OMRON

Artificial Intelligence
Machine Automation Controller

NX701-Z□00 / NY5□2-Z□00

Ultimate innovation
goes beyond impossible

SYSMAC
always in control

Manufacturing learns and evolves
at intelligent manufacturing sites

# AI and IoT help people and machines grow together at future factories

While manufacturing are rapidly becoming more advanced, the world faces a shrinking labor force and shortage of skilled engineers. Omron will realize a factory of the future where people and machines grow together by leveraging AI and IoT technologies at the machine level and converting tacit knowledge, such as intuition and experience of experts, into explicit knowledge.

Omron is aiming for a future factory realized by our system using AI controller

Non-stop equipment	Equipment maximizing performance	Zero defect equipment
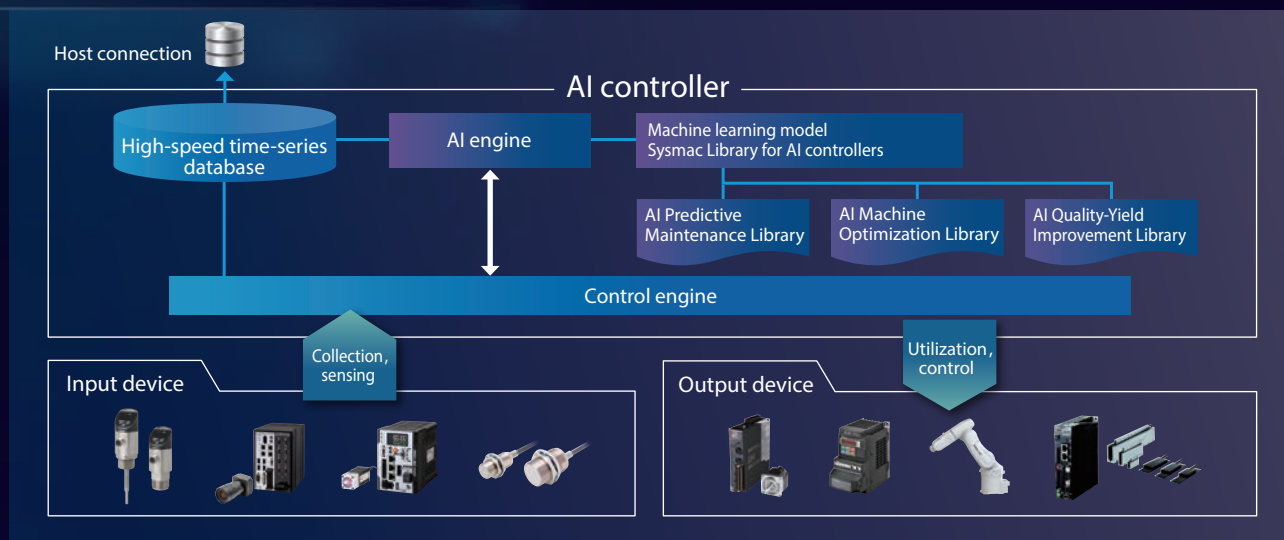
Ultimate AI edge controller born from the fusion of AI and control

The artificial intelligence machine automation controller (AI controller) integrates unique AI functionality into control, allowing you to leverage information at the machine level in real time. The AI controller can very quickly and accurately detect momentary irregularity of equipment and feed back to control in real time. As well as enabling trend monitoring at the machine level, this also prevents quality defects that occur on high-speed production lines within a very short time.

AI processing and feedback to control in real time after data monitoring
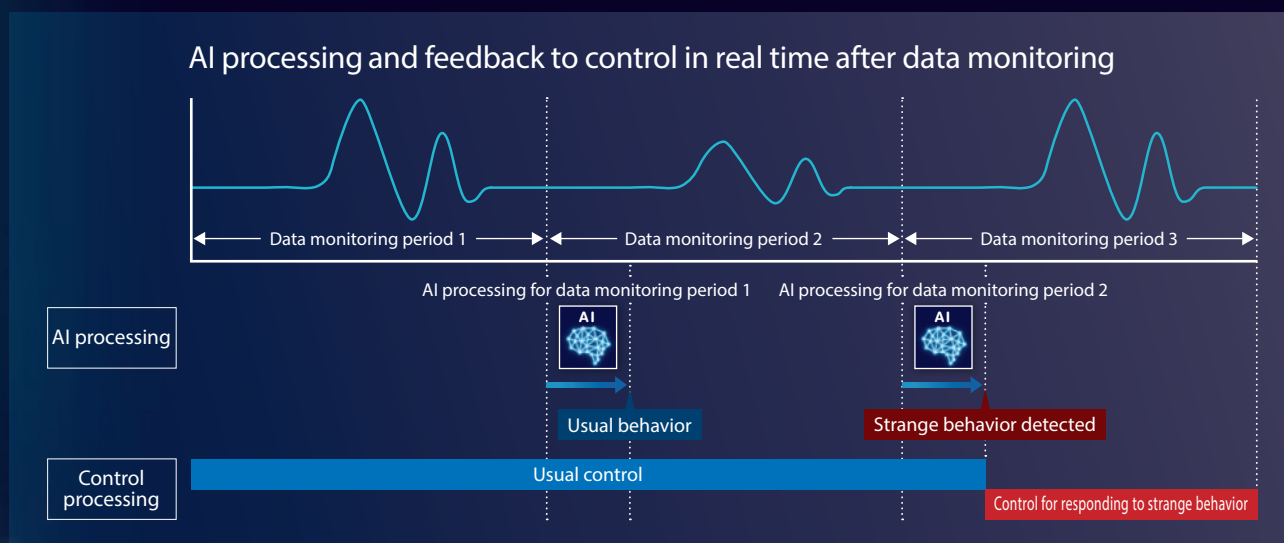
In addition, significant patterns which data scientists usually discover by mining data are provided as software functional components : Sysmac Library for AI controllers. The AI Predictive Maintenance Library to realize non-stop equipment is now available, and other libraries to realize equipment maximizing performance and zero defect equipment will also be available soon.

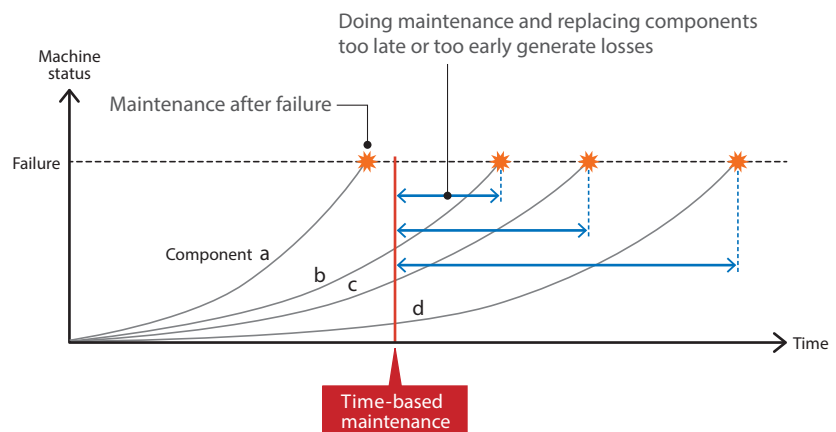# Predictive maintenance powered by AI realizes non-

Innovative status-based maintenance

Strange behavior is monitored using machine data in real time,
which allows you to carry out maintenance based on machine status when it is really necessary.

From :
Reactive or regular maintenance

Reactive or regular maintenance by experts
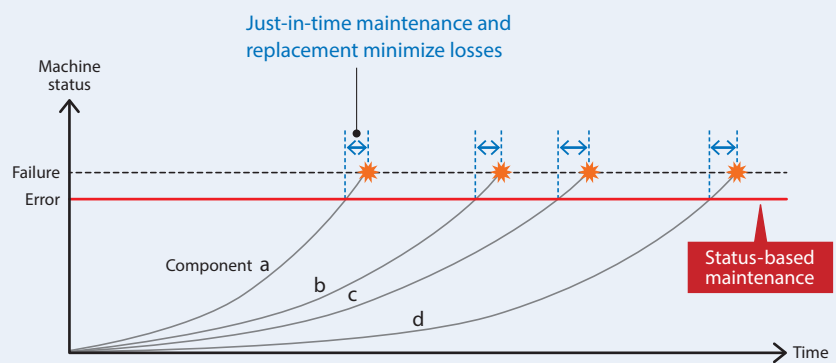
Skilled engineers perform maintenance based on their intuition and experience regularly or after failure has occurred (time-based maintenance).

Machine status

Doing maintenance and replacing components too late or too early generate losses

Maintenance after failure

Failure

Component a
b
c
d

Time

Time-based maintenance

To :
Predictive maintenance

Predictive maintenance using AI controller

AI monitors machine status using machine data. Predictive maintenance is performed based on machine status when it is necessary (status-based maintenance).

Machine status

Just-in-time maintenance and replacement minimize losses

Failure
Error

Component a
b
c
d

Time

Status-based maintenance

Benefits expected from predictive maintenance

1. Minimized downtime reduces production losses
2. Just-in-time maintenance reduces costs
3. Replacing components when necessary reduces stock of components
4. Error locations can be identified without analysis
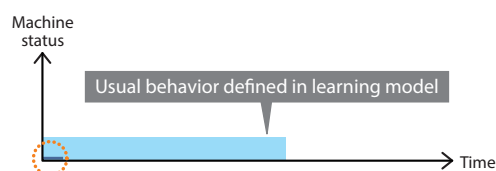5. Maintenance work can be standardized without special knowledge and skills

stop equipment

Predictive maintenance procedure using AI

Step 1
Generating a learning model

A learning model including a threshold value is generated from current machine data. (Usual behavior is learned.)

Machine status

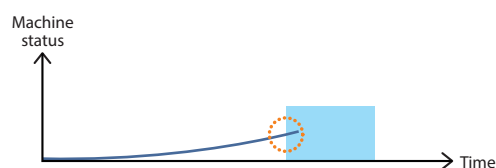Usual behavior defined in learning model

Time

Step 2
Monitoring the machine

The machine is monitored based on the learning model. If the machine status exceeds the threshold value, a notification is issued.
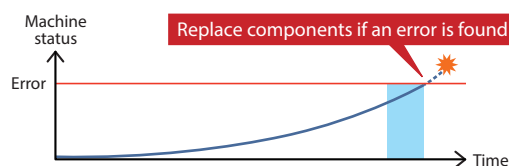
Machine status

Time
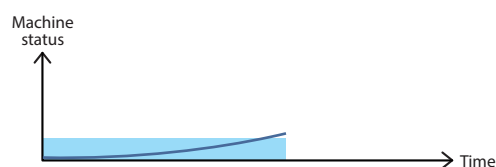
Step 3
Setting a new threshold value

The machine status is checked. If no error is found, a new threshold value is set.

Machine status

Time

Step 4
Replacing components

An error occurs while threshold value setting and monitoring are repeated. Components are replaced.

Machine status

Replace components if an error is found

Error

Time

Step 5
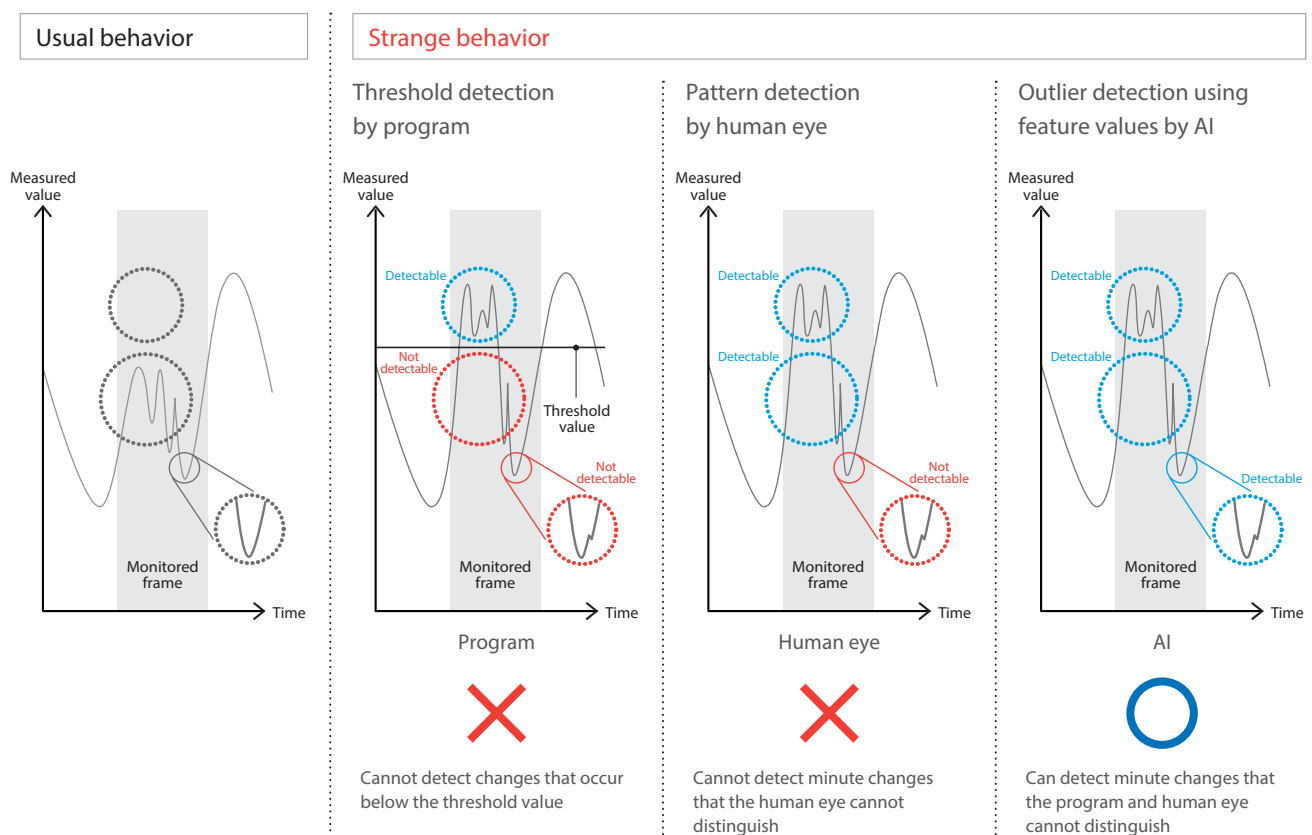### Generating a learning model with new components

A new learning model including the threshold value is generated based on the previous error level after components are replaced. Repeating these steps makes status-based maintenance more reliable.

Machine status

Usual behavior defined in new learning model

Time
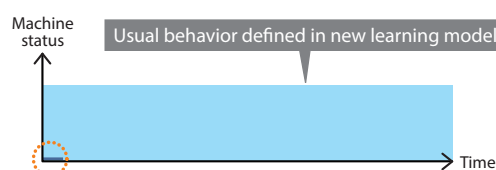
AI controller detects irregularity quickly and accurately

The unique data utilization functionality to provide ultimate edge control makes previously invisible machine status visible, which enables the AI controller to detect strange behavior of machines at the microsecond level.
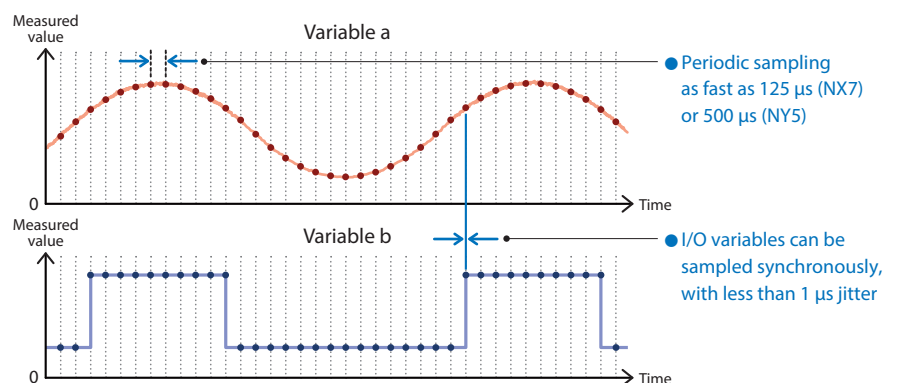
Comparison of detection capabilities between AI and conventional method
(time-series data such as voltage and current)

Usual behavior	Strange behavior		

Threshold detection by program

Pattern detection by human eye

Outlier detection using feature values by AI

Program ✕ — Cannot detect changes that occur below the threshold value

Human eye ✕ — Cannot detect minute changes that the human eye cannot distinguish

AI ◯ — Can detect minute changes that the program and human eye cannot distinguish

Functions to detect quickly and accurately

High-speed Time Series Database Function

Collection and storage of time-series data are fully synchronized with the control cycle. The periodically sampled data is used to understand machine behavior, enabling creation of accurate learning models and judgment. Moreover, the host connection functionality allows the linkage of AI between the host and machine levels, which helps optimize the introduction of IoT to factories.
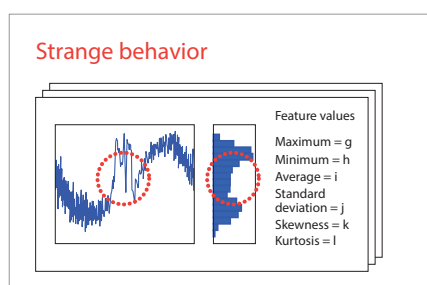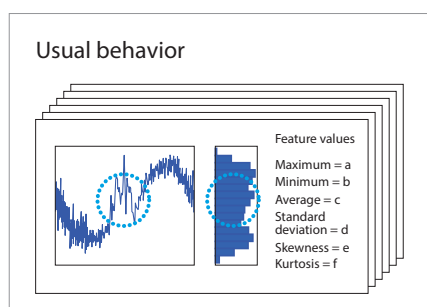
Variable a — ● Periodic sampling as fast as 125 μs (NX7) or 500 μs (NY5)

Variable b — ● I/O variables can be sampled synchronously, with less than 1 μs jitter

Data utilization to detect strange behavior

Data collection	Data analysis	Data utilization
Time-series data collection, feature value creation	Mining, machine learning	Real-time monitoring by AI

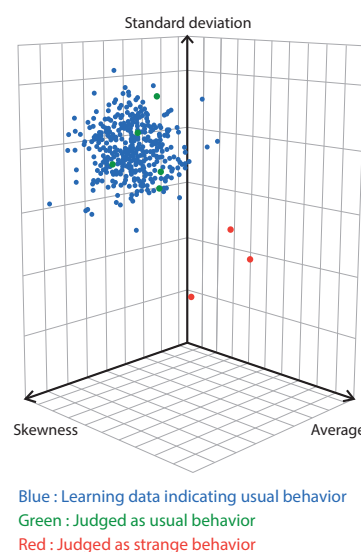Feature values are generated from data that is gathered when machine behavior is usual and strange.

Feature values which are used to judge behavior to be strange are selected. A machine learning model is generated from the analysis result.

The machine learning model is transferred to the AI controller. Machine status is monitored in real time.

Usual behavior

Feature values

Maximum = a
Minimum = b
Average = c
Standard deviation = d
Skewness = e
Kurtosis = f

Strange behavior

Feature values

Maximum = g
Minimum = h
Average = i
Standard deviation = j
Skewness = k
Kurtosis = l

Standard deviation < Θ1

Skewness < Θ2

Average < Θ3

Normal class

Normal class

Normal class

Abnormal class

Machine learning model

Standard deviation

Skewness

Average

Blue : Learning data indicating usual behavior
Light blue : Threshold value

Standard deviation

Skewness

Average

Blue : Learning data indicating usual behavior
Green : Judged as usual behavior
Red : Judged as strange behavior

Ultra-high-speed AI engine

The AI engine provides both speed and accuracy—Omron has developed an AI engine based on the machine learning engine Isolation Forest that is ideal for real-time processing and tuned it to increase detection accuracy. The algorithm applicable to multimodal data can be used for high-mix production lines where two or more operating modes are required.

Feature value 3

Feature value 2
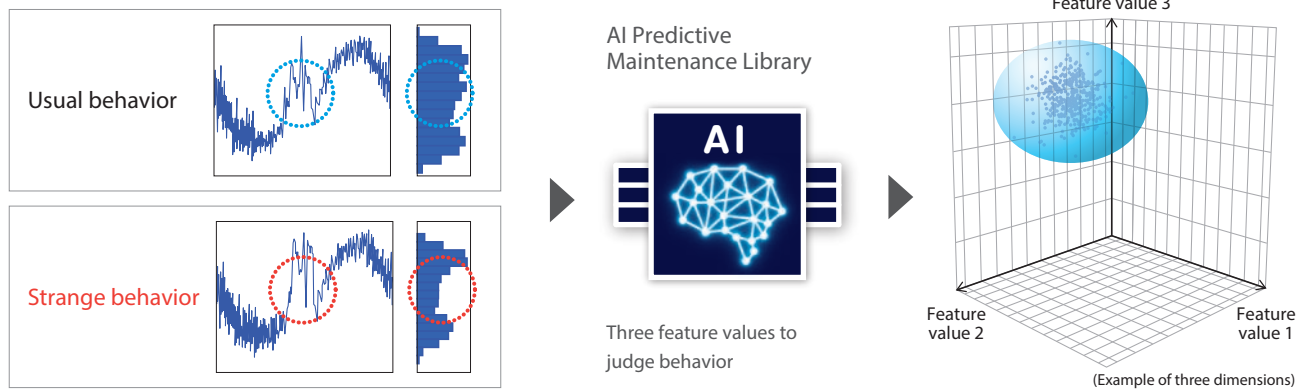
Feature value 1

(Example of three dimensions)
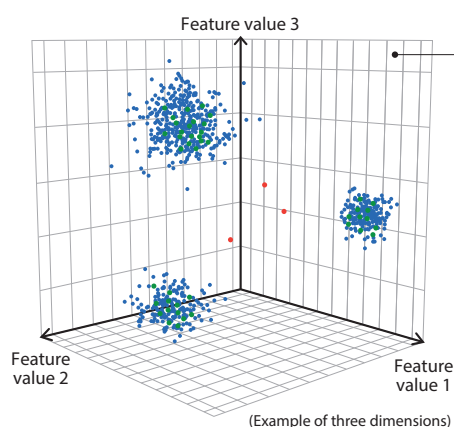
- Ultra-high-speed AI engine can calculate in several tens of microseconds

- One machine learning model can discriminate multiple operating modes

- Up to 16 feature dimensions

AI Predictive Maintenance Library enables non-stop

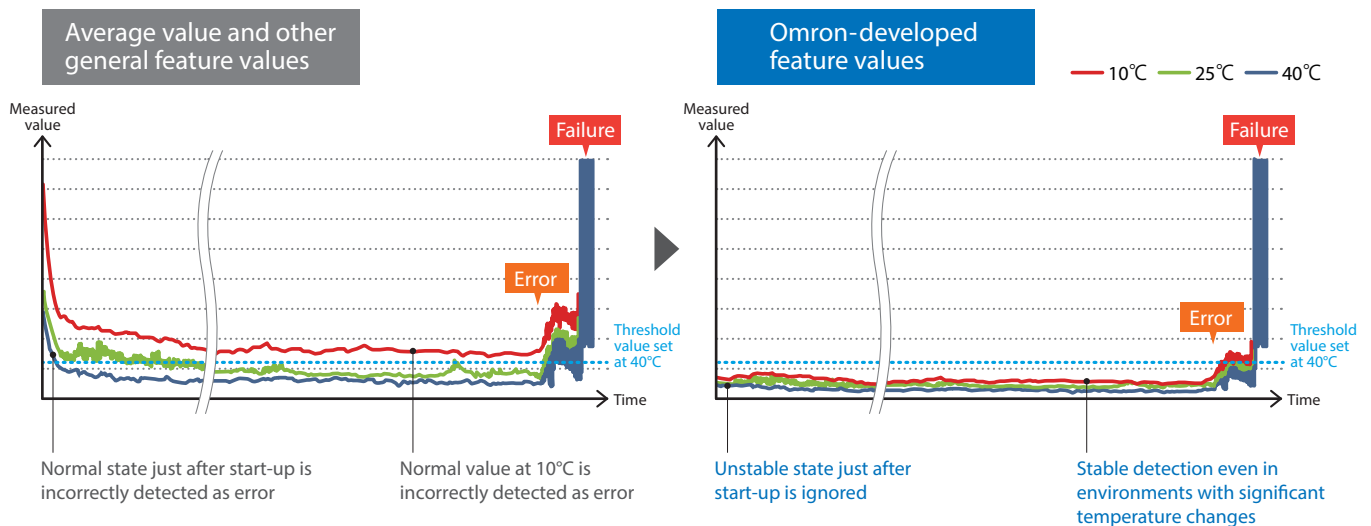## Software components for accurate detection of strange behavior

The AI Predictive Maintenance Library, a collection of software components,
calculates optimal future values to judge behavior from data of operating mechanisms.
You can now start to do predictive maintenance.

Usual behavior

Strange behavior

AI Predictive
Maintenance Library

AI

Three feature values to
judge behavior

Feature value 3

Feature value 2

Feature value 1

(Example of three dimensions)

Note. Omron engineers set learning data and threshold values optimized for your machine. Consult your Omron sales representative for details.

Robustness minimizes effects of environmental changes

Time elapses and ambient temperature changes throughout the day and year after the machine is started.
Omron has developed its own feature values that minimize the effects of environmental changes,
helping you stabilize your predictive maintenance activities.

Average value and other
general feature values

Omron-developed
feature values

— 10℃ — 25℃ — 40℃

Measured
value

Failure

Error

Threshold
value set
at 40℃

Time

Measured
value

Failure

Error

Threshold
value set
at 40℃

Time

Normal state just after start-up is
incorrectly detected as error

Normal value at 10℃ is
incorrectly detected as error

Unstable state just after
start-up is ignored

Stable detection even in
environments with significant
temperature changes

※The above results were obtained under Omron's test conditions. The same results are not guaranteed for all conditions.

equipment

System configuration

Omron helps you perform predictive maintenance using AI.
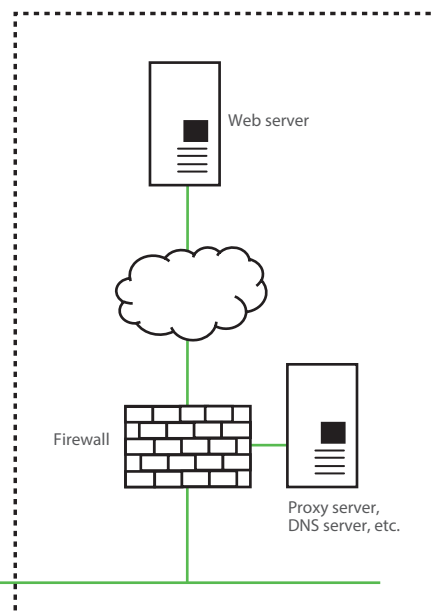
AI Controller Software

Configuration tool

Visualization tool

AI Viewer

AI Operator

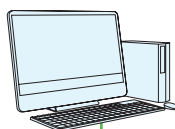Install a web server if you want to transfer calculation results to it

Web server

[NX Series]

Install the AI controller software in the host computer

• AI Operator   • AI Viewer

NA Programmable Terminal

Firewall

Proxy server, DNS server, etc.

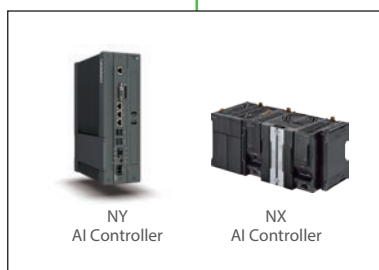EtherNet/IP

[NY Series]

Install the AI controller software in Windows on the NY Series

• AI Operator
• AI Viewer

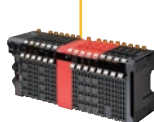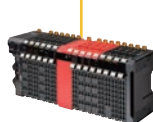NY AI Controller

NX AI Controller

AI controller

• Time Series Database Function
• Feature Value/Machine Learning Function
• WebAPI Connection Function

AI Predictive Maintenance Library

EtherCAT

EtherCAT slaves

Ordering Information

NX-series AI Controller

Product Name	Specifications			Current (Power) consumption	Model
	Program capacity	Memory capacity for variables	Number of motion axes		
NX701 CPU Units with AI function	80MB	4 MB : Retained during power interruption 256 MB : Not retained during power interruption	256	40W (including SD Memory Card and End Cover)	NX701-Z700
			128		NX701-Z600

NY-series AI Controller

Product Name	Specifications						Model
	Operating system	CPU type	Number of motion axes	RAM memory (non-ECC type)	Storage size	Interface option	
Industrial Box PC with AI function	Windows Embedded Standard 7-64bit	Intel®Core™ i7-4700EQ	64	16GB	128GB×2 SSD iMLC/pSLC	RS-232C	NY512-Z500-1XX214T1X
			32				NY512-Z400-1XX214T1X
			16				NY512-Z300-1XX214T1X
			64			DVI-D	NY512-Z500-1XX214T2X
			32				NY512-Z400-1XX214T2X
			16				NY512-Z300-1XX214T2X
Industrial Panel PC with AI function	Windows Embedded Standard 7-64bit	Intel®Core™ i7-4700EQ	64	16GB	128GB×2 SSD iMLC/pSLC	RS-232C	NY532-Z500-112214T10
			32				NY532-Z400-112214T10
			16				NY532-Z300-112214T10
			64			DVI-D	NY532-Z500-112214T20
			32				NY532-Z400-112214T20
			16				NY532-Z300-112214T20

For details, refer to the data sheet of the AI Machine Automation Controller NX/NY-Series.

AI Controller Software

Please purchase a DVD and required number of licenses the first time you purchase the Sysmac Studio.
DVDs and licenses are available individually. Each model of licenses does not include any DVD.

Product Name	Number of licenses	Model
AI Controller Standard Software*	— (Media only : DVD)	SYSMAC-AICSTE00D
	1 license	SYSMAC-AICSTE01L
	10 licenses	SYSMAC-AICSTE10L
	30 licenses	SYSMAC-AICSTE30L
	50 licenses	SYSMAC-AICSTE50L

* The AI Controller Standard Software and one license are bundled with the NY AI Controller.

● Support Software

Software Name	Specification
AI Operator	The AI Operator is a tool to configure AI function settings of the AI Controller as well as to monitor the status. It works on Windows. The AI Operator also provides a function for transferring results of calculation performed by the Feature Value/Machine Learning Function from the AI Controller to a computer.
AI Viewer	The AI Viewer is a tool to visualize feature values and results of equipment events that are output by the Feature Value/Machine Learning Function. It works on Windows. The AI Operator reads out data transferred from the AI Controller and displays it on a computer for the users to view.

Sysmac Library for AI Controller

Download Sysmac Library for AI Controller to your PC using AI Operator. Install the library before you use it.

Target Mechanism	Software model	Specification
AI Predictive Maintenance Library (Cylinder)	SYSMAC-ZPA001000W	CylinderStatus generates mechanism state variables that reflect the status of the cylinder referenced by the feature value / machine learning functions.
AI Predictive Maintenance Library (Ball Screw)	SYSMAC-ZPA002000W	BallScrewStatus generates mechanism state variables that reflect the status of the ball screw referenced by the feature value / machine learning functions.
AI Predictive Maintenance Library (Belt & Pulley)	SYSMAC-ZPA003000W	BeltPulleyStatus generates mechanism state variables that reflect the status of the belt & pulley referenced by the feature value / machine learning functions.

Target Mechanism	Number of licenses*	Model
AI Predictive Maintenance Library (Cylinder)	5 licenses	SYSMAC-ZPA001005L
	10 licenses	SYSMAC-ZPA001010L
	50 licenses	SYSMAC-ZPA001050L
AI Predictive Maintenance Library (Ball Screw)	5 licenses	SYSMAC-ZPA002005L
	10 licenses	SYSMAC-ZPA002010L
	50 licenses	SYSMAC-ZPA002050L
AI Predictive Maintenance Library (Belt & Pulley)	5 licenses	SYSMAC-ZPA003005L
	10 licenses	SYSMAC-ZPA003010L
	50 licenses	SYSMAC-ZPA003050L

* One license is required for each mechanism to monitor.

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