Preface

Nanorobotics is an emerging interdisciplinary technology area raising new scientific challenges and promising revolutionary advancements in applications such as medicine, biology, and industrial manufacturing. Nanorobots could be defined as intelligent systems with overall dimensions at or below the micrometer range that are made of assemblies of nanoscale components with individual dimensions ranging between 1 and 100nm. Nanorobots would be able to perform at least one of the following actions: actuation, sensing, signaling, information processing, intelligence, swarm behavior at the nanoscale. In an effort to disseminate the current advances in nanorobotics, and to stimulate a discussion on future research directions in this field, this book addresses the current state of the art and the growing interest of the robotics community. The editors believe that this book can invigorate new research interests in the development of nanorobotic systems and their use in different applications. The various chapters demonstrate that the area of nanorobotics can attract multidisciplinary teams of researchers, assembling skills and expertise from different disciplines, such as biology, robotics, engineering, medicine, nanotechnology, chemistry, and computer science.

The present book "*Nanorobotics: Current Approaches and Techniques*" is a collection of 21 excellent chapters that represent the large variety and high quality of nanorobotics research in terms of robot design and fabrication, actuation and sensing, manipulation, and control at the nanoscale. The editors have classified the authors' contributions into five main application domains. The volume begins with a part of six chapters introducing the vision and applications of nanorobotics. These chapters provide an overview of the state-of-the-art methodology and the foreseen applications of nanorobotics, such as space, environmental, biological, or medical applications. The next four parts are focusing on the various types of nanorobotic systems and their applications.

Section 2, "Nanomanipulation and Industrial Nanorobotics," collects three chapters addressing the problem of robotic manipulation at the nanoscale for industrial processes. These chapters are relevant to industrial nanorobotics (or otherwise called nanomanipulators) that can be used in the fabrication, manipulation, control, and assembly at the nanoscale. Techniques of nanomanipulation of 1D and 2D

nanomaterials through an imaging atomic force microscope (AFM) device or a scanning electron microscope (SEM) device are presented. Finally, mass transport at attogram (10^{-18}g) level using carbon nanotubes is introduced for the manipulation and assembly tasks in nanofluidics.

Section 3, "Nanomanipulation in Biomedical Applications," addresses the increasing interest in handling, understanding, and integrating biological systems, important to the fields of biomedicine, process industry, pharmacy, and biomaterial research. Three chapters demonstrate the nanomanipulation and nanohandling capabilities of nanorobots in a wide variety of biological materials such as cells, viruses, proteins, DNA, and RNA. Techniques related to noncontact manipulation (including fluidic force, magnetic force, electrical force, and optical tweezers) and contact manipulation (atomic force microscope probes, nano-grippers) are presented.

Section 4, "Inside the Body Nanorobotic Applications," describes different technologies for developing nanorobotic drug carriers including nanotubes, nanowires, nanoparticles, or biological bacteria. A major issue is the powering and steering control of these untethered devices in order to allow in vivo interaction with the human body. Three chapters describe wireless magnetic control of nano-drug delivery systems and, in particular, the generation of the required magnetic fields in dedicated magnetic setups or magnetic resonance imagery (MRI) systems. The advantages and limitations of both synthetic relying on magnetism and bacterial carriers relying on a self-propelling flagellated system are described and the advantages of combining both approaches for navigation in the vascular network are demonstrated. Finally, two other chapters describe the sensing strategies for early diagnosis of cancer by using different visual modalities.

Section 5, "Bio-Nano Actuators for Nanorobotics," presents bio-inspired mechanisms, actuators, sensors, and systems using biological elements. Four chapters expose the recent advances in protein, bacterial flagellar, and DNA-based nanorobotic systems.

It is difficult to cast a vision for the future of this newly sprung field. We hope that such ventures will be facilitated by this volume. We would like to express our gratitude to the authors for providing excellent contributions and descriptive illustrations. We would also like to acknowledge the tremendous efforts of the reviewers to complete this task on time. Finally, we would like to thank Alison Waldron, Senior Editor, and Merry Stuber, Editorial Assistant of Springer, for their enthusiastic support for this book, their continuous patience, and their skillful handling of technical issues related to publication of this book.

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