Mini-Course: **Dynamic models of social influence networks.**

**Lecturer:** Dr. Anton Proskurnikov, Associate Professor at Polytechnic of Turin, Italy.

**Target Audience:** Ph.D. students majoring in engineering, computer science, applied mathematics, mathematical methods in social sciences and/or economics.

**Course duration:** 6 lectures = 9 hours;

**Time interval:** week 38 (19/09/2022 - 23/09/2022).

**Examination:** Mini-project on numerical analysis of a dynamic model (report in PDF, 10 pages max), a brief quiz on the course material.

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**Prerequisites**

- To understand the lecture material, the following concepts are essential:
  
  **Linear algebra:** Basic operations with matrices and vectors (multiplication, inverse matrix, transposition etc.), eigenvalues and eigenvectors of a matrix.
  
  **Calculus:** The derivative of a function, limit of a function or a sequence.

- Other elements of mathematics that are useful yet not absolutely necessary:
  
  **Dynamical systems:** linear control theory (especially, stability criteria)
  
  **Graph theory:** nodes, directed/undirected arcs, paths, connectivity
  
  **Ordinary differential equations:** existence and uniqueness of the solution;
  
  **Probability theory:** expectation, variance, convergence of random variables

For the final project: you should be able to simulate dynamics of discrete-time and continuous-time systems (using software like Matlab/Simulink, Scilab, LabVIEW, Maple, Wolfram Mathematica, Python/C++/Java with special libraries etc.) Knowledge of LaTeX is not a prerequisite, but will greatly simplify the final report preparation.

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**General description of the course**

Can mathematics explain volatile behaviors of humans? Can mathematical models be found that are able to forecast the results of elections and referendums? Could the spread of extremist theories and fakes in social media be contained and mitigated? How to recognize the true opinion leaders among billions social media users?

We are still very far from having a compact and elegant set of equations that rule social dynamics and explain all facets of social life (as, e.g. the Maxwell equations in electromagnetism or the Schrödinger equation in quantum mechanics). At the same time, relatively simple yet instructive dynamic models have recently been proposed that portray important social phenomena and have already found applications in economics, finance and business (for instance, marketing, recommender systems and digital advertisement). A multidisciplinary theory studying dynamic processes over social networks is very young yet is developing rapidly; this new field lies at the crossroads of control theory, multi-agent systems theory, network science and data science.
The course offers a quick introduction into the most “mature” dynamic models that are called models of opinion formation under social influence. Apart from their sociological meaning, these models play an important role in multi-agent control and are closely related to some concepts of network science, such, e.g. centrality measures on social graphs. The concluding lecture of the course will also discuss some recent applications of opinion dynamics modeling.

The course syllabus
The structure of the lectures is preliminary and can be adjusted, taking into the structure of the audience and the students’ backgrounds. A mathematical introduction can be extended to make the course accessible for the broadest audience, including graduate students.


L5. When opinions modify the network: bounded confidence models, the Hegselmann-Krause and Deffuant-Weisbuch systems.

L6. From models to reality. Real-world applications, new challenges in social dynamics modeling.

Recommended literature
- Q. Zha et al., Opinion dynamics in finance and business: a literature review and research opportunities, Financial Innovation, 6(44), 2020;
Information about the lecturer

Anton Proskurnikov is Associate Professor at the Department of Electronic and Telecommunication Engineering (DET), Polytechnic of Turin, Italy. Before moving to Italy, he kept research positions at Delft University of Technology (2016-2019), the University of Groningen (2014-2016), Russian Academy of Sciences (2006-2021), St. Petersburg State University (2003-2013), and the industrial company Navis Engineering OY (2007-2013).

Anton Proskurnikov is an author of numerous surveys on agent-based models and sociological applications. His tutorial paper “A tutorial on modeling and analysis of dynamic social networks” (co-authored with R. Tempo) was recognized by IFAC and Elsevier award for the best paper published in Annual Reviews in Control journal (2020). The paper “Opinion Dynamics in Social Networks With Hostile Camps: Consensus vs. Polarization” is ranked by Web of Science as highly cited (top 1% of the academic field of Engineering). The article “Dynamical Social Networks” (co-authored with C. Ravazzi) is included into 2021 edition of the Springer Encyclopedia of Systems and Control, and the article “Consensus in Multi-Agent Systems” (co-authored with M. Cao) is included into Wiley Encyclopedia of Electrical and Electronics Engineering.

Anton Proskurnikov was a semi-plenary speaker of IFAC World Congress 2017, Toulouse, France and an invited lecturer of the international conference “Deliberation, Belief Aggregation, and Epistemic Democracy”, 2019, Paris France. He organized a number of workshops and tutorial sections on agent-based modeling in sociology, including the workshop “Dynamics and Control in Social Networks” on IEEE Conference on Decision and Control CDC 2016, Las Vegas, US and the tutorial “Dynamical Networks of Social Influence: Modern Trends and Perspectives” during IFAC World Congress 2020 (Virtual).

Anton Proskurnikov is Associate Editor at IEEE Transactions of Automatic Control. He also was Editorial Board Member of the Journal of Mathematical Sociology (2017-2021) and a guest editor of the International Journal of Control. He is Senior Member of IEEE, member of IEEE Control Systems Society Technical Committees on Networks and Communication Systems and on Healthcare and Medical Systems, member of IFAC Technical Committees 2.3 (Nonlinear Control) and 1.5 (Networked Systems).