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Design of controller for mobile robot in welding process of shipbuilding engineering

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Abstract

The present study describes the development of control hardware and software for a mobile welding robot. This robot is able to move and perform welding tasks in a double hull structure. The control hardware consists of a main controller and a welding machine controller. Control software consists of four layers. Each layer consists of modules. Suitable combinations of modules enable the control software to perform the required tasks. Control software is developed using C programming under QNX operating system. For the modularizing architecture of control software, we designed control software with four layers: Task Manager, Task Planner, Actions for Task, and Task Executer. The embedded controller and control software was applied to the mobile welding robot for successful execution of the required tasks. For evaluate this imbedded controller and control software, the field tests are conducted, it is confirmed that the developed imbedded controller of mobile welding robot for shipyard is well designed and implemented.

Keywords: Mobile welding robot; Modularized control architecture; Embedded controller; Industrial automation

1. Introduction

The need for autonomous welding tasks has increased recently in shipyards to improve productivity. Autonomous welding tasks using multi-axis robots have been used in many applications since the 1990s. However, the robots work only at a fixed location, and a crane is usually used to move the robots from one working location to another [1-4]. Therefore, we developed a self-driving mobile welding robot, which does not require a crane or a gantry device for mobility, in a ship's double hull structure.

This paper describes the development of control hardware and control software for a mobile welding robot that moves in transverse and longitudinal directions (Moving Tasks), performs welding tasks within the U-shaped welding areas and the brackets in a double hull structure (Welding Tasks), and detects the start and end points of the welding path (Sensing Tasks).

1.1 Double hull structure in a ship

Tankers, container carriers, liquefied natural gas carriers, and liquefied petroleum gas carriers should be provided with a double hull structure to maintain structural stability and to prevent environmental pollution caused by accidental collisions or stranding. Figure 1 shows the double hull structure of a very large crude oil carrier.

It is difficult to automate the manufacturing process of the double hull structure because of the enclosed area associated with increased compartmentalization for environmental safety. For these reasons, many studies have focused on automating the manufacturing process of the double hull structures in shipyards [5].

1.2 Welding target in a double hull structure and accessibility

A double hull structure consists of top and bottom plates, girders, and transverse web floors. The two plates cover the top and bottom of the double hull structure. The girders and transverse web floors divide the double hull structure into a number of closed sections. In each section, several reinforcing longitudinal stiffeners are arranged parallel to each other and these contain many small reinforcing stiffeners. Figure 2 shows the welding targets of the proposed robot (U-shaped part). The welding targets are located on both the top and bottom of the block. When the block is the open type, only one side is a welding target; the other side becomes a welding

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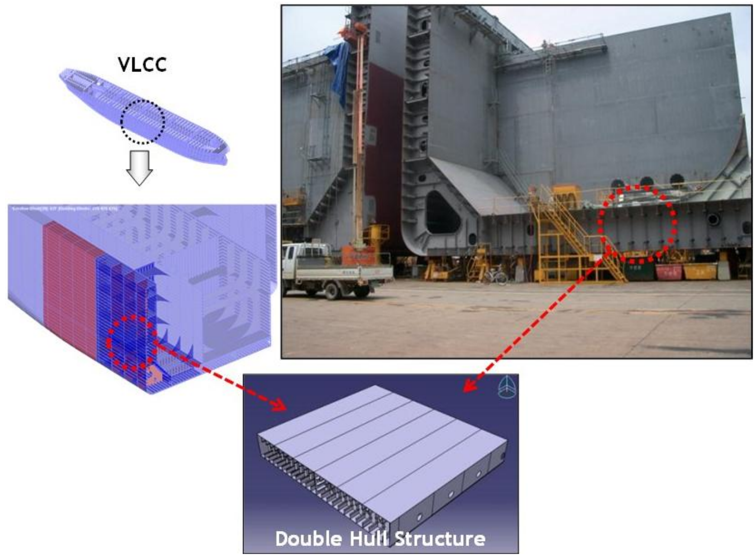

Figure 1. Double hull structure of a very large crude oil carrier (VLCC).

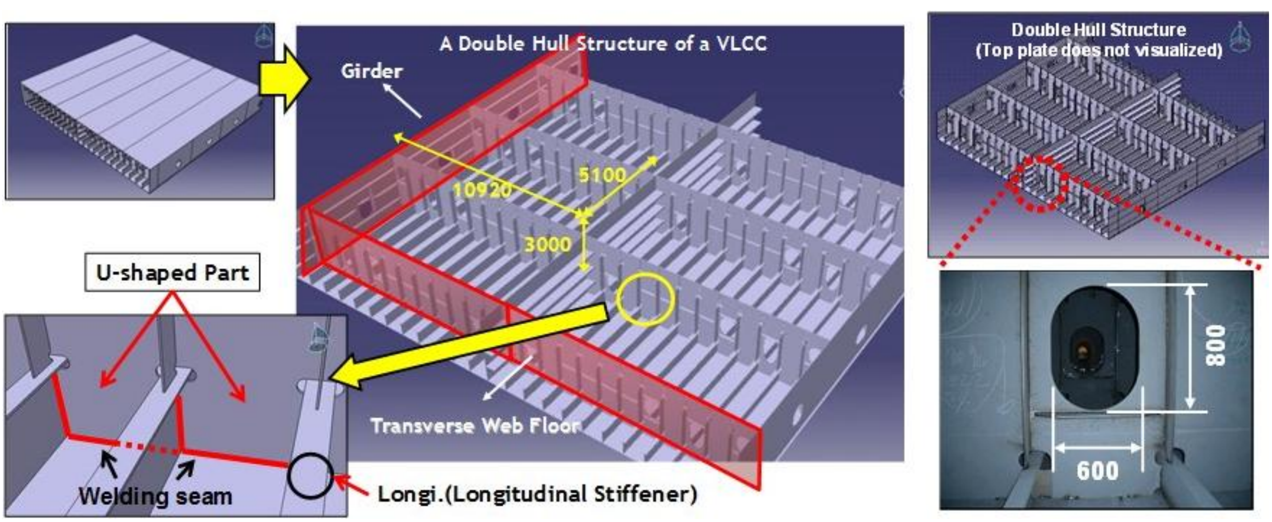

Figure 2. Welding target in a double hull structure and access hole on the transverse web floor in a double hull structure.

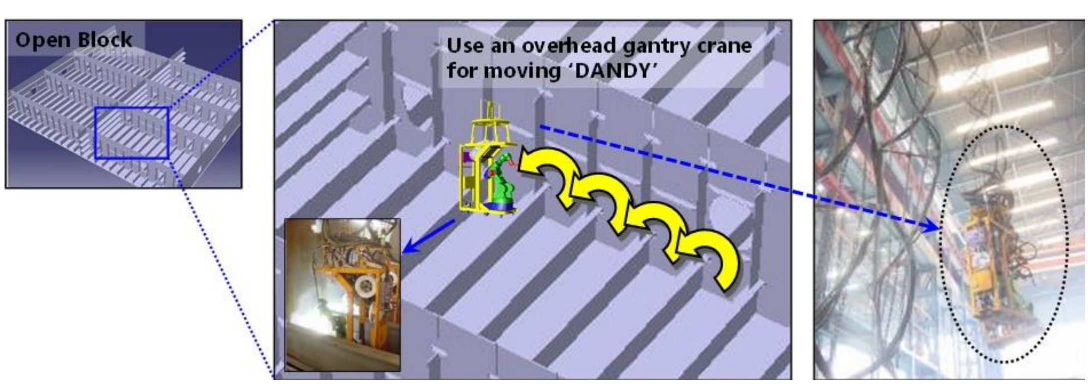

Figure 3. DANDY, a fixed welding robot used by Daewoo Shipbuilding & Marine Engineering in Korea.