

Contents

1	Introduction	1
1.1	The bigger picture	2
1.2	Dynamic models for legged systems	3
1.3	Physics of legged locomotion	8
1.4	Traditional legged locomotion planning	9
1.5	Trajectory optimization	10
2	Contributions	13
2.1	Relevant publications	13
2.2	Capability metrics of motion-planning algorithms	16
2.3	State-of-the-art motion-planning algorithms	19
2.4	List of contributions	21
3	Paper I: Simultaneous foothold and body optimization	23
3.1	Introduction	24
3.2	Approach	26
3.3	Results	32
3.4	Conclusions	35
4	Paper II: Vertex-based ZMP constraints	37
4.1	Introduction	38
4.2	Method	40
4.3	Implementation	44
4.4	Tracking the motion	49
4.5	Results	51
4.6	Conclusion	52
5	Paper III: Gait and trajectory optimization	55
5.1	Introduction	56
5.2	Trajectory optimization formulation	58
5.3	Robot model	60
5.4	Contact model	63
5.5	Results	67
5.6	Conclusion	70

Contents

6	Conclusions and outlook	71
6.1	Summary	71
6.2	Future directions	72
A	Appendix	73
A.1	Derivation of SRBD from Centroidal Dynamics	73
A.2	Derivation of LIPM from SRBD	74
A.3	Derivation of Capture Point	75
A.4	Dynamic constraint	76
A.5	Hermite parameterization	76
A.6	Euler angles and rates to angular velocities	76
	Bibliography	81
	Curriculum Vitae	91
	List of publications	91
	List of software	93