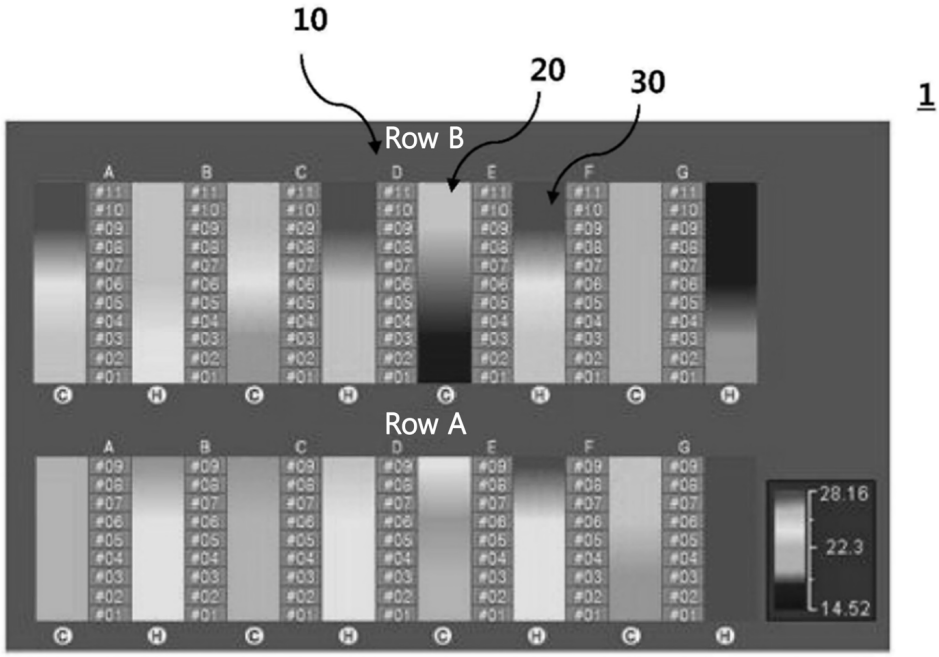


FIG. 1

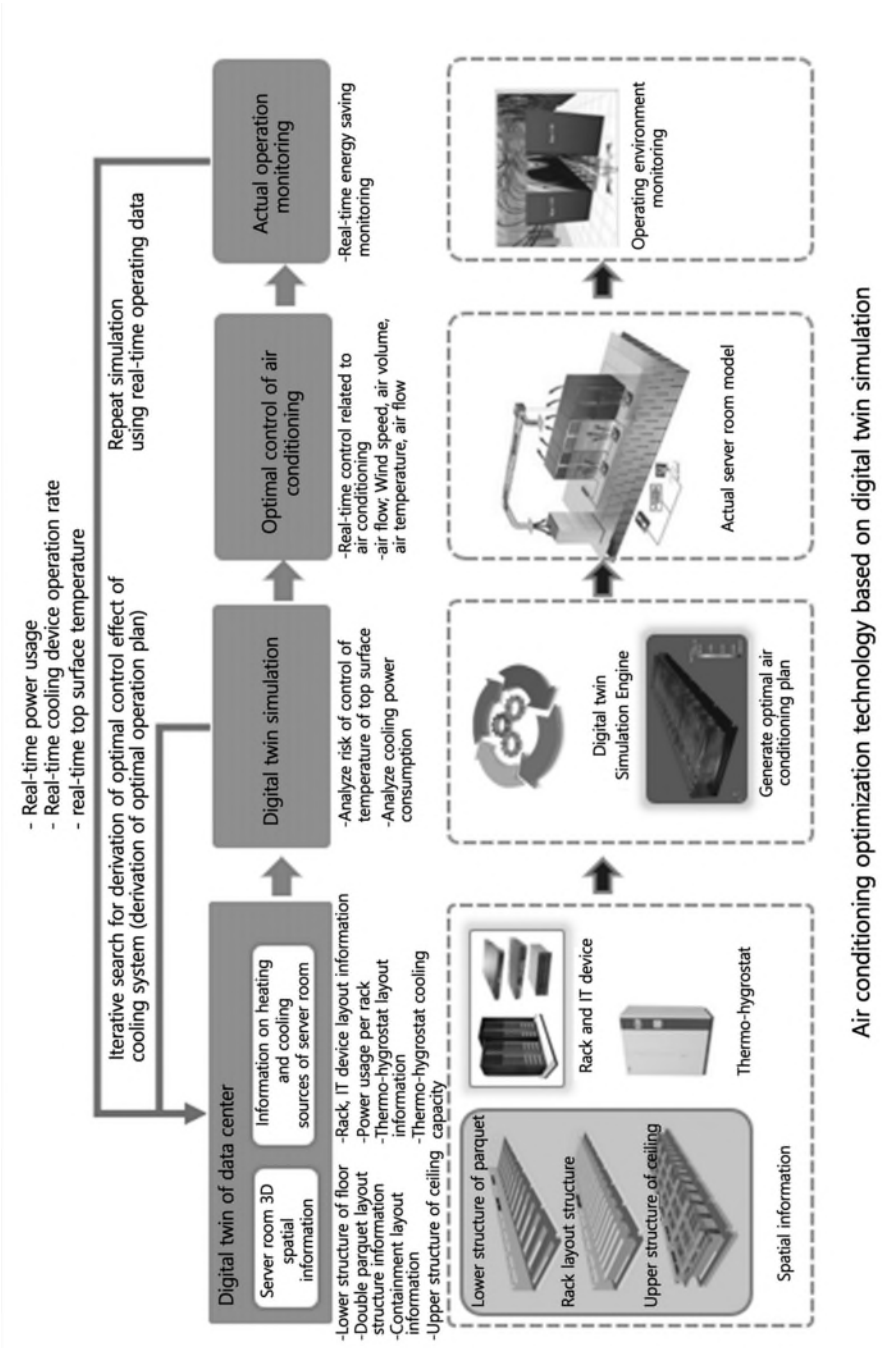

- Real-time power usage
- Real-time cooling device operation rate
- real-time top surface temperature
Iterative search for derivation of optimal control effect of cooling system (derivation of optimal operation plan)
Repeat simulation using real-time operating data
Digital twin of data center
Server room 3D spatial information
Information on heating and cooling sources of server room
-Lower structure of floor
-Double parquet layout structure information
-Containment layout information
-Upper structure of ceiling
-Rack, IT device layout information
-Power usage per rack
-Thermo-hygrostat layout information
-Thermo-hygrostat cooling capacity
Digital twin simulation
-Analyze risk of control of temperature of top surface
-Analyze cooling power consumption
Optimal control of air conditioning
-Real-time control related to air conditioning
-air flow, Wind speed, air volume,
air temperature, air flow
Actual operation monitoring
-Real-time energy saving monitoring
Lower structure of parquet
Rack layout structure
Upper structure of ceiling
Spatial information
Rack and IT device
Thermo-hygrostat
Digital twin Simulation Engine
Generate optimal air conditioning plan
Actual server room model
Operating environment monitoring
Air conditioning optimization technology based on digital twin simulation

FIG. 2

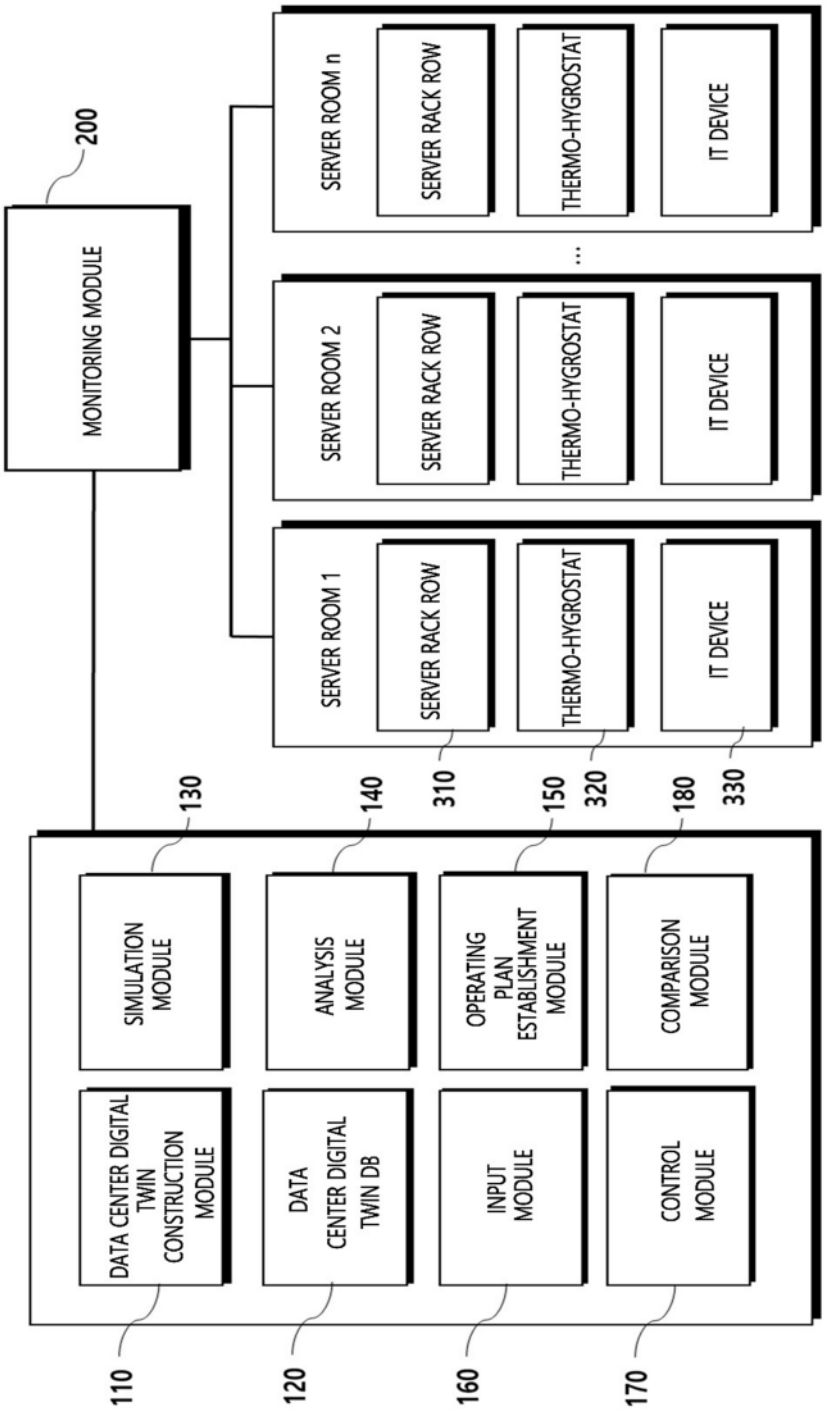

200
MONITORING MODULE
SERVER ROOM 1
SERVER RACK ROW
THERMO-HYGROSTAT
IT DEVICE
SERVER ROOM 2
SERVER RACK ROW
THERMO-HYGROSTAT
IT DEVICE
...
SERVER ROOM n
SERVER RACK ROW
THERMO-HYGROSTAT
IT DEVICE
310
320
330
130
140
150
180
SIMULATION MODULE
ANALYSIS MODULE
OPERATING PLAN ESTABLISHMENT MODULE
COMPARISON MODULE
DATA CENTER DIGITAL TWIN CONSTRUCTION MODULE
DATA CENTER DIGITAL TWIN DB
INPUT MODULE
CONTROL MODULE
110
120
160
170

FIG. 3

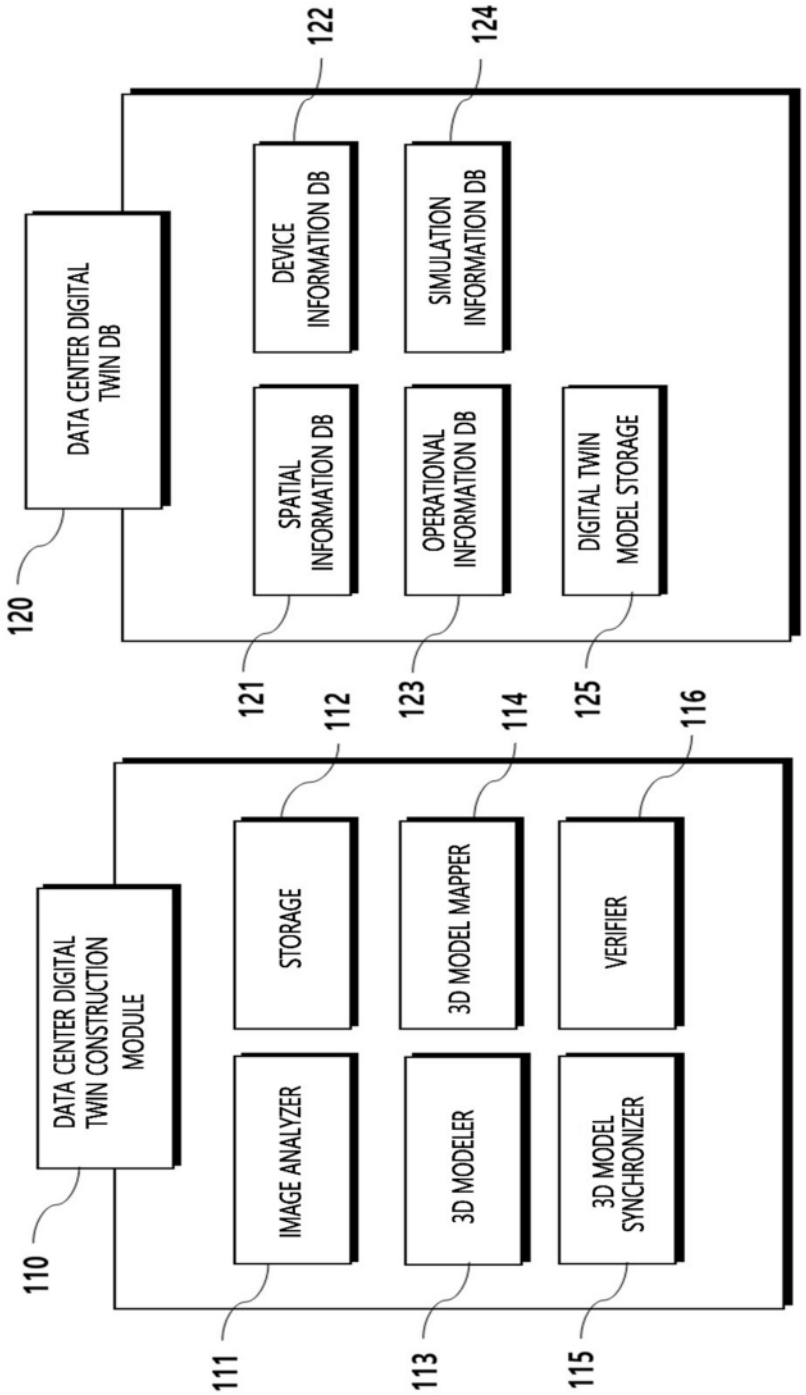

DATA CENTER DIGITAL TWIN CONSTRUCTION MODULE
110
IMAGE ANALYZER
111
STORAGE
112
3D MODELER
113
3D MODEL MAPPER
114
3D MODEL SYNCHRONIZER
115
VERIFIER
116
DATA CENTER DIGITAL TWIN DB
120
SPATIAL INFORMATION DB
121
DEVICE INFORMATION DB
122
OPERATIONAL INFORMATION DB
123
SIMULATION INFORMATION DB
124
DIGITAL TWIN MODEL STORAGE
125

FIG. 4

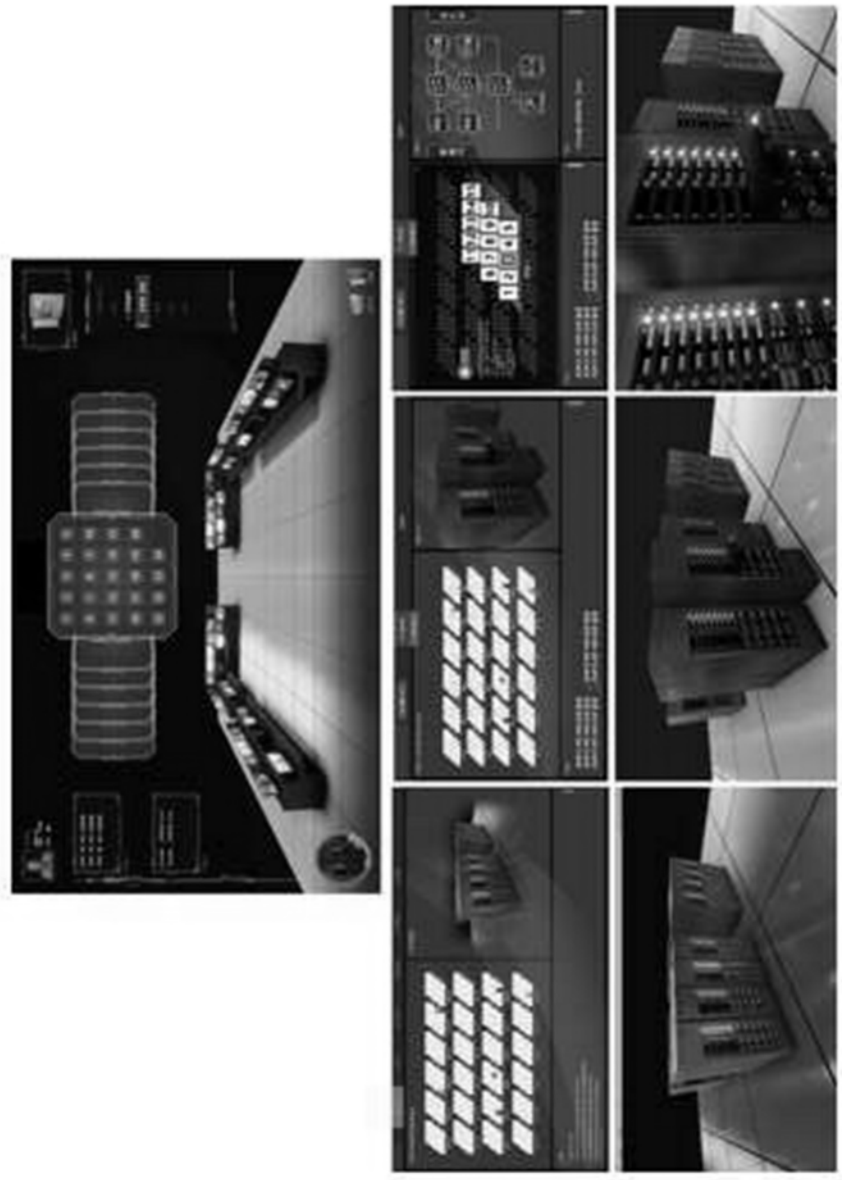
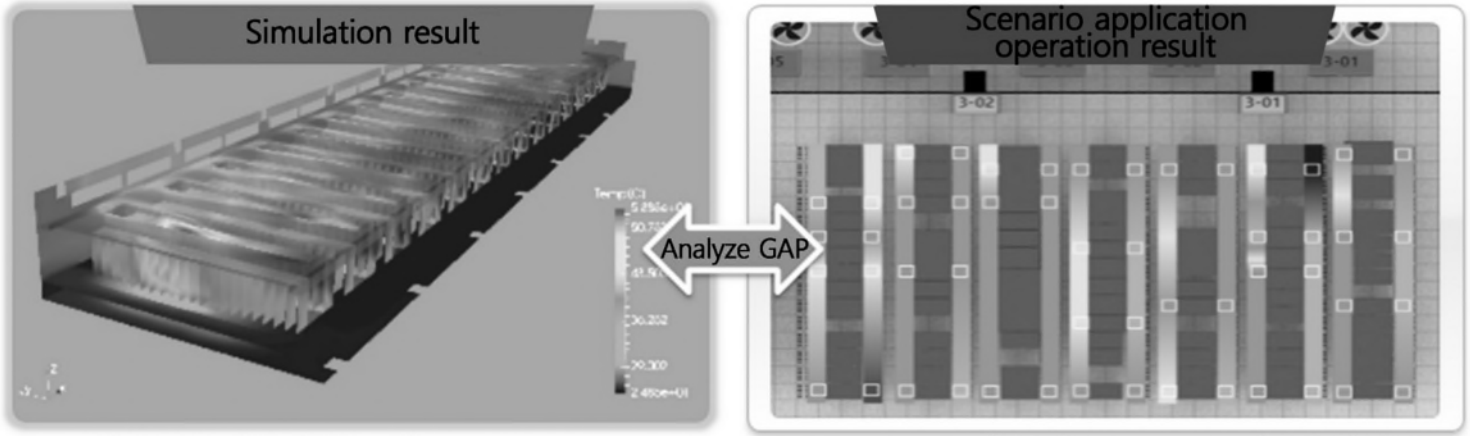


FIG. 5

☑ Error analysis for constructing accurate operating environment



- Data: Predicted data of power usage
- Data: Predicted data of environment of top surface

- data: Power usage detailed data
- data: Top surface environment operation data

- Comparative analysis of simulation results vs actual operation results
- Comparison report for air conditioning power, top surface temperature, wind speed according to plan and actual load
- Evaluate plan/operation suitability and analyze actual ROI

FIG. 6



FIG. 7B

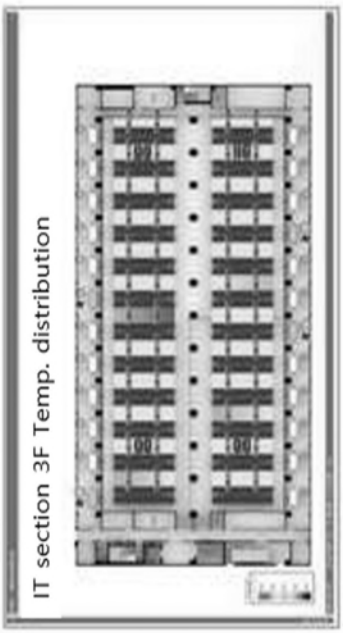


FIG. 7D



FIG. 7A



FIG. 7C

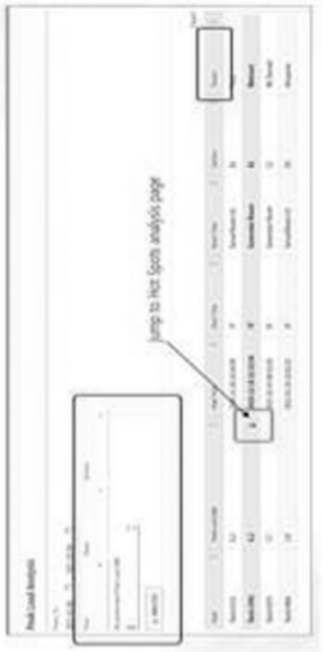


FIG. 8B

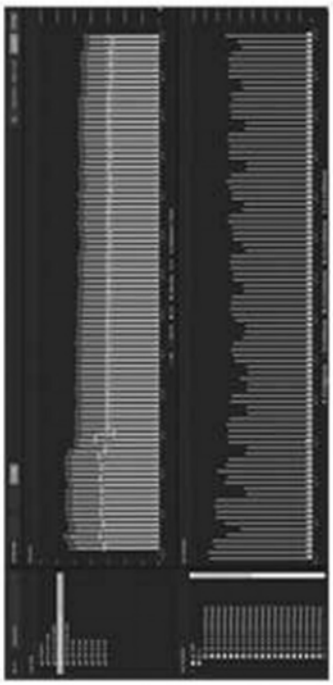


FIG. 8D

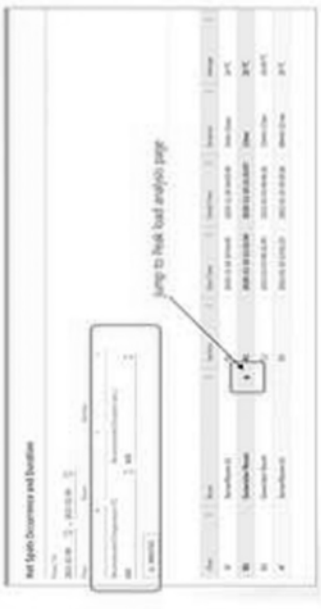


FIG. 8A

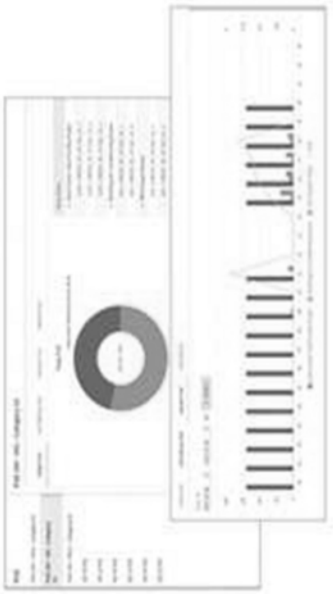


FIG. 8C

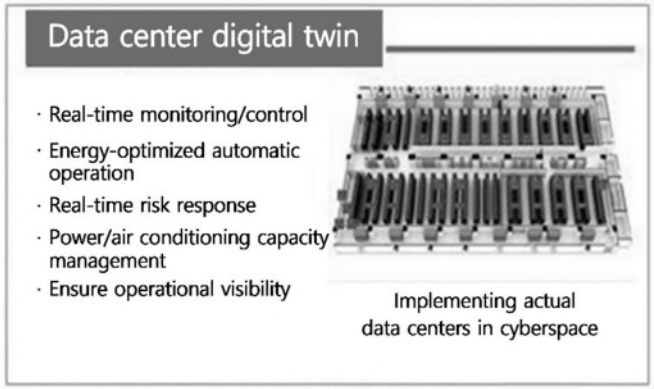


FIG. 9A

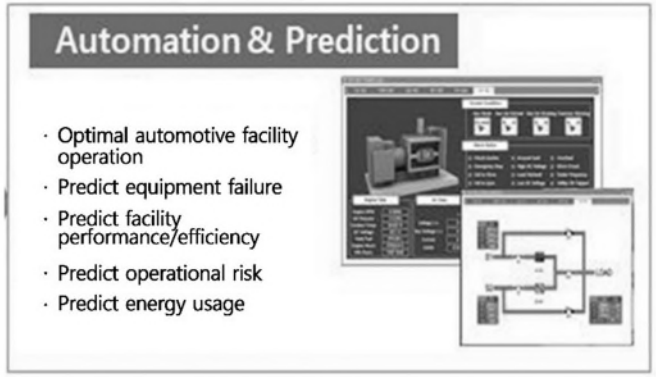


FIG. 9B



FIG. 9C

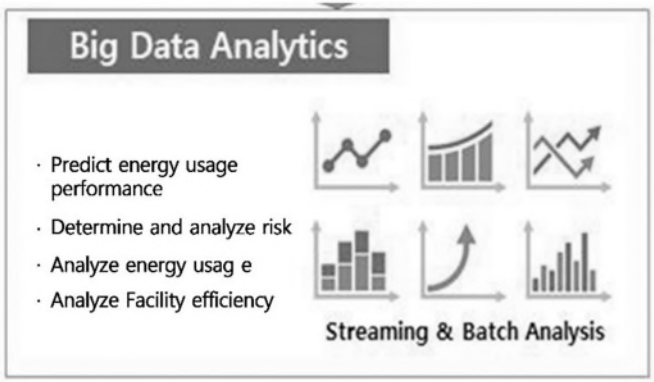


FIG. 9D

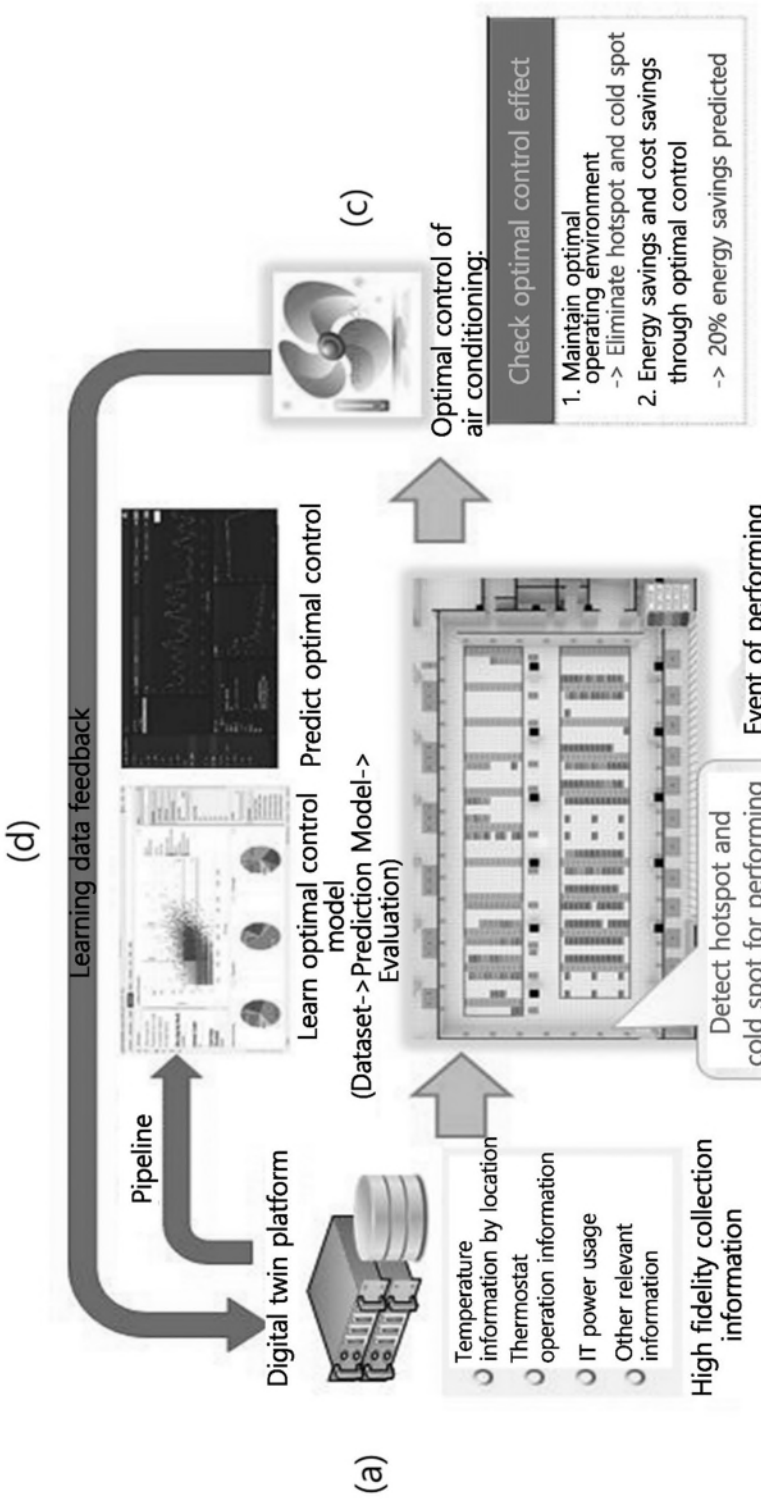

(a)
High fidelity collection information
Temperature information by location
Thermostat operation information
IT power usage
Other relevant information
Digital twin platform
Pipeline
(d)
Learning data feedback
(b)
Detect hotspot and cold spot for performing optimal control
Event of performing optimal control occurs
Learn optimal control model
(Dataset->Prediction Model->Evaluation)
Predict optimal control
(c)
Optimal control of air conditioning:
Check optimal control effect
1. Maintain optimal operating environment
-> Eliminate hotspot and cold spot
2. Energy savings and cost savings through optimal control
-> 20% energy savings predicted

FIG. 10