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Recent Progress of Neural Networks in Nuclear Structures

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In the burgeoning age of artificial intelligence (AI) and advanced technologies, neural networks have emerged as powerful tools, revolutionizing various scientific domains. This lecture, "Recent Progress of Neural Networks in Nuclear Structures," explores the intricate workings of these algorithms and their transformative impact on nuclear physics.
We begin by examining the fundamental principles that underpin neural networks and their learning processes, drawing from seminal works such as V. Vapnik's "The Nature of Statistical Learning Theory" [1]. This foundational understanding sets the stage for our exploration into the application of neural networks in nuclear physics. The lecture introduces recent advancements in machine learning (ML) techniques tailored for nuclear physics, as discussed in Boehnlein et al.'s comprehensive review, "Colloquium: Machine Learning in Nuclear Physics" [2]. We highlight how these ML algorithms accelerate complex calculations, offering unprecedented efficiency and accuracy. A significant portion of the lecture is dedicated to the application of ML in predicting nuclear masses, a critical area of research. We reference Mumpower et al.'s work on "Physically Interpretable Machine Learning for Nuclear Masses" [3], which highlightes the potential of ML in enhancing our understanding of nuclear structures.

Furthermore, we extend our discussion to the prediction of ground-state charge radii using support vector regression, as demonstrated by Jalili and Chen [4]. Additionally, we explore the application of ML in predicting alpha and beta decay, with research on "Nuclear Beta-Decay Half-Life Predictions and r-Process Nucleosynthesis Using Machine Learning Models" [5]. Through these discussions, the lecture underscores the pivotal role of neural networks in advancing nuclear physics, paving the way for future innovations and discoveries.

References:

[1] V. Vapnik, The Nature of Statistical Learning Theory (Springer Science and Business Media, 1999).
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[3] Mumpower, M., Sprouse, T., Lovell, A. and Mohan, A. Physically interpretable machine learning for nuclear masses. Physical Review C 106, L021301 (2022).
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[5] Jalili, A., Pan, F., Luo, Y. and Draayer, J. P. Nuclear beta-decay half-life predictions and r-process nucleosynthesis using machine learning models. Physical Review C 111, 034321 (2025).

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