Interdisciplinary Training in Complex Networks and Systems

Keywords: Interdisciplinarity, Graduate Training, Diversity, Systems Thinking

Extended Abstract

The promise, perhaps duty, of sound interdisciplinary research is to cut across the natural and social sciences devoted to various levels of organization without trivializing them [1]. The intricacies of scientific experimental work, however, make translating Complex Networks and Systems (CNS) data-driven methods difficult, yet essential, to effectively tackle humanity's complex, multiscale problems. Therefore, we replace difficult translation with natural integration in a "bilingual" training model. More specifically, in our dual-PhD-granting interdisciplinary program in network science and complex systems, faculty train students in both CNS *and* an additional program, e.g., Biology, Sociology, or Cognitive, Political, or Psychological & Brain Sciences.

The availability of large, heterogenous data sources and computers, together with the success of CNS and AI has, in effect, established a 2-D science landscape [2]: Traditional disciplines deal with their specific subject matter using experimental and observational methods and, orthogonally, CNS deals with any type of data due to the generality of its methods. Machine learning, e.g., applies to data from biochemical regulation and consumer behavior alike, and dynamical-systems-theory models range from chemical reactions to stock market prediction. This 2-D arrangement has deepened our knowledge of both traditional objects of study and general data and computing methodologies.

Interdisciplinarity, however, requires fuller competence in both dimensions. Interdisciplinarity, however, requires competence in both. This is a challenge in graduate training, which is typically in methods either experimental and observational (e.g., biology or sociology) *or* general (e.g., machine learning or data science) [1], and compounded by shortening academic periods [3, 4]. Still, recognizing that no single lab can address current complex challenges [5], research in the natural and social sciences has increasingly adopted methods that rely on computational analysis of large amounts of data and multivariate systems.

To support multidisciplinary, problem-driven research more effectively, our CNS PhD training program was designed to leverage the 2-D science landscape with the necessary interdisciplinary team culture [6,7]. CNS methodologies in hands-on, team-centered, and data-enabled activities become central practice in natural and social-science laboratories, transforming graduate STEM education with thoughtfully planned, truly interdisciplinary training. This program provided a distinctive training model for collaborative research praxis capable of transcending disciplinary boundaries (Figure 1). In our presentation, we will detail the four overarching goals of our training model which are both broad—workforce development and the institutionalization of interdisciplinary training—and trainee-specific—2-D research proficiency and collaborative skill development.

References

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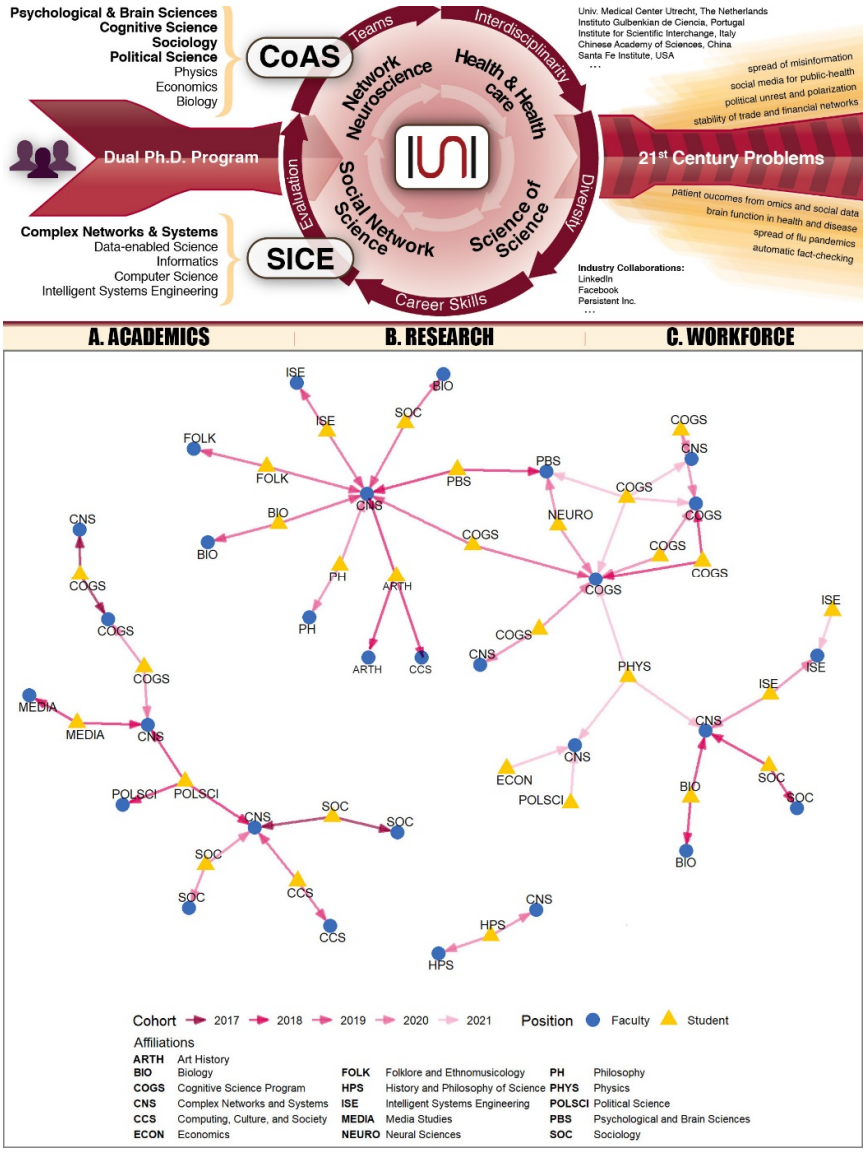

Figure 1: ***Top:*** *Summary of Training Program. (A) Academic training as dual PhD degree in CNS at the Luddy School of Informatics, Computing and Engineering (SICE) and a target program in the natural, behavioral, or social sciences from the College of Arts & Sciences (CoAS). (B) Research training in interdisciplinary project teams working in the major research threads pursued at the Indiana University Network Institute (IUNI); career skill development, diverse mentorship and recruitment activities, evaluation, and international and industrial collaboration are integral part of the training activity. (C) Production of an innovative workforce capable of tackling key XXIst century problems.* ***Bottom:*** *Network of “bilingual” dual-PhD trainees (yellow triangles), dual advisor faculty (blue circles), and their home program affiliations.*