Characterizing bearing equivalence in directed graphs

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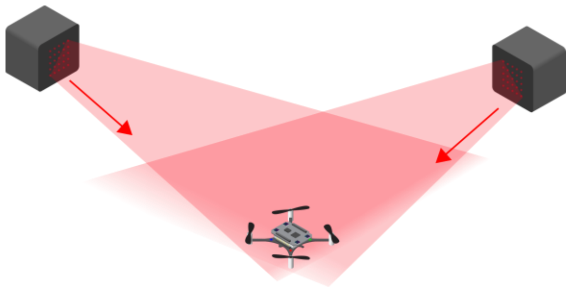
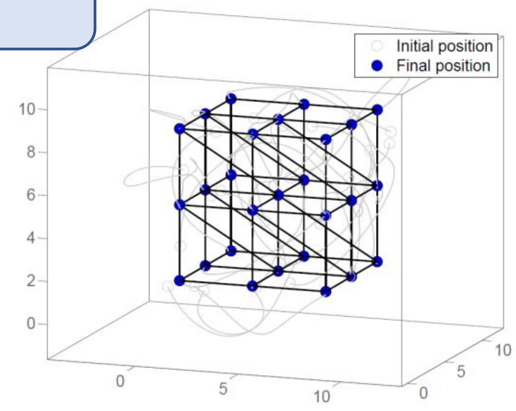
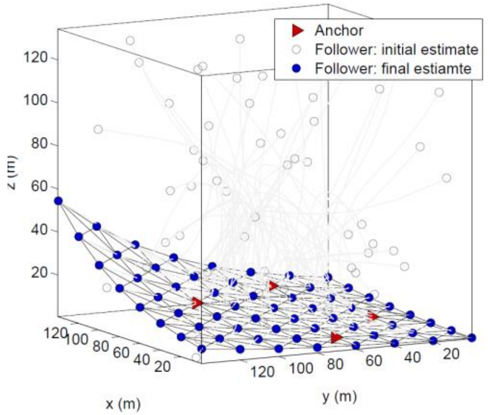
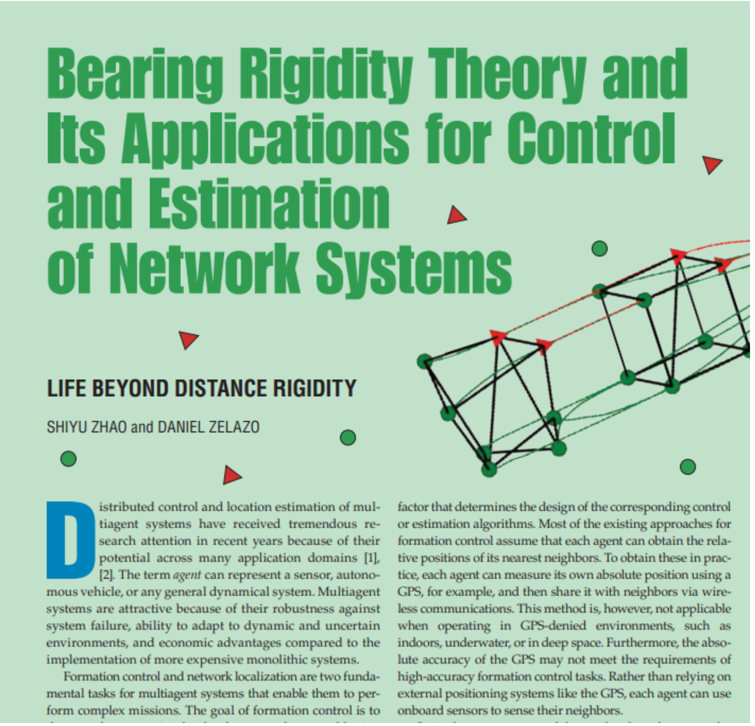


Vision-based measurement: multi-robot coordination with bearing information





Bearing-based formation and network localization



Bearing Rigidity Theory and Its Applications for Control and Estimation of Network Systems

LIFE BEYOND DISTANCE RIGIDITY

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Distributed control and location estimation of multiagent systems have received tremendous research attention in recent years because of their potential across many application domains [1], [2]. The term *agent* can represent a sensor, autonomous vehicle, or any general dynamical system. Multiagent systems are attractive because of their robustness against system failure, ability to adapt to dynamic and uncertain environments, and economic advantages compared to the implementation of more expensive monolithic systems.

Formation control and network localization are two fundamental tasks for multiagent systems that enable them to perform complex missions. The goal of formation control is to

factor that determines the design of the corresponding control or estimation algorithms. Most of the existing approaches for formation control assume that each agent can obtain the relative positions of its nearest neighbors. To obtain these in practice, each agent can measure its own absolute position using a GPS, for example, and then share it with neighbors via wireless communications. This method is, however, not applicable when operating in GPS-denied environments, such as indoors, underwater, or in deep space. Furthermore, the absolute accuracy of the GPS may not meet the requirements of high-accuracy formation control tasks. Rather than relying on external positioning systems like the GPS, each agent can use onboard sensors to sense their neighbors.

Bearing equivalence in directed graphs

Definition (Bearing equivalence)

A directed formation $\mathcal{G}(p)$ is *bearing equivalent* if $\mathrm{Null}(R_B) = \mathrm{Null}(L_B) = \mathrm{span}\{\mathbf{1} \otimes I_d, p\}$.

- New formula for bearing Laplacian matrix;
- Graphical characterizations of bearing equivalence (acyclic and cyclic digraphs);
- Spectrum analysis of digraph bearing Laplacians;
- Bearing-based formation control with stability guarantees.