An Alternative to Black-Scholes –
Pricing Options with Artificial Intelligence

Trading and stock markets have been extensively using Black-Scholes formulae to price European options which was originated from the seminal papers of Black and Scholes (1973) and Merton (1973) with focuses on the following assumptions:

1. Create risk-free portfolios through dynamic hedging so that the portfolios earn risk-free interest rate;
2. Ensure an absence of arbitrage environment (Efficient markets);
3. Ensure no commission;
4. Ensure no interest rate change; and
5. Assume that stock returns follow a lognormal distribution.

However, in the real world commissions do exit and interest rates can change. Whether markets are efficient or not is still debatable. Furthermore, volatility smile has proven that stock returns and foreign exchange markets do not follow a lognormal distribution. Since Black-Scholes formulae relies on these questionable underlying assumptions, an alternative approach should be considered. Recently, artificial intelligence technology has been applied to develop an option pricing system to adjust itself to dynamic environments with no underlying assumption. The idea was originated from the works of Hutchinson, Lo and Poggio (1994) and Malliaris and Salchenberger (1993). For instances, the use of neural networks [1] and genetic algorithms [2, 3] gives the following neural network equation to price options:

$$f(X, w) = \sum_{h=1}^{H} \beta_h g\left(\sum_{i=0}^{I} \gamma_{hi} x_i \right)$$

where β and γ are the weight arrays of the neural network, g(.) is a non-linear transfer function attached to each hidden unit, and the input parameters for this neural network are stock price (S), strike price (X), interest rate (r), time to maturity (T-t) and historical volatility σ_{30} (30 days volatility).

Similar system was discussed in [4] with Figure 1 as the graphical representation.

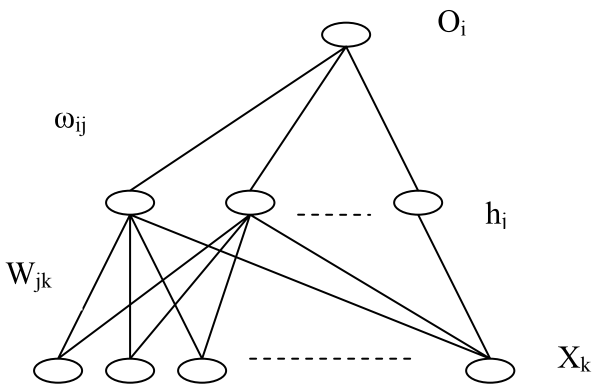

Figure 1. A single hidden layer Multi-Layer Perception (MLP) architecture

There are several methods to measure performance. For examples, the measures of square correlation between the actual and computed prices (R^2), mean deviation (MD), mean absolute deviation (MAD), mean proportionate deviation (MPD) and mean square deviation (MSD). Greek letters such as Delta, Gamma, theta and Vega are also very useful indicators on the performance.

Questions:

1. How to improve the non-linear transfer function g(.) so that it can be effectively used to price options at low computation complexity?
2. Can the neural network be extended to price American option?
3. Can the neural network be extended to price dividend paying stock options, currency and future options? What are the limitations of the models?

Reference:

[1] Julia Bennell and Charles Sutcliffe, "Black-Scholes versus Artificial Neural Networks In Pricing FTSE 100 Options", Intelligent Systems in Accounting, Finance and Management, 12, 243-260, 2004

[2] Shu-Heng Chen, Wo-Chiang Lee and Chia-Hsuan Yeh, "Hedging Derivative Securities with Genetic Programming", International Journal of Intelligent Systems in Accounting, Finance & Management, 8, 237-251, 1999.

[3] Ulrich Anders, Olaf Korn and Christian Schmitt, "Improving the Pricing of Options: A Neural Network Approach", Journal of Forecasting, 17, 369-388, 1998

[4] Henrik Amilon, "A Neural Network Versus Black-Scholes: A Comparison of Pricing and Hedging Performances", Journal of Forecasting, 22, 317-335, 2003