The First World Vocational College Skills Competition

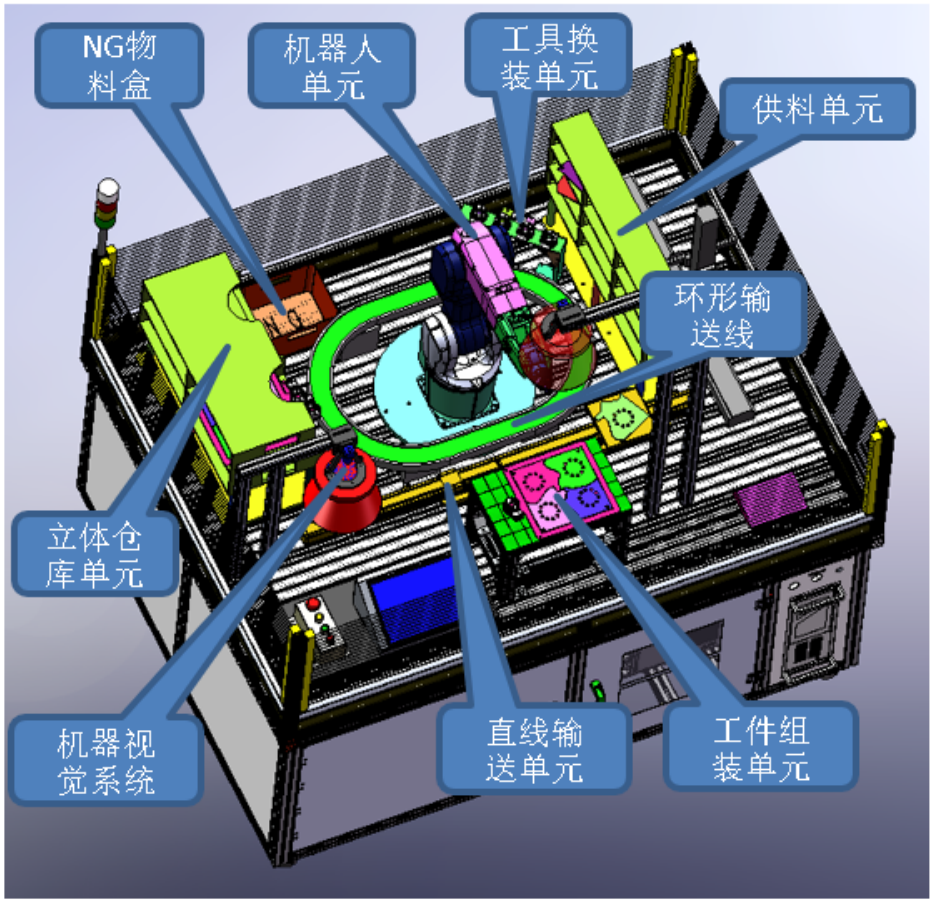
Industrial Robot Technologies Application

Test Project

Description of competition equipment:

The **competition platform for industrial robot and intelligent vision system application** includes a 6-DOF industrial robot, intelligent visual inspection system, PLC control system and a set of feed, linear conveying, circular conveying, assembly and warehousing mechanisms, with the aim to realize sorting, detection, handling, assembly, storage, etc. of workpieces, as shown in Fig. 1.

The **competition platform for industrial robot and intelligent vision system application** is composed of robot unit, vision system, tool change unit, feed unit, linear conveying unit, circular conveying unit, workpiece assembly unit and stereoscopic warehouse unit. Various components are installed on the profile desktop, mechanical structure, electrical control circuit and actuator are relatively independent, and the design of industrial standard parts is adopted. Mechanical assembly, electrical circuit design and wiring, PLC programming and debugging, intelligent vision flow design, and industrial robot programming and debugging can be carried out on this platform.



	NG material box
	Industrial robot unit
	Tool change unit
	Feed unit
	Circular conveying line
	Stereoscopic warehouse unit
	Machine vision system
	Linear conveying unit
	Workpiece assembly unit

Fig. 1 Competition Platform

1. Industrial robot unit

A 6-axis industrial robot is used. It can be fixed onto the profile experiment table and provided with a supporting teach pendant and controller to program, control and operate the robot. It can be equipped with multiple types of fixtures, suckers, measuring implements and tools for such operations as grabbing, sucking up, handling and assembling workpieces. Besides, it can use a machine vision camera for visual inspection of the product made by assembling workpieces.

2. Machine vision system

An industrial camera and the vision unit of light source are used for identification and positioning of products and color identification.

3. Tool change unit

The tool change unit is composed of a quick change master, quick change slaves, a gas clamp tooling, a sucker tooling, a visual tooling, a positioning tooling, and a tooling support, etc. The quick change master is installed on the end flange of the robot, and can be quickly connected with the quick change slaves for automatic circuit and gas circuit, so that the robot can change the fixture tooling automatically based on different tasks. The tooling support is installed on the profile experimental table for the robot to automatically place and take different toolings.

4. Feed unit

This unit is composed of a magazine, a pushing cylinder, a movement module of ejection cylinder, and a photoelectric sensor and installed on the profile experiment table to push workpieces from the workpiece magazine to the conveying line one by one.

5. Linear conveying unit

This unit is composed of a servo motor and a linear module and installed

on the profile experiment table to convey workpieces.

6. Workpiece assembly unit

This unit is installed on the profile rack to assemble workpieces.

7. Stereoscopic warehouse unit

With the 2×2 design including an upper layer and a lower layer, this unit can store 4 sets of finished products in total and also be used for temporary storage of empty product trays.

8. Circular conveying line

The circular conveying unit contains an AC speed governing system, which is composed of a frequency converter, a three-phase AC motor, an annular plate chain (belt conveyor) and a through-beam sensor, and installed on the profile experimental table to convey workpieces.

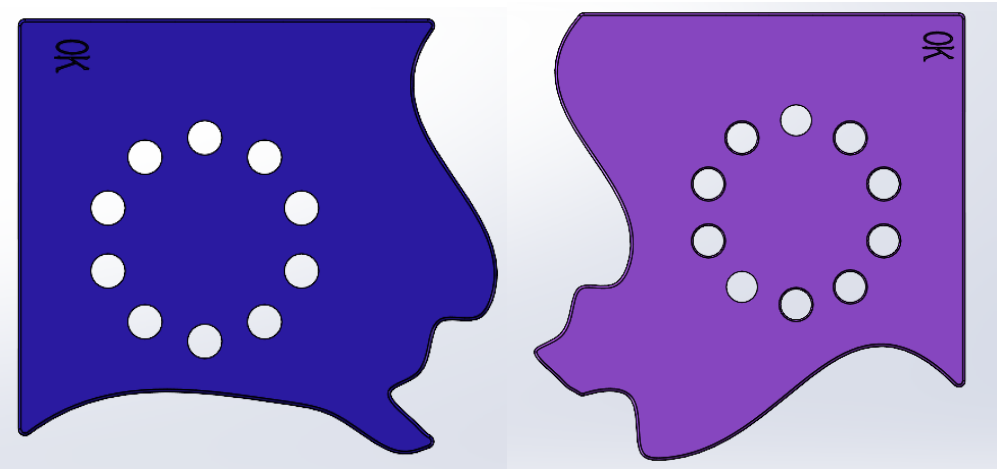
9. NG material box

In case of outputting materials from the feed unit, NG materials may be mixed with them. After being inspected by the machine vision system, these materials will be conveyed to the NG material box using a 6-axis robot arm.

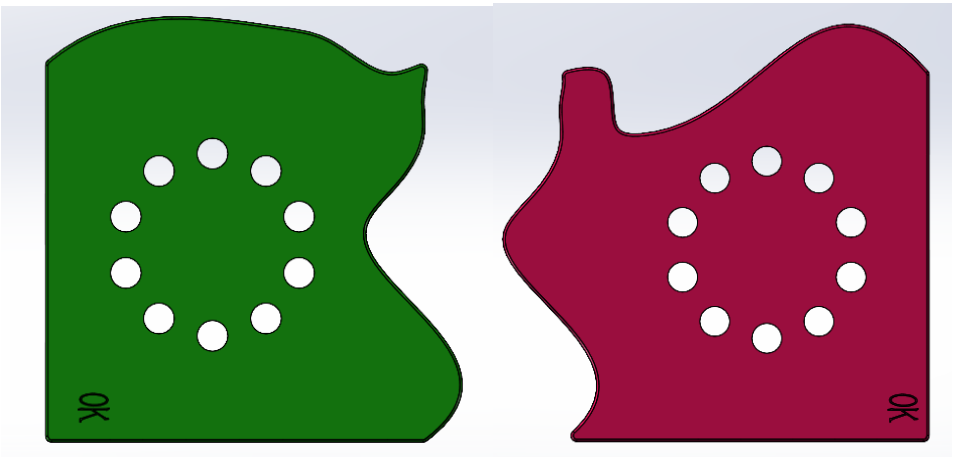
The main work objective is to realize visual sorting, visual identification, automatic assorting and warehousing. The basic flow is as follows: convey the workpieces of a product from the stereoscopic warehouse to the conveying line, sort out the required workpieces through visual identification, eliminate and put the deficient or nonconforming workpieces into the warehouse, then guide the robot to grab workpieces through visual positioning, and after the completion of grabbing, place the corresponding workpieces the corresponding positions on the tray; after four workpieces are successfully placed on the tray, carry out visual inspection for the quality of tray arrangement, and put finished products into the warehouse after the completion of the inspection.

The product is composed of 4 workpieces, i.e. Workpiece 1, Workpiece 2, Workpiece 3, and Workpiece 4.

The color and type of each workpiece (component) are shown in Fig. 2.



(a) workpiece 1 (blue) **(b) workpiece 2 (purple)**



(c) workpiece 3 (green) **(d) workpiece 4 (red)**

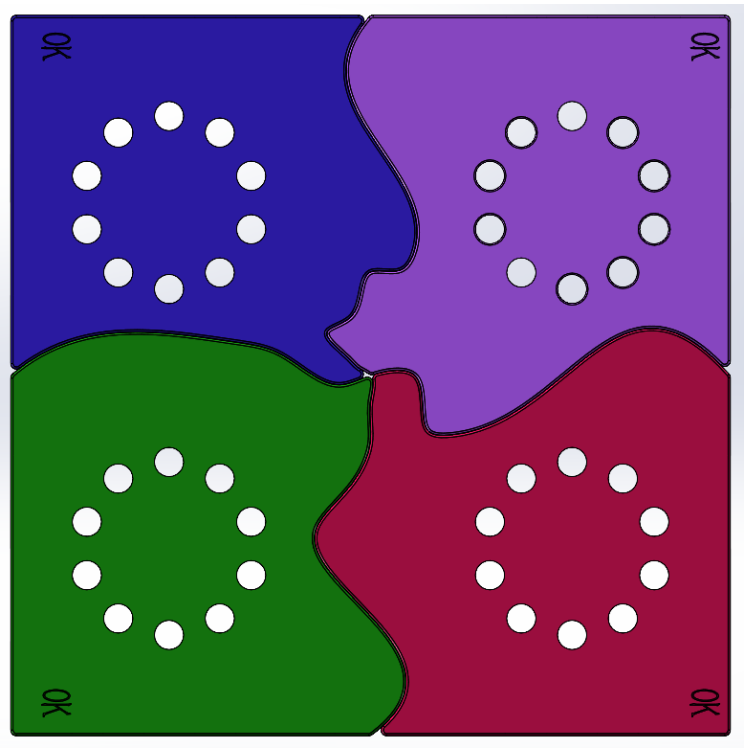


Fig. 2 Qualified Workpieces

As shown in Fig. 2, the corresponding workpieces are identified and grabbed, and finally, the pattern (as shown in Fig. 2) of the finished product is spliced on the assorting tray.

The tray structure and the state of workpieces placed on the tray are shown in Fig. 3. The tray is designed with grooves, in the middle of which is the **workpiece placement area**.

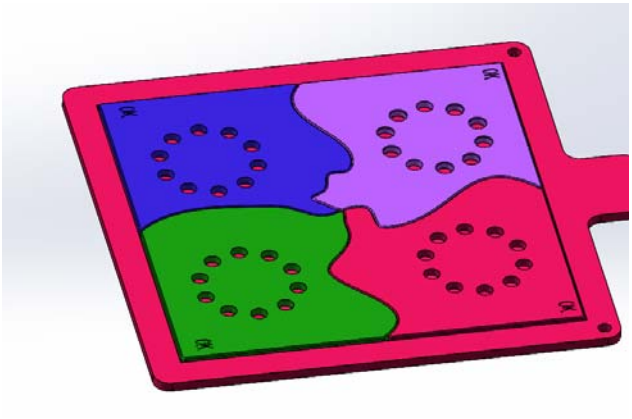


Fig. 3 State of Workpieces (to be Assembled) on the Tray

Assembly line is composed of four parts: a workpiece warehouse, an assembly line, an assembly area and a finished products warehouse. The defined workpiece magazine mainly stores four workpieces and other different workpieces, the assembly line mainly conveys workpieces from the finished products warehouse to the grabbing point, and the assembly area is mainly used to assemble and splice the four workpieces identified.

The finished products warehouse mainly stores the assembled workpieces and also temporarily stores other workpieces.

Table 3 shows the preset IP address of the industrial robot, and the IP addresses of the remaining main modules in the system can be modified by each team as the case may be.

Table 3 Preset IP Address of the Industrial Robot

No.	Name	IP address allocated	Remarks
1	Industrial robot	192.168.10.103	Preset

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Test Project

Module I

Notice for competitors:

1. The Test Project consists of 7 pages, and if there are any missing pages or illegible handwriting in the TP, please promptly indicate it to the judge and have it replaced.
2. During the Competition, two computers (including one industrial personal computer) are provided, and the references (i.e. product manuals of robot, PLC and frequency converter, and IO variable table of equipment) are stored in the "D:\First Competition Schedule\References" folder in .pdf format.
3. Teams should complete the contents specified in the Test Project within **3 hours**; the procedure documents created by competitors during the Competition shall be stored in the "D:\First Competition Schedule\Workstation No." folder, and no point will be awarded for any operating records or procedure documents failing to be stored in the designated position.
4. The Competition Papers submitted by competitors should not contain any

information about identity, such as school and name; otherwise, the results will be invalid.

5. If any damages and mechanical impacts to robot controller, I/O component, camera, PLC and frequency converter are caused by incorrect wiring or improper operation, it will be handled according to the deduction form.
6. The initial state and specific testing requirements of each task should be given at the start of the corresponding competition, prior to or during task marking in accordance with the assessment requirements.
7. Workpieces should not be stacked up in the assembly workstation, spare parts warehouse and finished products warehouse, and only one workpiece is allowed to be placed on one workpiece placement position at the same time.
8. During the fulfillment of each task, please promptly save programs and data.

Session: _____ Workstation No.: _____ Date: __

Installation, debugging and programming of industrial robot and machine vision system

Task I: Design and wiring of master control system circuit

(I) Installation and wiring of master control cabinet components

Before installation and wiring, the master control circuit board is in the state of basic wiring, and the wiring of master PLC, industrial robot and vision system shall be completed.

The requirements are as follows:

1) Complete the connection between the master PLC and the industrial robot;

2) Complete the connection between the master PLC and the intelligent vision system;

3) For the missing network cables, competitors are required to utilize the tools provided to strip and crimp cables, make network cable connectors, and correctly connect cables.

After completing (I) in Task I, please raise your hand to signal to the judge for judgment!

Task II: Mechanical installation

(I) Installation and air duct connection of mechanical unit

The requirements are as follows:

1) Complete the air duct connection between the robot and the end-of-arm tooling (EOAT) according to the pneumatic schematic diagram;

2) Complete the installation of all quick-change grippers in accordance with the assembly drawing.

After completing (I) in Task I, please raise your hand to signal to the judge for judgment!

Task III: Installation and debugging of vision system

Programming and debugging of 2D vision system

(I) 2D camera installation and network system connection

Complete the camera installation according to the camera support and parts provided on site. Next, complete the connection of camera, programmable computer, master control unit and touch screen.

The requirements are as follows:

1) Install the camera support and the camera;

2) Connect the power cord and communication cable of the camera.

3) Select and connect an appropriate lens and adjust the focus

The testing requirements are as follows:

Start the camera programming software, display the images in the field of

view of camera in real time, and adjust the camera support in the appropriate position.

(II) Backlight control setting

Conduct the programming on the master PLC to control the opening and closing of backlight and ensure that the intelligent camera can stably and clearly capture image signals in both states (ON/OFF) of backlight.

(III) Camera debugging and programming

In the vision programming software, open the sample program provided to complete the calibration of images and the sample learning tasks. (Place the sample program in the "D:\First Competition Schedule\References" folder.)

The requirements are as follows:

1) Calibrate images to realize the consistency of the size displayed in the camera and the actual physical size (with the size error of not more than ±5%);

2) Take photographs of the single workpiece on the tray, use the visual tools to write a camera vision program for learning the workpiece, and acquire the information about appearance and color of the workpiece;

3) Calibrate the single workpiece on the tray, acquire the shape, position and angular deviation of the workpiece, and utilize the visual tools to write a camera vision program for learning the workpiece. The camera lens center should be the zero position and the workpiece angle calibrated by the camera

should be zero degree;

After completing (I) - (III) in Task III, please raise your hand to signal to the judge for judgment!

Task IV: Programming and debugging of industrial robot system

(I) Industrial robot setting

Utilize the calibration rod and the calibration plane set on site to complete the setting of tool and the workpiece coordinate systems of the industrial robot; Manually enter the tool coordinate systems of four sets of grippers in line with the given data.

(II) Industrial robot teach programming

Through the teaching, programming and playback of an industrial robot teach pendant, 4 types of workpieces can be conveyed from the tooling fixing position to the designated position in the splicing area one by one to complete splicing.

The testing requirements are as follows:

After completing (I) - (II) in Task IV, please raise your hand to signal to the judge for judgment!

Note: **If a competitor fails to complete all debugging tasks in the first competition schedule, his/her tasks of the second competition schedule cannot continue to be judged in the second competition schedule.**

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Module II

Notice for competitors:

1. The Test Project consists of 6 pages, and if there are any missing pages or illegible handwriting in the TP, please promptly indicate it to the judge and have it replaced.
2. During the Competition, two programmable computers (including one industrial personal computer) are provided, and the references (i.e. product manuals of robot, PLC and frequency converter, and IO variable table of equipment) are stored in the "D:\Second Competition Schedule\References" folder in .pdf format.
3. Teams should complete the contents specified in the Test Project within **3.0 hours**; the procedure documents created by competitors during the Competition shall be stored in the "D:\Second Competition Schedule\Workstation No." folder, and no point will be awarded for any operating records or procedure documents failing to be stored in the designated position.
4. The Competition Papers submitted by competitors should not contain any

information about identity, such as school and name; otherwise, the results will be invalid.

5. If any damages and mechanical impacts to robot controller and I/O component, camera, PLC and frequency converter are caused by incorrect wiring or improper operation, it will be handled according to the deduction form.
6. The initial state and specific testing requirements of each task should be given at the start of the corresponding competition, prior to or during task marking in accordance with the assessment requirements.
7. Workpieces should not be stacked up in the assembly workstation, spare parts warehouse and finished products warehouse, and only one workpiece is allowed to be placed on one workpiece placement position at the same time.
8. During the fulfillment of each task, please promptly save programs and data.

Session: _____ Workstation No.: _____ Date: ___

Task I: Inspection of the accuracy of tasks in Module I

After Module II is formally started, competitors should inspect the process with the methods such as visual inspection and tactile inspection (touch), requiring:

1) Competitors should not operate the robot;

2) Competitors should not operate the computer;

3) Competitors should not tap on the touch screen;

4) Competitor should be allowed to read the Test Project of Module I

The inspection process lasts for a total of 10 minutes. After a competitor inspects various units of the equipment and confirms that no error is found, he/she should write the workstation number on confirmation form for confirmation. (**The true information such as school and name cannot be written**)

Task II: Debugging

Complete the control function debugging of various modules (tray line and assembly line) in the master control unit.

The baseplates for assembly workstation, spare parts warehouse and finished products warehouse have been installed on the plate link chain of the assembly line with the aim to prevent possible equipment damage caused by movement of the assembly line and avoid serious accidents of mechanical

collision.

 During operation, attention should be paid to the following points: when the reference point is searched, pay attention to the direction of motion of the assembly line, and complete the reference point searching within the range of motion.

(I) Identification and sorting of visual materials

Identify and calibrate the qualified materials.

The testing requirements are as follows:

1) Identify and calibrate the correct workpieces (1-4) respectively.

2) The calibration contents mainly consist of appearance and color of workpieces.

3) Place the nonconforming workpieces manually in the photo-taking position for identification and verification.

(II) Identification, positioning and grabbing of materials

Debug the PLC program to make PLC, robot and visual communication normal and realize the automatic grabbing of products from the conveying line by the robot.

The testing requirements are as follows:

1) Test the PLC, robot and vision signals.

2) Invoke the given control interface of the PLC and control the conveying line to move correctly.

3) Utilize the given communication example to conduct the logical processing of the data collected by the vision system and then send the data to the robot.

4) Make the three items cooperate to accurately grab products.

After completing (I) - (II) in Task II, please raise your hand to signal to the judge for judgment!

(III) Material splicing on the tray by the robot

The testing requirements are as follows:

1) Place the correct workpieces (1-4) identified to the designated position on the tray, and send incorrect workpieces to the waste basket.
2) Splice the four workpieces on the tray.
3) Finally splice them into the specified pattern.

(IV) Image recognition and warehousing of finished products

1) Take photographs of final products for visual verification.
2) Visually inspect whether the splicing effect meets the requirements (the score for matching with the template image should be higher than 0.5 point).

   Note: The matching score typically represents the level of similarity between the target and the template in the operators of the visual

matching algorithm, where 1 denotes 100% similarity and 0 denotes 0% similarity.

3) After visual testing is qualified, put finished products in the warehouse.

After completing (III) - (IV) in Task II, please raise your hand to signal to the judge for judgment!