[DESCRIPTION]

[Title of Invention]

ACTION-BASED SUPPORT SYSTEM AND PROGRAM STORAGE MEDIUM

[Technical Field]

[0001]

The present invention relates to an action-based support system for assisting a person in making an action decision according to circumstances in an environment, or for automatically making an action decision or executing an action on behalf of a person, and relates, for example, to a system that provides support using artificial intelligence.

[Background Art]

[0002]

As one example of action-based support, support for operational tasks provided to an operator of a plant, such as a chemical plant, can be given.

[0003]

Increasing the number of situations in which artificial intelligence automatically supports plant operation reduces the burden on operators.

[0004]

Related conventional art includes a plant operation support system described in PTL 1.

[0005]

This system includes a real-time inference system that is input with plant data generated by a plant system and that performs

inference, and an AI training system that is input with training data created using the plant data and that trains the real-time inference system. The AI training system includes a knowledge evaluation unit that evaluates a reliability of an inference result and requests an operator to participate in the creation of training data selectively in accordance with the result of evaluating the reliability.

[Citation List]

[Patent Literature]

[0006]

[PTL 1]

Japanese Patent Application Publication No. 2023-111624

[Summary of Invention]

[Technical Problem]

[0007]

In a plant in which serious errors cannot be permitted in operational tasks, it is desired that an action-based support system provides an operator with operational task recommendations that are as appropriate as possible. It is also desired that communication between the action-based support system and the operator is as easy for the operator to understand as possible, as in a conversation between people.

[0008]

The foregoing also applies to action support in various fields other than plant operations. Such fields may include driving assistance in automated driving for the driver of an

automobile, support for the physical and mental tasks of factory workers and office workers, and the like, for example.

[0009]

An object of the present invention is to provide an action-based support system that provides more accurate support to a person.

[0010]

Another object of the present invention is to make communication between an action-based support system and a person easier for the person to understand.

[0011]

Other objects of the present invention will become apparent from the following descriptions.

[Solution to Problem]

[0012]

An action-based support system according to one embodiment, for supporting a person who performs an action in accordance with circumstances of an environment, includes: a natural language system configured to perform interactive communication with the person by using natural language; and a predictive action system configured to take, as an input, environment data indicating the circumstances of the environment, generate a future prediction indicating future circumstances of the environment by using the environment data input, and generate a recommended action by using the future prediction generated.

[0013]

The natural language system is configured to take, as an input, the future prediction or the recommended action from the predictive action system, interpret or analyze the interactive communication with the person, generate a message expressed in natural language based on the future prediction or the recommended action input in accordance with a result of interpreting or analyzing the interactive communication, and provide to the person the message generated.

[0014]

An action-based support system according to one embodiment includes: a storage device storing a computer program; and a processor that mechanically reads and executes the computer program. By executing the computer program, the processor: performs interactive communication with the person by using natural language; inputs environment data indicating circumstances of the environment; generates a future prediction indicating future circumstances of the environment by using the environment data input; generates a recommended action using the future prediction generated; interprets or analyzes the interactive communication with the person; generates a message expressed in natural language based on the future prediction or the recommended action in accordance with a result of interpreting or analyzing the interactive communication; and provides to the person the message generated.

[Brief Description of Drawings]

[0015]

[Fig. 1]

Fig. 1 illustrates the hardware configuration of an action-based operation support system according to one embodiment.

[Fig. 2]

Fig. 2 illustrates the overall configuration of a plant system to which the action-based support system according to the present embodiment is applied, as well as functions and operations of the plant system during plant operation.

[Fig. 3]

Fig. 3 illustrates the configuration of the same plant system, as well as functions and operations of the plant system when reviewing past operations.

[Fig. 4]

Fig. 4 illustrates the configuration of the same plant system, as well as functions and operations of the plant system when registering operation knowledge.

[Fig. 5]

Fig. 5 illustrates an example of the configuration of a world model incorporated into a predictive action system in the action-based support system according to the present embodiment.

[Fig. 6]

Fig. 6 illustrates an example of the configuration of a recommended action generation unit in the plant operation

support system according to the present embodiment.

[Fig. 7]

Fig. 7 illustrates an example of the configuration of a causal logic learning unit in the plant operation support system according to the present embodiment.

[Fig. 8]

Fig. 8 illustrates an example of the configuration of a causal analysis logic unit in the plant operation support system according to the present embodiment.

[Description of Embodiments]

[0016]

An exemplary embodiment of the present invention will be described hereinafter with reference to the drawings. It should be noted that the embodiment described hereinafter is not intended to limit the invention as set forth in the claims, and that not all elements and combinations thereof described in the embodiment are necessarily essential as means to solve the invention.

[0017]

Note also that in the drawings described in the embodiments, parts having identical functions will be assigned the same reference signs, and redundant descriptions thereof will be omitted.

[0018]

Fig. 1 illustrates the physical configuration of a computer system to which an action-based support system according to

one embodiment is applied.

[0019]

As illustrated in Fig. 1, a computer system 200 includes a plurality of (or one) physical computers 201 connected to a network 240.

[0020]

The network 240 is one or more communication networks, and may include at least one of an FC (Fibre Channel) network and an IP (Internet Protocol) network, for example. The network 240 may be present outside the computer system 200.

[0021]

Each physical computer 201 is a general-purpose computer, for example, and includes physical computer resources 350. The physical computer resources 350 include a communication interface unit 251, a storage unit 252, and a processor unit 253 connected thereto.

[0022]

The computer system 200 may be a cloud computing system that provides XaaS (X as a Service), for example. Note that "XaaS" generally means a service that makes some resource necessary for constructing or operating a system (e.g., hardware, communication lines, a software execution environment, application programs, a development environment, and the like) usable over a network such as the Internet. The letter (or word) substituted for the "X" in XaaS differs depending on the type (service model) of the XaaS. Examples of XaaS include

PaaS (Platform as a Service), SaaS (Software as a Service), IaaS (Infrastructure as a Service), or HaaS (Hardware as a Service), for example.

[0023]

The action-based support system according to one embodiment can be realized by the processor unit 253 in the one or more physical computers 201 of the computer system 200 executing a computer program stored in the storage unit 252.

[0024]

An action-based support system according to one embodiment that is applied to support for the operation of a plant such as a chemical plant will be described hereinafter as one example. Figs. 2, 3, and 4 illustrate examples of the configuration and functions of an overall plant system including the action-based support system according to the present embodiment, as well as related systems peripheral thereto.

[0025]

As illustrated in Figs. 2, 3, and 4, a plant system 300 includes a plant 1, an operator 3, and a Distributed Control System (“DCS” hereinafter) 5. The plant system 300 further includes one or more user interface/user experience systems (“UIS” hereinafter) 7 and a Data Management System (“DMS” hereinafter) 9. The plant system 300 further includes the Action-Based Support System according to one embodiment (“ABSS” hereinafter) 11.

[0026]

A plurality of each of the other types of components 3, 5, 7, 9, and 11 may be present for one plant 1. However, for descriptive purposes, the following will focus on one component for each component type, and describe the operations and function thereof. Based on these descriptions, a person skilled in the art should easily understand even cases where a plurality of components are present for each component type.

[0027]

Fig. 2 illustrates the operation and functions of the plant system 300 during operation of the plant 1.

[0028]

As illustrated in Fig. 2, when the operator 3 inputs an operation instruction 23 to the UIS 7 (step 21), the operation instruction 23 is received by the DCS 5. The DCS 5 controls the plant 1 in accordance with the operation instruction 23 (step 25). The plant 1 operates in accordance with that control 27 (step 29).

[0029]

A large number of sensors that sense various states at corresponding locations (operating states such as temperature, pressure, and flow rate, the quality of materials and products, and the like) are provided at a large number of locations in the plant 1. The sensors sense the states at the corresponding locations and output sensor data indicating the locations and the state values thereof (step 31). The DCS 5

receives the sensor data (step 35). The DCS 5 also monitors the sensor data 33 received from the plant 1 and checks whether any anomalies are present, and when an anomaly is detected, notifies the operator 3 thereof through the UIS 7 (step 37). The DCS 5 outputs the received operation instruction, the received sensor data, and detected anomaly data in real time. Hereinafter, the operation instruction, the sensor data, and the anomaly data output from the DCS 5 are collectively referred to as “plant data”. The DMS 9 receives plant data 39 from the DCS 5 and stores the received plant data 39 in a plant data log base 41.

[0030]

The DMS 9 also includes an operation report log base 43 and an operation knowledge base 45. Operation reports created by the operator 3 (e.g., daily operation reports, handover messages, and the like) are stored as operation report logs in the operation report log base 43. In addition to the operation report logs, various documents related to the operation of the plant 1 (e.g., operation standard documents, operation procedure documents, operation rule documents, and the like) are also stored in the operation report log base 43. Various types of operation knowledge created by the operator 3 are stored in the operation knowledge base 45.

[0031]

When the plant 1 is operating, both the basic processing described above and operation support by the ABSS 11 are

further performed. The configuration and functions of the ABSS 11 will be described below.

[0032]

As illustrated in Fig. 2, the ABSS 11 is capable of communicating with other components of the plant system 300, such as the DCS 5, the DMS 9, and the UIS 7, and provides various support services to the operator 3 using communication with those other components. The ABSS 11 includes a Natural Language System ("NLS" hereinafter) 13 and a Predictive Action System ("PAS" hereinafter) 15.

[0033]

In the following, the two systems, namely the NLS 13 and the PAS 15, will be described as being included in the ABSS 11, as subsystems thereof; however, this is merely an example provided for descriptive purposes. In addition to the NLS 13 and the PAS 15, some or all of the DCS 5, the DMS 9, and the UIS 7 may be understood as subsystems of the ABSS 11.

[0034]

The NLS 13 of the ABSS 11 has a function of interpreting, analyzing, and generating messages using natural language that a human (the operator 3) routinely uses and can understand. The natural language here may include not only characters, sentences, or text that a human normally uses, but also other forms of expression that a human routinely uses and can understand, such as diagrams, tables, and pictures.

[0035]

The NLS 13 can input a natural language message, interpret or analyze the message, and, in accordance with a result of the interpretation or analysis, generate and output a new message expressed in an artificial language (e.g., a language used by a machine such as the DCS 5, the DMS 9, and/or the PAS 15) and/or a new message expressed in natural language. Additionally, the NLS 13 can also input an artificial language message, interpret or analyze the message, and, in accordance with a result of the interpretation or analysis, create and output a new message in natural language. To realize such a natural language processing function, the NLS 13 can include a deep neural network of a type called a Large Language Model ("LLM" hereinafter), such as a GPT (Generative Pre-trained Transformer).

[0036]

The NLS 13 is capable of communicating with components of the plant system 300, such as the PAS 15, the DMS 9, and the UIS 7, for example.

[0037]

The PAS 15 of the ABSS 11 has a role of generating information related to future operations of the plant 1, which is useful to the operator 3. The PAS 15 has a function for predicting the future behavior and state of the plant 1, and a function for generating, on the basis of the predicted future behavior and state, an action recommended to be performed by the operator 3 (in particular, an operation command recommended to

be given to the plant 1). To realize this predictive action function, the PAS 15 can include a deep neural network of a type called a World Model ("WM" hereinafter).

[0038]

The PAS 15 is capable of communicating with components of the plant system 300, such as the NLS 13, the DCS 5, the DMS 9, and the UIS 7, for example.

[0039]

During operation of the plant 1, the ABSS 11 can perform the following processing.

[0040]

As illustrated in Fig. 2, the PAS 15 of the ABSS 11 receives the plant data output from the DCS 5 in real time, and then, using the received plant data, generates and outputs a future prediction 53 of the behavior and state of the plant 1 (step 51). The PAS 15 further generates and outputs a recommended operation (an operation instruction recommended to be provided to the plant 1 in the future) 57 on the basis of the generated future prediction 53.

[0041]

The NLS 13 inputs the future prediction 53 and the recommended operation 57 output from the PAS 15. The NLS 13 uses the input future prediction 53 and recommended operation 57, respectively, to create explanatory messages expressing the future prediction 53 and the recommended operation 57 in natural language format that is easier for the operator 3 to

understand or easier to use, i.e., a future prediction message 61 and a recommended operation message 63 (step 59). The NLS 13 then conveys the created explanatory messages 61 and 63 to the operator 3 by displaying the messages 61 and 63, respectively, on the UIS 7.

[0042]

When creating each of the messages 61 and 63, the NLS 13 can retrieve data related to each of the input future prediction 53 and recommended operation 57 (e.g., a plant data log, an operation report log, an operation standard, an operation rule, operation knowledge, or the like) from the plant data log base 41, the operation report log base 43, and/or the operation knowledge base 45. The NLS 13 can then create the explanatory future prediction message 61 and the recommended operation message 63 by adding the retrieved related data to the future prediction 53 or the recommended operation 57, or by editing the data. Furthermore, the NLS 13 performs interactive communication with the operator 3 using natural language, and interprets or analyzes the interactive communication. Then, in accordance with a result of the interpretation or analysis, the NLS 13 can determine what kind of related data the operator 3 wants, and/or the format in which it is appropriate to express the messages 61 and 63 (e.g., text, a table, a diagram, a formula, a combination thereof, or the like), and can create the messages 61 and 63 in accordance with the determination.

[0043]

The operator 3 can use the messages 61 and 63 as reference or assistance information for appropriately operating the plant 1 (steps 65 and 67).

[0044]

Furthermore, the operator 3 can input an inquiry for any desired additional information into the UIS 7 in free natural language text (step 71), and this inquiry message 73 is received by the NLS 13 of the ABSS 11 through the UIS 7. The inquiry message 73 may be a message asking what result will be produced if a designated operation is performed, such as, for example, "What is your future prediction if operation 'xx' is performed?" Alternatively, the inquiry message 73 may be a message that asks what operation should be performed in order to acquire a designated result, such as, for example, "To what temperature should 'yy' be set in order to achieve a production amount of 'xx' for monomethylamine?" The specific content of the inquiry message 73 can be freely set by the operator 3.

[0045]

The NLS 13 of the ABSS 11 interprets or analyzes the received inquiry message 73, and determines a processing method to be performed to respond to the inquiry from the operator 3 (step 75). Several methods, including the following, can be given as examples of the processing method.

[0046]

[First Method]

This method is applicable when asked what result will be produced if a designated operation instruction is made, such as, for example, “What is your future prediction if operation ‘xx’ is performed?”, in the example described above. In this method, the NLS 13 makes an instruction 77 to the PAS 15 to change some of the plant data 39 used for the future prediction. Then, the PAS 15 makes a tentative future prediction using the changed plant data (step 79).

[0047]

For example, only a parameter value of the corresponding operation instruction in the actual plant data 39 input from the DCS 5 to the PAS 15 (e.g., a setting value such as the temperature or pressure at a specific location in the plant 1) is changed to the parameter value of the operation instruction designated by the inquiry message 73. The PAS 15 uses a combination of the changed operation instruction and other data in the actual plant data 39 as tentative plant data, and generates a tentative future prediction 81 indicating the queried result (step 79). The NLS 13 receives the generated tentative future prediction 81 and generates a response message 89 to the inquiry message 73 using the tentative future prediction 81 (step 87). The operator 3 can receive the response message 89 through the UIS 7 and use that message as reference information.

[0048]

[Second Method]

This method is applicable when asked what operation should be performed in order to acquire a designated result, such as, for example, “To what temperature should ‘yy’ be set in order to achieve a production amount of ‘xx’ for monomethylamine?” In this method, the NLS 13 analyzes, for example, at least some of various data managed in the databases 41, 43, and 45 of the DMS 9 (e.g., the plant data log, the operation report log, the operation knowledge, or the like), and selects one or more types of operation instructions that are highly likely to affect the result designated by the inquiry message 73 (i.e., that have a high correlation with the designated result). Then, the NLS 13 makes an instruction 77 to the PAS 15 to make tentative future predictions while changing the parameter value of the selected operation instruction to various values.

[0049]

In accordance with the instruction 77, of the actual plant data 39 input from the DCS 5, the PAS 15 changes only the parameter value of the selected operation instruction to various values, e.g., through trial and error, and generates the tentative future prediction 81 for each changed parameter value (step 79). The PAS 15 furthermore generates a tentative recommended operation 85 for each changed parameter value, using the tentative future prediction 81 (step 83).

[0050]

The NLS 13 receives, from the PAS 15, the tentative future

prediction 81 and the tentative recommended operation 85 corresponding to each of the various changed parameter values. Then, the NLS 13 selects the prediction, from among the various received tentative future predictions 81, that is closest to the result designated by the inquiry message 73, and selects the tentative recommended operation 85 corresponding to the selected tentative future prediction 81. The NLS 13 generates the response message 89 to the inquiry message 73 using the selected tentative future prediction 81 and tentative recommended operation 85 (step 87). The operator 3 can receive the response message 89 through the UIS 7 and use that message as reference information.

[0051]

[Third Method]

This method can also be applied when asked what operation should be performed in order to acquire a designated result, in the same manner as the second method described above. This method is a modified combination of the first and second methods described above. The NLS 13 analyzes, for example, at least some of the various data managed in the databases 41, 43, and 45 of the DMS 9 (e.g., the plant data log, the operation report log, the operation knowledge, or the like), and identifies one or more types of parameter values of one or more types of operation instructions that are effective for acquiring the result designated by the inquiry message 73. Then, the NLS 13 makes an instruction 77 to the PAS 15 to

change the corresponding part of the plant data 39 to the parameter value of the identified operation instruction, and to make a tentative future prediction using the changed plant data 39 as tentative plant data. The subsequent processes are the same as in the first method. In addition, a tentative future prediction is generated for each parameter value while changing the parameter value of the operation instruction to a plurality of lands, as in the second method. Then, on the basis of the plurality of tentative future predictions corresponding to the different parameter values, a tentative recommended operation corresponding to the tentative future prediction closest to the designated result is selected.

[0052]

Regardless of which of the first to third methods described above is used, the NLS 13 performs interactive communication with the operator 3 in step 87 of creating the response message, in the same manner as in step 59 described above, and interprets or analyzes the communication. Then, in accordance with a result of the interpretation or analysis, the NLS 13 can load data related to the tentative future prediction 81 or the tentative recommended operation 85 from the database 41, 43, or 45 of the DMS 9 and generate an explanatory response message 89 including the related data, so as to best satisfy the request of the operator 3.

[0053]

Fig. 3 illustrates the operation and functions of the plant

system 300 for reviewing past plant operations and retraining the ABSS 11.

[0054]

As illustrated in Fig. 3, when the operator 3 creates an operation report (e.g., a daily operation report) 103 using the UIS 7 (step 101), that operation report 103 is registered in the operation report log base 43 by the DMS 9. When the operator 3 enters an operation log request 107 that matches any condition (e.g., a time period, a location in the plant, a type of log to be taken, and the like) into the UIS 7 (step 105), the NLS 13 of the ABSS 11 loads the plant data log and/or the operation report log that match the above condition from the plant data log base 41 and/or the operation report log base 43, interprets or analyzes the log data, and generates an operation log message 111 that expresses a result of the interpretation or analysis using free text in natural language, a graph, and the like (step 109). In this step 109, the NLS 13 performs interactive communication with the operator 3 in the same manner as in step 59 illustrated in Fig. 2, and by interpreting or analyzing the interactive communication, the NLS 13 can select and load data related to the requested operation log from the database 41, 43, or 45 of the DMS 9 in accordance with a result of the interpretation or analysis (i.e., so as to best satisfy the request of the operator 3), and generate an explanatory operation log message 111 including the related data.

[0055]

The operation log message 111 is presented to the operator 3 through the UIS 7. The operator 3 can review and discuss the past operations while referring to the operation log message 111 (step 113).

[0056]

When the operator 3 creates the content of the review or discussion of past operations (called an “operation review” hereinafter) 117 as free text, for example, and inputs that content into the UIS 7, the NLS 13 of the ABSS 11 interprets or analyzes the free-text input content 117 and generates learning data 121 in a format usable for relearning in the PAS 15 (e.g., training data for supervised learning of the PAS 15) (step 119). At that time, the NLS 13 can load data related to the operation log message 111 presented to the operator 3 or the operation review 117 input from the operator 3 from the database 41, 43, or 45 of the DMS 9, and generate effective learning data 121 using the operation review 117 and the related data. When the input operation review 117 is, for example, “The operational task of setting the temperature of the target object ‘yy’ to ‘ww’ degrees at the date/time ‘xx’ was ‘vv’ minutes too early”, the NLS 13 creates, in addition to this operation review, learning data for the PAS 15 to learn at what timing and how to set the temperature of the target object “yy” when the plant data transitions in a similar manner, using, for example, a transition of the plant

data in a certain time period before and after the date/time "xx", an operation standard, an operation rule, and/or operation knowledge related to the temperature setting of the target object "yy", and the like.

[0057]

The created learning data 121 is stored and accumulated in a learning database 123. The PAS 15 performs relearning for the future prediction method and/or the recommended operation generation method using the learning data 121 (step 125). This relearning may be performed online automatically at a timing based on the amount of unlearned learning data in the learning database 123, the time that has passed since the previous relearning, or the like. Additionally, the relearning may be performed manually by an engineer at an appropriate time. In the latter type of relearning, the logic and/or the learning method used by the computer program of the PAS 15 or the like may also be improved, adjusted, and the like by an engineer.

[0058]

Fig. 4 illustrates the operations and functions of the plant system 300 for registering operation knowledge.

[0059]

As illustrated in Fig. 4, using the UIS 7, the operator 3 can create, as free text using natural language, a knowledge message 133 representing operation knowledge (a guide or guidelines indicating a specific operational task to be performed under specific circumstances) on the basis of, for

example, a result of the stated review and discussion of operations (step 113). The NLS 13 of the ABSS 11 interprets or analyzes the free-text knowledge message 133 that has been created, generates, on the basis of the result of that interpretation or analysis, operation knowledge having a predetermined data format for database registration, and registers the operation knowledge in the operation knowledge base 45.

[0060]

The NLS 13 of the ABSS 11 receives the plant data 39 output from the DCS 5 in real time. Alternatively, the NLS 13 acquires past plant data 39 from the plant data log base 41. The NLS 13 then retrieves operation knowledge that matches an operation condition included in the acquired plant data from the operation knowledge base 45. Furthermore, the NLS 13 searches the database 41, 43, or 45 for data related to the retrieved operation knowledge. Then, using the retrieved operation knowledge and related data, the NLS 13 generates an explanatory operation guide 139 that expresses the operation knowledge together with the related data in natural language so as to be easily understandable (step 137). At that time, in the same manner as in step 59 in Fig. 2, the NLS 13 can perform interactive communication with the operator 3, interpret or analyze the interactive communication, select and read related data desired by the operator 3 from the database 41, 43, or 45 of the DMS 9 in accordance with a result of the

interpretation or analysis (i.e., to best satisfy the request of the operator 3), and generate an explanatory operation guide 139 including the related data.

[0061]

The operation guide 139 generated by the NLS 13 is presented to the operator 3 through the UIS 7, and the operator 3 can use the guide as reference information (step 141).

[0062]

The operator 3 can also input an operation guide request 145 that matches any desired operation condition into the UIS 7 (step 143). In this case too, the NLS 13 loads operation knowledge that matches a condition designated by the request 145 and data related to the operation knowledge from the database 41, 43, or 45, generates an operation guide 139 in the same manner as described above, and then provides the operation guide 139 to the operation through the UIS 7 (step 137).

[0063]

Fig. 5 illustrates an example of the configuration of the PAS 15 of the ABSS 11 according to the present embodiment.

[0064]

The PAS 15 includes a world model, and the world model is configured to learn the dynamics (movements and changes) of the plant 1 to predict the future behavior and state of the plant 1 using that knowledge, and to plan operations of the plant 1 by the operator 3 using those predictions. As

illustrated, for example, in Fig. 5, the PAS 15 includes an encoder 151, a predictor 153, and a controller 155. The PAS 15 may further include a decoder 157.

[0065]

The encoder 151 inputs the plant data 39, which is a high-dimensional vector, in real time, and encodes that data into a low-dimensional latent vector 161 that includes highly important information regarding the behavior and state of the plant 1. The encoder 151 can be configured using a Variational Autoencoder (VAE), for example.

[0066]

The predictor 153 inputs the latent vector 161 from the encoder 151 and, on the basis of a history of the input latent vector 161, predicts a future image ("future vector" hereinafter) 163 of the latent vector 161 at a certain time point in the near future. The future vector 163 is fed back to the predictor 153, and the predictor 153 also uses the fed-back future vector 163 to predict a future vector 163 at a time point further in the future. The predictor 153 can be configured using a recurrent neural network (RNN) including a Mixture Density Network (MDN) output layer, for example.

[0067]

The future vector 163 output from the predictor 153 may be used as a future prediction 53 indicating future circumstances of the plant 1. Alternatively, the decoder 157 may decode the future vector 163 into a high-dimensional vector similar to

the plant data 39, and the decoded high-dimensional vector may be used as a future prediction 53. Like the encoder 151, the decoder 157 can be configured using a Variational Autoencoder (VAE), for example.

[0068]

The controller 155 inputs the output vectors 161 and 163 from the encoder 151 and the predictor 153, and generates a recommended operation 57 for the plant 1 using the output vectors 161 and 163.

[0069]

The future prediction 53 and the recommended operation 57 output from the PAS 15 are converted by the NLS 13 into explanatory messages 61 and 63 expressed in natural language and provided to the operator 3, as described with respect to step 59 in Fig. 2. The operator 3 can determine an actual operation instruction 23 and apply that instruction to the plant 1 by referring to the future prediction 53 and the recommended operation 57.

[0070]

Additionally, the change instruction 77 described with respect to step 75 in Fig. 2 can be executed by changing the corresponding part of the plant data 39 input to the encoder 151 in Fig. 5 using any of the first to third methods described above. As a result, the predictor 153 or the decoder 157 generates the tentative future prediction 81, and the controller 155 generates the tentative recommended operation

85. The tentative future prediction 53 and the tentative recommended operation 57 are converted by the NLS 13 into an explanatory message 89 expressed in natural language and provided to the operator 3, as described with respect to step 87 in Fig. 2.

[0071]

As illustrated in Fig. 5, as a result of the actual operation instruction 23 by the operator 3, the plant data 39 indicating the actual circumstances of the plant 1 is input to the encoder 151. The PAS 15 can automatically perform reinforcement learning by using the plant data 39 input to the encoder 151 as experience.

[0072]

Additionally, as illustrated in Fig. 5 (and as described with respect to step 119 in Fig. 3), the NLS 13 can generate learning data 121 on the basis of an operation review 117 from the operator 3, and then perform relearning of the PAS 15 using that learning data.

[0073]

In the one embodiment described above with reference to Figs. 2 to 5, the ABSS 11 includes the NLS 13 and the PAS 15. The PAS 15 is interposed between the plant 1 and the NLS 13. The PAS 15 inputs the plant data 39 output from the plant 1, generates a future prediction of the behavior and state of the plant 1 using the input plant data 39, and then generates a recommended operation for the plant 1 using the future

prediction.

[0074]

Additionally, the NLS 13 is interposed among the operator 3 (the UIS 7), the PAS 15, and the DMS 9 (the databases 41, 43, and 45). The NLS 13 can then receive a future prediction or a recommended operation from the PAS 15, convert the future prediction or the recommended operation into a message expressed in natural language, and provide the message to the operator 3 through the UIS 7. At that time, while interacting with the operator 3, the NLS 13 can acquire data related to the future prediction or the recommended operation, respectively, from the DMS 9, and, using the acquired related data, make the content of the message to be provided to the operator 3 more explanatory or specific.

[0075]

Additionally, the NLS 13 can receive a free-text message in natural language created by the operator 3, interpret or analyze the received message, and on the basis of a result of the interpretation or analysis, retrieve data requested by the operator 3 from the database 41, 43, or 45, and/or instruct the PAS 15 to generate a future prediction or a recommended operation requested by the operator 3, and return the result to the NLS 13. Then, the NLS 13 can convert the retrieved data and/or the returned future prediction or recommended operation into a message expressed in natural language and provide the message to the operator 3 through the UIS 7. In this case too,

the NLS 13 can acquire related data from the DMS 9 while interacting with the operator 3 and, using the related data, make the content of the message to be provided to the operator 3 more explanatory or specific.

[0076]

Accordingly, the ABSS 11 can provide useful and accurate support to the operator of the plant, and can provide communication to the operator that is accommodating and easy to understand.

[0077]

Fig. 6 is a diagram describing the generation of the recommended operation 57 based on the future prediction 53 by the PAS 15 in more detail. A recommended action generation unit 400 illustrated in Fig. 6 includes a causal logic unit 301, an operation history DB 302, and a causal logic learning unit 303.

[0078]

A future prediction 53 of the behavior and state of the plant 1 based on the plant data 39 is input to the causal logic unit 301 from a world model 158 in the PAS 15. Additionally, the causal logic unit 301 holds logic 96 indicating a relationship between the future prediction 53 and the recommended operation 57 based on the future prediction 53. The causal logic unit 301 generates the recommended operation 57 using the future prediction 53 and the logic 96.

[0079]

The causal logic unit 301 outputs recommendation information 91 including the future prediction 53 and the recommended operation 57 to the UIS 7, and outputs prediction information 92 including an ideal state 97 (see Fig. 7), which is the behavior or state of the plant 1 to be realized by performing the future prediction 53 and the recommended operation 57, to the operation history DB 302.

[0080]

The UIS 7 provides the recommendation information 91 from the causal logic unit 301 to the operator 3 by displaying the recommendation information 91. At this time, the recommendation information 91 may be displayed after being converted by the NLS 13 into an explanatory recommended message (e.g., the future prediction message 61 and the recommended operation message 63) expressed in natural language in a format that is easier for the operator 3 to understand or easier to use.

[0081]

Having been provided with the recommendation information 91, the operator 3 determines the actual operation instruction 23 by referring to the recommendation information 91, and inputs the instruction into the UIS 7. The UIS 7 outputs the input operation instruction 23 to the DCS 5, and the DCS 5 performs control 27 of the plant 1 in accordance with the operation instruction 23. Additionally, the UIS 7 outputs an actual operation 93 indicating the input operation instruction 23 to

the operation history DB 302.

[0082]

The operation history DB 302 receives the prediction information 92 from the causal logic unit 301, receives the actual operation 93 from the UIS 7, and receives, from the DCS 5, the plant data 39 after control 27 based on the operation instruction 23 has been performed, as an actual state 94 indicating the behavior or state of the plant 1 actually realized by the actual operation 93.

[0083]

On the basis of the prediction information 92, the actual operation 93, and the actual state 94, the operation history DB 302 stores an operation history 95 that is a history related to the actual operation 93. The operation history 95 indicates the actual operation 93, the actual state 94, the ideal state 97, and the like, for each future prediction 53, for example.

[0084]

The causal logic learning unit 303 acquires the operation history 95 from the operation history DB 302 and updates the logic 96 of the causal logic unit 301 on the basis of the operation history 95. The timing for updating the logic 96 is not particularly limited. For example, the logic 96 may be updated at regular intervals, each time the operation instruction 23 is input, or when an instruction is made by the operator 3 or the like.

[0085]

Fig. 7 is a diagram illustrating the configuration of the causal logic learning unit 303 in detail. The causal logic learning unit 303 illustrated in Fig. 7 includes a clustering unit 331 and a prioritization unit 332.

[0086]

The clustering unit 331 clusters the actual operations 93 included in the operation history 95 into a plurality of similar groups having sets of the future prediction 53 and the ideal state 97 included in the operation history 95 that are similar to each other, and outputs a clustering result 98. The method (algorithm) for performing the clustering is not particularly limited.

[0087]

On the basis of the operation history 95 and the clustering result 98, the prioritization unit 332 assigns a priority to each of one or more actual operations 93 corresponding to the combination of the future prediction 53 and the ideal state 97 included in the similar group, for each of the similar groups. Specifically, the prioritization unit 332 evaluates the actual operation 93 on the basis of the actual state 94 after the operation instruction 23 indicated by the actual operation 93 is input, and assigns a priority to each actual operation 93 on the basis of the evaluation result. For example, as the evaluation result, the prioritization unit 332 calculates a difference between the ideal state 97 and the actual state 94

(a difference between values of the sensor data indicating the ideal state 97 and the actual state 94, respectively), and assigns a priority to each actual operation 93 such that the priority increases as the evaluation result increases (as the difference between the ideal state 97 and the actual state 94 decreases). Note that instead of being calculated by the prioritization unit 332, the evaluation value may be calculated in advance and stored in the operation history DB 302.

[0088]

For each similar group, the prioritization unit 332 sets the actual operation 93 having the highest priority as recommended operation information. Additionally, for each similar group, the prioritization unit 332 updates the logic 96 held in the causal logic unit 301 by outputting a representative value of the combination of the future prediction 53 and the ideal state 97 in the similar group, and the recommended operation information, to the causal logic unit 301 as the logic 96.

[0089]

Fig. 8 is a diagram illustrating the configuration of the causal logic unit 301 in detail. The causal logic unit 301 illustrated in Fig. 8 includes a logic DB 311, a cause input unit 312, a cause DB 313, and a linking unit 314.

[0090]

The logic DB 311 holds the logic 96, and when newly receiving the logic 96 from the causal logic unit 301, updates the held

logic 96 with the new logic 96.

[0091]

On the basis of input data 99 input to a cause input auxiliary device 401, the cause input unit 312 generates and outputs cause information 100 related to a cause for which the future prediction 53 of the behavior and state of the plant 1 will occur. For example, for each operation recommendation state, which is a future prediction 53 for which input of the operation instruction 23 is recommended, the cause information 100 includes at least one of the following: a factor that causes the operation recommendation state; an ideal state; one or more operation candidates that are candidates for the operation instruction 23 recommended to be input to return the operation recommendation state to the ideal state; and a reason for inputting each operation candidate.

[0092]

The cause input auxiliary device 401 may be a Human Interface Device ("HID" hereinafter) into which text data is input, such as a keyboard, an image reading device such as a scanner, or the like. For example, when text data indicating the cause information 100 is directly input as the input data 99 to the cause input auxiliary device 401, the input data 99 may be used as the cause information 100, or an AI model or the like may be used to check whether the input data 99 is appropriate as the cause information 100, with appropriate data in the input data 99 being used as the cause information 100.

Additionally, when the cause input auxiliary device 401 loads a specification regarding the plant 1, an operation journal created in the past, or the like as an image, text in the image may be recognized and generated as the cause information 100.

[0093]

The cause DB 313 stores the cause information 100 from the cause input unit 312.

[0094]

The linking unit 314 generates the recommended operation 57 based on the future prediction 53 using the logic 96 in the logic DB 311 and the cause information 100 in the cause DB 313, and outputs the recommendation information 91 including the future prediction 53 and the recommended operation 57 to an LLM 315.

[0095]

For example, the linking unit 314 determines whether the future prediction 53 indicates an operation recommendation state for which input of the operation instruction 23 is recommended. The operation recommendation state is a state in which the sensor data indicates an anomalous value, for example, and a condition for determining whether the future prediction 53 is the operation recommendation state (e.g., a threshold for the sensor data) may be included in the cause information 100, or may be stored separately from the cause information 100, for example.

[0096]

When the future prediction 53 is the operation recommendation state, the linking unit 314 performs pattern matching between the future prediction 53 and the operation recommendation state in the cause information 100, and acquires an ideal state corresponding to the matching operation recommendation state. The linking unit 314 performs pattern matching between a combination of the future prediction 53 and the ideal state and a representative value of that combination in the logic 96, sets a recommended operation corresponding to the matching representative value as the recommended operation 57, and outputs recommendation information 91 including the future prediction 53 and the recommended operation 57 to the LLM 315.

[0097]

The recommendation information 91 can include various pieces of supplementary information in addition to the future prediction 53 and the recommended operation 57. The supplementary information is generated by the linking unit 314 on the basis of the cause information 100. The supplementary information is, for example, at least one of a factor that produces the operation recommendation state matching the future prediction 53; an ideal state corresponding the operation recommendation state; an operation candidate recommended to be input as a candidate for an operation instruction for returning the operation recommendation state to the ideal state; a reason for inputting the operation

candidate; and the like. The operation candidate is used as a second-best option for the recommended operation 57.

[0098]

The LLM 315 converts the recommendation information 91 from the linking unit 314 into a recommendation message 71B and outputs the message to the UIS 7.

[0099]

The configuration of the recommended action generation unit 400 described above is merely an example, and is not limited thereto. For example, the DBs such as the operation history DB 302, the logic DB 311, and the cause DB 313 may be stored in the DMS 9.

[0100]

In the recommended action generation unit 400 described above, the causal logic unit 301 outputs the recommendation information 91 including the generated recommended operation 57 to the UIS 7, and having confirmed the recommendation information 91, the operator 3 determines the actual operation instruction 23 and inputs the instruction into the UIS 7. However, the recommended operation 57 generated by the causal logic unit 301 may be input directly to the DCS 5 as the operation instruction 23. This makes it possible to automatically perform control 27 of the plant 1 in accordance with the future prediction 53, without human intervention. Additionally, the operator 3 may be made able to select whether the operation instruction 23 is to be determined by

the operator 3 confirming the recommendation information 91, or the recommended operation 57 is to be automatically input to the DCS 5 as the operation instruction 23. For example, when learning of the logic 96 is insufficient, the operator 3 checks the recommendation information 91; when learning of the logic 96 has become sufficient and automatically using the recommended operation 57 as the operation instruction 23 poses no problem, the recommended operation 57 may be automatically used as the operation instruction 23. Whether the learning of the logic 96 is sufficient may be determined by the operator 3, or may be determined according to whether a predetermined condition (e.g., the recommended operation 57 and the actual operation 93 matching equal to or larger than a predetermined number of times consecutively) is satisfied.

[0101]

In the embodiment described above with reference to Figs. 6 to 8, the causal logic unit 301 included in the PAS 15 generates a recommended operation 57 by further using logic indicating a relationship between the future prediction 53 of the behavior and state of the plant 1 and the recommended operation 57. Additionally, the causal logic unit 301 updates the logic on the basis of an actual operation in the plant 1 by the operator 3. This makes it possible to generate the recommended operation 57 appropriately.

[0102]

The foregoing embodiment has described a configuration in

detail to clearly describe the present invention, and is not necessarily limited to an embodiment having all of the configurations described. It is also possible to add, remove, or replace part of the configuration of each embodiment with other configurations.

[0103]

For example, the POSS 11 includes the NLS 13 as an interface system that performs communication, which is the exchange of information with the operator 3; however, the interface system is not limited to the NLS 13. As a message based on the future prediction 53 or the recommended operation 57, the interface system may provide another message instead of or in addition to the message expressed in natural language described above. Here, the message is notification information provided to the operator 3, and may include information indicating options for the operator 3 to select, interface components such as buttons and checkboxes for inputting a selection result, and the like. Examples of the options include whether to execute the recommended operation 57, candidates for the operation instruction 23 (the recommended operation 57 and candidate operations thereof), and the type and content of an inquiry to be input to the POSS 11. The notification information is not limited to this example, and may be any information that is accommodating and easy to understand for the operator. Additionally, the inquiry message and the like input to the POSS 11 are not limited to a message expressed in natural

language, and may be information (a message) indicating an option selected by the operator 3 or the like, for example.

[0104]

Additionally, the embodiment described above is merely one example intended to support an operator of a plant. The present invention can be implemented in various different modes for other purposes. For example, in an action-based support system according to one embodiment of the present invention, applied in order to support a person acting according to the circumstances in a certain environment, a person skilled in the art can easily understand the configuration, functions, same operations of the action-based support system by reading, in the above descriptions given with reference to Figs. 2 to 5, a combination of “plant” and “DCS” as “the environment”, “operator” as “person”, “plant data” as “environment data indicating the circumstances of the environment”, and “operation” as “action”.

[0105]

In the operation of the plant described above, serious errors in the operational tasks are not permitted. However, there may also be fields in which some level of error or inappropriateness in actual actions is not considered a significant problem. In an action-based support system applied in such a field, the action-based support system may be capable of executing a generated recommended action on behalf of a person.

[0106]

Additionally, part or all of each of the configurations, functions, processing units, processing means, and the like described above may be realized by hardware, through design by integrated circuits or the like, for example. The present invention can also be realized by software program code that realizes the functions of the embodiment. In this case, a storage medium on which the program code is recorded is provided to a computer, and a processor included in the computer reads out the program code stored in the storage medium. In this case, the program code itself read from the storage medium realizes the functions of the embodiment described above, and the program code itself and the storage medium storing the program code constitute the present invention. For example, a flexible disk, a CD-ROM, a DVD-ROM, a hard disk, an SSD (Solid State Drive), an optical disk, a magneto-optical disk, a CD-R, magnetic tape, a non-volatile memory card, ROM, or the like is used as the storage medium for supplying such program code.

[0107]

Additionally, the program code that realizes the functions described in the embodiment described above can be implemented in a wide range of programming or scripting languages, such as assembler, C/C++, perl, Shell, PHP, Java (registered trademark), Python, or the like.

[0108]

Furthermore, all or a part of the software program code that realizes the functions of the embodiment described above may be stored in advance in a storage resource of the computer; or may be stored as necessary in a storage resource of the computer from a non-transitory storage device of another device connected to a network, or from a non-transitory storage medium via an external I/F (not shown) included in the computer.

[0109]

Furthermore, by distributing the software program code that realizes the functions of the embodiment described above over a network, the program code may be stored in a storage means such as a hard disk or a memory of a computer or in a storage medium such as a CD-RW or a CD-R, and a processor included in the computer may read and execute the program code stored in the storage means or the storage medium.

[Reference Signs List]

[0110]

1 Plant

3 Operator

5 DCS (distributed control system)

7 UIS (user interface/user experience system)

9 DMS (data management system)

11 ABSS (action-based support system)

13 NLS (natural language system)

15 PAS (predictive action system)

41 Plant data log base

43 Operation report log base

45 Operation knowledge base

151 Encoder

153 Predictor

155 Controller

157 Decoder

[CLAIMS]

[Claim 1]

An action-based support system for supporting a person who performs an action in accordance with circumstances of an environment, the action-based support system comprising:

an interface system configured to perform communication with the person; and

a predictive action system configured to take, as an input, environment data indicating the circumstances of the environment, generate a future prediction indicating future circumstances of the environment by using the environment data input, and generate a recommended action by using the future prediction generated, wherein

the interface system is configured to take, as an input, the future prediction or the recommended action from the predictive action system, interpret or analyze the communication with the person, generate a message based on the future prediction or the recommended action input in accordance with a result of interpreting or analyzing the communication, and provide to the person the message generated.

[Claim 2]

The action-based support system according to claim 1, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person, and

the interface system is configured to acquire, from the data management system, first related data related to the recommended action input, create a message by using the recommended action input and the first related data acquired, and provide, to the person, the recommended action message created.

[Claim 3]

The action-based support system according to claim 1 or 2, wherein

the interface system is configured to be capable of accessing a data management system that manages data related to the environment and the action of the person, and

the interface system is configured to acquire, from the data management system, second related data related to the future prediction input, create a future prediction message by using the recommended action input and the second related data acquired, and provide, to the person, the future prediction message created.

[Claim 4]

The action-based support system according to claim 1 or 2, wherein

the interface system is configured to take, as an input, an inquiry message created by the person, interpret or analyze the inquiry message input, and input, to the predictive action system, tentative environment data obtained by partially changing the environment data in accordance with a result of interpreting or analyzing the inquiry message,

the predictive action system is configured to generate a tentative future prediction by using the tentative environment data input, and generate a tentative recommended action by using the tentative future prediction generated, and

the interface system is configured to take, as an input, the tentative future prediction or the tentative recommended action from the predictive action system, generate a response message based on the tentative future prediction or the tentative recommended action input, and provide to the person the response message generated.

[Claim 5]

The action-based support system according to claim 4,

wherein the interface system is configured to interpret or analyze the communication with the person, and generate the response message based on the tentative future prediction or the tentative recommended action in accordance with a result of interpreting or analyzing the communication.

[Claim 6]

The action-based support system according to claim 4, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person, and

the interface system is configured to acquire, from the data management system, third related data related to the tentative future prediction input, and create the response

message by using the tentative future prediction input and the third related data acquired.

[Claim 7]

The action-based support system according to claim 4, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person, and

the interface system is configured to acquire, from the data management system, fourth related data related to the tentative recommended action input, and create the response message by using the tentative recommended action input and the fourth related data acquired.

[Claim 8]

The action-based support system according to claim 1 or 2, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person, and

the interface system is configured to take, as an input, a log request created by the person, interpret or analyze the interactive communication with the person, acquire, from the data management system, fifth related data related to the log request input in accordance with a result of interpreting or analyzing the interactive communication, create a log message by using the fifth related data acquired, and provide to the person

the log message created.

[Claim 9]

The action-based support system according to claim 1 or 2, wherein

the predictive action system has a deep neural network that has learned, in advance, a method for generating the future prediction or the recommended action,

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person,

the interface system is configured to take, as an input, an action review created by the person, acquire, from the data management system, sixth related data related to the action review input, and create learning data for the predictive action system by using the action review input and the sixth related data acquired, and

the predictive action system is configured to re-train the deep neural network by using the learning data created.

[Claim 10]

The action-based support system according to claim 1 or 2,

wherein the interface system is configured to take, as an input, a knowledge message related to action knowledge created by the person, interpret or analyze the knowledge message input, generate action knowledge according to a result of interpreting or analyzing the knowledge message, and register the action knowledge generated in the data management system.

[Claim 11]

The action-based support system according to claim 1 or 2, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person,

the data management system is configured to manage one or more items of action knowledge, and

the interface system is configured to take, as an input, the environment data, acquire, from the data management system, related action knowledge related to the environment data input, acquire, from the data management system, seventh related data related to the environment data input or related to the related action knowledge acquired, create an action guide by using the related action knowledge and the seventh related data acquired, and provide to the person the action guide created.

[Claim 12]

The action-based support system according to claim 1 or 2, wherein

the interface system is configured to be capable of accessing a data management system configured to manage data related to the environment and the action of the person,

the data management system is configured to manage one or more items of action knowledge, and

the interface system is configured to take, as an input, an action guide request created by the person, acquire, from the

data management system, related action knowledge related to the action guide request input, acquire, from the data management system, eighth related data related to the action guide request input or related to the related action knowledge acquired, create an action guide by using the related action knowledge and the eighth related data acquired, and provide to the person the action guide created.

[Claim 13]

The action-based support system according to claim 1 or 2, wherein

the predictive action system has a deep neural network that has learned, in advance, a method for generating the future prediction or the recommended action, and

the predictive action system performs reinforcement learning for the deep neural network by using the environment data input.

[Claim 14]

The action-based support system according to claim 1 or 2,

wherein the predictive action system has a world model, and

the world model has:

an encoder configured to encode the environment data input, into an latent vector of a lower dimension;

a predictor configured to take, as an input, the latent vector from the encoder and generate a future vector indicating a future image of the latent vector; and

a controller configured to take, as an input, the latent vector from the encoder, take, as an input, the future vector from the predictor, and generate the recommended action.

[Claim 15]

An action-based support system for supporting a person who performs an action in accordance with circumstances of an environment, the action-based support system comprising:

a storage device configured to store a computer program, and a processor configured to mechanically read and execute the computer program, wherein

by executing the computer program, the processor:

performs communication with the person;

inputs environment data indicating circumstances of the environment;

generates a future prediction indicating future circumstances of the environment by using the environment data input;

generates a recommended action by using the future prediction generated;

interprets or analyzes the communication with the person;

generates a message based on the future prediction or the recommended action in accordance with a result of interpreting or analyzing the communication; and

provides to the person the message generated.

[Claim 16]

A program storage medium having stored therein a computer program capable of being read by a machine,

the program including operation code causing a processor to perform an action-based support method,

the action-based support method comprising:

performing communication with the person;

inputting environment data indicating circumstances of the environment;

generating a future prediction indicating future circumstances of the environment by using the environment data input;

generating a recommended action by using the future prediction generated;

interpreting or analyzing the communication with the person;

generating a message based on the future prediction or the recommended action in accordance with a result of interpreting or analyzing the communication; and

providing to the person the message generated.

[Claim 17]

The action-based support system according to claim 1 or 2,

wherein the predictive action system is configured to execute the recommended action generated.

[Claim 18]

The action-based support system according to claim 1 or 2, wherein the predictive action system is configured to generate

the recommended action by further using logic indicating a relationship between the future prediction and the recommended action, acquire action information indicating an actual action that is an action taken by the person after the message is provided, and update the logic on the basis of the action information.

[Claim 19]

The action-based support system according to claim 18,

wherein the predictive action system is configured to evaluate the action information on the basis of actual circumstances indicating circumstances of the environment after the actual action, and update the logic further on the basis of a result of the evaluation.

[Claim 20]

The action-based support system according to claim 19,

wherein the predictive action system is configured to cluster the action information into a plurality of groups, the future predictions of which are similar, and, on a group-by-group basis, update the logic on the basis of the action information, for which the result of the evaluation is highest, among the groups.

[Claim 21]

The action-based support system according to claim 20, wherein

the logic indicates a relationship between (i) a combination of the future prediction, and an ideal state

indicating circumstances of the environment to be realized by the person performing the recommended action, and (ii) the recommended action, and

the predictive action system is configured to cluster the action information into a plurality of groups, the sets of the future prediction and the ideal state of which are similar to each other.

[Claim 22]

The action-based support system according to claim 18, wherein

the predictive action system is configured to generate supplementary information about the recommended action by using cause information related to a cause of the future prediction, and

the interface system is configured to further take the supplementary information from the predictive action system as an input, and generate the message based on the supplementary information input.

[Claim 23]

The action-based support system according to claim 22,

wherein the cause information includes at least one of the cause, a candidate action that is a candidate for the recommended action to be made in accordance with the cause, a reason for performing the candidate action, and circumstances of the environment predicted to be realized by performing the candidate action.

[Claim 24]

A plant operation support system comprising:

the action-based support system according to claim 1, wherein

the interface system is a natural language system, and

the message is expressed in natural language.

[Claim 25]

A plant operation support system comprising:

an action-based support system for supporting a person who performs an action in accordance with circumstances of an environment, wherein the action-based support system includes:

a predictive action system configured to take, as an input, environment data indicating the circumstances of the environment, generate a future prediction indicating future circumstances of the environment by using the environment data input, and generate a recommended action by using the future prediction generated; and

a control system configured to control the environment in accordance with the recommended action.