| | |
|---|---|
| United States Patent Application Publication | 20250264860 |
| Kind Code | A1 |
| Publication Date | August 21, 2025 |
| Inventor(s) | MASATO; Yusuke et al. |


## METHOD AND SYSTEM FOR DETERMINING ABNORMALITY IN INDUSTRIAL MACHINE


### Abstract

A method of determining synchronization deviation includes acquiring first drive data indicative of a dynamic state of a first drive mechanism, acquiring second drive data indicative of a dynamic state of a second drive mechanism, extracting differences between the first drive data and the second drive data, deriving a cumulative sum of the differences, determining whether the cumulative sum exhibits linearity or non-linearity, and determining that the synchronization deviation has occurred between the first drive mechanism and the second drive mechanism when the cumulative sum exhibits non-linearity.



**Inventors:** **MASATO; Yusuke (Ishikawa, JP), DOBA; Eiji (Ishikawa, JP), OHZEKI; Shinya (Ishikawa, JP), ANADA; Kazuhisa (Ishikawa, JP)**

**Applicant:** **KOMATSU INDUSTRIES CORPORATION** (Kanazawa-shi, Ishikawa, JP)



**Family ID:** **1000008618740**

**Appl. No.:** **18/857321**

**Filed (or PCT Filed):** **June 02, 2023**

**PCT No.:** **PCT/JP2023/020654**

### Foreign Application Priority Data

| | | |
|---|---|---|
| JP | 2022-118821 | Jul. 26, 2022 |

### Publication Classification

**Int. Cl.:** **G05B19/4065** (20060101); **G05B19/416** (20060101)

**U.S. Cl.:**

CPC **G05B19/4065** (20130101); **G05B19/4166** (20130101);

## Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a U.S. National stage application of International Application No. PCT/JP2023/020654, filed on Jun. 2, 2023. This U.S. National stage application claims priority under 35 U.S.C. § 119 (a) to Japanese Patent Application No. 2022-118821, filed in Japan on Jul. 26, 2022, the entire contents of which are hereby incorporated herein by reference.

TECHNICAL FIELD
[0002] The present disclosure relates to a method and a system for determining abnormality in an industrial machine.
BACKGROUND ART
[0003] Detecting the occurrence of abnormalities may be desired in an industrial machine. As a result, in the prior art, an abnormality is determined by detecting a predetermined output value of the industrial machine with a sensor and comparing the detected output value with a threshold (for example, see Japanese Patent Laid-open No. H02-195498).
[0004] However, a pair of drive mechanisms that operate together in synchronization are provided to an industrial machine. For example, Japanese Patent No. 4198035 discloses a workpiece feeding device in a press line. The workpiece feeding line includes a cross bar, a pair of swinging bodies, and the pair of drive mechanisms. The pair of swinging bodies are respectively connected to the left and right end parts of the cross bar. The pair of drive mechanisms move the pair of swinging bodies.
SUMMARY
[0005] The pair of drive mechanisms in the above-mentioned workpiece feeding device both have the same structure and operate the pair of swinging bodies in synchronization. However, the synchronization of the pair of drive mechanisms may deviate. When a deviation in the synchronization of the pair of drive mechanisms occurs, it is difficult to operate the workpiece feeding device with accuracy. While the presence or absence of abnormalities can be detected for each of the pair of drive mechanisms in the above-mentioned conventional abnormality detection methods, it is difficult to detect a deviation of the synchronization of the pair of drive mechanisms. An object of the present is to accurately detect a synchronization deviation in an industrial machine that includes a pair of drive mechanisms that operate together in synchronization.
[0006] A method according to one aspect of the present disclosure is executed by a one or more computers for determining synchronization deviation between a first drive mechanism and a second drive mechanism in an industrial machine including the first drive mechanism and the second drive mechanism that operate together in synchronization. The method includes acquiring first drive data that indicates a dynamic state of the first drive mechanism, acquiring second drive data that indicates a dynamic state of the second drive mechanism, extracting differences between the first drive data and the second drive data, deriving a cumulative sum of the differences, determining whether the cumulative sum exhibits linearity or non-linearity, and determining that synchronization deviation has occurred between the first drive mechanism and the second drive mechanism when the cumulative sum exhibits non-linearity.
[0007] A system according to another aspect of the present disclosure is for determining synchronization deviation between a first drive mechanism and a second drive mechanism in an industrial machine including the first drive mechanism and the second drive mechanism that

operate together in synchronization. The system includes a storage device and one or more computers. The storage device stores first drive data that indicates a dynamic state of the first drive mechanism and second drive data that indicates a dynamic state of the second drive mechanism. The one or more computers are communicably connected to the storage device. The one or more computers extract differences between the first drive data and the second drive data. The one or more computers derive a cumulative sum of the differences. The one or more computers determine whether the cumulative sum exhibits linearity or non-linearity. The one or more computers determine that synchronization deviation between the first drive mechanism and the second drive mechanism has occurred when the cumulative sum exhibits non-linearity.
[0008] According to the present disclosure, deviation of synchronization is accurately detected in the industrial machine including the pair of drive mechanisms that operate together in synchronization.

---

## Description

BRIEF DESCRIPTION OF DRAWINGS
[0009] FIG. **1** is a schematic view of a predictive maintenance system according to an embodiment.
[0010] FIG. **2** is a front view of an industrial machine.
[0011] FIG. **3** is a front view illustrating a workpiece feeding device.
[0012] FIG. **4** is a side view illustrating a first drive mechanism.
[0013] FIG. **5** is a flow chart illustrating processing for a predictive maintenance service for the workpiece feeding device.
[0014] FIG. **6** is a flow chart illustrating processing for the predictive maintenance service for the workpiece feeding device.
[0015] FIG. **7**A illustrates an example of first drive data.
[0016] FIG. **7**B illustrates an example of second drive data.
[0017] FIG. **8** illustrates an example of difference data of the first drive data and the second drive data.
[0018] FIG. **9**A illustrates an example of analysis data.
[0019] FIG. **9**B illustrates an example of a Gaussian distribution of the analysis data.
[0020] FIG. **10** illustrates an example of cumulative sum data indicating that there is no synchronization deviation.
[0021] FIG. **11** illustrates an example of cumulative sum data indicating that there is synchronization deviation.
DESCRIPTION OF EMBODIMENTS
[0022] The following is an explanation of an embodiment with reference to the drawings. FIG. **1** is a schematic view of a predictive maintenance system **1** according to the embodiment. The predictive maintenance system **1** is a system for determining locations to be subjected to maintenance before the occurrence of a failure in an industrial machine. The predictive maintenance system **1** includes industrial machines **2** and **3**, a local computer **4**, and a server **5**.
[0023] As illustrated in FIG. **1**, the industrial machines **2** and **3** include a press machine **2** and a workpiece feeding device **3**. FIG. **2** is a front view of the industrial machines **2** and **3**. The press machine **2** includes a slider **11**, a slide drive mechanism **12**, a bolster **13**, a bed **14**, a die cushion device **15**, and a press controller **6**. The slider **11** is configured to move up and down. An upper die **16** is attached to the slider **11**. The slide drive mechanism **12** causes the slider **11** to operate. The slide drive mechanism **12** includes, for example, a servomotor.
[0024] The bolster **13** is disposed below the slider **11**. A lower die **17** is attached to the bolster **13**. The bed **14** is disposed below the bolster **13**. The die cushion device **15** applies an upward load to the lower die **17** during pressing. Specifically, the die cushion device **15** applies an upward load to

the lower die **17** during pressing. The press controller **6** controls the operations of the slider **11** and the die cushion device **15**.

[0025] The die cushion device **15** includes a cushion pad **18** and a die cushion drive mechanism **19**. The cushion pad **18** is disposed below the bolster **13**. The cushion pad **18** is configured to move up and down. The die cushion drive system **19** causes the cushion pad **18** to operate vertically. The die cushion drive mechanism **19** includes, for example, a servomotor.

[0026] The slide drive mechanism **12** and the die cushion drive mechanism **19** are connected to the press controller **6**. The press controller **6** includes a processor and a memory that are not illustrated. The slide drive mechanism **12** and the die cushion drive mechanism **19** are controlled by the press controller **6**. Consequently, a workpiece W**1** is pressed by the upper die **16** and the lower die **17**.

[0027] The workpiece feeding device **3** feeds the workpiece W**1** to be pressed. The workpiece feeding device **3** moves the workpiece W**1** in the feeding direction. The feeding direction is a direction perpendicular to the page of FIG. **2**. The direction perpendicular to the page of FIG. **2** is defined as the front-back direction of the workpiece feeding device **3**. The left-right direction in FIG. **2** is defined as the left-right direction of the workpiece feeding device **3**.

[0028] For example, the above-mentioned press machine **2** is a portion of a transfer press includes a plurality of press machines and the plurality of press machines are disposed side by side in the front-back direction. The workpiece feeding device **3** feeds the workpiece W**1** to be pressed in the press machine **2** to a processing position in another press machine. As illustrated in FIG. **2**, the workpiece feeding device **3** includes a first drive mechanism **21**, a second drive mechanism **22**, and a cross bar **23**.

[0029] FIG. **3** is a front view illustrating the workpiece feeding device **3**. FIG. **4** is a side view illustrating the first drive mechanism **21**. As illustrated in FIGS. **3** and **4**, the first drive mechanism **21** includes a first rail **31**, a first linear arm **32**, a first swing arm **33**, and a first slider arm **34**. The first rail **31** extends in the front-back direction. The first linear arm **32** is supported by the first rail **31**. As illustrated by arrow A**1** in FIG. **4**, the first linear arm **32** is movable in the front-back direction along the first rail **31**. The first swing arm **33** is connected to the first linear arm **32**. As illustrated by arrow A**2** in FIG. **4**, the first swing arm **33** is swingable about a first axis Ax**1** with respect to the first linear arm **32**. The first slider arm **34** is connected to the first swing arm **33**. As illustrated by arrow A**3** in FIG. **4**, the first slider arm **34** is movable along the first swing arm **33**.

[0030] The first drive mechanism **21** includes a first linear motor **35**, a first swing motor **36**, and a first slider motor **37**. The first linear motor **35** causes the first linear arm **32** to operate. The first swing motor **36** causes the first swing arm **33** to operate. The first slider motor **37** causes the first slider arm **34** to operate. Specifically, the first linear motor **35** moves the first linear arm **32** along the first rail **31**. The first swing motor **36** swings the first swing arm **33** about the first axis Ax**1**. The first slider motor **37** moves the first slider arm **34** along the first swing arm **33**.

[0031] The second drive mechanism **22** is disposed away from the first drive mechanism **21** in the left-right direction. The second drive mechanism **22** has a structure that has left-right symmetry with the first drive mechanism **21**. The second drive mechanism **22** includes a second rail **41**, a second linear arm **42**, a second swing arm **43**, and a second slider arm **44**. The second rail **41** extends in the front-back direction. The second linear arm **42** is supported by the second rail **41**. The second linear arm **42** is movable in the front-back direction along the second rail **41**. The second swing arm **43** is connected to the second linear arm **42**. The second swing arm **43** is swingable about a second axis Ax**2** with respect to the second linear arm **42**. The second slider arm **44** is connected to the second swing arm **43**. The second slider arm **44** is movable along the second swing arm **43**.

[0032] The second drive mechanism **22** includes a second linear motor **45**, a second swing motor **46**, and a second slider motor **47**. The second linear motor **45** causes the second linear arm **42** to operate. The second swing motor **46** causes the second swing arm **43** to operate. The second slider motor **47** causes the second slider arm **44** to operate. Specifically, the second linear motor **45** moves the second linear arm **42** along the second rail **41**. The second swing motor **46** moves the second swing arm **43** about the second axis Ax**2**. The second slider motor **47** moves the second slider arm **44** along the second swing arm **43**.

[0033] The cross bar **23** holds the workpiece W**1**. The cross bar **23** extends in the left-right direction between the first drive mechanism **21** and the second drive mechanism **22**. One end of the cross bar **23** is connected to the first slider arm **34**. The other end of the cross bar **23** is connected to the second slider arm **44**. Vacuum cups, for example, are attached to the cross bar **23** and hold the workpiece W**1** by suction.

[0034] As illustrated in FIG. **1**, the workpiece feeding device **3** includes a feeder controller **7**. The feeder controller **7** includes a processor and a memory that are not illustrated. The above-mentioned motors **35** to **37** and **45** to **47** are each servomotors. The feeder controller **7** controls the motors **35** to **37** and **45** to **47** thereby causing the first drive mechanism **21** and the second drive mechanism **22** to operate in synchronization. Specifically, the feeder controller **7** causes the first linear motor **35** and the second linear motor **45** to operate in synchronization. The feeder controller **7** causes the first swing motor **36** and the second swing motor **46** to operate in synchronization. The feeder controller **7** causes the first slider motor **37** and the second slider motor **47** to operate in synchronization. Consequently, the first drive mechanism **21** and the second drive mechanism **22** operate in synchronization and the workpiece W**1** is fed by the cross bar **23** moving in the feeding direction.

[0035] The local computer **4** communicates with the press controller **6** and the feeder controller **7**. As illustrated in FIG. **1**, the local computer **4** includes a processor **51**, a storage device **52**, and a communication device **53**. The processor **51** is, for example, a central processing unit (CPU). Alternatively, the processor **51** may be a processor different from a CPU.

[0036] The storage device **52** includes a non-volatile memory, such as a ROM, and a volatile memory, such as a RAM. The storage device **52** may include an auxiliary storage device, such as a hard disk or a solid state drive (SSD). The storage device **52** is an example of a non-transitory computer-readable recording medium. The storage device **52** stores computer commands and data for controlling the local computer **4**. The communication device **53** communicates with the server **5**.

[0037] The server **5** collects data for predictive maintenance from the workpiece feeding device **3** via the local computer **4**. The server **5** executes the predictive maintenance service based on the collected data. The server **5** communicates with a client computer **8**. The server **5** provides the predictive maintenance service to the client computer **8**. The predictive maintenance service is explained below.

[0038] The server **5** includes a first communication device **55**, a second communication device **56**, a processor **57**, and a storage device **58**. The first communication device **55** communicates with the local computer **4**. The second communication device **56** communicates with the client computer **8**. The processor **57** is, for example, a central processing unit (CPU). Alternatively, the processor **57** may be a processor different from a CPU. The processor **57** executes a process for the predictive maintenance service according to a program.

[0039] The storage device **58** includes a non-volatile memory, such as a ROM, and a volatile memory, such as a RAM. The storage device **58** may include an auxiliary storage device, such as a hard disk or a solid state drive (SSD). The storage device **58** is an example of a non-transitory computer-readable recording medium. The storage device **58** stores computer commands and data for controlling the server **5**.

[0040] The above-mentioned communication may be performed over a mobile communication network, such as 3G, 4G, or 5G. Alternatively, the communication may be performed over another wireless communication network, such as by satellite communication. Alternatively, the communication may be performed via a computer communication network, such as a LAN, a VPN, or the Internet. Alternatively, the communication may be performed over a combination of any of

the above communication networks.
[0041] Next, processing for the predictive maintenance service on the workpiece feeding device **3** will be explained. FIGS. **5** and **6** are flow charts illustrating processing for the predictive maintenance service for the workpiece feeding device **3**. As illustrated in FIG. **5**, the server **5** acquires first drive data in step S**101**. The first drive data is transmitted from the feeder controller **7** to the local computer **4**. The server **5** receives the first drive data from the local computer **4** and saves the first drive data in the storage device **58**.
[0042] The first drive data indicates a dynamic state of the first drive mechanism **21**. The first drive data includes, for example, the motor torque of the first slider motor **37**. The first slider motor **37** is subjected to feedback control by the feeder controller **7** and the motor torque of the first slider motor **37** is indicated, for example, with torque command values from the feeder controller **7** to the first slider motor **37**. The feeder controller **7** acquires the motor torque of the first slider motor **37** in a predetermined sampling period. The sample number is, for example, several hundred to several thousand but is not limited thereto. The first drive data includes a plurality of motor torques sampled over a predetermined time period.
[0043] In step S**102**, the server **5** acquires second drive data. The second drive data is transmitted from the feeder controller **7** to the local computer **4**. The server **5** receives the second drive data from the local computer **4** and saves the second drive data in the storage device **58**. The second drive data indicates a dynamic state of the second drive mechanism **22**. The second drive data includes, for example, the motor torque of the second slider motor **47**. The second slider motor **47** is subjected to feedback control by the feeder controller **7** and the motor torque of the second slider motor **47** is indicated, for example, with torque command values from the feeder controller **7** to the second slider motor **47**.
[0044] FIG. **7**A illustrates an example of the first drive data. The first drive data in FIG. **7**A depicts the motor torque waveform of the first slider motor **37**. The server **5** acquires the motor torque waveform of the first slider motor **37** as the first drive data. FIG. **7**B illustrates an example of the second drive data. The second drive data in FIG. **7**B depicts the motor torque waveform of the second slider motor **47**. The server **5** acquires the motor torque waveform of the second slider motor **47** as the second drive data.
[0045] In step S**103**, the server **5** extracts differences between the first drive data and the second drive data. The server **5** extracts the difference between the motor torques of the first slider motor **37** and the second slider motor **47** at the same time from the first drive data and the second drive data. The server **5** saves the extracted differences in the storage device **58** as difference data. The difference data includes a plurality of difference values of the motor torques sampled over a predetermined time period. FIG. **8** illustrates an example of the difference data of the first slider motor **37** and the second slider motor **47**.
[0046] In step S**104**, the server **5** generates analysis data. The server **5** generates the analysis data from the difference data by Fast Fourier transform. FIG. **9**A illustrates an example of the analysis data. In FIG. **9**A, the horizontal axis is the frequency and the vertical axis is the amplitude. The analysis data represents a power spectrum value for each frequency of the Fast Fourier transform.
[0047] In step S**105**, the server **5** extracts feature amounts from the analysis data. The server **5** acquires, as the feature amounts, an average and a standard deviation of the analysis data by performing Gaussian distribution on the analysis data. FIG. **9**B illustrates an example of a Gaussian distribution of the analysis data. In FIG. **9**B, the horizontal axis is a probability variable x and represents a power spectrum value. The vertical axis represents a probability density f(x). The probability density f(x) is expressed with the following formula (1). In formula (1), “μ” is the average. “σ” is the standard deviation.

[00001] $f(x) = \frac{1}{\sqrt{2}} \exp\left(-\frac{(x-\ )^2}{2\ ^2}\right)$ (1)

[0048] In step S**106**, the server **5** saves the analysis data and the feature amounts μ and σ in the

storage device **58**. As illustrated in FIG. **6**, the server **5** determines whether the first and second drive mechanisms **21** and **22** are normal in step S**107**. The server **5** determines whether the first slider motor **37** and the second slider motor **47** are normal from the feature amounts μ and σ corresponding to the difference data of the first slider motor **37** and the second slider motor **47**. The determination of whether the first slider motor **37** and the second slider motor **47** are normal may be performed by a well-known method in quality engineering.
[0049] For example, the server **5** determines whether the first slider motor **37** and the first slider arm **34** and the second slider motor **47** and the second slider arm **44** are normal by using the Mahalanobis-Taguchi method (MT method). In this case, the server **5** calculates the Mahalanobis distances of the feature amounts μ and σ received from the server **5** based on the feature amount μ and σ when the first slider motor **37** and the first slider arm **34** and the second slider motor **47** and the second slider arm **44** are normal. The server **5** determines that at least one of the first slider motor **37** and the first slider arm **34** and the second slider motor **47** and the second slider arm **44** is not normal when the Mahalanobis distances are greater than a threshold. However, the server **5** may determine whether the first and second drive mechanisms are normal using another method.
[0050] When the server **5** determines that the first slider motor **37** and the second slider motor **47** are not normal in step S**107**, the processing advances to step S**201** in FIG. **6**. The fact that the first slider motor **37** and the second slider motor **47** are not normal signifies a state in which the first slider motor **37** and the second slider motor **47** have not failed yet but deterioration has progressed a certain extent.
[0051] In step S**201**, the server **5** calculates the cumulative sum of the differences. The server **5** derives the cumulative sum of the differences of the motor torque of the first slider motor **37** and the second slider motor **47** from the above-mentioned difference data of the first slider motor **37** and the second slider motor **47**. FIG. **10** illustrates an example of cumulative sum data that indicates the cumulative sum of the differences.
[0052] In step S**202**, the server **5** determines whether the cumulative sum exhibits linearity. The server **5** determines whether the cumulative sum exhibits linearity based on, for example, a well-known determination method for linearity. As illustrated in FIGS. **10** and **11**, the server **5** determines whether changes of the cumulative sum over time exhibit linearity or non-linearity. As in indicator of linearity, for example, the server **5** determines that linearity is exhibited when the residual sum of squares (RSS) between a data interpolation line and the data is 2.0 to 3.0 or less. However, the numerical value of the indicator of the linearity is not limited thereto and may be a value suited to a model for analysis. FIG. **10** illustrates the cumulative sum data that exhibits linearity. FIG. **11** illustrates the cumulative sum data that does not exhibit linearity. When the cumulative sum does not exhibit linearity as illustrated in FIG. **11**, the server **5** determines that there is synchronization deviation between the first drive mechanism **21** and the second drive mechanism **22** in step S**203**.
[0053] When the cumulative sum exhibits linearity as illustrated in FIG. **10**, the server **5** determines that there is no synchronization deviation between the first drive mechanism **21** and the second drive mechanism **22** in step S**204**. In step S**205**, the server **5** determines that deterioration has progressed in either the first drive mechanism **21** or the second drive mechanism **22**.
[0054] The server **5** performs the same processing on the first drive data pertaining to the first linear motor **35** and the second drive data pertaining to the second linear motor **45**. The server **5** also performs the same processing on the first drive data pertaining to the first swing motor **36** and the second drive data pertaining to the second swing motor **46**. Consequently, the server **5** determines whether there is synchronization deviation in the first drive mechanism **21** and the second drive mechanism **22**. The server **5** also determines whether deterioration has progressed in either the first drive mechanism **21** or the second drive mechanism **22**.
[0055] The server **5** provides the results of the above determination as the predictive maintenance service to the client computer **8**. For example, the server **5** transmits the results of the determination

to the client computer **8** by email. Alternatively, the server **5** may display the determination results on a management screen displayed by a web browser.
[0056] In the system according to the present embodiment explained above, a determination is made as to whether the cumulative sum of the differences between the first drive data and the second drive data exhibits linearity or non-linearity. When the cumulative sum exhibits non-linearity, the occurrence of synchronization deviation between the first drive mechanism **21** and the second drive mechanism **22** is determined. Consequently, the deviation of synchronization is detected with accuracy in the workpiece feeding device **3** that includes the first drive mechanism **21** and the second drive mechanism **22** that operate together in synchronization.
[0057] Although an embodiment of the present disclosure has been described so far, the present disclosure is not limited to the above embodiment and various modifications may be made within the scope of the disclosure. For example, the above-mentioned processing for the predictive maintenance service is not limited to the workpiece feeding device **3** and may be performed on the press machine **2**. Alternatively, the industrial machine is not limited to the press machine **2** and the workpiece feeding device **3** and may include another machine, such as a welding machine or a cutting machine, or may include a workpiece feeding device used with such machines.
[0058] The configuration of the workpiece feeding device **3** may be changed. For example, a portion of the above-mentioned motors may be omitted. Alternatively, a motor may be added. The configuration of the server **5** may be changed. For example, the server **5** may include a plurality of computers. Processing performed with the above-mentioned server **5** may be distributed among the plurality of computers and executed. The server **5** may include a plurality of processors. A portion or all of the processing performed by the server **5** may be executed by the local computer **4**. For example, the processing of steps S**101** to S**105** may be executed by the local computer **4**.
[0059] A portion of the above-mentioned processing may be omitted or changed. The order of the above-mentioned processing may be changed. The method for determining the abnormality by means of the analysis data is not limited to that of the above embodiment and may be changed. The feature amount may include only one of the average μ and standard deviation σ of the Gaussian distribution. The analysis data is not limited to Fast Fourier transform and may be acquired with another frequency analysis, such as discrete Fourier transform.
[0060] The first drive data and the second drive data are not limited to the command values of the motor torques. The first drive data and the second drive data may be other parameters, such as the current values of the motors, the positions of the motors, or the rotation speeds of the motors, that indicate dynamic states of the first drive mechanism and the second drive mechanism.
[0061] According to the present disclosure, deviation of synchronization is accurately detected in the industrial machine including the pair of drive mechanisms that operate together in synchronization.

## Claims

**1**. A method executed by one or more computers for determining synchronization deviation between a first drive mechanism and a second drive mechanism in an industrial machine including the first drive mechanism and the second drive mechanism that operate together in synchronization, the method comprising: acquiring first drive data indicative of a dynamic state of the first drive mechanism; acquiring second drive data indicative of a dynamic state of the second drive mechanism; extracting differences between the first drive data and the second drive data; deriving a cumulative sum of the differences; determining whether the cumulative sum exhibits linearity or non-linearity; and determining that the synchronization deviation occurs between the first drive mechanism and the second drive mechanism when the cumulative sum exhibits non-linearity.
**2**. The method according to claim 1, further comprising performing frequency analysis on difference data indicative of the differences to acquire analysis data indicative of a power spectrum

of the difference data; deriving a Gaussian distribution of the analysis data and acquiring feature amounts representing the Gaussian distribution; and determining whether the first drive mechanism and the second drive mechanism are abnormal based on the feature amounts.

**3**. The method according to claim 2, further comprising determining that the first drive mechanism and the second drive mechanism are abnormal based on the feature amounts, and determining that deterioration of either of the first drive mechanism and the second drive mechanism is progressing when a determination is made that the cumulative sum exhibits linearity.

**4**. The method according to claim 1, wherein the first drive mechanism includes a first motor, the second drive mechanism includes a second motor, the first drive data indicates a torque waveform of the first motor, and the second drive data indicates a torque waveform of the second motor.

**5**. The control system according to claim **5**, wherein the industrial machine is a workpiece feeding device that feeds a workpiece to be pressed.

**6**. The method according to claim 5, wherein the industrial machine further includes a cross bar extending between the first drive mechanism and the second drive mechanism, the cross bar being configured to hold the workpiece, the first drive mechanism includes a first arm connected to one end of the cross bar, and a first motor configured to cause the first arm to operate, and the second drive mechanism includes a second arm connected to the other end of the cross bar, and a second motor configured to cause the second arm to operate.

**7**. A system for determining synchronization deviation between a first drive mechanism and a second drive mechanism in an industrial machine including the first drive mechanism and the second drive mechanism that operate together in synchronization, the system comprising: a storage device configured to store first drive data indicative of a dynamic state of the first drive mechanism and second drive data indicative of a dynamic state of the second drive mechanism; and one or more computers communicably connected to the storage device, the one or more computers being configured to extract differences between the first drive data and the second drive data, derive a cumulative sum of the differences, determine whether the cumulative sum exhibits linearity or non-linearity, and determine that the synchronization deviation occurs between the first drive mechanism and the second drive mechanism when the cumulative sum exhibits non-linearity.

**8**. The system according to claim 7, wherein the one or more computers is further configured to perform frequency analysis on difference data indicative of the differences to acquire analysis data indicative of a power spectrum of the difference data, derive a Gaussian distribution of the analysis data and acquire feature amounts representing the Gaussian distribution, and determine whether the first drive mechanism and the second drive mechanism are abnormal based on the feature amounts.

**9**. The system according to claim 8, wherein the one or more computers is further configured to determine that the first drive mechanism and the second drive mechanism are abnormal based on the feature amounts, and determine that deterioration of either of the first drive mechanism and the second drive mechanism is progressing when a determination is made that the cumulative sum exhibits linearity.

**10**. The system according to claim 7, wherein the first drive mechanism includes a first motor, the second drive mechanism includes a second motor, the first drive data indicates a torque waveform of the first motor, and the second drive data indicates a torque waveform of the second motor.

**11**. The method according to claim 7, wherein the industrial machine is a workpiece feeding device that feeds a workpiece to be pressed.

**12**. The system according to claim 11, wherein the industrial machine further includes a cross bar extending between the first drive mechanism and the second drive mechanism, the cross bar being configured to hold the workpiece, the first drive mechanism includes a first arm connected to one end of the cross bar, and a first motor configured to cause the first arm to operate, and the second drive mechanism includes a second arm connected to the other end of the cross bar, and a second motor configured to cause the second arm to operate.