A neural network framework for precise option pricing

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Objectives

- Develop further research in cryptocurrencies in financial instruments based on the work of Pagnottoni [1];
- Develop a more precise options pricing model over classical approaches such as the Black-Scholes-Merton Model [2] based on a neural network approach as proposed by Yao. *et al.* [3]

Introduction

- There is little research being done in options pricing for cryptocurrencies such as Bitcoin - Nakamoto [4]. This is esspecially important given the volatile nature of these cryptocurrency markets;
- A very well known option pricing model is the Black-Scholes-Merton model, extensively covered by Hull [5] which while has been proven to be useful in traditional options markets, there is still room for improvement in terms of precision;
- Pagnottoni [1] has accomplished successful research into improving precision using a neural network with classical pricing models such as trinomial trees, Monte Carlo simulation and finite difference method as input layers. In this paper, I propose a similar approach but using stochastic volatility models (which are considered more precise than traditional models) instead.

Benefits

The proposed protocol allows more precise options pricing for traders to make more rational decisions for European style call/put options, which will be consequently useful in the highly volatile cryptocurrency markets.

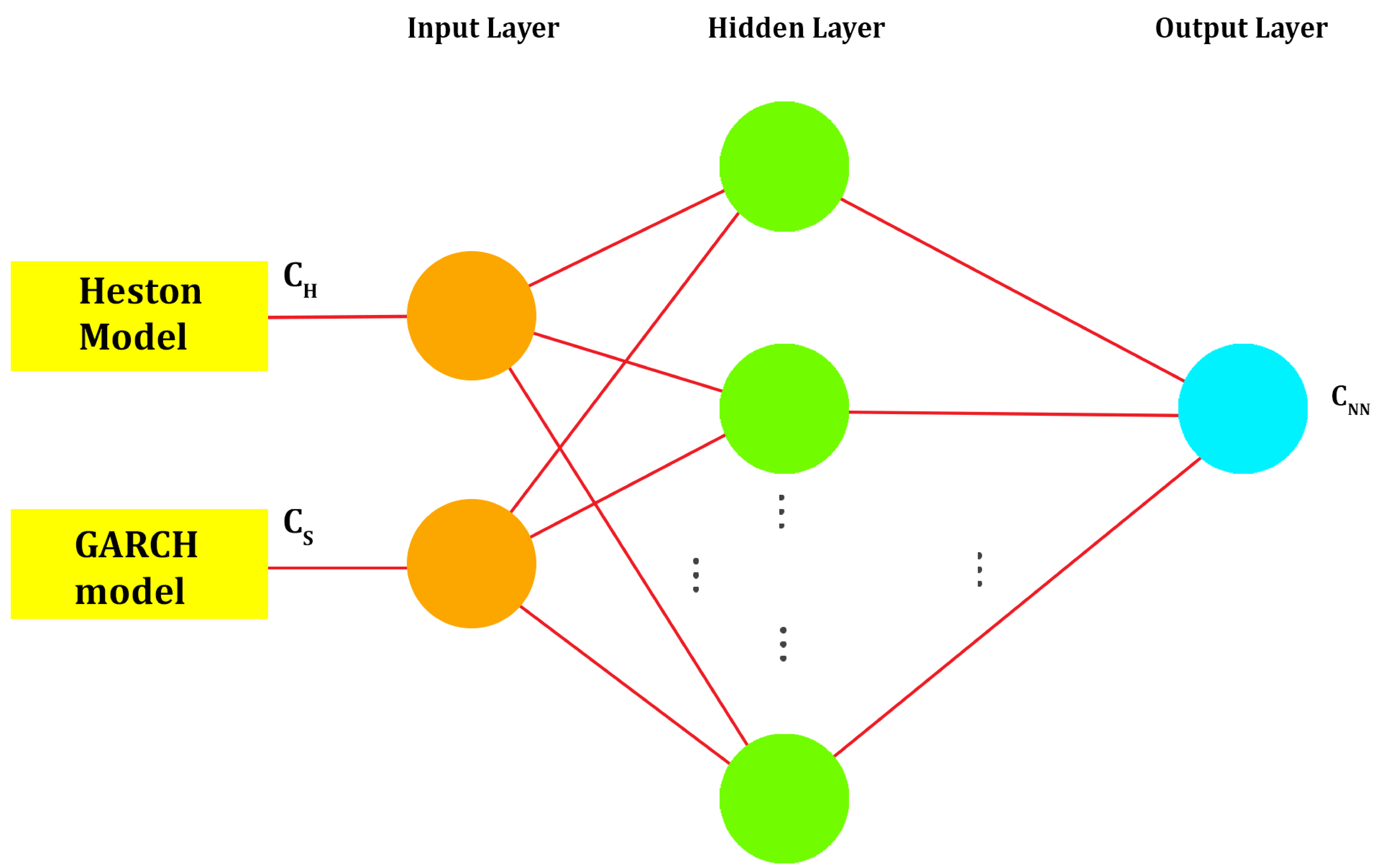

Figure 1: The multi-layer perceptron neural network model. H stands for the Heston model, S stands for the SABR model and NN stands for the neural network model.

Stochastic Models

Labordere [6] has done research in the improvements of Stochastic volatility models over traditional models such as the Black-Scholes-Merton model. Stochastic volatility means the the volatility of asset prices are not constant (assumed in the Black-Scholes-Merton model) and instead allows volatility to vary over time.

The treatment of the underlying security's volatility is a random process which is guided by variables - some of which include the price level of the underlying security, the tendency of volatility to revert to some long-run mean value, and the variance of the volatility process itself.

My research proposes a neural netowork using the Heston model and the SABR model.

Neural Networks

Following Pagnottoni [1], the network is formed similarly; using a two-step procedure. The first step consists of pricing options according to the Heston and SABR model. The prices obtained in this step are then used as input training vector of a neural network model in the second step. Model selection is considered given Stathakis [7] which discusses the appropriate number of hidden layers in the framework.

Performance Assessment

Performances of the pricing methods are assessed based off of the mean absolute error (MAE), mean supervised error (MSE) and the mean absolute percentage error (MAPE).

PC Setup

This model is made using Python alongside the following libraries: Pandas, NumPy, Matplotlib, Keras and Tensorflow.

Conclusion

This is an approach using an artificial neural network framework to be used for option pricing of cryptocurrencies. The methodology requires to initially price options using stochastic volatility models including the Heston model and the SABR model, then following by using these option prices as input layers of the neural network, which has the ability to refine the prior price predictions. It may help to conduct more research to improve precision further, for example by using high frequency data.

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