Part IV
TP Model Based Control Design of the Dual-Excenter Vibration Actuator

This part of the book is based on the results published in papers by Kuti et al. [11].

Vibration capabilities are essential in a variety of assistive and rehabilitation applications [1, 14, 19] and used in most hand-held personal informatics devices [2, 16–18], e.g., vibration-based notifications or sophisticated tactile feedback. Vibration capability in such devices is usually implemented using eccentric rotating mass (ERM) actuators (1DoF approach) composed of a DC micromotor with an eccentric rotor, or the so-called shaftless vibration motor [12]. A common disadvantage of these solutions is that the frequency and intensity of vibrations are coupled (resulting in 1 degree of freedom), which causes the generated vibrations to be less rich than in the case of 2-DoF approaches. Linear Resonant Actuators (LRAs), though widely used, are effective only when they operate at device-specific resonant frequencies.

In this section, we direct our focus on dual-excenter vibration actuators which contain two coaxial eccentric rotors driven by miniature DC motors [15]. This set-up enables the separate control of frequency and intensity through the modification of the angular velocity of and offset angle between the rotors. The general dynamics and control of such mechanical systems are detailed for example in [10, 13]. In the following we consider the configure with two coaxially located eccentric rotors driven by DC motors mounted on a common suspension [15]. The investigated mechanical system is nonlinear and parameter dependent. In particular, several environmental parameters, some of which are not even completely measurable (without significant noise), bring uncertainty into the system. Under such limitations, possibilities for mathematically rigorous treatment are also limited. Nevertheless, as we will see, the TP model transformation based design framework provides important advantages where such attempts are concerned.

We begin by noting that in the case of partially unknown system states, potential control solutions are restricted to static and dynamic output feedback schemes. The following works provide an important background relevant to such schemes:

- Chadli in [4] proposed a computationally inexpensive LMI system for constant output matrices, later extending the solution to cases where state observers are available together with a set of robust criteria.
- Guelton proposed a relaxation to such problems through the application of fuzzy descriptor redundancies and fuzzy Lyapunov functions with static, dynamic, and later robust H_∞ requirements [3, 8, 9].
- Chang adapted the above approaches to discrete-time systems [6]. Some further dynamic output feedback design methods prescribing robustness against parameter uncertainties and noise cancellation were proposed in [5, 7].

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