

WORKSHOP PROGRAM

HyTAC WORKSHOP TAKES PLACE MONDAY-FRIDAY, FROM 04.11.2019 TO 08.11.2019

04.11.2019

- **15:00 - 15:15**

Official Start and Welcome

- **15:15 - 16:30**

Invited Talk: "Hypernetworks for Complex Systems Analysis" -- Cliff Joslyn, Pacific Northwest National Laboratory

Abstract: In many areas of science, from cyber to biology and ecology to social systems like bibliometrics, systems with complex networked interactions produce challenging large-scale data sets. There are a number of general mathematical models used to understand these kinds of complex data, including dynamical and statistical models, and especially graphs and networks. But we can recognize traditional network science as a limiting case of a broader methodology, one which uses hypergrphs to natively represent the full complexity of the multi-way relationships present, thereby not being limited to the binary (two-place) relationships representable in graphs. While graphs dominate network analysis applications, they frequently do so at the expense of "cutting off" higher order, multidimensional interactions and dependences by limiting representations to "2-sections". And as hypergrphs explicitly generalize graphs, so a burgeoning "hypernetwork science" is generalizing network science, including development of multi-dimensional versions of standard network methods like centrality, connectivity, modularity, and clustering coefficients. The Pacific Northwest National Laboratory has been pursuing hypergraph analytics in a number of areas, including mathematics, methodology, applications, and software environments for both visualization and high performance computing. In this talk I will overview this portfolio of work, beginning with the mathematical foundations of hypernetwork analytics in the context of our HyperNetX open source software capability, with applications in computer network defense and computational proteomics. Scaling approaches and studies are described in the context of our Chapel Hypergraph Library (CHGL) for the high performance, data parallel programming language Chapel. Finally, we will describe another significant advantage of the hypergraph approach to complex systems analysis, namely its affordance of opportunities to analyze proper hypergraphs as topological objects, and thereby the potential for the use of the tools of higher order mathematics available in computational topology.

- **16:30 - 17:00**

Coffee Break

- **17:00 - 18:00**

Invited Talk: "Introduction to hypergraph clustering" -- Francois Theberge, TIMC and University of Ottawa

Abstract: Several graph clustering algorithms rely on the graph modularity measure to find good partitions of the vertices. In the first part of the talk, we briefly review graph modularity and how it relates to the Chung-Lu model. We show that the Chung-Lu model can be naturally extended to hypergraphs, leading to new definitions of hypergraph modularity. We present a simple hypergraph clustering algorithm based on one such definition. Next, we re-visit the commonly used definitions of graph and hypergraph Laplacian, as they appear in unsupervised and semi-supervised problems. For hypergraphs, we show that it is equivalent to a random walk on the vertices, leading to a re-definition of the problems on weighted graphs. This approach has been proposed recently to define a pseudo-hypergraph modularity, which can be used in graph-based clustering algorithms such as the Louvain algorithm. We discuss this approach, as well as other ideas and open questions.

05.11.2019

- **09:00 - 10:30**

Optimizing Julia packages -- Przemyslaw Szufel and Carmine Spagnuolo

- **10:30 - 11:00**

Coffee Break

- **11:00 - 12:00**

SimpleHypergraphs.jl: Novel Software Framework for Modelling and Analysis of Hypergraphs -- Carmine Spagnuolo

- **12:00 - 13:00**

Invited Talk: "Graph embeddings" -- Francois Theberge, TIMC and University of Ottawa

Abstract: A graph embedding is a mapping of the vertices of a graph into k-dimensional vectors. Good embeddings should capture the graph topology and vertex-to-vertex relationship. Several graph embedding algorithms are available and for each algorithm, parameters need to be set such as the dimension of the embedding space. As a result, selecting the best embedding is a challenging task and very often requires domain experts. We propose an unsupervised framework for the computation of divergence scores to compare the quality of different embeddings for a given graph, where quality is defined as preserving the community structure. The framework relies on two main ingredients: (i) a good, stable graph clustering algorithm, and (ii) a generalization of the Chung-Lu model for graphs which incorporates the geometry provided by the graph embedding. In order to validate our framework, we ran a large number of experiments with synthetic networks as well as real-world networks, using various embedding algorithms. We will also discuss open questions such as possible extensions to hypergraphs.

- **14:30 - 16:00**

Algorithms for hypergraph modularity optimization -- Pawel Pralat

- **16:00 - 16:30**

Coffee Break

- **16:30 - 18:00**

HyperNetX Demo -- Cliff Joslyn, Pacific Northwest National Laboratory

06.11.2019

- **09:00 - 10:30**

Hypergraphs HACKATHON presentations -- Moderators Bogumil Kaminski, Przemyslaw Szufel, Gennaro Cordasco, Vittorio Scarano

- **10:30 - 11:00**

Coffee Break

- **11:00 - 12:30**

Hypergraphs HACKATHON

- Free afternoon

07.11.2019

- **09:00 - 10:30**

Invited Talk: "Hypergraph Visualisation: a blended methods vision" -- Andrew Fish, University of Brighton

- **10:30 - 11:00**

Coffee Break

- **11:00 - 12:30**

Information Diffusion on Graph -- Gennaro Cordasco

- **14:30 - 16:00**

Hypergraphs HACKATHON

- **16:00 - 16:30**

Coffee Break

- **16:30 - 18:00**

Hypergraphs HACKATHON

08.11.2019

- **09:00 - 10:30**

Hypergraphs HACKATHON

- **10:30 - 11:00**

Coffee Break

- **11:00 - 13:00**

Hypergraphs HACKATHON Results Presentations -- Moderators Bogumil Kaminski, Przemyslaw Szufel, Gennaro Cordasco, Vittorio Scarano

- **14:30 - 16:00**

Discussion on next steps -- Moderator Vittorio Scarano

- **16:00 - 16:30**

Coffee Break