Orientation 2018

Welcome

SICE-PHD-CX-L@indiana.edu

www.sice.indiana.edu/graduate/degrees/informatics/complex-systems

cnets.indiana.edu/phd/

cns-nrt-students-l@list.indiana.edu

cns-nrt.indiana.edu

rocha@indiana.edu
Sikander Khare

United States

M.S. Complex Networks & Systems

B.S. 2017 Physics,
Imperial College London
Daniele Notarmuzi

Italy

Complex Networks & Systems

B.S. 2015 Physics,
Sapienza University of Rome
Kenzie Givens

United States

Complex Networks & Systems, Evolution, Ecology, & Behavior

B.A. 2017 Biology, Reed College
Patrick Kaminski

Germany

Complex Networks & Systems, Sociology

Bachelor’s 2014 Social Sciences, Humboldt University
(attended University of Bremen 2014-2017 but no degree)
Victoria Klimaj

United States

Complex Networks & Systems, Cognitive Science

B.A. 2013 Behavioral Neuroscience, Knox College
Sam Migirditch

United States

Complex Networks & Systems, Cognitive Science

B.S. 2018 Physics & Mathematics, Appalachian State University
Thomas Varley

United States

Complex Networks & Systems, Psychological & Brain Sciences

B.A. 2016 Neuroscience, Hampshire College
Shih-Chieh “Jeffrey” Wang
Taiwan

Complex Networks & Systems, Political Science

B.S. 2006 Political Science, Chinese Culture University
Yaojun “Harry” Yan

China

Complex Networks & Systems, Media School

B.S. 2013 Chinese Language & Literature, University of Macau & Nankai University
Wanying “Whitney” Zhao

China

Complex Networks & Systems, Cognitive Science

B.S. 2015 Information Management & Information Systems, Wuhan University
Our complex networks and systems program draws on world-class faculty in a distinctly multi-disciplinary environment. Our researchers are experts in network science, data science, computation, computational biology, statistical physics, cognitive science, and information science; they study multi-scale networks that extend across social, informational, technological, infrastructural, and biological systems.

Chair of advisory and dissertation committee from this group: advisor/mentor

Co-chair in the case of the CNS-NRT
# CNS Program

## Timeline and Course Structure

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<td>I609, I709, research rotations, electives (inc. PhD minor courses)</td>
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- **Advisory Committee**
- **Qualifying Exams**
- **Qualifying Exams**
- **Dissertation Committee**
- **Dissertation Proposal**
- **Dissertation Defense**

[https://cns-nrt.indiana.edu/rocha@indiana.edu](https://cns-nrt.indiana.edu/rocha@indiana.edu)
required courses

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Example


I502 - *Human-Centered Research Methods in Informatics*. Research methods in the social sciences as they pertain to Informatics. Starting point for further study of human-centered research methods.

I601 - *Introduction to Complex Systems*. Fractals, emergent behavior, chaos theory, cooperative phenomena, and other key concepts, with examples from many disciplines.

I606 - *Network Science*. Fundamental theories, algorithms, and key applications of network science across social and biological systems.

I609 - *Advanced Seminar in CNS I*. History, methodology and impact of CNS. Key literature and recent advances, focusing on interdisciplinary problems and the discovery of general principles of organization.

I709 - *Advanced Seminar in CNS II*. Late-breaking research to train students to think like a CNS researcher and apply methods to their research goals.
interdisciplinary training in complex networks & systems

dual PhD training in general-purpose systems and empirical science

NRT projects point the way to how STEM education ought to be, not how it has been.

Jim Lewis, NSF Director for Education & Human Resources

NSF Research Traineeship Opportunity

Interdisciplinary Complex Networks & Systems (@Informatics)

- Sustainable Food, Energy, and Water Systems (SFEWS): Rakesh Agrawal, Purdue University, and Aavudai Anandhi Swamy, Florida Agricultural and Mechanical University.
- A Training Incubator for Addressing Urban Environmental Change From Ridge to Reef (R2R): Steven Allison, University of California, Irvine.
- Improving Strategies for Hunger Relief and Food Security Using Computational Data Science: Lauren Davis, North Carolina Agricultural & Technical State University.
- Training the Next Generation of Researchers in Engineering and Deciphering of Miniature Brain Machinery: Martha Gillette, University of Illinois at Urbana-Champaign.
- Graduate Training Program in Sensory Science: Optimizing the Information Available for Mind and Brain: Victoria Interrante, University of Minnesota-Twin Cities.
- Computational Data Science to Advance Research at the Energy-Environment Nexus: Elisabeth Moyer, University of Chicago.
- Quantitative & Evolutionary STEM Training (QUEST): An Integrative Training Program for Versatile STEM Professionals to Solve Environmental and Global Health Problems: Melissa Pespeni, University of Vermont & State Agricultural College.
- Interdisciplinary Training in Complex Networks and Systems: Luis Rocha, Indiana University.
- Sustainable Oceans: From Policy to Science to Decisions: James Sanchirico, University of California, Davis.
- Boston UniverCity - Partnering Graduate Students and Cities to Tackle Urban Environmental Challenges: Pamela Templer, Boston University.
- Disaster Resilience and Risk Management (DRRM) - Creating Quantitative Decision Making Frameworks for Multi-Dimensional and Multi-Scale Analysis of Hazard Impact: Robert Weiss, Virginia Polytechnic Institute and State University.
The interdisciplinary approach @ Indiana University

The Social Symbiome. Multi-level complexity affects physical and mental well-being. Networks dynamics in interacting levels

- Olaf Sporns, Network Neuroscience
- Santo Fortunato, Complex Systems & Informatics
- Andrew J. Saykin, Brain Imaging and Genomic Approaches to Cognitive Disorders
- Bernice Pescosolido, Social networks effects on disease
### Traditional disciplines
- defined by specific discernable levels of human experience in nature and society
  - Psychology, Sociology, Political Science, Economics, Physics, Chemistry, Biology, etc.

### CNS, computational thinking
- General-purpose tools and universal laws
  - Search for **general principles** of organization
  - Produce machines and tools for all sciences
- Disciplines are orthogonal to traditional disciplines
  - Machine learning, network science, dynamical systems theory, operations research, data science, etc.

### 2-dimensional science
- traditional disciplines focus on experimental and observational methods for specific subject matter
- disciplines of CNS focus on generality of their own methods to any type of data
- Neither parallel disciplines nor general-purpose methods are sufficient to achieve **interdisciplinarity**
  - Team culture is necessary
  - E.g. Systems biology, computational biology, computational social science, etc.

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**Science**

- **Network Science**
- **Dynamical Systems**
- **Machine Learning**
- **Data Science**

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**Levels of experience**

- **Physiology**
- **Chemistry**
- **Molecular Biology**
- **Neuroscience**
- **Cognitive science**
- **Medicine**
- **Economics**
- **Political science**
- **Sociology**

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**CNS NRT**

cns-nrt.indiana.edu
rocha@indiana.edu
interdisciplinary training in complex networks and systems

- Graduate training in both dimensions
  - Integrated dual Ph.D. degree
    - Students are trained in CNS and domain-specific program
  - Embedded in interdisciplinary teams and research
    - Via the Indiana University Network Science Institute
      - 160+ faculty members who participate in CNS research
      - Interdisciplinary Ph.D. program committees, co-chaired by research mentors from both CNS and a target empirical domain
      - Integrates academic education with interdisciplinary hands-on research

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**NSF-NRT**

**CNS NRT**

**Psychological & Brain Sciences**
- Cognitive Science
- Sociology
- Political Science
- Physics
- Economics
- Biology

**CNS Network Science Institute**

- **CoAS**
- **SoIC**

**21st Century Problems**
- Spread of misinformation
- Social media for public-health
- Political unrest and polarization
- Stability of trade and financial networks
- Patient outcomes from omics and spatial data
- Brain function in health and disease
- Spread of flu pandemics
- Automatic fact-checking

**Scientific Collaborations:**
- Univ. Medical Center Utrecht, The Netherlands
- Instituto Gulbenkian de Ciência, Portugal
- Institute for Scientific Interchange, Italy
- Chinese Academy of Sciences, China
- Santa Fe Institute, USA

**Industry Collaborations:**
- LinkedIn
- Facebook
- Persistent Inc.

A. Academics | B. Research | C. Workforce
core faculty + more than 160 faculty at IUNI

https://cns-nrt.indiana.edu/
Interdisciplinary Training in Complex Networks and Systems

CNS NRT
advisory board

Melanie Mitchell, Portland State U.
Siddhartha Chaterjee, Persistent Inc.
Alessandro Vespignani, Northeastern U.
Travis Brown, Indiana University
Winter Mason, Facebook Inc.
Cristopher Moore, Santa Fe Institute
Souvik Ghosh, LinkedIn Corp.
Raissa D’Souza, U.C. Davis

Deadline for Applications: January 1st
Integrated dual-major Phd program

Interdisciplinary Training in Complex Networks and Systems

- Integrated Dual Phd Program
  - Informatics/CNS track
  - Cognitive Science, Political Science, Psychology and Brain Science, Sociology, Economics, Biology, Physics, Art History, Media School, etc.

- Current state (business-as-usual)
  - Dual-major degree mechanism exists per UGS
    - Student pursues all requirements of both programs except PhD Minor
    - Admitted to both programs

- Integrated dual-major Phd
  - Joint advisory and dissertation committees
    - Co-mentorship, with two co-chairs, and at least 2 members from each program
    - Joint qualifying exams, dissertation proposal, defense.
  - Curricular synergies
    - Research Rotations, course equivalences (within UGS rules)
  - Integrated cohort mechanisms
    - Simultaneous participation in key courses (I501, I609, I709)
    - Extended Colloquium, Research Showcases, Summer internships, Professional Development

- NSF-Support and dissemination

NRT Affiliate status available for non-NRT fellows. Call for summer fellowship in Spring semester.

https://cns-nrt.indiana.edu/
Interdisciplinary Training in Complex Networks and Systems

- **Dual research rotations**
  - Research rotation 1 with CNS-track faculty
  - Research rotation 2 with dual-major faculty
    - Integrated in dual program as independent study, research practice elective, or other project work.

- **Extended colloquium series**
  - Exceptional visiting scientist series with IUNI
    - Pre-visit seminar
    - Dedicated time with speaker

- **Summer Research Internship**
  - 12-month fellowship and **additional travel funds**
    - Research projects in NRT and IUNI faculty labs
    - Projects and training in academic centers and companies around the World
  - Can be integrated with research rotations

- **Second-year Research Project**
  - Ideally using research rotations and SRI for interdisciplinary research bridging both fields
    - Directed at publication

- **Professional development workshops**
  - Grant-writing, entrepreneurship, peer-reviewing

- **Yearly activities**
  - Welcome Reception
  - Research Showcase
  - Meeting with other NRT programs at NSF (2 fellows a year)

**NRT Affiliate** status available for non-NRT fellows.
Call for summer fellowship in Spring semester.

https://cns-nrt.indiana.edu/
### Example timetables of Dual-Phd with Natural Science programs

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<thead>
<tr>
<th>Year</th>
<th>Informatics CNS</th>
<th>Psychology &amp; Brain Sciences</th>
<th>Cognitive Science</th>
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<td>year 1</td>
<td>Fall</td>
<td>I501</td>
<td>P595, N500</td>
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<td>Spring</td>
<td>I502</td>
<td>P553, N501</td>
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<td>SRI</td>
<td>Research Rotations + Project + electives</td>
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<td>year 2</td>
<td>Fall</td>
<td>I601</td>
<td>P650</td>
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<td>Spring</td>
<td>I609</td>
<td>P657</td>
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<td>SRI</td>
<td>SRI/Res. Rotation</td>
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<td>Fall</td>
<td>I709</td>
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<td>year 4</td>
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Applications: January 1st
Example timetables of Dual-Phd with Social Science programs

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<td>Y576, Y657</td>
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<td>SRP I/Research</td>
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<td>Research Rotations +</td>
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<td>I609</td>
<td>Project + electives</td>
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Applications: January 1st
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**INFO-I 501 INTRO TO INFORMATICS (3 CR)**
11798 RSTR 11:15A-01:45P W I 232 Bollen J

**INFO-I 601 INTRODUCTN TO COMPLEX SYSTEMS (3 CR)**
14476 RSTR 09:30A-10:45A TR I 232 Flammini A

Or, for CNS-NRT fellows in Cognitive Science or PBS

**COGS-Q 580 INTRO TO DYN SYS IN COG SCI (3 CR)**
33116 01:00P-02:15P TR LH 035 Beer R

Perhaps?

**INFO-I 709 ADVANCED SEMINAR II INFORMATCS (3 CR)**
VT: COMPLEX SYSTEMS
35983 RSTR 10:00A-12:30P M I 105 Radicchi F

Other options (see my email):

**COGS-Q 530 PROGRAMMING METHODS IN COG SCI (3 CR)**
33118 RSTR 01:00P-02:15P TR LH 030 Izquierdo E

**ECON-E 626 GAME THEORY (3 CR)**
7349 RSTR 01:00P-02:15P TR WY 225 Melo E

**SOC-S 660 ADVANCED TOPICS (2-6 CR)**
VT: SOCIAL NETWORKS
CLSD 31396 PERM 01:30P-04:00P T S7 100 Pescosolido B

**COGS-Q 590 TOPICS IN COGNITIVE & INFO SCI (3 CR)**
37420 02:30P-03:45P TR HD TBA Hofstadter D

Topic: Counting and Categories

**CSCI-B 551 ELEM ARTIFICIAL INTELLIGENCE (3 CR)**
B 551 : CSCI-C 343 recommended
11227 RSTR 07:15P-08:30P MW IF 1106 Crandall D