ICFO



PhD THESIS DEFENSE: A machine learning ride in the physics theme park: from quantum to biophysics.

BORJA REQUENA POZO

April 24, 2024

11:00

Auditorium and Online (Teams)

The integration of artificial intelligence into research is propelling progress and discoveries across the entire scientific landscape. Artificial intelligence tools boost the development of novel scientific insights and theories by processing extensive data sets, guiding exploration and hypothesis formation, enhancing experimental setups, and even enabling autonomous discovery. In this thesis, we harness the power of machine learning, a sub-field of artificial intelligence, to study non-deterministic systems, which are amongst the hardest to characterize.

On one hand, we address problems inherent to the study of quantum systems and the development of quantum technologies. Quantum physics presents formidable challenges due to the associated exponential complexity with the size of the system at hand, as well as

its intrinsic stochastic nature and the presence of intricate correlations between its components. We employ reinforcement learning, a machine learning technique that excels at dealing with vast hypothesis spaces, to address some of these challenges. Notably, reinforcement learning has demonstrated super-human performance in multiple complex games like Go, which present similar characteristics to the problems encountered in the study of quantum physics. We use it to systematically simplify complex common problems in condensed matter and quantum information processing tasks, as well as to implement robust calibration schemes for quantum computers.
On the other hand, we focus on the characterization of complex stochastic processes, such as diffusion. Understanding diffusion processes is crucial to unravel the complex underlying physical and biological mechanisms governing them. This involves extracting meaningful parameters from the analysis of stochastic trajectories described by tracked particles. However, accurately capturing and analyzing the trajectories presents multiple challenges, stemming from the combination of their random nature, complex dynamics, and experimental drawbacks, such as noise. We develop machine learning algorithms to accurately extract such parameters, even when they vary with time, and demonstrate their applicability in experimental scenarios. Furthermore, we apply similar techniques to study the diffusion of internet users browsing an e-commerce website, predicting their likelihood to make a purchase before closing the session.

Wednesday April 24, 11:00 h. ICFO Auditorium
Thesis Director: Prof Dr. Maciej Lewenstein and Dr. Gorka Munoz Gill
Hosted by: Prof. Dr. Maciej Lewenstein