

Generation ROBOTS

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DEEP Robotics

Quadruped Robot Power Patrol Inspection Solution



Trends and challenges

Speeding Digitalizing Transformation

Smart Grid Transformation:

60 thousand converting stations
300 thousand power supply stations

The world is heading to the 4th industrial revolution, data and electricity are the foundation of industrial production.

The technological revolution and industrial revolution are on their way to a new era; digitalization and intelligenlization were becoming key factors in high-quality electric industry development. During The National 14th Five-Year Plan, our country is promoting digitalize power inspection.

Power grid, converting station and power supply station are one of the most important infrastructures in the country, its stable operation is the priority of the development of the economy and living, and there are many problems are needed to be solved in the process of transforming traditional power inspection into smart management, unmanned inspection.

Current Issues



Manual Inspection

- **Repeated Work**

Most of the power stations are still using manual inspection, which high repetitive and intense.

- **Inconsistency**

Inspection outcome is easily affected by personal issues, mental state, and work experience; miss-inspections and errors often occur.

- **Safety Issue**

Extreme conditions like storms, haze, and hail are threats to inspectors safety.

- **Employment**

Inspection position hiring problems, shortage of personnel, aging problems.



Traditional Robotic Inspection

- **Limited Adaptability**

Unable to operate on unstructured terrains, difficult to suit to the complex environment in power stations like stairwells, grassland, and muddy ground. Traditional robotics inspection cannot deploy flexibly due to lots of blind spots in the inspection area.

- **Cost**

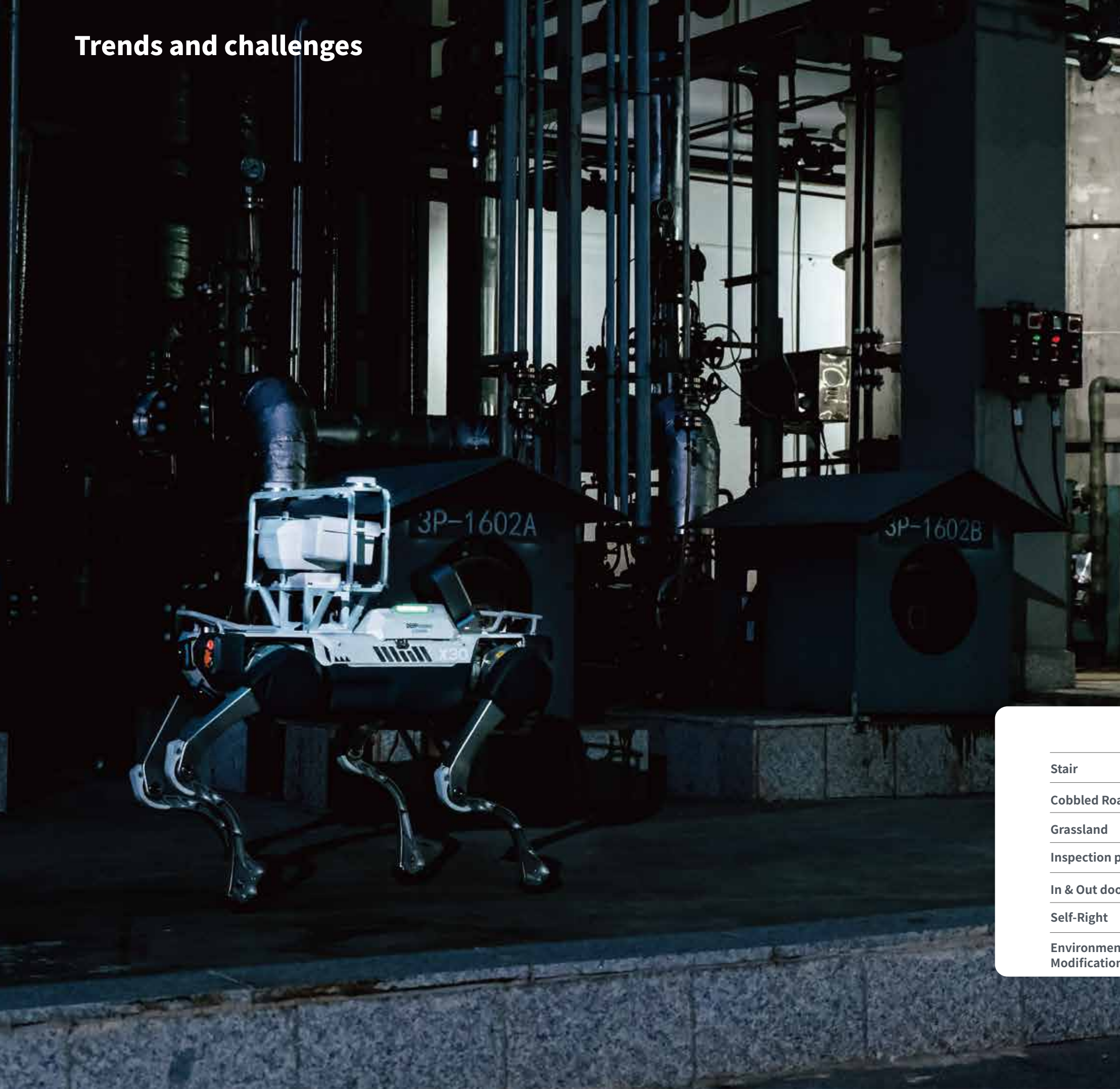
It is a huge cost to modify the environment for using wheeled or tracked robots.

- **Complicated System**

Unable to work in & outdoor at the same time; too many types of robotic deployment out there, huge workload.



Trends and challenges



Advantage

- Improve Level of Digitalization** Full access to the central control system, upload real-time data
- All-Terrian Full-Scene Coverage** Detect defects in time, prevent accident, and ensure safe operation of all devices
- 24h All-Weather Operation** Operator can know all situation in house (from far distance)
- Unmanned /Less manned** Only 2 X30 robot dogs for ±800kV EHV converter station
- In & Out Door Inspection** 1 robot dog full-scene coverage
- Shorten Inspection Distance** Boots efficiency, reduce workload
- Reduce Operators' Workload** Inspection under hash condition like storm, hail, low temperture

Comparisons

	Wheel	Track	Rail	Quadruped 
Stair	✗	✗	✗	✓
Cobbled Road	✗	✓	✗	✓
Grassland	✗	✓	✗	✓
Inspection pathway	Limited	Limited	Unchangeable	Flexible
In & Out door	✗	✗	✓	✓
Self-Right	✗	✗	✗	✓
Environmental Modification	Needed	Needed	Needed	No Needed

X30

Patrol Inspection Quadruped Robot

Parameter

Weight:	56kg	Standing Size:	1000*470*585 (mm)
Max. Speed:	≥4m/s	Endurance:	2.5 - 4h
Protection:	IP67	Mileage:	≥10km
Slope:	45°	Temperature	-20°~55°C
Load:	≥20kg	Step/Obstacle' s H:	≥20cm
Interface:	Ethernet External Output Power Supply (72V BAT)		

Function (Different models, different functions)

- | | |
|--|---|
| 01. Stair climbing perception | 02. Obstacle stop |
| 03. Auto-charging | 04. Fusion calibration algorithm |
| 05. Multi-sensor fusion localization algorithm | 06. Navigation planning algorithm |
| 07. Multi-sensor fusion mapping algorithm | 08. Built-in RTK module |
| 09. Smart light interaction interface | 10. Industrial-level navigation interface |





LiDAR (4)

- Weight: 256g
- Power: 6.5w (Temperature 25°C)
- Laser Wavelength: 905nm
- FOV: Horizontal 360°, Vertical -7°~ +52°
- Range: 40m @ 10% Reflectance
- Frame Rate: 10Hz
- Points Per Second: 200,000pts/s



Acoustic Imager

- Dimension: 170×170×65 (mm)
- Weight: 0.85kg
- Camera Parameters:
 - Field of View: 65°±3°
 - Camera Solution: 640p at 30fps
 - Video Solution: 720×1280 or 1920×1080
- Microphone Parameters:
 - Type: MEMS, Digital Port
 - Microphone Number: 64
 - Frequency Range: 2-52kHz
 - Detection Distance: 120m



Intelligent Controller

The navigation host motherboard simultaneously handles business-related program processing, primarily providing functions such as map construction and location navigation.

Parameter:

- Interface: 12V 24V
- Communication Interface: Ethernet; USB2.0; USB3.0

Built-in RTK (optional)

Parameter:

- Channel Spacing : 250 kHz
- Operating Mode : Half Duplex
- Frequency Stability : 1.5ppm
- Protocol Type : LoRa
- Max. data per second : 1000Byte



Bi-Spectrum Camera

- Visible Light: 5-160mm 32X optical zoom, 16X digital zoom, Max.image resolution 2506×1440
- Infrared: Resolution 384×288, thermography focal length 15mm, Field of view 24.55°(H)×18.54°(V), precision of thermal detection ±2 °C , Rang of thermal detection (-20°C~150°C, 0°C~550°C)
- Camera: Horizontal range 360°, vertical range -90°~+90°, preset precision ±0.1, IP67 protection level

Support auto-aperture, auto-focus, auto-color balance, black light compensation, noise balance, day-night lighting shift, behavior analysis, fire detection, fire faults alarm, etc.

Provide SDK for secondary development, meet the needs of image transmission, smart sensing, faults alarm, and other required patrol inspection functions.

Applicable Choices

Communication Location

- ▶ 4G/5G Modules
- ▶ GPS/RTK Modules
- ▶ More...
- Long range
- In&out door locating assist
- Others

Perception

- ▶ Sound Sensor ▶ Humidity Sensor
- ▶ Gas Sensor ▶ More...
- ▶ Bi-Spectrum Camera
 - Meter recognition
 - Valve' s switch status recognition
 - Transformer oil level recognition
 - Indicator status recognition
 - Equipment' s temperature detection
 - Gas concentration detection
 - Other abnormal on site recognitions
 - More....

Operation

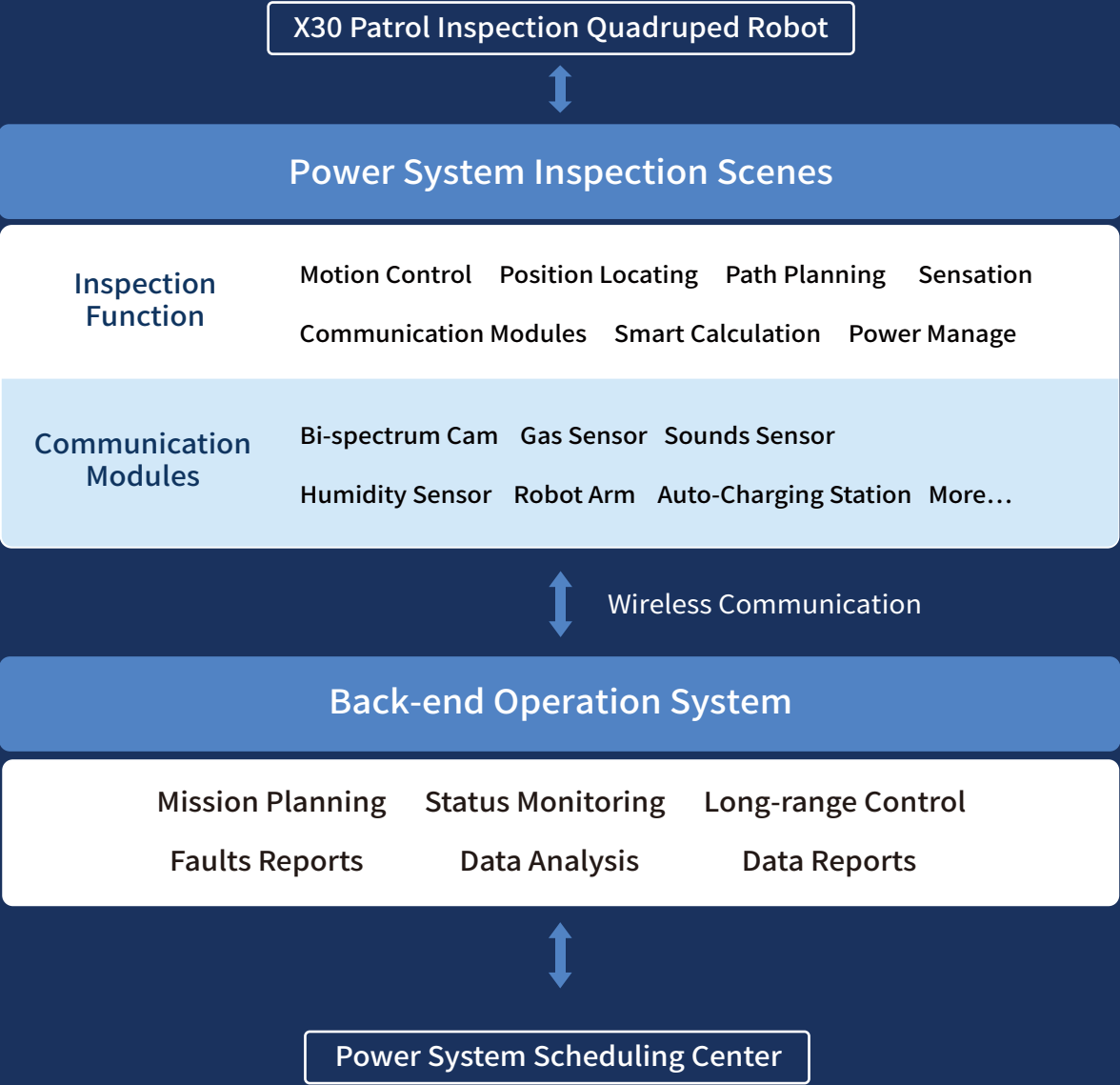
- ▶ Robot Arm ▶ Organizer
- ▶ Telescoping Mech ▶ More...
- Max-load carry
- Probing from difficult way
- Switch operation
- Other actuation operations

Collaboration

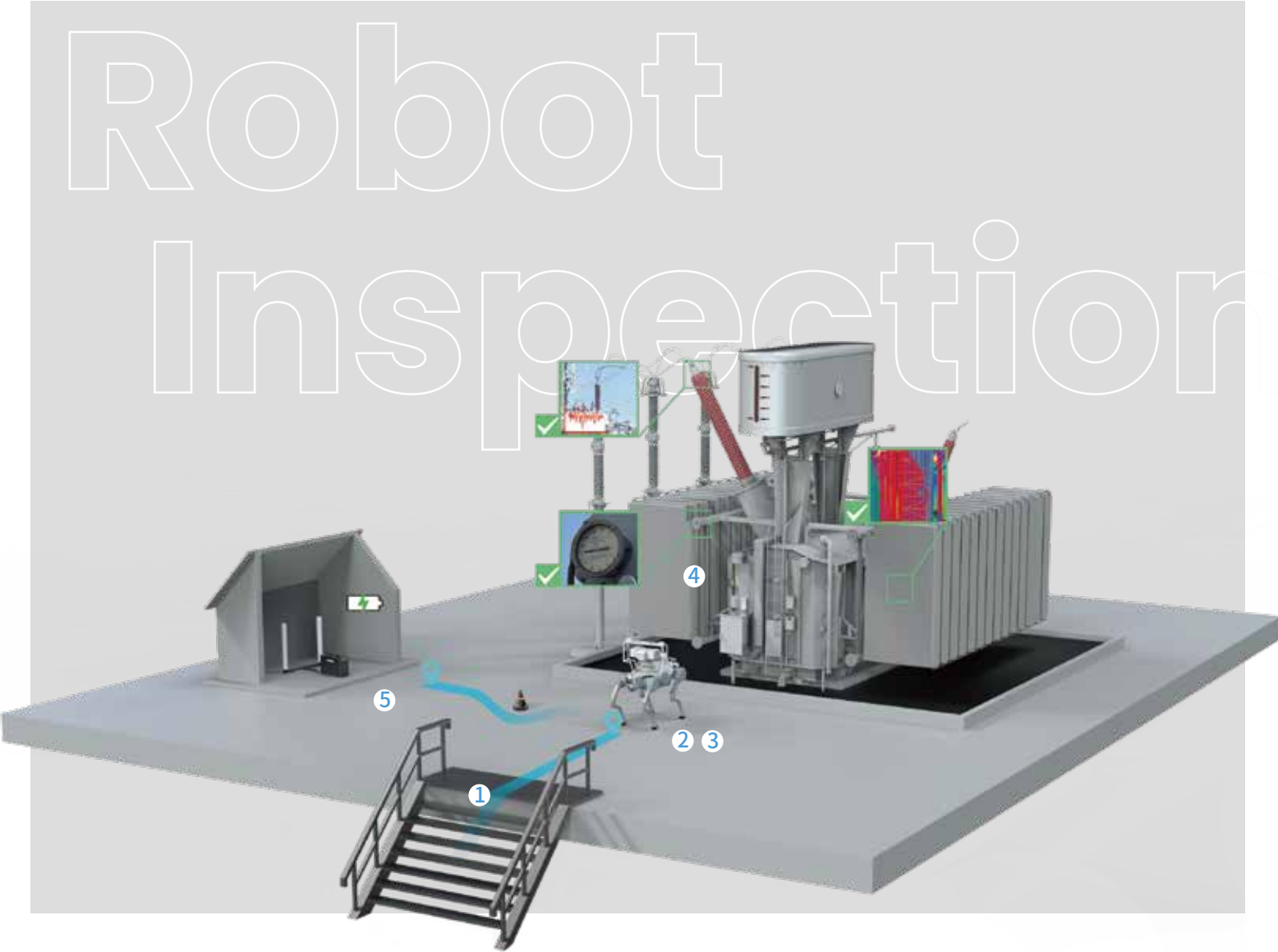
- ▶ Door/Ladder Control
- ▶ More...
- Collaborative command needs for different scenarios

Smart Power Inspection Solution

Structure



Work Flow



1. Explore targets & inspection path
2. Set up, test inspection location & mission
3. Real-time inspection based on pre-set navigation paths
4. Complete inspection, generate real-time results & reports
5. Return for auto-charge, and go for another round

Intelligent patrol platform

QUADRUPEd ROBOT
POWER PATROL INSPECTION SYSTEM



Recognition Accuracy

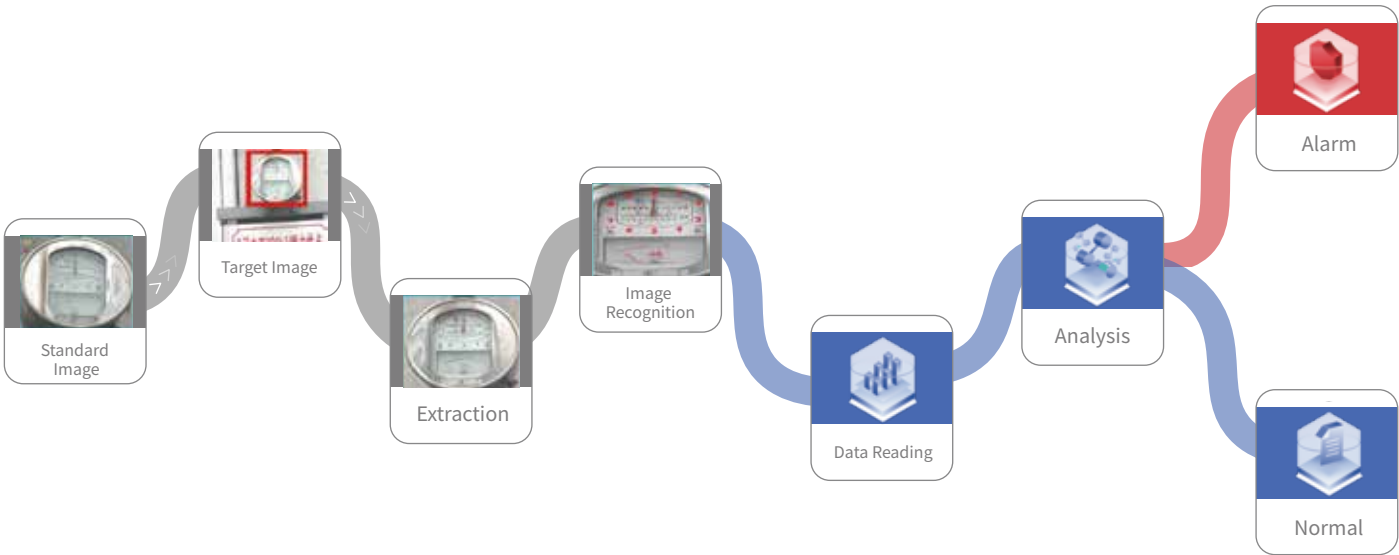


Locating Accuracy



Terrain Coverage Area

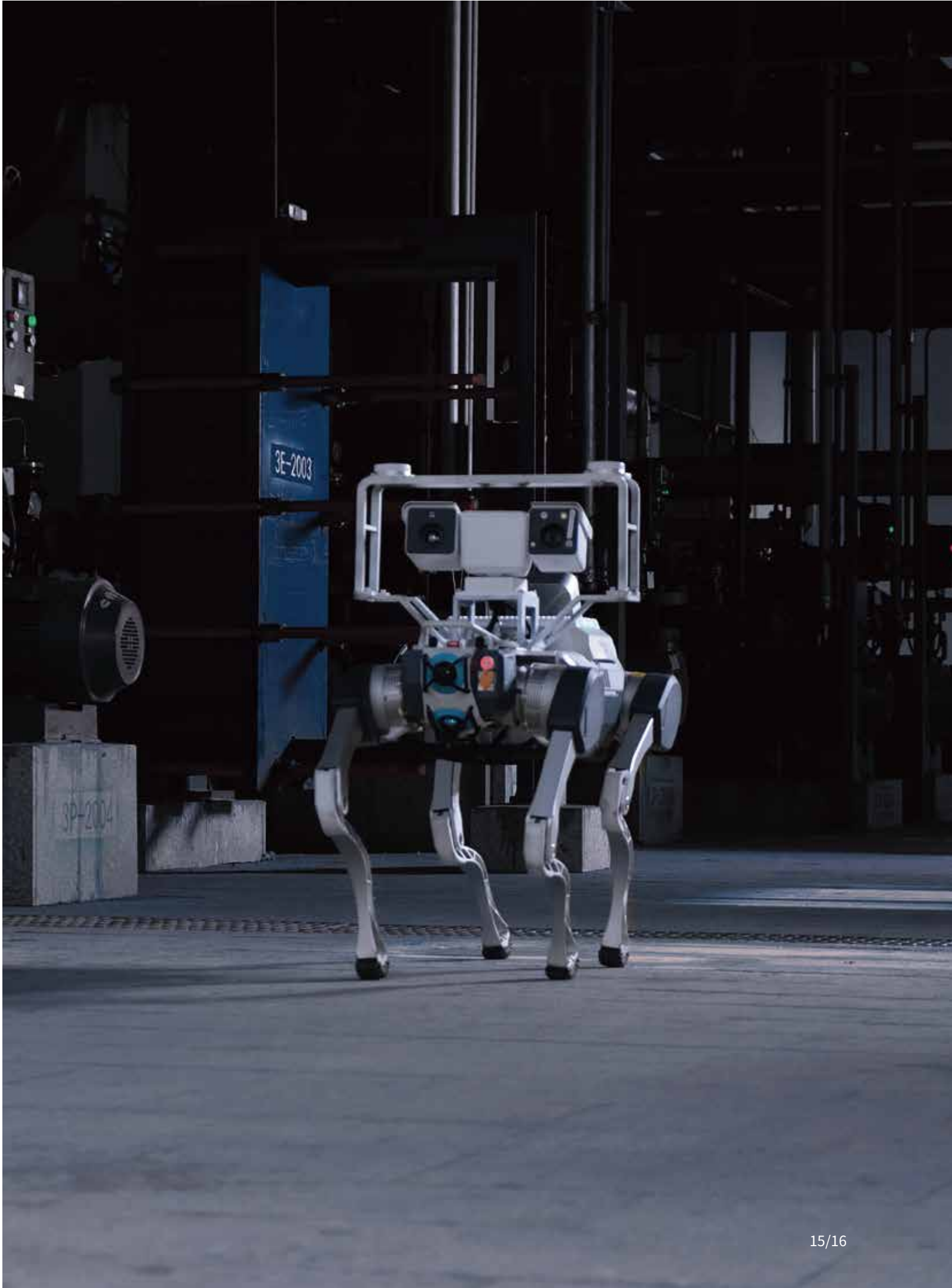
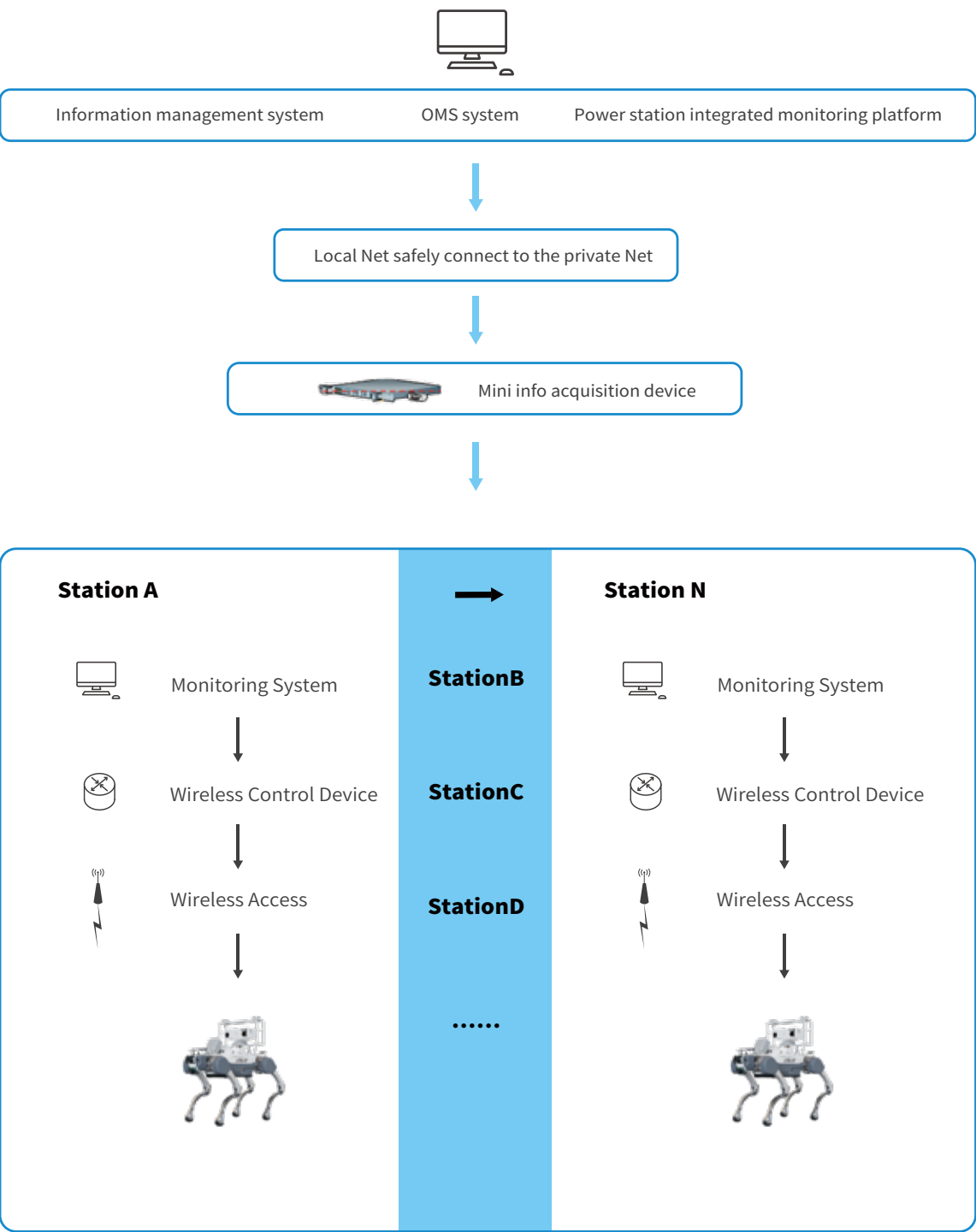
VISUAL PERCEPTION



 Lightning arrester pointer meter	 Respirator color range	 Gate identification
 Double pointer meter	 Indicator color	 Infrared device detect
 Oil Level Pointer Meter	 Liquid level meter color range	 Infrared temperature detect

Intelligent patrol platform

Network



Application cases



Autonomous Inspection Of Ultra-high Voltage Converter Stations

DEEP Robotics' smart power inspection solution integrates X30 quadruped robot and intelligent inspection platform with power industry applications. Without changing the original environment, X30 can traverse various obstacles such as steps and stairs. Combined with the integration of digital systems, it has realized the full process of robot dog inspection from data collection to backend access, data analysis, report generation, and defect warning.



Jiangsu Substation inspection

The secondary developed X20 robot has been deployed in a 110KV substation. The robot can complete tasks at preset points inside the substations such as open and shut switching cabinets, image acquisition, gauges reading, equipment appearance identification, infrared temperature measurement, etc; which can make up for the deficiency of multi-floors indoor inspection. The operation center will continue developing more applicable scenarios, and remotely complete various unmanned inspection duties and maintenance by additionally applying a robotic arm on the quadruped robot.



Hubei Substation Inspection

At the 220 kV Substation, the X20 quadruped robot is conducting intelligent inspections of the substation equipment. This is the first time that State Grid Jingzhou Power Supply Company has applied the robot dog inspection equipment to ensure timely detection of equipment defects during peak summer periods and to guarantee the safe and healthy operation of the equipment. Previously, manual inspections required 2 hours, but now, the robo-dog has replaced manual inspections, reducing the labor intensity and improving the quality and efficiency of inspections.



Asian Games Village Underground Cable Tunnels Inspection

State Grid has adopted X20 intelligent quadruped robot power cable tunnel inspection solution for the tunnel. They have added partial discharge detection sensors, infrared thermometers, video monitoring, and robot arms. Utilizing AI intelligent algorithms, they have established an intelligent inspection platform to achieve fully automated intelligent inspection and maintenance of critical equipment in the key areas of the power cable tunnel.



Robot Dog + Drone Inspection

At the 110 kV Substation, State Grid Power Supply Company is conducting an integrated intelligent maintenance inspection using "Robot Dog + Drone" to detect the operating status of the substation equipment. This intelligent maintenance inspection with "Robot Dog + Drone" enables autonomous inspection and automatic defect recognition. During peak summer periods, it allows for timely detection of equipment abnormalities, thereby enhancing the substation's reliable power supply capability.