Preface

Mobile robotic is a recent field that has roots in many engineering and science disciplines such as mechanical, electrical, mechatronics, cognitive and social sciences just to name few. A mobile robot needs efficient mechanisms of locomotion, kinematics, sensors data, localization, planning and navigation that enable it to travel throughout its environment. Scientists have been fascinated by conception of mobile robots for many years. Machines have been designed with wheels and tracks or other locomotion devices and/or limbs to propel the unit. When the environment is well ordered these machines can function well. Mobile robots have demonstrated strongly their ability to carry out useful work.

Intelligent robots have become the focus of intensive research in the last decade. The field of intelligent mobile robotics involves simulations and real-world implementations of robots which adapt themselves to their partially unknown, unpredictable and sometimes dynamic environments.

The design and control of autonomous intelligent mobile robotic systems operating in unstructured changing environments includes many objective difficulties. There are several studies about the ways in which, robots exhibiting some degree of autonomy, adapt themselves to fit in their environments. The application and use of bio-inspired techniques such as reinforcement learning, artificial neural networks, evolutionary computation, swarm intelligence and fuzzy systems in the design and improvement of robot designs is an emergent research topic. Researchers have obtained robots that display an amazing slew of behaviours and perform a multitude of tasks. These include, but are not limited to, perception of environment, localisation, walking, planning and navigation in rough terrain, pushing boxes, negotiating an obstacle course, playing ball, plant inspection, transportation systems, control systems for rescue operations, foraging strategies and design of automatic guided vehicles in manufacturing plants.

In this context, mobile robots designed using evolutionary computation approaches, usually known as *mobile evolutionary robotics*, have experienced significant development in the last decade. The fundamental goal of mobile evolutionary robotics is to apply evolutionary computation methods such as genetic algorithms, genetic programming, evolution strategies, evolutionary programming and differential evolution to automate the production of complex behavioural robotic controllers.

This volume offers a wide spectrum of sample works developed in leading research throughout the world about evolutionary mobile robotics and demonstrates the success of the technique in evolving efficient and capable mobile robots. The book should be useful both for beginners and experienced researchers in the field of mobile robotics. In the following, we go through the main content of the chapter included in this volume, which is organised in two main parts: Evolutionary Mobile Robots and Learning Mobile Robots

Part I. Evolutionary Mobile Robots

In Chapter 1, which is entitled *Differential Evolution Approach Using Chaotic Sequences Applied to Planning of Mobile Robot in a Static Environment with Obstacles*, the authors introduce a new hybrid approach of differential evolution combined with chaos (DEC) to the optimization for path planning of mobile robots. The new chaotic operators are based on logistic map with exponential decreasing, and cosinoidal decreasing. They describe and evaluate two case studies of static environment with obstacles. Using simulation results, the authors show the performance of the DEC in different environments in the planned trajectories. They also compared the results of DEC with classical differential evolution approaches. From the simulation results, The authors observed that the convergence speed of DEC is better than classical differential evolution. They claim that the simplicity and robustness of DEC, in particular, suggest their great utility for the problem's path planning in mobile robotics, as well as for other optimization-related problems in engineering.

In Chapter 2, which is entitled *Evolving Modular Robots for Rough Terrain Exploration*, the authors propose an original method for the evolutionary design of robotic systems for locomotion on rough terrain. They encompass the design of wheeled, legged or hybrid robots for their wide range of capabilities for support and propulsion. Their goal is to optimize the mechanical and the control system to achieve a locomotion task in a complex environment (irregular, sliding or even with uncertainties). They guarantee that the modular approach brings the possibility to match the diversity of tasks with the combination of assembly modes and that this global approach embeds an evolutionary algorithm with a dynamic simulation of the mobile robot operating in its environment. The authors claim that the hybrid encoding of the genotype allows evolving the robot morphology and its behaviour simultaneously.

They also propose specialized genetic operators to manipulate this specific encoding and to maintain their efficiency through evolution.

In Chapter 3, which is entitled *Evolutionary Navigation of Autonomous Robots Under Varying Terrain Conditions*, the authors present a fuzzy-genetic approach that provides both path and trajectory planning, and has the advantage of considering diverse terrain conditions when determining the optimal path. They modeled the terrain conditions using fuzzy linguistic variables to allow for the imprecision and uncertainty of the terrain data. The authors claim that although a number of methods have been proposed using GAs, few are appropriate for a dynamic environment or provide response in real-time. They guarantee that the proposed method is robust, allowing the robot to adapt to dynamic conditions in the environment.

In Chapter 4, which is entitled *Aggregate Selection in Evolutionary Robotics*, the authors investigate how aggregate fitness functions have been and continue to be used in evolutionary robotics, what levels of success they have generated relative to other fitness measurement methods, and how problems with them might be overcome.

In Chapter 5, which is entitled *Evolving Fuzzy Classifier for Novelty Detection and Landmark Recognition by Mobile Robots*, the authors present an approach to real-time landmark recognition and simultaneous classifier design for mobile robotics. The approach is based on the recently developed evolving fuzzy systems (EFS) method, which is based on subtractive clustering method and its on-line evolving extension called eClustering. The authors propose a novel algorithm that is recursive, non-iterative, incremental and thus computationally light and suitable for real-time applications. They report experiments carried out in an indoor environment (an office located at InfoLab21, Lancaster University, Lancaster, UK) using a Pioneer3 DX mobile robotic platform equipped with sonar and they introduce and analyse motion sensors as a case study. The authors also suggest several ways to use the engineered algorithm.

Part II. Learning Mobile Robots

In Chapter 6, which is entitled *Reinforcement Learning for Autonomous Robotic Fish*, the authors discuss applications of reinforcement learning in an autonomous robotic fish, called Aifi. They develop a three-layer architecture to control it. The bottom layer consists of several primary swim patterns. The authors use a sample-based policy gradient learning algorithm in this bottom layer to evolve swim patterns. The middle layer consists of a group of behaviours which are designed for specific tasks. They apply a state-based reinforcement learning algorithm, Q-learning in particular, in the top layer to find an optimal planning policy for a specific task. They claim that both simulated and real experiments show good feasibility and performance of the proposed learning algorithms.

In Chapter 7, which is entitled *Module-based Autonomous Learning for Mobile Robots*, the author implement a solution that uses qualitative and quantitative knowledge to make robot tasks able to be treated by Reinforcement Learning (RL) algorithms. The steps of this procedure include a decomposition of the overall task into smaller ones, using abstractions and macro-operators, thus achieving a discrete action space; the application of a state model representation to achieve both time and state space discretisation; the use of quantitative knowledge to design controllers that are able to solve the subtasks; learning the coordination of these behaviours using RL, more specifically Q-learning. The authors use and evaluate the proposed method on a set of robot tasks using a Khepera robot simulator. They test two approaches for state space discretisation were tested, one based on features, which are observation functions of the environment and the other on states. They compare the learned policies over these two models to a predefined hand-crafted policy. The authors claim that the resulting compact representation allows the learning method to be applied over the state-based model, although the learned policy over the feature-based representation has a better performance.

In Chapter 8, which is entitled *A Hybrid Adaptive Architecture for Mobile Robots Based on Reactive Behaviours*, the author first describe the high-level schemas commonly adopted for intelligent agent architectures, focusing on their constituent structural elements. Then they present the main organisation of the proposed architecture, where the behaviours used and the coordination layer are respectively explained. They also describe and analyse the experiments conducted with AAREACT and the obtained results.

In Chapter 9, which is entitled *Collaborative Robots for Infrastructure Security Applications*, the author addresses the scenario of a team of mobile robots working cooperatively by first presenting distributed sensing algorithms for robot localisation and 3D map building. They also present a multi-robot motion planning algorithm according to a patrolling and threat response scenario. The authors use neural network based methods for planning a complete coverage patrolling path.

In Chapter 10, which is entitled *Imitation Learning: An Application in a Micro Robot Soccer Game*, the authors present a robot soccer system that learns by imitation and by experience. They use both learning by imitation then learning by experience as a strategy to make robots grasp the way they should play soccer. The authors claim that repeating this process allows that robots can continuously improve their performance.

We are very much grateful to the authors of this volume and to the reviewers for their tremendous service by critically reviewing the chapters. The editors would also like to thank Prof. Janusz Kacprzyk, the editor-in-chief of the Studies in Computational Intelligence Book Series and Dr. Thomas Ditzinger from Springer-Verlag, Germany for their editorial assistance and excellent

collaboration to produce this scientific work. We hope that the reader will share our excitement on this volume and will find it useful.

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