

“ AI and Other Technology ”

Vol. 2 Controls and Regulations

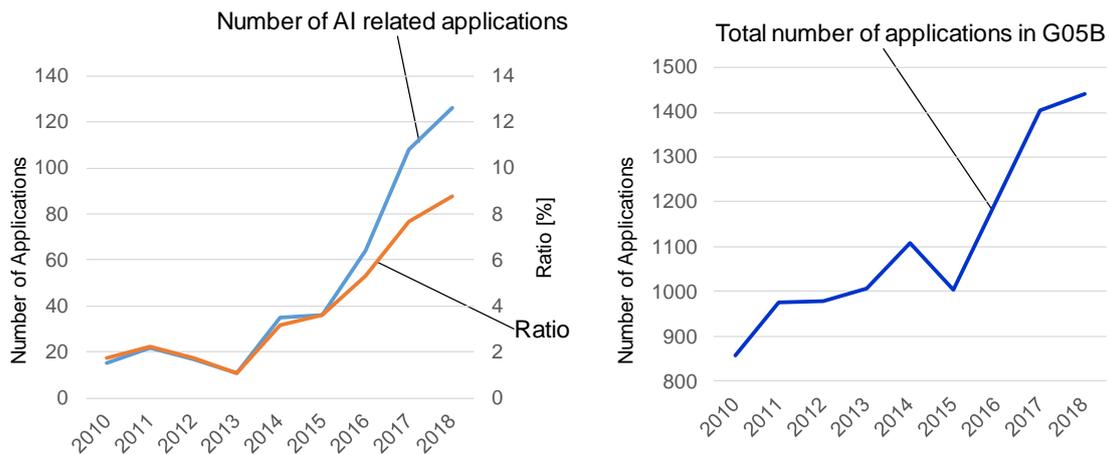
AI technology is used to operate manufacturing machines or plants appropriately in accordance with various events that occur in the manufacturing machines or the plants. For example, AI technology is used to determine conditions of manufacturing machines or plants based on inputs from sensors in the manufacturing machines or plants, to control the motion of the manufacturing machines or plants or perceived abnormal conditions.

This article focuses on AI-related patents in the field of control and regulation and shows some analyses and examples by reference to the following report by the JPO.

https://www.jpo.go.jp/system/patent/gaiyo/sesaku/ai/ai_shutsugan_chosa.html

(“Research on applications of AI-related inventions” – available only in Japanese)

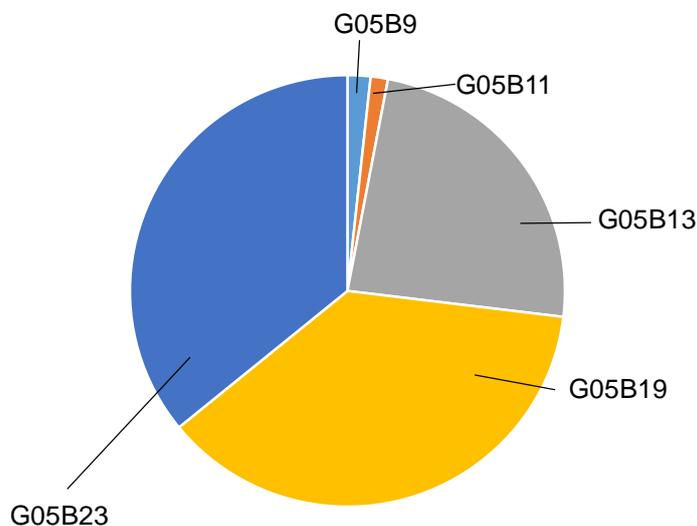
1) The number of patent applications of AI-related invention in the field of “Control or Regulating systems”
 The number of patent applications of AI-related inventions in the field of “Control or Regulating Systems” and the ratio of AI-related inventions in patent applications in the field of “Control or Regulating Systems” are as shown below.



As shown in the above graph, both the number and ratio of AI-related inventions in “Control or Regulating systems” field have been increasing since 2013.

2) Breakdown of Inventions by IPCs

The breakdown of inventions which were filed between 2016 and 2018, by their main IPCs, is shown as below.



Graph 4: Breakdown of inventions filed between 2016 and 2018

G05B 13: Adaptive Control Systems

G05B 19: Programme-control Systems

G05B 23: Testing or Monitoring of Control Systems

As can be seen from the above graph, the number of patent applications related to "Adaptive Control Systems (G05B 13)", "Programme-control Systems (G05B 19)", and "Testing or Monitoring of Control Systems (G05B 23)". It is thought that this is because AI technology is suitable for selecting appropriate parameters or for determining status of monitoring targets.

Characteristics of Claims

In claims of AI-related patents in the control and regulation field, the following two related inventions are mainly included:

1. Program regulations

To associate the operating state of the controlled target (manufacturing machines, machine tools, and etc.) with the order corresponding to the operating state and learn their relationship, and to regulate the order for the controlled target based on the detection results of the operating state by detecting means.

2. Tests and monitors

To associate the operating state of the monitoring target (manufacturing machines, plants, and etc.) with the situation (abnormality such as failures) corresponding to the operating state and learn their relationship, and to regulate the order for the monitoring target based on the detection results of the operating state by detecting means.

Claim Examples

1. Adaptive Control Systems (G05B 13/XX)

Example: Patent No.: 6650786

[Claim 1]

A control parameter automatic-adjustment apparatus that adjusts a control parameter which is used when a control apparatus of a plant calculates an operational control signal, the apparatus comprising:

- a simulator that simulates operation of the plant;*
- a learning unit that searches for an optimal control parameter using the simulator; and*
- a knowledge database that stores knowledge information which associates an amount of change in the control parameter with an amount of change in a state of the plant,*

wherein the learning unit includes a search range determination unit that determines a control parameter search range based on the knowledge information that is stored in the knowledge database,

wherein the search range determination unit:

- calculates similarity between combination of the setting values for the control parameters and the combination of the setting values for the control parameters that are stored in the knowledge database before operating the simulator,*
- determines whether one or more similar control parameters corresponding to the control parameters that have the similarity which is equal to or greater than a prescribed value that is set in advance are present among the control parameters that are stored in the knowledge database,*
- if one or more similar control parameters are present, calculates prescribed value of simulation measurement signal in the case operating the simulator with the control parameters, by using the simulation measurement signal corresponding to the similar control parameters that are stored in the knowledge database, and*
- if the prescribed value does not achieve a purpose, excludes the control parameters from the control parameter search range, and if the prescribed value achieves the purpose, includes the control parameters into the control parameter search range, so as to reduce the search range.*

[Brief Summary]

In the claim above, when adjusting a control parameter of a plant, the learning unit uses a simulator to search for an optimal parameter. The learning unit limits the parameter range of the parameters to be simulated based on similarities between the parameter to be simulated and the parameters stored in the database and removes the undesirable parameters from the search range based on the simulation results. Thereby, the search time can be shortened.

2. Programme-control Systems (G05B 19/XX)

Example: Patent No.: 6645934

[Claim 1]

A cell control system comprising:

- at least one manufacturing cell including at least one manufacturing machine; and*
- a cell controller for transmitting an operation instruction to the manufacturing machine based on a manufacturing plan received from a production planning device,*

wherein the cell controller includes:

- a machine operation instruction unit for transmitting the operation instruction to the manufacturing machine based on the manufacturing plan;*
- a noise value collection unit for collecting detected noise information;*

an operation information collection unit for collecting operation information of the manufacturing machine;

a learning unit for creating a learning model by performing machine learning using the operation information collected by the operation information collection unit as an input signal and the noise information collected by the noise value collection unit as an instruction signal;

an estimation unit for analyzing the learning model created by the learning unit to estimate operation information corresponding to a cause of noise detected by the manufacturing machine; and

an operation instruction change unit for instructing the machine operation instruction unit to change instruction content based on the operation information corresponding to a noise factor estimated by the estimation unit,

wherein the estimation unit performs a prediction using the learning model created by the learning unit to estimate a manufacturing machine having a low noise immunity in the manufacturing machine, and

the operation instruction change unit instructs the machine operation instruction unit to change communication content based on information about a noise immunity estimated by the estimation unit.

[Brief Summary]

In the claim above, the learning unit learns by associating the noise generated in the manufacturing cell comprising at least one manufacturing machine and its operation information, the estimation unit estimates the operation information of the manufacturing machine from the detected noise, and the operation instruction change unit makes an alarm to indicate if any of the manufacturing machines is not working appropriately. Thus, even the manufacturing cell comprises a plurality of manufacturing machines, and a manufacturing machine to be conducted with noise countermeasure can be found effectively.

3. Testing or Monitoring of Control Systems (G05B 23/XX)

Example: Patent Publication No.: 6643211

[Claim 1]

An abnormality detection system for detecting an abnormality of a monitoring target system, the abnormality detection system comprising:

a memory; and

a processor;

the processor being configured to perform

a symbolizing means which converts, based on a prescribed rule, a time-sequential event included in a log output by the monitoring target system into a symbolized event,

a learning means which learns, based on a normal-time log symbolized by the symbolizing means, a symbolized event sequence, which appears in a same pattern, as a frequently-appearing pattern; and

an abnormality detecting means which detects an occurrence or a nonoccurrence of an abnormality, based on whether not the frequently-appearing pattern is occurring in a monitoring-time log symbolized by symbolizing means, and

the abnormality detecting means being configured to

extract, based on a size of a symbolized event sequence constituting the frequently-appearing pattern, a symbolized event sequence to be a target of detection of whether or not the frequently-appearing pattern has occurred from the symbolized monitoring-time log, and

determine that an abnormality exists in the case which a partial pattern, which is a part of the frequently-appearing pattern, occurs in the extracted symbolized event sequence of the detection target

and, at the same time, in the case which a rest pattern, which is a pattern that appears after the partial pattern of the frequently-appearing pattern, does not appear regardless of a probability of occurrence of the frequently-appearing pattern including the partial pattern when the partial pattern occurs is equal to or larger than a prescribed threshold.

[Brief Summary]

In the claim above, the abnormality detection system learns patterns, which appear frequently in a normal time log and have a partial pattern A and a rest pattern A, and extracts patterns which appear frequently in a monitoring time log and have partial pattern A and rest pattern B. If the rest pattern B is not equal to the rest pattern A, the system determines that there is an abnormality.

Conclusion

As the claim examples above show, technologies combined with AI have been drawing more attention in the control and regulation field. AI technologies makes controlling targets (plants, for example) and detecting operation conditions of targets easy and effective. As mentioned in the above claim examples, it is important to set which information should be learned by association with other types of information that are used for controlling targets or detecting states of the targets.

AUTHOR



[Shimpei Kuroda](#)

Patent Attorney
Senior Manager

Mr. Kuroda specializes in industrial machinery. He conducted research on semiconductor devices for optical communication, such as semiconductor lasers. Mr. Kuroda regularly visits overseas clients mainly in Europe and the U.S. to provide them with updated information on IP matters in Japan. He has experience in the research and development of optical transmitters and receivers for long-distance optical communication and signal waveforms with a low error rate.