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Introduction to Physics-Informed Neural Networks and Their Applications to Partial Differential Equations

In this lecture, I introduce the basic ideas behind Physics-Informed Neural Networks (PINNs), a neural-network-based framework for computing approximate solutions to partial differential equations (PDEs). PINNs can be interpreted as a residual minimization framework based on a neural-network ansatz.
A key advantage of PINNs is their mesh-free formulation, which eliminates the need for explicit spatial discretization and the careful selection of mesh sizes required in classical finite difference or finite element methods. This feature makes PINNs particularly attractive for problems involving complex geometries or high-dimensional domains.
After presenting the fundamental principles of PINNs, I will explain how the method is constructed by incorporating governing equations and boundary conditions into the loss function of a neural network.
The second part of the lecture focuses on applications, illustrating how PINNs can be used to approximate solutions of the Eikonal equation and how this approach naturally connects to path planning problems. Practical considerations and representative examples will also be discussed to highlight both the strengths and limitations of the method.

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