Preface

This book addresses methods for adaptive control of distributed collector solar fields (DCSFs). These systems are plants that collect solar energy and deliver it in thermal form. Essentially, they are made of a pipe located at the focus of multiple rows of parabolic concentrating mirrors. The shape of this structure led to the name “parabolic trough” to designate the technology. Inside the pipe circulates a fluid (high temperature resistant oil or molten salt) that is heated by solar radiation, thereby accumulating energy. The thermal energy stored in the fluid may then be used for several purposes, such as water desalination or electric power generation in a boiler/turbine plant.

Since solar thermal plants are a “clean” source of renewable energy, the interest on DCSFs is growing steadily for obvious reasons. Indeed, in recent years, a significant number of commercial solar thermal plants of the so-called “parabolic trough” has been built throughout the world.

In addition to this practical interest, there is a scientific motivation stemming from the following issues:

1. They are distributed parameter systems, i.e. their dynamics depends on space as well as on time;
2. Their dynamics is nonlinear, with a bilinear structure;
3. They are uncertain systems, albeit with a structure which can be explored to design adaptive controllers that yield an improved performance with respect to “black box” approaches to control.

This book aims to present methods for controller design that meet the difficulties associated with these features, being strongly motivated by the specific dynamical structure of DCSFs. Considering the degree of uncertainty in plant dynamics knowledge, we focus on adaptive methods. Furthermore, different design methods are described that assume various degrees of knowledge about the plant structure. As such, some chapters are devoted to design methods that assume only a very limited knowledge about the plant. In order to improve performance, other chapters address methods that rely on the knowledge of a model, simple enough to be useful for controller design, but that captures the dominant plant dynamical features.

Although the book is about control of DCSFs, it does not fully address its automation in detail, or the optimization of its efficiency from a constructive point of view. Instead, the book concentrates on the problem that consists of, given a DCSF, how it can be operated so as to perform the correct manoeuvres, ensuring safe operating conditions and maximizing efficiency. The point of view assumed is the one of the new emerging area of cyber-physical systems, in which mathematical algorithms interact with physical systems in order to achieve a goal, in this case energy production.

The book provides a number of examples of plants that bear resemblances with DCSFs from a structural point of view when their mathematical models are considered. These examples help to explain how the algorithms described can be used in other contexts and also to illustrate their limitations and tuning. Indeed, an interesting feature consists of the fact that the approaches considered can be applied to other plants described by hyperbolic partial differential equations, in particular process plants in which transport phenomena occur, such as dryers, steam super-heaters or even, among other examples, traffic in highways.

Obviously, an important group of readers for this book are control designers interested in DCSFs. Furthermore, by the reasons explained above, this book can also be a source of inspiration for engineers dealing with such processes.

From an "academic" point of view, a nice feature of distributed solar fields is that their dynamics is rich enough to put challenges to the control designer, but at the same time simple enough to allow analytic work to be done in order to study the dynamics and use the conclusions reached to design nonlinear controllers. As such, the book is expected to be of considerable interest to researchers in control and to postgraduate and even advanced undergraduate students of Control.

Some parts of the book, especially the chapter devoted to dynamics and the design methods that directly rely on system nonlinear models may be of interest to applied mathematicians since they provide a case study and a source problem to illustrate other methods.

An important example, repeatedly used throughout the text concerns an experimental distributed collector solar field of Plataforma Solar de Almeria, located in the South of Spain. Indeed, a significant feature of the book consists of the fact that the control algorithms described are illustrated with actual experimental results performed in this plant.

The material covered is supported by several research projects, developed over many years, whose results have been published in peer reviewed journals and conference proceedings and in Ph. D. theses. As such, a number of people in addition to the authors contributed to the experimental results and the corresponding underlying ideas. The main contributions in this respect were made by F. V. Coito, who was involved in the initial experiments with MUSMAR, L. M. Rato, who contributed to dynamic weights in MUSMAR and the application of Switched Multiple Model Adaptive Control, L. Marreiros who cooperated in a case study with an air heating fan and M. Barão who contributed to feedback linearization and the use of control Lyapunov functions. The data concerning solar furnaces were obtained in cooperation with B. A. Costa.

INESC-ID provided the first author (J. M. L.) with the conditions, and the means, to work on this book. The book was partly written within the scope of the projects SFERA II (project number 312643) and STAGE-STE (project number 609837) supported by the European Commission under the FP7 programme. Part of the work was supported by contract PEst-OE/EEI/LA0021/2013.

Finally, the authors must acknowledge and thank the momentum received to complete this work provided by W. A. Mozart, L. van Beethoven, F. Chopin, F. Liszt, N. Paganini, F. Schubert, R. Schumann, F. Mendelssohn Bartholdy and P. I. Tchaikovsky. Without their multidimensional stimulation and encouragement this book could have never been finished.

Lisbon, Portugal, 2014

João M. Lemos
Rui Neves-Silva
José M. Igreja

http://www.springer.com/978-3-319-06852-7

Adaptive Control of Solar Energy Collector Systems
Lemos, J.M.; Neves-Silva, R.; Igreja, J.M.
2014, XXII, 253 p. 127 illus., Hardcover
ISBN: 978-3-319-06852-7