System integration of automatic welding robot for assembly line in shipbuilding (ICCAS2005)

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Abstract: Lately, the demand for automation in the industries has increased and automation system has continuously installed in various industrial fields. But automation for shipbuilding industries is more difficult than others. Because we must cope with diverse ship types and owner s various requirements. Nevertheless, for the past several years a steady development on welding robot for shipbuilding has been going on. Existing automatic welding robots are operated separately and do not communicate with each other. In the existing facilities, although a unit of robot has a good performance, and if all of units are not operated systematically, we are not satisfied with results of our system. So we suggest an integration and operation method of system units. System integration methods applied to our system have in many cases lead to lower cost and shorter lead time.
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Keywords: system integration, welding robot, shipbuilding, Going-Over a Wall, welding automation

1. INTRODUCTION

In shipbuilding industries, it is difficult to adapt automation robot because the industries have the characteristics that the small products many applications are produced and there are not regulated for producing rules. On the other hand, the need of automation for shipbuilding is increasing because there are recent increase of human labor cost, selling competition among shipbuilding companies and the tendency of avoiding difficult labor. Specially, the large scale assemble process of ship-body which needs large labor amount has automation requirement more than other processes. The welding automation robot of shipbuilding which does CO_2 arc-welding is used to assemble ship-body block.

In the case of general industry fields, the stationary robot welds moving objects and the object goes out from a robot workspace when welding task is conducted.

But it has a difficulty to move the objects in doing the task because the objects to be welded in shipbuilding process are very heavy and have very large dimensions. Thus, welding automation robots to be used in shipbuilding must approach objects in order to weld the object in the workspace of the robot.

In this research, The system of consists of the 6 axes articulated robots which are attached on mobile robots for flexible moving and gantry systems which are used to supply utilities to operating robots smoothly. This welding automation system could contribute to construct circulating structure of shipbuilding process. This circulating structure has advantages that it could increase profit due to increased productivity and get a good position of selling ships from a competitive price. Furthermore this automation system could prevent industrial accidents from isolating a dangerous environment such as a welding place from operators, and substitut professional welders who are reduced by their old age.

2. T E COMPONENT OF OVERALL S STEM

2.1 The detail term of a shipbuilding block

Cell: a region among longi. s and floors

Shell: a region among girders and floors

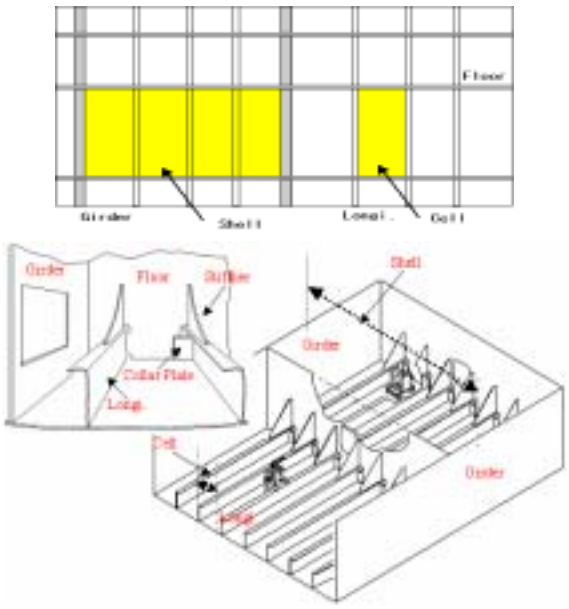


Fig. 1 The Term of block parts

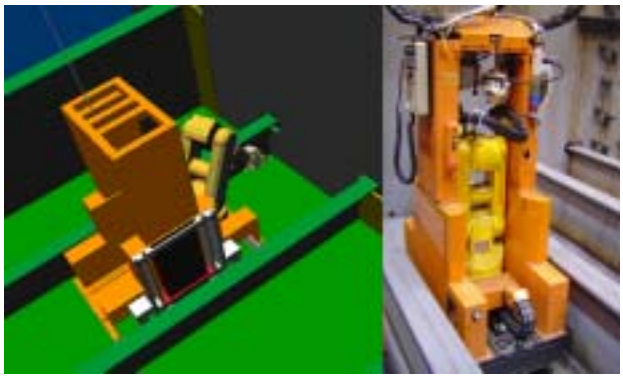


Fig. 2 The welding robot system

2.1 Going-Over a Wall Robot

Going-Over a Wall robot consists of an articulated mini robot and a cart to carry it. An articulated mini robot is a welding robot.

A welding robot of 6-DOF has small size and light weight, because it must be loaded on a carriage.

A carriage, which is a cart to carry a welding robot, takes DC motor, flexible robot loading/unloading mechanism and 2 - wheel omni-directional driving mechanism.

Fig. 2 describes a visualized picture and an actual picture.

This mobile robot works without operators in a shell. It crosses over a longi. and navigate autonomously in a cell.

Fig. 3 says how going-over a wall works.

2.2 Automatic gantry

Automatic gantry is a crane to supply utilities to welding robots and carriages. It is a basic objective of our gantry. Also, a gantry lifts welding robots, moves them to the next shell. Because a girder between two shells has height which a carriage cannot go over it.

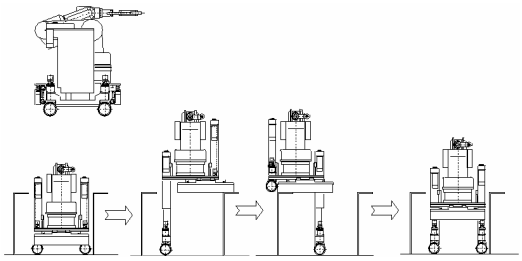


Fig. 3 The sequence of going over a wall

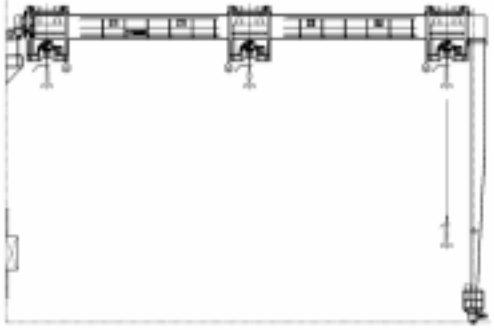


Fig. 4 Gantry crane

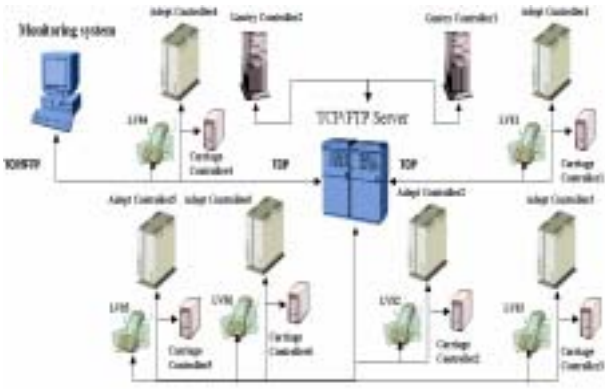


Fig. 5 Network layout

2.3 Overall System

Developed system has two sub-systems. Each sub-system consists of one gantry and three welding robots.

Welding robots have several unit systems, which are laser vision system (LVS) to track welding seam, evironment recognition system and many other sensing systems.

These unit systems are managed and operated by supervisor control system. SCS is an operating system. SCS and each unit system(SCS) is connected to TCP and FTP server.

SCS controls properly two gantries with job order. Job orders are scheduled by a scheduler to avoid robot interference. Also, SCS checks unit system states and commands an operation.

3. NETWORK AND MESSAGE MANAGEMENT

This system processed information by TCP/IP where individual system for event characteristic information and real-time are demanded, and processed by FTP prepared information in advance and unnecessary real-time.

3.1 Network structure

It consists of systems which are two sets of six robots and two gantry cranes, and each object is connected with the communication server as a client. It is a constituted network as shown Fig. 5.

3.2. Message protocol

This paper suggests an efficient communication method among sub-systems

To communicate efficiently between unit modules, the agreement on a communication message by which a mutual promise was made is required.

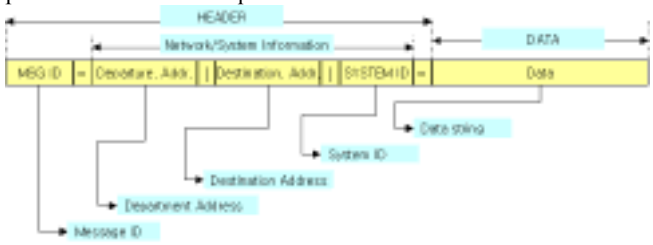


Fig. 6 Message format

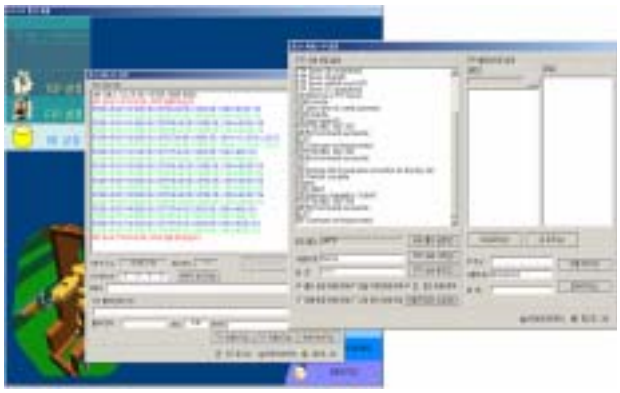


Fig. 7 Communication server system

It set to communication protocol base on a character sequence between a client and a host and this communication message format is very easy and can be parsed message string. Rapidly.

Message form is constituted as follows.

Message is consist of a message ID, network information and data.

Header part:

-Message ID for classifying a function for the received communication packet.

-Departure IP address.

-Destination IP address.

-System ID for transmission side

Data part:

- Strings and special character sequence set.

Message ID, network information, and data are divided by the equal mark (=) separator under a large category.

It divides under a details category by bar( ) separators and comma(,) separators.

Our processing messages is convenient and efficient by using such separator in message parsing.

3.3 Communication Server

A communication server basically has three functions, a TCP server for messages management, a FTP server for file up/download, and a communication history, storing job results data.

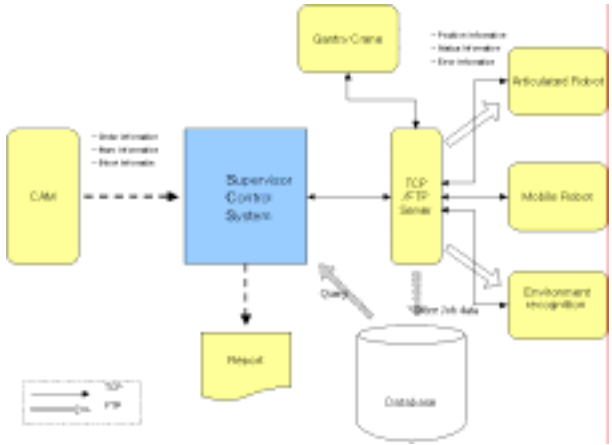
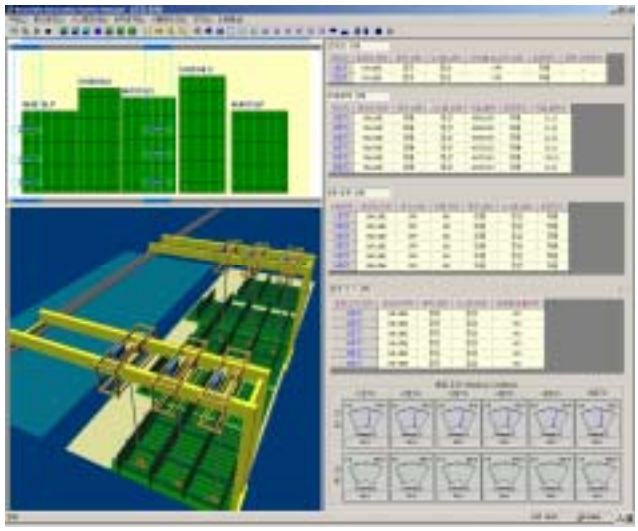


Fig. 8 Communication flow



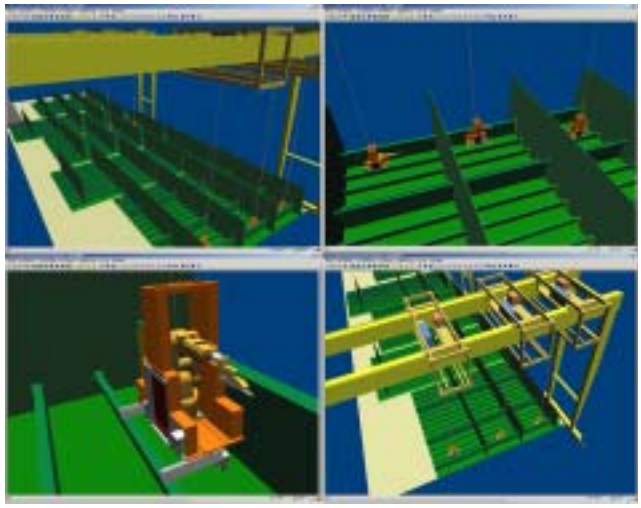


Fig. 9 Supervisor Control System

In TCP/IP server, the method of sending received messages to destination client is to send relevant address in received message.

4. SUPERVISOR CONTROL S STEM(SCS)

4.1 The overall structure of SCS

Supervisor control system is an integrated management system for automated welding robots in a assembly line.

The worker in an operating room gets robot position and status through SCS and cope with various errors or events in a factory.

SCS visualizes overall system configuration with Open-Inventor which is 3D graphic library. We implemented a virtual factory using VRML. This VRML has CAD information about blocks. And it displays network, robot operation and error status about each component.

4.2 Operation procedure

A worker inputs into block modeler with drawing, then creates a block infomation file using input s results or using a

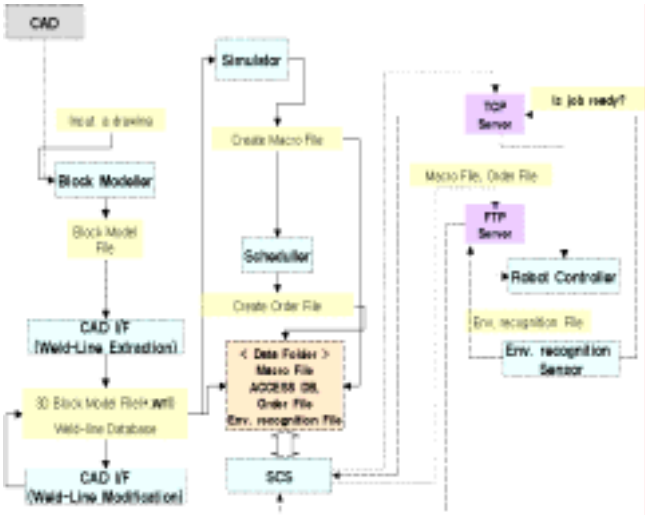


Fig. 10 The flowchart of operation precedure

CAD file from designers. We developed weld lines extraction algorithm from this block information, and our system store weld line information in database, and create 3D block model file(VRML). we use the model file to do simuation or to visualize real-time job operation.

Created welding lines are modified by users. They can delete and correct weld lines.

Next, we do create macro files simulate macro s and schedule by CAM.

Finally, when macro files and order files are created, we send macro file and job order file to each robot by SCS using FTP.

From now, we are ready to send command to each robot.
If SCS is received reply message for job command, worker can operate robot. Then worker push the button of pendent to start welding job.

Henceforth, welding robots come to carry out automatic welding without necessity in intervention of a worker until one work shell is finished.

Welding robots can go over longi freely in the region where they are assigned. Because SCS calculates target position using current position of robots and gives a movement command to robots

Supervisor control system is operated by two operating mode; automatic mode and semi-automatic mode.

In the automatic mode, Robots make it move as planned to carry out the schedule by the scheduler, and SCS gives a move command to gantry crane after gathering position of robots.

Thus, gantry crane tracks the position of robots automatically.

Semi-automatic mode is operated robots by worker who planned arbitrary schedule, gantry crane track the position of robots which go over longi, and the movement direction of gantry crane is determined by a direction of going over longi.

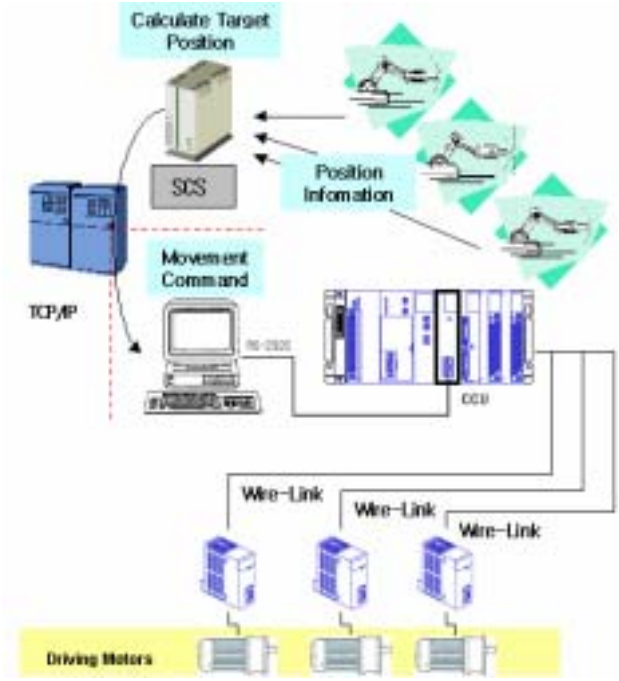


Fig. 11 Gantry crane control flow

4.3 The method to sysmetically operate two gantries

Two gantry cranes exist in this system, each gantry crane has three railway trolleys. This paragraph describes methods to determine moving positions of railway trolleys and the initial position of a block.

We determine positions of the other railway carriages using the foremost robot. That is, gantry crane A in left takes the most right robot as a basis, and gantry crane B is opposed to a case of gantry A. ou can confirm the rule in formula 1.
We cannot previously know where a block will be set, so we calculate the position with current position of each system component. Formula 2 refers to this method.

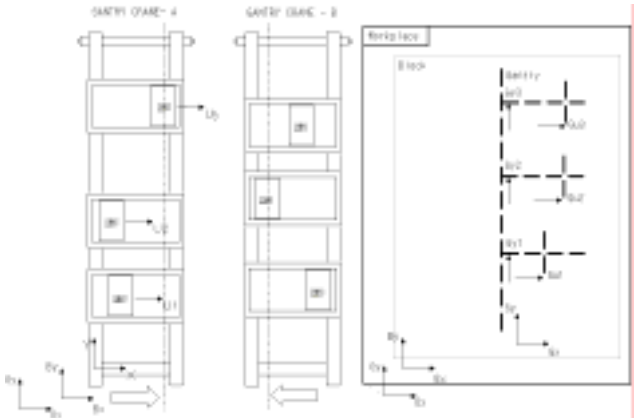


Fig. 12 The tracking method of gantry crane

GTx: Gantry Target position for X-Axis
GTy: Gantry Target position for Y-Axis
GTu: Gantry Target position for U-Axis
Gcx: Gantry Current position for X-Axis
Gcy: Gantry Current position for Y-Axis
Bx: Block position for X-Axis
By: Block position for Y-Axis
Ccx: Carriage Current position for X-Axis
Ccy: Carriage Current position for Y-Axis
GU_MAX: Gantry U-Direction Max. position
GU_MIN: Gantry U-Direction Min. position

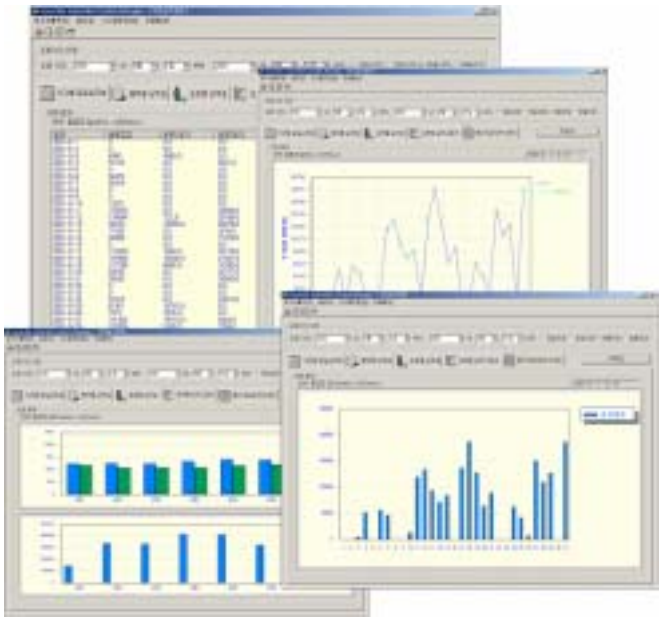


Fig. 13 Job analyzing system

GTx = Bx + Ccx(max) - GU MA (Left Gantry Crane)
GTx = Bx + Ccx(min) - GU MIN (Right Gantry Crane)
GTy[i] = By + Ccy[i]
GTu[i] = Bx + Ccx[i] - GTx (index i=1,2,3) (1)

Bx = -Ccx + (Gcx + Gcu)
By = -Ccy + Gcy (2)

5. JO ANAL ING S STEM

Job results of robots are stored in database. Operators can search them by each robot, block and date, and analyze statically. This job analyzing system is a very useful tool for both workers and managers, because they grasp easily their working results with various analyzing charts.

. CONCLUSION

Our system consists of two sub-systems, and one sub-system has three "Going-Over a Wall" robot systems and one gantry system

System Features:

● Robot unit consists of Articulated mini robot (6 D.O.F.) and omni-directional mobile robot, which has Going-Over a Wall mechanism, for autonomous navigation in the interior of welding block.

Articulated robot has LVS (Laser Vision Sensor) for seam tracking, recognition of start/end weld point and gap size measurement.

● Gantry unit supplies utilities for robot units and helps robots to go over a girder.

It is controlled automatically to interact robots and those utilities systematically.

●SCS(Supervisory control system)

-Intelligent network management.

-Real-Time monitoring to operation status.

●Job analyzing system

-Gathering actual job results and storing them into database in real-time.

-Database managements which has powerful searching function

The key to automation is system integration. Therefore, we suggest a method to operate efficiently a complicated and diversifiable system. And especially we focus on the network communication and operating process.

The developed system visualizes the operation environment using Open Inventor and communicates with the entire system via TCP/IP and FTP.

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