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Innovations in Intelligent Machines - 1

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Foreword

Innovations in Intelligent Machines is a very timely volume that takes a fresh look on the recent attempts of instilling human-like intelligence into computer-controlled devices. By contrast to the machine intelligence research of the last two decades, the recent work in this area recognises explicitly the fact that human intelligence is not purely computational but that it also has an element of empirical validation (interaction with the environment). Also, recent research recognises that human intelligence does not always prevent one from making errors but it equips one with the ability to learn from mistakes. The latter is the basic premise for the development of the collaborative (swarm) intelligence that demonstrates the value of the virtual experience pool assembled from cases of successful and unsuccessful execution of a particular algorithm.

The editors are to be complemented for their vision of designing a framework within which they ask some fundamental questions about the nature of intelligence in general and intelligent machines in particular and illustrate answers to these questions with specific practical system implementations in the consecutive chapters of the book.

Chapter 2 addresses the cost effectiveness of "delegating" operator's intelligence to on-board computers so as to achieve single operator control of multiple unmanned aerial vehicles (UAV). The perspective of cost effectiveness allows one to appreciate the distinction between the optimal (algorithmic) and the intelligent (non-algorithmic, empirical) decision-making, which necessarily implies some costs. In this context the decision to use or not to use additional human operators can be seen as the assessment of the "value" of the human intelligence in performing a specific task.

The challenge of the development of collaborative (swarm) intelligence and its specific application to UAV path planning over the terrain with complex topology is addressed in Chapters 3 and 4. The authors of these chapters propose different technical solutions based on the application of game theory, negotiation techniques and neural networks but they reach the same conclusions that the cooperative behaviour of individual UAVs, exchanging

information about their successes and failures, underpins the development of human-like intelligence. This insight is further developed in Chapter 8 where the authors look at the evolution-based dynamic path planning.

Chapter 5 emphasises the importance of physical constraints on the UAVs in accomplishing a specific task. To re-phrase it in slightly more general terms, it highlights the fact that algorithmic information processing may be numerically correct but it may not be physically very meaningful if the laws of physics are not taken fully into account. This is exactly where the importance of empirical verification comes to fore in intelligent decision-making.

The practice of processing uncertain information at various levels of abstraction (granulation) is now well recognised as a characteristic feature of human information processing. By discussing the state estimation of UAVs based on information provided by low fidelity sensors, Chapter 6 provides a reference material for dealing with uncertain data. Discussion of the continuous-discrete extended Kalman filter placed in the context of intelligent machines underlines the importance of information abstraction (granulation).

Chapters 7 and 9 share a theme of enhancement of sensory perception of intelligent machines. Given that the interaction with the environment is a key component of intelligent machines, the development of sensors providing omni directional vision is a promising way to achieving enhanced levels of intelligence. Also the ability to achieve, through appropriate sensor design, long distance (low accuracy) and short distance (high accuracy) vision correlates closely with the multi-resolution (granular) information processing by humans.

The book is an excellent compilation of leading-edge contributions in the area of intelligent machines and it is likely to be on the essential reading list of those who are keen to combine theoretical insights with practical applications.

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Preface

Advanced computational techniques for decision making on unmanned systems are starting to be factored into major policy directives such as the United States Department of Defence UAS Roadmap. Despite the expressed need for the elusive characteristic of "autonomy", there are no existing systems that are autonomous by any rigorous definition. Through the use of sophisticated algorithms, residing in every software subsystem (state estimation, navigation, control and so on) it is conceivable that a degree of true autonomy might emerge. The science required to achieve robust behavioural modules for autonomous systems is sampled in this book. There are a host of technologies that could be implemented on current operational systems. Many of the behaviours described are present in fielded systems albeit in an extremely primitive form. For example, waypoint navigation as opposed to path planning, so the prospects of upgrading current implementations are good if hurdles such as airworthiness can be overcome. We can confidently predict that within a few years the types of behaviour described herein will be commonplace on both large and small unmanned systems.

This research book includes a collection of chapters on the state of art in the area of intelligent machines. We believe that this research will provide a sound basis to make autonomous systems human-like.

We are grateful to the authors and reviewers for their vision and contribution. The editorial assistance provided by Springer-Verlag is acknowledged.

Editors

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