Making a Smart Plant with AI Technology

Takehito Yasui

Deputy General Manager - AI Solution Department
Chiyoda Corporation
Apply AI using machine learning (deep learning) to Process Plant
Introduce the development examples, and the concept of plant digital twin

2 steps to apply AI
1) Machine learning finds the correlation among big-data and predict objective variable with high accuracy. [Prediction model]
2) Change present condition (explanatory variables) to maximize objective variable with prediction model. [Optimization]
AI & Big Data utilize concept in process plant

Operation data, Maintenance data, Laboratory analysis data, Weather data etc. where handled separately, which will be used collectively for explanatory variables.
Sulphur concentration prediction in Desulphurization product

Desulphurization Unit

Feed (Flow, Composition, Blend ratio, etc.)
Reaction (Inlet T&P, Reactor ΔT · ΔP etc.)

Input (Explanatory Variables)

Quality control

AI

Prediction (Objective Variable): Sulphur Concentration

Machine Learning
Soft sensor

Machine learning finds subtle correlation but non-negligible from submulti-dimensional big data recursively and generate prediction model automatically.
Sulphur concentration prediction in Desulphurization product

Objective variable: 1 hour ahead Sulphur concentration in Product

More accurate estimation

Realizing smart operation of the plant, i.e. stabilize quality, further reduction in operation margin, improvement in efficiency, cost reduction and the like.
Design Case and Margin

Feed Composition: Heavy and Light
Climate: Hot Summer and Cold Winter, Rainy season,

Nameplate capacity is guaranteed in most severe case i.e. There are extra margins in every other case

But it was not practical to figure out optimum operating parameters continuously.
LNG AI Plant Optimizer

- LNG AI Plant Optimizer utilizes Deep Learning AI technology.
- AI Optimizer seamlessly advises plant operator of the optimum operation parameters for maximizing production.
  - Maximize Production by LNG AI Plant Optimizer support
  - Physical Plant Modification is not required.

- Outline of AI Optimizer -
Foaming Prediction in Acid Gas Removal Unit

Anomaly detection

Monitor feature index driving to abnormal state and detect its omen. AI can discover this feature index hidden in huge amount of operation data.

Prevent unscheduled plant shutdowns caused by malfunction or abnormal state.
The single stage C3 compressor recycling loop has four PID controllers, LC, PC, Speed and Anti-Surge Controller. Sometimes, this process becomes unstable since mutual control influences each other.

AI learned the action to stabilize the process by reinforcement learning approach. After learned, AI outputs the twelve PID parameter values (3x4) of the four controllers for each process state.

Examples of destabilization

[100%→50%Turn Down]
C3 evaporation reduction due to cold heat consumption decrease
①LC Close  ②PC inlet p down  ③SCS Speed Down

conflict

②Flow Down ASV Open  ②PC inlet p Up  ③SCS Speed Up
Deep reinforcement learning is a kind of machine learning adopted in Alfa-GO. AI agent itself searches for a better solution by huge amount of trial and error.
This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) in Japan.
AI support for Plant Life Cycle

AI Optimized Plant Design
- 3D model
- Data Base
  - Process Design
  - Safety Design
  - Piping Design
  - Mech. Design
  - Structure/Civil Design
  - Elec./Instr. Design
  - etc.
- Dynamic Simulator
- EPC

AI Optimized O&M
- Digital Plant Platform
- Digital Twin
  - Plant Operation Data
  - Prediction
  - Optimized AI support
  - Predicted Operation
  - Predicted Maintenance
  - etc.
  - Weather Forecast
- After EPC

© Chiyoda Corporation 2019, All Rights Reserved.
Open Plant Digital Twin Concept

As an application is added to the smartphone, it becomes a solution that can add a desired functional application to the 3D platform as needed.
The objective of applying AI technology to plant operation is to raise the client’s profitability, Quality and Efficiency without compromising safety, by applying it to:

1) Reduce the cost by running optimized and stable operations
2) Prevent unscheduled plant shutdowns
3) Stabilize process state and product quality

Process plant generates Big Data relating to physical theory. AI find correlation between huge number of variables, which is not necessarily a causal relationship. ⇒ Plant AI model should be evaluated applicability from an engineering point of view.
Thank You