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# DECENTRALIZED VIBRATION CONTROL OF A MULTI-LINK FLEXIBLE ROBOTIC MANIPULATOR USING SMART PIEZOELECTRIC TRANSDUCERS

**Abstract**

The work in this paper is aimed to develop a decentralized control method for minimizing vibration of a multi-link flexible robotic manipulator, using embedded smart piezoelectric transducers. The purpose is to develop a robust vibration control system, with a simple control architecture, that can be practically utilized in various robotic manipulator applications.

To achieve this, the dynamic modelling, transducer optimization and control design are presented in this work. The non-linear dynamic model of a flexible robotic manipulator with smart piezoelectric actuators/sensors, is developed based on the co-rotational finite element method. The method incorporates multiple co-ordinate (co-rotational) systems which rotates and translates with each element, so that the geometric non-linearity present in rotating manipulator systems can be dealt with efficiently. A constrained optimization method is then developed to determine the optimal location of piezoelectric transducers over the flexible links.

In this work, decentralized feedback control using a resonant control strategy and several sets of collocated piezoceramic actuator/sensor is proposed. The resonant control system is developed for each set of collocated actuator/sensor, with the aim of targeting specific structural resonances for the manipulator so that the overall vibration can be suppressed effectively. It can be shown that such a decentralized control system has a satisfactory robustness in the case of inaccurate dynamic modelling, which can occur in practical applications. An optimization method is then developed to optimize the control gain for each set of decentralized control system, in order to achieve optimal vibration control performance while maintaining sufficiently low control energy.

Numerical study on a two-link flexible manipulator shows that the actuator/sensor location and control gain are crucial in determining the overall vibration control performance. The developed resonant control can be used to minimize the vibration of manipulator effectively, demonstrated by the reduced residual vibration at the end-point of manipulator. Furthermore, the control system is demonstrated to be robust in the case of inaccurate dynamic modelling, although there is a reduction in control performance as expected.

In summary, a decentralized vibration control method has been proposed for regulating vibration of a flexible robotic manipulator. The use of smart piezoelectric transducers allows a compact sensing/actuation system. Moreover, the use of decentralized resonant control allows a robust and simple control system that can target certain structural resonances for effective vibration minimization.