Network Dynamics in the Social, Economic, and Financial Sciences

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Book of Abstract

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Speakers

Decision-making in interconnected multiagent networks: roles of frustration and social commitment

Claudio ALTAFINI
Linkoping University

The models of collective decision-making considered in this presentation are nonlinear interconnected systems with saturating interactions, similar to Hopfield newtorks. These systems encode the possible outcomes of a decision process into different steady states of the dynamics. When the model is cooperative, i.e., when the underlying adjacency graph is Metzler, then the system is characterized by the presence of two main attractors, one positive and the other negative, representing two choices of agreement among the agents, associated to the Perron-Frobenius eigenvector of the system. Such equilibria are achieved when there is a sufficiently high 'social commitment' among the agent (here interpreted as a bifurcation parameter). When instead cooperation and antagonism coexist, the resulting signed graph is in general not structurally balanced, meaning that Perron-Frobenius theorem does not apply directly.
It is shown that the decision-making process is affected by the distance to structural balance, in the sense that the higher the frustration of the graph, the higher the commitment strength at which the system bifurcates. An application to the problem of government formation in multiparty European democracies is discussed in detail.

Claudio Altafini received a Master degree ("Laurea") in Electrical Engineering from the University of Padova, Italy, in 1996 and a PhD in Optimization and Systems Theory from the Royal Institute of Technology, Stockholm, Sweden in 2001. From 2001 till 2013 he was with the International School for Advanced Studies (SISSA) in Trieste, Italy.
Since 2014 he is a Professor in the Division of Automatic Control, Dept. of Electrical Engineering at Linkoping University, Sweden.
His research interests are in the areas of nonlinear systems analysis and control, with applications to quantum mechanics, systems biology and complex networks.

Parsimonious models for opinion dynamics and social balance

Francesco BULLO
University of California Santa Barbara

Over the last 15 years, mathematical sociology has experienced a period of rebirth and incredible activity with diverse contributions from a broad range of scientists.
This talk will revisit two important models: averaging models for opinion dynamics and signed network dynamics for social balance. Starting with their history, underlying assumptions and validation, we propose simple, but meaningful modifications.
We will be inspired by the Occam's principle of parsimony, i.e., we will endeavor to propose simple models that explain rich behavior.

Francesco Bullo is a Professor with the Mechanical Engineering Department and the Center for Control, Dynamical Systems and Computation at the University of California, Santa Barbara. He was previously associated with the University of Padova (Laurea degree in Electrical Engineering, 1994), the California Institute of Technology (Ph.D. degree in Control and Dynamical Systems, 1999), and the University of Illinois. His research interests focus on network systems and distributed control with application to robotic coordination, power grids and social networks.
He is the coauthor of "Geometric Control of Mechanical Systems" (Springer, 2004) and "Distributed Control of Robotic Networks" (Princeton, 2009); his "Lectures on Network Systems" (Kindle Direct Publishing, 2019, v1.3) is available on his website. He received best paper awards for his work in IEEE Control Systems, Automatica, SIAM Journal on Control and Optimization, IEEE Transactions on Circuits and Systems, and IEEE Transactions on Control of Network Systems. He is a Fellow of IEEE, IFAC, and SIAM. He served on the editorial boards of IEEE, SIAM, and ESAIM journals, and as 2018 IEEE CSS President.

Sparse ℓ_1 and ℓ_2 center classifiers

Giuseppe C. CALAFIORE
Politecnico di Torino

The centroid classifier is a well known classification method which computes the centroids (sample averages) of the two classes in the training phase, and then classifies a new sample based on the least ℓ_2 distance from the class centroids. Such simple method is competitive with classical classifiers such as Naive Bayes and it has linear complexity. In this talk we discuss two sparse variants of classifiers based on central distance. The first method modifies the standard ℓ_2 centroid classifier by imposing an explicit sparsity constraint on the discrimination vector. The second method employs instead an ℓ_1 metric for computing the centers and distances, and also seeks for a sparse discriminant. Both methods thus effectively perform classification with simultaneous feature selection. A perhaps notable fact is that both these sparse training problems can be solved exactly and with almost-linear-time complexity.

Giuseppe C. Calafiore is a full professor at DET, Politecnico di Torino, where he coordinates the Systems and Data Science group, and an associate fellow of the IEIIT-CNR.
Dr. Calafiore held several visiting positions at international institutions: at the Information Systems Laboratory (ISL), Stanford University, California, in 1995; at the Ecole Nationale Supérieure de Techniques Avancées (ENSTA), Paris, in 1998; and at the University of California at Berkeley, in 1999, 2003, 2007, 2017 and 2018. He was a Senior Fellow at the Institute of Pure and Applied Mathematics (IPAM), University of California at Los Angeles, in 2010.
Dr. Calafiore is the author of more than 190 journal and conference proceedings papers, and of eight books. He is a Fellow of the IEEE. He received the IEEE Control System Society “George S. Axelby” Outstanding Paper Award in 2008. His research interests are in the fields of convex optimization, randomized algorithms, identification, and control of uncertain systems, with applications ranging from finance and economic systems to robust control, machine learning, and data science.

Decision-payoff co-evolutionary dynamics in a closed loop for population games

Ming CAO
University of Groningen

In response to the growing interest in how to efficiently influence complex systems of interacting self-interested agents, new efforts have been made to address open problems related to the analysis and control of evolutionary matrix games, with particular emphasis on applications in social, economic, biological and robotic networks.
In our evolutionary game models for networks of interacting agents, we consider both the decision-making dynamics of interacting multiple populations and the evolution of the environment affecting the game payoffs. It is then possible to perform global convergence analysis for the resulting closed-loop co-evolutionary dynamics, to identify in particular under what conditions the dynamics converge to periodic orbits.
The goal is to build a general framework towards optimal control of evolutionary games on networks and ultimately resolving social dilemmas in large populations of interacting self-interested agents.

Ming Cao has since 2016 been a professor of systems and control with the Engineering and Technology Institute (ENTEG) at the University of Groningen, the Netherlands, where he started as a tenure-track Assistant Professor in 2008.
He received the Bachelor degree in 1999 and the Master degree in 2002 from Tsinghua University, Beijing, China, and the Ph.D. degree in 2007 from Yale University, New Haven, CT, USA, all in Electrical Engineering. From September 2007 to August 2008, he was a Postdoctoral Research Associate with the Department of Mechanical and Aerospace Engineering at Princeton University, Princeton, NJ, USA. He worked as a research intern during the summer of 2006 with the Mathematical Sciences Department at the IBM T. J. Watson Research Center, NY, USA.
He is the 2017 and inaugural recipient of the Manfred Thoma medal from the International Federation of Automatic Control (IFAC) and the 2016 recipient of the European Control Award sponsored by the European Control Association (EUCA). He is a Senior Editor for Systems and Control Letters, and an Associate Editor for IEEE Transactions on Automatic Control, IEEE Transactions on Circuits and Systems and IEEE Circuits and Systems Magazine. He is a vice chair of the IFAC Technical Committee on Large-Scale Complex Systems.
His research interests include autonomous agents and multi-agent systems, complex networks and decision-making processes.

Sparse DCM for whole-brain effective connectivity from resting-state fMRI data

Alessandro CHIUSO
Università di Padova

Contemporary neuroscience has embraced network science and dynamical systems to study the complex and self-organized structure of the human brain. Despite the developments in non-invasive neuroimaging techniques, a full understanding of the directed interactions in whole brain networks, referred to as effective connectivity, as well as their role in the emergent brain dynamics is still lacking. The main reason is that estimating brain connectivity requires solving a formidable large-scale inverse problem from indirect and noisy measurements.
Building on the dynamic causal modeling framework, the present study offers a novel method for estimating whole-brain effective connectivity from resting-state functional magnetic resonance data. To this purpose sparse estimation methods are adapted to infer the parameters of our novel model, which is based on a linearized, region-specific haemodynamic response function. The resulting algorithm is shown to compare favorably with state-of-the art methods when tested on both synthetic and real data. We also provide a graph-theoretical analysis on the whole-brain effective connectivity estimated using data from a cohort of healthy individuals, which reveals properties such as asymmetry in the connectivity structure as well as the different roles of brain areas in favoring segregation or integration.

Alessandro Chiuso is Professor with the Dept. of Information Engineering, University of Padova.
He received the “Laurea” degree summa cum laude in Telecommunication Engineering from the University of Padova in July 1996 and the Ph.D. degree in System Engineering from the University of Bologna in 2000. He has been visiting research scholar with Washington University St. Louis (USA) and a Postdoctoral Fellow with KTH (Sweden).
Dr. Chiuso is chair of the IFAC TC1.1, an Associate Editor of IEEE Trans. on Control Systems Technology (2013-2017),Automatica (2008-), European Journal of Control (2011-). He was an Associate Editor of IEEE Trans. on Automatic Control (2010-2012), the IEEE Conference Editorial Board (2004-2009) and a member of the editorial board of IET Control Theory and Application (2007-2012). He also serves or has served as member of several conference program committees and technical committees.
His research interest are mainly in Machine Learning, Estimation, Identification Theory and Applications. Further information can be found on the personal web page (http://automatica.dei.unipd.it/people/chiuso.html).

A marketplace for data: an algorithmic solution

Munther A. DAHLEH
Massachusetts Institute of Technology

Machine Learning and Data Science (ML) is starting to take the place in industry that "Information Technology" had in the late 1990s: businesses of all sizes and in all sectors, are recognizing how necessary it has become to develop predictive capabilities for continued profitability of their core competencies. To be effective, ML algorithms rely on high-quality training data – and not just any data, but data that is specific to the business problem that ML is applied to. Obtaining relevant training data can be very difficult for firms to do themselves, especially those early in their path towards incorporating ML into their operations. This problem is only further exacerbated, as businesses increasingly need to solve these prediction problems in real-time (e.g. a ride-share company setting prices, retailers/restaurants sending targeted coupons to clear inventory), which means that data gets "stale" quickly. Therefore, it is imperative that there are real-time market structures for the buying and selling of training data for ML. Further it is insufficient to view ML performance metrics (e.g. RMSE) in isolation of real-world applications; for example, a 10% increase in prediction accuracy means very different things for a hedge fund maximizing profits vs. a retailer decreasing inventory costs vs. a hospital trying to save lives. Hence the value of a dataset will necessarily have to consider more than simply the prediction accuracy it provides. Domain knowledge will be just as essential, if not more so, if we aim to view data as an asset and create a rigorous method to define its value.
In this work, we aim to create a data marketplace – a robust matching mechanism to efficiently buy and sell data while optimizing social welfare and maximizing revenue. While the monetization of data and pre-trained models is an essential focus by many industries and vendors today, there does not exist a market mechanism that can price data and match suppliers to vendors while still addressing the (computational and other) complexity associated with creating a market platform. The challenge in creating such a marketplace stems from the very nature of data as an asset: (i) it can be replicated at zero marginal cost; (ii) its value to a firm is inherently combinatorial (i.e. the value of a particular dataset depends on what other (potentially correlated) datasets are available); (iii) its value to a firm is dependent on which other firms get access to the same data; (iv) prediction tasks and the value of an increase in prediction accuracy vary widely between different firms, and so it is not obvious how to set prices for a collection of datasets with correlated signals; (v) finally, the authenticity and truthfulness of data is difficult to verify a priori without first applying to a prediction task. Our proposed marketplace will take a holistic view of this problem and provide an algorithmic solution combining concepts from statistical machine learning, economics of data with respect to various application domains, algorithmic market design, and mathematical optimization under uncertainty. We will discuss some examples motivating this work.
This is joint work with Anish Agarwal, Tuhin Sarkar, and Devavrat Shah.

Munther A. Dahleh received the Ph.D. degree in electrical engineering from Rice University, Houston, TX, USA, in 1987.
Since 1987, he has been with the Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, where he is currently the William A. Coolidge Professor of electrical engineering and computer science, and the founding Director of the MIT Institute for Data, Systems, and Society. Previously, he held the position of the Associate Department Head of EECS. He is interested in networked systems with applications to social and economic networks, transportation networks, and the power grid. He is the coauthor (with I. Diaz-Bobillo) of the book Control of Uncertain Systems: A Linear Programming Approach (Prentice-Hall, 1995) and the coauthor (with N. Elia) of the book Computational Methods for Controller Design (Springer, 1998). Specifically, he focuses on the development of foundational theory necessary to understand, monitor, and control systemic risk in interconnected systems, drawing from various fields including game theory, optimal control, distributed optimization, information theory, and distributed learning.
Dr. Dahleh is the four times recipient of the George Axelby outstanding paper award for best paper in the IEEE TRANSACTIONS ON AUTOMATIC CONTROL. He is also the recipient of the Donald P. Eckman award from the American Control Council in 1993 for the best control engineer under 35.

Social network dynamics leading to community formation and residential segregation

Massimo FRANCESCHETTI
University of California at San Diego

In the 1960's Nobel Laureate Thomas Schelling came up with a dynamical system model predicting that racial segregation of neighborhoods arises even in the absence of racist sentiments, so long as individuals prefer to live adjacent to at least a small number of neighbors of their same type. In short: even moderate individual tendencies regarding neighbors can lead to global, undesired consequences. Although the model is quite simple, it gives a fascinating description at how individuals might self-segregate, even when they have no explicit desire to do so, and provides insight about the relationship between a system and its parts, or between "micro motives" and "macro behaviors".
In this talk, we provide a rigorous formulation in terms of a long-range interacting particle system, and provide additional insights in the evolution and final configuration of the system. First, we discuss a "shape theorem" for the spreading of the "affected" nodes in the network. This is the first result that precisely describes the transient dynamics of the model and shows a cascading process that creates segregated regions that are close to monochromatic balls with exponential radius in a given metric. We then study the limiting size of the largest monochromatic region, for a given interval of agents' preferences, showing that after a sufficiently long evolution time segregation occurs with high probability, and any agent is contained in a large monochromatic region of exponential size. This is the first high probability result for the two-dimensional version of the model. We also show that exponentially large almost monochromatic regions, namely regions where the fraction of nodes of the minority color vanishes, are expected for a wider interval of the individual preferences. We conclude by making some general considerations on the possible ways of curing segregation, given the insights provided by these results.
Based on joint work with Hamed Omidvar.

Massimo Franceschetti received the Laurea degree (with honors) in computer engineering from the University of Naples, Naples, Italy, in 1997, the M.S. and Ph.D. degrees in electrical engineering from the California Institute of Technology, Pasadena, CA, in 1999, and 2003, respectively.
He is Professor of Electrical and Computer Engineering at the University of California at San Diego (UCSD). Before joining UCSD, he was a postdoctoral scholar at the University of California at Berkeley for two years. He is coauthor of the book "Random Networks for Communication" and author of the book "Wave theory of information," both published by Cambridge University Press.
He was awarded the C. H. Wilts Prize in 2003 for best doctoral thesis in electrical engineering at Caltech; the S.A. Schelkunoff Award in 2005 for best paper in the IEEE Transactions on Antennas and Propagation, a National Science Foundation (NSF) CAREER award in 2006, an Office of Naval Research (ONR) Young Investigator Award in 2007, the IEEE Communications Society Best Tutorial Paper Award in 2010, and the IEEE Control theory society Ruberti young researcher award in 2012. He became an IEEE Fellow in 2018 and a Guggenheim fellow in 2019.

The closed loop between opinion formation and personalised recommendations

Paolo FRASCA
GIPSA-lab - CNRS Grenoble

In online platforms, recommender systems are responsible for directing users to relevant contents. In order to enhance the users' engagement, recommender systems adapt their output to the reactions of the users, who are in turn affected by the recommended contents.
In this work, we study a tractable analytical model of a user that interacts with an online news aggregator, with the purpose of making explicit the feedback loop between the evolution of the user's opinion and the personalised recommendation of contents. More specifically, we assume that the user is endowed with a scalar opinion about a certain issue and seeks news about it on a news aggregator: this opinion is influenced by all received news, which are characterized by a binary position on the issue at hand. The user is affected by a confirmation bias, that is, a preference for news that confirm her current opinion. The news aggregator recommends items with the goal of maximizing the number of user's clicks (as a measure of her engagement): in order to fulfill its goal, the recommender has to compromise between exploring the user's preferences and exploiting what it has learned so far.
After defining suitable metrics for the effectiveness of the recommender systems (such as the click-through rate) and for its impact on the opinion, we perform both extensive numerical simulations and a mathematical analysis of the model. We find that personalised recommendations markedly affect the evolution of opinions and favor the emergence of more extreme ones: the intensity of these effects is inherently related to the effectiveness of the recommender. We also show that by tuning the amount of randomness in the recommendation algorithm, one can seek a balance between the effectiveness of the recommendation system and its impact on the opinions.
Joint work with Wilbert Samuel Rossi and Jan Willem Polderman.

Paolo Frasca received the Ph.D. degree in Mathematics for Engineering Sciences from Politecnico di Torino, Turin, Italy, in 2009. Between 2008 and 2013, he has held research and visiting positions at the University of California, Santa Barbara (USA), the IAC-CNR (Rome, Italy), the University of Salerno (Italy), and the Politecnico di Torino. From 2013 to 2016, he has been an Assistant Professor at the University of Twente, the Netherlands. He has been a Visiting Professor at the LAAS, Toulouse, France in 2016 and at the University of Cagliari, Italy, in 2017. Since October 2016, he is a CNRS Researcher in Grenoble, France, affiliated to GIPSA-lab.
Dr. Frasca's research interests are in the theory of network systems and cyber-physical-social systems, with main applications to infrastructural and social networks. On these topics, he has an extended publication record that includes a book, published by Springer in 2018, and more than thirty journal papers. He is a recipient of the 2013 Best Paper Prize of the SIAM Journal on Control and Optimisation and a Senior Member of the IEEE.
Dr. Frasca has served in the Editorial Boards of several international conferences (including IEEE CDC, ACC, ECC, MTNS, IFAC NecSys, IFACWC) and is currently serving on the Editorial Boards of the International Journal of Robust and Nonlinear Control, the Asian Journal of Control, and the IEEE Control Systems Letters.

A model of anonymous influence with anti-conformist agents

Michel GRABISCH
Centre d'Economie de la Sorbonne

We study a stochastic model of anonymous influence with conformist and anti-conformist individuals. Each agent with a 'yes' or 'no' initial opinion on a certain issue can change his opinion due to social influence. We consider anonymous influence, which depends on the number of agents having a certain opinion, but not on their identity. An individual is conformist/anti-conformist if his probability of saying 'yes' increases/decreases with the number of 'yes'-agents.
We focus on three classes of aggregation rules (pure conformism, pure anti-conformism, and mixed aggregation rules) and examine two types of society (without, and with mixed agents). For both types we provide a complete qualitative analysis of convergence, i.e., identify all absorbing classes and conditions for their occurrence. Also the pure case with infinitely many individuals is studied. We show that, as expected, the presence of anti-conformists in a society brings polarization and instability: polarization in two groups, fuzzy polarization (i.e., with blurred frontiers), cycles, periodic classes, as well as more or less chaotic situations where at any time step the set of 'yes'-agents can be any subset of the society. Surprisingly, the presence of anti-conformists may also lead to opinion reversal: a majority group of conformists with a stable opinion can evolve by a cascade phenomenon towards the opposite opinion, and remains in this state.

Michel Grabisch (https://sites.google.com/site/michelgrabisch) received his graduate engineer diploma in 1979 from Ecole nationale des ingénieurs Electriciens de Grenoble (ENSIEG) with specialization in nuclear engineering. He received the Ph.D. degree in signal processing in 1982 from ENSIEG. After a two years post-doctoral stay at Tokyo Institute of Technology, he joined Thomson-Sintra ASM in 1984, in the Advanced Research Group, and worked on decision theory applied to sonar signals. From 1989 to 1991, he was in detachment at Tokyo Institute of Technology where he conducted research on fuzzy integral, pattern recognition, fuzzy control with Prof. Sugeno. He also participated during this time to the LIFE project (Laboratory for International Fuzzy Engineering Research). From 1991 to 2000, he was at the Central Research Laboratory of Thomson-CSF in projects involving fuzzy logic and decision theory.
From 2000 to 2002, he was associated professor at Université Pierre et Marie Curie, Paris. Since 2002, he is professor in computer sciences at Université Panthéon-Sorbonne, Paris. He is member of the Paris School of Economics. He is honorary senior member of the Institut Universitaire de France. His current interests are game theory, decision making, discrete mathematics, and networks.
He is co-editor-in-chief of 4OR, and associate editor of Annals of Operations Research, Mathematical Social Sciences, RAIRO.RO (2005-2019), TOP, Operations Research and Decisions Quarterly, IEEE Tr. on Fuzzy Systems (1998-2015), Fuzzy Optimization and Decision, and is member of the editorial board of many other journals.
He was co-organizer of the SING 7 Congress (Spain-Italy-Netherlands 7th Meeting on Game Theory) in July 2011 in Paris, and co-organizer of the 38th Linz Seminar on Fuzzy Set Theory (Set Functions in Games and Decision), February 2019.
He has authored and co-authored about 120 papers in refereed international journals, 5 books, and more than 100 papers in refereed international conferences.

Open multi-agents models with evolving composition

Julien M. HENDRICKX
Université catholique de Louvain

We consider multi-agent models whose composition evolve with time, as new agents keep arriving while other agents leave. These open models are indeed in many cases more realistic than the closed versions where the same set of agents remain in the system forever.
We show how this evolution affect the system behavior, and in particular that it results in phenomena that cannot be understood by considering a juxtaposition of isolated arrival and departure events.
We discuss the challenges in the analysis of open systems, study different coordination methods, and present fundamental limitation on their coordination properties.

Julien M. Hendrickx is professor of mathematical engineering at Université catholique de Louvain, in the Ecole Polytechnique de Louvain since 2010.
He obtained an engineering degree in applied mathematics (2004) and a PhD in mathematical engineering (2008) from the same university. He has been a visiting researcher at the University of Illinois at Urbana Champaign in 2003-2004, at the National ICT Australia in 2005 and 2006, and at the Massachusetts Institute of Technology in 2006 and 2008. He was a postdoctoral fellow at the Laboratory for Information and Decision Systems of the Massachusetts Institute of Technology 2009 and 2010, holding postdoctoral fellowships of the F.R.S.-FNRS (Fund for Scientific Research) and of Belgian American Education Foundation, and a resident scholar at CISE, Boston University, in 2018-2019.
Doctor Hendrickx is the recipient of the 2008 EECI award for the best PhD thesis in Europe in the field of Embedded and Networked Control, and of the Alcatel-Lucent-Bell 2009 award for a PhD thesis on original new concepts or application in the domain of information or communication technologies.

A theory of misinformation spread on social networks

Ali JADBABAIE
Massachusetts Institute of Technology

We study a strategic model of online news dissemination on a Twitter-like social network. Agents with heterogeneous priors decide whether to forward a piece of news they received to their followers. Each agent makes a forwarding decision based on whether the news can persuade the followers to think more like them in aggregate. Agents who do not receive the news do not know that the news exists. At the micro-level, we show how novelty and affirmation motives naturally emerge from the utility-maximizing behavior of the agents when persuasion is the main motive for sharing news. We characterize the dynamics of the news spread and establish the equation governing the steady state size of news cascades. Exact necessary and sufficient conditions are derived for emergence of a cascade, based on which we formulate the problem of finding the news precision level maximizing ex-ante likelihood of a sharing cascade. We show that if the cost associated with broadcasting to followers is sufficiently small, then a cascade occurs almost surely for news that has enough accuracy. When the cost associated with broadcasting passes a certain threshold, the optimal precision needed for a cascade is related to the aggregate wisdom of the crowd, and more precisely, to whether the aggregation of agents' prior beliefs concentrate on the truth. When the society as a whole is biased, i.e., there is a gap between the true state and the aggregation of prior perspectives, the truth almost always triggers a cascade. In contrast, in a wise or unbiased society, cascades are more likely to occur for false news, i.e., information that is likely to be inaccurate.
Our results complement the empirical findings that support wider spread of inaccurate/false news compared to accurate information on social networks. Next we also investigate the case where agents know about the news even when they do not receive it. This will make the model game theoretic ad far more complex. We investigate connections to the literature on Bayesian persuasion and disclosure games and characterize the equilibrium.
Joint work with Chin Chia Hsu (IDSS), Amir Ajorlou (IDSS), and Muhamet Yildiz (Economics).

Ali Jadbabaie is the JR East Professor of Engineering and Associate Director of the Institute for Data, Systems and Society at MIT, where he is also a faculty member of the Department of Civil and Environmental Engineering and a principal investigator in the Laboratory for Information and Decision Systems (LIDS). He also serves as the director of the Sociotechnical Systems Research Center, one of 13 major labs at MIT, and is the director of the Social and Engineering Systems PhD Program.
He received his Bachelors (with high honors) from Sharif University of Technology, a Master's degree in electrical and computer engineering from the University of New Mexico, and his PhD in control and dynamical systems from the California Institute of Technology. He was a postdoctoral scholar at Yale University before joining the faculty at Penn in July 2002. Prior to joining MIT faculty, he was the Alfred Fitler Moore Professor of Network Science and held secondary appointments in computer and information science and operations, information and decisions in the Wharton School.
He was the inaugural editor-in-chief of IEEE Transactions on Network Science and Engineering, and was a recipient of a National Science Foundation Career Award, an Office of Naval Research Young Investigator Award, the O. Hugo Schuck Best Paper Award from the American Automatic Control Council, and the George S. Axelby Best Paper Award from the IEEE Control Systems Society. His students have been winners and finalists of student best paper awards at various conferences. He is an IEEE fellow and the recipient of the 2016 Vannevar Bush Fellowship (US Department of Defense's equivalent of a MacArthur grant) from the office of Secretary of Defense of the United States. His current research interests include the interplay of dynamic systems and networks with specific emphasis on multi-agent coordination and control, distributed optimization, network science, and network economics.

The triple-filter bubble: using agent-based modeling to test a meta-theoretical framework for the emergence of filter bubbles and echo chambers

Jan LORENZ
Jacobs University gGmbH

Filter bubbles and echo chambers have both been linked recently by commentators to rapid societal changes such as Brexit and the polarization of the US American society in the course of Donald Trump's election campaign.
We hypothesize that information filtering processes take place on the individual, the social, and the technological levels (triple-filter-bubble framework). We constructed an agent-based modelling (ABM) and analysed twelve different information filtering scenarios to answer the question under which circumstances social media and recommender algorithms contribute to fragmentation of modern society into distinct echo chambers. Simulations show that, even without any social or technological filters, echo chambers emerge as a consequence of cognitive mechanisms, such as confirmation bias, under conditions of central information propagation through channels reaching a large part of the population. When social and technological filtering mechanisms are added to the model, polarization of society into even more distinct and less interconnected echo chambers is observed.
Merits and limits of the theoretical framework, and more generally of studying complex social phenomena using ABM, are discussed. Directions for future research such as ways of comparing our simulations with actual empirical data and possible measures against societal fragmentation on the three different levels are suggested.

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Jan Lorenz is a postdoctoral fellow and lecturer in Computational Social Science at Jacobs University. He obtained a PhD in Mathematics from University of Bremen and was a postdoc at ETH Zürich, Carl von Ossietzky University of Oldenburg, and GESIS.
He is interested in opinion dynamics and collective decisions and uses agent-based and data-driven dynamical modeling. He also worked on comparative projects on measuring social cohesion.

Graphon games: A statistical framework for network games and interventions

Francesca PARISE
Massachusetts Institute of Technology

Recent decades have witnessed tremendous progress in the theory of network games, which have been used to model and predict behavior in a vast range of settings involving strategic agents that interact with each other in a network environment. Examples include opinion dynamics and targeted marketing in social networks or economic exchange and international trade in financial networks. The standard theory of network games requires detailed information about the actual network guiding the strategic interactions. A drawback of this approach is that, as the size of the networks of interest increases, not only such information may be hard to come by, but predictions based on such information may not be robust.
In this talk, we introduce a new class of infinite population games, termed graphon games, and discuss how they can be used to model and control systems where the network of interactions may be very large and partially unknown. We first show that graphon games can be used to describe strategic behavior in heterogeneous populations of infinite size. We establish existence and uniqueness of graphon equilibria and derive general comparative statics results. Then, we study the equilibria of an ensemble of finite network games sampled from a stochastic network formation process (represented by the graphon). We provide explicit bounds on the distance of the equilibrium of any finite sampled network game and the corresponding graphon equilibrium in terms of the population size, and we characterize optimal interventions in sampled network games by a planner who knows the graphon but not the realized sampled network. Finally, we relax the assumption that agents know the sampled network and establish a tight link between the graphon equilibrium and the Bayesian Nash equilibrium of an incomplete information network game sampled from the graphon.

Francesca Parise is a postdoctoral researcher at the Laboratory for Information and Decision Systems at MIT and will join Cornell as Assistant Professor of Electrical and Computer Engineering in fall 2020. She defended her PhD at the Automatic Control Laboratory, ETH Zurich, Switzerland in 2016 and she received the B.Sc. and M.Sc. degrees in Information and Automation Engineering in 2010 and 2012, respectively, from the University of Padova, Italy, where she simultaneously attended the Galilean School of Excellence.
Francesca's main research interest is in control, network and game theory. She has worked on a broad set of topics, including systems biology, reachability analysis, distributed multi-agent systems, network analysis, aggregative games and opinion dynamics.
Francesca was recognized as an EECS rising star in 2017 and is the recipient of the Guglielmo Marin Award from the "Istituto Veneto di Scienze, Lettere ed Arti", the SNSF Early Postdoc Fellowship, the SNSF Advanced Postdoc Fellowship and the ETH Medal for her doctoral work.

Learning hidden influences in large-scale dynamical social networks

Chiara RAVAZZI
Consiglio Nazionale delle Ricerche

Interpersonal influence estimation from empirical data is a central challenge in the study of social structures and dynamics. Opinion dynamics theory is a young interdisciplinary science that studies opinion formation in social networks and has a huge potential in applications, such as marketing, advertisement and recommendations.The term social influence refers to the behavioral change of individuals due to the interactions with others in a social system, e.g. organization, community, or society in general. The advent of Internet has made a huge volume of data easily available that can be used to measure social influence over large populations.
Here, we aim at qualitatively and quantitatively infer social influence from data using a systems and control viewpoint. First, we introduce some definitions and models of opinions dynamics and review some structural constraints of online social networks, based on the notion of sparsity. Then, we review the main approaches to infer the network's structure from a set of observed data. Finally, we present some algorithms that exploit the introduced models and structural constraints, focusing on the sample complexity and computational requirements.

Chiara Ravazzi received the Ph.D. degree in Mathematics for engineering sciences from Politecnico di Torino, in 2011. In 2010 she was a visiting member at the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge. From 2011 to 2016, she held Postdoctoral positions with the Departments of Mathematics and Electronics and Telecommunications, Politecnico di Torino. Since 2017, she has been a Tenured Researcher with the Institute of Electronics, Computers and Telecommunications Engineering of the National Research Council of Italy (CNR-IEIIT), working with the Systems Modeling and Control Group.
Her current research interests lie in the broad areas of signal processing, optimization, and control of network systems. She has been serving as Member of the Conference Editorial Board of the IEEE CSS and as Associate Editor of the IEEE Transactions on Signal Processing since 2019.

Diffusion in large networks: is polarization possible?

Agnieszka RUSINOWSKA
Centre d'Economie de la Sorbonne

We investigate the phenomenon of diffusion in a countably infinite society of individuals interacting with their neighbors in a network. At a given time, each individual is either active or inactive. The diffusion is driven by two characteristics: the network structure and the diffusion mechanism represented by an aggregation function.
We distinguish between two diffusion mechanisms (probabilistic, deterministic) and focus on two types of aggregation functions (strict, Boolean). Under strict aggregation functions, polarization of the society cannot happen, and its state evolves towards a mixture of infinitely many active and infinitely many inactive agents, or towards a homogenous society. Under Boolean aggregation functions, the diffusion process becomes deterministic and the contagion model of Morris (2000) becomes a particular case of our framework. Polarization can then happen.
Our dynamics also allows for cycles in both cases. The network structure is not relevant for these questions, but is important for establishing irreducibility, at the price of a richness assumption: the network should contain infinitely many complex stars and have enough space for storing local configurations.
Joint work with Michel Grabisch and Xavier Venel

Agnieszka Rusinowska obtained her Ph.D. degree in Economics at Warsaw School of Economics in 2000. For almost 7 years she worked in the Netherlands, first at Tilburg University, then at the University of Nijmegen. Since 2007 she works at CNRS in France (2007 - 2010 in Lyon, since 2010 in Paris). Since 2011 she is CNRS Research Professor (Directeur de Recherche) at Centre d'Economie de la Sorbonne.
Her main research interests and competences concern Economic Theory, Game Theory, and Social Choice, with focus on social and economic networks, coalition formation, voting power, and bargaining. For over 10 years she is particularly interested in opinion and network dynamics, and influence.

A distributed push-pull brain network governs human irrationality during gambling

Sridevi SARMA
Johns Hopkins University

A person's decisions vary even when options stay the same, like when a gambler changes bets despite constant odds of winning. Internal bias (e.g., emotion) contributes to this variability and is shaped by past outcomes, yet its neurobiology during decision-making is not well understood. To map neural circuits encoding bias, we administered a gambling task to 10 participants implanted with intracerebral depth electrodes in cortical and subcortical structures. We predicted the variability in betting behavior within and across patients by individual bias, which is estimated through a dynamical model of choice. Our analysis further revealed that high-frequency activity increased in the right hemisphere when participants were biased towards risky bets, while it increased in the left hemisphere when participants were biased away from risky bets. Our findings provide the first electrophysiological evidence that risk-taking bias is a lateralized push-pull neural system governing counterintuitive and highly variable decision-making in humans.

Sridevi Sarma received the B.S. degree in electrical engineering from Cornell University, Ithaca NY, in 1994; and an M.S. and Ph.D. degrees in Electrical Engineering and Computer Science from Massachusetts Institute of Technology in, Cambridge MA, in 1997 and 2006, respectively. From 2000-2003 she took a leave of absence to start a data analytics company. From 2006–2009, she was a Postdoctoral Fellow in the Brain and Cognitive Sciences Department at the Massachusetts Institute of Technology, Cambridge. She is now an associate professor in the Institute for Computational Medicine, Department of Biomedical Engineering, at Johns Hopkins University, Baltimore MD.
Her research interests include modeling, estimation and control of neural systems using electrical stimulation.
She is a recipient of the GE faculty for the future scholarship, a National Science Foundation graduate research fellow, a L'Oreal For Women in Science fellow, the Burroughs Wellcome Fund Careers at the Scientific Interface Award, the Krishna Kumar New Investigator Award from the North American Neuromodulation Society, and a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE) and the Whiting School of Engineering Robert B. Pond Excellence in Teaching Award.

The buck-passing game

Marco SCARSINI
Luiss Guido Carli

We consider situations where a finite number of agents want to transfer the responsibility of doing a job (the buck) to their neighbors in a social network. This can be seen as network variation of the public good model. The goal of each agent is to see the buck coming back as rarely as possible. We frame this situation as a game where players are the vertices of a directed graph and the strategy space of each player is the set of her out-neighbors. Nature assigns the buck to a random player according to a given initial distribution. Each player pays a cost that corresponds to the asymptotic expected frequency of times that she gets the buck

We consider two versions of the game. In the deterministic one each player chooses one of her out-neighbors once and for all at the beginning of the game. In the stochastic version a player chooses a probability distribution that determines which of her out-neighbors will be chosen when she passes the buck. We show that in both cases the game admits a generalized ordinal potential whose minimizers provide equilibria in pure strategies, even when the strategy set of each player is uncountable. We also show the existence of equilibria that are prior-free, in the sense that they do not depend on the initial distribution used to initially assign the buck. We provide different characterizations for the potential, we analyze fairness of equilibria, and, finally, we discuss a buck holding variant in which players want to maximize the frequency of times they hold the buck. As an application of the latter we briefly discuss the PageRank game.

References

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Marco Scarsini is a Professor in the Department of Economics and Finance at LUISS, Rome, Italy. He obtained his Laurea in Economics and Social Sciences at Università Bocconi and his HDR in Applied Mathematics and Applications of Mathematics at Université Paris Dauphine. He had previous appointments in various universities.

He has written over one hundred papers and serves on the editorial board of several scientific journals. His main research areas are applied probability and game theory, with a particular focus on congestion games and social learning.

Production and Financial Networks in Interplay: evidence from Supplier-Customer and Credit Registers during the Recent Crisis

Fernando VEGA-REDONDO
Università Bocconi

We develop a model in which bank shocks originating in the financial networks propagate upstream and downstream along the production network, thus increasing significantly their original direct impact.
To test the model, our identification strategy exploits two administrative registers (the universe of both supplier-customer transactions and bank-firm loans in Spain), computing the predicted direct and indirect effects of financial shocks as predicted by the theory. We obtain support for these predictions, the induced effects being of similar magnitude when we compare:

(i) indirect real effects on the customer-supplier network versus direct financial shocks;

(ii) downstream versus upstream propagation;

(iii) first- versus higher-order effects.

Interestingly, we also find that market power amplifies the aggregate spillover effects of bank shocks.

Fernando Vega-Redondo is Professor of Economics at Bocconi University. He received his Ph. D. from the University of Minnesota in 1984 under the supervision of Leonid Hurwicz. He has taught at the Universities of Alicante (Spain), Pompeu Fabra (Barcelona, Spain), Essex (UK), Cornell (USA), and the European University Institute (Florence, Italy). He has supervised twenty six doctoral researchers and is the author of several books such as Complex Economic Networks (Cambridge University Press, 2006), Economics and the Theory of Games (Cambridge University Press, 2003), and Evolution, Games, and Economic Behavior (Oxford University Press, 1996).
His multidisciplinary research has led to more than one hundred publications in the fields of economics, game theory, biology, and physics. He is currently co-editor of Network Science and associate editor of Games and Economic Behavior, International Journal of Game Theory, and the Journal of Complex Networks.

The learning landscape in machine learning

Riccardo ZECCHINA
Università Bocconi

In machine learning the learning process consists in finding a minimizer of a loss function which measures how well the data are classified. This non convex optimization task is typically solved by tuning a huge number of parameters by stochastic gradient algorithms.
In this talk we present analytical and numerical results which show that the landscapes of basic learning devices (supervised and unsupervised) possess a very peculiar geometrical structures of the minima, which sheds light on the role of rare events and on the tradeoff between accessibility and generalization performance.

Riccardo Zecchina obtained the master's degree in Electronic Engineering from the Politecnico di Torino in 1989 and the PhD in theoretical Physics from the University of Torino in 1993. From 1997 to 2007 he was research scientist and head of the Statistical Physics Group at the International Centre for Theoretical Physics (Trieste). Then he was full professor to the Politecnico di Torino University. From 2007 to 2016 he was also visiting scientist at Microsoft Research (Redmond and Boston) and visiting professor at the University of Orsay. Starting from 2017, he is full professor at the Bocconi University in Milan, chair in Machine Learning and scientific director of the Artificial Intelligence lab (www.artlab.unibocconi.it).
The research interests of Riccardo Zecchina lie at the interface between statistical physics, computer science and machine learning. His papers of can be found on the ArXiv or on Scholar.
International Awards:
- 2016, Lars Onsager prize in Theoretical Statistical Physics by the American Physical Society, "For groundbreaking work applying spin glass ideas to ensembles of computational problems, yielding both new classes of efficient algorithms and new perspectives on phase transitions in their structure and complexity."
- 2011 Advanced grantee of the European Research Council (ERC) for the project "Optimization and inference algorithms from the theory of disordered systems"