Studies in Systems, Decision and Control

Volume 286

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Towards Analytical Techniques for Systems Engineering Applications

Springer

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ISSN 2198-4182 ISSN 2198-4190 (electronic)
Studies in Systems, Decision and Control
ISBN 978-3-030-46412-7 ISBN 978-3-030-46413-4 (eBook)
https://doi.org/10.1007/978-3-030-46413-4

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Introduction

One of the main objectives of systems engineering is to design, maintain, and analyze systems that help the users. To design an appropriate system for an application domain, we need to know:

- what are the users' desires and preferences, so that we know in what direction we should aim to change this domain, and
- what is the current state and what is the dynamics of this application domain, and
- how to use all this information to select the best alternatives for the system design and maintenance.

Designing a system includes selecting numerical values for many of the parameters describing the corresponding system and its subsystems. At present, in many cases, this selection is made by consulting experts and/or by following semi-heuristic recommendations (recommendations based partly on the past experience of system design and monitoring). Experience shows that such heuristic imprecise recommendations often lead to less-than-perfect results.

It is therefore desirable to come up with analytical techniques for system design, techniques that would be based on valid numerical analysis and on the solution of the corresponding optimization problems.

System engineering is a very broad discipline, with many different application domains. Each domain has its own specifics and requires its own analysis and, probably, its own analytical techniques.

In this dissertation, we formulate and analyze *general* problems corresponding to different stages of system design, implementation, testing, and monitoring, and show, on appropriate examples, how the corresponding analytical techniques can be applied to different application domains. Examples of our applications range from biological and biomedical systems (ranging from cows to humans) to social-related

systems (such as recommender systems) to physical systems (for which we provide a new system-based explanation for the minimum entropy principle) to engineering systems (for which we describe how to find the optimal proportion of testing on different levels of system design).

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