i-CONN

Interdisciplinary connectivity:

Understanding and Managing Complex Systems using Connectivity Science

MARIE SKŁODOWSKA-CURIE ACTIONS
Innovative Training Networks (ITN)
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(Grant Agreement No 859937)

Astrophysics and High Performance Computing Research Group http://ahpc.euc.ac.cy

European University Cyprus

AAI Scientific Cultural Services Ltd
Laboratory for Human Brain Dynamics (LHBD)
http://aaiscs.com/LHBD/

i-CONN Info

i-Conn is an Innovative Training Network (ITN) under the MARIE SKŁODOWSKA-CURIE ACTIONS of European Commission. This Research Fellowship Programme, started in October 2019 and it has a duration of four years.

i-CONN Aim:

The goal of this ITN is to train a new cohort of researchers specialized in the expanding field of connectivity science. These researchers will become capable of developing in the next 5 to 10 years interdisciplinary approaches to connectivity across a range of academic fields and real-life applications.

Our overarching aim is to overcome barriers to progress in using connectivity science to understand and manage complex systems. We will achieve this by learning from transdisciplinary perspectives and hence arrive at new insights into the behaviour of complex systems across diverse disciplines (Astrophysics, Computer Science, Ecology, Geomorphology, Hydrology, Neuroscience, Systems Biology and Social Science). The theoretical aim is to synthesize these new insights into common theories and approaches.

Objectives

1) Developing the theoretical underpinning of connectivity science for applications in complex systems;
2) Development of a unified framework of methods and approaches that can be applied across disciplines;
3) Exploring applications of connectivity science to understand, adapt to and manage complex systems.

Partners:

Consortium Member	Consortium Member	Legal Entity Short Name	Country	Dept./ Division / Laboratory
	Beneficiaries			
	Durham University	UDur	UK	Geography
	Jacobs University	Jacobs Uni (JU)	Germany	Life Sciences & Chemistry
	AAI Scientific Cultural Services Limited	AAISCS	Cyprus	Laboratory for Human Brain Dynamics
	European University Cyprus	EUC	Cyprus	Computer Science & Engineering
	Universitat Wien	UNIVIE	Austria	Geography and Regional Research
	Universitaet Fuer Bodenkultur Wien	BOKU	Austria	Institute of Hydrobiology and Aquatic Ecosystem Management
	Environment Agency	Environment Agency	UK	Strategic Catchment Partnerships
	Masarykova Univerzita	MU	Czech Republic	Department of Environmental Studies
	Universitie d'Aix Marseille	AMU	France	Institut de Neurosciences des Systèmes
	MODUL University Vienna	MUV	Austria	
	Partner Organisations			
	University of Sheffield	USFD	UK	Geography
	IIASA	IIASA	Austria	
	University of Maryland	UMD	USA	Sociology

i-CONN Research methodology and approach:

i-CONN is structured around six work packages (Figure 1): three research work packages (WPs1–3) detailed here, and a training (WP4), management (WP5), and dissemination and outreach (WP6) work packages.

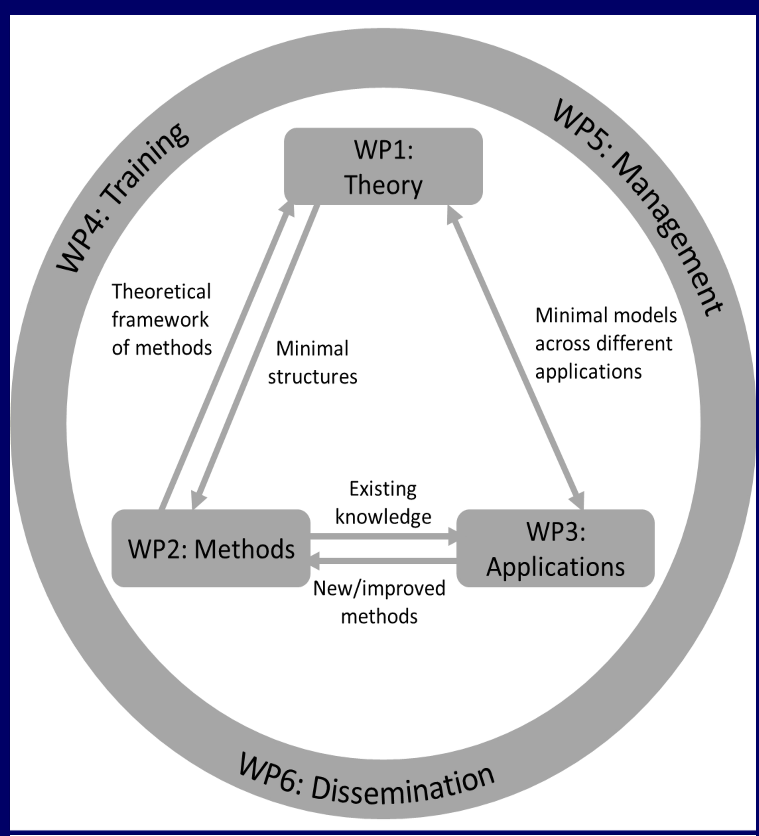

Figure 1. Linkages between the six work packages that structure the i-CONN network.

Fellows' individual projects:

Individual projects focus on one or more of the three objectives to deliver the science goals of the ITN (see Figure 2). Those that focus on conceptual and methodological issues draw upon the diversity of disciplines to make advances that will have benefit across the use and application of Connectivity Science. Those that focus upon applications are more likely to address specific problems facing one or more disciplines, but where interdisciplinary knowledge and experience can bring new insights and therefore lead to novel solutions.

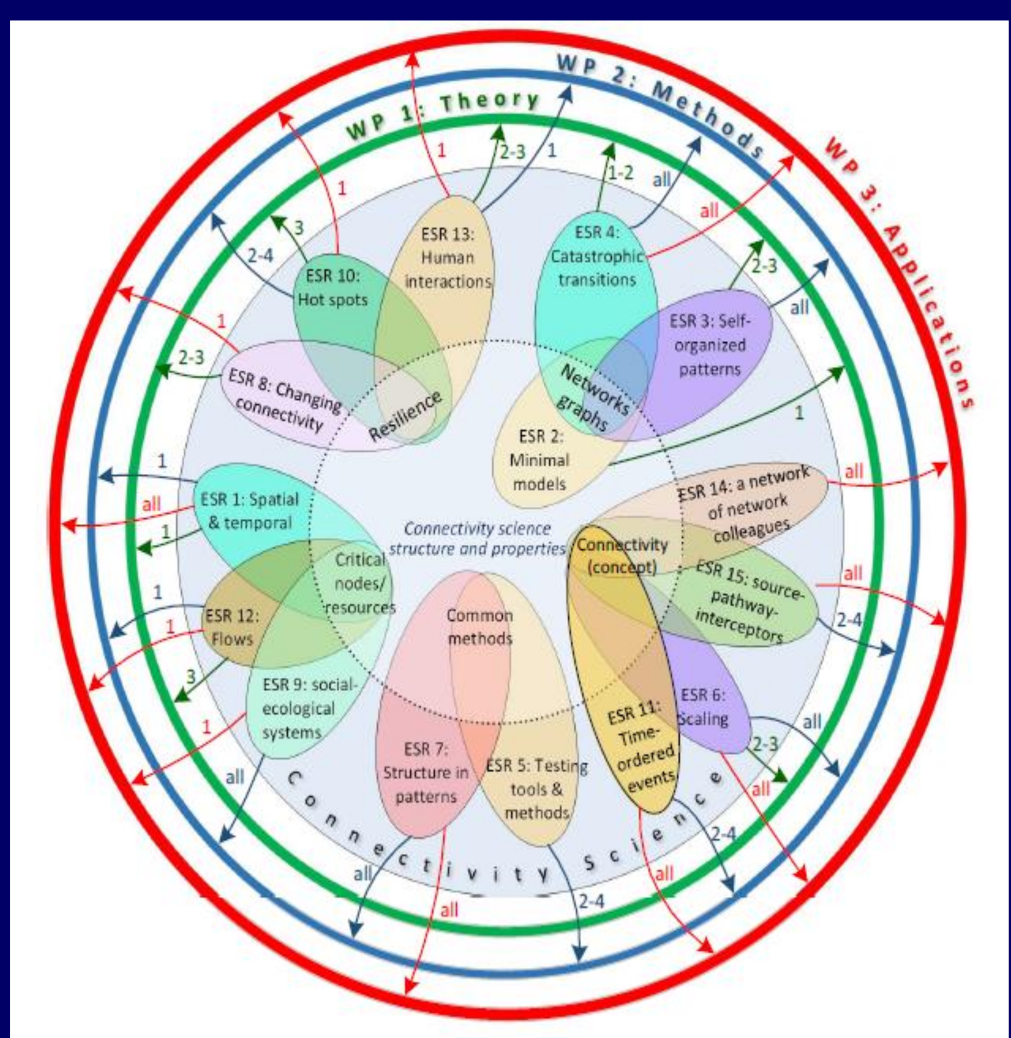

Figure 2. The contribution of each ESR to the scientific goals of the ITN. Thick arrows indicate the dominant WP to which the ESR contributes; numbers indicate the individual objects of the WP. Where no numbers are shown the ESR contributes to all objectives of the WPs.

ESR located in Cyprus:

- ✓ ESR7 (EUC)
  Structure in patterns in ordered datasets with applications in astrophysics, neuroscience and archaeology (WP2, WP3)
- ✓ ESR7 (AAISCS)
  Time-ordered events and connectivity (WP2, WP3).

Connectivity and complex systems: learning from a multi-disciplinary Perspective [1]

In recent years, parallel developments in disparate disciplines have focused on what has come to be termed connectivity; this concept is used in understanding and describing complex systems [2,3]. Conceptualisations and operationalisations of connectivity evolved largely within disciplinary boundaries, yet similarities in this concept and its application among disciplines are evident.

In any case, any implementation of the concept of connectivity carries with it both ontological and epistemological constraints, which leads us to ask if there is one type or set of approach(es) to connectivity that might be applied to all disciplines.

Turnbull et al in [1] explore *four* ontological and epistemological challenges in using connectivity to understand complex systems from the standpoint of widely different disciplines.

1) defining the fundamental unit for the study of connectivity;
2) Separating structural connectivity from functional connectivity;
3) understanding emergent behaviour; and
4) measuring connectivity.

We draw upon discipline-specific insights from Computational Neuroscience, Ecology, Geomorphology, Neuroscience, Social Network Science and Systems Biology to explore the use of connectivity among these disciplines. We evaluate how a connectivity-based approach has generated new understanding of structural-functional relationships that characterise complex systems and propose a 'common toolbox' underpinned by network-based approaches that can advance connectivity studies by overcoming existing constraints.

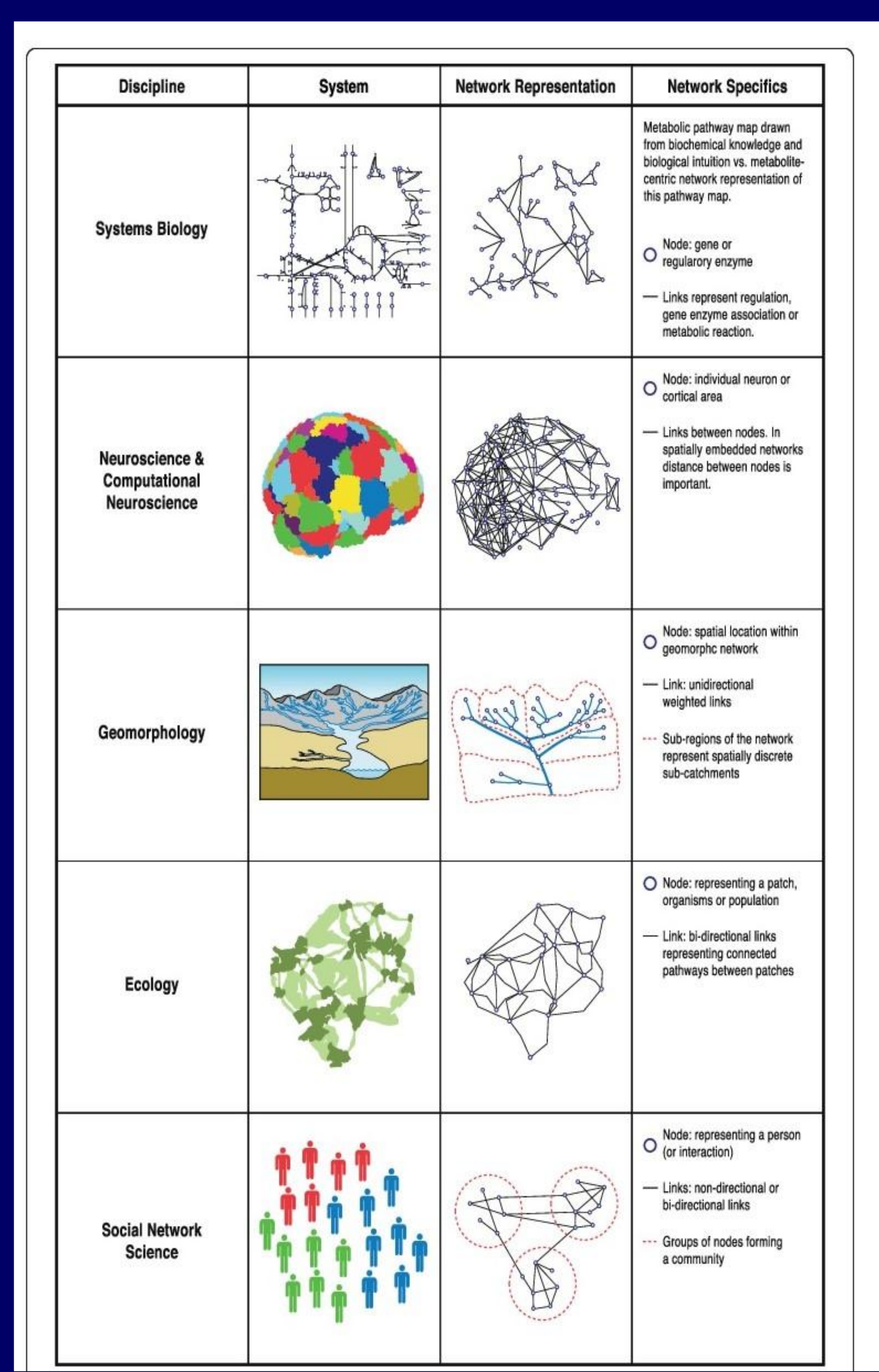

Figure 3. Network-based representation of structural and functional connectivity. Illustration of ways in which structural and functional connectivity within a multitude of systems can be conceptualised using a network-based approach across Sciences.

References

[1] L.Turnbull, M. Hütt, A. A. Ioannides, S. Kininmonth, R. Poeppl, K. Tockner, L. J. Bracken, S. Keesstra, L. Liu, R. Masselink & A. J. Parsons, "Connectivity and complex systems: learning from a multi-disciplinary perspective", *Applied Network Science*, volume 3, No. 11 (2018).

[2] E. Bullmore, O. Sporns "Complex brain networks: graph theoretical analysis of structural and functional systems", *Nat Rev Neurosci*, 10:186–198, (2009) .

[3] A. Barabási, and M. Pósfai, *Network science*, Cambridge University Press, Cambridge, (2016).