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Distributed coordination in multi-agent systems: a graph Laplacian perspective

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Introduction

- Distributed multi-agent coordination has been a very active subject studied extensively in last decades, including distributed consensus, formation control, sensor localization, distributed optimization, etc.
- This paper intends to present a survey from a new perspective in terms of graph Laplacian, which connects different research issues of multi-agent systems in one string for distributed coordination.

Introduction (Con'd)

We categorize the existing results in multi-agent systems into the following types:

- Ordinary Laplacian based protocols
- Signed Laplacian based protocols
- Complex Laplacian based protocols
- Generalized Laplacian based protocols

Survey of distributed multi-agent coordination (1)

Type	Ordinary Laplacian based protocols
Laplacian feature	The Laplacian matrix associated to a graph with positive and real weights
Research issues	<ul style="list-style-type: none">• Consensus• Translational formation control• Flocking• Distributed resource allocation

Survey of distributed multi-agent coordination (2)

Type	Signed Laplacian based protocols
Laplacian feature	The Laplacian matrix associated to a graph with real weights that may be positive or negative
Research issues	<ul style="list-style-type: none">• Bipartite consensus• Cluster consensus• Optimization over convergence speed• Affine formation control• Distance-based localization

Survey of distributed multi-agent coordination (3)

Type	Complex Laplacian based protocols
Laplacian feature	The Laplacian matrix associated to a graph with complex weights
Research issues	<ul style="list-style-type: none">• Similar formation control• Relative position based localization

Survey of distributed multi-agent coordination (4)

Type	Generalized Laplacian based protocols
Laplacian feature	The Laplacian matrix associated with a graph with weights that may be matrices, time-varying variables, or dynamic systems
Research issues	<ul style="list-style-type: none">• Bearing-angle based localization• Distributed coordination over switching topologies• Distributed coordination with dynamic gains

Future research directions

- Spectrum of variant graph Laplacians
- Distributed multi-agent coordination over directed and time-varying graphs
- Distributed multi-agent coordination with interaction dynamics
- Nonlinear multi-agent coordination
- Distributed coordination of heterogeneous agents

Conclusions

- This paper reviews some main results and progress in distributed multi-agent coordination from a graph Laplacian perspective.
- This paper also highlights several promising research directions along with some open problems that are deemed important for future study.