

Design, Modeling and Simulation of Mechatronic Systems

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Abstract: This paper describes a real time application of mechatronics with constructional details along with simulation results. Applications like part tracking and automatic speed control are of interest to the industry and the academic alike. Based on certain specific information about the system a control program is prepared and embedded in a microcontroller, so that it responds repetitively to various input parameters. To widen the range of control, it is necessary that a huge database of input-output information has to be provided to the microcontroller. In this paper, different sensing and actuating elements and details of microcontrol programming are presented with reference to typical applications such as component recognition strategy using a vision system, a remote controlled mobile robot, tracking system of moving components, and automatic speed control of laboratory diesel engine model. Some simulation results of the control are also presented.

Keywords: Proximity sensors, Microcontroller, solenoid, Relays, Linear actuators, Simulation

1. Introduction

During the last two decades, several applications of mechatronics came into light. Starting from the small toys to special purpose robots, significant developments have occurred. In some instances, an industrial or domestic equipment need to be controlled in a more effective and quick manner. This is usually achieved through a steady automation. For example, the speed regulation of an automobile by pedal control is a very crude way since at times unnecessary fuel consumption arises. In other situations, the coordination of sensing and actuation is an important issue. The time-delay between the sensing and control need to be properly estimated before actuation.

From the laboratory testing purpose, microcontrollers fitted on board circuits are quite commonly used [1-3] rather than the programmable controllers. Here, an ordinary computer control programs with branch and do statements is written in a high-level programming language based on a prior data of the system. This can be embedded into the microcontroller chip upon verification and the control action takes place without human intervention. Basically, all these digital circuits are operated with an important element known as timer (or clock). The continuous real world equipment is to be controlled by the analog signals only. A built-in analog to digital (A/D) and digital to analog (D/A) converters forms a part of the control circuit.

The Sensing element plays an important role in automation. Light Detecting Resistors (LDR) and proximity sensors are quite commonly used in many applications. Based on an object obstruction time, it sends the number of counts in unit time to the controller. In certain situations vision systems like, digital camera, with serial port acts as sensing element. Like the sensors, there are many actuators existing at present. Commonly, the position-actuating elements like the linear actuators (piston in cylinder), rotary actuators and force elements such as the grippers or simple electric make and break relays are actuated by the systems like the electric motor or the pneumatic power as per the instructions of a microcontroller. Figure 1 shows the control circuit with various elements in the form of a block diagram.

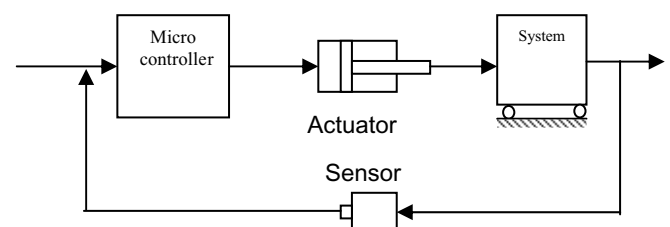


Fig. 1 General description of Mechatronic system



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In the present paper, the methodology of utilization of mechatronic elements based on the type of application is shown. Four cases are presented for monitoring and control applications. Section-2 deals with the description of each case including the essential elements involved. Relevant literature for each case is also presented appropriately. Section-3 describes the simulation results obtained.

2. Description of the Systems

There are four cases considered in the present work, which are common applications encountered in real time situations. These are described under two categories: one for only monitoring and the other for monitoring as well as for control tasks.

2.1 Vision system to identify the type of component on a moving conveyor belt

In many industrial situations, a digital camera is employed as a vision sensor to capture the images of the objects. The signals from the digital camera reach the computer screen through a serial port. A computer program, based on the number of pickcells then tracks the image. An illustrative case study is presented to show the effectiveness of the computer program for identifying the circular and square components on a moving belt conveyor system. A microcontroller activates the sequential motion of the conveyor. The black cotton-clothed conveyor is selected over which randomly spaced white pieces of circular and square paper stripes are mounted. For every five milliseconds, the conveyor-belt drive stops so as to capture the image through the camera. Figure 2 shows the layout of the entire system. The project makes the students to understand the working of the vision systems used in practice. It also provokes new thoughts in capturing the type of drawing in any Computer Aided Design (CAD) environment using some user-written computer programs.

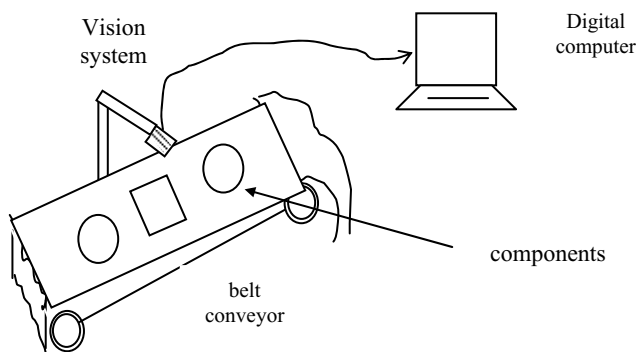


Fig.2 Vision system for component identification

Vision-systems in capturing of images are not uncommon. Luo *et al.* [4] described a computational approach to determine some main regions in photographic images. Kastrinaki *et al.* [5] provided a survey of video processing techniques for some traffic applications.

2.2 Remote controlled mobile robotic system

In many applications, robots are sent to far-off places to tackle a specific task. The control of such systems can be done through a closed circuit vision and with a remote controller. One such device is attempted here wherein a four-degree of freedom manipulator on a mobile platform working on pneumatic actuation system is fabricated as shown in Fig. 3.



Fig. 3 Remote controlled mobile robotic pneumatic system

A digital camera affixed to one of the limbs captures the image and passes on the information to the closed circuit television-set. The control of manipulator is achieved through a remotely operated teach pendant. The mobile platform provides redundant degrees of freedom and the manipulator becomes dexterous so as to overcome obstacle-collisions. Basic components of this model are the manipulator mechanism, four-wheeled mobile platform, vision-system, video card, remote controller panel (teach pendant), electric motor to drive the platform, pneumatic system to drive the links of the manipulator. Significant literature is available on the development of the mobile robotic systems. Tan *et al.* [6] presented an approach to decoupled force/position control of end-effector along the same direction for mobile redundant robot. Cheng *et al.* [7] gave the dynamics and control of redundantly actuated parallel manipulators. Barnes and Liu [8] provided a method to identify the hindered features through vision guided mobile robots.