Abstract

Applications in the areas of Robotics, involving large area maneuvers at high speeds, and *Large Space Structures* (LSS) have given rise to a great deal of interest in the study of the dynamics and control of Flexible Structures. The concept of *Intelligent Structures* has evolved from an attempt to actively control these Flexible Structures [43]. In this work theoretical and experimental studies on the dynamics and control of Intelligent beam structures have been made. Dynamics of planar flexible articulated manipulator links using a configuration of *Intelligent Structures* have been analyzed. Equations of motion for a flexible manipulator system in planar motion are obtained in symbolic form based on the Lagrange-Euler assumed modes method, using REDUCE [107], a symbolic manipulation software. The *Bond graph* technique is also used to model the dynamics of flexible manipulator systems. Raleigh and Timoshenko beam models are presented and analyzed based on the insight provided by Bond graphs. Since flexible structures can be modelled using the Assumed-modes method, it is convenient to actively control these structures by controlling their flexible modes. These modes can be independently controlled using the *IMSC (Independent Modal Space Control)* method, which is simple to design and implement as it involves very few computations in comparison to coupled control. The *IMSC* has been extended to the Travelling Independent Space Modal Control (*TIMSC*), which uses optimal actuator locations for the control of corresponding modes. The *IMSC* technique is further extended using independent observers, to control flexible modes in the presence of *control* and *observation spillovers*. A theoretical basis for the design of such an independent system, called *IMSO (Independent Modal Space Observer)*, in the presence of spillovers is also presented. Piezoelectric actuators and sensors are proposed to perform the required control. Piezoelectric actuator crystals *PZT (Lead Zirconate Titanate)* are bonded on the surface of the links and used for actuation. *PVDF (Polyvinylidene difluoride)* is proposed for sensors to measure the modal displacements and velocities. Computer simulations show that the proposed controller works effectively. The *IMSO* based control scheme is tested experimentally by controlling the first two modes of a thin flexible beam. A digital controller has been designed, fabricated and tested for this purpose. In experiments, PZT actuators are used for actuation, and strain gauge sensors for sensing displacements. The experiments show the effectiveness of the proposed *IMSO* based controller for flexible structures.

Keywords

Large Space Structure, Intelligent Structures, Flexible Manipulator arms, Piezoelectric Ceramic Actuators, Bond Graphs, Digital Control, Modal Control