Software Designing Simulator for Controlling Multiple-Mechanism Carrier System

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Abstract

This paper presents a software design simulation method for controlling multiple mechanism carrier system (MMCS), which is mainly used in a wrapping machine or a case packing machine. This method uses a mechanical tool-work interactive model proposed in this paper, in order to represent the interactive behaviors between some tools and a work driven by their tools, in which four effect states of a work are defined.

Based on this method, a 3-D simulation system has been built. It consists of shape modeling of each device, behavior definitions of tools, and control logic using if-then expression. By applying it to a case packing machine having about 30 mechanical devices and 100 inputs/outputs for control, the effectiveness of this method has been shown in general verification of control logic specification in an early software design phase and the possibility of smooth communication tool between mechanical and software designers.

1. Introduction

Recently, the concurrent engineering method using simulation technologies has been developed, in the specification investigation, designing and manufacturing domain of production equipment and machinery provider. Especially, dynamic simulations has become available for direct understanding of detail motions or performances of structures, mechanisms, production line, and distributed center facilities as illustrated in Figure 1.[1],[2],[3] Moreover, in a software development, for example, 3-D CAD and simulation techniques have been developed and are used for prototyping or early verification of control software for discrete process facilities and robot handling equipments. [4],[5],[7]

However, verifications of the software specification for controlling these machines, still require a software designer's / developer's skill, because a wrapping machine or a case packing machine, is often used in the final process, is being built up by multiple-mechanism carrier system (MMCS). This capability is for prediction its mechanism and motions with their own 3-D model in respect to the MMCS. This prevents releasing dependency in software debugging work on the site of the actual machine that has been assembled, because there are not any appropriate simulation methodologies to cover the domain for MMCS, shown in Figure 1.

The reasons why the environment for the software development in the domain of MMCS has not been settled, are as follows: 1) The understanding of 3-D prospects of mechanics is needed for software designing based upon mechanical specification. So, there is a wide gap between the MMCS software designing and the ordinary method for PLC software development etc.[6] 2) The various modeling for conventional simulation method is difficult to be applied directly. In other words, a queuing model for discrete process equipment lacks modeling details; the servo driving model and kinetic processing model for motion devices– for example, robot manipulation and mechanism simulation do not represent the multiple mechanisms because of poor adjustability to sequential control. [4]

So, this view suggests the need of the 3-D simulation method for MMCS. Our research adopts a framework of simulation

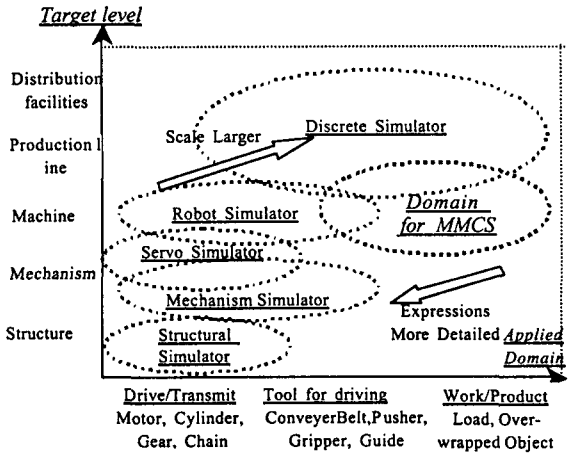

Fig.1.Dynamic simulation used for machinery/equipment field

in appropriate details to use 3-D shape modeling of each device such as tool, work driven by the tool, and sensor, with these simple behavior definitions and the easy representation of control logic specification. This study attempts to adopt symbolical processing for 3-D mechanical motion image to be familiar to a software designer to use this simulation method as an effective verification method of control logic specification in the software design of mechanism control.

2. Mechanical Tool-Work Interactive Model

This section discusses the needs and the basic frame of mechanical tool-work interactive model to simulate MMCS.

2.1 Needs of Mechanical Tool-Work Interactive Model

A wrapping machine or a case packer consists of various kinds of devices that conform required mechanisms. Additionally, each device transports works supplied from upper stream devices, for example, over-wrapped object like carton and wrapping materials to lower stream devices by driving or handling of tools. These tools properly transmit the driving source - motor or air cylinder to work's action. As illustrated in Fig. 2, the routes of work to be transported have a complicated sequence, both in length and width, up and down because of downsizing and enhancement of production capacity.

In order to simulate these consecutive carrier mechanisms,

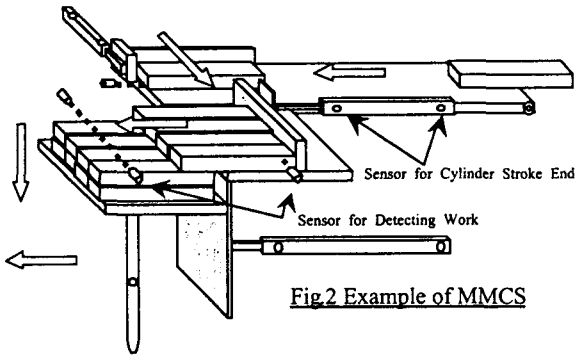

Fig.2 Example of MMCS