

DESCRIPTION

Title of Invention

INFORMATION PROCESSING SYSTEM, INFORMATION PROCESSING METHOD, LEARNING SYSTEM, AND LEARNING METHOD

[Technical Field]

[0001]

The present disclosure relates to an information processing system, an information processing method, a learning system, and a learning method.

Priority is claimed on Japanese Patent Application No. 2023-146237, filed September 8, 2023, the content of which is incorporated herein by reference.

[Background Art]

[0002]

Patent Document 1 discloses an information processing device that acquires process data including at least one of a plurality of combustion process measurement values and a plurality of control values in a combustion facility, acquires or generates image data based on thermal image information captured by an imaging unit that is provided in the combustion facility and captures an image inside the combustion facility, predicts a steam generation amount after a predetermined prediction time based on the process data and the image data, and controls a waste incineration furnace based on a predicted steam generation amount prediction value.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication
No. 2021-188813

[Summary of Invention]

[Technical Subject]

[0004]

However, in the information processing device described in Patent Document 1, although the steam generation amount prediction value can be obtained, there is a technical subject that it is difficult to obtain a correspondence relationship between the steam generation amount prediction value and an operation content of the combustion facility which is to be performed according to the steam generation amount prediction value.

[0005]

The present disclosure has been made to solve the above-described subjects, and an object of the present disclosure is to provide an information processing system, an information processing method, a learning system, and a learning method capable of deriving an appropriate operation content relating to a combustion facility.

[Subject to be solved]

[0006]

To solve the above-described subjects, an information processing system according to the present disclosure is an information processing system for a combustion facility, the system including: an acquisition unit configured to acquire state quantity information that is information relating to a state quantity of the combustion facility; and an operation content derivation unit configured to input the state quantity information acquired by the acquisition unit and derive an operation content, which corresponds to the input state quantity information, of a supply

apparatus configured to supply an object to be incinerated to the combustion facility by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility.

[0007]

An information processing method according to the present disclosure is an information processing method relating to a combustion facility, the method including: acquiring state quantity information that is information relating to a state quantity of the combustion facility; and inputting the state quantity information and deriving an operation content, which corresponds to the input state quantity information, of a supply apparatus configured to supply an object to be incinerated to the combustion facility by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility.

[0008]

A learning system according to the present disclosure is a learning system for a combustion facility, the learning system including a learning unit configured to perform reinforcement learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility, an operation content of a supply apparatus configured to supply an object to be incinerated to the combustion facility, and a reward corresponding to a state of the combustion facility.

[0009]

A learning method according to the present disclosure is a learning method for a combustion facility, the learning method including performing reinforcement

learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility, an operation content of a supply apparatus configured to supply an object to be incinerated to the combustion facility, and a reward corresponding to a state of the combustion facility.

[Advantageous Effects of Invention]

[0010]

According to the information processing system, the information processing method, the learning system, and the learning method of the present disclosure, it is possible to derive an appropriate operation content relating to the combustion facility.

[Brief Description of Drawings]

[0011]

FIG. 1 is a schematic configuration diagram illustrating an entire combustion facility according to an embodiment of the present disclosure.

FIG. 2 is a block diagram I illustrating a functional configuration of the combustion facility according to the embodiment of the present disclosure.

FIG. 3 is a view schematically illustrating a change in a configuration of a neural network in reinforcement learning according to the embodiment of the present disclosure.

FIG. 4 is a view illustrating an example of an operation content linked to an output layer in the reinforcement learning according to the embodiment of the present disclosure.

FIG. 5 is a view illustrating an example of a reward value relating to a change in a configuration of a neural network in the reinforcement learning according to the embodiment of the present disclosure.

FIG. 6 is a flowchart illustrating an information processing method according to the embodiment of the present disclosure.

FIG. 7 is a flowchart I illustrating a learning method according to the embodiment of the present disclosure.

FIG. 8 is a block diagram II illustrating a functional configuration of the combustion facility according to the embodiment of the present disclosure.

FIG. 9 is a flowchart II showing the learning method according to the embodiment of the present disclosure.

FIG. 10 is a hardware configuration diagram illustrating a configuration of a computer according to the embodiment of the present disclosure.

[Description of Embodiments]

[0012]

Hereinafter, a control device according to embodiments of the present disclosure will be described with reference to the drawings. In the following description, the same reference numerals are assigned to configurations having the same or similar functions. Repeated description of the configurations may be omitted. In the present disclosure, "based on XX" means "at least based on XX", and may include a case where one element exists based on another element in addition to XX. In addition, "based on XX" is not limited to a case where XX is directly used, and may also include a case where calculation or processing is performed on XX. In the present disclosure, "XX or YY" is not limited to a case of either XX or YY, and may also include a case of both XX and YY. The same applies to a case where the number of selective elements is three or more. "XX" and "YY" are any elements (for example, any information).

[0013]

In the present disclosure, a term "acquire" is not limited to a case where information is actively acquired by transmitting a transmission request, and may also include a case where the information is acquired by passively receiving the information transmitted from another device. In addition, a term "acquisition" is not limited to a case where target information (information to be acquired) is directly acquired from the outside, and may also include a case where the target information is generated and acquired by performing calculation or processing on the information obtained from the outside.

[0014]

(First Embodiment)

<1. Overall Configuration of Incineration Facility>

FIG. 1 is a schematic configuration diagram illustrating an overall configuration of a combustion facility SF according to an embodiment. A combustion facility SF is, for example, a stoker furnace in which an object G to be incinerated is municipal garbage, industrial waste, biomass, or the like. Hereinafter, for convenience of description, the term "object G to be incinerated" will be referred to as "garbage G". The combustion facility SF is not limited to a stoker furnace, and may be a different type of incineration facility. In the present embodiment, the combustion facility SF includes, for example, a crane 1, an incinerator 2, a heat recovery steam generator 3, a temperature controlling tower 4, a bag filter 5, an exhaust gas duct 6, a chimney 7, and an information processing system 100.

[0015]

The crane 1 transports the garbage G stored in a garbage pit to a hopper 11 of the incinerator 2 to be described later and puts the garbage G into the hopper 11. The crane 1 includes a grip portion 1a that grips the garbage G and a weight sensor 1b

provided in the grip portion 1a. The weight sensor 1b is, for example, a load cell. The weight sensor 1b detects the weight of the garbage G gripped by the grip portion 1a in a state in which the garbage G is gripped and lifted by the grip portion 1a. A detection result of the weight sensor 1b is in a state in which the detection result can be acquired by an acquisition unit 110 of the information processing system 100.

[0016]

The incinerator 2 is a furnace that combusts the garbage G while transporting the garbage G put into the hopper 11 (to be described later). The incinerator 2 generates a flue gas as a result of combustion of the garbage G inside the incinerator 2. The generated flue gas is fed to the heat recovery steam generator 3 provided in an upper portion of the incinerator 2. The heat recovery steam generator 3 heats water by exchanging heat between the flue gas generated in the incinerator 2 and water, and generates steam.

[0017]

The flue gas passing through the heat recovery steam generator 3 is cooled at the temperature controlling tower 4, and is fed to the bug filter 5. The flue gas is discharged to the atmosphere through the exhaust gas duct 6 and the chimney 7 after soot or dust is removed by the bug filter 5. A gas concentration sensor 6a is provided in the exhaust gas duct 6. The gas concentration sensor 6a detects a concentration (for example, a CO concentration) of various gases contained in the flue gas flowing through the exhaust gas duct 6. The detection result of the gas concentration sensor 6a may include one or more of an oxygen concentration, an NO_x concentration, and an SO_x concentration in addition to or instead of the CO concentration. The detection result of the gas concentration sensor 6a is transmitted to the acquisition unit 110 of the information processing system 100.

[0018]

<2. Incinerator>

Next, the incinerator 2 will be described in detail. For example, the incinerator 2 includes a supply mechanism 10, a furnace body 20, a stoker 30, a plurality of wind boxes 41, a discharge chute 42, a furnace 43, and a blowing mechanism 50.

[0019]

<2.1 Supply Mechanism>

The supply mechanism 10 is a mechanism that temporarily stores the garbage G delivered by a crane 1 and sequentially supplies the garbage G toward a treatment space V of the furnace body 20 (to be described later). The supply mechanism 10 includes, for example, the hopper 11, a feeder 12, an extrusion apparatus 13, an object measurement device 14, and a moisture measurement device 15.

[0020]

The hopper 11 is a storage portion provided to supply the garbage G into the furnace body 20. The garbage G conveyed by the crane 1 is charged into the hopper 11. The hopper 11 includes an inlet portion 11a and an outlet portion 11b. The inlet portion 11a is an inlet portion for the garbage G to be put in from the outside. The inlet portion 11a extends, for example, in a vertical direction. The garbage G put into the inlet portion 11a moves downward due to gravity. The outlet portion 11b is provided below the inlet portion 11a. The outlet portion 11b is an outlet portion that guides the garbage G supplied from the inlet portion 11a toward the treatment space V in the furnace body 20 to be described later. The outlet portion 11b extends, for example, in a horizontal direction.

[0021]

The feeder 12 is a device that supplies the garbage G to the furnace body 20. The feeder 12 is an example of a “supply apparatus”. Hereinafter, a reciprocating type feeder 12 that supplies the garbage G to the furnace body 20 by performing a reciprocating motion will be described as an example. The feeder 12 is not limited to the reciprocating type, and may be a rotary type feeder 12 that supplies the garbage G by performing a rotary motion.

[0022]

The feeder 12 is provided in the outlet portion 11b of the hopper 11. The feeder 12 has a plate shape along a bottom portion of the outlet portion 11b of the hopper 11, and is disposed along the bottom portion of the outlet portion 11b of the hopper 11. The feeder 12 is movable back and forth along a direction from the outlet portion 11b of the hopper 11 toward the treatment space V of the furnace body 20. The feeder 12 is driven by the extrusion apparatus 13 and extrudes the garbage G accumulated inside the hopper 11 (for example, the outlet portion 11b of the hopper 11) toward the treatment space V of the furnace body 20. A stroke of the feeder 12, a moving speed of the feeder 12, and a stop time of the feeder 12, related to a supply amount of the garbage G, are controlled by the extrusion apparatus 13.

[0023]

The object measurement device 14 is a measurement device that measures a height of the garbage G to be put into the hopper 11 by the crane 1. The object measurement device 14 is, for example, a light detection and ranging (LiDAR). The object measurement device 14 is provided, for example, at the inlet portion 11a of the hopper 11, and detects the height of the garbage G passing through the inlet portion 11a of the hopper 11. The object measurement device 14 may directly detect the volume of the garbage G through three-dimensional measurement instead of the height

of the garbage G. The detection result of the object measurement device 14 is transmitted to the acquisition unit 110 of the information processing system 100.

[0024]

The moisture measurement device 15 is a measurement device that measures a value (for example, a moisture content or a moisture amount) relating to the moisture contained in the garbage G to be put into the hopper 11. In the present embodiment, the moisture measurement device 15 includes an irradiation unit and a detection unit provided in the hopper 11, and an analysis unit. The irradiation unit irradiates the garbage G accumulated in the hopper 11 with an electromagnetic wave in a predetermined frequency band. The detection unit receives the electromagnetic wave that is emitted from the irradiation unit, passes through the garbage G, or is reflected by the garbage G. For example, the analysis unit stores in advance correlation information indicating a relationship between a change in characteristics of the electromagnetic wave (for example, a change in amplitude or a change in phase) and the moisture content. The analysis unit detects the moisture content contained in the garbage G based on the change in the characteristics of the electromagnetic wave between the irradiation unit and the detection unit, and the correlation information.

[0025]

In the present embodiment, the irradiation unit and the detection unit of the moisture measurement device 15 are provided slightly above the feeder 12, and detect the moisture content of the garbage G accumulated on an upper surface of the feeder 12. A detection result of the moisture measurement device 15 is in a state in which the detection result can be acquired by the acquisition unit 110 of the information processing system 100.

[0026]

<2.2 Furnace Body>

The furnace body 20 is equipment provided adjacent to the hopper 11 and combusting the garbage G while transporting the garbage G. Hereinafter, a transport direction of the garbage G in the combustion facility SF will be referred to as a "transport direction D". The furnace body 20 includes a dry stage 20a, a combustion stage 20b, and a post-combustion stage 20c in this order from an upstream side toward a downstream side in the transport direction D. The dry stage 20a is a region which is located upstream of the combustion stage 20b and the post-combustion stage 20c and in which the garbage G supplied from the hopper 11 is dried prior to combustion on the stoker 30. The combustion stage 20b and the post-combustion stage 20c are regions where the garbage G in a dried state after passing through the dry stage 20a is combusted on the stoker 30. In the combustion stage 20b, diffusion combustion occurs due to a thermal decomposition gas generated from the garbage G, and a luminous flame F is generated. In the post-combustion stage 20c, since fixed carbon combustion occurs after the diffusion combustion of the garbage G, the luminous flame F is not generated. The combustion stage 20b and the post-combustion stage 20c are examples of the treatment space V for combusting the garbage G. The dry stage 20a is an example of a region on an upstream side of the treatment space V in the transport direction D.

[0027]

In the present embodiment, the furnace body 20 includes a visible light camera 21 and an infrared camera 22. The visible light camera 21 and the infrared camera 22 are disposed on a downstream side of the treatment space V in the transport direction D, and capture an image of the upstream side in the transport direction D from the downstream side. In the present embodiment, the visible light camera 21 and the

infrared camera 22 are provided at an end portion (hereinafter, referred to as a “furnace back end”) on the downstream side of the furnace body 20 in the transport direction D. For example, the visible light camera 21 and the infrared camera 22 capture an image of the upstream side in the transport direction D from the downstream side through a window portion provided at the furnace back end of the furnace body 20. For example, the visible light camera 21 and the infrared camera 22 are disposed at positions adjacent to each other in an up-down direction or a right-left direction.

[0028]

The visible light camera 21 images the luminous flame F from the furnace back end of the furnace body 20. An imaging result of the visible light camera 21 is in a state in which the imaging result can be acquired by the acquisition unit 110 of the information processing system 100.

[0029]

The infrared camera 22 images the luminous flame F and the garbage G accumulated in the dry stage 20a (that is, on the upstream side of the treatment space V) of the furnace body 20 from the furnace back end of the furnace body 20. In addition, in the present embodiment, the infrared camera 22 images the outlet portion 11b of the hopper 11 by transmitting the luminous flame F from the furnace back end of the furnace body 20. For example, the infrared camera 22 captures an image (an image showing a state of accumulation of the garbage G) including the garbage G accumulated on the feeder 12 at the outlet portion 11b of the hopper 11. An imaging result of the infrared camera 22 is in a state in which the imaging result can be acquired by the acquisition unit 110 of the information processing system 100.

[0030]

In the present embodiment, an image including both the dry stage 20a of the

furnace body 20 and the outlet portion 11b (for example, the garbage G accumulated on the feeder 12) of the hopper 11 is captured by one infrared camera 22. Alternatively, the furnace body 20 may be separately provided with a first infrared camera that images the dry stage 20a of the furnace body 20 and a second infrared camera that images the outlet portion 11b (for example, the garbage G accumulated on the feeder 12) of the hopper 11. In addition, the infrared camera 22 may be provided at another position instead of the furnace back end of the furnace body 20.

[0031]

<2.3 Stoker>

The stoker 30 includes a plurality of grates 31 and a grate drive device 32 (not shown). The plurality of grates 31 form a stoker surface 30a that serves as a bottom surface (for example, a bottom surface of the treatment space V) of the furnace body 20. The garbage G is supplied in a layered shape to the stoker surface 30a by the supply mechanism 10. The stoker surface 30a is provided over the dry stage 20a, the combustion stage 20b, and the post-combustion stage 20c which are described above. The plurality of grates 31 include a fixed grate and a movable grate. The fixed grate is fixed to an upper surface of the wind boxes 41 (to be described later). The movable grate reciprocates along the transport direction D at a constant speed. In this manner, the garbage G is transported to the downstream side while the garbage G located on the movable grate and the fixed grate (on the stoker surface 30a) is stirred and mixed.

[0032]

<2.4 Wind box, Discharge Chute, Furnace>

The wind box 41 is provided below the stoker 30, and supplies combustion air into the furnace body 20 through the stoker 30. A plurality of the wind boxes 41 are

arranged in the transport direction D. Each of the wind boxes 41 includes a wind box pressure sensor 41a. The wind box pressure sensor 41a detects a pressure inside the wind box 41. The pressure inside the wind box 41 corresponds to a pressure of combustion air supplied to the inside of the furnace body 20 through a primary air line 52 to be described later. A detection result of the wind box pressure sensor 41a is in a state in which the detection result can be acquired by the acquisition unit 110 of the information processing system 100.

[0033]

The discharge chute 42 is a device that drops the garbage G completely combusted and turned into ash to an ash extrusion apparatus located below the furnace body 20. The discharge chute 42 is provided in the furnace back end of the furnace body 20.

[0034]

The furnace 43 extends upward from an upper portion of the furnace body 20. The flue gas generated by the combustion of the garbage G inside the treatment space V is fed to the heat recovery steam generator 3 through the furnace 43.

[0035]

<2.5 Blowing Mechanism>

The blowing mechanism 50 supplies air (for example, the combustion air) into the furnace body 20. The blowing mechanism 50 includes, for example, a blower 51, the primary air line 52, an air preheater 53, a secondary air line 54, a damper 55, and an air flow sensor 56.

[0036]

The blower 51 is a pressure blower that pumps the air (for example, the combustion air) into the furnace body 20. For example, the blower 51 includes a first

blower 51A and a second blower 51B. The first blower 51A pumps the combustion air into the furnace body 20 (for example, the treatment space V) through the primary air line 52 and the wind box 41. The second blower 51B pumps the combustion air into the furnace 43 through the secondary air line 54.

[0037]

The primary air line 52 connects the first blower 51A and the wind box 41. One or more (for example, a plurality of) primary air dampers 55A are provided partway along the primary air line 52. The primary air damper 55A changes a flow rate of the combustion air flowing through the primary air line 52 in accordance with an opening degree of the primary air damper 55A.

[0038]

The air preheater 53 is a heat exchanger that preheats the air pumped from the first blower 51A. For example, the air preheater 53 is provided partway along the primary air line 52.

[0039]

The secondary air line 54 connects the second blower 51B and the furnace 43. Secondary air supplied into the furnace 43 moves toward the garbage G from above the stoker 30. One or more (for example, a plurality of) secondary air dampers 55B are provided partway along the secondary air line 54. The secondary air damper 55B changes a flow rate of the combustion air flowing through the secondary air line 54 in accordance with an opening degree of the secondary air damper 55B. For convenience of description, the primary air damper 55A and the secondary air damper 55B will be collectively referred to as a “damper 55” in the following description.

[0040]

The air flow sensor 56 detects a flow rate of air (for example, the combustion

air) supplied to the inside of the furnace body 20. The air flow sensor 56 includes, for example, a first air flow sensor 56A and a second air flow sensor 56B. The first air flow sensor 56A is provided partway along the primary air line 52 and detects a flow rate of air supplied through the primary air line 52. The second air flow sensor 56B is provided partway along the secondary air line 54 and detects a flow rate of air supplied through the secondary air line 54. In the following description, the phrase "detection result of the air flow sensor 56" includes, for example, a detection result of the first air flow sensor 56A and a detection result of the second air flow sensor 56B.

[0041]

<3. Heat Recovery Steam Generator>

Next, the heat recovery steam generator 3 will be described. The heat recovery steam generator 3 includes, for example, a boiler body 61, a pipeline 62, a radiation temperature sensor (infrared temperature sensor) 63, an in-furnace pressure sensor 64, a water supply flow sensor 65, and a superheater flow sensor (steam amount sensor) 66.

[0042]

The boiler body 61 is connected to the furnace 43 of the incinerator 2. The flue gas generated in the incinerator 2 flows into the boiler body 61. The radiation temperature sensor 63 and the in-furnace pressure sensor 64 are provided in the boiler body 61. The radiation temperature sensor 63 detects a temperature inside the boiler body 61. The in-furnace pressure sensor 64 detects a pressure inside the boiler body 61. A detection result of the radiation temperature sensor 63 is transmitted to the acquisition unit 110 of the information processing system 100. A detection result of the in-furnace pressure sensor 64 is in a state in which the detection result can be acquired by the acquisition unit 110 of the information processing system 100.

[0043]

The pipeline 62 extends inside the boiler body 61. The pipeline 62 is provided with a plurality of superheaters and a plurality of temperature reducers. Water is supplied from a water supply unit to an inlet portion of the pipeline 62. At least a portion of the water flowing through the pipeline 62 is heated by heat exchange inside the boiler body 61, and flows toward an external device (for example, a turbine) as main steam. In addition, the term "steam amount" in the present disclosure means the amount of the main steam flowing from the pipeline 62 toward an external device (for example, the turbine).

[0044]

The water supply flow sensor 65 is provided at an inlet portion of the pipeline 62 and detects a flow rate of water supplied to the pipeline 62. The superheater flow sensor 66 is provided partway along the pipeline 62 and detects a flow rate of a fluid (for example, steam) flowing through the pipeline 62. For example, the superheater flow sensor 66 includes a first superheater flow sensor 66A that detects a flow rate (primary superheater temperature reducer flow rate) of a fluid passing through a primary temperature reducer, and a second superheater flow sensor 66B that detects a flow rate (secondary superheater temperature reducer flow rate) of a fluid passing through a secondary temperature reducer. In the following description, a phrase "detection result of the superheater flow sensor 66" includes, for example, a detection result of the first superheater flow sensor 66A and a detection result of the second superheater flow sensor 66B. The detection results of the water supply flow sensor 65 and the superheater flow sensor 66 are transmitted to the acquisition unit 110 of the information processing system 100.

[0045]

<4. Information Processing System>

Next, the information processing system 100 will be described.

FIG. 2 is a block diagram illustrating a functional configuration of the combustion facility SF according to the embodiment. The information processing system 100 comprehensively controls the combustion facility SF. For example, the information processing system 100 controls combustion of the garbage G in the treatment space V of the furnace body 20. In the present embodiment, the information processing system 100 includes, for example, the acquisition unit 110, a storage unit 120, an operation content derivation unit 130, a control unit 140, and a learning system 160. In addition, the information processing system 100 may include a notification unit 150. Alternatively, the information processing system 100 may include a notification unit 150 instead of the control unit 140. In the present disclosure, the device to be controlled by the information processing system 100 is the above-described extrusion apparatus 13 (feeder 12).

An operation of each unit in the information processing system 100 described below corresponds to a part of an information processing method and a learning method of the present disclosure.

[0046]

<4.1 Acquisition Unit>

The acquisition unit 110 acquires a detection result or the like detected by the various sensors described above included in the combustion facility SF. For example, the acquisition unit 110 acquires the detection result (the weight of the garbage) of the weight sensor 1b, the detection result (the height of the garbage) of the object measurement device 14, the detection result (the in-furnace temperature) of the radiation temperature sensor 63, the detection result (the superheater temperature

reducer flow rate) of the superheater flow sensor 66, and the detection result (the CO concentration or the like) of the gas concentration sensor 6a. The detection result (the superheater temperature reducer flow rate) of the superheater flow sensor 66 is an example of the "steam amount".

[0047]

In addition, a detection result (a garbage moisture detection result) of the moisture measurement device 15, an imaging result of the visible light camera 21 (a combustion flame image), an imaging result of the infrared camera 22 (a garbage layer image), a detection result of the wind box pressure sensor 41a (a wind box pressure), a detection result of the air flow sensor 56 (the pressurized air flow rate), a detection result of the in-furnace pressure sensor 64 (an in-furnace pressure), and a detection result of the water supply flow sensor 65 (a water supply flow rate) are in a state of being able to be acquired by the acquisition unit 110.

[0048]

The information that is acquired or can be acquired by the acquisition unit 110 is a value relating to a state quantity of the combustion facility SF. In the present disclosure, the information processing system 100 controls the extrusion apparatus 13 (feeder 12) by using the value relating to the state quantity of the combustion facility SF. The acquisition unit 110 writes the acquired state quantity in the storage unit 120 as a history of the state quantity (referred to as a state quantity history 122) and stores the state quantity in the storage unit 120.

[0049]

The acquisition unit 110 further acquires state quantity information by statistically processing the value relating to the state quantity of the combustion facility SF for a predetermined time length. The term "state quantity information" in

the present disclosure is a representative value obtained by statistically processing the value relating to the state quantity of the combustion facility SF for a predetermined time length. For example, the state quantity information is an average value of values relating to the state quantity of the combustion facility SF in the predetermined time length. The state quantity information is not limited to the average value, and may be a median value or a most frequent value.

[0050]

The predetermined time length is a time length including a time difference between a point of time when supply of the garbage G is performed by the extrusion apparatus 13 (feeder 12) and a point of time when a fluctuation in the state quantity (for example, the steam amount) of the combustion facility SF occurs in response to the supply. For example, the predetermined time length is a time length including a time difference between a point of time when the garbage G is supplied by the extrusion apparatus 13 (feeder 12) and a point of time when a fluctuation most significantly correlates with the state quantity (for example, the steam amount) of the combustion facility SF in response to the supply. From another viewpoint, the predetermined time length is longer than a time taken for the feeder 12 to make one round trip. The predetermined time length is, for example, 20 minutes.

[0051]

In addition, the acquisition unit 110 acquires an operation content (referred to as a derivation operation content 121) derived by the operation content derivation unit 130, a learning model M to be described later, and a control target value SV of the steam amount from the storage unit 120.

[0052]

<4.2 Storage Unit>

The derivation operation content 121, the learning model M, the control target value SV of the steam amount, and the state quantity history 122 are written and stored in the storage unit 120.

[0053]

<4.3 Operation Content Derivation Unit>

The operation content derivation unit 130 inputs the state quantity information acquired by the acquisition unit 110 to the learning model M by using the learning model M, and derives the operation content of the extrusion apparatus 13 (feeder 12) which corresponds to the input state quantity information. In the present disclosure, the learning model mounted on the operation content derivation unit 130 is referred to as the learning model M. In the learning model M, learning is performed based on a correspondence relationship between the state quantity information acquired by the acquisition unit 110, the operation content of the extrusion apparatus 13 (the operation content of the feeder 12) which corresponds to a case where the state quantity information is acquired, and a reward corresponding to a state (for example, the steam amount) of the combustion facility SF resulting from the operation content of the extrusion apparatus 13 (the operation content of the feeder 12). The state of the combustion facility SF resulting from the operation content of the above-described extrusion apparatus 13 (the operation content of the feeder 12) means a state (for example, the steam amount) of the combustion facility SF after a predetermined time (for example, 20 minutes) from an operation of the operation content of the above-described extrusion apparatus 13.

[0054]

Thereafter, the operation content derivation unit 130 outputs the derived derivation operation content to the control unit 140. In addition, the operation

content derivation unit 130 may output the derived derivation operation content to the notification unit 150. The operation content derivation unit 130 performs updating from the learning model M to the learning model M stored in the storage unit 120 at a predetermined timing.

[0055]

<4.4 Control unit and Notification Unit>

The control unit 140 performs combustion control of the treatment space V based on the derivation operation content output by the operation content derivation unit 130. Specifically, the control unit 140 outputs a control instruction value to the extrusion apparatus 13 (feeder 12) based on the derivation operation content output by the operation content derivation unit 130, and controls the feeder 12. The control unit 140 increases a supply amount of the garbage G in a case where combustion is promoted. On the other hand, the control unit 140 reduces the supply amount of the garbage G in a case where the combustion is suppressed.

[0056]

For example, in a case where the information processing system 100 includes the notification unit 150, the notification unit 150 notifies an operator (operator of the combustion facility SF) of the derivation operation content output by the operation content derivation unit 130. The notification unit 150 is, for example, a display device including a display screen for displaying the derivation operation content output by the operation content derivation unit 130. The operator may manually input the control instruction value to the extrusion apparatus 13 (feeder 12) based on the derivation operation content given in the notification and control the feeder 12.

[0057]

<4.5 Learning System>

The learning system 160 includes a learning unit 161. The learning unit 161 of the learning system 160 performs reinforcement learning of the learning model M stored in the storage unit 120 after acquiring the learning model M via the acquisition unit 110. For example, the learning unit 161 performs the reinforcement learning of the learning model M based on a correspondence relationship between the state quantity information, the operation content of the extrusion apparatus 13 (feeder 12), and the reward.

[0058]

<5. Outline of Processing of Learning Model>

Here, an outline of the learning model M in the present disclosure will be described with reference to FIGS. 3 to 5. The learning model M is present in the operation content derivation unit 130, and the state quantity information acquired by the acquisition unit 110 is input to the learning model M. The learning model M is a feed forward neural network as illustrated in FIG. 3. When the state quantity information after the statistical processing is input to the learning model M as an input layer, the learning model M outputs an expected value for each of a plurality of operation content candidates of the extrusion apparatus 13 (feeder 12) to an output layer. The input state quantity is a value relating to the state quantity of the combustion facility SF that is acquired or can be acquired by the acquisition unit 110. Examples of the input state quantity include a lower heating value (LHV), a concentration of a discharged substance (CO concentration), a supply amount of the garbage G, and a steam amount. Two or more of the state quantities are input to the learning model M. In the present embodiment, the input state quantity is a representative value (for example, an average value) of each of the lower heating value (LHV), the concentration of the discharged substance (CO concentration), the supply

amount of the garbage G, and the steam amount in a predetermined time length.

[0059]

The input state quantity information may be a representative value (or a representative image) of each of the detection result (the garbage moisture detection result) of the moisture measurement device 15, the imaging result (the combustion flame image) of the visible light camera 21, the imaging result (the garbage layer image) of the infrared camera 22, the detection result (the wind box pressure) of the wind box pressure sensor 41a, the detection result (the pressurized air flow rate) of the air flow sensor 56, the detection result (the in-furnace pressure) of the in-furnace pressure sensor 64, and the detection result (the water supply flow rate) of the water supply flow sensor 65 in the predetermined time instead of a part or all of the state quantities described above.

[0060]

Among the expected values (the expected values for each of the plurality of operation content candidates of the extrusion apparatus 13 (feeder 12)) output to the output layer of the learning model M, an operation content candidate corresponding to the largest expected value is output to the control unit 140 or the notification unit 150 by the operation content derivation unit 130 as the derivation operation content.

[0061]

The acquisition unit 110 may perform the following estimation separately from the statistical processing. The estimation performed by the acquisition unit 110 is treated as the state quantity. That is, in the present embodiment, a value relating to the state quantity in which the following estimation is performed is input to the learning model M.

[0062]

The acquisition unit 110 acquires the detection result (the garbage weight) of the weight sensor 1b and the detection result (the garbage height) of the object measurement device 14. The acquisition unit 110 estimates the supply amount of the garbage G as the state quantity from the garbage weight, the garbage height, and the operation content of the extrusion apparatus 13 (supply apparatus). However, the method for estimating the supply amount of the garbage G is not limited to the above.

[0063]

The acquisition unit 110 acquires the detection result (the garbage weight) of the weight sensor 1b, the detection result (the garbage height) of the object measurement device 14, and the detection result (the in-furnace temperature) of the radiation temperature sensor 63. The acquisition unit 110 obtains the in-furnace temperature corresponding to the supply amount (estimated amount) of the garbage G from the detection results and the operation content of the extrusion apparatus 13 (supply apparatus), and the LHV is estimated as the state quantity by calculating combustion data in reverse based on these.

[0064]

As illustrated in FIG. 4, the operation content of the extrusion apparatus 13 (supply apparatus) is defined by a combination of two or more of an operation amount of a first operation element of the feeder 12, an operation amount of a second operation element of the feeder 12 different from the first operation element, and a stop time of the feeder 12. For example, when the feeder 12 is a reciprocating feeder, the first operation element is a stroke (feeder stroke ST) of the feeder 12. The second operation element is a speed (feeder speed SD) of the feeder 12.

[0065]

In a two-dimensional map relating to the operation content of FIG. 4, the first

operation element is the feeder stroke ST, and the second operation element is the feeder speed SD. In FIG. 4, there are 40 patterns of combinations of the first operation element and the second operation element, which are five patterns of the feeder speed SD and eight patterns of the feeder stroke ST. The 40 patterns are a plurality of operation content candidates of the extrusion apparatus 13 (feeder 12) set in the output layer of the learning model M. That is, 40 patterns of operation content candidates are discretely set in the output layer of the learning model M. Among expected values output to the output layer of the learning model M, an operation content corresponding to the largest expected value is a combination of the feeder stroke ST : α and the feeder speed SD : β among the 40 patterns in FIG. 4. The operation content is not limited to the two-dimensional map, and may be a three-dimensional map in which a stop time is added to a combination of the first operation element and the second operation element.

[0066]

After the feeder 12 is controlled based on the output derivation operation content, the learning unit 161 of the learning system 160 performs reinforcement learning of the learning model M. When a fluctuation in the state quantity of the combustion facility SF occurs in response to the supply of the garbage G by the feeder 12 after a predetermined time, the learning unit 161 receives the state quantity information (also referred to as a detection value) after the derived operation content is executed and a control target value from the acquisition unit 110. The control target value is a target value corresponding to a detection value of at least one index included in the state quantity information. The reward is derived based on a magnitude of a difference between the detection value and the control target value. For example, the learning unit 161 uses a detection value PV of the steam amount, which is one of

indices included in the state quantity information (detection value) after the operation content is executed, and the control target value SV of the steam amount.

[0067]

As shown in FIG. 5, the learning unit 161 derives a reward based on the magnitude of the difference between the detection value PV of the steam amount and the control target value SV of the steam amount. The reward is classified in stages. For example, the reward may be set in advance for the learning model M. Alternatively, the reward may be stored in the storage unit 120, and may be input into the learning model M by the learning unit 161 after being acquired by the acquisition unit 110.

[0068]

In step ST24 to be described later, the learning unit 161 changes a weighting relating to the expected value based on the reward. The learning unit 161 changes the weighting relating to the expected value by updating the connection weight between each node from the input layer to the output layer. By repeating the reinforcement learning, the learning model M learns an operation content that increases the reward with respect to the state quantity. The learning unit 161 performs the reinforcement learning of the learning model M at a predetermined timing.

[0069]

<6. Processing Flow>

Next, an example of a processing flow in the information processing system 100 described above will be described. However, the order of processing described below is not limited to the following example and may be changed as appropriate.

[0070]

<6.1 Information Processing Method>

First, an information processing method relating to the combustion facility SF will be described.

The information processing method in the present embodiment is executed according to a flowchart illustrated in FIG. 6. First, the acquisition unit 110 of the information processing system 100 acquires the state quantity from each detection result (step ST11). Next, the acquisition unit 110 of the information processing system 100 writes the acquired state quantity as the state quantity history 122 of the storage unit 120 (step ST12). Next, the acquisition unit 110 of the information processing system 100 performs statistical processing on the state quantity acquired in step ST11 (step ST13). In this manner, the acquisition unit 110 acquires the state quantity information, which is information on the state quantity of the combustion facility SF. Next, the operation content derivation unit 130 of the information processing system 100 receives the state quantity information in which the state quantity is statistically processed from the acquisition unit 110, and inputs the state quantity information into the learning model M (step ST14). Next, the operation content derivation unit 130 of the information processing system 100 derives the operation content of the extrusion apparatus 13 (feeder 12) corresponding to the input state quantity information (step ST15), and outputs the derived operation content to the control unit 140 or the notification unit 150 (step ST16).

[0071]

<6.2 Learning Method>

Next, a learning method for the combustion facility SF will be described.

The learning method in the present embodiment is executed according to the flowchart illustrated in FIG. 7. The learning method described below is also executed in parallel in an operation stage of the incineration facility SF.

[0072]

First, the acquisition unit 110 of the information processing system 100 acquires the state quantity information (detection value) after executing the operation content based on the state quantity history 122 of the storage unit 120, and acquires the operation content of the extrusion apparatus 13 (feeder 12) from the derivation operation content 121 of the storage unit 120 (step ST21). In this case, the acquisition unit 110 performs statistical processing on the state quantity after executing the operation content in advance (step ST21a). Next, the acquisition unit 110 of the information processing system 100 acquires the control target value SV from the storage unit 120 (step ST22).

[0073]

Next, the learning unit 161 of the learning system 160 of the information processing system 100 receives the state quantity information (detection value PV) after executing the operation content and the control target value SV from the acquisition unit 110, and derives a reward from the detection value PV and the control target value SV (step ST23). Next, the learning unit 161 of the learning system 160 changes the weighting relating to the expected value based on the operation content of the extrusion apparatus 13 (feeder 12) from the derivation operation content 121 of the storage unit 120 and a reward corresponding to the operation content (step ST24).

[0074]

In this manner, the learning unit 161 performs reinforcement learning of the learning model based on a correspondence relationship between the state quantity information that is information on the state quantity of the combustion facility SF, the operation content of the supply apparatus that supplies an object to be incinerated to the combustion facility SF, and the reward corresponding to the state of the

combustion facility SF. Next, the learning unit 161 of the learning system 160 writes the learning model M, which is updated by changing the weighting, in the storage unit 120 (step ST25).

[0075]

<7. Operational Effects>

According to the information processing system 100 and the information processing method having the above-described configuration, it is possible to use the learning model M that learns the operation content for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the information processing system 100 and the information processing method of the present embodiment can derive an appropriate operation content relating to the combustion facility SF. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0076]

In addition, according to the learning system 160 and the learning method having the above-described configuration, the learning model M can learn an operation content for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the learning system 160 and the learning method of the present embodiment can derive an appropriate operation content relating to the combustion facility SF. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0077]

In addition, the steam amount may vary greatly depending on a supply state of the garbage G or properties of the garbage G. Since combustion properties (LHV or the like) and powder engineering properties (adhesion amount or the like) in the

properties of the garbage G are greatly affected by the season and the climate, sensitivity of a control target parameter such as the steam amount may also vary from moment to moment. For example, in a case where the supply apparatus is controlled based on prediction of the steam amount, it is necessary to construct a control logic corresponding to a prediction value of the steam amount. When a rule-based logic is used, the number of branching processes corresponding to the prediction value of the steam amount becomes enormous, and it is difficult to take all seasonal fluctuations into account.

[0078]

According to the information processing system 100 and the information processing method having the above-described configuration, the learning model M that learns the operation pattern for which the reward with respect to the state quantity of the combustion facility SF is high can be used. Accordingly, in the information processing system 100 and the information processing method of the present embodiment, a logic for deriving an appropriate operation content relating to the combustion facility SF can be automatically constructed in consideration of seasonal fluctuations. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0079]

In addition, according to the learning system 160 and the learning method having the above-described configuration, the learning model M can learn the operation pattern for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the learning system 160 and the learning method of the present embodiment can automatically construct a logic for deriving an appropriate operation content relating to the combustion facility SF in

consideration of seasonal fluctuations. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0080]

(Second Embodiment)

<8. Information Processing System>

Hereinafter, an embodiment of an information processing system 100B according to the present disclosure will be described as a second embodiment with reference to FIG. 8. Components common to the first embodiment will be assigned with the same reference signs, and detailed description thereof will be omitted.

[0081]

In the present embodiment, the information processing system 100B includes, for example, an acquisition unit 110, a storage unit 120B, an operation content derivation unit 130, a control unit 140, and a learning system 160B. In addition, the information processing system 100B may include a notification unit 150. Alternatively, the information processing system 100B may include the notification unit 150 instead of the control unit 140. In the present disclosure, the device to be controlled by the information processing system 100B is the above-described extrusion apparatus 13 (supply apparatus).

[0082]

In addition, the learning model M in the present embodiment is generated based on an initial model generated by the pre-learning based on the correspondence relationship between the state quantity information and the operation content of the extrusion apparatus 13 (feeder 12) obtained from a past operation history of an operator. Based on the initial model, the pre-learning is performed based on the correspondence relationship between the state quantity information acquired by the

acquisition unit 110, the operation content of the extrusion apparatus 13 (feeder 12), and a reward corresponding to the operation history of the operator. Subsequently, reinforcement learning based on the correspondence relationship between the state quantity information acquired by the acquisition unit 110 described in the first embodiment, the operation content of the supply apparatus, and the reward corresponding to the state of the combustion facility SF is performed. An operation of each unit added in the information processing system 100B described below corresponds to a part of the information processing method and the learning method of the present disclosure.

[0083]

In the information processing system 100B, the storage unit 120B newly stores an operation history (referred to as an operator operation history 123) of the extrusion apparatus 13 (feeder 12) by the operator.

[0084]

In the information processing system 100B, a learning unit 161B generates the initial model of the learning model M by performing reinforcement learning as the pre-learning in addition to the reinforcement learning described in the first embodiment. In the present embodiment, the information processing system 100B includes a generation unit 162 in which some functions are added to the learning system 160B. The generation unit 162 generates the initial model of the learning model M by the pre-learning based on the correspondence relationship between the state quantity information and the operation content of the extrusion apparatus 13 (feeder 12) obtained from the operation history of the operator.

[0085]

The learning method in the present embodiment is performed according to the

flowchart illustrated in FIG. 9. The learning method described below is also executed in parallel even in the operation stage of the incineration facility SF.

[0086]

First, the generation unit 162 of the information processing system 100B sets an initial model before learning (step ST20B). The operation content derivation unit 130 of the information processing system 100B receives the state quantity information in which the state quantity is statistically processed by the acquisition unit 110, and inputs the state quantity information to the learning model M by using the initial model as the learning model M. Subsequently, the operation content derivation unit 130 derives the operation content of the extrusion apparatus 13 (feeder 12) corresponding to the input state quantity information (step ST21B).

[0087]

Next, the acquisition unit 110 of the information processing system 100B acquires the operation history (operator operation history 123) of the operator from the storage unit 120B (step ST22B). Next, the learning unit 161B of the learning system 160B in the information processing system 100B pre-learns the learning model M based on a correspondence relationship between past state quantity information, the operation content of the extrusion apparatus 13 (feeder 12) derived by using the learning model M corresponding to a case where the state quantity information is acquired, and the reward based on the operation of the operator actually performed in a case where the state quantity information is acquired. Specifically, in the above-described pre-learning, the reward is derived by the learning unit 161B based on the degree of matching between the operation content of the extrusion apparatus 13 (feeder 12) derived by using the learning model M and the operator operation history 123 (step ST23B).

[0088]

Note that as the pre-learning of the learning model M, instead of or in addition to the degree of matching between the operation content of the extrusion apparatus 13 derived by using the learning model M and the operator operation history 123, the reinforcement learning based on a correspondence relationship between the state quantity information acquired in the past, the operation content of the operator included in the operator operation history 123 corresponding to a case where the state quantity information is acquired, and the reward corresponding to a state (for example, steam amount) of the combustion facility SF resulting from the operation content of the operator may be performed. For example, in the present embodiment, the reward in the pre-learning is derived by reflecting the operation content of the operator included in the operator operation history 123, and a magnitude of a difference between a detection value and a control target value of at least one index included in the state quantity of the combustion facility SF in correspondence with the operation content of the operator.

[0089]

Next, the learning unit 161B of the learning system 160B changes a weighting relating to an expected value based on the reward (step ST24). Accordingly, the learning unit 161B performs the reinforcement learning as the pre-learning based on the initial model, based on the correspondence relationship between the state quantity information acquired by the acquisition unit 110, the operation content of the extrusion apparatus 13 (feeder 12), and the reward corresponding to the operation history of the operator. Next, the learning unit 161B of the learning system 160B writes the learning model, which is updated by changing the weighting, in the storage unit 120B (step ST25).

[0090]

The learning unit 161B of the learning system 160B performs reinforcement learning similar to that in the first embodiment after performing reinforcement learning as the pre-learning of the initial model based on the operation content of the extrusion apparatus 13 (feeder 12) derived by using the learning model M and the reward derived from the operator operation history 123. That is, the reinforcement learning of the learning model M is performed based on the correspondence relationship between the state quantity information acquired by the acquisition unit 110, the operation content of the extrusion apparatus 13 (the operation content of the feeder 12) corresponding to a case where the state quantity information is acquired, and the reward corresponding to the state of the combustion facility SF (for example, the steam amount) resulting from the operation content of the extrusion apparatus 13 (the operation content of the feeder 12). As described above, the learning model M is obtained based on the initial model. Alternatively, the learning unit 161B may perform the reinforcement learning on the initial model by appropriately selecting the reinforcement learning as the pre-learning and the reinforcement learning of the first embodiment to obtain the learning model.

[0091]

<9. Operational Effects>

According to the information processing system 100B and the information processing method having the above-described configuration, the learning model M that learns the operation pattern for which the reward with respect to the state quantity of the combustion facility SF is high can be used. Accordingly, the information processing system 100B and the information processing method of the present embodiment can derive an appropriate operation content relating to the combustion

facility SF. As a result, it is easy to maintain the combustion facility SF in a target state.

[0092]

In addition, according to the learning system 160B and the learning method having the above-described configuration, the learning model can learn the operation pattern for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the learning system 160B and the learning method of the present embodiment can derive an appropriate operation content relating to the combustion facility SF. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0093]

Further, according to the information processing system 100B and the information processing method having the above-described configuration, since training is performed based on the degree of matching with the operator operation history 123, it is possible to automatically construct a logic that takes an operation pattern similar to that of the operator who performs the control of the supply apparatus based on the state quantity information. Accordingly, since the operation pattern in consideration of cooperation with other existing information processing systems is constructed, it is possible to stably control the extrusion apparatus 13 (feeder 12) when the information processing system 100B in the present disclosure is introduced. Therefore, in the information processing system 100B and the information processing method of the present embodiment, it is possible to derive an appropriate operation content relating to the combustion facility SF while reflecting the operation pattern of the operator.

[0094]

In addition, according to the learning system 160B and the learning method having the above-described configuration, since training is performed based on the degree of matching with the operator operation history, it is possible to automatically construct a logic that takes an operation pattern similar to that of the operator who performs the control of the extrusion apparatus 13 (feeder 12) based on the state quantity information. Accordingly, since the operation pattern in consideration of cooperation with other existing information processing systems is constructed, it is possible to stably control the supply apparatus when the information processing system 100B in the present disclosure is introduced. Therefore, in the learning system 160B and the learning method of the present embodiment, it is possible to derive an appropriate operation content relating to the combustion facility SF while reflecting the operation pattern of the operator. As a result, the amount of fluctuation in the steam amount in the combustion facility SF can be suppressed.

[0095]

<10. Other Embodiments>

Hereinbefore, the embodiments of the present disclosure are described in detail with reference to the drawings, but specific configurations are not limited to the embodiments, and design changes and the like within a scope not departing from the gist of the present disclosure are also included. The initial model in the present disclosure may be an initial model generated by pre-learning based on a correspondence relationship between state quantity information in a facility different from the combustion facility SF and an operation content of a supply apparatus in the facility different from the combustion facility SF. For example, the learning unit 161B of the learning system 160B trains the learning model M based on a correspondence relationship between past state quantity information, the operation

content of the extrusion apparatus 13 (feeder 12) derived by using the learning model M corresponding to a case where the state quantity information is acquired, and the operation content of the extrusion apparatus 13 (feeder 12) executed in another facility in a case where the state quantity information is acquired. In this case, the learning unit 161B derives a reward based on the degree of matching between the operation content of the extrusion apparatus 13 (feeder 12) derived by using the learning model M and the operation content of the extrusion apparatus 13 (feeder 12) executed in another facility.

[0096]

In addition, the operation content of the extrusion apparatus 13 (feeder 12) may be learned in a state in which correction based on a ratio of sizes of the combustion facility SF and another facility is performed to consider a difference in size between the combustion facility SF provided with the information processing system 100 and another facility.

[0097]

In this case, after the reinforcement learning as the pre-learning is performed on the initial model of a modification example, processing may proceed to the reinforcement learning of the first embodiment based on the reward derived from the detection value and the control target value. Alternatively, reinforcement learning may be performed on an initial model of the modification example by appropriately selecting reinforcement learning as the pre-learning and the reinforcement learning of the first embodiment to obtain a learning model.

[0098]

According to such a configuration, in the present modification example, it is possible to derive an appropriate operation content relating to the combustion facility

SF, while reflecting the operation pattern on another facility.

[0099]

FIG. 10 is a hardware configuration diagram illustrating a configuration of a computer 1100 according to the present embodiment. For example, the computer 1100 includes a processor 1110, a main memory 1120, a storage 1130, and an interface 1140.

[0100]

Each functional unit of the information processing system 100 or the information processing system 100B described above is mounted on the computer 1100. An operation of each functional unit described above is stored in the storage 1130 in a form of a program. The processor 1110 reads the program from the storage 1130, develops the read program in the main memory 1120, and executes the above-described processing in accordance with the program. In addition, the processor 1110 secures a storage area that is used by each of the above-described functional units in the main memory 1120 in accordance with the program.

[0101]

The program may be configured to realize some of functions exhibited by the computer 1100. For example, the program may exhibit a function in combination with another program previously stored in the storage 1130, or in combination with another program installed in another device. In addition, the computer 1100 may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to or instead of the above configuration. Examples of the PLD include a programmable array logic (PAL), a generic array logic (GAL), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). In this case, functions that are realized by the processor 1110 may be

partially or entirely realized by the integrated circuit.

[0102]

As an example of the storage 1130, a magnetic disk, a magneto-optical disc, or a semiconductor memory can be used. The storage 1130 may be an internal medium directly connected to a bus of the computer 1100 or may be an external medium connected to the computer 1100 through the interface 1140 or a communication line. In addition, when the program is distributed to the computer 1100 via the communication line, the computer 1100 receiving the distributed program may develop the program in the main memory 1120 to execute the above-described processing. In addition, the program may be used to partially realize the above-described functions. In addition, the program may be a so-called difference file (difference program) that realizes the above-described functions in combination with another program previously stored in the storage 1130.

[0103]

<Additional Notes>

The information processing system 100 or the information processing system 100B described in each embodiment is understood as follows, for example.

[0104]

(1) An information processing system 100 according to a first aspect is an information processing system for an incineration facility SF, the system including: an acquisition unit 110 configured to acquire state quantity information that is information relating to a state quantity of the combustion facility SF; and an operation content derivation unit 130 configured to input the state quantity information acquired by the acquisition unit 110 and derive an operation content, which corresponds to the input state quantity information, of a supply apparatus (feeder 12) configured to supply

an object G to be incinerated to the combustion facility SF by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility SF.

[0105]

According to such a configuration, it is possible to use a learning model that learns an operation content for which a reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the information processing system 100 according to the first aspect can derive an appropriate operation content relating to the combustion facility SF. As a result, it is easy to maintain the combustion facility SF in a target state.

[0106]

(2) An information processing system 100 according to a second aspect is the information processing system 100 according to (1), in which the state quantity information is a representative value obtained by statistically processing a value relating to the state quantity of the combustion facility SF for a predetermined time length.

[0107]

According to such a configuration, by performing statistical processing on the state quantity for a predetermined time length, it is possible to reduce an influence of a detection value of a state quantity that instantaneously increases (or decreases) on the state quantity that can instantaneously fluctuate. Accordingly, the information processing system 100 according to the second aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0108]

(3) An information processing system 100 according to a third aspect is the information processing system 100 according to (2), in which the predetermined time length is a time length including a time difference between a point of time when the supply of the object G to be incinerated is performed by the supply apparatus (feeder 12) and a point of time when a fluctuation in the state quantity occurs in response to the supply.

[0109]

According to such a configuration, by performing the statistical processing of the state quantity for a predetermined time length, which is a relatively long time as described above, it is possible to reduce the influence of the detection value of the state quantity that instantaneously increases (or decreases) on the state quantity that can instantaneously fluctuate after the supply of the object G to be incinerated. Accordingly, the information processing system 100 according to the third aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0110]

(4) An information processing system 100 according to a fourth aspect is the information processing system 100 according to any one of (1) to (3), in which the operation content of the supply apparatus (feeder 12) is defined by a combination of two or more of an operation amount of a first operation element of the supply apparatus, an operation amount of a second operation element of the supply apparatus different from the first operation element, and a stop time of the supply apparatus.

[0111]

According to such a configuration, the operation content of the supply apparatus (feeder 12) can be defined in detail. Accordingly, the information processing system 100 according to the fourth aspect can derive a more appropriate

operation content relating to the combustion facility SF.

[0112]

(5) An information processing system 100 according to a fifth aspect is the information processing system 100 according to any one of (1) to (4), in which the supply apparatus (feeder 12) is a reciprocating or rotary feeder, and the operation content of the supply apparatus is defined by a combination of two or more of a stroke (feeder stroke ST) of the feeder 12, a speed (feeder speed SD) of the feeder 12, and a stop time of the feeder 12.

[0113]

According to such a configuration, the supply of the object G to be incinerated can be controlled by defining the operation content of the supply apparatus (feeder 12) in detail. Accordingly, the information processing system 100 according to the fifth aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0114]

(6) An information processing system 100 according to a sixth aspect is the information processing system 100 according to any one of (1) to (5), in which the reward is derived based on a magnitude of a difference between a detection value of at least one index included in the state quantity information and a target value of the index.

[0115]

According to such a configuration, it is possible to derive an operation content in which a reward is increased based on the magnitude of the difference between the state quantity (detection value) after executing the operation content and the control target value. Accordingly, the information processing system 100 according to the

sixth aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0116]

(7) An information processing system 100 according to a seventh aspect is the information processing system 100 according to any one of (1) to (6), in which the state quantity is two or more of a lower heating value, a concentration of a discharged substance, a supply amount of the object to be incinerated, or a steam amount.

[0117]

According to such a configuration, it is possible to input the state quantity that can be changed by supply of the object G to be incinerated to the combustion facility SF. Accordingly, the information processing system 100 according to the seventh aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0118]

(8) An information processing system 100 according to an eighth aspect is the information processing system 100 according to any one of (1) to (7), further including a learning unit configured to perform reinforcement learning of the learning model based on the correspondence relationship between the state quantity information acquired by the acquisition unit, the operation content of the supply apparatus, and the reward.

[0119]

According to such a configuration, it is possible to change a weighting of an expected value in each operation content based on the correspondence relationship between the operation content of the supply apparatus and the reward by using the reinforcement learning. Accordingly, the information processing system 100

according to the eighth aspect can derive a more appropriate operation content relating to the combustion facility SF.

[0120]

(9) An information processing system 100B according to a ninth aspect is the information processing system 100B according to any one of (1) to (8), in which the learning model is obtained by performing reinforcement learning based on the correspondence relationship between the state quantity information acquired by the acquisition unit 110, the operation content of the supply apparatus, and the reward corresponding to the state of the combustion facility SF based on an initial model generated by pre-learning based on at least a correspondence relationship between the state quantity information and the operation content of the supply apparatus obtained from an operation history of an operator.

[0121]

According to such a configuration, the information processing system 100B according to the ninth aspect can derive an appropriate operation content relating to the combustion facility SF while reflecting the operation pattern of the operator. In this manner, it is possible to ensure a certain degree of accuracy at a stage of the initial model.

[0122]

(10) The information processing system 100B according to a tenth aspect is the information processing system 100B according to any one of (1) to (9), in which the learning model is obtained by performing reinforcement learning based on the correspondence relationship between the state quantity information acquired by the acquisition unit 110, the operation content of the supply apparatus, and the reward corresponding to the state of the combustion facility SF, based on an initial model

generated by pre-learning based on at least a correspondence relationship between the state quantity information in another facility and the operation content of the supply apparatus provided in the other facility.

[0123]

According to such a configuration, the information processing system 100B according to the tenth aspect can derive an appropriate operation content relating to the combustion facility SF while reflecting the operation content in another facility. In this manner, it is possible to ensure a certain degree of accuracy at a stage of the initial model.

[0124]

(11) An information processing method according to an eleventh aspect is an information processing method relating to a combustion facility SF, the method including: acquiring state quantity information that is information relating to a state quantity of the combustion facility SF; and inputting the state quantity information and deriving an operation content, which corresponds to the input state quantity information, of a supply apparatus (feeder 12) configured to supply an object G to be incinerated to the combustion facility SF by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility SF.

[0125]

According to such a configuration, it is possible to use a learning model that learns an operation content for which a reward with respect to the state quantity of the combustion facility SF is high. Accordingly, in the information processing method according to the eleventh aspect, it is possible to derive an appropriate operation

content relating to the combustion facility SF. As a result, it is easy to maintain the combustion facility SF in a target state.

[0126]

(12) A learning system 160 according to a twelfth aspect is a learning system for a combustion facility SF, the learning system including: a learning unit configured to perform reinforcement learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility SF, an operation content of a supply apparatus (feeder 12) configured to supply an object G to be incinerated to the combustion facility SF, and a reward corresponding to a state of the combustion facility SF.

[0127]

According to such a configuration, the learning model can learn an operation content for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, the learning system 160 according to the twelfth aspect can derive an appropriate operation content relating to the combustion facility SF. As a result, it is easy to maintain the combustion facility SF in a target state.

[0128]

(13) A learning method according to a thirteenth aspect is a learning method for a combustion facility SF, the method including: performing reinforcement learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility SF, an operation content of a supply apparatus (feeder 12) configured to supply an object G to be incinerated to the combustion facility SF, and a reward corresponding to a state of the combustion facility SF.

[0129]

According to such a configuration, the learning model can learn an operation content for which the reward with respect to the state quantity of the combustion facility SF is high. Accordingly, in the learning method according to the thirteenth aspect, it is possible to derive an appropriate operation content relating to the combustion facility SF. As a result, it is easy to maintain the combustion facility SF in a target state.

[Industrial Applicability]

[0130]

According to the above-described aspects, it is possible to derive an appropriate operation content relating to the combustion facility.

[Reference Signs List]

[0131]

SF: incineration facility

G: object to be incinerated (garbage)

1: crane

1a: grip portion

1b: weight sensor

2: incinerator

3: heat recovery steam generator

4: temperature controlling tower

5: bag filter

6: exhaust gas duct

6a: gas concentration sensor

7: chimney

10: supply mechanism

11: hopper
12: feeder
13: extrusion apparatus
14: object measurement device
15: moisture measurement device
20: furnace body
21: visible light camera
22: infrared camera
30: stoker
31: grate
32: grate drive device
41: wind box
41a: wind box pressure sensor
42: discharge chute
43: furnace
50: blowing mechanism
51: blower
52: primary air line
53: air preheater
54: secondary air line
55: damper
56: air flow sensor
56A: first air flow sensor
56B: second air flow sensor
61: boiler body

62: pipeline

63: radiation temperature sensor (infrared temperature sensor)

63: radiation temperature sensor

64: in-furnace pressure sensor

65: water supply flow sensor

66: superheater flow sensor (steam amount sensor)

66: superheater flow sensor

66A: first superheater flow sensor

66B: second superheater flow sensor

100: information processing system

100B: information processing system

110: acquisition unit

120: storage unit

120B: storage unit

130: operation content derivation unit

140: control unit

150: notification unit

160: learning system

160B: learning system

161: learning unit

161B: learning unit

162: generation unit

1100: computer

1110: processor

1120: main memory

1130: storage

1140: interface

Claims

[Claim 1]

An information processing system for a combustion facility, the system comprising:

an acquisition unit configured to acquire state quantity information that is information relating to a state quantity of the combustion facility; and

an operation content derivation unit configured to input the state quantity information acquired by the acquisition unit and derive an operation content, which corresponds to the input state quantity information, of a supply apparatus configured to supply an object to be incinerated to the combustion facility by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility.

[Claim 2]

The information processing system according to Claim 1,

wherein the state quantity information is a representative value obtained by statistically processing a value relating to the state quantity of the combustion facility for a predetermined time length.

[Claim 3]

The information processing system according to Claim 2,

wherein the predetermined time length is a time length including a time difference between a point of time when the supply of the object to be incinerated is performed by the supply apparatus and a point of time when a fluctuation in the state quantity occurs in response to the supply.

[Claim 4]

The information processing system according to Claim 1 or 2,
wherein the operation content of the supply apparatus is defined by a combination of two or more of an operation amount of a first operation element of the supply apparatus, an operation amount of a second operation element of the supply apparatus different from the first operation element, and a stop time of the supply apparatus.

[Claim 5]

The information processing system according to Claim 1 or 2,
wherein the supply apparatus is a reciprocating or rotary feeder, and
the operation content of the supply apparatus is defined by a combination of two or more of a stroke of the feeder, a speed of the feeder, and a stop time of the feeder.

[Claim 6]

The information processing system according to Claim 1 or 2,
wherein the reward is derived based on a magnitude of a difference between a detection value of at least one index included in the state quantity information and a target value of the index.

[Claim 7]

The information processing system according to Claim 1 or 2,
wherein the state quantity is two or more of a lower heating value, a concentration of a discharged substance, a supply amount of the object to be incinerated, or a steam amount.

[Claim 8]

The information processing system according to Claim 1 or 2, further

comprising:

a learning unit configured to perform reinforcement learning of the learning model based on the correspondence relationship between the state quantity information acquired by the acquisition unit, the operation content of the supply apparatus, and the reward.

[Claim 9]

The information processing system according to Claim 1 or 2,

wherein the learning model is obtained by performing reinforcement learning based on the correspondence relationship between the state quantity information acquired by the acquisition unit, the operation content of the supply apparatus, and the reward, based on an initial model generated by pre-learning based on at least a correspondence relationship between the state quantity information and the operation content of the supply apparatus obtained from an operation history of an operator.

[Claim 10]

The information processing system according to Claim 1 or 2,

wherein the learning model is obtained by performing reinforcement learning based on the correspondence relationship between the state quantity information acquired by the acquisition unit, the operation content of the supply apparatus, and the reward, based on an initial model generated by pre-learning based on at least a correspondence relationship between the state quantity information in another facility and the operation content of the supply apparatus provided in the other facility.

[Claim 11]

An information processing method relating to a combustion facility, the method comprising:

acquiring state quantity information that is information relating to a state

quantity of the combustion facility; and

inputting the state quantity information and deriving an operation content, which corresponds to the input state quantity information, of a supply apparatus configured to supply an object to be incinerated to the combustion facility by using a learning model trained based on a correspondence relationship between the state quantity information, the operation content of the supply apparatus, and a reward corresponding to a state of the combustion facility.

[Claim 12]

A learning system for a combustion facility, the learning system comprising:

a learning unit configured to perform reinforcement learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility, an operation content of a supply apparatus configured to supply an object to be incinerated to the combustion facility, and a reward corresponding to a state of the combustion facility.

[Claim 13]

A learning method for a combustion facility, the learning method comprising:

performing reinforcement learning of a learning model based on a correspondence relationship between state quantity information that is information relating to a state quantity of the combustion facility, an operation content of a supply apparatus configured to supply an object to be incinerated to the combustion facility, and a reward corresponding to a state of the combustion facility.