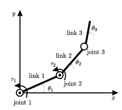
Nonholonomic Motion Planning
Chairs: Kostas Kyriakopoulos, Yoshi Nakamura

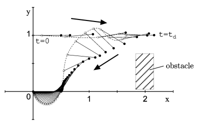
Design of a Desirable Trajectory and Convergent Control for 3-D.O.F. Manipulator with a Nonholonomic Constraint

T. Yoshikawa[1], K. Kobayashi[2] and T. Watanabe[1]
[1]Kyoto University and [2]Osaka University

- This paper is concerned with control of a 3 link planar underactuated manipulator. We have already proposed a control law that guarantees the convergence of its state to a given desirable trajectory and to any desired final point, and a design method of the desirable trajectory, but this method has a limitation on the location of the initial state.
- In this paper, we propose a design method of a desirable trajectory that starts from any given initial point, converges to any given desired final point, and on the way passes through any given desired passing point that can be specifyed rather freely.
- We did simulation to verify the validity of our approach. We show the convergence of the state of the system to the desirable trajectory which we design and finally to the origin even when there exists an initial error. We also show that we can derive a desirable trajectory that satisfies some given requirements such as avoiding obstacles.
- In this paper, we have propsed a design method of a desirable trajectory that satisfies given requirements much better than the previous method. We have presented simulation results in order to show the validity of this method.



3 link planar manipulator

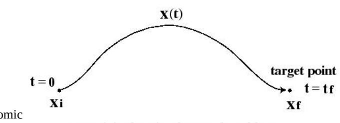


The behavior of link 3

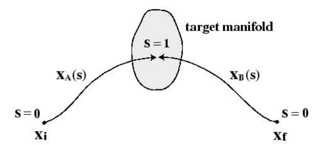
Near-Optimal Motion Planning for Nonholonomic Systems Using Time-Axis Transformation and Gradient Method

Makoto Iwamura, Motoji Yamamoto and Akira Mohri
Kyushu University

- In this study, an optimal motion planning scheme using time-axis transformation and gradient method is proposed for nonholonomic systems. The motion planning of nonholonomic systems is formulated as a nonlinear optimal control problem.
- The optimal control problem is too difficult to solve due to peculiar difficulty in the control of the nonholonomic systems. To alleviate the difficulty, we convert the optimal control problem to a bidirectional, fixed-domain optimal control problem by using quasi-time variable.
- A numerical algorithm which is based on the gradient method is developed for the optimal control problem and its convergence property with respect to final state error is proved.
- The optimal motion planning scheme is apllied to a 2-link planar free-joint manipulator. Simulation results show the effectiveness of the proposed optimal motion planning scheme.



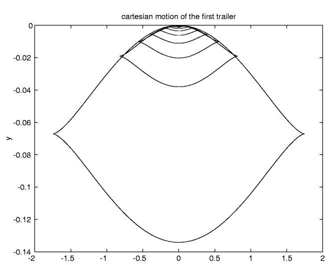
(a) original optimal control problem



(b) bidirectional optimal control problem

Stabilization of the general two-trailer system

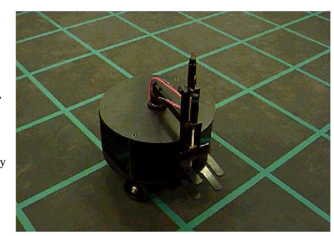
M. Vendittelli and G. Oriolo
Universit di Roma "La Sapienza"



Two Hybrid Control Schemes for Nonholonomic Robots

B. Young, J. Lawton and R. Beard
Brigham Young University

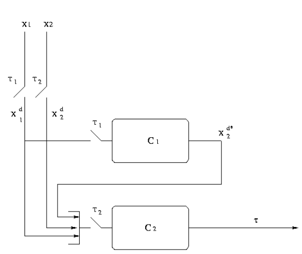
- The objective of the paper is to develop hybrid control strategies that regulate a differentially driven mobile robot to within a specified ball of a desired position and angle, where the ball is not greater than the variance of the sensor noise.
- Using the geometry of the problem, the maneuvers are broken into two components. One maneuver changes robot orientation and the other maneuver drives (or shoots) the robot toward its goal. By combining these two maneuvers, control laws are obtained which practically regulate a robot. The control laws use a dynamic model, which includes static friction.
- Two hybrid controls are derived which are shown to practically regulate a differentially driven mobile robot. Convergence proofs for both control laws are shown and guidelines for choosing the control gains are given.
- Hardware results show that the control strategies practically regulate a differentially driven mobile robot. In addition, the gains for the control strategies agreed with guidelines presented in the proofs.



Multi-Level Stabilizing Control of an Nonholonomic Vehicle and Its Discreate-Time Multirate Implementation

L. Palopoli, F. Conticelli and B. Allotta
Scuola Superiore Sant' Anna

- The addressed problem is controlling the relative position between a moving target and an autonomous nonholonomic vehicle. The purpose is to analyse the performance loss when a continuous time control law is approximated by a multirate digital controller.
- The continuous time control law is synthesized using the backstepping approach. The control law structure naturally leads to a multilevel and multirate digital approximation.
- The controller performance is assessed by using a quadratic index, assigning different frequencies to each subcontroller.
- The results show that the outer frequency has a greater influence on the system performance than the inner one.



Small Radius Attainability Spheres for Driftless Non-holonomic Systems

Ignacy Duleba
Wroclaw University of Technology

- Design nonholonomic spheres for driftless nonholonomic systems centered at the origin of the Ph. Hall frame.
- Directions of motion (weighted Ph. Hall basis elements) produced with controls applying the generalized C-B-H-D formula.
- Simulations for unicycle-type robots.
- The analytic and constructive solution, applicable to motion planning.