A Technique for Dynamic Modelling of a Two-link Flexible Manipulator

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Abstract: The paper presents dynamic modelling of a two-link flexible manipulator model. An explicit, complete, and accurate nonlinear dynamic model of the system is developed using assumed mode method. The Lagrangian approach is used to derive the dynamic model of the structure. The model equations are verified with various bang-bang input torque profiles.

Keywords: dynamic model; manipulator; Lagrangian.

I. INTRODUCTION

Flexible link manipulators are attractive because they avoid the large inertia forces associated with traditional, large section, rigid link manipulators. Flexible robot manipulators with less mass are lighter in weight, consume less power, require smaller actuators, are more maneuverable and controllable, have less overall cost and higher payload to robot weight ratio. Unlike rigid manipulators, the dynamics of manipulators incorporate the effects of mechanical flexibility in the links.

Link flexibility is a consequence of the lightweight construction of links in the manipulator arms that are designed to operate at high speed with low inertia. Thus, flexible manipulators undergo two types of motion, i.e., rigid and flexible motion. Because of the intricacy of these motions, the resulting dynamic equations of flexible manipulators are highly complex and, in turn, the control task becomes more challenging compared to that for rigid robots. Each flexible link can be modeled as a distributed parameter system where the motion is described by a coupled system of ordinary and partial differential equations (PDE).

PDEs and boundary equations of a two-link flexible manipulator system are obtained by matching the ideal force and bending moment at the elbow joint, allowing the equations to be computed without recourse to dynamic formulations [1]. On the other hand, the vibration modes of a generic two-link flexible manipulator are studied as a function of the link length and tip mass distribution. Necessary and sufficient conditions are developed for all vibration modes to exhibit a node at the manipulator.

Various approaches have been developed which can mainly be divided into two categories: the numerical analysis approach.

II. A TWO-LINK FLEXIBLE MANIPULATOR

In this work, a two-link flexible manipulator moves in the horizontal plane as considered. Fig. 1 shows a two-link flexible robot manipulator system considered in this study. The first link has length \( l_1 \) and uniform mass density per unit length \( \rho_1 \). The free link is clamped at the center of the first link. The second link is attached to the tip of the first link. \( \theta_1 \) and \( \theta_2 \) represent the angular positions of the two links.

The inertial coordinate frame \( \theta_1 \) and \( \theta_2 \) are the angular position and \( z_2 \) is the transverse component of the