

Closed-Loop Motion Control for Mobile Robotics

Rich recently came up with two closed-loop drive train designs for mobile robots. All it took were some inexpensive permanent magnet motors and a simple feedback scheme. In this article, he covers everything from PID control and tuning to trajectory generation and operational space control for two robot bases. He also explains the software.

The mechanical components that make up robots aren't getting much cheaper. That's the bad news. The good news, of course, is that electronics and processors continue their steady march toward higher performance and lower cost. As an engineer, you have to figure out how to use the extra resources and capabilities most effectively. In some cases, extra processing allows you to use lower-cost mechanical components, which can effectively reduce the system's overall cost.

With this idea in mind, I'll tackle the robot drive train armed with a modest amount of computing power. When I'm done, you'll have two different closed-loop drive train designs that would make R2-D2's head spin with envy. I'll show you how to accomplish this using inexpensive permanent magnet motors and a clever feedback scheme that requires no mechanical overhead. Let's begin by addressing the topic of motors.

MOTOR OPTIONS

Clearly, selecting a motor is one of the most important decisions to make when designing the drive train. If you've played with motors and gears, you've certainly developed the following intuition: more gear reduction results in less speed and more torque, and less gear reduction results in more speed and less torque. Modified RC servomotors, which are often used in robot drive trains, have large gear reductions (typically 300:1) resulting in high torques and low speeds. As a

result, robots that use them are typically slow. Large gear reductions make some problems easier, as you'll see, but no one wants a slow robot if they can help it. If you've used these motors, you might have wanted to trade in some torque for some speed.

The 9-V Lego motors shown in Photo 1 are readily available. They are part of the Mindstorms kit, so you can build the rest of your robot base out of Legos, which is a good thing for the mechanically challenged like me.

Fortunately, the Lego motor has much less gear reduction (14:1) and is well suited for attaching a wheel directly to the output shaft. If you've done this, you know that you get a quick robot, but it's difficult to control. Particularly, when you shut off power

to the motor, the robot takes much longer to stop. With less gear reduction, the robot will coast!

Sometimes stopping quickly is important (e.g., stairs ahead), or your robot may do something hazardous to its health. This brings up an important point: motors with high gear reductions stop quickly when power is removed. But this is a silly reason to use these motors. It's like telling a beginning driver to drive only in first gear to avoid getting into an accident. What the driver really needs is better driving skills. Similarly, what you need is a better motor controller.

CLOSING THE LOOP

A motor controller that doesn't receive any feedback information from the motor is an open-loop controller. The main advantage of open-loop controllers is simplicity. All that's required is a way to control the voltage or current going to the motor. The Lego Mindstorms RCX controller, for example, uses an open-loop motor controller that allows you to select from several voltages (by varying the pulse-width modulator duty cycle) depending on how much speed and torque you want to deliver to your robot's wheels.

A disadvantage of open-loop control is inaccuracy. Others include the inability to deal with uncontrollable variables such as bumps in a floor, inclines, and low batteries, which can create an undesirable situation by slowing or stop-



Photo 1—Lego is an excellent medium for implementing robots such as the four-wheeled HUMR. The Gameboy Advance acts as the controller and provides 32-bit RISC processing performance, a color LCD, and sound.

Closed Loop Motion Control For Mobile Robotics

JL Elias



Closed Loop Motion Control For Mobile Robotics:

Adaptive Motion Control of Mobile Robots Liqiang Feng,1992 Robot Motion and Control 2007 Krzysztof R.

Kozłowski,2009-06-10 Robot Motion Control 2007 presents very recent results in robot motion and control Forty one short papers have been chosen from those presented at the sixth International Workshop on Robot Motion and Control held in Poland in June 2007 The authors of these papers have been carefully selected and represent leading institutions in this field

Informatics in Control, Automation and Robotics Joaquim Filipe,Jean-Louis Ferrier,Juan Andrade Cetto,2008-09-27

The present book includes a set of selected papers from the fourth International Conference on Informatics in Control Automation and Robotics ICINCO 2007 held at the University of Angers France from 9 to 12 May 2007 The conference was organized in three simultaneous tracks Intelligent Control Systems and Optimization Robotics and Automation and Systems Modeling Signal Processing and Control The book is based on the same structure ICINCO 2007 received 435 paper submissions from more than 50 different countries in all continents From these after a blind review process only 52 were accepted as full papers of which 22 were selected for inclusion in this book based on the classifications provided by the Program Committee The selected papers reflect the interdisciplinary nature of the conference The diversity of topics is an important feature of this conference enabling an overall perception of several important scientific and technological trends These high quality standards will be maintained and reinforced at ICINCO 2008 to be held in Funchal Madeira Portugal and in future editions of this conference Furthermore ICINCO 2007 included 3 plenary keynote lectures given by Dimitar Filev Ford Motor Company Patrick Millot Universit de Valenciennes and Mark W Spong University of Illinois at Urbana Champaign

Intelligent Robotics and Applications Xuguang Lan,Xuesong Mei,Caigui Jiang,Fei Zhao,Zhiqiang Tian,2025-01-24 The

10 volume set LNAI 15201 15210 constitutes the proceedings of the 17th International Conference on Intelligent Robotics and Applications ICIRA 2024 which took place in Xi an China during July 31 August 2 2024 The 321 full papers included in these proceedings were carefully reviewed and selected from 489 submissions They were organized in topical sections as follows Part I Innovative Design and Performance Evaluation of Robot Mechanisms Part II Robot Perception and Machine Learning Cognitive Intelligence and Security Control for Multi domain Unmanned Vehicle Systems Part III Emerging Techniques for Intelligent Robots in Unstructured Environment Soft Actuators and Sensors and Advanced Intelligent and Flexible Sensor Technologies for Robotics Part IV Optimization and Intelligent Control of Underactuated Robotic Systems and Technology and application of modular robots Part V Advanced actuation and intelligent control in medical robotics Advancements in Machine Vision for Enhancing Human Robot Interaction and Hybrid Decision making and Control for Intelligent Robots Part VI Advances in Marine Robotics Visual Linguistic Affective Agents Hybrid augmented Agents for Robotics and Wearable Robots for Assistance Augmentation and Rehabilitation of human movements Part VII Integrating World Models for Enhanced Robotic Autonomy Advanced Sensing and Control Technologies for Intelligent Human Robot

Interaction and Mini Invasive Robotics for In Situ Manipulation Part VIII Robot Skill Learning and Transfer Human Robot Dynamic System Learning Modelling and Control AI Driven Smart Industrial Systems and Natural Interaction and Coordinated Collaboration of Robots in Dynamic Unstructured Environments Part IX Robotics in Cooperative Manipulation MultiSensor Fusion and Multi Robot Systems Human machine Co adaptive Interface Brain inspired intelligence for robotics Planning control and application of bionic novel concept robots and Robust Perception for Safe Driving Part X AI Robot Technology for Healthcare as a Service Computational Neuroscience and Cognitive Models for Adaptive Human Robot Interactions Dynamics and Perception of Human Robot Hybrid Systems and Robotics for Rehabilitation Innovations Challenges and Future Directions *Advances in Robots Trajectories Learning via Fast Neural Networks* Jose De Jesus Rubio, Yongping Pan, Jeff Pieper, Mu-Yen Chen, Juan Humberto Sossa Azuela, 2021-05-14 Motion Control Federico Casolo, 2010-01-01 The book reveals many different aspects of motion control and a wide multiplicity of approaches to the problem as well. Despite the number of examples however this volume is not meant to be exhaustive it intends to offer some original insights for all researchers who will hopefully make their experience available for a forthcoming publication on the subject *Motion Control of Underactuated Mechanical Systems* Javier Moreno-Valenzuela, Carlos Aguilar-Avelar, 2017-07-11 This volume is the first to present a unified perspective on the control of underactuated mechanical systems. Based on real time implementation of parameter identification this book provides a variety of algorithms for the Furuta pendulum and the inertia wheel pendulum which are two degrees of freedom mechanical systems. Specifically this work addresses and solves the problem of motion control via trajectory tracking in one joint coordinate while another joint is regulated. Besides discussions on extensions to higher degrees of freedom systems are given. The book aimed at control engineers as well as graduate students ranges from the problem of parameter identification of the studied systems to the practical implementation of sophisticated motion control algorithms. Offering real world solutions to manage the control of underactuated systems this book provides a concise tutorial on recent breakthroughs in the field: original procedures to achieve bounding of the error trajectories convergence and gain tuning guidelines **Proceedings of 2020 Chinese Intelligent Systems Conference** Yingmin Jia, Weicun Zhang, Yongling Fu, 2020-09-29 The book focuses on new theoretical results and techniques in the field of intelligent systems and control. It provides in depth studies on a number of major topics such as Multi Agent Systems Complex Networks Intelligent Robots Complex System Theory and Swarm Behavior Event Triggered Control and Data Driven Control Robust and Adaptive Control Big Data and Brain Science Process Control Intelligent Sensor and Detection Technology Deep learning and Learning Control Guidance Navigation and Control of Flight Vehicles and so on. Given its scope the book will benefit all researchers engineers and graduate students who want to learn about cutting edge advances in intelligent systems intelligent control and artificial intelligence *Introduction to Mobile Robot Control* Spyros G Tzafestas, 2013-10-03 *Introduction to Mobile Robot Control* provides a complete and concise study of

modeling control and navigation methods for wheeled non holonomic and omnidirectional mobile robots and manipulators The book begins with a study of mobile robot drives and corresponding kinematic and dynamic models and discusses the sensors used in mobile robotics It then examines a variety of model based model free and vision based controllers with unified proof of their stabilization and tracking performance also addressing the problems of path motion and task planning along with localization and mapping topics The book provides a host of experimental results a conceptual overview of systemic and software mobile robot control architectures and a tour of the use of wheeled mobile robots and manipulators in industry and society Introduction to Mobile Robot Control is an essential reference and is also a textbook suitable as a supplement for many university robotics courses It is accessible to all and can be used as a reference for professionals and researchers in the mobile robotics field Clearly and authoritatively presents mobile robot concepts Richly illustrated throughout with figures and examples Key concepts demonstrated with a host of experimental and simulation examples No prior knowledge of the subject is required each chapter commences with an introduction and background

Autonomous Mobile Robots: Control, planning, and architecture S. Sitharama Iyengar, Alberto Elfes, 1991 Instruments, Measurement, Electronics and Information Engineering J.Z. Ma, 2013-08-08 Selected peer reviewed papers from the 2013 International Conference on Precision Mechanical Instruments and Measurement Technology ICPMIMT 2013 May 25 26 2013 Shenyang Liaoning China

Cloud Computing Victor C.M. Leung, Min Chen, 2014-04-29 This book constitutes the thoroughly refereed post conference proceedings of the 4th International Conference on Cloud Computing Cloud Comp 2013 held in Wuhan China in October 2013 The 28 revised full papers were carefully reviewed and selected from numerous submissions and cover topics such as mobile cloud computing services applications IoT on cloud architectures and big data cloud assisted pervasive computing and services management and virtualization for cloud cloud security

Intelligent Motion Control , 1990

Engineering Providing of Industrial Development Wen Jin, 2014-09-12 Selected peer reviewed papers from the 2014 2nd Asian Pacific Conference on Mechatronics and Control Engineering APCMCE 2014 August 8 9 2014 Hong Kong

Motion Control (MC'98) D. Georges, 1999 Paperback This workshop comprised three plenary sessions three invited sessions and fifty six regular papers which were selected by the International Programme Committee and came from twenty one countries The three plenary sessions covered the following topics Control of Self Optimizing Exercise Machines Motion Control Problems in Automotive Control and Control for Simulated Human and Animal Motion The three invited sessions were devoted to Non Holonomic Motion Control Hybrid Control of Mechanical Systems and Intelligent Motion Control The regular sessions covered the following domains Friction and Backlash High Precision Motion Control Actuators and Sensors Mobile Robots and Non Holonomic Systems Automotive Control Rigid Robot Control Flexible Structures Walking Robots High Precision Motion Control Motion Control AC Motor Drives and Intelligent Motion Control

Mechatronics and Machine Vision 2003 John Billingsley, 2003 This book presents a specially edited selection of papers

from the 10th Annual Conference of Mechatronics and Machine Vision in Practice M2VIP 2003 which provides a forum for international experts and researchers to present and review advances in Mechatronics and Machine Vision The conference was held in Perth Australia 9 11 December 2003 Robot Control 1994 (SYROCO '94) Lorenzo Sciavicco, Claudio Bonivento, F. Nicolò, 1995 **Mechanism & Mechanical Devices Sourcebook 5E (PB)** Neil Sclater, 2011-08-05 THOUSANDS OF DRAWINGS AND DESCRIPTIONS COVER INNOVATIONS IN MECHANICAL ENGINEERING Fully revised throughout this abundantly illustrated reference describes proven mechanisms and mechanical devices Each illustration represents a design concept that can easily be recycled for use in new or modified mechanical electromechanical or mechatronic products Tutorials on the basics of mechanisms and motion control systems introduce you to those subjects or act as a refresher Mechanisms and Mechanical Devices Sourcebook Fifth Edition contains new chapters on mechanisms for converting renewable energy into electrical power 3D digital prototyping and simulation and progress in MEMS and nanotechnology based on carbon nanotubes A new chapter on stationary and mobile robots describes their roles in industry science national defense and medicine The latest advances in rapid prototyping are also discussed This practical guide will get you up to speed on many classical mechanical devices as well as the hot new topics in mechanical engineering COMPREHENSIVE INDEX MAKES IT EASY TO FIND SUBJECTS OF INTEREST GLOSSARIES OF TERMS ON CAMS GEARS MECHANISMS MOTION CONTROL ROBOTICS WIND TURBINES PUMPS AND 3D DIGITAL PROTOTYPING AND SIMULATION COVERAGE OF MOBILE ROBOTS THAT EXPLORE MARS PERFORM MILITARY DUTIES AND PUBLIC SERVICE HANDLE AUTOMATED DELIVERY CONDUCT SURVEILLANCE FROM THE AIR AND SEARCH UNDER THE SEA DETAILS ON THE MECHANISMS IN RENEWABLE ENERGY AND WIND TURBINE AND SOLAR THERMAL FARMS AND WAVE MOTION POWER PLANTS Mechanisms and Mechanical Devices Sourcebook Fifth Edition covers Basics of mechanisms Motion control systems New stationary and mobile robots New mechanisms for renewable power generation Drives and mechanisms with linkages gears cams gears and ratchets Clutches and brakes Latching fastening and clamping devices and mechanisms Chains belts springs and screws Shaft couplings and connections Motion specific devices Packaging conveying handling and safety mechanisms and machines Torque speed tension and limit control systems Instruments and controls pneumatic hydraulic electric and electronic New 3D digital prototyping and simulation techniques New rapid prototyping methods New directions in mechanical engineering Mobile Robots, 2001 **Advanced Research on Applied Mechanics and Manufacturing System** Helen Zhang, David Jin, X.J. Zhao, 2012-12-13 Selected peer reviewed papers from the 2012 International Conference on Applied Mechanics and Manufacturing System AMMS 2012 November 24 25 2012 Guangzhou China

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