Abstract

The process of pricing products that arise from the finance and insurance industries are associated with several challenges. Typically used numerical methods such as Monte Carlo simulations or the Finite Difference Methods (FDMs) can take excessively long to run if high levels of accuracy are required. The FDMs in particular can also exhibit significant errors if certain mathematical conditions are not met. In addition, if a product has a high-dimensional partial differential equation (PDE) form, the computation time can easily grow exponentially with respect to the number of dimensions. This paper will explore the capabilities of Physics-Informed Neural Networks (PINNs) for solving pricing problems, and their potential for circumventing the mentioned obstacles. We will first apply a PINN to price an American Option using the Hamilton-Jacobi Bellman (HJB) PDE formulation, and compare its performance against the Crank-Nicolson FDM. We will then use the PINN framework developed for American options to price Variable Annuities (VA) with the Guaranteed Minimum Income Benefit (GMIB) optional rider. Although we were able to implement PINNs for both products that returned accurate prices, we found that in their current form, both networks were unable to avoid the issue of long run times.

Keywords: Physics-Informed Neural Network, Hamilton-Jacobi Bellman Equation, Variable Annuity, American Option, Finite Difference Method