

Machine learning inverse problems in many-body soft matter systems

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Colloids are nano- to micron-sized particles suspended in a solvent and subject to thermal motion. A precise control over the flow and the structural properties of the colloidal particles is a requisite in applications such as cargo delivery with colloidal carriers and lab-on-a-chip processing. External fields are often used to generate structure and to sustain flows in colloidal systems. However, the response of the colloids to external perturbations is often complex due to the many-body internal interactions between the particles. We use here machine learning techniques to learn the internal force field in many-body systems. In non-equilibrium situations, a neural network receives as input the density and the velocity profiles in the neighborhood of a given space point and it gives the local value of the internal force as output. We can then reconstruct the external force field required to generate the desired dynamical evolution of the system. This constitutes the solution of an inverse problem in statistical physics that can help us to improve lab-on-a-chip devices, to study memory effects, and to calculate transport coefficients and relaxation times. Moreover, the local learning approach allows us to study systems much larger than the initial ones used in the training stage, opening a route to describe macroscopic systems with microscopic resolution.