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(Universal Physics-Informed Neural Networks: Symbolic Differential Operator Discovery in Biological Sciences

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This talk surveys the application of the symbolic discovery of differential operators in situations where experimental data is sparse, specifically in biology. The small data regime in machine learning can be made more manageable by incorporating prior knowledge about the underlying dynamics. Physics-Informed Neural Networks (PINNs) have been extremely successful in reconstructing entire ODE or PDE solutions using only a single point or a few measurements of the initial condition. The Universal PINN approach (UPINN) further enhances the power of PINNs by adding a neural network that learns the representation of unknown hidden terms in the differential equation or the entire equation. Given only a few data points from the differential equation, the algorithm outputs a surrogate solution and a black-box representation of the hidden terms. These hidden-term neural networks can then be converted into symbolic equations using symbolic regression techniques like AI Feynman. The UPINN demonstrates strong performance in identifying drug action in chemotherapeutics, Lotka-Volterra predator-prey interactions, and interactions within a model of cell apoptosis, even when provided with limited measurements of noisy data.