



LUND UNIVERSITY

Stabilization of Vehicle Formations-A Case Study

Gattami, Ather; Berglund, Johannes

Published in:

Book of Abstracts of Third Swedish Workshop on Autonomous Robotics

2005

[Link to publication](#)

Citation for published version (APA):

Gattami, A., & Berglund, J. (2005). Stabilization of Vehicle Formations-A Case Study. In P. Ögren (Ed.), *Book of Abstracts of Third Swedish Workshop on Autonomous Robotics* FOI.

Total number of authors:

2

General rights

Unless other specific re-use rights are stated the following general rights apply:

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Stabilization of Vehicle Formations - A Case Study

Ather Gattami, Johannes Berglund
Department of Automatic Control, Lund University
Box 118, SE-221 00 Lund, Sweden
E-mail: ather@control.lth.se

August 9, 2005

We consider a practice example of stabilization of vehicle formations, namely six vehicles from the Multi-Vehicle Wireless Testbed (MVWT) used at Caltech. Powerful theoretical results on homogeneous interconnected systems are used for stability analysis and controller design. Each vehicle has a rectangular shape seen from above, with two fans to control its motion, see Figure 1. The nonlinear dynamics of the vehicle are given by

$$\begin{aligned} m(\ddot{r} - r\dot{\beta}^2) &= -\mu\dot{r} + (F_R + F_L)\cos(\theta - \beta) \\ m(r\ddot{\beta} + 2\dot{r}\dot{\beta}) &= -\mu r\dot{\beta} + (F_R + F_L)\sin(\theta - \beta) \\ J\ddot{\theta} &= -\mu r^2\dot{\theta} + (F_R - F_L)r_f \end{aligned} \quad (1)$$

The nonlinear dynamics are linearized and we obtain a linear system for the error dynamics which has two inputs, the fan forces F_R and F_L and two outputs, the polar coordinates r and β . The task is to stabilize all vehicles in a prespecified formation. There is no common coordinate-system. Each vehicle can only measure the relative distance to a limited number of other vehicles. Using the fact that the system is homogeneous, existing results from [1] can be used for *separately* finding a decentralized controller for every vehicle. We show stability for the case where the interconnection graph is given in Figure 2. Every node denotes a vehicle, and for instance, the graph shows that vehicle 1 can sense the distance to vehicle 2 and 6, vehicle 2 can sense the distance to vehicle 1 and 3, and so on. Other interconnections can also be used using the same

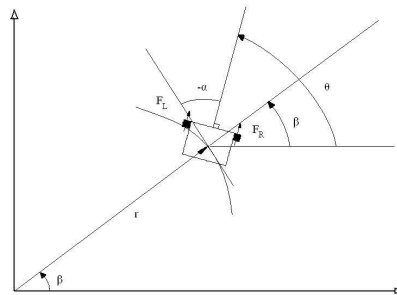


Figure 1: The Multi-Vehicle Wireless Testbed vehicle.

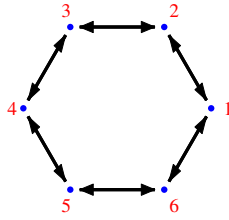


Figure 2: The interconnection graph.

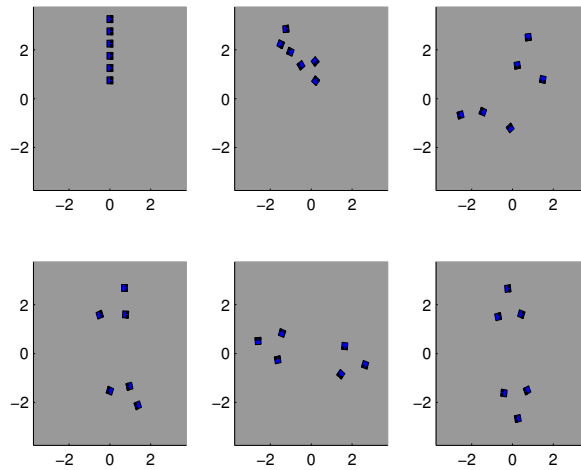


Figure 3: The vehicles starts in a row and the task is to make them rotate in two groups around a center that is agreed on online. The simulation shows that they end up rotating in the desired grouping counter-clockwise.

methods for analysis and controller design. A simulation is presented in Figure 3.

References

- [1] Ather Gattami, Richard M. Murray. *A Frequency Domain Condition for Stability of Interconnected MIMO Systems*. In Proc. ACC 2004, Boston, USA.
- [2] Johannes Berglund. *Stabilization of Vehicle Formations - A Case Study*. Master's Thesis ISRN LUTFD2/TFRT-5751-SE, June 2005. Dept. of Automatic Control, Lund university, Lund, Sweden.
- [3] L. Cremean, W. Dunbar, D. van Gogh, J. Hickey, E. Klavins, J. Meltzer, R. M. Murray. *The Caltech Multi-Vehicle Wireless Testbed*. In CDC 2002.