Knowledge discovery in eco-evolutionary biology-inspired federated networks ROBHOOT

1 Excellence

1.1 Radical vision of a science-enabled technology

Ecosystems collapse around the globe in the absence of technologies to discover novel ways of sustainable exploitation of complex ecosystems. In this regard, rapid, real time, heterogeneous- and cooperation-based, discovery computation is currently a major issue revolving around data-driven intelligent machines and knowledge inspired societies facing global sustainability challenges. Several of these properties are found in evolving networks being these changes occurring in dynamic connectivity patterns and/or traits in neurons and populations in natural ecosystems. However, evolving networks are not used for discovery computation yet, despite rapid changes in trait and interaction have been observed in experimental and theoretical systems [16, 18]. Evolving networks are characterized by feedbacks between the ecology and evolution of interacting traits, the eco-evolutionary feedbacks, to produce novel trait changes with new functional properties in ecosystems. This results in new computational properties, like interactions (i.e., cooperation, competition, antagonism, etc), and information processing and learning capabilities. Conventional Artificial Intelligence (AI) computation is rapidly moving towards explainable and discovery pattern inference [22] but often avoids evolutionary changes for exploring new computing capabilities [27]. The same situation occurs for artificial neural networks that also make limited use of novel computing capabilities as a consequence of evolutionary changes in interactions and traits [29]. **The goal of this project is to implement eco-evolutionary-biology inspired solutions to make discovery computation based on rapidly evolving traits and interactions**. The exploitation of evolving connections and traits will allow us to create novel discovery computation solutions for natural ecosystems facing sustainability challenges like overexploitation of the Seas, where harvesting renewable resources are in the point of diminishing returns for many species, communities and ecosystems (refs +++).

Why should we go deeper into diversifying information processing for discovery computation? With connections and traits represented in a spatially distributed network, as found in natural ecosystems, it is possible to untangle mapping of many spatiotemporal inputs onto many output functions considering evolutionary processes among many distinct traits and agents to decipher new solutions for harvesting renewable resources. This allows representing real-time solutions for spatiotemporal ecosystems with evolving renewable resources, which is a key problem in many digital and natural ecosystems.

To show the capabilities of the ROBHOOT approach, we will complement novel implementations of evolutionary biology-AI discovery computation with full reproducibility, automation, visualization and reporting to trigger its properties at large-scale (Figure 1). **The main impact of ROBHOOT is to provide novel open-source software for reproducible discovery computation solutions to substantially improve ecosystem sustainability relevant for community-rich digital and natural ecosystems**. To support this notion, we will perform eco-evolutionary biology-AI network inspired simulations of data-heterogeneity based networks. The central goals of ROBHOOT are:

1. To extend existing theories of eco-evolutionary biology-AI inspired solutions to decipher the factors driving discovery computation in federated networks. This will allow us to identify novel paths of reliable solutions for ecosystem sustainability.
2. To investigate how spatiotemporal evolutionary biology-AI-inspired networks can mimic the empirical patterns of natural and socio-technological ecosystems when large and heterogeneous exploiting groups and species coexist.
3. To develop fast, reproducible and automated discovery eco-evolutionary biology-inspired computation prototypes for real-time information processing tasks.
4. To arrive at powerful discovery computation principles for forecasting in federated networks when evolutionary changes in interactions and traits occur in a large and diverse pool of species, technologies and human groups.

1.2 Science-to-technology breakthrough that addresses this vision