Position domain collaborative control with multirate sampling for a laser scanner-stage system

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Abstract

Laser processing is indispensible to today's engineering industry, thanks to its fabrication quality, flexibility and automation possibilities. As a key component enabling precision laser processing, galvanometer scanners are now widely used in many applications such as laser drilling, laser polishing and additive manufacturing, owing to the high speed of galvanometers. However, the working area of the galvanometer scanner is relatively small comparing to the linear motion stage. So in large-scale precision fabrication scenarios, both galvanometer scanners and motion stages are needed. For most of the exisiting laser processing equipment, these two motion systems work in a step-scan fashion, leading to stitching errors of fabricated workpieces. In this paper, we propose a novel collaborative control method supporting large area laser microprocessing, in which the two motion subsystems work simuteneouly during a fabrication process. Each subsystem moves in a continuous fashion, hence stitching errors can be eliminated and the processing efficiency can be significantly improved as well.

In order to achieve a collaborative control, a feedback control mechanism from one subsystem to another is required to ensure the synchronization of two subsystems. It is worth noting that the sampling frequencies of the two subsystems are much different. If the tracking errors are calculated and fedback by the two signals with different sampling frequencies, it could deteriorate the tracking error and even the system stability. To deal with this issue, we resort to the multirate sampling method. Specifically, the sampled-data observer is utilized to obtain discrete output signals, and the inter-sample output predictor is utilized to reconstruct continuous signals. By this way, the feedback signals of the two subsystems can be computed with the same sampling time.

Furthermore, we propose a position domain contour tracking strategy, combining with the axial internal model controllers. The contour precision plays an important role in planar motion tracking,

and the proposed control method significantly reduce the contour errors. An internal model controller is integrated due to its powerful capability to track the reference govened by a specific dynamics, and the error dynamics is transformed into the position domain by a variable substitution. Thus, the control design can be implemented accordingly. The stability analysis of the proposed control strategy is provided, and the simulation and experimental results show that the proposed control method is able to achieve an enhanced contour tracking performance for a laser scanner-stage system.

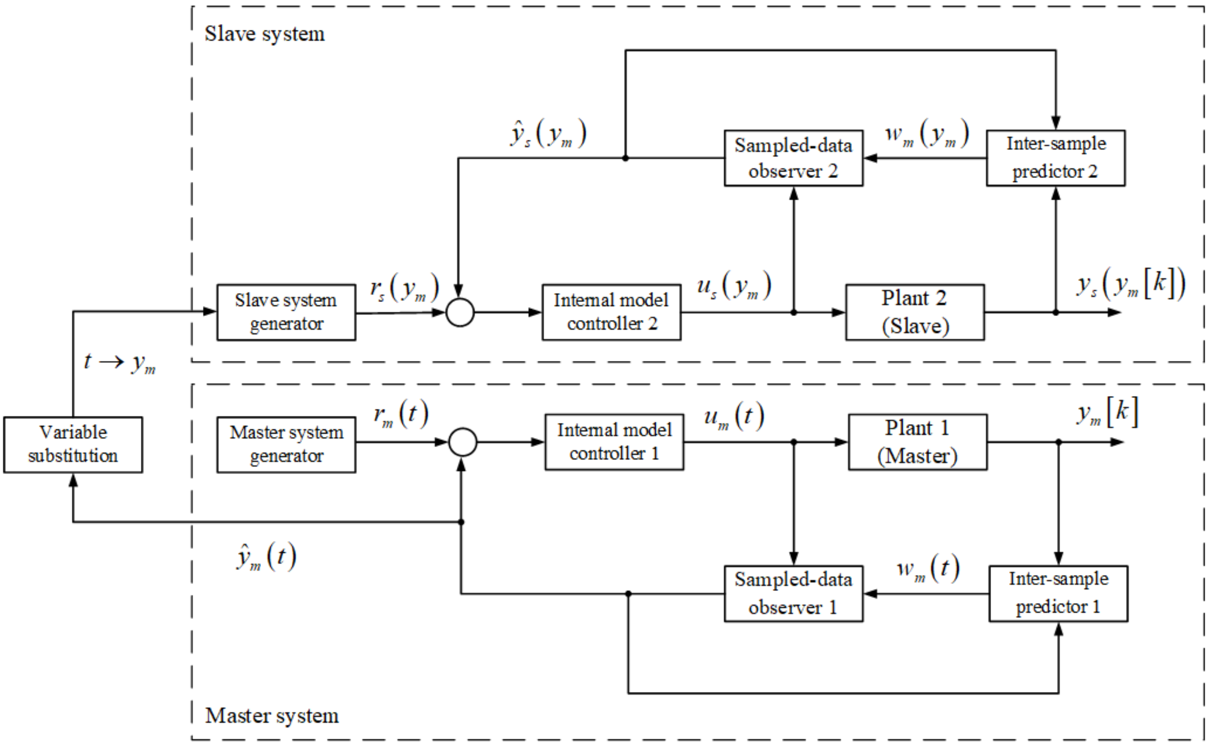

Figure 1: Block diagram of the proposed collaborative control structure.