

# Industry 4.0 “Smart Factory” Solution

## 1. Image



## 2. Overview

Connecting factory machines and personnel to the network to enable dialogue between machines and between humans and machines, factories capable of realizing this manufacturing approach are known as smart factories. With the national 2025 smart manufacturing plan and the popularization of AI education, vocational colleges and universities have placed greater emphasis on the teaching construction of corresponding majors. Our current task is to enable students to understand, experience, learn, and practice the various modules of smart, unmanned factories both in schools and classrooms.

## 3. Composition of Smart Manufacturing Production Lines

Composed of an industrial 6-axis robot, a 3-axis robotic arm, a flexible CNC lathe, a flexible CNC milling machine, an RFID system, a PLC workstation, a smart warehouse, a central control console, conveyor belts, and other components, the system realizes automated loading/unloading and processing without human intervention. The robot follows instructions to deliver and retrieve materials for the two machines. The system enables programming of industrial robot loading/unloading workstations, integration of loading/unloading systems, RFID system application, PLC system programming, CNC lathe and milling machine programming, fieldbus communication training, and other aspects. It allows students to easily master the flexible processing production system combining industrial 6-axis robots and CNC machines, meeting their learning and operational needs for industrial robots. Through studying and training with this system, students gain a comprehensive understanding and experience of the overall construction and application of smart, unmanned factories.

#### **4. Market Applications**

This production line can serve as training equipment for colleges, vocational schools, and polytechnics in majors such as mechanical manufacturing and automation, mechatronics, and robotics. It can also be used for comprehensive learning and training in the setup of Industry 4.0 smart, unmanned factories by educational training institutions, corporate engineers, and graduate students during their advanced training stages.

#### **5. Related Courses It Supports**

Fundamentals and Operation of Robotics, Mechanical Manufacturing and Fundamentals, Mechanical Engineering Testing Technology, Mechanical and Electrical Drive Control, Hydraulic and Pneumatic Transmission, Robotics Technology and Applications, Mechatronics System Design, CNC Technology, Mechatronics System Simulation, CAD/CAM, PLC Principles and Applications, Digital Manufacturing Technology, Fault Diagnosis of Mechanical and Electrical Equipment, Manufacturing Technology, Multi-axis CNC Machining Technology, Virtual and Simulation Technology, etc.

#### **6. Workflow**

The 3-axis robotic arm retrieves materials from the raw material warehouse and places them on the conveyor belt. The RFID system reads the values, and the conveyor belt transports the materials to the 6-axis robot, which loads and unloads them to the CNC turning unit for part processing. The finished parts are then sent back to the conveyor belt and transported to the smart warehouse, where the 3-axis robotic arm stores the finished parts, with the RFID system reading the values. Based on actual teaching needs, schools can add expansion modules such as visual inspection and MES smart management systems to this basic workflow.

#### **7. Advantages and Characteristics of the Production Line**

- A. **Small Footprint:** The production line area can be as small as 9 square meters, eliminating the need to worry about space constraints. It can be installed even in small classrooms.
- B. **Low Construction Cost:** Based on large industrial equipment, this set of equipment extracts and condenses core technologies into a small, flexible manufacturing system that is easy for students to learn and use, significantly reducing construction costs for vocational colleges and universities.
- C. **Safe and User-Friendly:** The system incorporates multiple safety protection measures to ensure learners' safety. Using small CNC machines as the carrier for the flexible manufacturing system eliminates students' psychological pressure towards large equipment, facilitating their participation in hands-on operations.
- D. **Comprehensive:** It integrates robot operation and programming, CNC processing, PLC application, and communication, organically combining actuators, control systems, drive systems, and various professional disciplines.
- E. **High Expandability:** Designed with modularity and layering, different programs are designed for different functional needs. These functions can operate independently or be integrated with other modules to form a system. High-speed bus communication protocols are adopted between the CNC and drives, supporting MES system functions.


## 8. Configuration List

- 1 Six-axis industrial robot Set 1
- 2 CNC turning center Unit 1
- 3 CNC milling center Unit 1
- 4 PLC unit Set 1
- 5 Intelligent warehouse Set 1
- 6 Three-coordinate robotic arm Set 1
- 7 RFID management platform Set 1
- 8 Conveyor belt Set 1
- 9 Touch screen control console Set 1
- 10 Industrial-grade CNC system for turning Set 1
- 11 Industrial-grade CNC system for milling Set 1
- 12 Aluminum alloy workbench Set 1
- 13 SMC parallel robotic gripper Set 1
- 14 Three-jaw pneumatic chuck Set 1
- 15 Automatic milling machine clamp Set 1
- 16 6-axis robot control system Set 1
- 17 Teaching pendant and cables Set 1
- 18 Air source compressor station Set 1

### Details for List of product

<b>Model: C19B</b>	<b>Product name: Small Bench Top CNC Milling Machine</b>
<b>Image</b>	<b>Features</b>
	<p>(1) Operates on 220V voltage, occupies a small footprint, consumes low power, and utilizes a combination of transparent acrylic and sheet metal to enhance observation safety while ensuring structural stability and full enclosure.</p> <p>(2) Enhanced functionality with three-axis linkage, equipped with an industrial-grade CNC system compatible with internationally standard programs, featuring automatic fault detection and alarm functions, as well as power failure memory function.</p> <p>(3) The spindle employs a brushless DC motor with high power and large torque.</p> <p>(4) The spindle motor has a power of 1.1KW, suitable for milling, drilling, engraving, and other processing techniques.</p> <p>(5) The three-axis tracks are covered with dust-proof and chip-resistant retractable shields to protect the tracks and ball screws from wear caused by cutting fluid and residual materials.</p> <p>(6) The three-axis C3-grade precision dual-nut ball screws undergo medium-frequency heat treatment and precision grinding, with preload applied to each axis to reduce thermal deformation, resulting in high positioning and repetition accuracy.</p>


			(7) This machine comes standard with an automatic door. Users can optionally equip it with automatic clamping fixtures (customer needs to provide workpiece data), which can be integrated with robotic arms and other machines to form a small-scale automated factory production line.
Spec.	1	X Axis	300mm
	2	Y Axis	130mm
	3	Z Axis	200mm
	4	Spindle Speed	100-3000Rpm
	5	spindle power	1.1KW
	6	Feeding Drive	closed loop motor
	7	Feeding Speed	X/Y Axis 4000mm/min Z Axis3000mm/min
	8	Spindle Taper	MT3
	9	The 4 <sup>th</sup> Axis	Optional
	10	Max.drilling/milling capacity	13mm
	11	Max. end milling capacity	16mm
	12	spinlde to column	170mm
	13	Spindle to table	70-280mm
	14	T-slot	12mm-3
	15	Power	AC220V/50Hz
	16	Product Size	1050*905*920mm
	17	CNC Controller	XD818MD3/Optional

<b>Model: C59</b>	<b>Product name: Small Bench Top CNC Lathes Machine</b>
<b>Image</b>	<b>Features</b>
	<ol style="list-style-type: none"> <li>1 This machine is equipped with an industrial-grade CNC system and ball screws, characterized by its small size, high precision, stable performance, and cost-effectiveness. With servo positioning control, it achieves rapid and precise positioning. The four-station electric tool post enables the processing of complex workpieces, making it an ideal choice for small part processing. It can be configured with front or rear pneumatic chucks and automatic feeding devices. It can be customized for automation upgrades according to Industry 4.0 standards. Multiple machines can be centrally managed and monitored, supporting various communication methods for data exchange. The host computer program interface can be developed independently by customers, offering simplicity and convenience. It is compatible with FMS and is the preferred entry-level choice for flexible machining research in universities and colleges. It can be equipped with other mainstream CNC systems according to user needs, such as Guangshu and KND.</li> <li>2 This machine features high precision, protective devices, and a cooling system. It can automatically turn various rotary surfaces such as cylindrical, conical, and special-shaped surfaces, and can also perform thread turning, boring, and reaming with high efficiency and strong applicability.</li> <li>3 The bed guide rails are precision-ground after ultra-audio frequency quenching, resulting in high hardness and rigidity. The headstock, guide rails, bed saddle, and carriage have substantial dimensions.</li> <li>4 The bed saddle is processed using plastic attachment technology,</li> </ol>

	<p>allowing for smooth movement, reducing wear on the bed guide rails, preventing creeping phenomena, ensuring high precision, and a long service life. The ball screws adopt an integral internal circulation design, supported and pre-tightened by angular contact ball bearings. The guide rails and ball screws are centrally lubricated, providing flexible movement, reducing thermal deformation, and ensuring stable precision.</p> <p>5 The bed saddle, after undergoing special processing, moves smoothly, reducing wear on the bed guide rails, preventing creeping phenomena, ensuring high precision, and a long service life. The ball screws adopt an integral internal circulation design, supported and pre-tightened by angular contact ball bearings. The guide rails and ball screws are centrally lubricated, providing flexible movement, reducing thermal deformation, and ensuring stable precision.</p> <p>6 The spindle is equipped with a precision self-centering three-jaw pneumatic chuck, with internal and external jaws suitable for processing parts of various sizes.</p> <p>7 The spindle motor has a power of 1.1KW and a spindle speed of 300-1750 Rpm, suitable for processing end faces, cutting grooves, and turning threads.</p>
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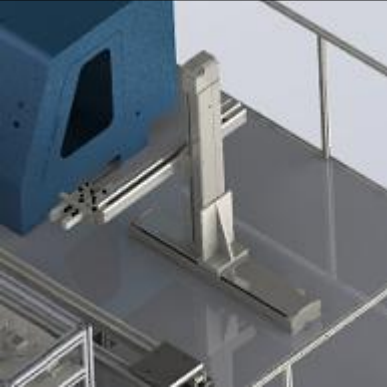
Spec.	1	X Axis	90mm
	2	Z Axis	295mm
	3	Spindle Bore Hole	26mm
	4	Tailstock Taper	MT#2
	5	Spindle Taper	MT#4
	6	Spindle Power	1.1KW
	7	Main Axis Speed	300~1750r/min
	8	Maximum clamping size of chuck	φ 100mm
	9	Max. swing over bed	φ 210mm
	10	Feeding Speed	Z Axis 6000mm/min
	11		X Axis 6000mm/min
	12	Maximum torque of X-axis stepper motor	2.2N/m
	13	Maximum torque of Z-axis stepper motor	2.2N/m
	14	Tailstock travel 尾座行程	50mm
	15	Positioning accuracy	≤0.03
	16	Repeated positioning	0.02mm
	17	Tool Library	4 tool positions
	18	Angles	360°
	19	Tool rotation accuracy	0.005 mm
	20	Cooling system	Yes
	21	CNC Controller	XD818TD3
	22	Power	AC220V/50Hz
	23	Net weight	280KG
	24	Product size/dimension	1300*900*800mm

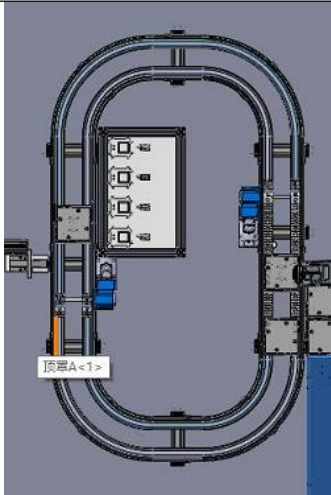
**Product name: Six degree of freedom industrial robot**


Image	Features
	<ol style="list-style-type: none"> <li>1 1. Basic components and principles of industrial robots (motor, gearbox, driver, controller), capable of completing basic electrical wiring and structural installation;</li> <li>2 2. Familiar with the basic movements of industrial robots, including joint movements, interpolation movements, linear interpolation movements, circular interpolation movements, etc;</li> <li>3 3. Master the coordinate system of industrial robots (user coordinate system, tool coordinate system, robot coordinate system, world coordinate system) and proficiently convert coordinate systems;</li> <li>4 4. Master the basic programming instructions for industrial robots and program them;</li> <li>5 5. Master the use and programming of motion control cards;</li> <li>6 6. Master comprehensive programming for simulating various scenarios in robot systems;</li> <li>7 7. The end is equipped with a pneumatic gripper, as well as a dual function tool for grabbing bar materials and block materials, and an installation bracket, which can complete the feeding attachment action of grabbing materials and placing them in the CNC lathe machining center and CNC milling center</li> </ol>

Spec.	1	Number of Axes of Freedom	6 Axis
	2	Function	3C, painting, sanding, loading/unloading, handling, etc. ;
	3	Payload	6kg
	4	Arm Reach	750mm
	5	Repetitive Positioning Accuracy	±0.05mm
	6	Drive Mode	DC SERVO DRIVE
	7	Body Weigh	≤85kg
	8	Energy Consumption	2.5 KW
	9	Maximum Motion Range	J1: ±170° J2: +120~-85° J3: +83~-150° J4: ±180° J5: ±135° J6: ±360°
	10	Maximum Motion Speed	a)J1/J2/ J3: 200° /s b)J4: 400° /s c)J5: 356° /s d)J6: 600° /s
	11	End I/O	DI * 2; DO * 2; AI * 2
	12	Communication Method	TCP/IP, Modbus, EtherCAT
	13	Programming Language	Supports Blockly, graphical programming, Lua, etc.
	14	Installation Method	Floor-standing/Table-top

	15	Operating Temperature	0°C~45°C
	16	Operating Humidity	10%-95%, non-condensing
	17	Number of Controlled Axes	≥6 axes, with the option for external expansion axes
	18	Drag Teaching	Supports zero-force drag of the robot, enabling quick handheld teaching
	19	Trajectory Replay	The entire trajectory and end actions can be recorded during drag and teach. After teaching, the full trajectory can be reproduced, achieving what is taught.
	20	Teaching Method	Handheld teaching pendant
	21	Communication Interface	EtherCAT (for external expansion axes), Ethernet 21. I/O Interface: ≥16 digital outputs; ≥16 digital inputs/outputs (multiplexed); ≥2 analog outputs (0V-10V voltage, 4mA-20mA current); ≥2 analog inputs (0V-10V voltage, 4mA-20mA current)
	22	Protection Grade	≥IP20
	23	Power Supply	AC380
	24	SMC Parallel Robotic Gripper	Included

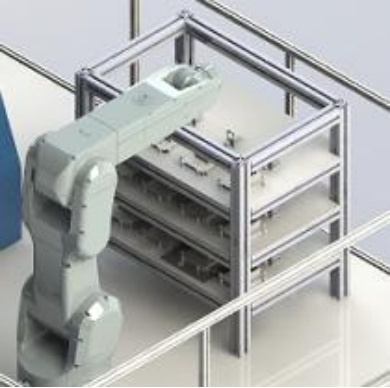
<b>Three-axis coordinate robotic arm</b>			
<b>Image</b>		<b>Features</b>	
		<p>Centered with the RFID system, it realizes monitoring of workpieces; communicates with the intelligent warehouse system to monitor the material status in the warehouse in real-time; communicates with the machine vision inspection system; communicates with the central control computer;</p> <p>The end is equipped with a pneumatic gripper, which also has dual-functional tools for gripping bar stock and block parts, as well as a mounting bracket. It can complete the auxiliary action of grabbing materials and delivering them to the CNC lathe machining center and the CNC milling center.</p>	
<b>Spec.</b>	1	X Axis	450mm
	2	Y Axis	350mm
	3	Z Axis	500mm
	4	Loading rate	≥1kg
	5	Pneumatic finger	Available According to the project,
	6	control system	PLC
	7	Ball screw	1605
	8	linear guide rail	HIWIN linear guide rail
	9	Feeding Speed	X/Y Axis 3000mm/min Z Aixs 2000mm/min
	10	Positioning accuracy	0.02mm
	11	Repeated positioning	0.01mm
	12	Feed control	Closed-loop stepper motor (servo motor optional)

Product name: <b>Circular assembly line unit</b>			
Image		Features	
		<p>The fixed frame of the assembly line is composed of 60*40 aluminum profiles arranged in a quadrilateral shape (ABCD), and two conveyor belts transport the workpiece trays in a circular direction.</p>	
Spec.	1	Fixed frame of the assembly line	Composed of 60*40 aluminum profiles arranged in a quadrilateral shape (ABCD), two conveyor belts transport the workpiece trays in a circular direction
	2	Bottom support	Adjustable metal lifting feet
	3	Connection method	Chain connection
	4	Overall dimensions	3500*1500mm
	5	Material loading and unloading blocking mechanism	Pneumatic cylinder method
	6	Material of the bottom of the assembly line trough	Stainless steel plate
	7	AC motor power	$\geq 200W$
	8	Motor drive method	PLC control system
	9	Conveying speed	1-7 meters per minute


Product name: <b>assembly line unit</b>			
Image		Features	
			
Spec.	1	Fixed frame of the assembly line	Composed of 60*40 aluminum profiles arranged in a quadrilateral shape (ABCD), two conveyor belts transport the workpiece trays in a circular direction
	2	Bottom support	Adjustable metal lifting feet
	3	Connection method	Chain connection
	4	Overall external dimensions	1m*



	5	Material loading and unloading and blocking mechanism	Pneumatic cylinder method
	6	Material of the bottom of the assembly line trough	Stainless steel plate
	7	AC motor power	$\geq 200W$
	8	Conveying speed	1-7 meters per minute
	9	Motor drive method	PLC control system
	10	Motor power	0.24kw, Variable Frequency Stepless Speed Regulation
	11	Material transfer plate	1 unit
	12	Wide flexible single chain plate	100mm


<b>Product name: Stereoscopic Warehouse Unit</b>			
<b>Image</b>		<b>Features</b>	
		<p>The main function of the stereoscopic warehouse unit is to provide the system with two major storage functions: raw material processing for workpieces and finished product storage. It employs three-tier shelving to store unit loads and utilizes corresponding material handling equipment to perform inbound and outbound operations for goods.</p>	
Spec.	1	The frame of the stereoscopic warehouse	Aluminum profile with a thickness of $\geq 40mm$
	2	Bottom support	4 adjustable metal lifting feet
	3	Electrical box	Sheet metal with a glossy white baked enamel finish
	4	Number of storage bins	12
	5	Layout of storage bins	Three-tier, four-column layered layout
	6	External dimensions	1500*1200*1700mm
	7	Method of bin detection	NPN proximity switch
	8	Detection of workpieces in bins	Touchscreen display
	9	Dimensions of pallets	150*150*12mm/100*90mm
	10	Method of pallet clamping	Aluminum alloy top support method or pneumatic cylinder clamping method
	11	Method of pallet detection	Electronic label

## Vision Inspection System

Image	Features
	<p>The primary function of the inspection unit is to verify the accuracy, appearance, and shape quality of workpieces. It captures images of the workpieces through cameras and uses an image processor to determine whether the workpieces are qualified. Unqualified workpieces are rejected, while qualified workpieces are conveyed to the next unit. Unqualified workpieces are diverted to a reject bin.</p>


Spec.	1	Camera	Effective pixels	≥30 万
	2		Color	Color
	3		Pixel size	≥2.2 * 2.2um
	4		Lens mount	C-Mount
	5		Optical filter	≥650nm
	6		Signal-to-noise ratio	≥40dB
	7		Dynamic range	≥60dB
	8		Shutter type	Rolling shutter exposure
	9		Exposure time	Bayer format: ≥16 μ s to 1sec; Other formats: ≥28 μ s to 1sec Bayer form: ≥16 μ s~1sec; 其他格式: ≥28 μ s~1sec
	10		Exposure control	Automatic/Manual
	11		Data interface	USB3.0
	12		Data format	Mono 8/10/12 , Bayer GR 8/10/10p/12/12p , YUV422_YUYV_Packed, YUV422_Packed, RGB8
	13	Lens	Focal length	≥12mm
	14		Maximum image circle diameter	≥1/1.8 " ( φ 9mm)
	15		Lens aperture	≥F2.8~F16
	16		Lens angle of view (DHV)	≥1/1.8 " : 39.8° , 33.2° , 22.5°
	17		Optical distortion	≤-0.005%
	18		Flange focal distance (back focus)	≥17.526mm
	19		Minimum object distance	≥0.1m
	20		Filter thread	≤M27 * 0.5
	21	Software	Functions	include presence/absence/orientation detection, color/position judgment, positioning, 2D dimension measurement, ID recognition, character recognition, etc.;
	22		Positioning function	≥10 tools, including rapid feature matching,

			high-precision feature matching, circle finding, Blob analysis, caliper tool, edge finding, edge intersection, parallel line finding, etc.;
	23	Measurement tool	≥ 10 tools, including line-circle measurement, line-line measurement, circle fitting, straight line fitting, pixel statistics, histogram tool, etc.;
	24	Calibration tool	≥6 tools, including calibration plate calibration, N-point calibration, distortion calibration, etc.;
	25	Alignment tool	≥ 4 tools, including camera mapping, point set alignment, etc.;
	26	Image processing tool	≥ 10 tools, including image mosaicking, morphological processing, image filtering, image enhancement, sharpness evaluation, affine transformation, ring unwrapping, etc.;
	27	Logic tool	≥ 10 tools, including conditional detection, formatting, character comparison, point set, time-consuming statistics, etc.;
	28	Recognition tool 识别工具	≥ 4 tools, including barcode recognition, QR code recognition, etc.;
	29	Communication mode	Communication mode: Supports Modbus communication, PLC communication, IO communication, etc.;
	30	Editable software operation interface	Yes


Touch Screen Control Console			
Image		Feature	
		<p>The main control console includes a PLC electrical control and I/O communication system, which is primarily responsible for controlling peripheral equipment and robots, as well as implementing the overall process and logic control of the intelligent manufacturing unit. The touchscreen is responsible for the human-machine interface and setting operational data.</p>	
Spec.	1	Working Voltage	DC24V
	2	Dimensions	500*270*315
	3	Material	painted sheet metal
	4	LCD Screen	Not less than 10.2 inches
	5	Backlight	LED
	6	Display Colors	65535 True Color
	7	Resolution	>1024x600
	8	Display Brightness	200cd/m2
	9	Touch Screen	Resistive
	10	Input Voltage	24 ± 20% VDC
	11	Rated Power	5.5W
	12	Processor	Cortex-A8, 600MHz
	13	Memory	>128M
	14	System Storage	>128M





			(operating environment 0-50°C) ±1%
14		Signal Module Expansion	Up to 8 signal modules
15		Signal Board Expansion	Up to 1 signal board
16		Communication Module Expansion	Up to 3 communication modules
17		High-speed Counters: Single-phase	3 at 100 kHz and 3 at 30 kHz clock frequencies; Quadrature phase: 3 at 80 kHz and 3 at 20 kHz clock frequencies
18		Pulse Output	4
19	Performance	Boolean Operation Execution Speed	0.08μs/instruction
20		Move Word Execution Speed	1.7μs/instruction
21		Real Math Operation Execution Speed	2.3μs/instruction
22	Communication	Port Count	
23		Type	以太网
24		Connections	HMI X3 programming device X1 Ethernet instructions in user programs X8 CPU-to-CPU X3
1		Power	Voltage Range
2	Hold-up Time (Power-off)		10 ms at 24 V DC
3	Maximum Ripple Noise		<10 MHz

FIRD UNIT	
Image	Features
	<p>An RFID system unit is a non-contact automatic identification system that automatically identifies target objects through radio frequency (RF) wireless signals. It is used for recording information on workpiece materials, processing path records, and product traceability management. The system consists of RFID tags and RFID readers. The tags are installed on the tooling plates where the workpieces are placed, recording the information of the parts placed on those tooling plates. RFID readers are installed at each workstation where the tooling plates pass through. When a workpiece arrives at the workstation, the system can use the reader to identify the transportation and processing route of the workpiece. Each tooling plate for transportation is equipped with an RFID tag, and at each processing workstation, the materials need to be read, and the information is transmitted to the server via the network. This allows for real-time tracking of material location information and storage location information, enabling traceability management of materials, finished products, and semi-finished products.</p>
Spec.	1 Operating Frequency 13.56MHz

2	Supported Standard	SO/IEC 15693/ISO 18000-3M1
3	Operating Voltage	+12V~+24V DC
4	RF Out Power	0.1W
5	Maximum Power Consumption	1W
6	Card reading Indicator	LED (flashes when reading a card)
7	Card reading Distance	1cm
8	Communication Interface	RS485
9	Communication Protocol	Modbus
10	Protection Level	IP67
11	Operating Temperature	-10° C~+65° C
12	Dimension	Ø30×75mm

Air compressor			
Image		Features	
		Provide air pressure for the pneumatic working parts of the entire equipment.	
Spec.	1	Operation Time	18.1, capable of continuous 24-hour operation;
	2	Power	1.1KW
	3	Displacement	80L/min
	4	Pressure	7.0Pa
	5	Cooling Method	风冷
	6	Overall dimensions	L730mm×W360×H620mm
	7	Net Weight	35Kg
	8	Air Storage Tank Capacity	50L

Aluminium Working Platform			
Image		Feature	
		The workbench frame includes the following: one cabinet frame capable of installing equipment of 1.6 and 1.7 sizes; all relevant auxiliary materials inside the cabinet, including power distribution, wire ducts, buttons, indicator lights, grounding, terminals, air pipes, etc.; and installation and wiring of equipment inside the frame according to the design.	
Spec.	1	Size (approximately)	3500×3200×1200mm
	2	Structure	Integrated rack design, platform + fence
	3	Material	Aluminium profile
	5	Fence	Transparent acrylic
	6	Casters	Movable
	7	Leveling Feet	Height ajustable

Personal Computer			
Image		Feature	
		Processing data analysis from vision tests	
Spec.	1	CPU	$\geq 8$ cores, main frequency $\geq 10$ th generation I5
	2	Hard Drive	$\geq 1$ TB+256G
	3	Memory (RAM)	$\geq 16$ G
	4	Graphics (GPU)	$\geq 1060$ ti
	5	WIFI	Yes
	6	Monitor	$\geq 21.5$ inch

User Site Map



工业4.0智能制造实训平台

