Deep Gradient Flow Methods for Option Pricing in Diffusion Models

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We develop a novel deep learning approach for pricing European options written on assets that follow (rough) diffusion dynamics. The option pricing problem is formulated as a partial differential equation, which is approximated via a new implicit-explicit gradient flow time-stepping approach, involving approximation by deep, residual-type Artificial Neural Networks (ANNs) for each time step. In particular, we split the PDE operator in a symmetric gradient flow with known energy functional and an asymmetric part in which we substitute the neural network of the previous time step, so that we can treat it explicitly. We compare our method with the related Deep Galerkin Method (DGM) and with deriving the conditional characteristic function of the stock price which leads to the option price with the COS method. In the lifted Heston model with twenty volatility processes, the curse of dimensionality makes deriving the characteristic function too slow, while our method remains fast and accurate.