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Deep Neural Networks Methods for Mean Field Game Master Equation

A mean field game (MFG) approximates a large-player symmetric game and its mean field equilibrium is fully characterized by the so-called master equation. The master equation is typically a non-linear, partial differential equation. While the master equation's well-posedness is known, an analytical solution is not known. What's more, classical discretization methods for solving the master equation suffer from the curse of dimensionality. In this joint work with Ethan Zell and Mathieu Lauriere, we study two algorithms to efficiently solve the master equation in many dimensions. We call one algorithm the Deep Backward Mean Field Game method (DBMFG) and the other is the Deep Galerkin Method (DGM) of Sirignano and Spiliopoulos. We provide novel proofs of the correctness of the algorithms. Due to the structure of the master equation, we cannot rely on the argument of Sirignano and Spiliopoulos for the correctness of the DGM in this application, nor can we rely on the proof of an analogous deep backward method introduced by Pham et. al. for the DBMFG. Instead, we use the structure of the MFG to overcome these difficulties. Time permitting, I will conclude with some of the numerical results.