

DESCRIPTION

Title

EQUIPMENT FAILURE PREDICTION DIAGNOSIS DEVICE AND METHOD

5

Technical Field

[1]The present disclosure relates to equipment failure prediction diagnosis device and method, which enable precognition preservation of equipment by monitoring the state of equipment in real time using data provided from an equipment group.

[2]

Background Art

[3]In the field of equipment diagnostics, the application of Prognostics and Health Management (PHM) is increasingly being used to identify the current condition of equipment under diagnosis and to predict failures.

[4]Prognostics and Health Management (PHM) is rapidly growing not only to reduce costs but also to ensure stable system operation and to realize a cost-effective, downtime-free maintenance system.

[5]In order to detect failures in equipment under diagnosis in advance, a method may be used in which the measurement results from a sensor connected to the equipment are compared with a user-defined upper limit.

[6] Meanwhile, technological advancements in the equipment sector have enabled a single piece of equipment to perform a variety of tasks, and the structure of the equipment has become more complex, making it increasingly difficult to set
5 uniform upper limits or for users to define them manually.

[7] Therefore, it is necessary to propose a failure prediction management plan that enables a more precise understanding of the equipment's state under various conditions.

[8]

10 [9] The matters described above as background technology are intended solely to enhance understanding of the background of the present disclosure and should not be regarded as an acknowledgment that they constitute related art known to those skilled in the art.

15 [10]

Disclosure

Technical Problem

[11] Accordingly, the present disclosure has been made into consideration of the above problems occurring in the related
20 art. A technical problem to be solved by the present disclosure is to provide an equipment failure prediction diagnosis device and method that enable more accurate and efficient predictive maintenance by processing sensed information according to the operational characteristics of

the equipment under diagnosis and using it for learning and failure prediction.

[12]

[13] The objectives of the present disclosure are not limited to those mentioned above, and other objectives not explicitly stated will be clearly understood by those skilled in the art from the following description.

[14]

Technical Solution

[15] In order to accomplish the above objectives, an equipment failure prediction diagnosis device may be provided, the device including: a collection part configured to receive operation state information of equipment under diagnosis through a sensor connected to the equipment under diagnosis; a preprocessing part configured to perform a segmentation of the operation state information into a plurality of sections on the basis of whether the equipment under diagnosis is operating in a constant-speed mode or a gear mode, and to preprocess segmented operation state information to extract valid information for each section; and a diagnosis part configured to learn normal operation criteria of the equipment under diagnosis on the basis of the extracted valid information, to predict a failure of the equipment under diagnosis on the basis of the learned normal operation criteria and the valid

information extracted after learning, and to output a result of a prediction.

[16] For example, the preprocessing part may be configured to determine a unit pattern of the operation state information
5 when the equipment under diagnosis is operating in the gear mode and to perform the segmentation of the operation state information into the determined unit pattern.

[17] For example, the preprocessing part may be configured to extract a plurality of patterns from the operation state
10 information and to determine the unit pattern on the basis of a similarity judgment between one and at least some of remaining patterns of the extracted plurality of patterns.

[18] For example, the preprocessing part may be configured to perform the segmentation of the operation state information
15 into the plurality of sections on the basis of preset time intervals when the equipment under diagnosis is operating in the constant-speed mode.

[19] For example, the preprocessing part may be configured to perform the segmentation on the basis of a start signal and an
20 end signal for the equipment under diagnosis, the signals being received from an external source.

[20] For example, the preprocessing part may be configured to extract the valid information from a portion of the operation
state information, wherein the portion falls within a range
25 corresponding to characteristic information of the equipment

under diagnosis, the characteristic information being received from an external source.

[21] For example, the preprocessing part may be configured to extract the valid information including a frequency value from the operation state information that falls within the range corresponding to the characteristic information on the basis of the number of drive shafts of the equipment under diagnosis.

[22] For example, the preprocessing part may be configured to extract the valid information, further including a time value, from the operation state information that falls within the range corresponding to the characteristic information, when the number of drive shafts of the equipment under diagnosis exceeds a preset number.

[23] For example, the diagnosis part may be configured to perform the prediction on the basis of a degree of discrepancy between the normal operation criteria and the valid information.

[24] For example, the diagnosis part may be configured to learn the normal operation criteria on the basis of a feature value of the valid information.

[25] For example, the diagnosis part may be configured to extract the feature value by performing dimensionality reduction on the valid information, and to perform the learning and the prediction through a process of restoring the extracted feature value.

[26] For example, the diagnosis part may be configured to perform the learning and the diagnosis by inputting the valid information into a predetermined artificial intelligence algorithm.

5 **[27]** For example, the diagnosis part may be configured to learn the normal operation criteria for each type of equipment and to perform the prediction on the basis of the normal operation criteria corresponding to the type of the equipment under diagnosis among the learned normal operation criteria.

10 **[28]** For example, when an operation change signal of the equipment under diagnosis is received from an external source, the diagnosis part may be configured to relearn the normal operation criteria on the basis of the operation state information acquired by the collection part after receiving the
15 operation change signal.

[29] For example, the diagnosis part is configured to output a work signal for maintenance of the equipment under diagnosis when the failure of the equipment under diagnosis is predicted.

[30]

20 **[31]** In order to accomplish the above objectives, an equipment failure prediction diagnosis method may be provided, the method including: acquiring operation state information of equipment under diagnosis through a sensor connected to the equipment under diagnosis; performing a segmentation of the operation
25 state information into a plurality of sections on the basis of

whether the equipment under diagnosis is operating in a constant-speed mode or a gear mode; preprocessing segmented operation state information on the basis of preset conditions to extract valid information for each section; learning normal
5 operation criteria of the equipment under diagnosis on the basis of the extracted valid information; predicting a failure of the equipment under diagnosis on the basis of the learned normal operation criteria and the valid information extracted after the learning; and outputting a result of a prediction.

10 **[32]**

Advantageous Effects

[33] According to various embodiments of the present disclosure as described above, it is possible to predict a failure of the equipment under diagnosis in advance and to
15 perform maintenance activities to ensure normal operation.

[34] Through this, it is possible to prevent a decrease in production efficiency caused by equipment downtime.

[35] In particular, by precisely monitoring the state of the equipment under diagnosis in real time using high-quality
20 information collected from it, the performance of failure prediction may be improved.

[36]

[37] The effects that may be achieved by the present disclosure are not limited to those mentioned above, and other
25 effects not explicitly stated will be clearly understood by

those skilled in the art to which the present disclosure pertains from the following description.

[38]

Description of Drawings

5 **[39]** FIG. 1 is a diagram illustrating an example of an implementation of an equipment failure prediction diagnosis device to which embodiments of the present disclosure may be applied.

10 **[40]** FIG. 2 is a diagram illustrating the configuration of the equipment failure prediction diagnosis device according to one embodiment of the present disclosure.

15 **[41]** FIG. 3 is a flow diagram illustrating a process of performing a segmentation of operation state information in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

[42] FIG. 4 is a diagram illustrating a valid information extraction process in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

20 **[43]** FIG. 5 is a diagram illustrating a learning and diagnosis process in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

[44] FIG. 6 is a diagram illustrating an equipment failure prediction diagnosis method according to the embodiment of the present disclosure.

[45]

5 Mode for Disclosure

[46] Specific structural and functional descriptions of the embodiments disclosed in this specification or application are provided solely for illustrative purposes to explain the embodiments according to the present disclosure. The
10 embodiments according to the present disclosure may be implemented in various forms and should not be construed as limited to those described in this specification or application.

[47] The embodiments according to the present disclosure may
15 undergo various modifications and may take various forms. Therefore, specific embodiments are illustrated in the drawings and described in detail in this specification or application. However, this is not intended to limit the embodiments according to the present disclosure to the specific forms
20 disclosed, and it should be understood that all modifications, equivalents, and substitutions falling within the spirit and technical scope of the present disclosure are included.

[48] Unless otherwise defined, all terms used herein, including technical or scientific terms, have the same meaning
25 as commonly understood by one of ordinary skill in the art to

which this disclosure pertains. Terms defined in commonly used dictionaries, such as those defined in commonly used dictionaries, should be interpreted as having a meaning consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense, unless expressly defined herein.

[49] Hereinafter, embodiments disclosed in this specification will be described in detail with reference to the accompanying drawings, but the same or similar components are assigned the same reference numerals regardless of reference numerals, and overlapping descriptions thereof will be omitted.

[50] The terms "module" and "part" for the components used in the following description are given or mixed in consideration of only the ease of writing the specification and do not have distinct meanings or roles by themselves.

[51] in describing the embodiments disclosed in this specification, when it is determined that detailed descriptions of related known technologies may obfuscate the gist of the embodiments disclosed in this specification, the detailed description thereof will be omitted. In addition, the accompanying drawings are only to aid in easy understanding of the embodiments disclosed in this specification, and the technical idea disclosed herein is not limited by the accompanying drawings, and all changes included in the spirit

and scope of the present disclosure should be understood to include equivalents or substitutes.

[52] Terms including ordinal numbers such as first, second, and the like may be used to describe various elements, but the
5 elements are not limited by the terms. The above terms are used only for the purpose of distinguishing one component from another.

[53] When a component is referred to as being "connected" or "coupled" to another component, it may be directly connected
10 or coupled to another component, but it should be understood that other components may exist in between. On the other hand, when a component is referred to as being "directly connected" or "directly connected" to another component, it should be understood that there are no other components in between.

15 **[54]** A singular expression includes a plural expression unless the context clearly dictates otherwise.

[55] In this specification, terms such as "comprises" or "have" are intended to designate that the features, numbers, steps, operations, components, parts, or combinations thereof
20 described in the specification exist and should be understood that it does not preclude the possibility of addition or existence of one or more other features, numbers, steps, operations, components, parts, or combinations thereof.

[56] A controller may include a communication device that
25 communicates with other controllers or sensors to control the

function in charge, a memory that stores an operating system or logic commands and input/output information, and one or more processors that perform determination, calculation, and decision, and the like necessary for controlling the function
5 in charge.

[57]

[58] The equipment failure prediction diagnosis device and method according to one embodiment of the present disclosure propose to more precisely analyze the operation state of the
10 equipment under diagnosis by preprocessing the collected information on the basis of the operating characteristics of the equipment under diagnosis. By learning and diagnosing the operation state by equipment types, this enables more accurate and efficient predictive maintenance.

15 **[59]** Before explaining the equipment failure prediction diagnosis device and method according to the present disclosure, an implementation example of an equipment failure prediction diagnosis system to which embodiments of the present disclosure may be applied will first be explained.

20 **[60]**

[61] FIG. 1 is a diagram illustrating an example of an implementation of an equipment failure prediction diagnosis device to which embodiments of the present disclosure may be applied.

[62] With reference to FIG. 1, an equipment failure prediction diagnosis system, to which embodiments of the present disclosure may be applied, may be implemented by including equipment sensors 11 to 13 connected to different equipment, an edge computing device 20, and a cloud 30. However, this configuration is only an example, and the configuration of the equipment failure prediction diagnosis system to which the embodiments of the present disclosure may be applied is not necessarily limited to this. Hereinafter, each configuration will be described.

[63] First, a first equipment sensor 11, a second equipment sensor 12, and a third equipment sensor 13 may each be connected to different types of equipment and may be used to acquire information such as vibration, current, speed, and temperature from the connected equipment. In addition, each of the first, second, and third equipment sensors 11, 12, and 13 may be implemented as a plurality of sensors connected to respective equipment and utilized to acquire different types of information.

[64] For example, the first equipment sensor 11 may be connected to logistics or transportation equipment, such as conveyor belts; the second equipment sensor 12 may be connected to production equipment, such as lifters, and the third equipment sensor 13 may be connected to production equipment, such as assembly robots. These sensors may be used

to collect information on the equipment used throughout a series of processes.

[65] Information collected through the first to third equipment sensors 11 to 13 may be transmitted to the edge computing device 20, and the edge computing device 20 may
5 diagnose the state of the equipment on the basis of the collected information.

[66] More specifically, the edge computing device 20 may be composed of a first module 21 and a second module 22 that
10 perform different functions.

[67] For example, the first module 21 may be connected to the equipment group and may perform the function of collecting information from the first to third equipment sensors 11 to 13 and transmitting the collected information to the second
15 module 22. In this case, the first module 21 may be implemented as a plurality of individual boards, each corresponding to the type of equipment under diagnosis and having at least one input channel. Here, the first module 21 may also be expressed as a Data acquisition (DAQ) module in
20 that it performs an information collection function.

[68] The first module 21 may be variably configured to correspond to the equipment under diagnosis. For example, the individual boards may be configured to be detachable so that they may be replaced depending on the equipment under
25 diagnosis.

[69] Meanwhile, the second module 22 may perform a function of preprocessing information received from the first module 21 and learning and diagnosing the state of the equipment through the preprocessed information. In this case, the
5 second module 22 may be implemented by including a common board that diagnoses information of the equipment under diagnosis, input from at least one of a plurality of input channels, in real time through a diagnosis model corresponding to the corresponding channel.

10 **[70]** The second module 21 may be operated jointly regardless of the individual board configuration of the first module 22 and may receive a diagnostic model from the cloud 30 to be described later, perform learning and diagnosis of the equipment state, and output the results of the learning and
15 diagnosis.

[71] The individual board of the first module 21 and the common board of the second module 22 may be equipped with at least one processor that performs judgment, calculation, decision, and the like to perform each function.

20 **[72]** Meanwhile, the cloud 30 may be implemented as a server, accessible through a wireless communication network and the like, and a diagnostic model and database that are operating on the server. The cloud 30 may distribute the diagnostic model as described above and may collect the results of
25 learning and diagnosis output from the edge computing device

20 and store them in a database. In particular, the cloud 30 may transmit a diagnostic model corresponding to the equipment under diagnosis to the edge computing device 20, so that the edge computing device 20 may be used in common without being
5 limited to the type of equipment and may perform a failure prediction diagnosis optimized for each equipment under diagnosis.

[73] In the case where an equipment failure prediction diagnosis system is configured like this, the versatility of
10 the diagnosis system may be increased, and a large amount of information may be collected and processed quickly near the equipment, thereby improving the failure prediction diagnosis performance. In particular, in the case where such an equipment failure prediction diagnosis system is implemented
15 in a smart factory with high automation, the control of the smart factory becomes easier, and productivity may be improved through continuous maintenance activities.

[74] The equipment failure prediction diagnosis device according to one embodiment of the present disclosure may be
20 applied to such a system and, in particular, may be implemented by including the edge computing device 20.

[75] Hereinafter, the configuration of the equipment failure prediction diagnosis device according to one embodiment of the present disclosure will be described in more detail.

25 **[76]**

[77] FIG. 2 is a diagram illustrating the configuration of the equipment failure prediction diagnosis device according to one embodiment of the present disclosure.

[78] With reference to FIG. 2, the equipment failure prediction diagnosis device 100, according to one embodiment of the present disclosure, may include a collection part 110, a preprocessing part 120, and a diagnosis part 130. FIG. 2 mainly illustrates components related to the equipment failure prediction diagnosis device 100 according to one embodiment of the present disclosure. It is obvious that the actual equipment failure prediction diagnosis device 100 may be implemented with more or fewer components than those described here.

[79] First, the collection part 110 may acquire information on the operation state of the equipment under diagnosis through a sensor connected to the equipment under diagnosis. The information on the operation state of the equipment under diagnosis may include, for example, information on vibration, temperature, current, speed, and the like according to the operation of the equipment under diagnosis.

[80] The collection part 110 may collect operation state information for a plurality of equipment under diagnosis pieces and may also collect different types of information through a plurality of sensors connected to one equipment under diagnosis piece. For example, when the equipment under

diagnosis is an automatic assembly robot, the collection part 110 may collect operation state information, including vibration information for each axis, through sensors connected to each axis of the robot.

5 **[81]** The preprocessing part 120 may perform a segmentation of the operation state information into a plurality of sections on the basis of whether the equipment under diagnosis is operating in a constant-speed mode or a gear mode, and preprocess segmented operation state information to extract
10 valid information for each section.

[82] Here, whether the equipment under diagnosis is operating in the constant-speed mode or the gear mode may be determined on the basis of the operation state information or acquired by receiving it from an external source.

15 **[83]** In addition, the valid information may refer to data from which elements such as noise, which are unnecessary for learning and diagnosis or detrimental to accuracy, have been filtered out, and it may be acquired by preprocessing the operating state information, which constitutes the original
20 information.

[84] The preprocessing part 120 performs preprocessing on the basis of whether the equipment under diagnosis is operating in the constant-speed mode or the gear mode. This may allow the operational characteristics of the equipment to be

reflected in the equipment failure prediction diagnosis, enabling optimized diagnosis for each piece of equipment.

[85] For example, when the equipment under diagnosis is operating in the gear mode, the preprocessing part 120 may
5 determine a unit pattern from the operation state information and may perform the segmentation of the operation state information on the basis of the determined unit pattern.

[86] Equipment that operates in the gear mode, such as industrial robots or wireless mobile devices, exhibits
10 periodically repeating operation patterns. Therefore, by determining the unit pattern of the operation state information and performing the segmentation of the information on the basis of that pattern, the accuracy of failure prediction diagnosis may be improved.

[87] In particular, by determining the unit pattern as
15 described above and segmenting the operation state information accordingly, the sampling rate of the operation state information may be increased compared to when it is processed using signals from the external source. Additionally, the
20 operation state information may be processed independently of any external signals.

[88] More detailed information on a process of performing the segmentation of operation state information is described below with reference to FIG. 3.

[89] FIG. 3 is a flow diagram illustrating a process of performing a segmentation of operation state information in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

5 **[90]** With reference to FIG. 3, the preprocessing part 120 may extract a plurality of patterns from the operation state information (Raw data, Date 1 to Date 3) and determine a unit pattern (Cycle index) on the basis of the similarity judgment between one of the extracted plurality of patterns (ref) and
10 at least some of the remaining patterns (target).

[91] Returning to FIG. 2, the preprocessing part 120 may perform the segmentation of the operation state information into a plurality of sections on the basis of preset time intervals when the equipment under diagnosis is operating in
15 the constant-speed mode.

[92] In addition, the preprocessing part 120 may further perform the segmentation of the operation state information, which has already been segmented according to the unit pattern, into a plurality of sections on the basis of preset
20 time intervals, when the equipment under diagnosis is operating not only in the constant-speed mode but also in the gear mode.

[93] Meanwhile, during the process of performing the segmentation of the operation state, when a start/finish
25 signal of the equipment under diagnosis is received from the

external source, the preprocessing part 120 may reflect the start/finish signal in the segmentation of the operation state.

[94] For example, the start/finish signal from the external
5 source may be transmitted by Programmable Logic Controller (PLC) signals or Manufacturing Execution System (MES).

[95] The segmentation and processing of operation state information will be described in more detail below with reference to FIG. 4.

10 **[96]** FIG. 4 is a diagram illustrating a valid information extraction process in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

[97] With reference to FIG. 4, the preprocessing part 120,
15 according to one embodiment of the present disclosure, may segment the operation state information according to a preset time interval (Time Windowing). This process may be performed by setting the window size, and the amount of valid information used for learning and diagnosis may be adjusted
20 according to the time interval setting.

[98] More specifically, when the time interval is set to a smaller value, the operation state information is segmented into more sections, which may increase the amount of valid information available for learning and diagnosis.
25 Conversely, when the time interval is set to a larger value,

the operation state information may be segmented into fewer sections, potentially reducing the amount of valid information usable for learning and diagnosis. The smaller the time interval, the more advantageous it is for capturing changes
5 within the interval, whereas the larger the time interval, the better the overall resolution.

[99] Meanwhile, the preprocessing part 120 may preprocess the segmented operation state information to extract valid information. In this case, the preprocessing may include a
10 process of converting the operation state information into a frequency domain.

[100] More specifically, the preprocessing part 120 may transform the operating state information through Fast Fourier Transform (FFT) or Short Time Fourier Transform (STFT) to
15 produce an FFT Spectrum or STFT Colormap, and extract valid information from the produced result.

[101] In particular, the preprocessing part 120 may extract valid information for a range corresponding to the characteristic information of the equipment under diagnosis,
20 the characteristic information being received from the external source. The range corresponding to the characteristic information may be expressed as a frequency band, and the preprocessing part 120 may extract valid information by including the main frequency values within the
25 frequency band corresponding to the characteristic

information of the equipment under diagnosis. In this case, the sampling frequency and conversion resolution may be further reflected in the extraction of valid information.

[102] Meanwhile, in the process of extracting valid
5 information, the number of drive shafts of the equipment under diagnosis may be further considered. When the number of drive shafts of the equipment under diagnosis is no greater than a preset number, the preprocessing part 120 may extract valid information in a one-dimensional form (1D vector)
10 including the main frequency values from the FFT spectrum. When the number of drive shafts of the equipment under diagnosis exceeds the preset number, the preprocessing part 120 may extract valid information in a two-dimensional form (2D vector) including additional time values through STFT
15 transformation, thereby securing additional information for use in learning and diagnosis.

[103] The extracted valid information may be segmented for use in a training set for learning and a test set for verification.

[104] Returning to FIG. 2, the diagnosis part 130 learns
20 normal operation criteria of the equipment under diagnosis on the basis of the extracted valid information and may predict a failure of the equipment under diagnosis on the basis of the learned the normal operation criteria and the valid information extracted after learning.

[105] Here, learning of the normal operation criteria may be performed on the basis of a feature value of valid information, and the diagnosis part 130 may extract the feature value through dimensionality reduction of valid
5 information.

[106] In addition, failure prediction of the equipment under diagnosis may be performed on the basis of the degree of discrepancy between the normal operation criteria and the valid information, and for this purpose, the diagnosis part
10 130 may perform a process of extracting the feature value through dimensionality reduction of the valid information and restoring the extracted feature value.

[107] In particular, these learning and diagnosis processes may be performed by inputting the extracted valid information
15 into a predetermined artificial intelligence algorithm. The artificial intelligence algorithm may include at least one of machine learning, neural networks, deep learning, classification algorithms, or a combination thereof, and may, for example, be implemented as deep learning with an auto-
20 encoder structure.

[108] Furthermore, the diagnosis part 130 may learn the normal operation criteria for each type of equipment and perform failure prediction on the basis of the normal operation criteria corresponding to the type of equipment under
25 diagnosis among the learned the normal operation criteria.

[109] Meanwhile, when the diagnosis part 130 acquires an operation change signal of the equipment under diagnosis from the external source, it may relearn the normal operation criteria on the basis of the operation state information
5 collected after acquiring the operation change signal.

[110] When the diagnosis result is derived through the process described above, the diagnosis part 130 may output the diagnosis result and display the state of the equipment under diagnosis, and maintenance activities of the equipment
10 may be linked on the basis of the output diagnosis result.

[111] More detailed information about the learning and diagnosis process of the diagnosis part 130 will be described below with reference to FIG. 5.

[112]

15 **[113]**

[114] FIG. 5 is a diagram illustrating a learning and diagnosis process in the equipment failure prediction diagnosis device according to the embodiment of the present disclosure.

20 **[115]** The diagnosis part 130 may perform learning and diagnosis on the equipment under diagnosis by inputting valid information (feature vector) extracted through the preprocessing part 120 into an auto-encoder model.

[116] The input valid information (Feature vector) is
25 compressed into the feature value through a dimensionality

reduction process (Encoder), and learning and diagnosis are performed on the basis of how similar the restored result is to the input valid information, through a process of restoring the compressed feature value (Decoder), that is, how well the restoration was performed.

[117] The diagnosis part 130 learns the normal operation criteria on the basis of the extracted feature value and may perform a failure prediction diagnosis of the equipment under diagnosis on the basis of the degree of discrepancy between the feature value for the newly collected operation state information and the normal operation criteria. In this process, the degree of discrepancy between the normal operation criteria and the feature value for the newly collected operation state information may be determined through the mean absolute error (MAE), and the degree of discrepancy may be expressed or converted into anomaly scores.

[118] Hereinafter, the above-described equipment failure prediction diagnosis process is explained with reference to the flow chart.

[119]

[120] FIG. 6 is a diagram illustrating an equipment failure prediction diagnosis method according to the embodiment of the present disclosure.

[121] With reference to FIG. 6, first, in step S310, the collection part 110 acquires information on the operation

state of the equipment under diagnosis through a sensor connected to the equipment.

[122] In step S320, the preprocessing part 120 performs the segmentation of the operation state information acquired through the collection part 110 into the plurality of sections on the basis of whether the equipment under diagnosis is operating in the constant-speed mode or the gear mode. Then, in step S330, it extracts valid information to be used for learning and diagnosis from the segmented operation state information.

[123] In step S340, the diagnosis part 130 learns the normal operation criteria of the equipment under diagnosis on the basis of the valid information extracted through the preprocessing part 120, and in step S350, it performs a failure prediction diagnosis of the equipment under diagnosis on the basis of the learned the normal operation criteria. Afterwards, when the diagnosis result is derived, the diagnosis part 130 outputs a failure prediction result in S360 so that predictive maintenance of the equipment under diagnosis may be performed.

[124] The equipment failure prediction diagnosis method according to one embodiment of the present disclosure as described above may be performed by the equipment failure prediction diagnosis device described above. More specific details regarding the equipment failure prediction diagnosis

method have been described above in connection with the equipment failure prediction diagnosis device, and thus will be omitted below.

[125]

5 **[126]** According to various embodiments of the present disclosure as described above, it is possible to predict the failure of equipment under diagnosis in advance and perform maintenance activities to ensure normal operation.

[127] Through this, a decrease in production efficiency due to equipment downtime may be prevented.

[128] In particular, by precisely monitoring the state of the equipment under diagnosis in real time using high-quality information collected from it, the performance of failure prediction may be improved.

15 **[129]**

[130] While the present disclosure has been described and illustrated with respect to specific embodiments, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the technical spirit of the present disclosure, as defined by the following claims.

[131]

[132] [Description of the Reference Numerals in the Drawings]

[133] 100: equipment failure prediction diagnosis device

25 **[134]** 110: collection part

[135] 120: preprocessing part

[136] 130: diagnosis part

CLAIMS

[Claim 1] An equipment failure prediction diagnosis device, the device comprising:

5 a collection part configured to receive operation state information of equipment under diagnosis through a sensor connected to the equipment under diagnosis;

 a preprocessing part configured to segment the operation state information into a plurality of sections based on whether
10 the equipment under diagnosis is operating in a constant-speed mode or a variable-speed mode, and to preprocess segmented operation state information to extract valid information for each section; and

 a diagnosis part configured to learn normal operation
15 criteria of the equipment under diagnosis based on the extracted valid information, to predict a failure of the equipment under diagnosis based on the learned normal operation criteria and the valid information extracted after learning, and to output a result of a prediction.

20

[Claim 2] The device of claim 1, wherein the preprocessing part is configured to determine a unit pattern of the operation state information, based on the equipment under diagnosis being operating in the variable-speed mode and
25 to segment the operation state information according to

the determined unit pattern.

[Claim 3] The device of claim 2, wherein the preprocessing part is configured to extract a plurality of patterns from the operation state information and to determine the unit pattern based on the a similarity judgment between one and at least some of remaining patterns of the extracted plurality of patterns.

[Claim 4] The device of claim 1, wherein the preprocessing part is configured to segment the operation state information into the plurality of sections based on preset time intervals, based on the equipment under diagnosis being operating in the constant-speed mode.

[Claim 5] The device of claim 1, wherein the preprocessing part is configured to segment based on a start signal and an end signal for the equipment under diagnosis, the signals being received from an external source.

[Claim 6] The device of claim 1, wherein the preprocessing part is configured to extract the valid information from a portion of the operation state information, wherein the portion falls within a range corresponding to characteristic information of the equipment under

diagnosis, the characteristic information being received from an external source.

[Claim 7] The device of claim 6, wherein the preprocessing part is configured to extract the valid information including a frequency value from the operation state information that falls within the range corresponding to the characteristic information based on the number of drive shafts of the equipment under diagnosis.

[Claim 8] The device of claim 7, wherein the preprocessing part is configured to extract the valid information, further including a time value, from the operation state information that falls within the range corresponding to the characteristic information, based on the number of drive shafts of the equipment under diagnosis exceeding a preset number.

[Claim 9] The device of claim 1, wherein the diagnosis part is configured to predict based on a degree of discrepancy between the normal operation criteria and the valid information.

[Claim 10] The device of claim 1, wherein the diagnosis part is configured to learn the normal operation criteria

based on a feature value of the valid information.

[Claim 11] The device of claim 10, wherein the diagnosis
part is configured to extract the feature value by
5 performing dimensionality reduction on the valid
information, and to perform the learning and the
prediction through a process of restoring the extracted
feature value.

10 [Claim 12] The device of claim 1, wherein the diagnosis
part is configured to perform the learning and the
prediction by inputting the valid information into a
predetermined artificial intelligence algorithm.

15 [Claim 13] The device of claim 1, wherein the diagnosis
part is configured to learn the normal operation criteria
for each type of equipment and to perform the prediction
based on the normal operation criteria corresponding to
the type of the equipment under diagnosis among the
20 learned normal operation criteria.

[Claim 14] The device of claim 1, wherein, based on an
operation change signal of the equipment under diagnosis
being received from an external source, the diagnosis part
25 is configured to relearn the normal operation criteria

based on the operation state information received by the collection part after receiving the operation change signal.

5 [Claim 15] The device of claim 1, wherein the diagnosis part is configured to output a command signal for maintenance of the equipment under diagnosis, based on the failure of the equipment under diagnosis is predicted.

10 [Claim 16] An equipment failure prediction diagnosis method, the method comprising:

receiving operation state information of equipment under diagnosis through a sensor connected to the equipment under diagnosis;

15 performing a segmentation of the operation state information into a plurality of sections based on whether the equipment under diagnosis is operating in a constant-speed mode or a variable-speed mode;

preprocessing segmented operation state information based on preset conditions to extract valid information for each section;

learning normal operation criteria of the equipment under diagnosis based on the extracted valid information;

25 predicting a failure of the equipment under diagnosis based on the learned normal operation criteria and the valid

information extracted after the learning; and
outputting a result of a prediction.