Preface

The purpose of this book is to present theoretical and practical topics related to snake robots. Snake robots are robotic mechanisms designed to move like biological snakes. The advantage of such mechanisms is their ability to move and operate in challenging environments where human presence is unwanted or impossible. Future applications of these mechanisms include search and rescue operations, inspection and maintenance in industrial process plants, and subsea operations. Research on snake robots has been conducted for several decades. For instance, the world's first snake robot was developed in Japan already in 1972. There are, however, still many theoretical and practical aspects of snake robot locomotion which have not yet been addressed in the snake robot literature. Current literature is characterised by numerous different approaches to modelling, development, and control of these mechanisms, but a unified theoretical foundation of snake robots has not yet been established.

In this book, we attempt to target these limitations of current literature on snake robots. The main goal of the book is to contribute to the mathematical foundation of the control theory of snake robots, and also stimulate and support future research on these fascinating mechanisms. To this end, the book is a complete treatment of snake robotics, with topics ranging from mathematical modelling techniques, mechatronic design and implementation, and control design strategies. In particular, several new approaches to modelling snake robot locomotion are presented. Moreover, numerous properties of snake robot dynamics are derived using nonlinear system analysis tools, and several new control strategies for snake robots are proposed. The book also describes the development of two snake robots that are employed to experimentally validate many of the theoretical results. Whereas previous literature has mainly focused on flat surface locomotion, a distinct feature of the book is the strong focus on locomotion in uneven and cluttered environments. The organisation of the book is detailed in Sect. 1.5.

Although the results presented in this book are new and based on recent conference and journal publications, they are presented at an initial level which is accessible to audiences with a standard undergraduate background in control theory or mechatronics. The book is written in a clear and easily understandable manner with numerous figures and pictures which help illustrate and visualise the material. The target audience of this book includes academic researchers and graduate students with an interest in snake robots or underactuated systems in general. The book may

also be used for self-study or as a reference by engineers and applied mathematicians, and by anyone who would like to find out more about the exciting field of snake robotics. We believe the book will be particularly useful to new researchers taking on a topic related to snake robotics since the book provides an extensive overview of the snake robot literature and also represents a suitable starting point for research in this area.

We are indebted to a number of people who have been integral to the completion of this book. We express our sincere gratitude to Professor Scott David Kelly (University of North Carolina at Charlotte), Professor Shugen Ma (Ritsumeikan University), and Professor Ole Morten Aamo (Department of Engineering Cybernetics at NTNU) for their feedback to the material in this book in conjunction with their participation in the doctoral dissertation of Pål Liljebäck.

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