Low-dimensional manifold discovery from unstructured data of meshless Multiphysics

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Project Summary: In the past five decades, mathematical and numerical methods, in conjunction with improved computational resources, have enabled numerical modeling and simulation of multiphysics systems: from magneto-hydrodynamics in astrophysics to chemically reacting and turbulent flows in combustion. However, many state-of-the-art numerical methods require large computational overhead, are time- intensive, and can be intractable for many complex multiphysics problems. Meshless numerical methods, for instance, are a cornerstone for modeling extreme events relevant to the Department of Defense and national security, but their deployment remains elusive in multi-query tasks such as uncertainty quantification, optimization, and control. The focus of the current program is to drastically reduce the cost of these meshless numerical approaches through the development of computational, mathematical, and deep learning methods that discover low-dimensional embeddings where their solutions evolve. Overall, the proposed program aims to deliver mathematical infrastructure that enables the cheap and robust deployment of meshless methods in multi-query tasks for a wide range of multiphysics problems relevant to the Department of Defense.
