

Precision Programming of Roving Robots

Project-Based Fundamentals of Wheeled, Legged and
Hybrid Mobile Robots

Francis Nickols
Yueh-Jaw Lin



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Series Editor's Preface

Dear Reader,

The ASME Press Robotics Engineering Book Series continues to present research and engineering accomplishments in the key areas of robotics. I am delighted to introduce a book by Dr. Francis Nickols and Dr. Yueh-Jaw Lin from the University of Nottingham Ningbo China. Entitled *Precision Programming of Roving Robots*, this book has launched a new area of our robotics publications, namely textbook supplements for undergraduate students. As specified in the subtitle, this book concerns with project-based fundamentals of wheeled, legged and hybrid mobile robots.

The authors has a notable experience of undergraduate and graduate teaching that is multiplied by engineering work in the automotive industry. A distinguished feature of the book is a mechatronics-based approach to mobile robots that is presented in a form of a lab operation manual to assist students with their projects and, thus, to comprehend a lecture course on roving robots. Remarkably, the book focuses on precision sensorless actuation of robot movements. Hence, the learning outcome of the book is the precision programming of robots to perform accurate behavior pattern movements.

The book can serve as a supplement to undergraduate courses on robotics engineering that allows students to learn course material “in action” by doing actual projects in the lab environment.

The Robotics Engineering Book Series is committed to both assisting eminent scholars in publishing their findings and introducing outstanding new researchers and educators to the world of books in Robotics. We look forward to close collaboration with researchers, engineers and academia around the world.

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Contents

Series Editor's Preface	iii
Editorial Board	iv
Preface	xiii
Acknowledgement	xvii
1 Basic motion of wheeled vehicles in a ground plane (A forerunner to legged vehicles)	1
1.1 Introduction	1
1.2 Simplified motion of a single wheel	1
1.3 The Instantaneous Centre of Rotation, the ICofR	2
1.4 Fixing the ICofR at a set point	4
1.5 The Instantaneous <i>Axis</i> of Rotation, the IAofR	6
1.6 Wheel angular velocity when vehicle turns corners	8
1.7 Mechanical Computation of steering angle	9
1.8 An Omnidirectional tricycle	11
1.9 Simultaneous body translation and rotation	13
1.10 Achieving sun and planet motion	15
1.11 Viennese waltz behaviour	16
1.12 Applications of Viennese waltz behaviour	18
1.12.1 Retreating motion in a corridor	18
1.12.2 Rotating on the spot	18
1.12.3 Rotating about a fixed point	18
1.12.4 Motion in a straight line with no rotation, i.e. pure translation	19
1.13 Analysis and programming of Viennese waltz behaviour into the robot	19
1.13.1 Analysis of a planet wheel circulating <i>inside</i> sun wheel	19
1.13.2 Analysis of a planet wheel circulating <i>outside</i> sun wheel	22
1.14 Practical examples of a robot acting as the planet wheel	23
1.14.1 Robot rotating as a planet wheel on the <i>inside</i> of a sun wheel	23
1.14.2 Robot rotating as a planet wheel on the <i>outside</i> of a sun wheel	23
1.15 More interesting ideas for wheeled vehicles	24
1.15.1 Tricycle with 3 degree-of-freedom wheels	24
1.15.2 Programming the tricycle to emulate a 4-wheeled automobile	26
1.15.3 Multi-segmented trailer motion	26

2	The Servo Teach Module	29
2.1	Introduction	29
2.2	The Futaba integrated servomechanism, the 'servo'	29
2.3	The servo teach module	31
2.4	Servo Teach Module programme code	32
2.5	Hysteresis noise filter	34
3	The Tricycle Robot: a mobile programmable 'drive-by-wire' electric vehicle	37
3.1	Introduction	37
3.2	Description of tricycle components	38
3.3	The tricycle microcomputer system	41
3.4	The dual push-rod mechanism that actuates the tricycle drive wheel	43
3.5	Kinematic analysis of the push-rod mechanism	44
3.6	So, what can Basic Stamp microcomputers compute?	47
3.7	Wheel servo computation algorithm to rotate drive wheel	48
3.8	How to compute servo angles, LS and RS using the Basic Stamp microcomputer	50
3.9	Basic Stamp 16-bit integer accurate computational method	54
3.10	Making the equations in table 3.2 suitable for the Basic Stamp microcomputer	56
3.11	The Tricycle steering system	58
3.12	A Planar Odometer that computes vehicle location coordinates, x , y , ϕ	64
3.13	Odometer algorithm to compute x , y and ϕ	67
3.14	Programming of the tricycle to undertake a figure-of-eight locomotion path	69
3.15	Some tips for odometer computing with the Basic Stamp	70
3.16	Complete PBasic figure-of-eight programming code listing with comments and explanations	71
4	Programming of walking legs, their leg tip motion and the leg tip digital locus	85
4.1	Introduction	85
4.2	The 3 degree-of-freedom leg, (3dof leg)	87
4.3	Leg layout of omni-directional robot	88
4.4	The leg tip locus	89
4.5	Translation of the robot body	91
4.6	Details of the leg tip locus	92

4.7	Height modification of the rectangular locus	93
4.8	Leg tip speed along the locus	94
4.9	Computing leg tip speed as a function of step height and step amplitude	95
4.10	Leg tip locus design specification	96
4.11	Achieving the leg tip locus specification via a <i>Digital Locus</i>	98
4.12	Using the n-variable to increment the leg tip through a walking locus	100
4.13	The breakpoints of the digital locus, bp1 and bp2	101
4.14	Distance travelled by leg tip along the digital locus	104
4.15	Computation of, R, and, Z, values of the leg tip on the digital locus	107
4.16	The clock; adding time to the control of leg tip position	110
4.17	Using microcomputers to step the digital locus through a sequence	111
4.18	The 50Hz, 20ms clock	111
4.19	The two anti-phase sawtooth waveforms to produce the double tripod gait	114
4.20	Dynamic Response of the leg servos	120
4.21	Computing, R, and, Z, values of the Digital Locus using a BS2SX computer program	121
5	Inverse kinematics analysis: Servo angles, S1, S2, S3 as a function of Leg Tip cylindrical coordinates, R, Z, θ	125
5.1	Introduction: The story so far	125
5.2	The meaning of 'Inverse Kinematics'	126
5.3	Description of the three degree-of-freedom (3dof) leg system	127
5.4	Microcomputer architecture to control a multi-legged robot	128
5.5	The Central Pattern Generator, the CPG	129
5.6	Mechanical system geometry of the 3dof leg	129
5.7	Kinematics analysis of the 3dof leg system	130
5.8	Minimising the polar second moment of inertia of the leg system	131
5.9	Coupled displacement of the leg tip	132
5.10	Decoupling the leg system	135
5.11	Deriving an inverse kinematics equation for $S1 = f1(R, \theta)$	136
5.12	Deriving an inverse kinematics equation for $S2 = f2(R, \theta, Z)$ in three stages	138
5.12.1	1 st stage is to calculate location of knee joint	138
5.12.2	2 nd stage is to analyse 4-bar mechanism	139

5.12.3	3 rd stage is to apply 4-bar mechanism analysis to leg system	141
5.13	Deriving an inverse kinematics equation for $S3 = f3(R, \theta, Z)$ in two stages	143
5.13.1	1st stage is to calculate angle, $A5$	144
5.13.2	2nd stage is to calculate angle, $S3$	145
5.14	Graphs of $S1$, $S2$ and $S3$ values at boundaries of the cylindrical coordinate frame	146
5.14.1	Graph of $S1$ servo values	147
5.14.2	Graph of $S2$ servo values	148
5.14.3	Graph of $S3$ servo values	149
6	Inverse kinematics synthesis: Computing of $S1$, $S2$, $S3$ from cylindrical coordinates, R, Z, θ	151
6.1	Introduction	151
6.2	The piecewise construction of the cylindrical coordinate frame	152
6.3	Computing the $S1$ servo angle with 1 st and 2 nd order equations	154
6.4	Computing the $S2$ and $S3$ servos with 1 st order equations	159
6.5	Example computing of $S2$ in T7 sector	162
6.6	Servo $S3$ computation	163
6.7	Corrections	165
7	Inverse kinematics using the ServoTeach Module: a project-based, hands-on solution using experimentation	167
7.1	Introduction	167
7.2	Description of apparatus – Overview	168
7.3	Description of apparatus – Detailed	169
7.4	Manual control of $S1$, $S2$ and $S3$ servomechanisms	170
7.5	Steps in programming Leg Tip straight line motion along R -axis at $\theta=0^\circ$, $Z=0\text{mm}$	172
7.5.1	Step 1 Calibrate coordinates, $R=0\text{mm}$, $Z=0\text{mm}$, $\theta=0^\circ$	172
7.5.2	Step 2 Calibrate coordinates, $R=40\text{mm}$, $Z=0\text{mm}$, $\theta=0^\circ$	173
7.5.3	Step 3 Record servo values	174
7.5.4	Step 4 Derive 1 st order inverse kinematics equations	174
7.5.5	Step 5 Formulate Basic Stamp code using 1 st order equations	175
7.5.6	Step 6 Assess precision of programming using 1 st order equations	176

7.6	Steps in deriving an accurate inverse kinematics equation using 2 nd order Taylor series equations	178
7.6.1	Step 1 Increase accuracy by adding mid-range coordinate	178
7.6.2	Step 2 Derive accurate 2 nd order inverse kinematics equation	178
7.6.3	Step 3 Formulate Basic Stamp code using 2 nd order equations	179
7.6.4	Step 4 Assess precision of programming using 2 nd order equations	180
7.7	Increasing the positioning resolution of the leg tip	181
7.8	Basic Stamp microcomputer maths computation. Some rules, procedures and tips	183
7.9	Leg tip planar motion: programming the leg tip to travel to any coordinate, R, Z, in the, $\theta=0^\circ$ plane	184
7.10	Programme code listing for knob controlled R, Z positioning of leg tip in $\theta=0^\circ$ plane	193
8	Walking gaits and motion control	195
8.1	Introduction	195
8.2	Review of the leg tip locus	195
8.3	The “5-on” gait	196
8.4	Microcomputer real-time program for the 5-on gait	199
8.5	Wave or ‘ripple’ action of leg tip motion during walking	201
8.6	The “4-on” gait	202
8.7	The “3-on” or “double tripod” gait	205
8.8	Morphing of the radical waveforms during gait transition	207
8.9	Locomotion speed in each gait	207
8.10	The support polygon for static stability	208
8.11	Walking on 4 legs	210
8.12	Walking robot turning about an Instantaneous Centre of Rotation, IC of R	214
8.13	Steps in computing the curvature of the leg tip locus	224
8.13.1	Calculation to transform point, a, location into cylindrical, R, θ , coordinates	225
8.13.2	The coordinates of point, a, in 4 quadrants of the leg tip cylindrical coordinate frame	227

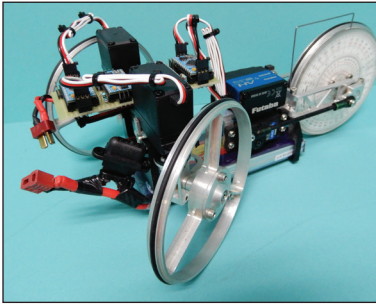
8.13.3	First the computation of, θ_{LBcomp}	228
8.13.4	Now the computation of, R_{comp}	228
8.14	Computation of, plangle, P, and radius of curvature, L	229
9	The complete Basic Stamp PBasic code for one leg of a Roving Robot	231
9.1	The variables	231
9.2	Pin output initialisation	232
9.3	The constants	232
9.4	Servo constants initialisation	233
9.5	The main programme starts now	233
9.6	Twelve Branch vectors to compute the inverse kinematics equations	235
9.7	Output of the servo values	241
9.8	The subroutines to compute inverse kinematic equations for S1, S2, S3	242
10	2-Wheeled-2-Legged Rickshaw Robot: replacing some wheels with legs and programming its Central Pattern Generator	243
10.1	Introduction	243
10.2	Steering kinematics of the Tricycle and Rickshaw Robots	244
10.3	Plan view geometry of the Rickshaw Robot	244
10.4	The Central Pattern Generator, the CPG	245
10.5	Rotating the LF and RF legs by 30° to become parallel	247
10.6	The Figure-of-Eight path and how to negotiate it with the Rickshaw Robot	247
10.7	Plan for negotiating the Figure-of-Eight	248
10.8	Computing the Algorithm for negotiating the Figure-of-Eight path	250
10.9	The Basic Stamp Central Pattern Generator Code	252
11	Omni-directional Hexapod Robot: Programming its Central Pattern Generator	261
11.1	Introduction	261
11.2	The hierarchical, multi-cored, parallel processing microcomputer control system of the Hexapod Robot	263
11.3	Precision programming the Hexapod Robot to follow a Figure-of-Eight path	264

11.4	Programme to implement Translational Figure-of-Eight programme	265
11.5	Programme to follow a curved Figure-of-Eight path	269
11.6	Calculations of, plangle, and, amp, for each leg to negotiate the curved figure- of-eight.	270
11.7	Programme code to implement the curved figure-of-eight walking pattern	271
11.8	Closing comments	275
	Brief Biographies of the Authors	277
	Index	279

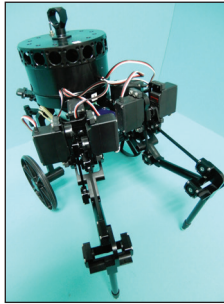
Preface

Project-Based fundamentals of wheeled, legged and hybrid robots

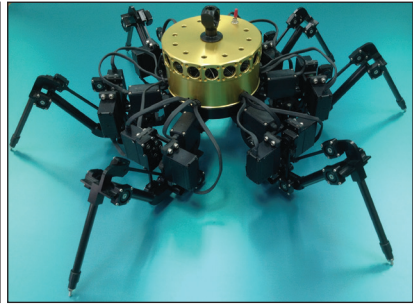
This book is designed primarily as a mechatronics and robotics textbook supplement for undergraduate students. More precisely it serves as a project-based laboratory operations manual for an academic course related to mobile roving robots. The book explains how to programme precision behaviour pattern motions in a ground plane using these three roving robots shown below.



The 'Tricycle' Robot
A 3-wheeled Robot



The 'Rickshaw' Robot
A 2-wheeled, 2-legged
Robot



The 'Hexapod' Robot
A six-legged omnidirectional
Robot

The three roving robots are graded in complexity from the all-wheeled Tricycle Robot through to the hybrid wheeled and legged Rickshaw Robot up to the most complex of the three, the all-legged Hexapod Robot. The precision programming of behaviour patterns for the three robots is demonstrated, evaluated and measured with a 'figure-of-eight' pattern that is marked out on to a 4.8metre \times 2.4 metre table as shown below. Robots are programmed to travel consecutively from node 1 to node 2, then nodes, 5, 4, 3, 2, 5, 6 and back to node 1. Target 'bulls-eyes' at each node are given accuracy marks from 1 to 10 such that 10 marks are given for the robot stopping at the centre of the bulls-eye. *Sensor-less* dead-reckoning precision programming is used to programme the robot to travel through the figure-of-eight path. The book does not cover the design and programming of robots with sensors that measure quantities in the outside observed world. This is an important aspect since the authors believe that sensorless behaviour patterns are fundamental to actuated reactionary patterns that are built into biological systems. Sensors such as vision and touch sensors serve mainly to learn, to correct, or to fine-tune, built-in behaviour patterns.

Based on such a premise, this book solely concentrates on sensorless actuation of robot motion. For example, we as human beings are exercising sensorless behaviour patterns all the time; for example, the act of getting off our chair to stand up is to execute a particular actuated routine. Yes, your senses adjust the routine based on height of the chair and other factors, but largely it is a set muscular routine that is executed. So this is the flavour of the book, i.e. precision sensorless behaviour pattern actuation. You can imagine that this means your robot is blind-folded. As soon as your blind-folded robot can perform behaviour patterns accurately then sensors can be added further to improve its performance. Such programmed actuation is fundamental to robotics and forms the basis of the learning outcomes from this book.

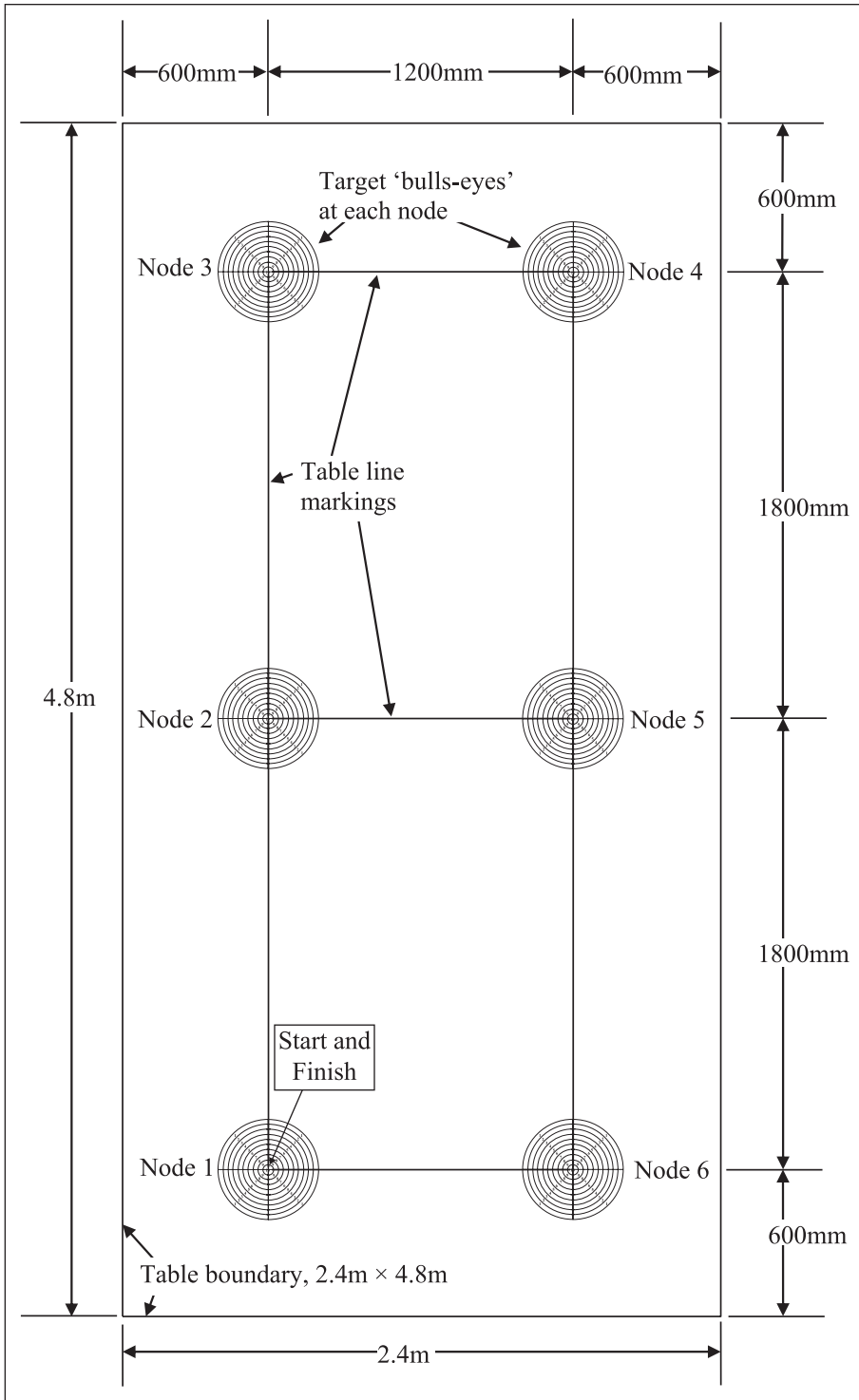


Diagram of the 'Vehicle Motion in a Ground Plane' table showing nodes and target 'bulls-eyes'. This table is used to evaluate robot motion computer programmes.

The book is designed primarily as a mechatronics and robotics experiential and project-based teaching and learning platform for tertiary students. It is also graded in that starting with the Tricycle Robot, students build up their knowledge and experience of programming to be able to tackle the Rickshaw Robot and finally the most complex robot, i.e., the Hexapod Robot. As regards the academic level, the book is aimed at university and college students. However, nowadays the authors are seeing robotics curricula extending down into schools so this book can also be very useful for giving ideas to teachers at school level. Furthermore, the book provides useful ideas for driverless vehicles and robots as well as for educationalists who are developing practical project-based teaching and learning modules.

The book covers the concept of a robot turning about an Instantaneous Centre of Rotation, ICofR, and how a wheeled and/or legged robot is programmed to achieve such motion in a ground plane. Programming concepts move on to creating behaviour and motion patterns in legged robots eventually leading to the design of a hierarchical central pattern generator, CPG, for the hexapod robot. Early chapters are concerned with wheeled vehicles and how Taylor series equations are used to simplify complex inverse kinematic control equations. Wheeled vehicles serve as a smooth introduction to legged motion which suddenly becomes complex. Understanding wheeled motion lessens the sudden jump in understanding the complexity of programming legged motion.

The real time programming code is executed on Parallax.com Basic Stamp2 series microcomputers using the PBasic language which means 'Parallax Basic'. The language is very easy to learn and you get your robot up and running and operational very fast. Even though the programming language is straightforward, almost like writing short English instructions, you can develop complex real-time, parallel processing, interconnected, multi-cored microcomputer systems tailored to your own application. The book gives the code at all stages of the robot motion and behaviour pattern programming. Since the code is given in PBasic it is easy for students and readers to alter the code to use an alternative microcomputer to their liking. The choice of microcomputer and programming language is like politics and religion meaning that every robot constructor and programmer has his or her own views together with preferences as to the best hardware and software to use.

The robots featured in this book have all been created by the author and used in experiential project-based teaching and learning classes. Hence the book is tried and tested. The authors see themselves as teachers, mentors and coaches. This means that students are taught with both theoretical and experiential learning concepts and then as they gain proficiency, mentoring is gradually lessened. Students then begin to exhibit problem solving abilities, sometimes in novel ways, thus becoming promising inventors and autonomous learners and only needing teachers as sounding boards. This has certainly been the case when using the Tricycle Robot, the Rickshaw Robot and the Hexapod Robot in our classroom.

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