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(54) Title: METHOD AND SYSTEM FOR MANAGING ASSET PERFORMANCE

(57) Abstract: A method and system for managing asset performance is disclosed that includes receiving one or more real-time data and asset-type corresponding at least one asset during an operation of the asset. Upon determination of an absence of a validated historical data corresponding to the asset, a training data is generated based on a set of libraries corresponding to the asset. The set of libraries correspond to a pre-defined data template for the asset-type. The training data is generated by identifying the set of libraries from a library database based on the asset-type or by customizing one or more pre-defined data templates corresponding to the set of libraries. Alerts corresponding to a future anomaly are determined based on the training data using first machine learning models. Further, one or more corrective actionable are generated corresponding to the alerts.

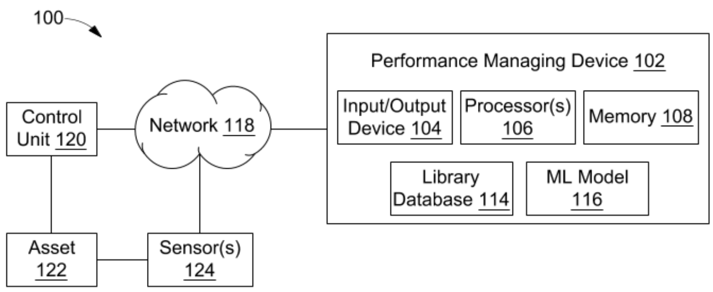

FIG. 1

<u>FORM 2</u>

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

METHOD AND SYSTEM FOR MANAGING ASSET PERFORMANCE

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

Technical Field

[001] This disclosure relates generally to data processing methodology, and more particularly to a system and a method for managing asset performance.

BACKGROUND

[002] Asset-driven industries like O&G and CPG etc., depend on asset performance for productivity. Plants utilize conventional methods and systems to achieve optimum or required asset performance and reliability. The conventional method, however, cannot proactively address asset breakdowns or plant shutdowns with an appropriate lead time for preparation/mitigation of such breakdowns or shutdowns. Further, it is very time intensive to find the root cause of such breakdowns or shutdowns using traditional analysis due to the size of asset-driven industries. Accordingly, the productivity of the asset-driven industry is impacted based on the duration of the asset downtime or inefficiency in the performance of assets.

[003] Further, due to the presence of legacy systems, the detection and repair of assets due to breakdowns become very challenging. Thus, leading to complete plant shutdowns until the detection of the faulty asset. Presently, there are basic tools available for monitoring and managing asset health, but those tools are majorly ticketing tools and require a lot of manual intervention to find out the faults in the assets.

[004] Therefore, there is a requirement for an efficient and reliable methodology for managing asset performance in order to maximize the efficiency of asset-driven industries.

SUMMARY OF THE INVENTION

[005] In an embodiment, a method of managing performance of at least one asset is disclosed. The method may include receiving by a processing device, real-time data and an asset type corresponding to the at least one asset during an operation of the at least one asset. In an, embodiment the at least one asset may include a unique identifier. The method may further include determining an absence of validated historical data corresponding to the at least one asset. Further, the method may include generating by the processing device training data based on a set of libraries corresponding to the least one asset. In an embodiment, the determination of the set of libraries corresponds to a pre-defined data template for the asset type. In an embodiment, the set of libraries may determine by the set of libraries from a library database based on the asset type of at least one asset. In another embodiment, the list of libraries may be determined by customizing one or more pre-defined data templates corresponding to the set of libraries. The method may include generating by the processing device one or more alerts corresponding to a future anomaly determined based on the training data using one or more first machine learning models, wherein each of the one or more first machine learning models may train to generate alerts for a plurality of asset types based on the validated historical data for each of the asset types. The method may also include generating by the processing device, one or more corrective actionable corresponding to one or more alerts.

[006] Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

BRIEF DESCRIPTION OF THE DRAWINGS

[007] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[008] **FIG. 1** is a block diagram of an asset performance management system for managing asset performance, in accordance with an embodiment of the present disclosure.

[009] **FIG. 2** is a functional block diagram of the performance managing device, in accordance with an embodiment of the present disclosure.

[010] **FIG. 3** is a flowchart of the first anomaly detecting model, in accordance with an embodiment.

[011] **FIG. 4** is a flowchart for predicting future anomalies and prescribing corrective actionable for an asset, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DRAWINGS

[012] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope being indicated by the following claims. Additional illustrative embodiments are listed.

[013] Presently, the conventional method however, cannot proactively address asset breakdowns or plant shutdowns with an appropriate lead time for preparation/mitigation of such breakdowns or shutdowns. Further, it is very time intensive to find the root cause of such breakdowns or shutdowns using traditional analysis due to the size of asset-driven industries. Accordingly, productivity of the asset-driven industry is impacted based on the duration of the asset downtime or inefficiency in the performance of assets. Therefore, the present invention provides a methodology for managing asset performance in order to maximize the efficiency of the asset-driven industries.

[014] Referring now to **FIG. 1**, a block diagram of an asset performance managing system 100 for managing asset performance is illustrated, in accordance with an embodiment of the present disclosure.

[015] The asset performance managing system 100 includes a performance managing device 102, one or more assets 122, one or more sensors 124 and a control unit 120.

[016] By way of an example, one or more assets 122 may be various machinery installed in a manufacturing unit or a production unit of an industry. In an embodiment, the machinery may include, but not limited to, reciprocating compressors, boilers, pumps, heat exchangers, gas turbines, etc. Since the machinery is in general legacy systems i.e. they are analog systems and are to be manually monitored to determine any kind of anomaly or breakdown. Accordingly, timely corrective action is required in case of any asset breakdown to avoid plant shutdowns. With digitization across the industrial spectrum, such analog machinery is made digital by way of sensors and controllers. Accordingly, each of the assets 122 may include one or more sensors 124 to measure one or more operating parameters of the assets 122. In an embodiment, the sensors 124 may include, but not limited to, temperature sensors, flow meters, level sensors, pressure sensors, light sensors, temperature sensors, speed sensors, proximity sensors, heat sensors, weight sensors, liquid leakage sensors, torque sensors, pressure sensors, gas sensors, oil level sensors, vibration sensors, etc. The sensors 124 may be associated to each of the assets 122 for monitoring one or more operating parameters to determine operational data of the asset in order to determine its performance. In an embodiment, the operational data may include, but not limited to, gas supply pressure, rotor axial position, discharge pressure, discharge temperature, turbine speed, pressure flow, suction drum pressure, suction temperature, steam pressure, steam turbine inlet steam flow, steam turbine inlet steam temperature, gas compositions, etc. In an embodiment, the sensors 124 may have a unique ID to identify the corresponding asset 122 to which the sensors 124 are associated with. Thus, each asset 122 may be identified based on its unique ID.

[017] In an exemplary embodiment, an industry may include a five-stage reciprocating compressor as asset 122 which may have multiple sensors 124 installed across multiple stages of the five-stage reciprocating compressor that may collect various data points like gas supply pressure, rotor axial position, discharge pressure, discharge temperature, turbine speed, pressure flow, suction drum pressure, suction temperature, steam pressure, steam turbine inlet steam flow, steam turbine inlet steam temperature, gas compositions (Oxygen, Carbon dioxide, Nitrogen, etc.), etc. The data collected may be stored on an external database server (not shown) such as, but not limited to, a historian server which may be accessed by the performance managing device 102.

[018] In another embodiment, the operational data from the sensors 124 may be transmitted to an external database which may already include asset master data for each of the assets 122. The external database may map the operational data received from the sensors 124 for each of the asset 122 to a unique ID of the asset 122. Further, the external database may also provide the performance managing device 102 the master asset data of each of the assets 122 such as, but not limited to unique-id of the asset, asset-type, name, location, region, plant, etc.

[019] In an embodiment, the operational data of the assets 122, as determined by the sensors 124 may be transmitted to the performance managing device 102 via a wireless or wired network 118. The performance managing device 102 may also store the operating parameters may be received from the sensors 124 corresponding to the unique ID of the asset 122 in the memory 108. In an embodiment, the operating parameters may be transmitted to the performance managing device 102 via the control unit 120. In an embodiment, the control unit 120 may include software executable controllers which may be implemented on hardware platform or a hybrid device that combines controller functionality.

[020] The performance managing device 102 may be implemented in any computing device which may be configured or operatively and communicatively coupled to the control unit 120 through a wireless or wired communication network 118. In an embodiment, the computing device may include, but not limited to, a laptop computer, a desktop computer, a notebook, a workstation, a portable computer, a personal digital assistant, a handheld, or a mobile device. Further, one or more users may communicate with the system 100 through one or more user input/output devices 104 provided in the performance managing device 102.

[021] The performance managing device 102 may include a processor 106 and a memory 108. The memory 108 may store instructions that, when executed by the processor 106, cause the processor 106 to monitor and manage performance of the one or more assets 122, as discussed in greater detail below. In an embodiment, examples of processor(s) 106 may include, but are not limited to, an Intel® Itanium® or Itanium 2 processor(s), or AMD®

Opteron® or Athlon MP® processor(s), Motorola® lines of processors, Nvidia®, FortiSOC™ system on chip processors or other future processors. In an embodiment, the memory 108 may be a non-volatile memory or a volatile memory. Examples of non-volatile memory may include, but are not limited to a flash memory, a Read Only Memory (ROM), a Programmable ROM (PROM), Erasable PROM (EPROM), and Electrically EPROM (EEPROM) memory. Examples of volatile memory may include but are not limited to Dynamic Random Access Memory (DRAM), and Static Random-Access memory (SRAM). The memory 108 may also store one or more operational parameters detected by the one or more sensors 124 associated with one or more assets 122 along with unique ID of each of the assets 122.

[022] In an embodiment, the communication network 118 may be a wired or a wireless network or a combination thereof. The network 118 can be implemented as one of the different types of networks, such as Common Industrial Protocol (CIP) network, DeviceNet network, ethernetIP network, intranet, local area network (LAN), wide area network (WAN), the internet, Wi-Fi, LTE network, CDMA network, and the like. Further, the network 116 can either be a dedicated network or a shared network. The shared network represents an association of the different types of networks that use a variety of protocols, for example, Common Industrial Protocol (CIP), Open Platform Communication (OPC) protocols, Hypertext Transfer Protocol (HTTP), Transmission Control Protocol/Internet Protocol (TCP/IP), Wireless Application Protocol (WAP), and the like, to communicate with one another. Further, the network 118 can include a variety of network devices, including routers, bridges, servers, computing devices, storage devices, and the like.

[023] In an embodiment, the control unit 120 may be communicably connected to one or more industrial assets 122 to monitor and control their respective operations. According to the current disclosure, the performance of industrial assets is managed by the performance managing device 102 in order to efficiently run the processes being performed by each of the assets 122 as per predefined operating envelopes or threshold levels. The controller I/O can include digital I/O that may be transmitted and received as discrete voltage signals to and from the industrial devices, or analog I/O that transmits and receives analog voltage or current signals to and from the devices. The controller I/O can be received by the control unit 114 which may then be processed to covert from analog to digital or digital to analog signals in order to be read into and controlled by the control programs or the components using one or more analog to digital converters or digital signal processing algorithms. In an embodiment, the control unit 120 may transmit the signals to the performance managing device 102, which in turn may be saved in the memory 108.

[024] In an embodiment, the performance managing device 102 may pre-process the data collected from one or more sensors 124 to perform data quality assessment and sanitize or cleanse the operational data. The performance managing device 102 may cleanse the data in order to ensure consistency, accuracy, completeness, uniqueness, timelines, zero variance and overall quality score.

[025] Further, the performance managing device 102 may pre-process the data collected from one or more sensors 124 to transform the data from one format to another based on one or more data transformation operations such as, but not limited to, data aggregation, data union, data joins, data masking, data filter, etc. The pre-processed data may then be utilized by the performance managing device 102 to determine efficiency information for each of the assets 122.

[026] In an embodiment, the performance managing device 102 may also receive asset master data from an external database. In an embodiment, external database may include, but not limited to, OSI/PI historian which may contain sensor data collected from the assets 124. In an embodiment, the asset master data may be received from databases such as, but not limited to, SAP, Salesforce, RDBMS, Files, etc. The asset master data may include all the information of the one or more assets 122 currently being used in the industrial setup such as, but not limited to, asset-type information corresponding to the one or more assets 122, historical anomaly and alert data, and set of libraries or pre-defined data templates corresponding to each of the one or more asset types.

[027] The performance managing device 102 may determine one or more assets 122 based on the received unique IDs from the sensors 124 and correlate the master asset data received for each of the assets 122 to determine efficiency information or performance information based on the pre-processed real-time data. The performance managing device 102 may determine one or more anomalies based on the efficiency information determined for each of the assets 122. The performance managing device 102 may utilize a plurality of anomaly detection models, which may include, but not limited to, K-Means, LSTM, Random Forest, etc. Based on the outputs of each of the plurality of anomaly detection models, the performance managing device 102 may generate one or more alerts with an alert system (not shown). The alerts may include generating one or more incident tickets on an alert system (not shown) which may be a service incident tool such as, but not limited to, ServiceNow™ etc. The alerts may further include warnings and notifications generated based on the determination of one or more anomalies in the performance of at least one asset 122 based on its efficiency information or anomaly detection.

[028] The performance managing device 102 may then receive a validation of each of the alerts generated to determine if the alerts is a true positive or a false positive. In an embodiment, the one or more incident tickets may be updated by the user by giving the inputs related to the anomaly for which the incident ticket was generated. In an embodiment, the user may validate the alerts based on a comparison with historical alert data or historical anomaly data corresponding to each of the assets 122 or various asset types. In an embodiment, the historical alert data may include one or more historical alerts recorded corresponding to one or more historical anomalies or incidents for each assets 122 and asset types. In an embodiment, the user input may include providing a validation of the incident ticket based on user's expert opinion and monitoring of the assets 122 by providing an input if the alert generated is valid or not. In an embodiment, each of the anomaly detection models may be checked for their accuracy based on the validation received for the alerts from the user. Accordingly, the anomaly detection models may be re-trained based on the validation of the alerts and validated historical data may be updated to include the asset type, the unique ID, the anomaly detected, a corrective action taken to remedy the anomaly based on the validation feedback from the user. Accordingly, a user may provide a validation feedback to validate the generated alerts based on the historical alert data.

[029] Accordingly, the re-trained anomaly detection models may be more efficient in determining anomalies in the assets 122 based on the validation feedback. Further, the performance managing device 102 may save the validated historical data in the memory 108 for each of the asset 122 which may include the asset type, the unique ID, the anomaly detected, any corrective action taken to remedy the anomaly based on the validation feedback from the user.

[030] In an embodiment, the performance managing device 102 may also predict or determine any future anomaly in at least one of the assets 122. The performance managing device 102 may determine the future anomaly based on the validated historical data for the corresponding asset 122 based the unique ID and asset type of the asset 122. In an embodiment, in case validated historical data for an asset 122 is not available in case there were no anomalies detected for an asset in the past or in case an asset is newly configured or newly deployed.

[031] In such a scenario, the performance managing device 102 may determine a set of libraries or first principle libraries for the asset for which no validated historical data may be present. In an embodiment, the set of libraries may be predefined in a library database based on one or more pre-defined library template modules for each asset type. The template modules may contain predefined programs which may be executed based on the equation templates created for different asset types. The set of libraries may define an operating envelope for an asset type. In an embodiment, in case the set of libraries is not available equation templates may be customized based on the asset type to determine the set of libraries and thus the operating envelopes. The set of libraries determined may be updated and stored in the library database 114. In an embodiment, the operating envelopes may include one or more predefined thresholds corresponding to the operating parameters of the asset 122. The performance managing device 102 may determine training data for each asset 122 based on the validated historical data or the set of libraries determined for each asset 122 based on its corresponding asset-type.

[032] In an embodiment, the performance managing device 102 may utilize machine learning (ML) models 116 which may include one or more machine learning predictive algorithms and prescriptive algorithms. The ML models 116 may determine or predict any future anomaly that may occur in the one or more assets 122 based on the training data determined for each asset 122 based on the asset-type. Further, the ML models 116 may be trained to generate alerts for a plurality of asset types based on validated historical data for each of the asset types. Further, based on the future anomaly determined one or more alerts may be generated. In an embodiment, the alerts generated may include providing a visual or audio notification by the performance managing device 102. In an embodiment, the ML models 116 may include prescriptive machine learning models to generate or provide one or more corrective actionables in form of recommendations in order to prevent the predicted future anomaly corresponding to the asset 122. In an embodiment, the ML models 116 may provide one or more corrective actionables based on historical corrective actionable data comprising one or more corrective actions taken for historically generated alerts which may be applied for currently generated alerts for proactive maintenance.

[033] The ML models 116 may further be trained based on a feedback received with respect to the corrective actionables generated. In an embodiment, each model performance may be viewed on the input/output device 104. The model performance dashboard (not shown) may be rendered on the input/output device 104 based on which performance of each model may be viewed. In an embodiment, the dashboard my provide various attributes of each model, such as, but not limited to, predictions generated, the corrective actionables generated and the accuracy information of various machine learning predictive algorithms and machine learning prescriptive algorithms. In an embodiment, the accuracy of various machine learning predictive algorithms and machine learning prescriptive algorithms may be determined based on the validation of the predictions and the recommended corrective actions selected as correct or incorrect by the user. Accordingly, using model performance dashboards (not shown), a closed loop feedback mechanism may be established to receive feedback from a user which may help train the model to make it more accurate and reliable.

[034] Further, the alerts may be notified to the user such as the asset engineer or supervisor to monitor the asset 122 and act proactively as per the recommended corrective actions.

[035] Referring now to **FIG. 2**, a functional block diagram 200 of the performance managing device 102 is illustrated, in accordance with an embodiment of the present disclosure. In an embodiment, the performance managing device 102 may include a data pre-processing module 202, a data transformation module 204, an anomaly detection module 206, a library determining module 208, a predictive module 210 and a prescriptive module 212.

[036] The data pre-processing module 202 may perform a quality assessment of the real-time data received from the one or more sensors 124 and further to cleanse the data to derive quality statistics information of each of the asset 122. In an exemplary embodiment, an industry may include a five-stage reciprocating compressor as asset 122 which may have multiple sensors 124 installed across multiple stages of the five-stage reciprocating compressor and may collect various operational data points as sensor tags like gas supply pressure, rotor axial position, discharge pressure, discharge temperature, turbine speed, pressure flow, suction drum pressure, suction temperature, steam pressure, steam turbine inlet steam flow, steam turbine inlet steam temperature, gas compositions (Oxygen, Carbon dioxide, Nitrogen, etc.), etc. The data collected may be stored it on an external database server (not shown) such as, but not limited to, a historian server which may be accessed by the performance managing device 102.

[037] Further, the external database may also provide master asset data of the asset 122 such as, the unique-id of the five-stage reciprocating compressor, asset-type, name, location, region, plant, etc.

[038] The data pre-processing module 202 may cleanse the data based on consistency, accuracy, completeness, uniqueness, timelines, zero variance and overall quality score, etc. In an exemplary embodiment, consistency of data may be determined based on number of inconsistencies in the data received for a pre-defined time period or during the operation of the asset 122 as per pre-defined threshold range. In an embodiment, the consistency of data for each operating parameter may be provided as a percentage. Table 1 below shows an exemplary data received from the sensors 124 and Table 2 below provides the consistency determined for the data.

timestamp	discharge temperature	suction temperature
10-03-2023 14:00:00	40	95
10-03-2023 14:10:00	45	90
10-03-2023 14:20:00	49.5	93
10-03-2023 14:30:00	42	96

TABLE 1

	Consistency
discharge temperature	75%
suction temperature	100%

TABLE 2

[039] In an embodiment, the data pre-processing module 202 may check the accuracy of data may be determined based on data errors in terms of null values detected compared to real-time values. Table 3 below shows an exemplary data received from the sensors 124 and Table 4 below provides the accuracy determined for the data.

timestamp	discharge temperature	suction temperature
10-03-2023 12:00:00	40	93
10-03-2023 12:10:00	45	92
10-03-2023 12:20:00	null	null
10-03-2023 12:30:00	42	null
10-03-2023 12:40:00	43	null
10-03-2023 12:50:00	200	null
10-03-2023 13:00:00	44	94
10-03-2023 13:10:00	45	93

TABLE 3

	Accuracy
discharge temperature	75%
suction temperature	50%

TABLE 4

[040] Further, the data pre-processing module 202 may determine the completeness of the operational data based on a percentage of missing values across pre-defined time period or during the operation of the asset 122 for each parameter. Table 5 below shows an exemplary data with missing values received from the sensors 124 and for which the completeness determined is 75% for the data.

timestamp	discharge temperature
10-03-2023 12:00:00	40
10-03-2023 12:10:00	45
10-03-2023 12:20:00	null
10-03-2023 12:30:00	42

TABLE 5

[041] Further, the data pre-processing module 202 may determine a percentage of no variance in data values corresponding to a parameter for a pre-defined time period or during the operation of the asset 122. Table 6 below shows an exemplary data received from the sensors 124 and for which the variance determined is 0% for the data.

timestamp	**discharge temperature**
10-03-2023 17:00:00	40
10-03-2023 17:10:00	40
10-03-2023 17:20:00	40
10-03-2023 17:30:00	40

TABLE 6

[042] In an embodiment, the data pre-processing module 202 may determine a percentage of uniqueness based on a number of duplicate records across the operational data for each operational parameter. Table 7 below shows an exemplary data received from the sensors 124 and for which the uniqueness determined is 0% for the data.

timestamp	**discharge temperature**
10-03-2023 17:00:00	40
10-03-2023 17:10:00	40
10-03-2023 17:20:00	40
10-03-2023 17:30:00	40

TABLE 7

[043] In an embodiment, the data pre-processing module 202 may determine a percentage of timeliness based on pendency or delay in updating of the records. Table 8 below shows an exemplary data received from the sensors 124 and for which the timeliness determined is 75% for the data.

timestamp	**discharge temperature**
10-03-2023 16:00:00	40
10-03-2023 16:10:00	45
10-03-2023 16:50:00	47
10-03-2023 17:00:00	49

TABLE 8

[044] In an embodiment, the data pre-processing module 202 may cleanse the operational data based on predefined rules to manage any consecutive null values, same values, handing value as per offline condition and so on. Table 9 below shows an exemplary data received from the sensors 124 comprising null values and Table 10 shows the corresponding cleansed data.

timestamp	**discharge temperature**
11-03-2023 16:00:00	40
11-03-2023 16:10:00	null
11-03-2023 16:20:00	null

11-03-2023 16:30:00	45
…	…
12-05-2023 14:30:00	null
12-05-2023 14:40:00	null
12-05-2023 14:50:00	null
12-05-2023 15:00:00	null

TABLE 9

timestamp	discharge temperature
11-03-2023 16:00:00	40
11-03-2023 16:10:00	40
11-03-2023 16:20:00	40
11-03-2023 16:30:00	45
…	…
12-05-2023 14:30:00	null
12-05-2023 14:40:00	null
12-05-2023 14:50:00	null
12-05-2023 15:00:00	null

TABLE 10

[045] The data transformation module 204 may perform transformation of the pre-processed data from one format to another format, by performing one or more data transformation functions, including but not limited to, aggregation, unions, joins, masking, filter, etc. The data transformation module 204 may transform the data for further processing which may be utilized for determining the operational efficiency of the asset 122.

[046] The anomaly detection module 206 may detect the anomalies in the asset 122 which may be identified based on the unique ID of the asset 122. The anomaly detection module 206 may utilize one or more machine learning algorithms such as, but not limited to, K-Means, LSTM, Random Forest, etc. The machine learning algorithms may be trained based on one or more feedback received for historical anomaly data corresponding to various assets 122 and asset types. In an embodiment, the one or more feedback may be utilized for validating the one or more anomalies generated by a user such as a field engineer, technician, etc.

[047] Based on the anomalies detected one or more alerts may be generated by raising a ticket on a service incident tool (not shown). In an embodiment, the feedback may be received in order to validate the alerts generated by the anomaly detection module 206 by providing a corrective action required to remedy the anomaly in order to resolve the alert generated. In an embodiment, the user feedback may include providing an input if the alerts generated are false or true. Accordingly, the machine learning algorithms may be trained to enhance their accuracy based on the feedback from the user. Accordingly, validated historical data may be generated based on the validated alerts and anomalies for each asset and asset type and which would set up a solution base that may be trusted to reflect the performance history of the asset 122.

[048] Based on the validated historical data generated for each asset 122, the predictive module 208 may determine training data which may enable prediction of a future anomaly and may generate one or more alerts based on the predicted future anomaly. In case, the validated historical data is not available or present for an asset 122, the first principle module 210 may be used to generate training data for an asset 122 based on one or more sets of libraries pre-defined for the assets 122 and asset types. In an embodiment, the set of libraries corresponds to pre-defined data templates for various asset types. In an embodiment, the first principle module 210 may be connected to a library database which may store one or more predefined library templates or sets of libraries corresponding to each asset type. The set of libraries may contain predefined programs that may be executed based on equation templates created for different asset types. In case, the asset 122 is a new asset and belongs to an asset type for which no set of libraries may be present or pre-defined, then the pre-defined library templates may be customized to generate training data. In an embodiment, the pre-defined library templates may include data equations related to the performance of asset types similar to the asset 122 for which no set of libraries is present. The data equations may be customized based on one or more pre-defined operating ranges or thresholds to generate a new set of libraries that may be added to the library database. In an exemplary embodiment, a pre-defined template for an asset type, but not limited to, of air compressor may be defined as equations 1-4 as mentioned below:

[049] $\boldsymbol{n_{is} = n_w \div n_a}$ …………….. equation (1)

[050] In an embodiment, n_{is} is isentropic efficiency, n_w is isentropic work done and n_a is actual work done.

[051] $\boldsymbol{n_w = V \times \rho \times z \times R \times (273 + t) \times \gamma/(\gamma - 1) \times [(P2/P1)(\gamma - 1)/\gamma - 1]}$ …………….. equation (2)

[052] In an embodiment, for equation (2), V = Volume in cum/m, Z=Compressibility factor, ρ = Air density, R= Universal gas constant, γ=Ratio of specific heat, $273 + t$= Temperature conversion.

[053] Volumetric efficiency = Efficiency Swept Volume ÷ Swept Volume …………….. equation (3), and

[054] Clearance Ratio = Clearance Volume ÷ Swept Volume …………….. equation (4).

[055] Thus, the predictive module 208 may utilize the training data determined based on the set of libraries to determine or predict one or more future anomalies of asset 122 and generate one or more alerts corresponding to the future anomaly. In an embodiment, the predictive module 208 may include one or more predefined machine learning predictive algorithms which get executed in order to predict future anomalies. Further, the predictive module 208 may receive feedback for the alerts generated corresponding to the future anomalies as they are notified in advance for the plant or asset care engineer to act proactively.

[056] The prescriptive module 212 may include one or more predefined machine learning prescriptive algorithms which gets executed in order to prescribe a corrective action or the best course of action for proactive maintenance or prevention of the future anomaly. In an embodiment, the prescriptive module 212 may prescribe one or more corrective action using based on additional data sources by matching the anomaly in the incidence report system and the corresponding resolution steps that were applied for proactive maintenance of the anomaly. In an embodiment, the performance managing device 102 may generate control signals and transmit to the control unit 120 for the control unit 120 to optimize the parameters of one or more asset 122 in accordance with the recommended corrective actions or based on one or more alerts generated for an anomaly or future anomaly. In an embodiment, the prescriptive module 212 may display an output comprising data which matches for the currently identified alert with the historically predicted asset failures based on the past historical failure records by displaying a prescription message to follow as corrective actions or steps before the failure happens to ensure the safety and proper functioning of the assets 122.

[057] Referring now to **FIG. 3**, a flowchart 300 for anomaly determination is illustrated, in accordance with an embodiment of the present disclosure. At step 302, operational data of the asset 122 may be received from the sensors 124 along with the provisioning of asset master data from a database. In an embodiment, the asset master data may include asset type corresponding to the unique IDs of each of the asset and historical service incident records and set of libraries corresponding to various asset types. Further, operating envelope or configurations may be created by setting up IT infrastructure comprising a dashboard that includes the required methodology to manage the performance of the assets 122. At step 304, the performance managing device 102 may perform quality assessment for the data collected from the one or more sensors 124 to derive quality statistics information and to clean the data in order to ensure consistency, accuracy, completeness, uniqueness, timelines, zero variance and overall quality score. At step 306, the pre-processed data may be transformed from one format to another based on one or more data transformation operations such as, but not limited to, data aggregation, data union, data joins, data masking, data filter, etc. The pre-processed data may then be utilized by the performance managing device 102 to determine efficiency information for each of the assets 122 and store the transformed data in the memory 108.

[058] At step 306, the performance managing device 102 may identify one or more assets 122 based on the received unique IDs from the sensors 124 and correlate the master asset data for each of the assets 122 and determine one or more anomalies in the assets 122 may be determined based on the real-time operational data and the historical anomaly data using one or more machine learning algorithms such as, but not limited to K-Means, LSTM, Random Forest, etc. Once the anomalies in each of the assets 122 are determined, the performance managing device 102 may generate one or more alerts. In an embodiment, the alerts may include generating one or more incident tickets on an alert system (not shown) which may be a service incident tool such as, but not limited to, Jira™ etc. The alerts may further include warnings and notifications generated based on the determination of one or more anomalies in the performance of at least one asset 122 based on its efficiency information or anomaly detection.

[059] At step 310, the alerts generated for the anomalies detected may be validated by receiving a feedback if the alert is a true positive or false positive value. The feedback may be based on historical alert data or historical anomaly data corresponding to each of the assets 122 or various asset types. Based on the validation received, the machine learning algorithms may be re-trained for enhancing their accuracy for anomaly detection. Further, at step 312 best performing machine learning algorithms may be determined based on the validation of the alerts generated to determine which algorithm predicted the anomaly accurately. Further, validated historical data may be updated for each asset 122 that may include, but not limited to, the asset type, unique ID, the anomaly detected, and any corrective action taken to remedy the anomaly based on the validation feedback from the user.

[060] At step 314, the performance managing device 102 may determine if validated historical data is present for each asset 122. In case there is no validated historical data present for an asset the performance managing device 102 may determine if a set of library is present for the corresponding asset at step 316.

[061] At step 318, in case a set of libraries are not available for an asset 122, the performance managing device 102 may customize equation templates based on the asset type to determine the set of libraries and to determine operating envelops. The set of libraries determined may be updated and stored in the library database 114.

[062] Further, at step 320, training data for each asset 122 may be determined based on the set of libraries or the validated historical data for each asset 122.

[063] At step 322, the performance managing device 102 may determine or predict any future anomaly that may occur in the one or more assets 122 based on the training data determined based on validated historic data or set of libraries determined for each asset 122 based on the asset-type. The performance managing device 102 may utilize machine learning (ML) models 116 which may include one or more machine learning predictive algorithms.

[064] At step 324, the performance managing device 102 may validate the future anomalies and the alerts generated corresponding to the future anomalies. In an embodiment, a user may validate the predicted future anomaly based on physical asset monitoring or historical anomaly data corresponding to the asset 122. The user may validate the future anomaly by providing an input if the predicted anomaly is a false positive or a true positive. Based on the validation of the future anomalies and the alerts the machine learning predictive algorithms may be re-trained to enhance their accuracy.

[065] At step 326, the performance managing device 102 may prescribe one or more corrective actions to be taken in order to prevent the occurrence of the future anomalies in the assets 122. The performance managing device 102 may utilize machine learning (ML) models 116 which may include one or more machine learning prescriptive algorithms.

[066] At step 328, the performance managing device 102 may monitor the performance of each asset 122 based on various predicted anomalies and the corresponding prescriptive corrective action for each asset 122. The performance information may be viewed on the input/output device 104 based on outputs of various machine learning predictive algorithms and machine learning prescriptive algorithms on a model performance dashboard (not shown) which may be rendered on the input/output device 104 based on which performance of each model may be viewed. In an embodiment, the dashboard may provide various attributes of each model, such as, but not limited to, predictions generated, the corrective actionable generated and the accuracy information of various machine learning predictive algorithms and machine learning prescriptive algorithms.

[067] Referring now to **FIG. 4**, a flowchart 400 for predicting future anomalies and prescribing corrective actionable for an asset is disclosed, in accordance with an embodiment of the present disclosure. Each step of the flowchart 400 may be executed by various modules (same as the modules of the system 100).

[068] At step 402, real-time data and an asset-type corresponding to the at least one asset 122 during an operation of the at least one asset 122 may be received, wherein each asset 122 has a unique identifier or unique ID assigned to it.. At step 404, the performance managing device 102 may determine if validated historical data corresponding to each of the asset 122 is present. At step 406, in case the validated historical data corresponding to an asset 122 is not present, the perfomance managing device 102 may determine if a set of libraries are present for the asset for which validated historical information is not present. In an embodiment, each of the set of libraries correspond to a pre-defined data template for the asset type. At step 408, in case set of libraries are not present, one or more pre-defined data templates corresponding to the set of libraries may be customized based on the asset type of the at least one asset 122 to generate the set of libraries corresponding to the asset 122. At step 410, training data for each asset 122 may be determined based on the set of libraries identified from a library database based on the asset type of the each of assets 122 or the set of libraries determined by customization of the one or more pre-defined data templates. At step 412, one or more alerts corresponding to a future anomaly determined or predicted may be generated based on the validated historical data or the training data using one or more first machine learning models. In an embodiment, the one or more first machine learning models may include various machine learning predictive algorithms and machine learning prescriptive algorithms that may be trained to generate alerts for a plurality of asset types based on validated historical data for each of the asset types. At step 414, one or more corrective actionables corresponding to the one or more alerts may be generated.

[069] It is intended that the disclosure and examples be considered as exemplary only, with a true scope of disclosed embodiments being indicated by the following claims.

WE CLAIM:

1. A method of managing performance of at least one asset, the method comprising:

receiving, by a processing device, real-time data and an asset-type corresponding to the at least one asset during an operation of the at least one asset, wherein the at least one asset has a unique identifier;

upon determination of an absence of a validated historical data corresponding to the at least one asset:

generating, by the processing device, a training data based on a set of libraries corresponding to the least one asset,

wherein each of the set of libraries correspond to a pre-defined data template for the asset type, and wherein the set of libraries is determined by at least one of:

identifying, by the processing device, the set of libraries from a library database based on the asset type of the at least one asset, or

customizing, by the processing device, one or more pre-defined data templates corresponding to the set of libraries based on the asset type of the at least one asset;

generating, by the processing device, one or more alerts corresponding to a future anomaly determined based on the validated historical data or the training data using one or more first machine learning models, wherein the each of the one or more first machine learning models have been trained to generate alerts for a plurality of asset types based on validated historical data for each of the asset types; and

generating, by the processing device, one or more corrective actionables corresponding to the one or more alerts.

2. The method as claimed in claim 1, wherein the validated historical data corresponding to the at least one asset is determined by:

pre-processing, by the processing device, the real-time data for evaluating one or more operational parameters associated with the at least one asset;

determining, by the processing device, one or more alerts corresponding to the at least one asset based on the one or more operational parameters using one or more second machine learning models; and

validating, by the processing device, the one or more alerts based on a comparison with a historical alert data corresponding to the at least one asset, wherein the historical alert data comprises one or more historical alerts recorded corresponding to one or more historical anomalies for each asset type.

3. The method as claimed in claim 2, wherein the one or more second machine learning model is re-trained, by the processing device, based on the validation of the one or more alerts.

4. The method as claimed in claim 1, wherein the one or more corrective actionables are generated using one or more third machine learning models.

5. The method as claimed in claim 1, wherein the one or more pre-defined data templates are derived based on one of the validated historical data and an intrinsic working of the asset type.

6. The method as claimed in claim 1, wherein the customized one or more pre-defined data templates are stored in the library database for subsequent generation of the training data for the asset type.

7. The method as claimed in claim 1, wherein the real-time data is received from one or more sensors associated to the at least one asset and include the unique identifier of the at least one asset, and wherein the asset type is determined based on an asset master data provisioned from a database.

8. A system of managing performance of at least one asset, the system comprises:

a processor; and

a memory coupled to the processor, wherein the memory stores processor-executable instructions, which, on execution, causes the processor to:

receive real-time data and an asset-type corresponding to the at least one asset during an operation of the at least one asset, wherein the at least one asset has a unique identifier;

upon determination of an absence of a validated historical data corresponding to the at least one asset:

generate a training data based on a set of libraries corresponding to the least one asset,

wherein each of the set of libraries correspond to a pre-defined data template for the asset type, and wherein the set of libraries is determined by at least one of:

identification of the set of libraries from a library database based on the asset type of the at least one asset, or

customization of one or more pre-defined data templates corresponding to the set of libraries;

generate one or more alerts corresponding to a future anomaly determined based on the validated historical data or the training data using one or more first machine learning models, wherein the each of the one or more first machine learning models have been trained to generate alerts for a plurality of asset types based on validated historical data for each of the asset types; and

generate one or more corrective actionables corresponding to the one or more alerts.

9. The system as claimed in claim 8, wherein the processor is configured to:

pre-process the real-time data for evaluating one or more operational parameters associated with the at least one asset;

determine one or more alerts corresponding to the at least one asset based on the one or more operational parameters using one or more second machine learning models; and

validate the one or more alerts based on a comparison with a historical alert data corresponding to the at least one asset, wherein the historical alert data comprises one or more historical alerts recorded corresponding to one or more historical anomalies for each asset type.

10. The system as claimed in claim 9, wherein the one or more second machine learning model is re-trained based on the validation of the one or more alerts.

Dated this 27th day of March 2023

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ABSTRACT

METHOD AND SYSTEM FOR MANAGING ASSET PERFORMANCE

A method and system for managing asset performance is disclosed that includes receiving one or more real-time data and asset-type corresponding at least one asset during an operation of the asset. Upon determination of an absence of a validated historical data corresponding to the asset, a training data is generated based on a set of libraries corresponding to the asset. The set of libraries correspond to a pre-defined data template for the asset-type. The training data is generated by identifying the set of libraries from a library database based on the asset-type or by customizing one or more pre-defined data templates corresponding to the set of libraries. Alerts corresponding to a future anomaly are determined based on the training data using first machine learning models. Further, one or more corrective actionable are generated corresponding to the alerts.

[To be published with FIG. 1]

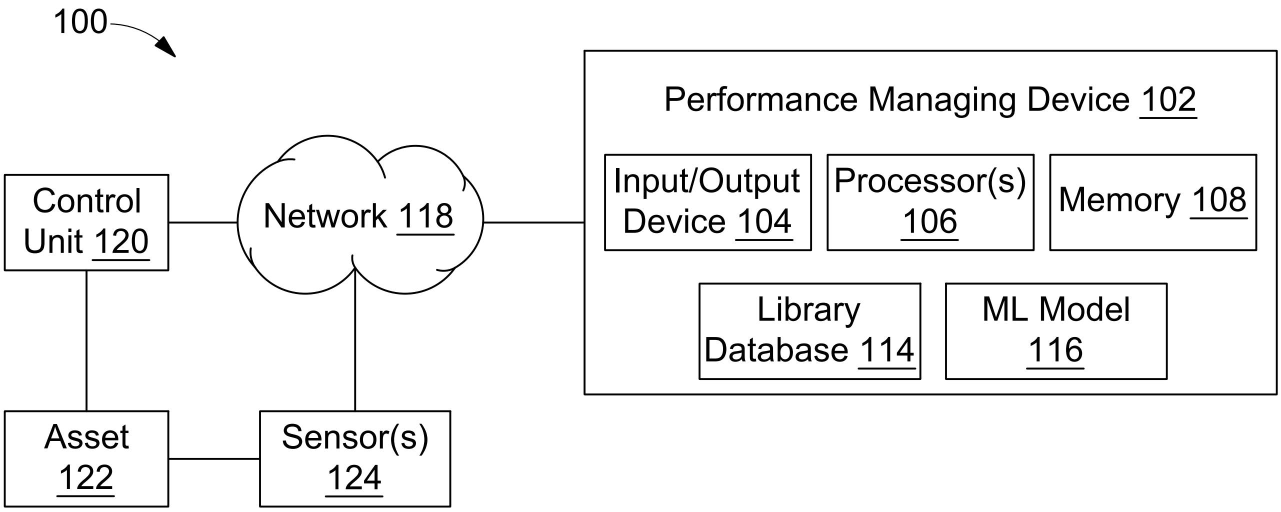

FIG. 1

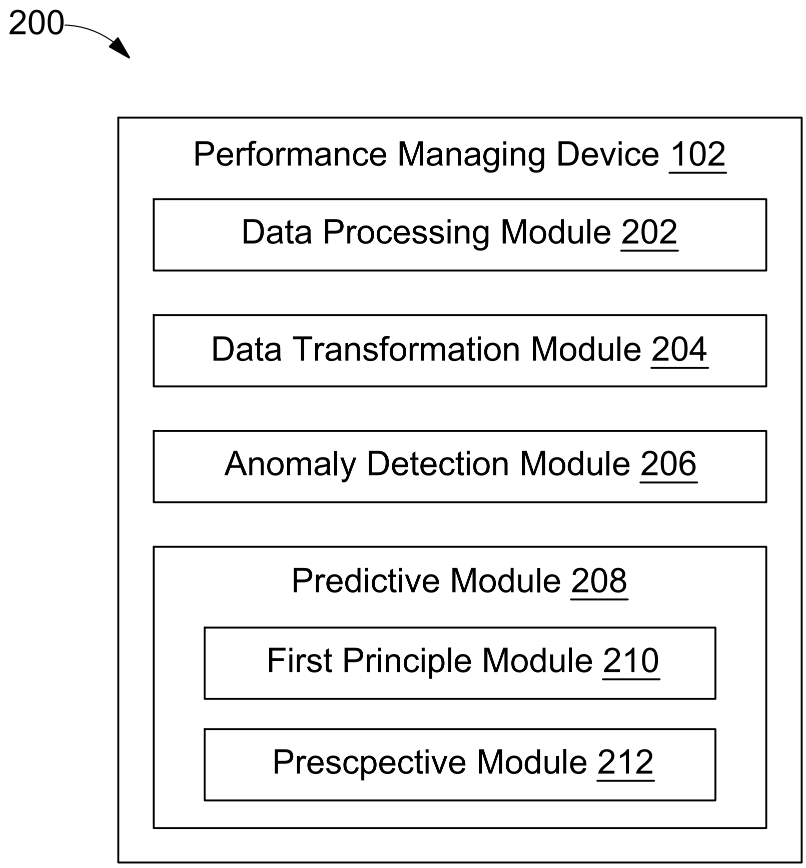

FIG. 2

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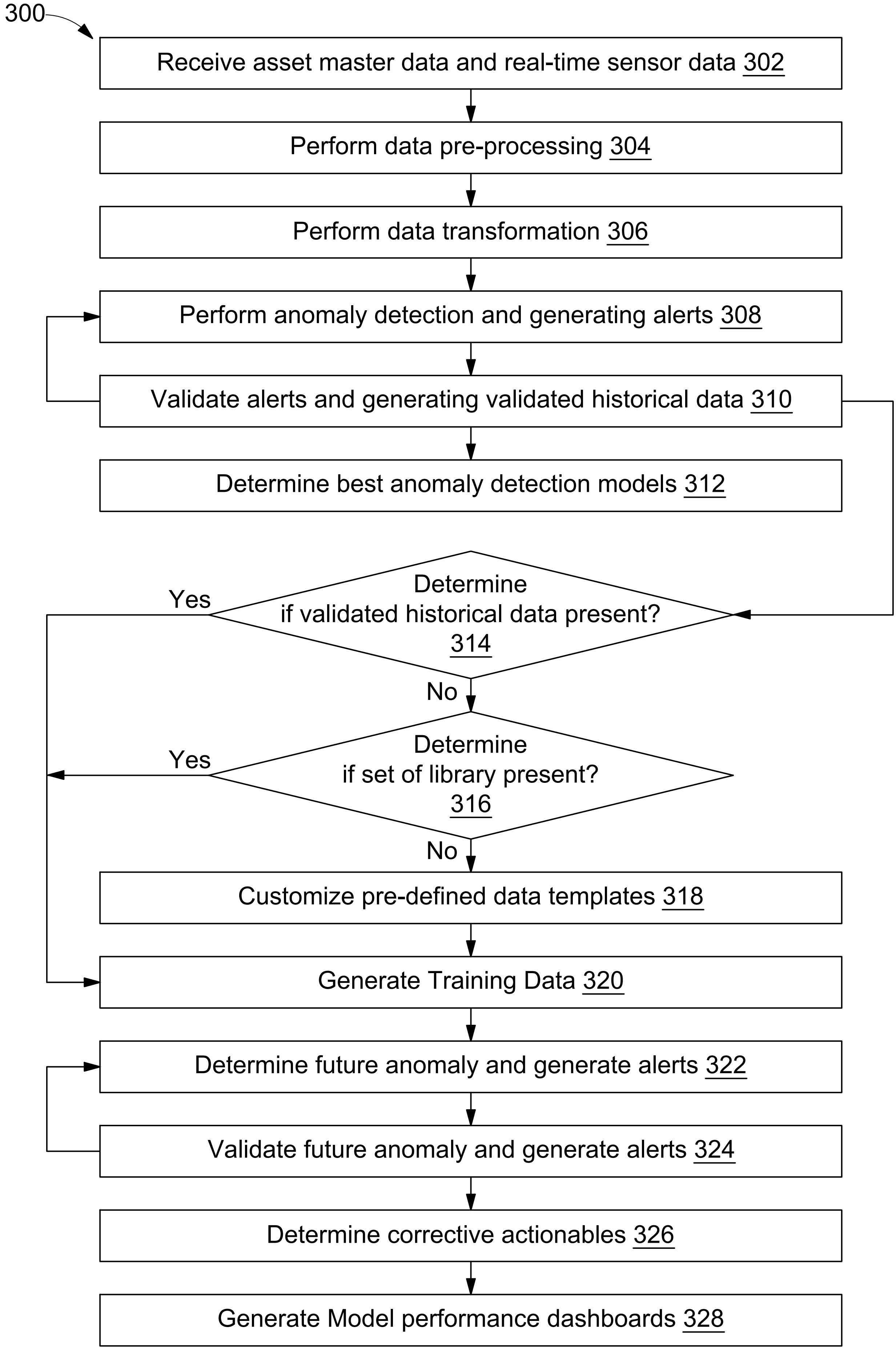

FIG. 3

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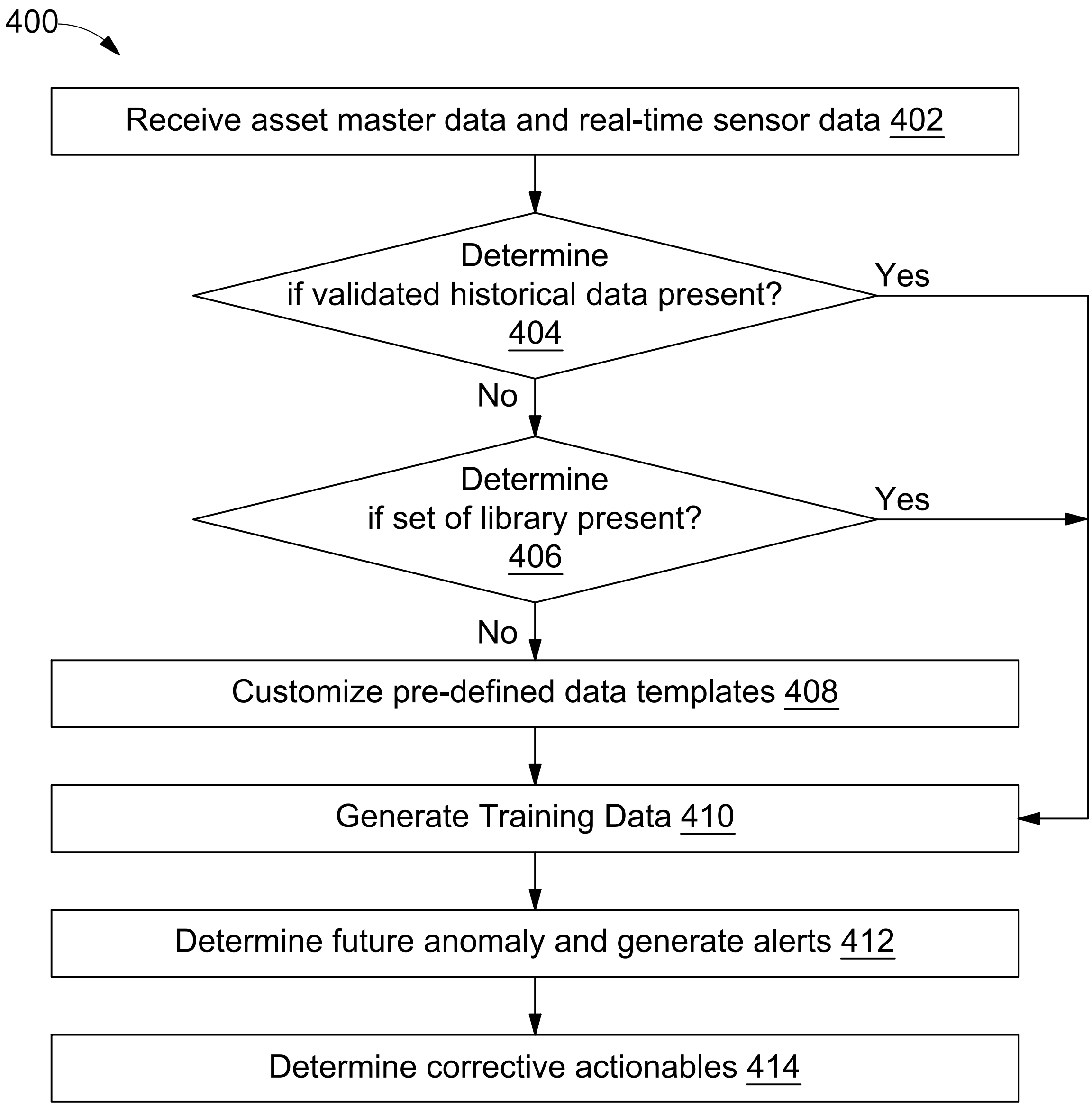

FIG. 4

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