

4. The display device according to claim 3,

wherein the plurality of types of graphs include both of a graph showing the history of the process data in time series and a graph showing the history of the process data in non-time series.

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

wherein in a case where a specific graph is selected from the plurality of types of graphs displayed in the first region, the operation state of the plant is displayed in the second region using the specific graph.

6. A display method of displaying an operation state of a plant, the display method comprising:

a selection option display step of displaying a plurality of types of graphs representing the operation state of the plant in a first region as selection options; and

an operation state display step of displaying the operation state of the plant in a second region using any graph among the plurality of types of graphs displayed in the selection option display step.

7. A control device that controls a display device that displays an operation state of a plant, the control device comprising:

an acquisition unit that acquires process data of the plant;

a generation unit that generates a plurality of types of graphs representing the operation state of the plant

based on the process data acquired by the acquisition unit;
and

a display control unit that displays the plurality of types of graphs in a first region of the display device as selection options and that displays the operation state of the plant in a second region of the display device using the graphs.

8. The control device according to claim 7, further comprising:

a reception unit that receives a selection of a graph, wherein in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received by the reception unit, the display control unit displays the operation state of the plant in the second region using the specific graph.

9. The control device according to claim 7 or 8, wherein the display control unit stores the graphs generated by the generation unit in a storage unit.

10. The control device according to claim 9, wherein the display control unit reads the graphs stored in the storage unit and displays the graphs in the second region of the display device.

11. A control method of controlling a display device that displays an operation state of a plant, the control method comprising:

an acquisition step of acquiring process data of the plant;

a generation step of generating a plurality of types of graphs representing the operation state of the plant based on the process data acquired in the acquisition step; and

a display control step of displaying the plurality of types of graphs in a first region of the display device as selection options and of displaying the operation state of the plant in a second region of the display device using the graphs.

12. The control method according to claim 9, further comprising:

a reception step of receiving a selection of a graph,

wherein in the display control step, in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received in the reception step, the operation state of the plant is displayed in the second region using the specific graph.

13. The control method according to claim 11 or 12, wherein in the display control step, the graphs generated in the generation step are stored in a storage unit.

14. The control method according to claim 13, wherein in the display control step, the graphs stored in the storage unit are read and displayed in the second region of the display device.

15. A computer program causing a computer to execute a control method of controlling a display device that displays an operation state of a plant,

wherein the control method includes

an acquisition step of acquiring process data of the plant,

a generation step of generating a plurality of types of graphs representing the operation state of the plant based on the process data acquired in the acquisition step, and

a display control step of displaying the plurality of types of graphs in a first region of the display device as selection options and of displaying the operation state of the plant in a second region of the display device using the graphs.

16. The computer program according to claim 15, wherein the control method further includes a reception step of receiving a selection of a graph, and in the display control step, in a case where a selection of a specific graph from the plurality of types of graphs displayed in the first region is received in the reception step, the operation state of the plant is displayed in the second region using the specific graph.

17. The computer program according to claim 15 or 16, wherein in the display control step, the graphs generated in the generation step are stored in a storage unit.

18. The computer program according to claim 17, wherein in the display control step, the graphs stored in the storage unit are read and displayed in the second region of the display device.