

Control of Distributed Parameter Systems

July 23-27, 2007

Book of Abstracts

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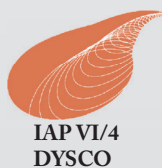
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CDPS 2007

**IFAC Workshop on
CONTROL OF DISTRIBUTED PARAMETER SYSTEMS**

University of Namur (FUNDP)
Namur, Belgium
July 23-27, 2007

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An H_∞ -observer at the boundary of an infinite dimensional system

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Abstract

We design and analyze an H_∞ -observer which works at the boundary of an infinite dimensional system with scalar disturbances. The system is a model of a UV disinfection process, which is used in water treatment and food industry.

Keywords

Robust filter design, observers, boundary control theory, H_∞ -optimization

3.1 Introduction

In many (control) applications where (bio)chemical reactions and transport phenomena occur, measurement and control actions take place at the boundaries. While a theoretical framework already exist ([1] and references therein), there is little attention to apply this theory in practice, as far as we know.

In [2], the analysis and design of a Luenberger observer for a UV disinfection example is explored. In this paper, we analyze a robust Luenberger-type observer for the same system with boundary inputs and boundary outputs, see [2] for physical background,

$$\frac{\partial x}{\partial t}(\eta, t) = \alpha \frac{\partial^2 x}{\partial \eta^2}(\eta, t) - v \frac{\partial x}{\partial \eta}(\eta, t) - bx(\eta, t), \quad x(\eta, 0) = 0 \quad (3.1)$$

$$x(0, t) = w_1(t), \quad \frac{\partial x}{\partial \eta}(1, t) = 0, \quad y(t) = x(\eta_1, t) + w_2(t), \quad (3.2)$$

on the interval $\eta \in (0, 1)$. Furthermore, α , v , and b are positive constants and corresponding to the diffusion constant, constant flow velocity and micro-organism light susceptibility

constant, respectively. The signals $u(t)$, $w_1(t)$, $w_2(t)$ and $y(t)$ represent a scalar input, disturbance (or error) at the inlet boundary ($\eta = 0$), disturbances or errors on the output and a scalar output, respectively.

We design a dynamic Luenberger-type observer,

$$\frac{\partial \hat{x}}{\partial t}(\eta, t) = \alpha \frac{\partial^2 \hat{x}}{\partial \eta^2}(\eta, t) - v \frac{\partial \hat{x}}{\partial \eta}(\eta, t) - b \hat{x}(\eta, t), \quad \hat{x}(\eta, 0) = 0 \quad (3.3)$$

$$\hat{x}(0, t) = 0, \quad \frac{\partial \hat{x}}{\partial \eta}(1, t) = K(t) * (y(t) - \hat{y}(t)), \quad y(t) = \hat{x}(\eta_1, t), \quad (3.4)$$

with K to be designed, and $*$ denotes the convolution product. As a consequence, the dynamics for the error $\varepsilon(\eta, t) = x(\eta, t) - \hat{x}(\eta, t)$ is written as

$$\frac{\partial \varepsilon}{\partial t}(\eta, t) = \alpha \frac{\partial^2 \varepsilon}{\partial \eta^2}(\eta, t) - v \frac{\partial \varepsilon}{\partial \eta}(\eta, t) - b \varepsilon(\eta, t), \quad \varepsilon(\eta, 0) = 0 \quad (3.5)$$

$$\varepsilon(0, t) = w_1(t), \quad \frac{\partial \varepsilon}{\partial \eta}(1, t) = K(t) * (\varepsilon(\eta_1, t) + w_2(t)). \quad (3.6)$$

Please notice that the correction to possible disturbances w takes place at the boundary.

3.2 H_∞ -filter problem

The aim is now to design a K such that the disturbances w_1 and w_2 have hardly any influence on $\varepsilon(1, t)$. This would enable us to predict the value of x at $\eta = 1$ accurately. Since the future of the output cannot be used, we see that K must be causal. We can write this problem as a standard H_∞ -filtering problem, i.e. ,

$$\inf_{K \text{ causal}} \sup_w \frac{\|\varepsilon(1)\|_2}{\|w\|_2}$$

with $w(t) = (w_1(t) \ w_2(t))^T$.

In [2], we already explored the exponential stability for the error dynamics (3.5)–(3.6) with constant gain. In the talk we shall further outline the procedure of how K is designed for the UV-disinfection example.

Bibliography

- [1] R.F. Curtain and H. Zwart. *An Introduction to Infinite Dimensional Linear Systems Theory*. Springer-Verlag, New York, 1995.
- [2] D. Vries, K. Keesman, and H. Zwart. A Luenberger observer for an infinite dimensional bilinear system: a UV disinfection example. *Accepted for SSSC'07, Foz de Iguassu, Brazil*.