Stabilization of Vehicle Formations-A Case Study

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Stabilization of Vehicle Formations - A Case Study

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We consider a practicle 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

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

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

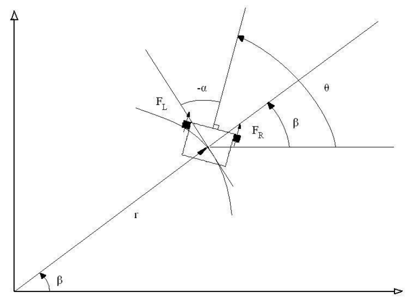

Figure 1: The Multi-Vehicle Wireless Testbed vehicle.

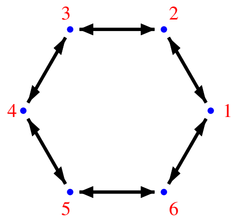

Figure 2: The interconnection graph.

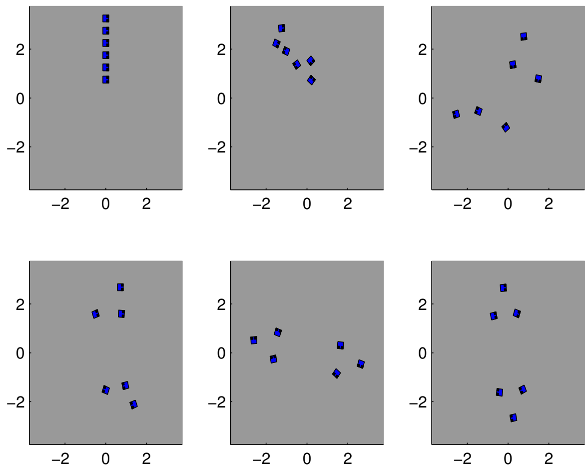

Figure 3: The vehicles starts in a row and the task is to make them rotate in two groups around a center that is agreed on online. The simulation shows that they end up rotating in the desired grouping counter-clockwise.

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

References

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