Multi-Agent Systems

Kai Cai

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Zoom

Meeting ID: 993 3804 4669

Passcode: mas2022

Link:

https://omu-ac-jp.zoom.us/j/99338044669?pwd=cHNzUHdQKzg1SkkxckJCTmVRZC9VUT09

- Turn on your video, unless your bandwidth is too low

- Unmute yourself only when you want to talk or are asked to talk

- All lectures are recorded (let me know if you have issues)

Teams as backup

1. Open your Teams app

2. Search “cai@omu.ac.jp”

3. Write to me a message with your name and omu email address

→ I will create a Team and a Mailing list for this course

Introduction

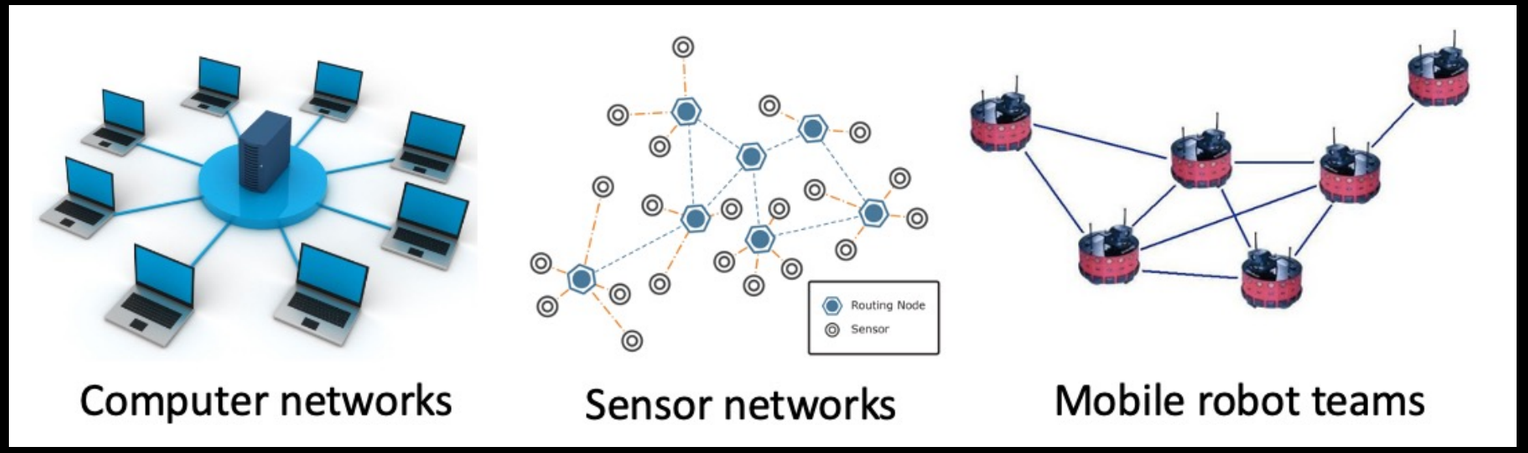
Examples in nature

Flocking

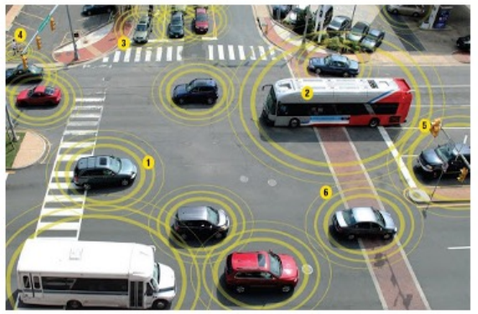
Schooling

Synchronization

Examples in engineering



Applications

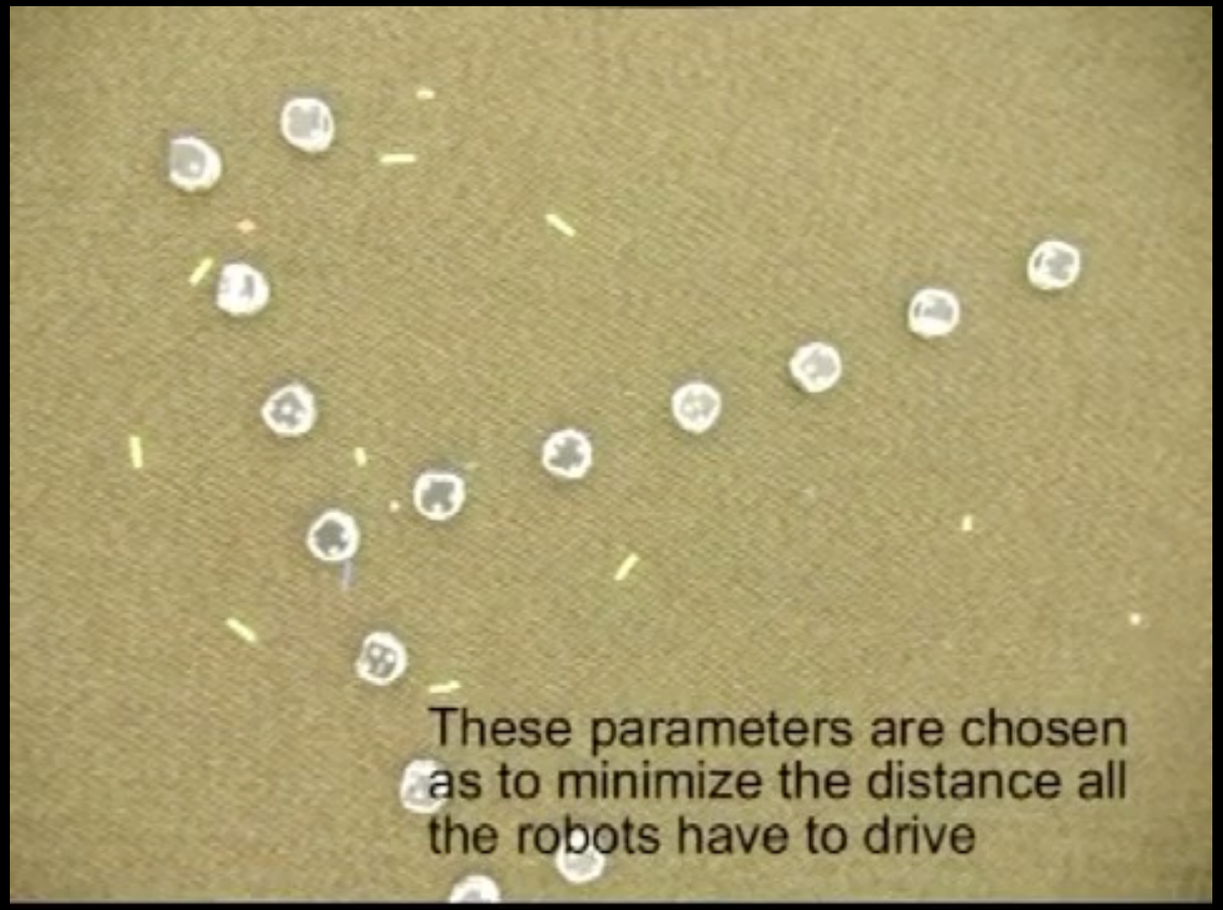


Smart transportation

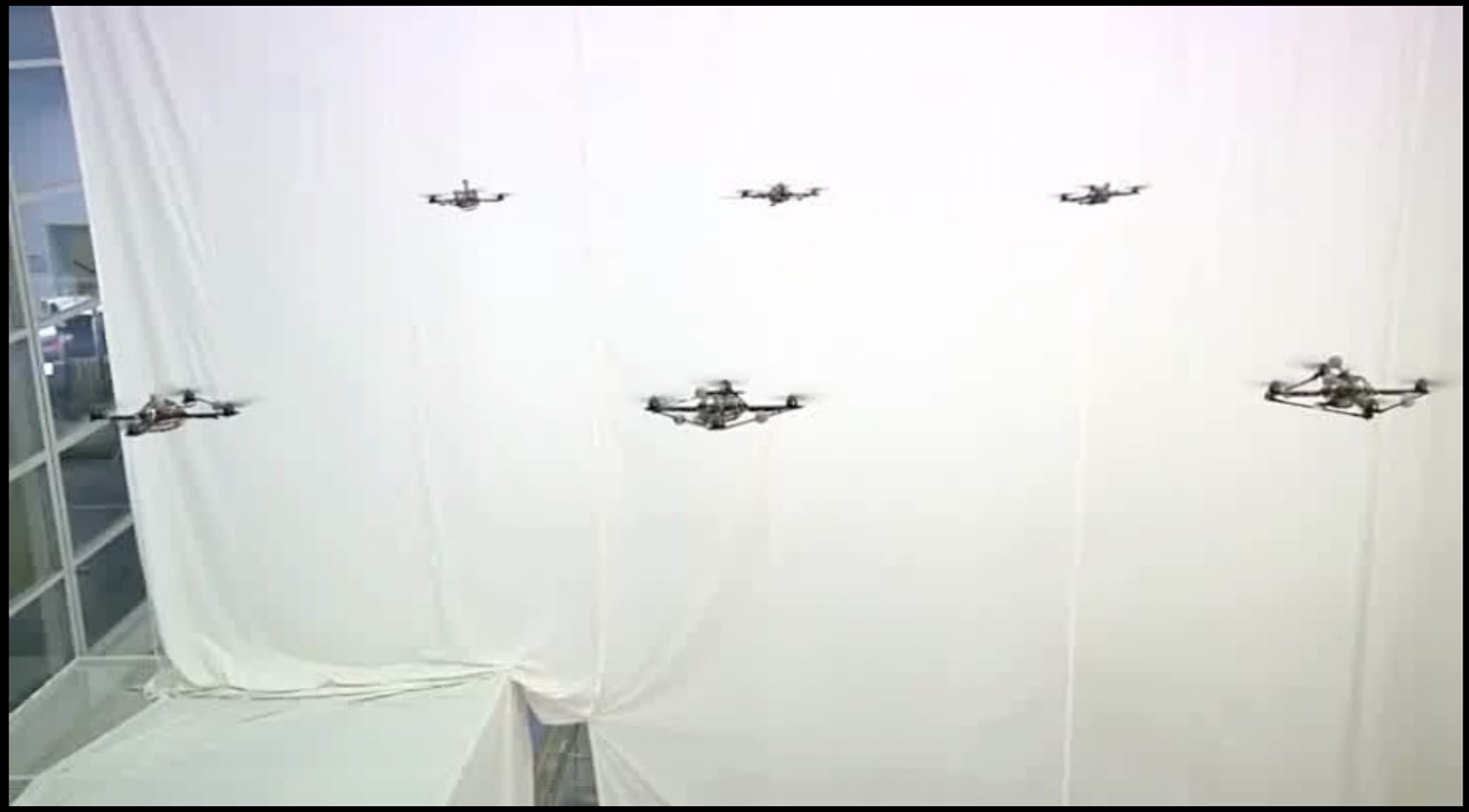
Power grid

Logistic automation

Applications



Applications



Applications

Applications

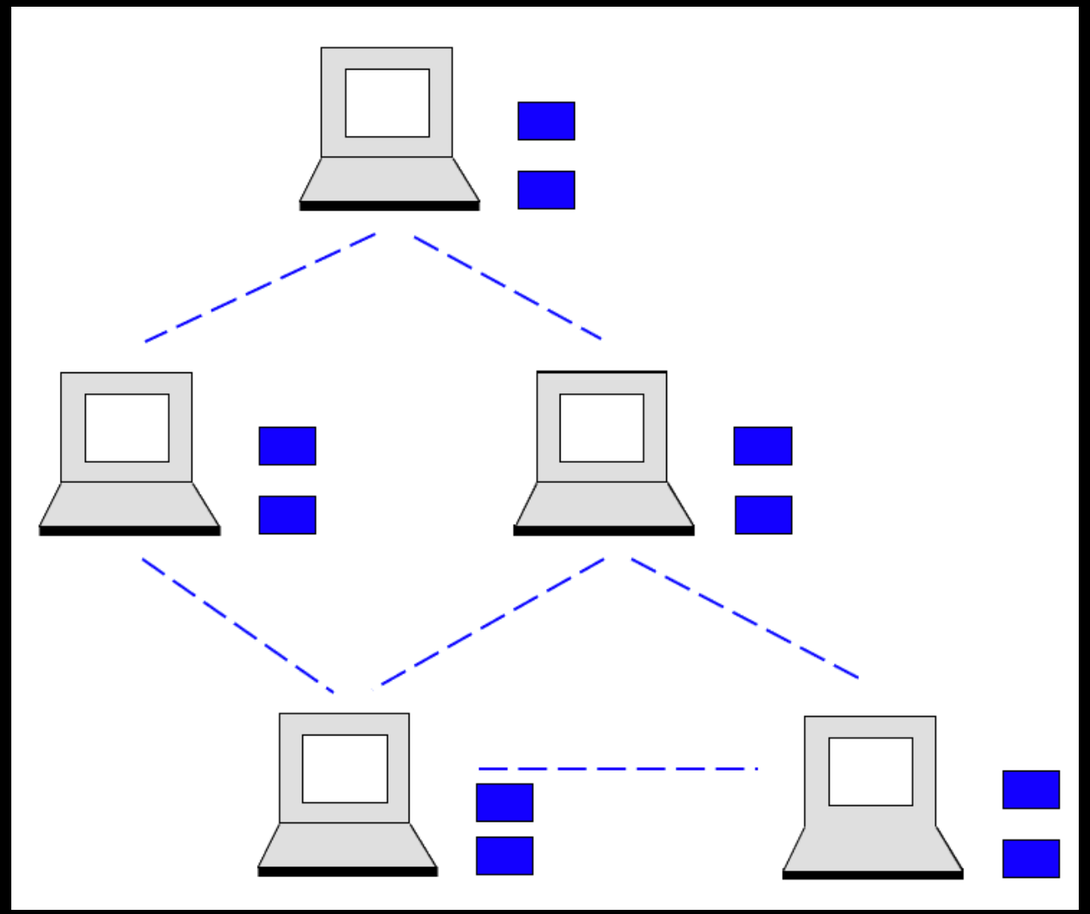
In this course

1. Modeling of multi-agent systems

2. Formulation of fundamental cooperative control problems

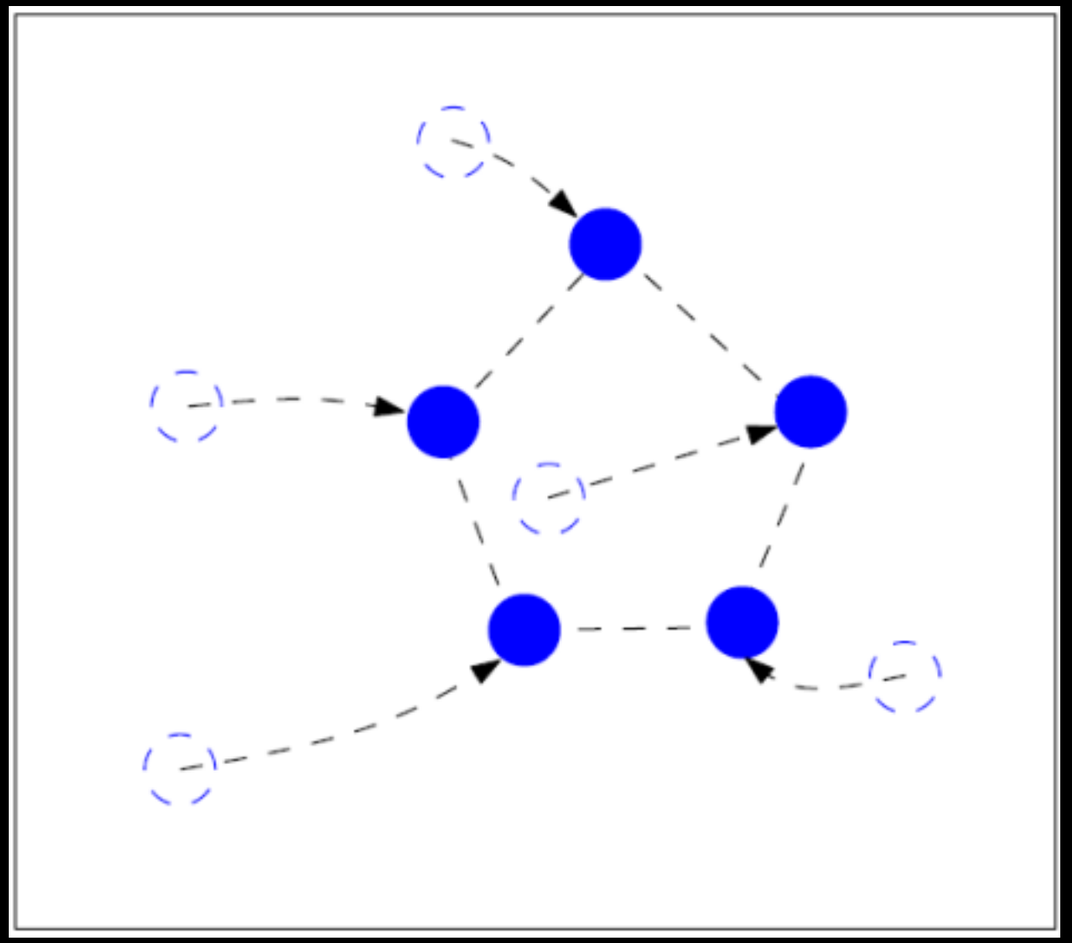
3. Design of distributed control algorithms for solving these problems and analysis tools

Averaging

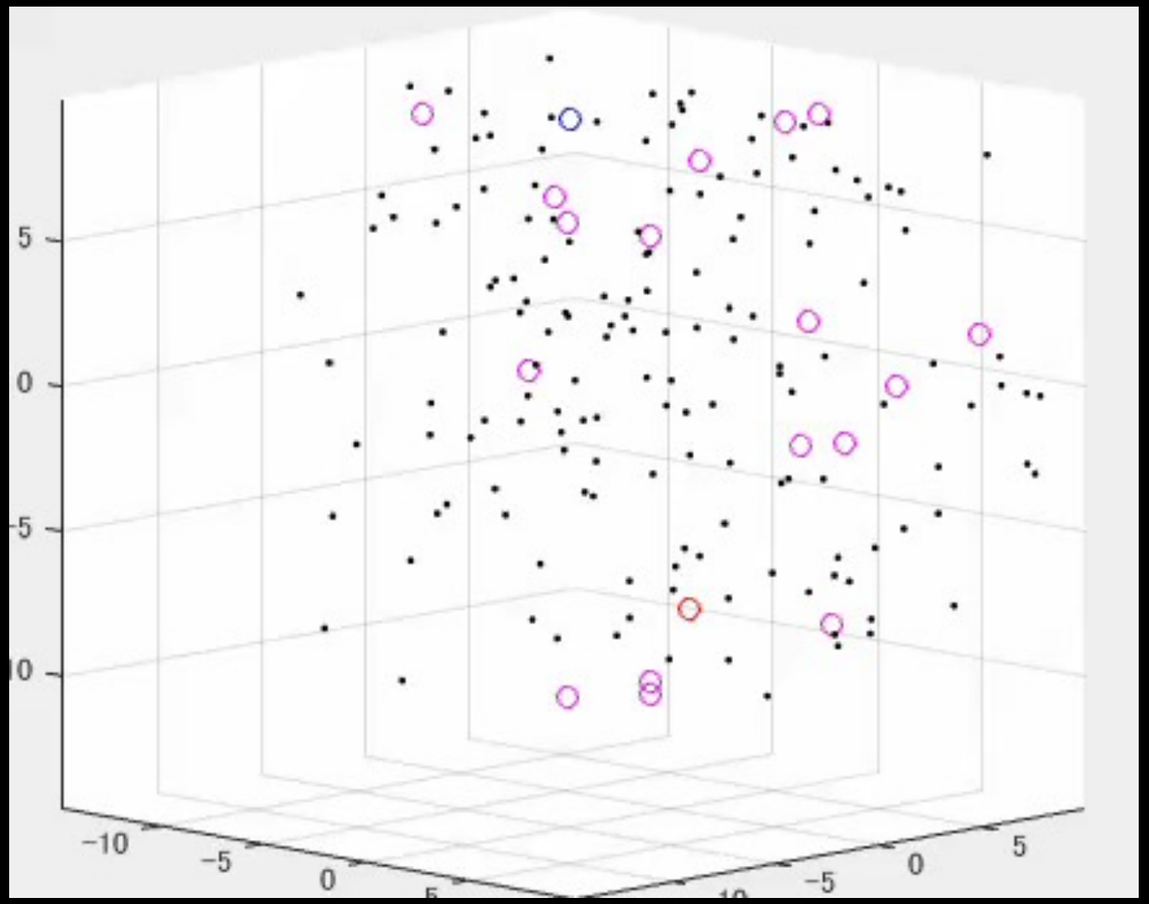


Consensus

2D formation



3D formation



Hottest topic in control

Keywords:

Multi-agent systems

Cooperative control

Networked systems

Networked control

CDC 2022 program

Day 1:

CDC 2022 Technical Program Tuesday December 6, 2022 Tuesday Wednesday Thursday Friday Next Top

Click on the day's program and use the arrow keys for easy horizontal and vertical scrolling

			09:30-10:00 Room T19 TuAM_BR		
10:00-12:00 Tulum Ballroom F Regular Session TuAT06 *Kernel-Based Identification*	10:00-12:00 Tulum Ballroom G Regular Session TuAT07 *Estimation*	10:00-12:00 Tulum Ballroom H Regular Session TuAT08 *Alternating Direction Method of Multipliers*	10:00-12:00 Maya Ballroom I Regular Session TuAT09 *Consensus of Multi-Agent Systems*	10:00-12:00 Maya Ballroom II Regular Session TuAT10 *Stochastic Systems I*	10:00-12:00 Maya Ballroom III Regular Session TuAT11 *Distributed Parameter Systems I*
			12:00-13:30 Room T19 TuLU_BR		
13:30-15:30 Tulum Ballroom F Regular Session TuBT06 *Identification of Linear Systems*	13:30-15:30 Tulum Ballroom G Regular Session TuBT07 *Fault Tolerant Systems I*	13:30-15:30 Tulum Ballroom H Regular Session TuBT08 *Barrier Functions in Constrained Control*	13:30-15:30 Maya Ballroom I Regular Session TuBT09 *Network Analysis and Control I*	13:30-15:30 Maya Ballroom II Regular Session TuBT10 *Stochastic Systems II*	13:30-15:30 Maya Ballroom III Regular Session TuBT11 *Distributed Parameter Systems II*
			15:30-16:00 Room T19 TuPM_BR		
16:00-18:00 Tulum Ballroom F Regular Session TuCT06 *Neural Networks for Identification*	16:00-18:00 Tulum Ballroom G Regular Session TuCT07 *Fault Tolerant Systems II*	16:00-18:00 Tulum Ballroom H Regular Session TuCT08 *Learning and Optimization*	16:00-18:00 Maya Ballroom I Regular Session TuCT09 *Network Analysis and Control II*	16:00-18:00 Maya Ballroom II Regular Session TuCT10 *Stochastic Systems III*	16:00-18:00 Maya Ballroom III Regular Session TuCT11 *Robust Control I*

CDC 2022 program

Day 2:

CDC 2022 Technical Program Wednesday December 7, 2022 Previous Tuesday Wednesday Thursday Friday Next Top

Click on the day's program and use the arrow keys for easy horizontal and vertical scrolling

			WeAM_BR		
10:00-12:00 Tulum Ballroom F Regular Session WeAT06 *Parameter Identification*	10:00-12:00 Tulum Ballroom G Invited Session WeAT07 *Modular Design and Verification of Control Systems*	10:00-12:00 Tulum Ballroom H Regular Session WeAT08 *Resilient Control Systems*	10:00-12:00 Maya Ballroom I Regular Session WeAT09 *Cooperative Control*	10:00-12:00 Maya Ballroom II Regular Session WeAT10 *Stochastic Systems IV*	10:00-12:00 Maya Ballroom III Regular Session WeAT11 *Robust Control II*
			12:00-13:30 Room T19 WeLU_BR		
13:30-15:30 Tulum Ballroom F Regular Session WeBT06 *Identification for Control*	13:30-15:30 Tulum Ballroom G Invited Session WeBT07 *Online Learning, Optimization, and Game Theory I*	13:30-15:30 Tulum Ballroom H Regular Session WeBT08 *Formal Verification and Synthesis*	13:30-15:30 Maya Ballroom I Regular Session WeBT09 *Networked Control Systems I*	13:30-15:30 Maya Ballroom II Regular Session WeBT10 *Stochastic Optimal Control I*	13:30-15:30 Maya Ballroom III Regular Session WeBT11 *Robust Control III*
			15:30-16:00 Room T19 WePM_BR		
16:00-18:00 Tulum Ballroom F Regular Session WeCT06 *Estimation and Input Design*	16:00-18:00 Tulum Ballroom G Invited Session WeCT07 *Online Learning, Optimization, and Game Theory II*	16:00-18:00 Tulum Ballroom H Regular Session WeCT08 *Social and Financial Networks*	16:00-18:00 Maya Ballroom I Regular Session WeCT09 *Networked Control Systems II*	16:00-18:00 Maya Ballroom II Regular Session WeCT10 *Stochastic Optimal Control II*	16:00-18:00 Maya Ballroom III Regular Session WeCT11 *Robust Control IV*

CDC 2022 program

Day 3:

CDC 2022 Technical Program Thursday December 8, 2022 Previous Tuesday Wednesday Thursday Friday Next Top

Click on the day's program and use the arrow keys for easy horizontal and vertical scrolling

10:00-12:00 Tulum Ballroom F Regular Session ThAT06 *Linear Estimation*	10:00-12:00 Tulum Ballroom G Invited Session ThAT07 *Multi-Agent Optimization and Games*	10:00-12:00 Tulum Ballroom H Invited Session ThAT08 *Robust Distributed Optimization, Estimation, and Coordination in Multi-Agent Systems*	10:00-12:00 Maya Ballroom I Regular Session ThAT09 *Linear Systems I*	10:00-12:00 Maya Ballroom II Regular Session ThAT10 *Discrete-Event Systems*	10:00-12:00 Maya Ballroom III Regular Session ThAT11 *Sliding Mode Control*
		12:00-13:30 Room T19 ThLU_BR			
13:30-15:30 Tulum Ballroom F Regular Session ThBT06 *Nonlinear Estimation*	13:30-15:30 Tulum Ballroom G Invited Session ThBT07 *Distributionally Robust Optimization and Control*	13:30-15:30 Tulum Ballroom H Regular Session ThBT08 *Secure Control Systems*	13:30-15:30 Maya Ballroom I Regular Session ThBT09 *Linear Systems II*	13:30-15:30 Maya Ballroom II Regular Session ThBT10 *Markov Processes*	13:30-15:30 Maya Ballroom III Regular Session ThBT11 *Uncertain Systems I*
		15:30-16:00 Room T19 ThPM_BR			
16:00-18:00 Tulum Ballroom F Regular Session ThCT06 *Estimation and Filtering*	16:00-18:00 Tulum Ballroom G Invited Session ThCT07 *Estimation and Control of Infinite-Dimensional Systems I*	16:00-18:00 Tulum Ballroom H Regular Session ThCT08 *Privacy and Security*	16:00-18:00 Maya Ballroom I Regular Session ThCT09 *Stability of Linear Systems*	16:00-18:00 Maya Ballroom II Regular Session ThCT10 *Mean Field Games*	16:00-18:00 Maya Ballroom III Regular Session ThCT11 *Uncertain Systems II*

Work done in this group

Multi-agent consensus:

IEEE TRANSACTIONS ON AUTOMATIC CONTROL, VOL. 56, NO. 9, SEPTEMBER 2011 2087

Quantized Consensus and Averaging on Gossip Digraphs

Kai Cai, *Member, IEEE*, and Hideaki Ishii, *Member, IEEE*

Automatica 48 (2012) 2750–2761

Contents lists available at SciVerse ScienceDirect

Automatica

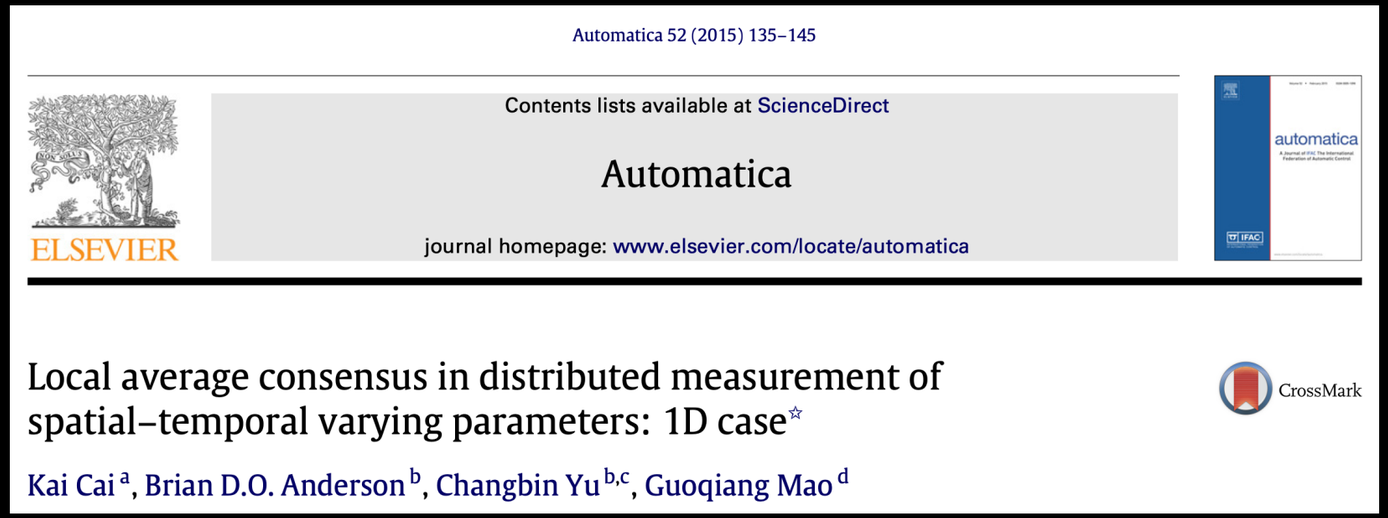
journal homepage: www.elsevier.com/locate/automatica

Average consensus on general strongly connected digraphs☆

Kai Cai [a,1], Hideaki Ishii [b]

Work done in this group

Multi-agent averaging:



Automatica 52 (2015) 135–145

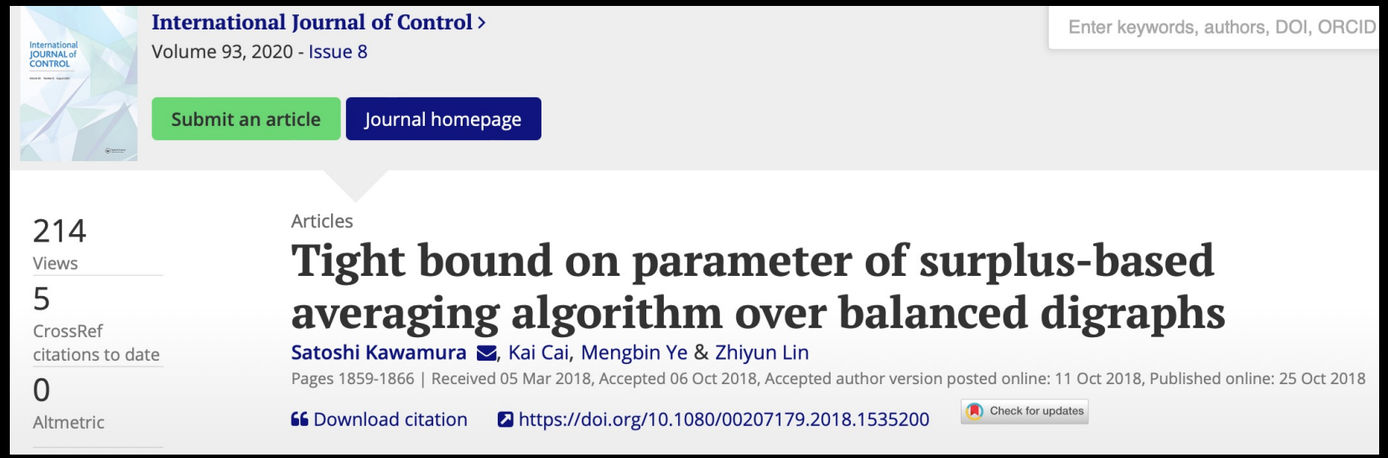
Contents lists available at ScienceDirect

Automatica

journal homepage: www.elsevier.com/locate/automatica

Local average consensus in distributed measurement of spatial–temporal varying parameters: 1D case☆

Kai Cai [a], Brian D.O. Anderson [b], Changbin Yu [b,c], Guoqiang Mao [d]



International Journal of Control ›

Volume 93, 2020 - Issue 8

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Articles

Tight bound on parameter of surplus-based averaging algorithm over balanced digraphs

Satoshi Kawamura, Kai Cai, Mengbin Ye & Zhiyun Lin

Pages 1859-1866 | Received 05 Mar 2018, Accepted 06 Oct 2018, Accepted author version posted online: 11 Oct 2018, Published online: 25 Oct 2018

Download citation | https://doi.org/10.1080/00207179.2018.1535200 | Check for updates

Work done in this group

Multi-agent optimization:

A Distributed Algorithm for Resource Allocation Over Dynamic Digraphs

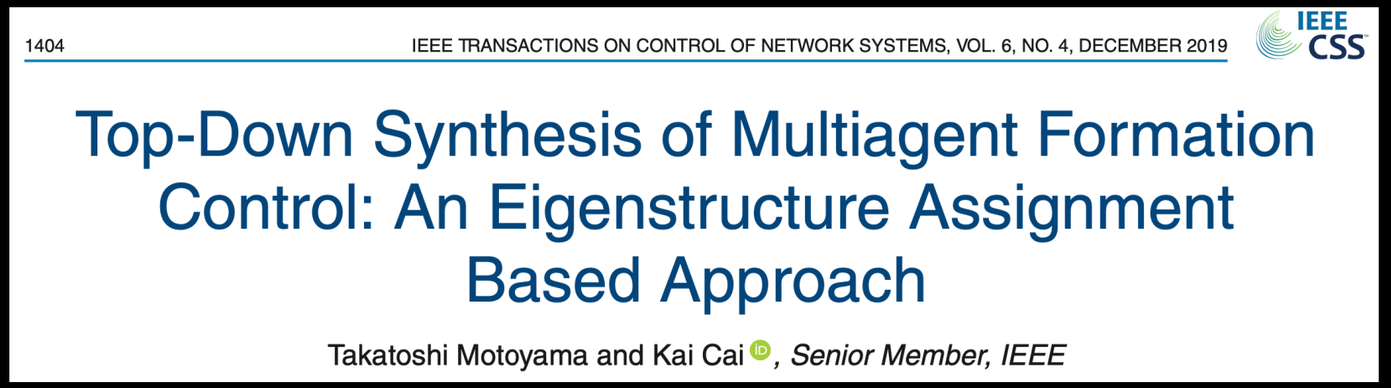
Yun Xu, Tingrui Han, Kai Cai, Zhiyun Lin, *Senior Member, IEEE*, Gangfeng Yan, and Minyue Fu, *Fellow, IEEE*

Distributed Dual Gradient Tracking for Resource Allocation in Unbalanced Networks

Jiaqi Zhang, Keyou You, *Senior Member, IEEE*, and Kai Cai, *Senior Member, IEEE*

Work done in this group

Multi-agent formation:



1404 IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS, VOL. 6, NO. 4, DECEMBER 2019

IEEE CSS

Top-Down Synthesis of Multiagent Formation Control: An Eigenstructure Assignment Based Approach

Takatoshi Motoyama and Kai Cai, *Senior Member, IEEE*

Advanced Robotics ›

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Survey Paper

A new perspective on cooperative control of multi-agent systems through different types of graph Laplacians

Kai Cai & Masaaki Nagahara

Received 24 Mar 2022, Accepted 15 Jun 2022, Published online: 11 Jul 2022

Download citation | https://doi.org/10.1080/01691864.2022.2093616 | Check for updates

Book in progress

This monograph will be used as a reference for this course.

Course content

1. Graph theory

2. Averaging

3. Consensus

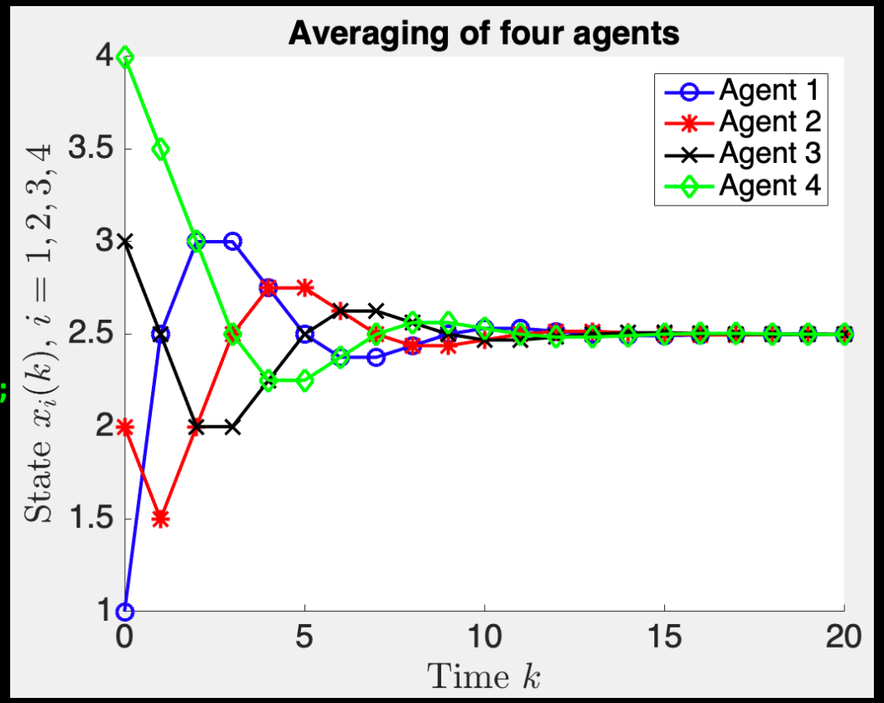
4. 2D formation

5. 3D formation

* Matlab codes for simulation

Matlab codes

```
clear all;

% # of agents
n = 4;
% simulation step size
Size = 21;

% state vector
x = zeros(n,Size);
% initial state
x(:,1) = [1; 2; 3; 4];
% random initial condition
% x(:,1) = -10 + (10-(-10))*rand(n,1);

% adjacency matrix
A = [0   0    0   1/2;
    1/3  0    0    1/3;
     0  1/2   0    0;
     0   1/3   1/3   0];

% degree matrix
D = diag(A*ones(n,1));

% Laplacian matrix
L = D - A;
```



Matlab tutorials

1. Two (or three) Matlab tutorials will be given by TA on 12/02 and 12/09 (possibly 12/16)

2. TA:

Kento Kugo (m21tb017@st.osaka-cu.ac.jp)

Zhaojian Cai (m21tb301@st.osaka-cu.ac.jp)

3. Download Matlab 2015 from:

https://www.control.eng.osaka-cu.ac.jp/teaching/mas2022

4. Install Matlab before 12/02

5. Set up OMU VPN for off-campus use

Grading

Final project 100%

1. Reading assignment 50%

2. Matlab simulation project 50%

Information and contacts

1. Moodle (schedule & slides)

2. Course website (all materials)
https://www.control.eng.osaka-cu.ac.jp/teaching/mas2022

3. Q & A
Moodle message or email: cai@omu.ac.jp (Cai)
m21tb017@st.osaka-cu.ac.jp (Kento Kugo)
m21tb301@st.osaka-cu.ac.jp (Zhaojian Cai)