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# Control of Traffic Systems in Buildings

With 101 Figures

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To our families

# Series Editors' Foreword

The series *Advances in Industrial Control* aims to report and encourage technology transfer in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. New theory, new controllers, actuators, sensors, new industrial processes, computer methods, new applications, new philosophies..., new challenges. Much of this development work resides in industrial reports, feasibility study papers and the reports of advanced collaborative projects. The series offers an opportunity for researchers to present an extended exposition of such new work in all aspects of industrial control for wider and rapid dissemination.

The interplay between general theoretical methods and the industrial application is a very important part of the field of control engineering. Sometimes the control problem can be described quite succinctly and mathematically and the engineer is able to find an existing mathematical method to solve the problem with little modification. In other cases, the problem posed by the control application leads to new theoretical methods and a new engineering field emerges. But sometimes the solution to the control problem posed by an application is a non-trivial extension of an existing theory–application interplay in this *Advances in Industrial Control* monograph by Sandor Markon, Hajime Kita, Hiroshi Kise and Thomas Bartz-Beielstein. The applications area is that of transportation systems within buildings. This covers a surprising range of systems: elevators, escalators, moving walkways, horizontal elevators, all for human passengers. For cargo transportation there are specialised freight elevators, conveyor systems, autonomous guided vehicles and stacker cranes. These systems are often integral components within larger systems with even nominally autonomous systems often being integrated within larger systems like factory, warehouse or, perhaps not so well known, hospital automation systems.

The volume is divided into four parts with the first covering a description of the various in-building passenger and freight transportation systems. Modelling and simulation techniques occupy the second part of the monograph. As might be expected, the keynotes for this part are sequential, discrete and

constrained processes with queue and schedule behaviour to be modelled and simulated.

Part III of the monograph moves on to the methods of intelligent and optimal control. This part opens with an interesting historical preview that discusses the ultimate failure of heuristic rule methods as transportation systems became more technologically complex. This is followed by a review- and tutorial-type chapter on modern optimal control approaches like neural networks, genetic algorithms and combinational optimisation. The application of these techniques to specific in-building transportation systems occupies the remainder of the monograph and forms Part IV of the volume. These chapters report on such systems as elevator control, elevator-group control, multi-car elevator systems, autonomous-guided-vehicle routing control and warehouse scheduling.

Apart from the contributions to the individual in-building transportation control problems found in the various chapters, this monograph draws together the various in-building transportation systems and presents them as a coherent class of technological problems in control engineering. This is a singular achievement and the monograph is a very welcome entry to the *Advances in Industrial Control* series.

M.J. Grimble and M.A. Johnson
Glasgow, Scotland, U.K.

# Preface

This book is the result of a loose but long cooperation among the authors. Gradually we came to realize that the problems that we had been trying to make sense of from our different perspectives, are in fact very closely related. Seen in this light, our research results now in turn appear to hold some message for a rather wider audience.

To illustrate what we mean, let us take a step back, and look at our urban life from a birds' eye point of view. We will try to sketch a possible train of thought that might lead to a fresh view of the role of in-building transportation.

Civilization is the history of cities, where people gather, forming creative communities. For any human achievements to arise, merchants, artisans, scientists, artists had to be near to others, so as to share and exchange artifacts and ideas. This was made possible by the emergence of large-scale groups, living in urban settings.

Cities are compact, and this fact could be said to be their *raison d'etre*, as it reduces the need to move people and goods. But there is a limit, and transportation cannot be eliminated altogether. How close we can get to each other is ultimately determined by our physical and psychological properties, and the dimensions of our buildings reflect these constraints.

The height of floors, length of corridors, and so on, are fitted to human scales, and there is not much we can do to reduce these distances further. It is safe to say that we can consider these dimensions as given. Similar arguments based on human factors, like the tolerance of acceleration, or our reaction times, tend to limit the speed of transportation equipment in buildings. Thus at a point, in moving people and goods inside buildings, further improvements must come from smarter use of existing resources, and not from brute force.

This book is about the struggle to conquer this "last mile", or rather last hundred meters, of the distances separating people, and of the rapid advances that have happened in the last two decades in control engineering for building transportation systems.

Many techniques that were developed in this field are rather generic, and one of our goals is to make them accessible to a wider audience. This is done in the hope that by adapting these methods, better controls might solve such problems that otherwise one would be tempted to attack by throwing more resources at them.

The general structure of the book is as follows:

- In Part I, we review very briefly the "plants", that is, the systems that we need to control. This part is not making any pretentions at being an introduction to the system design of elevators or other transportation systems; for that, we recommend some excellent existing books. We are just trying to whet the appetite of the academic community to this fascinating but rather neglected field of study.
- In Part II, we give an overview of a few modeling and simulation techniques that form a necessary background for experimenting with modern control methods. Here again we are not trying to make a complete review; instead, we just give a glimpse of a few, rather subjectively selected, topics; mostly those that we have actually found important in our work.
- With Part III we arrive at the central topic of this work: introducing the control methods that are revolutionizing our subject field. We have tried to collect not only the established "state-of-the-art" techniques, but also some experimental and controversial ones. We hope that the reader will find the exposition usable and maybe thought provoking.
- Part IV is again a necessarily incomplete section; we have picked some specific topics from our research work that could help the reader see how the methods of Part III are used in practice. The examples range from almost completely theoretically oriented ones, through proposed solutions to practical problems, to actual implemented methods that power commercial systems.

Our hope is that this book could be a bridge between researchers, who might want to try their hand at this interesting field; and practiting engineers, who might find just the right solution to the difficult control problems that they encounter in their work.

Finally, the authors wish to thank the many people and organizations, whose support and help have made possible our research.

H. Kita and S. Markon want to thank first our teacher, Dr. Yoshikazu Nishikawa, President of Osaka Institute of Technology, who has kindled our interest in this field.

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T. Bartz-Beielstein expresses his thanks to Prof. Hans-Paul Schwefel and Prof. Günter Rudolph of Dortmund University who provided a productive working atmosphere. Prof. Thomas Bäck of Leiden University established his contact with S. Markon. The cooperation with Prof. Dirk Arnold of Dalhousie University and Mike Preuß and Christian Lasarczyk of Dortmund University produced valuable scientific results.

Kyoto,
January 2006 *S. Markon, H. Kita, H. Kise, and T. Bartz-Beielstein*

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