

---

## Bibliography

---

- [AL15] C. Altafini and G. Lini. Predictable dynamics of opinion forming for networks with antagonistic interactions. *IEEE Trans. Autom. Control*, 60(2):342–357, 2015.
- [Bap10] R. B. Bapat. *Graphs and Matrices*. Springer, 2010.
- [BAW11] H. Bai, M. Arcak, and J. Wen. *Cooperative Control Design*. Springer, 2011.
- [Bul22] F. Bullo. *Lectures on Network Systems*. Kindle Direct Publishing, 2022.
- [CAYM15] K. Cai, B. D. O. Anderson, C. Yu, and G. Mao. Local average consensus in distributed measurement of spatial-temporal varying parameters: 1d case. *Automatica*, 52(2):135–145, 2015.
- [CI11] K. Cai and H. Ishii. Quantized consensus and averaging on gossip digraphs. *IEEE Trans. Autom. Control*, 56(9):2087–2100, 2011.
- [CI12] K. Cai and H. Ishii. Average consensus on general strongly connected digraphs. *Automatica*, 48(11):2750–2761, 2012.
- [CLC<sup>+</sup>16] W. Chen, J. Liu, Y. Chen, S. Z. Khong, D. Wang, T. Basar, L. Qiu, and K. H. Johansson. Characterizing the positive semidefiniteness of signed laplacians via effective resistances. In *Proc. IEEE Conf. on Decision and Control*, pages 985–990, 2016.
- [CWL<sup>+</sup>17] W. Chen, D. Wang, J. Liu, T. Basar, and L. Qiu. On spectral properties of signed laplacians for undirected graphs. In *Proc. IEEE Conf. on Decision and Control*, pages 1999–2002, 2017.
- [CWRKG20] J. Chen, H. Wang, M. Rubenstein, and H. Kress-Gazit. Automatic control synthesis for swarm robots from formation and location-based high-level specifications. In *Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, pages 8027–8034, 2020.
- [CYRC13] Y. Cao, W. Yu, W. Ren, and G. Chen. An overview of recent progress in the study of distributed multi-agent coordination. *IEEE Trans Industrial informatics*, 9(1):427–438, 2013.

- [DB10] F. Dorfler and F. Bullo. Synchronization and transient stability in power networks and non-uniform kuramoto oscillators. *SIAM J. Control and Optimization*, 50(3):1616–1642, 2010.
- [DB14] F. Dorfler and F. Bullo. Synchronization in complex networks of phase oscillators: A survey. *Automatica*, 50(6):1539–1564, 2014.
- [DCB13] F. Dorfler, M. Chertkov, and F. Bullo. Synchronization in complex oscillator networks and smart grids. *Proc. National Academy of Sciences*, 110(6):2005–2010, 2013.
- [FJB16] N. E. Friedkin, P. Jia, and F. Bullo. A theory of the evolution of social power: Natural trajectories of interpersonal influence systems along issue sequences. *Sociological Science*, 3:444–472, 2016.
- [FM16] B. A. Francis and M. Maggiore. *Flocking and Rendezvous in Distributed Robotics*. Springer, 2016.
- [GR00] C. Godsil and G. Royle. *Algebraic Graph Theory*. Springer, 2000.
- [GS10] F. Garin and L. Schenato. A survey on distributed estimation and control applications using linear consensus algorithms. In A. Bemporad, M. Heemels, and M. Johansson, editors, *Networked Control Systems, Lecture Notes in Control and Information Sciences, Springer*, pages 75–107, 2010.
- [HLZ<sup>+</sup>17] T. Han, Z. Lin, R. Zheng, Z. Han, and H. Zhang. A barycentric coordinate based approach to three-dimensional distributed localization for wireless sensor networks. In *Proc. IEEE Int. Conf. on Control & Automation*, pages 600–605, 2017.
- [INK19] T. Ikeda, M. Nagahara, and K. Kashima. Maximum hands-off distributed control for consensus of multiagent systems with sampled-data state observation. *IEEE Trans. Control of Network Systems*, 6(2):852–862, 2019.
- [JLM03] A. Jadbabaie, J. Lin, and A. S. Morse. Coordination of groups of mobile autonomous agents sing nearest neighbor rules. *IEEE Trans. Autom. Control*, 48(6):988–1001, 2003.
- [KBG14] A. Khanafer, T. Basar, and B. Gharesifard. Stability properties of infection diffusion dynamics over directed networks. In *Proc. IEEE Conf. on Decision and Control*, pages 6215–6220, 2014.
- [KCK20] S. Kawamura, K. Cai, and M. Kishida. Distributed output regulation of heterogeneous uncertain linear agents. *Automatica*, 119:109094, 2020.

- [LDY<sup>+</sup>13] Z. Lin, W. Ding, G. Yan, C. Yu, and A. Giua. Leader-follower formation via complex laplacian. *Automatica*, 49:1900–1906, 2013.
- [LFD15] Z. Lin, M. Fu, and Y. Diao. Distributed self localization for relative position sensing networks in 2d space. *IEEE Trans. Sig. Proc.*, 63(14):3751–3761, 2015.
- [LHZF16] Z. Lin, T. Han, R. Zheng, and M. Fu. Distributed localization for 2-d sensor networks with bearing-only measurements under switching topologies. *IEEE Trans. Sig. Proc.*, 64(23):6345–6359, 2016.
- [Lun12] J. Lunze. Synchronization of heterogeneous agents. *IEEE Trans. Autom. Control*, 57(11):2885–2890, 2012.
- [LWC<sup>+</sup>16] Z. Lin, L. Wang, Z. Chen, M. Fu, and Z. Han. Necessary and sufficient graphical conditions for affine formation control. *IEEE Trans. Autom. Control*, 61(10):2877–2891, 2016.
- [LWHF14] Z. Lin, L. Wang, Z. Han, and M. Fu. Distributed formation control of multi-agent systems using complex laplacian. *IEEE Trans. Autom. Control*, 59(7):1765–1777, 2014.
- [LWHF16] Z. Lin, L. Wang, Z. Han, and M. Fu. A graph laplacian approach to coordinate-free formation stabilization for directed networks. *IEEE Trans. Autom. Control*, 61(5):1269–1280, 2016.
- [MC19] T. Motoyama and K. Cai. Top-down synthesis of multi-agent formation control: an eigenstructure assignment based approach. *IEEE Trans. Control of Network Systems*, 6(4):1404–1414, 2019.
- [ME10] M. Mesbahi and M. Egerstedt. *Graph Theoretic Methods in Multiagent Networks*. Princeton University Press, 2010.
- [OGNK13] K. Oles, E. Gudowska-Nowak, and A. Kleczkowski. Efficient control of epidemics spreading on networks: Balance between treatment and recovery. *PLoS ONE*, 8(6):e63813, 2013.
- [OPA15] K. K. Oh, M. C. Park, and H. S. Ahn. A survey of multi-agent formation control. *Automatica*, 53:424–440, 2015.
- [OS06] R. Olfati-Saber. Flocking for multi-agent dynamic systems: Algorithms and theory. *IEEE Trans. Autom. Control*, 51(3):401–420, 2006.

- [OS07] R. Olfati-Saber. Distributed Kalman filtering for sensor networks. In *Proc. IEEE Conf. on Decision and Control*, pages 5492–5498, 2007.
- [OSFM07] R. Olfati-Saber, J. A. Fax, and R. M. Murray. Consensus and cooperation in networked multi-agent systems. *Proc. IEEE*, 95(1):215–233, 2007.
- [PR11] A. Pikovsky and M. Rosenblum. Dynamics of heterogeneous oscillator ensembles in terms of collective variables. *Physica D: Nonlinear Phenomena*, 240(9):872–881, 2011.
- [RB08] W. Ren and R. W. Beard. *Distributed Consensus in Multi-vehicle Cooperative Control*. Springer, 2008.
- [Ren08] W. Ren. Synchronization of coupled harmonic oscillators with local interaction. *Automatica*, 44(12):3195–3200, 2008.
- [SS08] L. Scardovi and R. Sepulchre. Synchronization in networks of identical linear systems. *Automatica*, 45(11):2557–2562, 2008.
- [SVC<sup>+</sup>16] M. Saska, V. Vonasek, J. Chudoba, J. Thomas, G. Loianno, and V. Kumar. Swarm distribution and deployment for cooperative surveillance by micro-aerial vehicles. *J. Intelligent & Robotic Systems*, 84:469–492, 2016.
- [WSA11] P. Wieland, R. Sepulchre, and F. Allgower. An internal model principle is necessary and sufficient for linear output synchronization. *Automatica*, 47(5):1068–1074, 2011.
- [XHC<sup>+</sup>17] Y. Xu, T. Han, K. Cai, Z. Lin, G. Yan, and M. Fu. A distributed algorithm for resource allocation over dynamic digraphs. *IEEE Trans. Sig. Proc.*, 65(10):2600–2612, 2017.
- [YLA<sup>+</sup>18] M. Ye, J. Liu, B. D. O. Anderson, C. Yu, and T. Basar. Evolution of social power in social networks with dynamic topology. *IEEE Trans. Autom. Control*, 63(11):3793–3808, 2018.
- [YLAC21] M. Ye, J. Liu, B. D. O. Anderson, and M. Cao. Applications of the Poincare-Hopf theorem: Epidemic models and Lotka-Volterra systems. *IEEE Trans. Autom. Control*, 67(4):1609–1624, 2021.
- [Zha18] S. Zhao. Affine formation maneuver control of multiagent systems. *IEEE Trans. Autom. Control*, 63(12):4140–4155, 2018.
- [ZYC20] J. Zhang, K. You, and K. Cai. Distributed conjugate gradient tracking for resource allocation in unbalanced networks. *IEEE Trans. Sig. Proc.*, 68:2186–2198, 2020.

---

# Index

---

- adjacency matrix, 26  
affine formation control algorithm, 219  
affine formation control problem, 211  
anchor agent, 186, 236  
aperiodic, 19  
arbitrary dimensional localization algorithm, 246  
arbitrary dimensional localization problem, 238  
averaging problem, 54  
  
backward reachable, 18  
balanced, 17  
  
Cartesian product, 15  
closed-loop system, 150, 153  
column-stochastic matrix, 34, 56  
condition number, 77  
configuration, 186, 236  
consensus algorithm, 112  
consensus problem, 109  
consensus value, 110  
consensus vector, 117  
continuous time, 109  
continuously differentiable, 76  
control input, 109  
control input vector, 127, 148  
controllable, 129, 149  
convergence factor, 66, 92, 117  
convex, 103  
coordinate frame, 165  
  
degree, 17  
degree matrix, 35  
  
detectable, 128, 152  
digraph, 15, 25  
    simple, 15  
    subdigraph, 17  
discrete time, 53  
distributed algorithm, 54, 109  
double integrator, 141  
doubly-stochastic matrix, 34  
  
economic dispatching problem, 99  
edge, 15  
    edge set, 15  
    loop, 15  
    multiple, 15  
Erdos-Reyni random digraph, 72  
  
fixed point, 192, 196, 244  
formation shape, 158, 208  
free agent, 186, 236  
  
generator, 131  
generic, 164  
Gershgorin disc, 113  
gradient, 76  
gradient descent, 79  
  
harmonic oscillator, 128  
Hessian, 76  
  
inverted pendulum, 142  
irreducible matrix, 27  
  
Jordan block, 114

- Jordan canonical form, 65, 114
- k-reachable, 23
- k-root subset, 23
- kernel, 36
- Kronecker product, 130, 210
- Lagrange function, 93
- Lagrange multiplier, 94
- Laplacian matrix, 35
- complex, 35
  - out-degree Laplacian matrix, 36
  - signed, 35
  - standard, 35
- leading principal submatrix, 171
- Lebesgue measure, 42, 165
- linear time-invariant system, 127, 148
- Lipschitz-continuous gradient, 76
- matrix exponential, 113, 117, 137, 178
- maximal strongly connected, 20
- minor, 42
- neighbor, 17
- neighbor set, 17
- nilpotent matrix, 115
- node, 15
- end-node, 15
  - head, 15
  - node set, 15
  - tail, 15
- nonnegative matrix, 26, 27, 30
- null space, 36
- observable, 129, 152
- observation output vector, 127, 148
- observer, 131, 152
- optimal matching distance, 66
- optimal solution, 76
- optimal value, 76
- optimization problem, 77
- orthogonal matrix, 27
- out-degree, 17
- out-degree matrix, 36
- out-neighbor, 17
- out-neighbor set, 17
- output feedback control, 153
- path, 18
- cycle, 18
  - length, 18
- periodic, 19
- permutation matrix, 27
- Perron-Frobenius Theorem, 34
- pole assignment, 152
- positive matrix, 26
- primitive matrix, 30
- principal minor, 169, 194, 220, 247
- reachable, 18
- reducible matrix, 27
- relative bearing angle, 191
- relative distance, 191
- relative position, 158, 191, 208, 242
- resource allocation problem, 93
- root, 19
- rotation matrix, 242
- row-stochastic matrix, 34, 56
- similar configuration, 158
- similar formation control algorithm, 167
- similar formation control problem, 160
- single integrator, 109
- singular value decomposition, 208
- smooth, 76, 104
- spanning k-tree, 23
- spanning tree, 19

- spectral radius, 33
- spectrum, 26, 33
- stabilizable, 128, 149
- state feedback control, 149
- state vector, 127, 148
- strictly convex, 103
- strong component, 20
  - closed, 21
- strong duality, 95
- strongly connected, 18
- strongly convex, 76, 103
- subdigraph, 17
  - induced subdigraph, 17
  - spanning subdigraph, 17
- surplus, 56
- surplus-based averaging algorithm, 57
- surplus-based optimization algorithm, 81
- surplus-based resource allocation algorithm, 95
- synchronization algorithm, 131
- synchronization problem, 128
- target configuration, 158, 208
- two-dimensional localization algorithm, 193
- two-dimensional localization problem, 188
- undirected graph, 16
- unitary matrix, 85, 208
- weight, 25
- weight-balanced, 35
- weighted average, 117
- weighted degree, 35
- weighted digraph, 26
- weighted out-degree, 35