Carolina Dynamics Symposium - Titles and Abstracts

UNC Charlotte

Friday, April 12th - Sunday April 14th, 2022

Van Cyr, Bucknell University

Friday, 3:00 pm

Chaotic Almost Minimal Systems

A celebrated theorem of Furstenberg says that any closed subset of $S^1 = \mathbb{R}/\mathbb{Z}$ that is invariant under the maps $x \mapsto 2x \pmod 1$ and $x \mapsto 3x \pmod 1$ is either equal to S^1 or finite. There are many interesting things to ask about this system and a wide variety of questions remain open. In this talk, based on recent joint work with B. Kra and S. Schmeiding, I will introduce an abstraction of the $\times 2, \times 3$ system to what we call a *chaotic almost minimal system*. After providing definitions, I will survey some results on the interplay between the acting group and the kinds of phenomena that are possible.

Lori Alvin, Furman University

Saturday 9:00 - 9:25 am

Persistent Recurrence in Unimodal Maps

We investigate the notion of persistent recurrence in unimodal maps. Our goal is to provide a symbolic characterization of when the turning point of a unimodal map is persistently recurrent and determine how persistent recurrence relates to other topological properties.

James Kelly, Christopher Newport University

Saturday 9:30 - 955 am

A characterization of infinite topological entropy for a class of linear operators

We discuss the translation operator on weighted function spaces. We present a characterization for this operator having positive topological entropy and show this is also equivalent to infinite topological entropy. In addition, we discuss other properties that are shown to be equivalent under this characterization, and we show how this fits into a "hierarchy of chaos" for this class of dynamical system.

This talk is based on joint work with Will Brian.

Sunitha Basodi, TReNDS Center, Georgia State University

Saturday 10:00 - 10:25 am

Training deep neural networks by dynamically amplifying gradients

Deep learning models offer superior performance compared to other machine learning techniques for a variety of tasks and domains but pose their own challenges. In particular, deep learning models require larger training times as the depth of a model increases and suffer from vanishing gradients. In this talk, we present a way to address these issues by dynamically determining the layers of the model where the gradients are amplified, using a formulated approach that analyzes gradient fluctuations of layers while training the model. We also present the mathematical formulation and demonstrate results of our detailed experiments performed on simpler and deeper neural networks using two different intelligent measures and two different thresholds that determine the amplification layers, and a training strategy where gradients are amplified only during certain epochs. Our amplification method offers better performance compared to the original models even when the models are trained with higher learning rates.

Xingjie Helen Li, UNC Charlotte

Saturday 11:00 - 11:25 am

Coarse-Graining of stochastic systems

Efficient simulation of SDEs is essential in many applications, particularly for ergodic systems that demand efficient simulation of both short-time dynamics and large-time statistics. To achieve the efficiency, dimension reduction is often required in both space and time. In this talk, I will talk about our recent work on both spatial and temporal reductions.

For spatial dimension reduction, the Mori-Zwanzig formalism is applied to derive equations for the evolution of linear observables of the Langevin dynamics for over-damped cases.

For temporal dimension reduction, we introduce a framework to construct inference-based schemes adaptive to large time-steps (ISALT) from data, achieving a reduction in time by several orders of magnitudes while preserving structures of the system.

This is a joint work with Dr. Thomas Hudson from the University of Warwick, UK; Dr. Fei Lu from the Johns Hopkins University and Dr Xiaofeng Felix Ye from SUNY at Albany, and Dr. Molei Tao from Georgia Institute of Technology.

C. Evans Hedges, The University of Denver

Saturday 11:30 - 11:55 am

Equilibrium States are (at least somewhat) Gibbs

This talk will cover an introduction to thermodynamic formalism in the subshift setting. Given an energy function, one primary goal of thermodynamic formalism is to understand equilibrium states: invariant measures that maximize entropy plus average energy. We will build intuition for this theory in the setting of $\mathbb{Z}$ actions, after which we will discuss a few important results in the $\mathbb{Z}^d$ setting. I will then present new results that generalize those of Garcia-Ramos and Pavlov as well as Meyerovitch to the countable, amenable G action setting.

Krishna Pusuluri, TReNDS Center, Georgia State University

Saturday 12:00 - 12:25 pm

Complex neural dynamics and coupling at multiple spatiotemporal scales

In this talk, we showcase a broad range of complex neural dynamics at multiple spatiotemporal scales, ranging from isolated neurons and small scale networks with dynamics on the order of milliseconds to whole brain network dynamics on the order of minutes. We present several recently developed approaches and discuss dynamics such as bursting, tonic spiking and chaotic mixed-mode oscillations in individual neuron models, the transitions between activity types, and emergent network phenomena through synergistic interactions seen in realistic neural circuits. We discuss the origin and coexistence of multistable rhythms in oscillatory neural networks of inhibitory coupled cells. We discuss how network connectivity and intrinsic properties of the cells affect the dynamics, and how even simple circuits can exhibit a variety of mono/multi-stable rhythms. Lastly, we discuss large scale dynamic spatial brain networks in human resting state functional magnetic resonance imaging (rsfMRI) data that show synchronized growth and shrinkage over time, with several dynamical features of these networks and the coupling between them showing strong associations with cognitive behaviors and psychiatric disorders such as Schizophrenia.

Tamara Kucherenko, City University New York

Saturday 2:15 - 3:00 pm

Phase transitions on one-dimensional symbolic systems

A phase transition is observed when one follows an evolution of a system depending on continuous external factors and a sharp change of the behavior of the system happens. One way to study the mechanism of this phenomenon is by utilizing tools of thermodynamic formalism. In this setting a phase transition means co-existence of several equilibrium states, which, in particular, occurs at the points of non-differentiability of the pressure with respect to a parameter regarded as the inverse temperature. We discus several results, classical and recent, concerning the number and frequency of phase transitions on symbolic systems, as well as the existence of freezing phase transitions. In the latter case we focus on the type of potentials which would trigger a freezing phase transition and the support of the resulting ground state.

Martin Schmoll, Clemson University

Saturday 3:30 - 3:55 pm

Wasserstein distances, linear transport and probabilistic frames

We consider probabilistic frames, which are probability measures on $\mathbb{R}^n$ whose support contains a vector basis. We assign an ellipsoid to each probabilistic frame that resembles Wasserstein distances on the space of probabilities. Together with some estimates for Wasserstein distances this gives a potent tool to solve several questions in frame theory. This is a report on an ongoing (PhD related) project with Dongwei Cheng.

Kitty Yang, UNC Asheville

Saturday 4:00 - 4:25 pm

Dynamics of gapped digit tilings

A gapped digit tiling is a one dimensional subshift arising from a constant shape substitution. We can think of gapped digit tilings as generalizations of constant length substitutions. We show that gapped digit tilings are conjugate to constant length substitutions, and investigate which constant length substitutions arise as gapped digit tilings.

Rich Neidinger, Davidson College

Saturday 4:30 - 5:00 pm

Iterative Behavior(s) when Alternating Logistic Functions

We explore interesting parameter plane graphics for iterative behavior of real quadratic functions and try to understand the dynamics. Specifically, we alternate applying $f_c(x) = cx(1-x)$ or $f_d(x) = dx(1-x)$ to an initial x_0 (which can be formalized as a skew product). Sometimes the common critical point $x_0 = 0.5$ results in different behavior depending on whether you start with f_c or with f_d! Sometimes there is only one bounded behavior (an attracting periodic cycle or aperiodic basin) and sometimes there are two such behaviors. This expands on previous work with more observations and analysis of what is possible, including interesting behavior when $c > 4$ or $d > 4$. As with the classic one-parameter logistic, graphics reveal amazing complexity in the dependence on these two parameters.

Sergei Miles, UNC Charlotte

Sunday 9:30 - 9:55 am

Infinite and 0 topological entropy results for weighted ℓ^p sequence spaces

In linear dynamics, bounded linear operators over infinite-dimensional Banach spaces have been shown to be able to exhibit interesting characteristics including topological transitivity, topological mixing, and even chaos in the sense of Devaney. In this talk new results for infinite and 0 topological entropy for the weighted ℓ^p space together with the backward shift will be given. In particular, when the weight sequence is summable over a subset of $\mathbb{N}$ with positive upper density then infinite entropy will be achieved. Furthermore, when an arbitrary ratio of the weights is bounded above then 0 entropy is guaranteed.

Jade Raymond, UNC Charlotte

Sunday 10:30 - 10:55 am

De Finetti's Theorem, Ergodicity, and Abstract Nonsense

De Finetti's Theorem is a statistical result about the structure of the joint distribution of sequences of random variables which are "exchangeable", meaning that the joint distribution of a finite subset of the random variables is identical under arbitrary permutations of those variables. From the perspective of ergodic theory however, de Finetti's Theorem is a classification of the ergodic measures for a particular group action on sequence spaces. In this talk, I will present an equivalent characterization of ergodicity which makes the classification of these ergodic measures rather straightforward, giving an ergodic proof of de Finetti's Theorem. Furthermore, through the use of Abstract Nonsense™, I will present a generalization of de Finetti's Theorem which gives a characterization of the ergodic measures for a broader class of group actions on sequence spaces.

Jim Wiseman, Agnes Scott College

Sunday 11:00 - 11:30 am

Shift equivalence for finite relations

Numerical approximation of dynamical systems leads to finite relations (multivalued maps). We study shift equivalence, a natural dynamical invariant, in this setting, and show that each equivalence class has a simple canonical representative. If we assume a linear structure, then the canonical representative is especially simple. (Joint work with Marian Mrozek and Mateusz Pryzbylski.)