BIO-INSPIRED EMERGENT CONTROL OF LOCOMOTION SYSTEMS

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To our parents

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Preface

Living creatures show distinct abilities to interact adaptively with their environment. These characteristics find their roots in the self-organizing dynamics of neural circuits, which in nonlinear science represent the highest example of emergent system behavior. In this work bio-inspired locomotion control is achieved by means of arrays of locally coupled nonlinear systems (Cellular Nonlinear Networks). The main point of the approach is that nonlinear oscillators are an efficient way not only to model the principles underlying neural structures devoted to locomotion control in living creatures, but more importantly to implement them to build autonomous walking robots. In this context the concepts of self-organization and synchronization, universal paradigms of science and real world laws, play a fundamental role in the emergence of the complex behavior of the network of nonlinear circuits. The proposed method is efficient at all levels of the hierarchical control of locomotion: the low level of gait generation, reflex and sensory feedback implementation, and the high level of posture stabilization and behavioral modules. The strategy introduced is hardware-oriented, so the concepts of emergent behavior and self-organization can be appreciated in chip devices applied to walking machines. Experimental results obtained with a prototype of the VLSI chip implementing the Cellular Nonlinear Network generating the locomotion pattern and tests on a bio-inspired insect-like robot are presented.

This book constitutes a complete monograph on new locomotion control strategies of bio-inspired robots implemented through Cellular Nonlinear Networks (CNNs). The new approach for locomotion control, based on emergent properties of nonlinear dynamical systems, is exhaustively described and several case studies are presented. Topics related to the problem of locomotion control from low level to high level control are addressed.

The book contains both a detailed introduction on the fundamentals of Cellular Nonlinear Networks and bio-inspired control and research results with particular emphasis on applications. The proposed methodology is illustrated with the help of several examples dealing with bio-inspired hexapod robots. The present book is thus aimed both at newcomers to the field of bio-inspired locomotion control and graduate students in advanced courses on bio-inspired robotics as well as PhD students and researches both from academic institutions and industrial companies. In particular, the main features of the approach beneficial to the reader are the following: analog computation is used to control locomotion systems; realization of well-tested circuit for control is discussed; each reader could implement its own circuits at low cost (few dollars for each analog unit).

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Contents

<i>Preface</i>	vii
1. Introduction	1
1.1 The Central Pattern Generator (CPG)	2
1.2 Locomotion control in hexapods	4
1.3 Main topics of the work	6
2. CNN-based Central Pattern Generators	9
2.1 Introduction	9
2.2 Brief overview on CNN architectures	12
2.3 The CPG neuron	14
2.3.1 The synapse model	18
2.4 The CNN-based CPG	21
2.4.1 RD-CNNs to design artificial locomotion patterns	22
2.4.2 Guidelines for CNN-based CPG design	24
2.5 Example: the caterpillar gait for hexapods	28
2.6 A spatio-temporal algorithm for controlling locomotion of a hexapod robot	32
2.7 Motor-neurons and inter-neurons	37
3. CNN-based CPGs with sensory feedback and VLSI implementation	43
3.1 Direction control	43
3.1.1 The CPG cell	44
3.1.2 CPG with sensory feedback for direction control	47
3.2 Feedback from ground contact sensors	50

3.2.1	Behavior of the CNN neuron driven by a periodic forcing signal	51
3.2.2	CPG with ground contact feedback: results	54
3.3	Reflex implementation	57
3.3.1	The elevator reflex	57
3.3.2	The searching reflex	58
3.4	Speed control	60
3.4.1	Speed of the gait	61
3.4.2	Locomotion pattern	63
3.5	The CNN-based CPG VLSI chip	63
3.5.1	The hybrid approach	63
3.5.2	The VLSI Circuit Design	64
3.5.3	Experimental results	66
4.	Decentralized locomotion control	73
4.1	CNN-based decentralized control model	73
4.1.1	The decentralized control paradigm	75
4.1.2	The CNN leg controller	77
4.1.3	The whole control system and results	80
4.1.3.1	CNN Decentralized Control	80
4.1.3.2	Choice of the parameters of the model	83
4.1.3.3	Robustness of the CNN Decentralized Controller	86
4.2	Integrate-and-fire neurons and decentralized control	88
4.2.1	The leg controller	90
4.2.1.1	Biological motivations	90
4.2.1.2	The integrate-and-fire neuron	90
4.2.1.3	Scheme of the leg controller	91
4.2.1.4	The elevator reflex	95
4.2.2	The whole control scheme	97
4.3	CPG and decentralized control	99
5.	A gallery of bio-inspired robots	101
5.1	Lampbot: A lamprey robot controlled by RD-CNN	101
5.2	MTA hexbot: a hexapod robot controlled by MTA-CNN	106
5.3	MTA hexbot II: a remote-controlled hexapod robot	110
5.4	MTA hexbot III: a robot driven by the CNN-based CPG VLSI chip	112

6. High-level analog control: attitude control and Motor Maps	115
6.1 CNN-based attitude control	115
6.1.1 The CNN for gait control	117
6.1.2 The attitude control CNN	119
6.1.3 Experimental tests	123
6.2 Motor Maps and attitude control	125
6.2.1 Motor Maps	125
6.2.2 Motor Maps for Chaos Control	129
6.2.3 Motor Maps for attitude control	132
6.2.4 Motor Map-based attitude control in a simplified biped model	136
6.3 Learning with Motor Maps	142
7. High-level analog control: Turing patterns and autowaves	145
7.1 Reaction-Diffusion CNN	146
7.2 Navigation control based on Turing patterns	148
7.2.1 Turing patterns and CNNs	149
7.2.2 From CNN patterns to action patterns	151
7.2.3 Experimental Setup	153
7.2.4 To probe further	154
7.3 Navigation control based on autowaves	156
7.3.1 The CNN algorithm	157
7.3.2 Implementation on a roving robot and experimental results	160
8. Conclusions	165
Appendix A HexaDyn and CNNTLab: two tools for bio- inspired locomotion control	171
A.1 HexaDyn, a simulator for the hexapod robot	171
A.2 CNNTLab	173
Appendix B Design of the CNN circuit	177
Appendix C A chaos-based sensor for bio-inspired robots	181
C.1 Continuous CPPM	181
C.2 The CPPM Sonar	183

<i>References</i>	189
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<i>Index</i>	197
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