CoCo Seminar Series
Fall 2023

Relational Models of Complex Systems: Hierarchy and Topology of High Order Interactions

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Wednesday September 27, 2023 12:00-1:00pm EDT
On Zoom (meeting link available on http://coco.binghamton.edu/)

Mathematical modeling of complex systems has alternate foundations. The tradition of mathematical systems theory defines a complex system as a multi-relation; that is, a generalized tensor, or subset of a cross product of heterogeneous dimensions. Then the particular nature of these dimensions can provide data with e.g. temporal, spatial, quantitative, categorical, ordinal, or any other properties required by a problem domain. Data are then represented as multi-dimensional, generalized, heterogeneous vectors or points, operationally, like in the style of rows in a pandas dataframe recording the multiway relationships of all of the columns (dimensions). While high dimensionality is the general case, such systems can be decomposed into interacting two-dimensional (binary) projections, and surprising complexity remains even in the paradigmatic case of the humble binary relation. The ubiquity and flexibility of binary relations affords opportunities to derive not only other formal representations from them, but most importantly, the mappings between such. This, in turn, supports the application of specialized methods from one technical field to another. Specifically, we will describe how we can maneuver the landscape encompassing high order network science, hierarchy theory, and topological data modeling by grounding data representations in a common systems perspective. Illustration will be made on cyber, molecular biological, and open source data.

Cliff Joslyn is the chief scientist for Knowledge Sciences at the Pacific Northwest National Laboratory (PNNL) in Seattle, and visiting professor of Systems Science at Binghamton University (SUNY). His past positions include team leader for Mathematics of Data Science at PNNL, adjunct professor of Systems Science at Portland State University, team leader in the Computer Science division at the Los Alamos National Laboratory, and postdoctoral scientist at NASA's Goddard Space Flight Center. Cliff's research aims to explore classes of mathematical, formal, and conceptual models, their interrelation and integration, and their application to interdisciplinary data science problems. Cliff's mathematical work draws on computational topology, order and lattice theory, category theory, hypergraph analytics, generalized information theory and non-standard probability, multivariate data analysis, and relational data modeling. To these formal approaches he brings a perspective on semantic information theory and computational semiotics, in the context of the cybernetic philosophy of modeling and evolutionary systems. Thus, his work is generally strongly engaged with semantic technology, formal ontologies, and the engineering of supportive software technologies. Cliff has led and supported computer and information science research efforts for the US government for over 30 years, leading projects in blockchains for nuclear safeguards, information integration for proteomics and metabolomics, network defense, semantic technologies for open source analytics, reliability analysis for engineered systems, and high-performance graph analytics. A software engineer since the origins of the PC era, and a web pioneer from the dawn of the Internet age, he holds a BA with High Honors in Cognitive Science and Mathematics from Oberlin College, an MS and PhD in Systems Science from SUNY Binghamton, and is a Senior Member of the ACM.

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