Preface

Robots and Automata are notionally related. In this context, Automata (originated from the latinization of the Greek word "αυτόματον") as self-operating autonomous machines, invented from ancient years can be easily considered as the first steps of these robotic-like efforts. On other words, an Automaton is a self-operating machine, while a robot is a hardware agent with role(s) to operate usually without an immediate human operator. Automata are useful tools for formal descriptions of robots. Automata themselves are formally represented by final state machines: the abstract machines which take finite number of states and change their state while triggered by certain conditions. Authors of the book bring together concepts, architectures and implementations of Lattice Automata and Robots. Lattice Automata are minimal universal instantiation of space and time. A Lattice Automaton is either a regular array of finite state machines or collectives of mobile finite state machines inhabiting a discrete space. In both cases the finite states machines, or Automata, update their states by the same rules depending on states of their immediate neighbours. Automata and Robots often share the same notional meaning: Automata are mathematical models of robots and also they are integral parts of robotic control systems.

The book opens with inspiring text by Rosenberg—Chap. 1—on computational potential of groups of identical finite-state machines. The chapter lays somewhat foundational theoretical background for the rest of the book.

Modular robots are kinematic machines of many units capable for changing its topology by dynamically updating connections between the units. To develop efficient algorithms of reconfiguration, we represent the robotic units by configurations of Lattice Automata and study Automaton transition rules corresponding to reconfiguration. The topic is studied in full details in three chapters: Chap. 2 by Stoy introduces the reader to the theoretical and general aspects of modular reconfigurable robots in Lattice Automata; Chap. 3 by Eckenstein and Yim reproduces all the up-to-date related works and corresponding modular reconfigurable robotic systems; while in Chap. 4, Tomita and co-authors provide full details for some of these modular systems, namely Fractum and M-Tran in every possible aspect and discuss the general problems of Lattice-based robotic systems.

Motion control and path planning are amongst key problems of robotics, they put high demands on detailed knowledge of environment and consume substantial computational resources. Five chapters explicitly deal with these problems. Thus, Arena and co-authors, in Chap. 5, use Automaton networks to control locomotion of the fly-inspired robot. Efficient ways of routing, an abstract version of path planning, are designed and analysed by Hoffman and Désérable in Chap. 6. Marchese proposes to use particular families of Cellular Automata to provide an optimal representation of space and maps in precise parallel motion planning, in Chap. 7. Charalampous and co-authors in Chap. 8 adapt classical designs of Cellular Automaton based shortest path finders to undertake autonomous collision-free navigation. Moreover, Ioannidis and co-authors proposed the employment of Cellular Automata advanced with Ant Colony Optimization techniques resulting to Cellular Robotic Ants synergy coordination for tackling the path planning problem for robotic teams in Chap. 9.

Further applications of Lattice Automata in Robotics are presented in the following chapters. A novel method of map representation is proposed in Chap. 10 by Kapoutsis and his co-authors. There, a configuration of elevation heights is converted to cells' states; thus, an entire map is represented by a Cellular Automaton configuration. Cellular Automata have been a classical tool in image processing community since mid-1970s, yet, there is still vast lands of unexplored features and algorithms. In his Chap. 11, Nalpantidis demonstrates practical, real-life implementation of Cellular Automaton algorithms onboard of a mobile robot.

The last two chapters deal with cooperative actions in large-scale robotic collectives. In both chapters, robots are oscillating mechanisms arranged on a two-dimensional array: their aim is to adjust their oscillations or states to produce a specified vibration pattern. Silva and co-authors, in Chap. 12 provide modelling and analysis of the space–time behaviour of such collectives and transitions between different modes of behaviour. Application of the vibrating automaton array to physical manipulator of objects in real life is studied by Georgilas and co-authors in Chap. 13. They show how Automaton model of an sub-excitable medium can be used to purposefully transport objects.

All chapters are written in an accessible manner and lavishly illustrated. The book will help computer and robotic scientists and engineers to understand mechanisms of decentralised functioning of robotic collectives and to design future and emergent reconfigurable, parallel and distributed robotic systems.

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