The Final Oral Examination for the Degree of

DOCTOR OF PHILOSOPHY
(Department of Mechanical Engineering)

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“Distributed H∞ Control of Segmented Telescope Mirrors”

Thursday, July, 31, 2014
9 a.m.
David Turpin Building, room A144

Supervisory Committee:
Dr. Afzal Suleman, Department of Mechanical Engineering, UVic
   (Co-Supervisor)
Dr. Edward J. Park, Mechanical Systems Engineering, SFU
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Dr. Wanda Boyer, Department of Educational Psychology and
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Abstract

Segmented mirrors are to be used in the next generation of the ground-based optical telescopes to increase the sizes of the primary mirrors. A larger primary mirror enables the collection of more light, which results in higher image resolutions. The main reason behind the choice of segmented mirrors over monolithic mirrors is to reduce manufacturing, transportation, and maintenance costs of the overall system. Although segmented mirrors reduce the cost, they bring new challenges to the telescope control problem. The vast number of inputs and outputs make the computations for centralized control schemes intractable. Any centralized controller employed also results in a system that is vulnerable to a complete system failure due to a malfunction of the controller. However, by using a network of simple individual segment controllers (i.e. distributed controllers) that can address the two levels of coupling among segments the same objectives can be achieved. Since segments share a common support structure, there exists a coupling among segments at the dynamics level. Any control action in one segment may excite the natural modes of the support structure and disturb other segments through this common support. In addition, the objective of maintaining a smooth mirror surface requires minimization of the relative displacements among neighbouring segment edges. This creates another level of coupling generally referred to as the objective coupling. This dissertation investigates the distributed $H_\infty$ control of the segmented next generation telescope primary mirrors against wind disturbance that is going to be the dominant disturbance source. Three distributed $H_\infty$ control techniques are tested on three segmented primary mirror models: dynamically uncoupled model, dynamically coupled model and the finite element model of Thirty Meter Telescope project. It is shown that the distributed $H_\infty$ controllers can satisfy the stringent imaging performance requirements.
Publications


