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A Neural Black–Scholes Formula

Despite its central role in option markets, the implied volatility surface (IVS) remains exceptionally difficult to calibrate to quoted call prices without breaching fundamental economic constraints. We resolve this long-standing problem by deriving a simple, model-free, smooth call option pricing formula describing a (sparse fully-trained) two-layer neural network matching quoted market call prices; both in the strike and maturity. Our formula is *adaptively arbitrage free* (AF) in that is necessrily produces an arbitrage-free call surface whenever the quoted market data is arbitrage-free. The regularity of our data-driven call surface allows us obtain a closed-form reconstruct risk-neutral dynamics for the underlying only using the available market call quotes via the Dupire formula. Moreover, on AF data, our IVS is guaranteed to uniformly approximate call slices at an optimal rate of $\mathcal{O}(1/n^2)$ all all points between any quoted market prices, using n neurons.

We demonstrate state-of-the-art predictive power with virtually no computational overhead, across synthetic data and real-world cryptocurrency markets, by routinely achieving several orders of magnitude greater accuracy than both industry and deep learning benchmarks. Our model-free option pricing formula is subsumes the classical *Black–Scholes* (BS) formula, in that it uses the BS put price as its activation function.

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