

minimal change rot

freestyle change blue

würde aus meiner sicht gehörig umschieben
 part 1: approach and methods (oder so)
 c1 control archi and systems c2 simulation
 c3 hardware
 part 2: baseline behavior library
 part 3: architecture unsup locomot learning
 part 4: conclusion

Contents

Introduction

Motivation	1
Ansatz/Model (brief)	3
Related Work	3
Outline	3

I A baseline behavior library ~~of evolved gait controllers~~ 4

1 Control Architecture start simple und add details during descent 5

1.1 Dynamical Systems	6
1.2 Control Basics	9
1.2.1 Proportional-Integral-Derivative Controller	11
1.2.2 Non-linear extensions to PID control	13
1.3 Cognitive Sensorimotor Loops	14
1.4 Advanced Non-linear Controllers for Multi-Joint Robots	21
1.4.1 Sensor and Motor Space Definition	22
1.4.2 Generalized Non-linear Controller	24
1.4.3 A simple bipedal gait pattern	29
1.4.4 Reducing the number of weights	31

2 Simulated Environment and Robots 35

2.1 Simloid	35
2.2 Robot model	37
2.2.1 Body Model	37
2.2.2 Joint Model	38
2.2.3 Angle and Velocity Sensor Models	38
2.2.4 Acceleration Sensor Model	38
2.2.5 Electromechanical Motor Model	39
2.3 Joint Friction Model	41
2.3.1 Friction Models	42
2.3.2 The BRUSH Friction Model	44
2.4 Simulated Robots	47
2.4.1 Pendulum	50
2.4.2 Crawler	51
2.4.3 Tadpole	51
2.4.4 Quadruped	52

2.4.5	Humanoid	53
2.4.6	How to handle undesired terminal states	55
2.5	Scenarios for increasing the robustness of walking	55
3	A Baseline Behavior Library of evolved gait and beyond oder so	59
3.1	Artificial Evolution—Terms and Principles	59
3.2	The gait controller as subject to evolution	64
3.2.1	Initial Values for starting Populations	64
3.2.2	Symmetry Assumption	65
3.3	Fitness Functions for Legged Robots	66
3.3.1	Running fast	66
3.3.2	Constraints	67
3.3.3	Walking efficiently	68
3.3.4	Slowing Down and Stopping	68
3.3.5	Seeds	69
3.4	Proposal for a simple Generation-free Algorithm	70
3.5	Experiments and Results	71
3.5.1	Crawling	72
3.5.2	Walking	72
3.5.3	Running	73
3.5.4	Starting and Stopping	73
3.5.5	Directional Locomotion	74
3.5.6	Walking under Disturbances	75
3.5.7	Operators and Hyper-Parameters	76
3.6	Behavior Library Overview	77
	Summary of Part One	82
II	Hannah—An open-source fourlegged robotic platform for research and development	84
4	Mechanical Design	86
4.1	Introducing Hannah	86
4.2	Free/Libre Open-Source Hardware Designs	88
4.3	Low-cost, Lightweight, and Highly Available Parts	90
4.4	Reusability and Generalization	91
4.5	Fast-Prototyping, Manufacturing, and Materials	92
4.6	Legs and Drives	94
4.6.1	Tooth Belt Transmission	94
4.6.2	Leg Assembly Concept	96
4.6.3	Knee Joints, Lower Legs, and Feet	98
4.7	Torso base structure	98
4.8	Shells	100

den Part II in zwei teile teilen, c4 + c5 ab in den Appendix, c6 in Part I als 'hardware'

5	Electronics, Communication and Control	103
5.1	Architecture Summary	103
5.2	Requirements for Robotic Drives	104
5.3	Sensorimotor	106
5.3.1	Overvoltage and Constant Voltage Operation	107
5.3.2	Additional Sensors	108
5.4	Limb Controller	111
5.4.1	Bus System	111
5.4.2	Spinal Cord Communication	113
5.4.3	Motor Cord Communication	114
5.4.4	Power Supply Management	114
5.4.5	Application Interface	115
5.4.6	Diagnostics Interface	117
6	Bridging the Reality Gap	118
6.1	A Simulation Model for the Hannah Robot	120
6.1.1	Sensor Model Parameters	120
6.1.2	Motor Model Parameters	121
6.2	Evolving Gaits for Hannah	122
6.3	Domain Randomization	122
6.4	Testing Simulation Results on Hardware	124
III	Proposal of an architecture for unsupervised robot locomotion learning	126
7	Model and Hypotheses	127
7.1	A General View on Sensorimotor Flow	127
7.2	A Model for Self-Supervised Sensorimotor Learning	129
7.3	Hypotheses	129
8	Methods	130
8.1	Supervised Learning	130
8.1.1	Stochastic Gradient Descent	131
8.1.2	Backpropagation	131
8.1.3	Adam	133
8.2	Unsupervised Learning	134
8.2.1	Autoencoder Neural Networks	136
8.2.2	Self-Organizing and Growing Networks	138
8.2.3	Growing Neural Gas	139
8.2.4	Homeokinesis	140
8.3	Reinforcement Learning	144
8.3.1	State-Action Value Function Learning	147
8.3.2	Boltzmann-Softargmax Action Selection	149
8.3.3	Episodic vs. Continuous Learning	152

vllt weglassen, eh klar, keep it simple

alles was hier nicht contribution ist, entweder introduction oder part i oder appendix

das hier bist du und ausbauen. ich weiss ich nicht endgültig, c8 + c9 haben zusammen 40 seiten aber prerequisite charakter, da sollten results in balance dazu stehen

Contents

8.3.4	Reward Functions for Walking Robots	153
8.3.5	Learning Everything Simultaneously	155
8.4	Intrinsic Motivation	156
9	Implementation of a Self-Supervised Sensorimotor Learning Agent	161
9.1	A Growing Multi-Expert Structure	161
9.1.1	GMES Algorithm	163
9.2	Implementation of the Model	170
9.2.1	Self-Organizing State and Behavior Spaces	170
9.2.2	The intrinsically motivated learner	170
10	Experiments and Results	173
10.1	Tadpole all directions	173
10.2	Hannah forwards	173
10.3	Summary, Conclusions, and Outlook	173
	Bibliography	174

noch so als idee, markier mal zum arbeiten auch im TOC die sections mit deinen contrbutions. das ist ja das wichtigste

ansonsten sieht top aus und weitermachen. remember, blau ist freestyle owald, ungehemmt