Monte Carlo Simulation of American and European Style Option Contract Pricing using the Julia Programming Language

Background. An option contract is an equity derivative whose value is based on the price movements of an underlying asset, for example a single company stock or an equity basket such as an exchange traded fund (ETF). Equity options provide the right, but not the obligation, to buy (call option) or sell (put option) a quantity of stock or ETF, where one option contract controls 100 shares of an individual company stock or ETF, at a set price (strike price), within a certain period of time (prior to the expiration date). European option contracts can be exercised only on the expiration date, while American style option contracts can be exercised at any time between the time the option was purchased and the expiration date.

Financial engineers, traders and investors use option contracts to control the risk associated with taking a position (buying or selling) an underlying asset, or to speculate on the price movements of an underlying asset. They also use option contracts to take positions in an underlying asset without actually buying or selling the asset. This is advantageous because taking an option position allows significant leverage; the amount of capital needed is much less with an option compared to a similar position in the underlying asset directly. However, this leverage comes at a price. Option buyers are charged (by option sellers) a premium for the rights and privileges associated with the option contract. This premium is a function of the price of the underlying asset, the volatility of the asset price, and the time to expiration.

Objectives. The objective of this project is to develop a monte carlo approach to simulate the price of combinations of European and American style option contracts in the presence of dividend payments from the underlying asset. Toward this objective, geometric brownian motion models of the price variation of the underlying asset will be developed and used in combination with discrete, and continuous option pricing algorithms to produce an option price prediction as a function of market factors and contract parameters. Option price predictions will be back-tested using historical data, and forward tested by comparing predicted and current option prices for different underlying asset classes, both collections of single companies and a broad range of ETFs.

Approach. The option pricing algorithms and asset pricing models will be implemented in the Julia programming language. Lattice based approaches will be used to provide discrete alternatives to the Black–Scholes–Merton model modified to include dividend payments, and American style option contracts. The latter approach for valuing American style option contracts involves using the Black–Scholes–Merton model as a constraint in an optimal stopping problem calculation.

Deliverables. All project codes, documentation and testing data will be made available under an MIT software license on GitHub. The student will submit a project report, and present the project findings at department, college and university symposia.