CELLS AND ROBOTS : MODELING AND CONTROL OF LARGE-SIZE AGENT POPULATIONS

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Cells and Robots is an outcome of the multidisciplinary research spreading over Biology, Robotics and Hybrid Systems Theory. It is inspired by modeling reactive behavior of the immune system cell population. Each cell is considered as an independent agent. The state of the agent is uniquely defined by discrete and continuous variables. Therefore, a Hybrid Systems modeling approach is applied and the relation between the individual agent dynamics and the observed population dynamics is investigated. Following statistical physics reasoning, we disclose the form of the mathematical structure behind this relation. In our modeling approach, there is no difference if the cells are naturally or artificially created agents, such as robots. This appears even more evident when we introduce a case study concerning a large-size robotic population scenario. Under this scenario, we also formulate the optimal control of maximizing the probability of robotic presence in a given region and discuss the application of the Minimum Principle for partial differential equations to this problem.

Simultaneous consideration of cell and robotic populations is of mutual benefit for Biology and Robotics, as well as for the general understanding of multi-agent system dynamics. Biological experiments involving cell populations are the real-life realization of systems with a large amount of agents, while large-size robotic populations can be considered as their mechanistic analogy. The robotic systems are usually made to be manipulated with a specific purpose, e.g. terrain exploration, and therefore, their modeling is closely connected with their control. Cells can also be engineered and their behavior controlled, so as to lead to significant advances in medicine.

The text of this monograph is based on the PhD thesis of the first author. The work was the second best in the 5th edition of Georges Giralt Award for the best European PhD thesis in Robotics, annually awarded by the European Robotics Research Network (EURON).

Keywords associated with the book: Multi-Agent Systems, Stochastic Hybrid Automata, Immune System, T-Cell population, Robotics, Agent Population Dynamics, Agent Population Optimal Control

Audience: The monograph is aimed at researchers and postgraduate students working in the area of Multi-Agent Systems, including natural and artificial agents, such as cells and robots, respectively. This includes areas of the immune system modeling, Computational Biology, Bio-Medical Engineering, Robotics, Nano-Robotics, molecular devices, nanotechnology, aero-space applications. The monograph includes results related to the stochastic hybrid systems and the application of the optimal control for partial differential equations. Therefore, it is also of interest to engineers and mathematicians working in the theoretical development of Control System Theory and its applications.