Opportunity Title: Developing Advanced Metrics for Hypernetwork Analysis
Opportunity Reference Code: ICPD-2022-25

Organization Office of the Director of National Intelligence (ODNI)

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How to Apply **Create and release your Profile on Zintellect** – Postdoctoral applicants must create an account and complete a profile in the on-line application system. **Please note: your resume/CV may not exceed 2 pages.**

Complete your application – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.

Additional information about the IC Postdoctoral Research Fellowship Program is available on the program website located at: https://orise.orau.gov/icpostdoc/index.html.

If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.

Application Deadline 2/28/2022 6:00:00 PM Eastern Time Zone

Description **Research Topic Description, including Problem Statement:**

Developing methodologies for understanding complex systems is increasingly important as data science becomes more ubiquitous. One subset of complex systems include complex network structures, which can be used to represent social networks, computer networks, metabolic pathways, libraries within an open-source coding ecosystem, etc. Complex network structures are typically represented as graphs, where vertices and edges represent items within the system and their connections, respectively. While graphs and their associated metrics are useful in understanding these types of complex networked systems, their utility is limited to analyzing pairwise relationships between entities, while real world systems can contain multi-way relationships. Hypergraphs are higher-order mathematical abstractions of graphs that can represent multi-way group interactions with higher fidelity than standard graphs. In hypergraphs, edges can connect more than two nodes, thus capturing higher-order connectivity within a system. While numerous metrics have been developed to analyze graphs (e.g., graph walk methods, spectral methods, etc.), analogous methods for hypergraph analysis are still a relatively nascent field of mathematics. Developing novel methods of hypergraph analysis relevant to data science would aid significantly in understanding the properties of complex network systems.

Example Approaches:

Possible approaches include the following, among others: 1) Generalizing walk metrics (e.g, betweenness centrality) from standard graphs (i.e, 2-hypergraphs) to n-hypergraphs. 2) Developing methods to project n-hypergraphs onto 2-hypergraph topologies to enable spectral analysis while minimizing information loss.

Relevance to the Intelligence Community:

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The ability to understand complex network systems, such as social networks, open-source coding ecosystems, and computer networks would have significant implications for the Intelligence Community (IC). In particular, advances in this field would better enable the IC to anticipate changes in networked complex adaptive systems, which would facilitate enhanced strategic warning. For example, understanding the dynamics of open-source coding ecosystems (e.g., Python) on which the IC depends will enable the IC to identify and better prepare for dynamic network changes or vulnerabilities that could adversely impact operations.

Key Words: Graph Theory, Topology, Hypergraphs, Hypernetworks, Network Science, Social Networks, Complex Systems, Antifragility

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five years of the application deadline
- Proposal must be associated with an accredited U.S. university, college, or U.S. government laboratory
- Eligible candidates may only receive one award from the IC Postdoctoral Research Fellowship Program

Research Advisor Eligibility

- Must be an employee of an accredited U.S. university, college or U.S. government laboratory
- Are not required to be U.S. citizens

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (2)
  - **Computer, Information, and Data Sciences** (16)
  - **Earth and Geosciences** (21)
  - **Engineering** (27)
  - **Environmental and Marine Sciences** (14)
  - **Life Health and Medical Sciences** (45)
  - **Mathematics and Statistics** (10)
  - **Other Non-Science & Engineering** (2)
  - **Physics** (16)
  - **Science & Engineering-related** (1)
  - **Social and Behavioral Sciences** (27)