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Industrial Arc Welding Robot Defect Tracking System in Automotive Industry

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Abstract - **Industrial robots are important in production processes especially automotive industry for increase rate of production, products quality promotion, continues working and lower manufacturing cost. Also robots improve labors conditions in automotive production lines so that they can do repetitive processes and pieces displacement by minimum possible force. Regarding to reduction of labors, multi purpose and high speed of robots, they can have plentiful usage in industry but fast and exact defect tracking of industrial robots in case of incidence of faults is one of the automatic industrial factories problems which cause to stop production. In this essay, at first a concise introduction is explained about industrial robot structure, then robot defect tracking program is presented in order to fast and easy tracking of defects which are created and proposal presentation to remove those defects.**

Index terms - Arc welding robot structure, Industrial robot defect tracking, Automotive industry.

I. INTRODUCTION

Simultaneous industry and technology progress in various fields are entirely changed modern world feature and human life. Development of research and scientific fruition from one side and utilize the practical results of these researches in industrial world, is provided plenty of possibilities for development of industrial environment. In this direction, mankind access to robots and using this mankind manufactured tool in industry and living environment is reckoned great valuable success. Robots appearance and use of automation in industrial processes, is created a large amount of changes in different industry.

Promotion products quality, increasing rate of production, decreasing production cost, increase productivity, decrease damages, increase flexibility, work ability in hazardous area, increase safety in work area and many other cases are advantages of using robots in today's industry.

Nowadays robots are used in most of industries among automotive industries, space industries, medical applications, electronic industries, army industries, transport industries, food industries, etc.

An industrial robot consists of a multi purpose machine with programming ability that has characteristic and abilities like human. In nowadays robots are seen most similarity with human system in robots mechanical arms, which are used for various industrial duties. From characteristic point of view like ability of taking decision, reply to input sensing and connection establishment with another machines is less similarity between robot and human. Robots are used for applications like welding, material handling, painting and assembling in industry.

Expression of robot industry organization in definition of industrial robot is an industrial robot consist of one multi purpose skilled mechanical arm with programming ability that is used in order to material, components, tools, or special devices displacement in various movement path and for various duties accomplish.

Skilled mechanical arm is an arm that should have ability of pick up and displacement of things exactness and desired velocity.

Programming ability means that a robot is able to do diverse duties with changing work schedule. Thus, robot is a tool which is programmable for accomplish various duties.

In this essay, in order to easy tracking of robot errors during production by technicians, we proceed to check and evaluation HR006 Hyundai robot which is used in automobile production line for arc welding of automobile body [1].

At first, it is necessary that we should have brief knowledge in field of above mention robot structure, components and peripheral devices in order to recognition and simple tracking of robot errors.

II. INDUSTRIAL ROBOT STRUCTURE

HR006 Hyundai robot is six degree of freedom, the repeatability of this robot is ± 0.1 mm, the weight that could be grasped is 6 Kg and weight of this robot is 145 Kg that are shown in Fig.1 and Table I [2][3][4].

This robot has plentiful applications in various industries consist of arc welding, material handling, machine loading / unloading, sealing, cutting, polishing [2].
This robot will have appropriate efficiency in an environment with below conditions:

Free from corrosive gas or liquids, explosive gases, excessive electrical noise, normal humidity %75, ambient temperature between zero to $45°C$ [2].

Fig.1 HR006 Hyundai robot

TABLE I
HR006 Hyundai Robot Specifications

Item			Specifications
Construction			Articulated
Structure			Articulated type
Degree of freedom			6 Axes
Drive system			AC servo system
Maximum Motion range	Arm	Swivel	±180°
		Horizontal	+150° ~ −90°
		Vertical	+90° ~ −115°
	Wrist	R2 Rotating	±180°
		B Bending	±135°
		R1 Twisting	±320°
Maximum speed	Arm	Swivel	160 °/sec
		Horizontal	175 °/sec
		Vertical	175 °/sec
	Wrist	R2 Rotating	300 °/sec
		B Bending	300 °/sec
		R1 Twisting	480 °/sec
Payload			6 Kg
Allowable Wrist torque	R2	Rotating	12 (N.m)
	B	Bending	10 (N.m)
	R1	Twisting	6 (N.m)
Repeatability			±0.1mm
Ambient temperature			0 ~ 45°C
Weight			145 Kg
Operating range area			2.14 m (Side view)
Installation method			Floor, ceiling, wall

III. ARC WELDING ROBOT COMPONENTS

Components of robot are shown in Fig.2. Robot controller is the main part of system that includes a microcomputer and interfaces for connection with robot peripheral devices [4] [5].

System operator needs a monitor and a keyboard in order to robot training programs editing and robot operation status control.

A teaching pendant (T/P) is the other robot communication device attached to the system controller that is used for manual training of robot positions, parameter settings and online programming [4][5].

Field Bus provides serial connection bus, digital, bi-directional among element level devices like sensors, actuators, relays, motors, controllers, robots and etc [6][7][8].

Arc welding robot system is constructed with welding robot, robot controller, CPU (central processing unit), robot programming pendant, low pass filter, A/D converter, personal computer, Field Bus module, Field Bus cable, CCD (charge coupled device) camera, welding power source, welding wire feeder, welding torch, supplying shielding gas, gas regulator, gas cylinder, work piece, power switch, terminal to welding torch (+), terminal to work piece (-), metal consent to welding wire feeder, consent to gas heater, welding cable, control cable, gas hose, lead wire of gas heater, secondary cable to work piece, primary cable, nozzle cleaner, cooling water system, DC SMPS (power supply system and SR1 is input power), CNRTP (Connector of teach pendant), CNEC (connection with encoder signal) [9][10].

It is possible occur technical defect on above mentioned parts thus it is required to define defect tracking system.
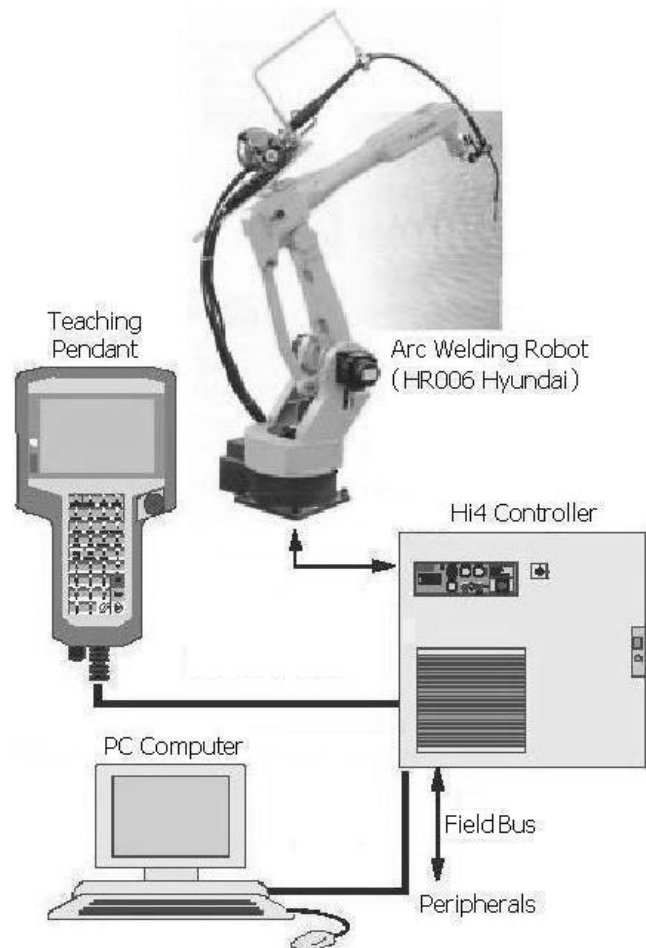

Fig.2 Components of HR006 Hyundai robot

IV. ROBOT DEFECT TRACKING SYSTEM

For automotive mass production and continuous production in order to increase of daily production, necessity to automation production line is mandatory affair, but robots like any other mechanical and electrical devices need periodically maintenance. Because machinist factories have several shifts during day and night, as a result continuous and concentrate presence of maintenance department experts in order to repair robots created problems in production line is necessary. It takes more time and cost because sometimes several hours are needed to find robot defect.

Thus, we prepared an industrial robot defect tracking system after knowledge mechanical, electronic and control industrial robot specifications and gathering experts and technicians' experiences in robot maintenance department [4][5][7][10].

At first, all kind of robot errors should recognize, which a number of robot error codes, descriptions and causes appear during production process that is shown in Table II [4][5][7][10]. These error codes appear in alarm form on teaching pendant display panel is shown in Fig.2, for example: error 0008.

Next step is to prepare defect tracking. Four kinds of robot errors were explained in Table II that is shown in Fig.3.

The final step is program preparing that this program is written both by prolog and oracle but prolog has below advantages:

1) Prolog is logical and declarative language.

2) Prolog provides simple environment, so that doesn't need specialized training for labors and utilizable for different individuals.

3) Prolog can easily install and execute on computer and doesn't need any advanced hardware.

Code of appeared error on teaching pendant display panel is read by program and then program with asking questions tries to find created defect and presenting proposal to remove defect.

In other words, program with getting reply from user and asking other questions, tracks created problem and offers setting, repair, change the defective piece or re-check connections among devices.

Robot defect tracking program in prolog language for utilize users is shown in Fig.4.

TABLE II
A NUMBER OF HR006 HYUNDAI ROBOT ERRORS

| Code	Description	Cause	Action
E0008	Motor temperature is raised.	Temperature of motor has risen high.	- Check wiring of motor. - Stop the robot and cool the motors, then operate it again. - If the same error occurs, reduce operating speed.
E0015	Teaching pendant does not work.	Communication with teaching pendant is abnormal or teaching pendant is malfunction.	- Check the connection with the teaching pendant and cable disconnection. - Replace the teaching pendant.
E0022	Check up I/O board communication cable.	Main CPU board cannot receive expected packet data within 20 ms from the I/O board.	
E0023	Field bus power is not supplied.	The field bus power line is not supplied.	Check up the field bus power line.
E0024	Field bus network connection error.	Field bus network interface was not good.	Check up the field bus network cable connections.
E0105	Cable not connected.	The communication was not possible on account of broken encoder wires.	
E0113	Over current.	Over current flows through the motor or amplifier.	- Check CNEC, CNBS of servo CPU board and CNBS of servo amp logic board. - Check the connector between the controller and the robot.
E0114	Control voltage drop.	Control power +15 V was dropped, SR1 for discharge control in drive unit was wrong.	
E0115	Command error.	Received packet data from main CPU board was wrong.	- Power off and check whether the board is inserted properly.
E0117	Too large position drift.	Position error exceeded the set value.	If the robot works normally, the setting value for the position error is too small, tune it.
E0118	Too large speed drift.	Speed error exceeded the set value.	
E0122	Cannot make servo on.	When executing servo on or releasing power saving mode, servo on was not executed within the set time.	- Power off and power on again.
E0124	Cannot clear servo error.	Motor on was not able because of servo error.	- Clear the servo error.
E0138	Can't return to previous position.	The distance for returning to the previous position exceeded the set value.	- Check servo gain. - Check encoder power. - Check encoder wiring.
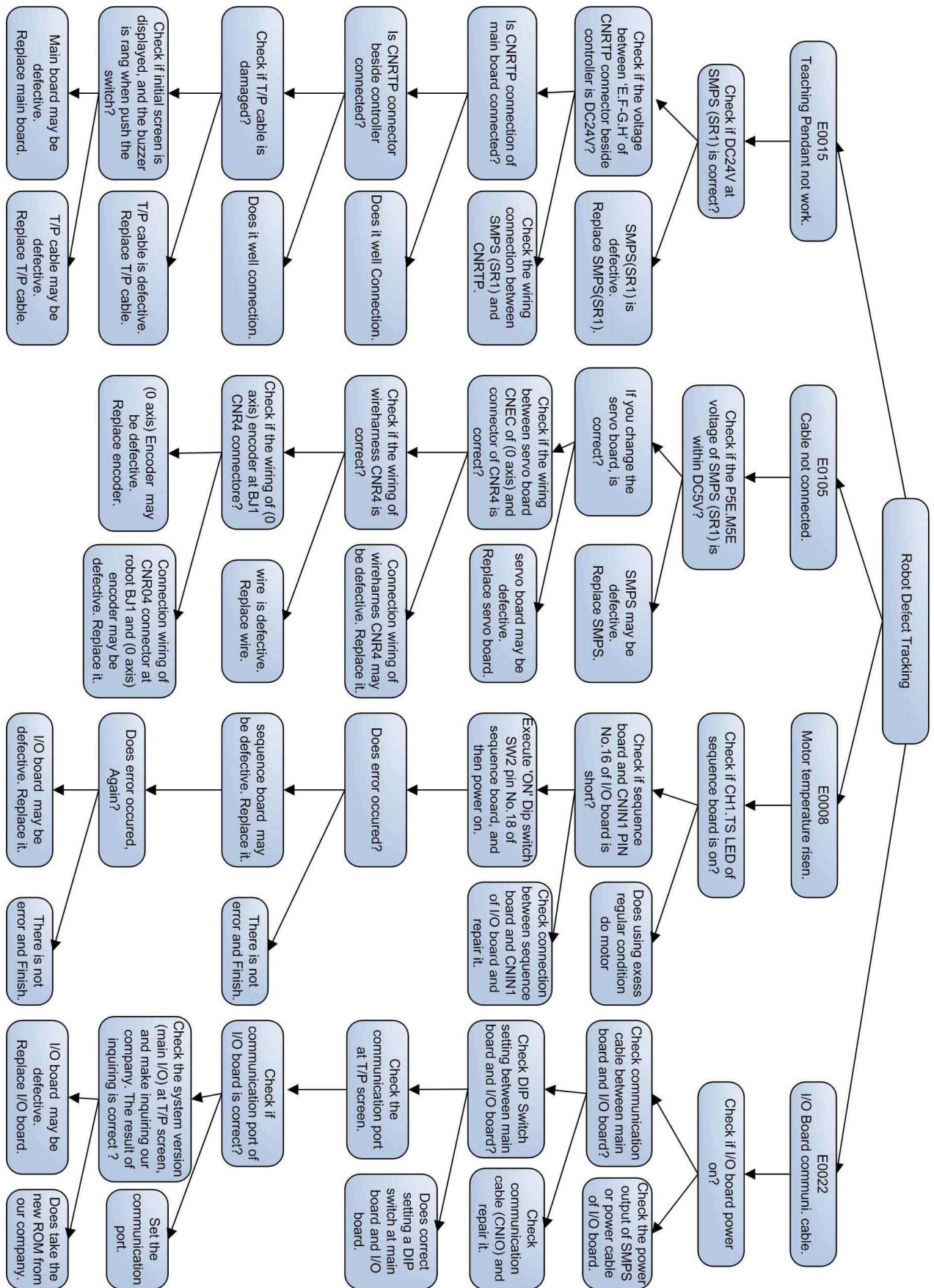
E0015 Teaching Pendant not work.

Check if DC24V at SMPS (SR1) is correct?

Check if the voltage between 'E·F·G·H' of CNRTP connector beside controller is DC24V?

SMPS(SR1) is defective. Replace SMPS(SR1).

Is CNRTP connection of main board connected?

Check the wiring connection between SMPS (SR1) and CNRTP.

Is CNRTP connector beside controller connected?

Does it well connection.

Check if T/P cable is damaged?

Does it well Connection.

Check if initial screen is displayed, and the buzzer is rang when push the switch?

T/P cable is defective. Replace T/P cable.

Main board may be defective. Replace main board.

T/P cable may be defective. Replace T/P cable.

E0105 Cable not connected.

Check if the P5E.M5E voltage of SMPS (SR1) is within DC5V?

If you change the servo board, is correct?

SMPS may be defective. Replace SMPS.

Check if the wiring between servo board CNEC of (0 axis) and connector of CNR4 is correct?

servo board may be defective. Replace servo board.

Check if the wiring of wireharness CNR4 is correct?

Connection wiring of wireharnes CNR4 may be defective. Replace it.

Check if the wiring of (0 axis) encoder at BJ1 CNR4 connectore?

wire is defective. Replace wire.

Check if the wiring of (0 axis) encoder at BJ1 CNR4 connectore?

(0 axis) Encoder may be defective. Replace encoder.

Connection wiring of CNR04 connector at robot BJ1 and (0 axis) encoder may be defective. Replace it.

E0008 Motor temperature risen.

Check if CH1.TS LED of sequence board is on?

Check if sequence board and CNIN1 PIN No.16 of I/O board is short?

Does using exess regular condition do motor

Execute 'ON' Dip switch SW2 pin No. 18 of sequence board, and then power on.

Check connection between sequence board and CNIN1 of I/O board and repair it.

Does error occured?

sequence board may be defective. Replace it.

There is not error and Finish.

Does error occured, Again?

I/O board may be defective. Replace it.

There is not error and Finish.

E0022 I/O Board communi. cable.

Check if I/O board power on?

Check the power output of SMPS or power cable of I/O board.

Check communication cable between main board and I/O board?

Check communication cable (CNIO) and repair it.

Check DIP Switch setting between main board and I/O board?

Does correct setting a DIP switch at main board and I/O board.

Check the communication port at T/P screen.

Check if communication port of I/O board is correct?

Set the communication port.

Check the system version (main I/O) at T/P screen, and make inquiring our company. The result of inquiring is correct ?

Does take the new ROM from our company.

I/O board may be defective. Replace I/O board.

Robot Defect Tracking

Fig.3 HR006 Hyundai robot defect tracking

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Fig.4 Program for HR006 Hyundai robot defect tracking by prolog language

V. CONCLUSION

During 10 to 15 years past that industrial revolution is accomplished, automotive production lines is outspread automated and this trend has better industrial, economic and social results, in widespread level. Fast jumping in automotive system development is discussed industrial determined duties in robotic form but robots like any other mechanical and electronic device face with technical problems so that need to maintenance.

In this essay, we prepared an expert program with recognition all kinds of robot errors during production process in order to tracking created errors, with getting appropriate reply from the user, give proposal setting, repair, changing defective piece or re-check in connections among devices. So this affair causes easily error tracking, fast and exact defect tracking of technical problems which are created in robot during production, preventing from longstop in production line at the time of error appearing in robot, increase of production rate and ease of defect tracking of robots by labors.

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