Unwinding Complexity

Program & Abstracts

Organizing Committee

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December 18 - December 19, 2023, London, UK

https://financialcomputingucl.github.io/unwinding_complexity/

	Monday 18 December	Tuesday 19 December
	ROOM: G22 & G23 NorthWest Wing	ROOM: G22 & G23 NorthWest Wing
09:00 - 09:45	Registration & Breakfast	Registration & Breakfast
09:45 - 10:00	**Tomaso Aste** (University College London) - Welcome Message	
10:00 - 10:20	**Rosario Mantegna** (Università degli Studi di Palermo, Palermo, IT)	**Denis Weaire** (Trinity College Dublin, Dublin, IE)
10:20 - 10:40	**Andrea Baronchelli** (City University of London, London, UK)	**Alexander Denev** (Turnleaf Analytics, London, UK)
10:40 - 11:00	**Álvaro Cartea** (University of Oxford, Oxford, UK)	**Gary Delaney** (CSIRO, Melbourne, AU)
11:00 - 11:30	Coffee Break	Coffee Break
11:30 - 11:50	**Luciano Pietronero** (Enrico Fermi Research Center, Rome, IT)	**Eva Micheler** (London School of Economics and Political Science, London, UK)
11:50 - 12:10	**Yaacov Mutnikas** (S&P Global Market Intelligence, London, UK)	**Elsa Arcaute** (The Alan Turing Institute, London, UK)
12:10 - 12:30	**Diego Garlaschelli** (IMT Advanced School Lucca, Lucca, IT)	**Gerd Schröder-Turk** (Murdoch University, Perth, AU)
12:30 - 12:50	**Adam Binnie & Laurent Chaminade** (World Scientific Publishing, London, UK)	**Matthias Schröter** (Max Plank Institute, Göttingen, DE)
12:50 - 14:00	Lunch Break	Lunch Break
14:00 - 14:20	**David Sherrington** (University of Oxford, Oxford, UK)	
14:20 - 14:40	**Ginestra Bianconi** (Queen Mary University of London, London, UK)	**Sandra Vengadasalam** (Bloxberg, Munich, DE)
14:40 - 15:00	**Guido Caldarelli** (Università Ca' Foscari Venezia, Venice, IT)	**Vincenzo Nicosia** (Queen Mary University of London, London, UK)
15:00 - 15:20	**Vito Latora** (Queen Mary University of London, London, UK)	**Won Min Song** (Icahn School of Medicine, New York City, US)
15:20 - 15:40	**Dror Kenett** (Financial Industry Regulatory Authority, Washington DC, US)	**Yoed Kenett** (Technion Israel Institute of Technology, Haifa, IL)
15:40 - 16:00	ROOM: South Cloisters	**Derek Abbott** (University of Adelaide, Adelaide, AU)
16:00 - 16:20	Coffe Break & Poster Session	Closing Remarks
16:20 - 16:40		
16:40 - 17:30		
	ROOM: Jeremy Bentham	
17:30 - 18:30	Debate on Technology, Society & Science **Emilio Barucci** (Politecnico di Milano, Milan, IT) **Jiahua Xu** (University College London, London, UK) **Ariane Chapelle** (Chapelle Consulting, London, UK)	
18:30 - 21:30	ROOM: Ground Floor, UCL Computer Science, 66-72 Gower Street	
	Reception	

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The map of the campus can be downloaded at the following link (see page 2): https://rawcdn.githack.com/FinancialComputingUCL/unwinding_complexity/01ca2e1279813ffd9309bf428973eb7de12efeda/program/campus-map.pdf

ABSTRACTS' BOOKLET

Rosario Mantegna (Università degli Studi di Palermo, Palermo, IT)

Since 1999 similarity-based networks have been introduced and investigated in many complex systems. We present a brief overview of the development of main ideas and methods in this research area with a focus on the filtering of information in multivariate time series and applications of filtering procedures in portfolio optimisation. Specifically, we highlight the difference of the amount of information carried by hierarchical trees obtained from hierarchical clustering and similarity-based networks. The role of the topology of the network is also highlighted in the case of the minimum spanning tree and of the planar maximally filtered graph.

Andrea Baronchelli (City University of London, London, UK) - **Buyer-seller networks in online marketplaces, from mainstream platforms to the dark web.**

Online marketplaces play a crucial role in legal and illegal e-commerce, yet their empirical properties are not well understood due to a lack of large-scale data. In this talk, I will consider buyer-seller networks by analysing 245 million transactions on one e-commerce platform and 28 dark web markets. Despite the differences between the marketplaces, I will show striking regularities in user behaviour and propose a simple model to replicate the main empirical observations. The findings provide insights into the formation mechanisms of buyer-seller networks, and highlight the central role of buyer memory and preferential attachment mechanisms.

Álvaro Cartea (University of Oxford, Oxford, UK) - **Spoofing Order Books with Learning Algorithms.**

This paper proposes a dynamic model of the limit order book to test if a trading algorithm will learn to spoof the order book. We derive testable conditions that are simple and easy to implement because they depend only on the parameters of the model. Our results show that as a market maker becomes more tolerant to bearing inventory risk, the learning algorithm will find optimal strategies that spoof the book more frequently. The conditions are tested with order book data from Nasdaq and we show that market conditions are conducive for an algorithm to learn to spoof the order book.

Luciano Pietronero (Enrico Fermi Research Center, Rome, IT)

Economic Fitness and Complexity (EFC) is the recent economic discipline and methodology we have developed in the past ten years. EFC makes use and develops the modern techniques of data analysis to build economic models based on a scientific methodology inspired by the science of Complex Systems with special attention to quantitative tests to provide a sound scientific framework. It consists of a data based and bottom up approach that considers specific and concrete problems without economic ideologies and it acquires information from the previous growth data of all countries with methods of Complex Networks, Algorithms and Machine Learning. Its main characteristics are the scientific rigor, the precision in the analysis and in the forecasting, transparency and adaptability. According to Bloomberg Views: “New research has demonstrated that the ”fitness” technique systematically outperforms standard methods, despite requiring much less data”. Up to now we have considered mostly the analysis of countries. The present challenge is to extend these methodology also for firms. This requires new data and new concepts.

Diego Garlaschelli (IMT Advanced School Lucca, Lucca, IT) - **Multiscale network renormalisation: Scale-invariance without geometry.**

Systems with lattice geometry can be renormalised exploiting their coordinates in metric space, which naturally define the coarse-grained nodes. By contrast, complex networks defy the usual techniques, due to their small-world character and lack of explicit geometric embedding. Current network renormalisation approaches require strong assumptions (e.g., community structure, hyperbolicity, scale-free topology), thus remaining incompatible with generic graphs and ordinary lattices. Here we introduce a graph renormalisation scheme valid for any hierarchy of heterogeneous coarse-grainings, thereby allowing for the definition of “block-nodes” across multiple scales. This approach identifies a class of scale-invariant networks characterised by a necessary and specific dependence on additive hidden variables attached to nodes, plus optional dyadic factors. If the hidden variables are annealed, they lead to realistic scale-free networks with assortativity and finite local clustering, even in the sparse regime and in the absence of geometry. If they are quenched, they can guide the renormalisation of real-world networks with node attributes and distance-dependence or communities. As an application, we derive an accurate multiscale model of the International Trade Network applicable across arbitrary geographic partitions. These results highlight a deep conceptual distinction between scale-free and scale-invariant networks, and they provide a geometry-free route to renormalisation.

David Sherrington (University of Oxford, Oxford, UK) - **Spin glass theory and beyond.**

Simple models of an ‘interacting agent’ character involving frustrated interactions and quenched randomness, originally devised to try to understand unusual behaviour of some metallic magnetic alloys have led to subtle mathematical methods and insightful concepts. Although the original materials are not (so far) of practical application, the knowledge gained has led to significant progress in understanding in many other complex systems, both physical and manmade, including several of practical application, fundamental probability theory, hard optimization and artificial intelligence. There are also many further potentially stimulating extensions for understanding and engineering social and economic macroscopic behaviour. I shall give a brief glimpse of some of these ideas that have interested me.

Ginestra Bianconi (Queen Mary University of London, London, UK) - **Topology shapes dynamics of higher-order networks.**

Higher-order networks capture the interactions among two or more nodes and they are raising increasing interest in the study of brain networks. Here we show that higher-order interactions are responsible for new non-linear dynamical processes that cannot be observed in pairwise networks. We reveal how non-linear dynamical processes can be used to learn the topology, by defining Topological Kuramoto model and Topological global synchronization. These critical phenomena capture the synchronization of topological signals, i.e. dynamical signal defined not only on nodes but also on links, triangles and higher-dimensional simplices in simplicial complexes. Moreover will discuss how the Dirac operator can be used to couple and process topological signal of different dimensions, formulating Dirac signal processing. Finally we will reveal how non-linear dynamics can shape topology by formulating triadic percolation. In triadic percolation triadic interactions can turn percolation into a fully-fledged dynamical process in which nodes can turn on and off intermittently in a periodic fashion or even chaotically leading to period doubling and a route to chaos of the percolation order parameter. Triadic percolation changes drastically our understanding of percolation and can describe real systems in which the giant component varies significantly in time such as in brain functional networks and in climate.

Guido Caldarelli (Università Ca' Foscari Venezia, Venice, IT) - **Laplacian renormalisation group for heterogeneous networks.**

The renormalisation group is the cornerstone of the modern theory of universality and phase transitions and it is a powerful tool to scrutinize symmetries and organisational scales in dynamical systems. However, its application to complex networks has proven particularly challenging, owing to correlations between intertwined scales. To date, existing approaches have been based on hidden geometries hypotheses, which rely on the embedding of complex networks into underlying hidden metric spaces. Here we propose a Laplacian renormalisation group diffusion-based picture for complex networks, which is able to identify proper spatiotemporal scales in heterogeneous networks. In analogy with real-space renormalisation group procedures, we first introduce the concept of Kadanoff super-nodes as block nodes across multiple scales, which helps to overcome detrimental small-world effects that are responsible for cross-scale correlations. We then rigorously define the momentum space procedure to progressively integrate out fast diffusion modes and generate coarse-grained graphs. We validate the method through application to several real-world networks, demonstrating its ability to perform network reduction keeping crucial properties of the systems intact.

Vito Latora (Queen Mary University of London, London, UK) - **Explosive cooperation in social dilemmas on higher-order networks.**

Understanding how cooperative behaviours can emerge from competitive interactions is an open problem in biology and social sciences. While interactions are usually modelled as pairwise networks, the units of many real-world systems can also interact in groups of three or more. Here, we introduce a general framework to extend pairwise games to higher-order networks. By studying social dilemmas on hypergraphs with a tunable structure, we find an explosive transition to cooperation triggered by a critical number of higher-order games. The associated bistable regime implies that an initial critical mass of cooperators is also required for the emergence of prosocial behavior. Our results show that higher-order interactions provide a novel explanation for the survival of cooperation.

Dror Kenett (Financial Industry Regulatory Authority, Washington DC, US)

In this talk, I will first provide a general overview of the U.S. financial regulatory ecosystem. Then I will introduce the Financial Regulatory Industry Authority (FINRA), its core mission and mandate - investor protection and integrity of the U.S. securities markets - and the various functions FINRA performs. I will discuss the two main areas regulated by FINRA: 1) the regulation of how broker-firms operate and comply with regulation, known as member supervision; and 2) the structure and operation of U.S. securities markets, known as market regulation. I will then move to discuss the recent regulatory response and buildup of infrastructure and capabilities in the digital asset space, and will provide some examples of current FINRA rules that have touchpoint with the digital asset space. Finally, I will present some of the resources developed internally in FINRA - the crypto hub, crypto asset investigation team, and the blockchain lab.

Denis Weaire (Trinity College Dublin, Dublin, IE) - **Packing 'em in – a personal history.**

This will be a personal history, with some account of prehistory, of experiences in packing and tiling. My personal career wandered in and out of this subject, beginning with an interest in the crystal structures of the elements, ending up in the rich range of phenomena of foams, many of which are encountered in the kitchen, the bathroom and the pub. Inspiration was drawn from Cyril Stanley Smith and John Desmond Bernal, among others. It was particularly pleasing to outdo a fellow-Ulsterman, Lord Kelvin, by producing a cellular division of space into cells of equal volume with lower surface area than his supposed optimum. How I came upon the idea is a good example of what universities are (or were) intended to be, that is, places where different subjects could interact, and cross-fertilise, at every level. And art and science meet in surprising places.

Alexander Denev (Turnleaf Analytics, London, UK)

Alternative Data is nowadays becoming widely available and easily accessible to financial practitioners, but its use does not come without challenges.The methods used to structure the data into useful features have evolved rapidly in the past decade (e.g., RNNs, CNNs etc.). Time series methods also had to adapt to deal with features selection with potentially thousands of predictors when the number of observations in time is relatively small. Regularisation, treatment of missing data, outliers, non-stationarity and non-linearities must become part of the baggage to dealt with predictions of macroeconomic and financial variables.This talk will show that if tackled properly, alternative data is an invaluable source of improved predictive performance.

Gary Delaney (CSIRO, Melbourne, AU) - **AI Driven Design of Complex Granular Matter for Industrial Applications.**

Granular materials are ubiquitous in modern industrial processes and exhibit intricate behaviours that can be harnessed for a wide range of applications. The interplay between particle morphology (incl. shape and size distribution), particle-particle interaction properties, and the resulting complex macroscopic behaviour offers great potential for designing optimal granular materials for specific industrial applications. To unlock this potential, we propose an AI-driven approach that seamlessly integrates physics-based computational models and real-world experiments. We show how by tailoring particle properties, we can design granular materials that exhibit precisely tailored macroscopic behaviours for a given application. We present results for the specific case of design of optimal soft robotic jamming grippers, tackling the problem of optimising both the properties of the granular material and also the bounding membrane's shape and mechanical behaviour. Our results show how we can harness the intricate interplay between particle properties and macroscopic behaviour to optimise industrial processes across a multitude of domains.

Elsa Arcaute (The Alan Turing Institute, London, UK) - **Multiscalar interdependencies.**

In this talk, we explore the intricate connections between cities at various scales. We employ commuting networks to uncover multiscale interdependencies that enable us to analyse city systems at both regional and macro-regional levels. This approach provides valuable insights into the diverse attributes of labour markets and enables us to categorise city systems without being restricted by governance constraints. Moreover, this method assists us in determining the appropriate scale at which interventions should be considered.

Gerd Schröder-Turk (Murdoch University, Perth, AU) - **Hyperuniform hidden order in amorphous sphere configurations from Lloyd's algorithm.**

Partitioning space into cells is central to many fields of science and technology, as well as to resource distribution problems in economics and telecommunication. The nature of such cellular partitions is often defined by optimization with respect to certain properties, such as interface area in the Kelvin problem, packing density in the Kepler problem, or cell centrality as in the Quantizer problem. In all known cases, the optimal solutions are crystalline configurations with long range order. Amorphous disordered structures are generally considered to be intermittent metastable states that prevent the system from attaining the optimal ordered structures. To date, no optimization problem has been identified where the groundstate is a disordered configuration. While we do not find a disordered groundstate, we here show that the use Lloyd's algorithm as a fast quench generates a very stable universal disordered state in the three-dimensional Quantizer problem, despite the existence of lower-energy crystalline configurations.

Matthias Schröter (Max Plank Institute, Göttingen, DE) - **How spheres get in contact with each other.**

One of the many seminal contributions of Tomaso was devising a way how to measure in a statistical correct way the number of contacts an average sphere will form in a packing. Building on this method some of his friends and collaborators have continued analyzing a number of different experimental systems. The results have had repercussions for the theory of granular packings. They disprove one popular approach, the so-called Jamming paradigm, and they apparently justify a competing mean-filed type theory. I will present new experimental and machine learning results which show that the mean field approach does also not capture the whole phenomenon and that it can even be completely wrong.

Vincenzo Nicosia (Queen Mary University of London, London, UK) - **Diffusive measures of network correlations.**

A system is usually considered ”complex” if it is characterised by non-trivial emerging structural properties, or if it exhibits a collective behaviour that is not just a simple linear superposition of the dynamics of its components. Structural correlations are one of the specific signatures of complexity, whereby the way in which the relations among the constituents of system are organised shows quantifiable differences from what one would observe in a uniform null-model. In this talk we will give an overview of a series of measures of structural correlations in complex systems, based on the properties of diffusive dynamics occurring over their interaction network, namely random walks. We show that this family of measures allows to take into account correlations at microscopic, mesoscopic, and global scales, and provides a principled manner to compare the structural properties and the dynamics of complex systems of different nature and function.

Won Min Song (Icahn School of Medicine, New York City, US) - **Multi-scale system modelling to predict pro-tumorigenic regulators of melanoma and its micro-environment.**

Melanoma is highly aggressive tumour that accounts 80% of skin cancer-related deaths. Recently, tumours were found to evade the immune surveillance by turning off the switches on T lymphocytes, the immune cells with capacity to recognise and kill the tumour cells. Accordingly, immunotherapies that turn these switches back on to harbor the immune cells' anti-tumour capacity, have emerged in standard-of-care to treat advanced metastatic melanoma, improving the overall 5-year survival rate from 10% to 50%. But, the majority still relapses after the treatments. Of those, the primary resistance to immunotherapy, i.e. unresponsive cases at initial treatment (40-65%), arises due to tumour intrinsic factors, and can manifest in the early disease stages. However, the majority of current clinical trials are still focused on advanced tumours, under-exploring the opportunities for early-stage detection and therapies for the tumour intrinsic factors. To this end, we hypothesise that these resistances manifest as consequences of inter-wined signalling network of dis-regulated pathways in tumour and its surrounding ecosystem called tumor microenvironment (TME). We will leverage network embedding technique on topological sphere to construct data-driven model of gene interaction network. We leveraged the primary tumor cohort curated The Cancer Genome Atlas (TCGA) for the model construction, identified the subnetworks associated with patients' prognosis, predicted and experimentally validated upstream regulators of these subnetworks as novel primary melanoma regulators. Among the these regulators, we present ZNF180, a transcription factor that controls critical pro-tumorigenic functions for melanoma cells to maintain its genomic integrity, metastasise and resist against the immunotherapy. Particularly, we highlight its role in immunotherapy resistance by leveraging multi-modal large-scale data from cellular resolutions (i.e. single-cell sequencing data) to bulk-tissue cohorts curating clinical follow-up from >100 patients to evaluate its implications in patient outcomes. Lastly, we will present the potential therapeutic avenues to target the ZNF180-axis to combat the immunotherapy resistance with conventional regimens, thereby addressing currently unmet clinical needs.

Yoed Kenett (Technion Israel Institute of Technology, Haifa, IL) - **Investigating the complexity of creative thinking.**

The human mind can be extremely flexible as we solve problems and create new ideas. How can we study the complex cognitive and neural processes and dynamics that give rise to creativity? Although cognitive theories in different domains are strongly based on a network perspective, the application of network science to quantitatively study cognition is limited in scope. The application of network science in cognition provides a powerful quantitative approach to represent cognitive systems (e.g., memory, language); enables a deeper understanding of cognition by capturing how the structure and processes operating on a network structure interact to produce behavioral phenomena; and provides a quantitative framework to model the dynamics of cognitive systems. I will present a series of studies that investigate how differences in semantic memory network structure relate to different facets of creativity in low and high creative individuals. Finally, I will demonstrate how the quantitative language of networks can be used to bridge across different levels of analysis (computational, behavioral, neural).