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Design of Nonlinear Feedback Controllers for Robot Tracking via the State Dependent Riccati Equation Method

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1 Introduction

After many years of research, there are various methods for the project of nonlinear controllers. However, there is still the need for a methodology that would allow one to evaluate not only stability, but also performance and robustness of a significant number of nonlinear systems. Control via the State Dependent Riccati Equation (SDRE) method appears, then, as a relevant tool. In this project, the authors were concerned with developing control strategies for tracking of different reference trajectories by a mobile robot. Simulations were performed in MATLAB which exhibit the action of the SDRE controller.

2 Robot Model and Control Designs

As described in [2], the mobile robot may be modelled by the following six differential equations:

$$m(\dot{u} - vr) = U_1 \tag{1}$$

$$m(\dot{v} + ur) = U_2 \tag{2}$$

$$J\dot{r} = U_3 \tag{3}$$

$$\dot{x}_p = u\cos\psi - v\sin\psi \tag{4}$$

$$\dot{y}_p = u\sin\psi + v\cos\psi \tag{5}$$

$$\dot{\psi} = r \tag{6}$$

where m is the mass of the robot, u and v are velocities in the x and y directions, r is the rotational velocity about the z axis, ψ is the angle between the line through the center of mass and x_p, J is the moment of inertia and U_1, U_2 and U_3 represent forces and torque.

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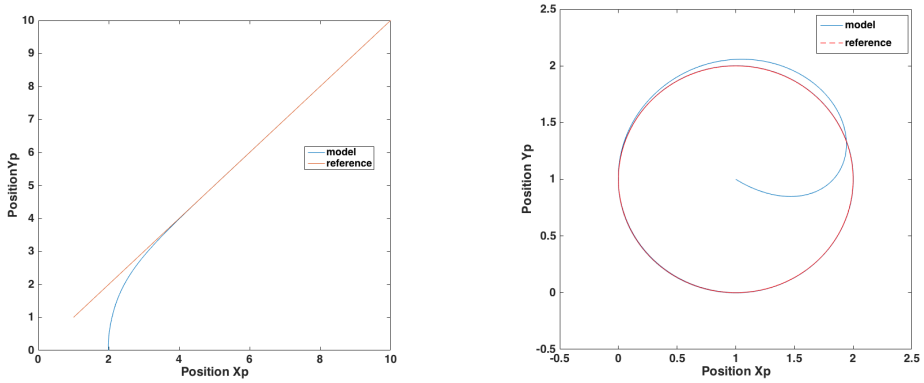

(a) Line (b) Circle

Figure 1: Reference trajectory and robot trajectory using SDRE Control

Choosing each of the differentiated variables as state variable and defining a reference system, one achieves an error system upon which the control will act. According to [1], the SDRE method to find the suboptimal solution consists of: (a) Use direct parameterization to bring the nonlinear dynamics to the state-dependent coefficient (SDC) form, (b) Solve the state-dependent Riccati equation, (c) Construct the nonlinear feedback controller and (d) Integrate the control with the system and repeat from (b).

3 Concluding Remarks

Notice that the SDRE method was effective since the error variables approximate zero as time goes by and the position variables follow the trajectories given by the references, as the line and circle exposed earlier. It is important to emphasize that SDRE control allowed the treatment of six state equations in a nonlinear system and exhibited robustness to the uncertainty in parameters and a well-behaved steady-state response. Furthermore, its additional degrees of freedom may be used to improve system's performance.

Acknowledgment

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References

[1] C. P. Mracek and J. R. Cloutier. Control designs for the nonlinear benchmark problem via the state-dependent Riccati equation method. *International Journal of Robust and Nonlinear Control*, vol. 8, pp. 401-433, 1998.

[2] K. J. Worral and E. W. McGookin. A mathematical model of a lego differential drive robot. University of Glasgow, 2002.