

Conceptual Design and Simulation of a Multibody Passive-Legged Crawling Vehicle

by

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(Abstract)

Rugged terrains, including much of the earth's surface, other planets, and many man-made structures, are inaccessible to wheeled and tracked vehicles. This has inspired research into legged vehicles. Prior to the research described here, virtually all legged vehicle designs relied on the concept of mounting actuated leg-type mechanisms onto a single rigid frame or chassis. This dissertation research explores and advances a novel vehicle concept that uses passive legs attached to an actuated multibody structure. This new vehicle moves only its actuated body trunk to achieve locomotion; thus moving in a manner similar to that used by insect larvae known as caterpillars. The passive-legged design is termed a "crawling" vehicle, to differentiate it from "walking" vehicles, which have powered legs.

A conceptual design for the proposed vehicle was developed using insights from observations of caterpillar specimen geometry, gaits, leg trajectories, and ranges of motion. The flexible, segmented body of the robot is realized using a series of actuated truss-like mechanisms, resulting in a configuration similar to the body structure of caterpillars.

A computer simulation was developed to verify the concept and to assist in creating future designs. This simulation includes a parametric model of the robot structure, an efficient kinematics model, a motion programming method based on six-dimensional parametric cubic trajectories, static stability analysis, actuator velocity and acceleration analysis, wire-frame animations, and rendering, thus providing synthesis and analysis tools for this new class of vehicle.

Results of this work show that by using properly designed Stewart-Gough platform mechanisms for the vehicle multibody structure, a range of motion very similar to that of caterpillars is achievable. Simulation tests showed that imitating the caterpillars' primary gait (or stepping sequence) yields superior speed and efficiency, with little reduction of stability, when compared to a simpler, more obvious gait.

With proper controls, this crawling vehicle will, like its biological counterpart, be intrinsically stable and have excellent maneuverability over rough terrain. The crawling vehicle is shown to be a viable legged locomotion system that may prove to have superior rough terrain mobility to all previous types of man-made land vehicles.

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Table of Contents

<i>List of Figures</i>	<i>xvii</i>
<i>List of Tables</i>	<i>xxi</i>
1. Introduction and Literature Review	1
1.1 The All-Terrain Mobility Problem	1
1.2 Research Approach	2
1.3 Classification of Vehicles	3
1.4 The Advantages of Legged Vehicles on Rough Terrain	5
1.5 The Advantages of Multibody Vehicles on Rough Terrain	8
1.6 Stability—The Key to Rough Terrain Mobility	9
1.6.1 Defining Stability	9
1.6.2 Static Stability	13
1.6.3 Quasi-Static Stability	13
1.6.4 Quasi-Dynamic Stability	14
1.6.5 Dynamic Stability	14
1.7 Review of Mobile Robot Morphology	16
1.7.1 Multibody Wheeled Robots	18
1.7.2 Single-Body Legged Robots	20
1.7.3 Multibody Legged Robots	28
1.7.3.1 Multibody Active-Legged Robots	28
1.7.3.2 Multibody Passive-Legged Robots	29

1.8 Relating the Literature to the Present Work	34
1.8.1 Dynamic Stability Versus Static Stability	36
1.8.1.1 Advantages of Dynamic Stability vs. Static Stability	37
1.8.1.2 Disadvantages of Dynamic Stability vs. Static Stability	38
Terrain Perception	38
Bandwidth	39
Handling of Unforeseen Events	41
1.8.1.3 Static Stability: A More Reliable Choice Using Current Technology	43
1.8.2 Multibody Passive-Legged Morphology	44
1.8.3 Similar Work	47
1.8.4 Other Contributions from the Literature	51
1.9 Objectives and Scope	51
1.9.1 Stages of Design	52
1.9.2 Configuration Design Tools	53
1.9.3 Scope of This Research	55
1.10 Overview	56
2. Conceptual Design	59
2.1 Basic Components of a Legged Robot	60
2.2 Physical Structure	60
2.2.1 Actuation Units	62
2.2.1.1 Selection Criteria for the Actuation Unit Mechanisms	62
2.2.1.2 Variable Geometry Truss Technology	64
2.2.1.3 Candidate VGT Unit Cells	68
2.2.1.4 Candidate Octahedral VGT's	69
2.2.1.5 Alternate Stewart-Gough Platform Mechanisms	76
2.2.2 Leg Pair Assemblies	79
2.2.3 Summary of the Physical Structure	85
2.3 Introductory Motion Programming	88
2.3.1 Hierarchy of Motion	88
2.3.2 Basic Maneuvers	89
2.4 Power Source	94

2.5	Sensors	96
2.5.1	Internal Sensors	97
2.5.2	External Sensors	98
2.5.3	Sensor Fusion	100
2.5.4	Mapping	101
2.6	Navigation and Controls	103
2.6.1	A Functional Decomposition of the Crawling Vehicle Controls	103
2.6.1.1	Destination Selection	105
2.6.1.2	Global Path Selection	106
2.6.1.3	Local Path Selection	107
2.6.1.4	Gait Selection	108
2.6.1.5	Gait Generation	110
2.6.1.6	Foothold Selection	110
2.6.1.7	Leg Pair Trajectory Specification	111
2.6.1.7.1	Joint Space Trajectory Specification	113
2.6.1.7.2	Cartesian Space Trajectory Specification	114
2.6.1.7.3	Selecting the Basic Trajectory Specification Method	115
2.6.1.8	Trajectory Generation	119
2.6.1.9	Inverse Kinematics	119
2.6.1.10	Actuator Controls	119
2.6.1.11	The Contention Problem	121
2.6.2	Control Behaviors	125
2.6.3	Control Hardware Architecture	129
2.6.3.1	Centralized Control Versus Distributed Control	129
2.6.3.1.1	Advantages of Centralized Control Relative to Distributed Control	129
2.6.3.1.2	Disadvantages of Centralized Control Relative to Distributed Control	130
2.6.3.2	Control Hardware Architecture Examples	131
2.6.3.3	Proposed Control Hardware Architecture	133
2.6.3.3.1	Control System Hardware Requirements	133
2.6.3.3.2	Selecting the Number of Controls Processing Packages and Their Mounting Locations	134
2.6.3.3.3	The Robot Control Processor Network	137
2.6.3.3.4	Allocating Functions to the Processors	140
2.6.3.3.5	Controls Hardware Architecture Summary	143

2.7 Chapter Summary	144
3. Caterpillar Locomotion	146
3.1 Introduction	146
3.1.1 Previous Studies of Animal Locomotion	147
3.1.2 Caterpillars	149
3.2 Experimental Program	152
3.2.1 Videotaping Caterpillar Locomotion	152
3.2.2 Determination of Workspace	154
3.3 Experimental Results	155
3.3.1 Caterpillar Geometry and Workspace	155
3.3.2 Caterpillar Gaits	155
3.3.2.1 Rough Terrain	160
3.3.2.2 Crossing Large Obstacles	161
3.3.2.3 Recovering After a Fall	162
3.3.3 Leg Pair Trajectories	162
3.4 Application to Robot Design	163
3.4.1 Legs	164
3.4.2 Actuation Units	164
3.4.3 Linear Actuators	164
3.4.4 Motion Programming	165
3.4.5 Payload Boxes	166
3.5 Chapter Summary	167
4. Modeling	169
4.1 Geometric Parameters	171
4.2 Modeling Robot Position	176
4.2.1 Coordinate Frames	177
4.2.2 Defining Robot Geometry	181
4.2.3 Coordinate Frame Transformations	183
4.3 Inverse Kinematics	187
4.4 Stability Analysis	188

4.5	Defining Motion	195
4.5.1	Moving Leg Pairs	196
4.5.2	Defining New Transformation Matrices	199
4.5.3	Updating the Local Frame	200
4.6	Deriving Motion Data	202
4.6.1	Velocity and Acceleration	202
4.6.2	Interpreting Motion Data Graphs	204
4.7	Summary	207
5.	Motion Programming	208
5.1	Leg Pair Trajectories	210
5.1.1	Desirable Traits for the Leg Pair Trajectory Specification Algorithm	210
5.1.2	Trajectory Curve Selection	212
5.1.3	Specifying Leg Pair Location in XYZ Space	213
5.1.4	Specifying Leg Pair Orientation in Roll-Pitch-Yaw Space	215
5.1.5	Simple Leg Steps	216
5.1.6	Compound Leg Steps	220
5.2	Gaits	221
5.2.1	Traditional Gait Analysis Definitions	221
5.2.2	The Step Interval	224
5.2.3	The Wave Interval	225
5.2.4	Timing Considerations	227
5.2.5	Vehicle Speed	228
5.2.6	Example Gait Diagrams	231
5.2.6.1	A Simple Example Motion Program ($\sigma = 1.0, \omega = n$)	232
5.2.6.2	An Example with Overlapping Leg Steps ($\sigma = 0.5, \omega = n$)	232
5.2.6.3	An Example with Compound Leg Steps ($\sigma = 0.5, \omega = n$)	234
5.2.6.4	An Example of Multiwave Locomotion ($\sigma = 1.0, \omega < n$)	235
5.2.6.5	An Example of Discrete Wave Locomotion ($\sigma = 0.6, \omega > n$)	237
5.3	Motion Programming Guidelines	240
5.3.1	Practical Limitations on Vehicle Velocity	241
5.3.2	Modulating Vehicle Velocity	241
5.3.3	Selecting Gait Parameters	243

5.3.4	Constraints on Gait Parameter Modification	243
5.4	Chapter Summary	245
6.	The Simulation	246
6.1	The Set Robot Geometry Module	249
6.2	The Input Motion Module	249
6.3	The Replay Motion Module	251
6.4	The Analyze Motion Module	252
6.4.1	Robot Center of Gravity	252
6.4.2	Synthesizing Link Lengths	253
6.4.3	Evaluating Link Lengths and Assembly Checking	254
6.4.3.1	The Assembly Constraint	257
6.4.3.2	The Workspace Uniformity Constraint	257
6.4.3.3	The Workspace Lateral Symmetry Constraint	258
6.4.4	Using the Linear Actuator Workspace Constraints	258
6.5	Chapter Summary	259
7.	Modeling and Simulation Results	261
7.1	Example Robot Models	262
7.2	The Design Implications of Stability	264
7.3	Overview of the Motion Program Test Cases	267
7.3.1	Creating a Uniform Basis for Comparing the Motion Programs	269
7.3.2	The Robot Design for the Test Cases	269
7.3.3	Placement of the Local Coordinate Frame	271
7.4	Motion Program Test Case Procedure	272
7.4.1	The Workspace Equality Constraint	272
7.4.2	The Workspace Full-Range Constraint	273
7.4.3	The Average Velocity Equality Constraint	274
7.4.4	The Four Step Procedure for Each Test Case	274
7.5	Test Case #1: Step Interval (σ) = 1.0	276
7.6	Cycloidal Transformation of the Parametric Variable	279

7.7	Test Case #2: Step Interval (σ) = 1.0, with Cycloidal Spacing	283
7.8	Test Case #3: Step Interval (σ) = 0.52	286
7.9	Test Case #4: Step Interval (σ) = 0.52, with Pitching	290
7.10	Chapter Summary	296
7.11	Conclusion	301
8.	<i>Future Work and Conclusions</i>	302
8.1	Future Work	302
8.1.1	Some Important Future Test Cases	303
8.1.1.1	Other Vehicle Designs	303
8.1.1.2	Straight Ahead Locomotion	304
8.1.1.3	Climbing and Turning	304
8.1.2	Modeling Improvements	305
8.1.2.1	Modeling Rough Terrain	305
8.1.2.2	Improvements to the Stability Margin Algorithm	306
8.1.3	Motion Program Algorithm Extensions	308
8.1.3.1	Rough Terrain Trajectory Specification	308
8.1.3.2	Guarded Motions	309
8.1.3.3	Specifying Supporting Leg Pair Pitch Angles	309
8.1.3.4	Cantilever Maneuvers for Large Obstacle Crossing	310
8.1.4	Simulation Tool Improvements	311
8.1.5	Control in Contention	313
8.1.6	Hardware Construction Plan of Action	316
8.2	Technical Summary	318
8.2.1	The Multibody Passive-Legged Crawling Vehicle	319
8.2.2	Advantages of the Crawling Vehicle	320
8.3	Contributions of this Work	321
8.3.1	Designing the Crawling Vehicle at the Conceptual Level	322
8.3.2	Studying the Mobility of Caterpillars	322
8.3.3	Creating a Mathematical Model	323
8.3.4	Developing a Flexible Motion Programming Method	323
8.3.5	Creating Simulation Design Tools	323

8.3.6	Verifying the Conceptual Design	324
8.3.7	Discovering Design Rules	324
8.4	Conclusion	324
References		327
Appendix A		345
Appendix B		347
Appendix C		349
Vita		352

List of Figures

1.1 —	Types of Land Vehicles	4
1.2 —	Compaction Resistance of a Wheel in Soft Soil (After Bekker (1956) and Todd (1985))	6
1.3 —	Example of an Instantaneously <i>Stable</i> Vehicle	10
1.4 —	Example of an Instantaneously <i>Unstable</i> Vehicle	11
1.5 —	Year by Year Comparison of the Number of Mobile Robotics Papers to the Total Number of Robotics Papers	17
1.6 —	Enabling Technologies for Rough Terrain Mobility and Their Interdependencies	35
1.7 —	A Multibody Passive-Legged Vehicle Performing a Cantilever Maneuver....	45
1.8 —	A Multibody Passive-Legged Vehicle Performing a Bridging Maneuver Across a Ditch-Like Obstacle	46
2.1 —	The Basic Physical Structure of the Crawling Vehicle: An Alternating Sequence of Leg Pair Assemblies and Actuation Units.....	62
2.2 —	Basic Truss Unit Cells	67
2.3 —	A Long-Chain Truss Structure Based Upon Six Octahedral Unit Cells	69
2.4 —	A Comparison of the Double Octahedral and Single Octahedral VGT's	70
2.5 —	A Functional Double-Octahedral VGT	72
2.6 —	A Stewart-Gough Platform	75
2.7 —	Side View of the Initial Configuration of the Stewart-Gough Platform Spheric Joints (Illustration after Mele (1991)).....	78
2.8 —	Section A-A View of the Initial Configuration of the Stewart-Gough Platform Spheric Joints (Illustration after Mele (1991)).....	78

2.9 — Side View of the “Mele Configuration” of the Stewart-Gough Platform Spheric Joints (After Mele (1991))	79
2.10 — Section A-A View of the “Mele Configuration” of the Stewart-Gough Platform Spheric Joints (After Mele (1991)).....	79
2.11 — A Leg Pair Assembly	80
2.12 — A Foot Design for use on Soft Sand or Snow.....	84
2.13 — A Multibody Passive-Legged Crawling Vehicle using a VGT-like Configuration for the Spheric Joints of the Stewart-Gough Platform Mechanisms	87
2.14 — A Multibody Passive-Legged Crawling Vehicle using the “Mele Configuration” for the Spheric Joints of the Stewart-Gough Platform Mechanisms	87
2.15 — A Simplified Leg Step	89
2.16 — Forward Motion Using a Simple Wave Gait.....	90
2.17 — A Simple Turning Maneuver.....	91
2.18 — Climbing Over a Small Obstacle	92
2.19 — The Sidestepping Gait.....	94
2.20 — Functional Decomposition of the Crawling Vehicle Controls Hierarchy	104
2.21 — Connection Diagram of the Robot LAN.....	138
2.22 — Allocation of Controls Functions Between the Processing Packages Located in the “Head” and in the Leg Pairs.....	142
3.1 — Gait Diagram of a Cockroach's "Tripod Gait".....	149
3.2 — Side View of a Standing Tent Caterpillar	150
3.3 — Side View of a Pitching Tent Caterpillar	150
3.4 — Bottom View of Turning (Yawing) Tent Caterpillar	151
3.5 — Locomotion Sequence of a Tent Caterpillar (Note that the segment numbering scheme used here is different than that used in entomology literature).....	158
3.6 — Tent Caterpillar Gait Diagram	159
3.7 — Eastern Tent Caterpillar Climbing a Large “Hill”	161
3.8 — Comparison of Compound Linear Actuator and Simple Linear Actuator...	165
3.9 — Rounded Top Payload Boxes	166
3.10 — A Crawling Vehicle Using Payload Boxes with Rounded Tops.....	167

4.1 —	Basic Stewart-Gough Platform-Based Crawler with $N = 4$	171
4.2 —	Leg Pair Assembly Geometric Parameters	173
4.3 —	Payload Box Centroid Coordinate Frame. Used for Defining the Spheric Joint Y-Z Locations.	174
4.5 —	Leg Pair Coordinate Frame	180
4.6 —	System of Coordinate Frames	180
4.7 —	Coordinate Frame Transformations	186
4.8 —	A Stability Plot of a Crawling Vehicle as it is Turning	190
4.9 —	Specifying a New Position for Leg Pair 2	198
4.10 —	Link Length, Velocity, and Acceleration Graphs of a Single Actuation Unit of a Robot Which is Beginning a Turn	206
5.1 —	Parametric Cubic Curve with Tangent Vectors.....	215
5.2 —	C.G. Location vs. Time for a 6 Leg Pair Robot Performing a $\sigma = 0.52, \omega = 6.0$ Gait for Two Locomotion Cycles, Starting from and Ending with a Complete Stop.	230
5.3 —	Gait Diagram of a $\sigma = 1.0, \omega = 4.0$ Wave Gait, Performed on a 4 Leg Pair Robot.	232
5.4 —	Gait Diagram for a $\sigma = 0.5, \omega = 6.0$ Gait, Performed on a 6 Leg Pair Robot.	233
5.5 —	Gait Diagram for a $\sigma = 0.5, \omega = 6.0$ Gait with Pitching, Performed on a 6 Leg Pair Robot.	235
5.6 —	Gait Diagram of a $\sigma = 1.0, \omega = 3.125$ Wave Gait, Performed on a 4 Leg Pair Robot.	236
5.7 —	Gait Diagram of a $\sigma = 0.6, \omega = 9$ Motion Program, Performed on a 6 Leg Pair Robot	238
6.1 —	Crawling Vehicle Simulation Program Main Modules with Inputs and Outputs	248
7.1 —	A Crawling Robot Design Rendered with the Simulation Programs.....	262
7.2 —	More Example Crawling Robot Designs Rendered with the Simulation Programs. (Note the differing actuation unit arrangements and geometries.)	263
7.3 —	Coordinate System Used for Specifying Leg Pair Trajectory.....	271

7.4 —	Link Length, Velocity, and Acceleration Graphs for an Actuation Unit Performing the $\sigma = 1.0, \omega = 6.0$ Gait, with $\lambda = 0.336\text{m}$, No Pitching, and Constant Parametric Variable Spacing.....	278
7.5 —	The Cycloidal Transformation of the Parametric Variable.....	281
7.6 —	Cubic Curve X-Z Foot Trajectory Using Linear Spacing of the Parametric Variable, u	282
7.7 —	Cubic Curve X-Z Foot Trajectory Using Cycloidal Spacing of the Parametric Variable, u^*	282
7.8 —	Link Length, Velocity, and Acceleration Graphs for an Actuation Unit Performing the $\sigma = 1.00, \omega = 6.0$ Gait, with $\lambda = 0.336\text{m}$, No Pitching, and Cycloidal Parametric Variable Spacing.	284
7.9 —	Link Length, Velocity, and Acceleration Graphs for an Actuation Unit Performing the $\sigma = 0.52, \omega = 6.0$ Gait, with $\lambda = 0.349\text{m}$, No Pitching, and Cycloidal Parametric Variable Spacing.	288
7.10 —	Link Length, Velocity, and Acceleration Graphs for an Actuation Unit Performing the $\sigma = 0.52, \omega = 6.0$ Gait, with $\lambda = 0.653\text{m}$, 15.5° Pitching, and Cycloidal Parametric Variable Spacing.	294
7.11 —	Comparison of Motion Program Leg Step Maximum Stride Lengths.....	298
7.12 —	Comparison of Motion Program Peak Velocities	298
7.13 —	Comparison of Motion Program Peak Accelerations	298
8.1 —	The One Degree of Freedom Test Rig (image by Patrick Brennan).....	314
8.2 —	The V-Frame Test Rig (from Mele (1991)).....	314
8.3 —	Planar Test Rig	316
8.4 —	Test and Construction Plan.....	317
8.5 —	The Multibody Passive-Legged Crawling Vehicle and its Biological Counterpart, the Caterpillar (<i>Malacosoma americanum</i>)	326
C.1 —	Specifying a New Position for Leg Pair 2 Relative to its Current Position ..	350

List of Tables

3.1 — Approximate Physical and Locomotion Characteristics of Eastern Tent Caterpillars.....	156
7.1 — Worst Case Stability Plots for $\sigma = 1.0, \omega = n$ Gait and Varying Numbers of Leg Pairs.....	264
7.2 — Worst Case Stability Plots for $\sigma = 0.52, \omega = n$ Gait and Varying Numbers of Leg Pairs.....	264
7.3 — Geometric Parameters for the Tested Robot.....	268
7.4 — Test Case #1 Motion Program Parameters	274
7.5 — A Sequence of Side Views and Stability Plots of a Robot Performing the $\sigma = 1.00, \omega = 6.0$ Gait.	283
7.6 — Test Case #3 Motion Program Parameters	285
7.7 — A Sequence of Side Views and Stability Plots of a Robot Performing the $\sigma = 0.52, \omega = 6.0$ Gait, without Pitching.....	287
7.8 — Test Case #4 Motion Program Parameters	289
7.9 — A Sequence of Side Views and Stability Plots of a Robot Performing the $\sigma = 0.52, \omega = 6.0$ Gait with Pitching.....	293
7.10 — Comparison of Simultaneous Motions of the Motion Test Cases	298