Simultaneous Topology Identification and Control for Complex Networks

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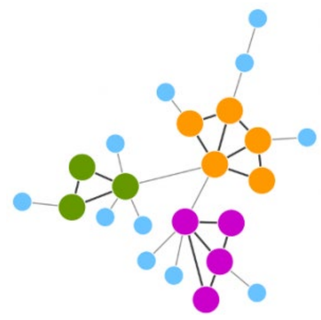


Motivation & Research goals

Graphs help to understand the relationships among different systems, ranging across social networks, distributed robots, sensor networks and biological systems. Communication graph is a key to achieve the coordination tasks among agents. The graph structure of numerous systems remains **unclear** to us, such as the communication network graph in biological systems, social networks, traffic systems, economic systems. Interference and control can be implemented to identify the unknown topology graph and achieve some cooperation tasks. The aim of this research is to develop a systematical framework of merging **topology identification** and **control**.

Problem statement

The dynamics of each agent i

$$\dot{x}_i = f_i\big(t, x_i(t)\big) + \sum_{j=1}^{N} l_{ij}(t) g_{ij}\Big(x_j(t)\Big) + u_i(t)$$

$f_i\big(t, x_i(t)\big)$: internal dynamics

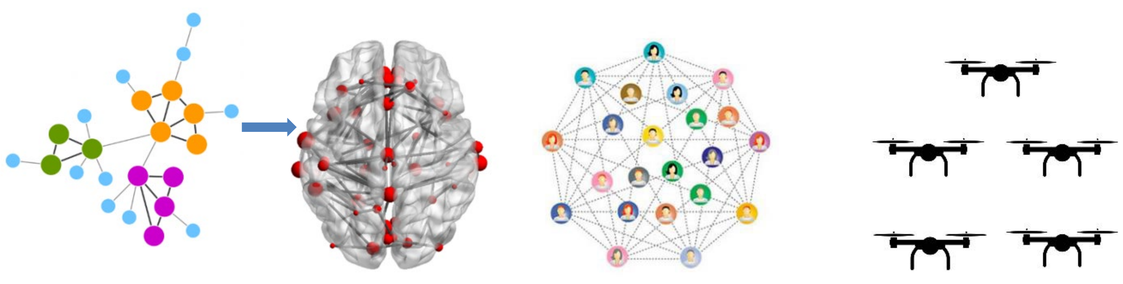
$g_{ij}\Big(x_j(t)\Big)$: effect from neighbors

$u_i(t)$: control input

$l_{ij}\ (t)$: unknown connection weight.

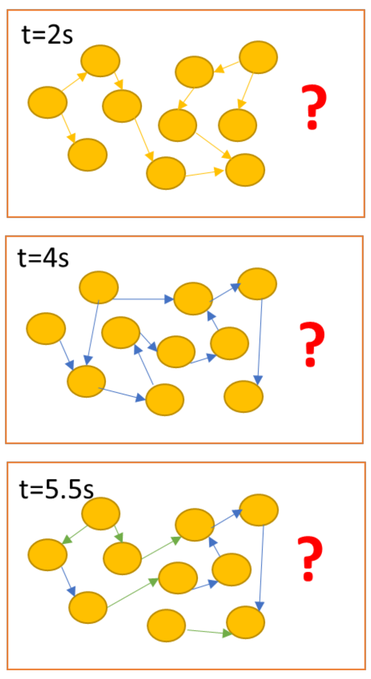
The goal is by designing controllers

- to estimate the unknown topology graph and perform control tasks simultaneously
- to implement a priori graph information
- to estimate switching and time-varying topology

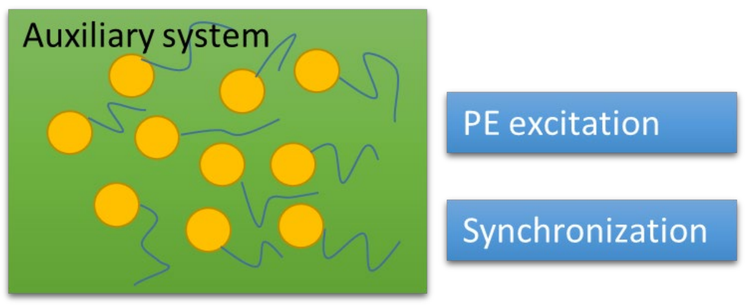


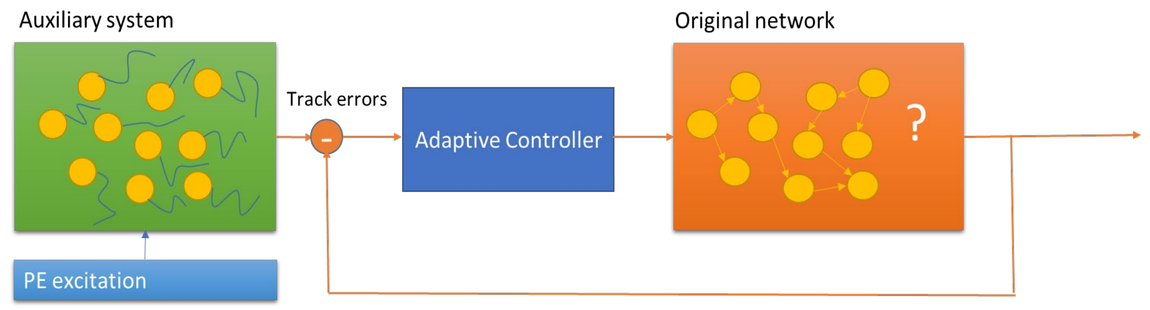
Methods & Results

Simultaneous time-varying topology ID and synchronization [1]



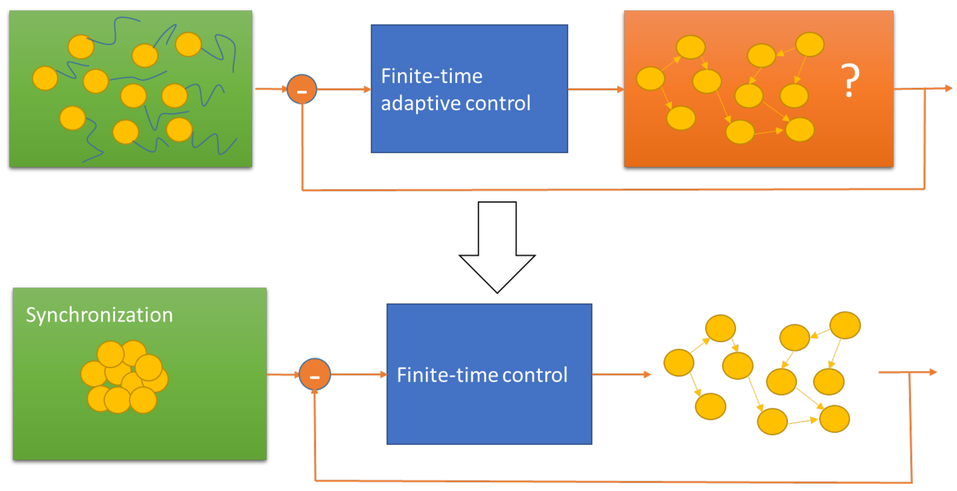
- Adaptive control-based method based on δ-persistency of excitation
- Bound topology estimation and synchronization errors





Finite-time Topology ID and synchronization [2]

- Accurate adaptive parameter estimation
- Finite-time sychronization



Topology identification with a priori graph structure

- Laplacian matrix
- Undirected graph

Switched topology ID

- A framework of identifying the graph switching time sequence
- A scheme that identifies the switched topology

Future work

- Application in a large scale of network
- Performance improvement of topology ID

References

[1] Nana Wang, Esteban Restrepo, Dimos V. Dimarogonas. "Simultaneous Topology Estimation and Synchronization of Dynamical Networks with Time-varying Topology." 63rd IEEE Conference On Decision And Control, Milano, 2024,
[2] Nana Wang. " Network Identification and Control for Heterogeneous Multi-Agent Systems ." Licentiate dissertation, KTH Royal Institute of Technology, Stockholm, 2024.

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