

Goal-Based Control and Planning in Biped Locomotion Using Computational Intelligence Methods

Juan José Figueredo Uribe

Tutor:
Jonatan Gómez Perdomo, PhD

Submitted in total fulfilment of the requirements
of the degree of Master of Engineering

February 18, 2008

Facultad de Ingeniería
Universidad Nacional de Colombia

DRAFT

Contents

1	Introduction	3
1.1	Goals	3
1.2	Main Contributions	3
1.3	Contents Overview	3
2	Preliminaries	4
2.1	Introduction	4
2.2	Biped Walking	5
2.2.1	Biped Model	5
2.2.2	Static and Dynamic Stability	5
2.2.3	Biological Considerations on Biped Locomotion	6
2.2.4	Robustness and Non-structured environments	7
2.2.5	Planning Beyond Periodic Walking	7
2.3	Neural Fields	7
2.3.1	Mathematical Model	7
2.3.2	Local Solutions	7
2.3.3	Bifurcation and Modes	7
2.4	Evolution and Adaptation	7
2.4.1	Evolutionary Algorithms	7
2.4.2	Niching	7
2.4.3	Dynamic Environments and Co-evolution	7
2.5	Computational Intelligence Applied to Biped Robotics: A Survey	7
2.5.1	Central Pattern Generator (CPG) Methods	8
2.5.2	Trajectory Tracking Methods	13
2.5.3	Dynamic Walking Control	15
2.5.4	Static Walking Control	20
2.5.5	Current Trends on Research and Future Perspectives	22
3	Neural Fields as Control and Planning Systems	23
3.1	Introduction	23
3.2	Goal-Based Planning and Control Planning	23
3.3	Neural Fields Model for Control and Planning	23
3.4	Comparison with Other Computational Intelligence Techniques	23
3.5	Comparison with Traditional Control Schemes	23
3.6	Experimental Framework	23
3.7	Experimental Results	23
3.8	Discussion	23
4	Evolution of Neural Fields	24
4.1	Introduction	24
4.2	The Need for Adaptation	24
4.3	Previous Adaptation Schemes for Neurocontrollers	24
4.4	Evolution of Neural Fields	24
4.5	Co-evolution and Strategies for Global Optimization	24
4.6	Co-evolution and Evolutionary Landscape Adaptation for Neural Fields	24
4.7	Experimental Framework	24
4.8	Experimental Results	24
4.9	Discussion	24

5	Goal-Based Control and Planning in Biped Locomotion	25
5.1	Introduction	25
5.2	Computational Intelligence Methods in Biped Locomotion	25
5.3	Neural Fields for Control in Biped Locomotion	25
5.4	Neural Fields for Goal-Based Planning in Biped Locomotion	25
5.5	Acquisition of New Goals by Evolution	25
5.6	Sustainable Learning by Evolutionary Landscape Adaptation	25
5.7	Experimental Framework	25
5.8	Experimental Results	25
5.9	Discussion	25
6	Conclusions	26
6.1	Main Contributions	26
6.2	Future Work	26