Instructions for Final Presentations and Reports

UCSB Mechanical Engineering, Winter 2024, ME/ECE 269
Course Title: **Network Systems: Dynamics and Control**

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General instructions

- Decide topic for your Final Report and Final Presentation and email me:
  1. your topic
  2. which paper or two papers you will present
  3. if you are working alone or in a team (and if so, with whom).
- Work in groups: I strongly recommend the formation of groups of two students per topic.
- Topic selection: A list of possible topics is given below. Topics are assigned on a "first come first serve". I will share a google document with the list of selected projects.
- Requirement: your topic needs to be related to the material covered in class.
- I collected some advice on how to review a paper, how to write in a precise, concise, and well-structured manner, and how to organize, practise and deliver your presentation. Please download and read http://motion.me.ucsb.edu/pdf/FBullo-GettingItWrite.pdf

Final Report

The report should contain a meaningful review, explanation, and elaboration of one or multiple paper(s) in the literature. Simply copy/pasting + light revision of the paper(s) is not sufficient.

Requested report length = 10 pages, single column, single space between rows, 11 points, and .75in margin. Recommended structure and instructions:

1. Title, Authors, Date, Subtitle with course number and quarter
2. Section 1: Introduction with one paragraph each for (a) problem description and motivation, (b) literature review (at least 1 sentence per bibligraphical item, at least 6 bibliographical items), (c) summary of content you the report.
3. Section 2: Preliminaries/review of notation (consistent with the book)
4. Section 3: Actual content, possibly with lemmas, theorems, examples, and tutorial graphics
5. Section 4: Simulation results. Depending upon the complexity of the model, I may expect you to simulate the dynamics and not simply cut and paste the simulation results from the literature.
6. Bibliography: mandatory, at least 5 items. Feel free to use:
   http://motion.me.ucsb.edu/book-lns/LecturesNetworkSystems-Biblio-FB.bib

7. Conclusion with critical analysis of selected papers

If you re-use images (previously generated by yourself or others), then cite the source and the copyright information carefully.

Final Presentation

- Length: 25+5 minutes each.
- Consider this presentation your opportunity to teach some important concepts to your colleagues.
- You will grade each other's presentation performance via the feedback form: `http://motion.me.ucsb.edu/ME269-Winter2024/handouts/feedback-form-workshop.pdf`
- I expect everybody to attend and evaluate everybody else's presentation.
- Intructions: Please do not cut and paste parts of papers and reports. I expect you to actually write your own slides. It is okay to include a few selected graphics from the literature (with attribution).

Document writing using LaTeX or Word/Powerpoint

My suggestion is to use LaTeX, but ultimately I leave it up to you to choose of software for the report and presentation. To get learn about LaTeX, I suggest having a copy of `The-not-so-short-introduction-to-latex.pdf` at `https://tobi.oetiker.ch/lshort/lshort.pdf`

Evaluation criteria for final report and presentation

1. *Technical comprehension and accuracy:* Understanding and accurate presentation of the technical content, methodologies, results, and conclusions of the assigned research papers.
2. *Critical analysis and evaluation:* Critical analysis of methods and findings (practicality, efficiency, and potential applications)
3. *Clarity and organization:* Clear concise language and accurate technical terms. Logical structure. The report should logically flow from problem definition to main results and conclusions. Effective communication of complex ideas. Use of diagrams or models where helpful.
4. *Ethical use of sources:* Accurate use of citations and clear explanation of the key related literature.
5. *Relationship with course material:* Identify and emphasize connections and overlap with course material and text.

Special independent project

In lieu of a final report and presentation, I offer the possibility to complete a special independent project. This possibility is open to a single student or to a team of two studens. The project consists in completing solutions to the following exercises: E3.8, E4.16, E5.20, E5.22, E9.5, E9.8, E9.10, E10.4, E10.6, E12.3. If you are interested, please contact me and we can discuss details.

Schedule for final report

Communicate the your topic to me by Thursday February 1st, 2024.

The final report is due on Friday of week 9, i.e., Friday March 8th at 11:59pm, via email to me.

Schedule for final presentations

We will have final presentations during the two official lectures on week 10 (Mon and Wed) and during the final exam on Thursday March 21st at 12pm-3pm. (Recall: Final exam week is Mon March 28 - Friday March 22)

Schedule of presentations: final presentations will be assigned by alphabetical order, starting with a randomly selected letter in class. https://randomwordgenerator.com/letter.php

The final slides are after all presentations on Thursday March 21st at 11:59pm, via an email to me.

Possible Topics for Final Presentations and Report

1. Dissipativity for control design in network systems
   - M. Arcak, C. Meissen, and A. Packard. *Networks of Dissipative Systems: Compositional Certification of Stability, Performance, and Safety*. Springer, 2016, ISBN 978-3-319-29928-0. doi:10.1007/978-3-319-29928-0 (I can explain which sections)
2. Network systems in "Evolutionary Games and Population Dynamics"
   - J. Hofbauer and K. Sigmund. *Evolutionary Games and Population Dynamics*. Cambridge University Press, 1998, ISBN 052162570X (book in my office)
3. Epidemic models over digraphs:
   - highly influential: P. Van den Driessche and J. Watmough. Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission. *Mathematical Biosciences*, 180(1):29–48, 2002. doi:10.1016/S0025-5564(02)00108-6
   - Lyapunov functions with SEIR with vital dynamics: H. Guo, M. Y. Li, and Z. Shuai. A graph-theoretic approach to the method of global Lyapunov functions. *Proceedings of the American Mathematical Society*, 136(8):2793–2802, 2008. doi:10.1090/S0002-9939-08-09341-6
   - SI/SIS/SIR network models: W. Mei, S. Mohagheghi, S. Zampieri, and F. Bullo. On the dynamics of deterministic epidemic propagation over networks. *Annual Reviews in Control*, 44:116–128, 2017. doi:10.1016/j.arcontrol.2017.09.002
   - connection with degree-based models: A. d'Onofrio. A note on the global behaviour of the network-based SIS epidemic model. *Nonlinear Analysis: Real World Applications*, 9(4):1567–1572, 2008. doi:10.1016/j.nonrwa.2007.04.001
4. Random graph theory:
   R. Albert and A.-L. Barabási. Statistical mechanics of complex networks. *Reviews of Modern Physics*, 74(1):47–97, 2002. doi:10.1103/RevModPhys.74.47
   Chapter in M. E. J. Newman. *Networks: An Introduction*. Oxford University Press, 2010, ISBN 0199206651
5. Collective motions in planar robotic systems:
   - R. Sepulchre, D. A. Paley, and N. E. Leonard. Stabilization of planar collective motion: All-to-all communication. *IEEE Transactions on Automatic Control*, 52(5):811–824, 2007. doi:10.1109/TAC.2007.898077
   - R. Sepulchre, D. A. Paley, and N. E. Leonard. Stabilization of planar collective motion with limited communication. *IEEE Transactions on Automatic Control*, 53(3):706–719, 2008. doi:10.1109/TAC.2008.919857
6. Master stability analysis and network optimization for synchronized oscillators:
   - G. Russo and M. Di Bernardo. Contraction theory and master stability function: Linking two approaches to study synchronization of complex networks. *IEEE Transactions on Circuits and Systems II: Express Briefs*, 56(2):177–181, 2009. doi:10.1109/TCSII.2008.2011611
   - T. Nishikawa and A. E. Motter. Maximum performance at minimum cost in network synchronization. *Physica D: Nonlinear Phenomena*, 224(1-2):77–89, 2006. doi:10.1016/j.physd.2006.09.007
7. Randomized consensus algorithms:
   - A. Tahbaz-Salehi and A. Jadbabaie. A necessary and sufficient condition for consensus over random networks. *IEEE Transactions on Automatic Control*, 53(3):791–795, 2008. doi:10.1109/TAC.2008.917743

- D. Acemoglu, G. Como, F. Fagnani, and A. Ozdaglar. Opinion fluctuations and disagreement in social networks. *Mathematics of Operation Research*, 38(1):1–27, 2013. doi:10.1287/moor.1120.0570

8. Impulsively-coupled oscillators:
A. Mauroy, P. Sacré, and R. J. Sepulchre. Kick synchronization versus diffusive synchronization. In *IEEE Conf. on Decision and Control*, pages 7171–7183, Maui, HI, USA, December 2012. doi:10.1109/CDC.2012.6425821

9. Rigidity theory and formation control:
    - K.-K. Oh, M.-C. Park, and H.-S. Ahn. A survey of multi-agent formation control. *Automatica*, 53:424–440, 2015. doi:10.1016/j.automatica.2014.10.022

10. Distributed Kalman filter:
    - R. Carli, A. Chiuso, L. Schenato, and S. Zampieri. Distributed Kalman filtering based on consensus strategies. *IEEE Journal on Selected Areas in Communications*, 26(4):622–633, 2008. doi:10.1109/JSAC.2008.080505
    - F. S. Cattivelli and A. H. Sayed. Diffusion strategies for distributed Kalman filtering and smoothing. *IEEE Transactions on Automatic Control*, 55(9):2069–2084, 2010. doi:10.1109/TAC.2010.2042987

11. Parallel computing:
    - D. P. Bertsekas and J. N. Tsitsiklis. Some aspects of parallel and distributed iterative algorithms - A survey. *Automatica*, 27(1):3–21, 1991. doi:10.1016/0005-1098(91)90003-K

12. Coherence in large-scale networks:
    - B. Bamieh, M. R. Jovanovic, P. Mitra, and S. Patterson. Coherence in large-scale networks: Dimension-dependent limitations of local feedback. *IEEE Transactions on Automatic Control*, 57(9):2235–2249, 2012. doi:10.1109/TAC.2012.2202052

13. Reaction-diffusion systems:
    - M. Arcak. Certifying spatially uniform behavior in reaction-diffusion PDE and compartmental ODE systems. *Automatica*, 47(6):1219–1229, 2011. doi:10.1016/j.automatica.2011.01.010

14. Network Small Gain Theorem
    - Z.-P. Jiang, A. R. Teel, and L. Praly. Small-gain theorem for ISS systems and applications. *Mathematics of Control, Signals and Systems*, 7:95–120, 1994. doi:10.1007/BF01211469
    - T. Liu, D. J. Hill, and Z.-P. Jiang. Lyapunov formulation of ISS cyclic-small-gain in continuous-time dynamical networks. *Automatica*, 47(9):2088–2093, 2011. doi:10.1016/j.automatica.2011.06.018
    - S. N. Dashkovskiy, B. S. Rüffer, and F. R. Wirth. Small gain theorems for large scale systems and construction of ISS Lyapunov functions. *SIAM Journal on Control and Optimization*, 48(6):4089–4118, 2010. doi:10.1137/090746483

15. Random walks on graphs (Thomson principle, conductance, hitting times):
    - Chapter 9 “Random Walks on Graphs” in: B. Bollobás. *Modern Graph Theory*. Springer, 1998, ISBN 0387984887
    - L. Lovász. Random walks on graphs: A survey. In T. Szönyi D. Miklós, V. T. Sós, editor, *Combinatorics: Paul Erdős is Eighty*, volume 2, pages 353–398. János Bolyai Mathematical Society, 1993

16. Financial networks, stability and risk
    - D. Acemoglu, A. Ozdaglar, and A. Tahbaz-Salehi. Systemic risk and stability in financial networks. *American Economic Review*, 105(2):564–608, 2015. doi:10.1257/aer.20130456

- M. Elliott, B. Golub, and M. O. Jackson. Financial networks and contagion. *American Economic Review*, 104(10):3115–53, 2014. doi:10.1257/aer.104.10.3115

17. Network formation games

    - M. O. Jackson. A survey of models of network formation: Stability and efficiency. In G. Demange and M. Wooders, editors, *Group Formation in Economics; Networks, Clubs and Coalitions*. Cambridge University Press, 2005. URL: https://web.stanford.edu/~jacksonm/netsurv.pdf
    - V. Bala and S. Goyal. A noncooperative model of network formation. *Econometrica*, 68(5):1181–1229, 2000. doi:10.1111/1468-0262.00155

18. Distributed optimization

    - T. Yang, X. Yi, J. Wu, Y. Yuan, D. Wu, Z. Meng, Y. Hong, H. Wang, Z. Lin, and K. H. Johansson. A survey of distributed optimization. *Annual Reviews in Control*, 47:278–305, 2019. doi:10.1016/j.arcontrol.2019.05.006

19. Synchronization of coupled state-space oscillators

    - Z. Aminzare and E. D. Sontag. Synchronization of diffusively-connected nonlinear systems: Results based on contractions with respect to general norms. *IEEE Transactions on Network Science and Engineering*, 1(2):91–106, 2014. doi:10.1109/TNSE.2015.2395075

20. Contraction Analysis of Monotone Systems

    - Y. Kawano, B. Besselink, and M. Cao. Contraction analysis of monotone systems via separable functions. *IEEE Transactions on Automatic Control*, 65(8):3486–3501, 2020. doi:10.1109/TAC.2019.2944923

21. Energy and Dissipation in Consensus Systems

    - H. Mangesius. *Energy and dissipation in consensus systems*. PhD thesis, Technische Universität München, 2021. URL: https://mediatum.ub.tum.de/doc/1585119/document.pdf (wonderful recent PhD thesis)

22. Dynamic average consensus

    - S. S. Kia, B. Van Scoy, J. Cortes, R. A. Freeman, K. M. Lynch, and S. Martinez. Tutorial on dynamic average consensus: The problem, its applications, and the algorithms. *IEEE Control Systems*, 39(3):40–72, June 2019. doi:10.1109/mcs.2019.2900783