# Book Review

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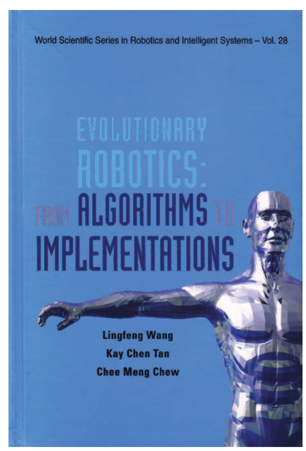
# Evolutionary Robotics: From Algorithms to Implementations

***Evolutionary Robotics: From Algorithms to Implementations*** by Lingfeng Wang, Kay Chen Tan, and Chee Meng Chew, World Scientific, Singapore, 2006, pp. 247. ISBN: 981-256-870-0.

The book authored by Wang, Tan, and Chew is a refreshing and much needed addition to the field of Robotics, and concentrates on the application of soft computing—evolutionary algorithms, neural networks, and fuzzy logic—for intelligent sensing, learning, and robot navigation. The book deals with both analytical and practical issues of these enabling technologies in the realization of autonomous robotic navigation. It presents background theory, system developments, and simulation studies along with case studies, particularly emphasizing the practical aspects of walking robots. The book is well written, readable, and is concise yet comprehensive. It is more suited as a convenient reference book for researchers and practicing professionals, rather than a classroom textbook. If worked examples and end-of-chapter problems were added, the book would easily serve as a text for a graduate course on Intelligent Walking Robots.

To examine the significance of the book it is useful to understand the nature of the technological context of the work. Soft computing cooperatively uses fuzzy logic, neural networks, and genetic algorithms for knowledge representation and processing, and to some degree for mimicking the reasoning and decision-making process of a human [1]. Conventional artificial intelligence (AI) on the other hand, has relied heavily on predicate logic and symbolic manipulation for the processing of descriptive information and "knowledge" in realizing some degree of intelligent behavior. The knowledge itself may be represented in a special high-level language. The decisions that are made through processing of such "artificial" knowledge, perhaps in response to data such as sensory signals, may possess characteristics of intelligent decisions of a human. Biological analogies exist for fuzzy, neural, and genetic approaches, which are the main constituents of soft computing. In the context of bio-inspiration of various methodologies, fuzzy techniques attempt to approximate human knowledge and the associated reasoning process; neural networks are a simplified and "artificial" representation of the neuron structure of a brain; and genetic algorithms follow procedures that are crudely similar to the process of evolution in biological species. Techniques of soft computing have a particular appeal in view of these biological analogies that exist. This is no accident because in soft computing it is the behavior of human intelligence that would be mimicked. Biological analogies and key characteristics of several techniques of soft computing are listed in Table 1 [1]. The book reviewed here deals with the use of such bio-inspired techniques in the field of robotics in general and robot navigation in particular.




Future generations of mobile robots may be expected to carry out round-the-clock navigation and operation in unstructured and dynamic environments, with minimal human intervention. It will be necessary that these systems maintain consistency of operation and cope with unfamiliarities, disturbances and unexpected variations in the robot and its operating environment. This will call for tremendous flexibility, accuracy, and some level of autonomous operation, which translates into a need for higher degree of intelligence and adaptivity. Smart robots and robotic systems will exhibit an increased presence and significance in a wide variety of applications. There is clearly a need to incorporate a greater degree of intelligence and a higher level of autonomy in mobile robots. Realization of intelligent robots will require the appropriate integration of such devices as sensors, actuators and controllers which themselves may have to be "intelligent." The book under review is an important contribution towards this objective.

Based primarily on the authors' own research, the book consists of nine chapters, an index, and an extensive list of

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**TABLE 1 Biological analogies in the techniques of soft computing.**

| TECHNIQUE | CHARACTERISTIC | BIOLOGICAL ANALOGY |
|---|---|---|
| FUZZY LOGIC | USES FUZZY RULES AND APPROXIMATE REASONING | HUMAN KNOWLEDGE |
| NEURAL NETWORKS | NETWORK OF MASSIVELY CONNECTED NODES | NEURON STRUCTURE IN BRAIN |
| GENETIC ALGORITHMS | DERIVATIVE-FREE OPTIMIZATION | BIOLOGICAL EVOLUTION |
| CONVENTIONAL AI | USES PREDICATE LOGIC AND SYMBOLIC PROCESSING OF INFORMATION | SYMBOLIC LANGUAGES |

references. Chapter 1 deals with the application of artificial evolution in autonomous robot navigation. This introductory chapter gives a comprehensive review of the pertinent literature, focusing on approaches that use neural networks, evolutionary computing, and fuzzy logic. Some attention is given to "learning" approaches. Ending with an extensive bibliography, the chapter sets the stage for the rest of the book.

Chapter 2 deals with the use of evolvable hardware in robots, for adapting to changes. Application of evolvable hardware in evolutionary robotics is surveyed. Some representative experiments are presented. An extensive bibliography is listed.

Design and real-time implementation of autonomous robot navigation systems using evolvable hardware are addressed in Chapter 3. In particular, an evolvable robot controller at the hardware gate level that is capable of adapting to dynamic changes in the environment is developed. It is implemented on field programmable gateway array-based robot turret, and evolutionary computing is applied as a learning tool to guide the artificial evolution at the hardware level. A physical real-time implementation is provided as an illustration of the developed approach. Light source following and obstacle avoidance by a robot with traction fault are demonstrated. A comprehensive bibliography is given.

Chapter 4 is on intelligent sensor fusion and learning for autonomous robot navigation. Target recognition is achieved using fuzzy-logic-based sensor fusion. Grid map-oriented path planning is used for determination of navigation path and adaptation. A multi-level architecture is used for implementation of the technologies. Robustness and flexibility in dealing with robotic behaviors and dynamic environment are demonstrated using a real-world application. A comprehensive bibliography is given at the end of the chapter.

Chapter 5 is a brief chapter, which addresses the topic of task-oriented developmental learning of humanoid robots. In the developed approach, using real-time experience, a robot is able to automatically represent multiple tasks. An evolvable partitioned tree structure is used for the knowledge base of task representation. By this means, a specific task branch can be used, without having to consider the entire knowledge base (tree), with clear advantages in speed and accuracy. A prototype is designed and implemented on a Khepera robot and experiments conducted. Results show that with this method, a robot is able to redirect itself by interacting with its environment. Also, learned tasks can be updated to satisfy varying specifications in the real world. A comprehensive bibliography is given at the end of the chapter.

Chapter 6 examines bipedal walking through reinforcement learning. A general control architecture is presented for bipedal walking, using the divide-and-conquer approach. A motion control algorithm is formulated using this basis and the virtual model approach. Key parameters of the system for stable walking are learned using reinforcement learning. Simulation results from two bipedal walking robots show that the local speed control method is effective in reducing the learning time. A comprehensive bibliography is given at the end of the chapter.

Chapter 7 treats the topic of swing time generation for bipedal walking. Here genetic algorithms (GA) and fuzzy logic are combined for generating stable sequences for bipedal walking. The linear inverted pendulum model with fuzzy decision making is used for this purpose. GA is used to optimize the parameters of the fuzzy decision making system. A comprehensive bibliography is given at the end of the chapter.

Chapter 8 concludes the body of the book by presenting some important issues in bipedal walking. It applies genetic algorithms to optimize key parameters in the walking control of a humanoid robot. Virtual model control is used as the control framework. Here ankle gain is important in regulating forward velocity during walking. Stable walking gates and smooth velocity profiles are achieved by this approach, as demonstrated using simulations. A bibliography is given at the end of the chapter.

Chapter 9 concludes the book by summarizing the important developments presented in the book. Future directions for possible research and focus are indicated as well.

The shortcomings of the book are quite minor, and may be handled in a future edition. Specific suggestions are to include cross references for various chapters, provide full descriptions of various acronyms at their first citing, and add further illustrative examples. They will increase the value of the book. In the present form, the book is particularly valuable for researchers and practitioners of intelligent robot navigation, as a convenient and advanced reference. The authors have been able to expand the horizons of the field and to introduce novel ways of looking at the traditional problem of robot navigation. Some research topics are indicated as well, making the book suitable for researchers in the use of soft computing in robotic navigation. The book is quite readable, and it challenges the readers to explore further ideas and issues in the field. In this sense, the main objectives of the authors have been successfully achieved.

## Reference

[1] F.O. Karray and C.W. de Silva, *Soft Computing and Intelligent Systems Design—Theory, Tools, and Applications*, Addison-Wesley, Pearson, New York, 2004.