Summary of PhD Dissertation of Norbert Fogarasi entitled

Polynomial Time Heuristic Optimization Methods Applied to Problems in Computational Finance

Computational finance is one of the most dynamically advancing fields of research over the last 60 years. With the advancement in computational hardware speed and heuristic techniques, many problems which were once believed to be intractable have been solved or sufficiently good approximations have been found. Recent research works in computational finance focus on finding fast approximations which can be applied in real-time, high frequency algorithmic trading applications as well as finding reliable approximate solutions to hard problems which have desirable runtime and generalization characteristics.

This dissertation has the same aims in two critically important research areas: portfolio selection and optimal scheduling, both of which have profound importance in present day financial computing. Optimal portfolio selection is one of the very first problems posed in the field in the 1950's and remains relevant to this day. Rather than the classical mean-variance approach, we look at the problem of selecting sparse portfolios which maximize mean reversion. I apply various search heuristics and stochastic search techniques which find approximate solutions to the resulting NP hard problem in polynomial time. Scheduling theory is also a very pertinent area of research with applications in many different disciplines, including computational finance. I look at a classical problem in the field and develop a number of near-optimal heuristics to find good approximate solutions with extremely favorable scalability properties.

In both cases, I show the viability and superiority of my methods on both a vast number of randomly generated synthetic data series as well as on real historical data, such as historical time series of major equity indices (S&P 500) and interest rate swap rates. For selecting sparse portfolios which maximize mean reversion, I do not only explain how to elegantly adapt stochastic search techniques to the problem, but I make a number of improvements upon the results found in the literature in terms of parameter fitting based on historical data for both the VAR(1) and the Ohrnstein-Uhlenbeck models. For scheduling tasks on identical machines such that total weighted tardiness is minimized, I show how the problem can be converted to a quadratic optimization form to be able to apply well-known heuristic algorithms. I further improve the method by smart choice of initial point for the iterative algorithm and suggest a method to further improve by perturbing this smart initial value. Using these results, large-scale Monte Carlo simulation computations can be significantly sped up for financial computations.

In both cases, the suggested methods result in double digit percentage improvement over the next best known heuristic method on both generated and real historical time series. I also conclude that the newly developed heuristic methods have good generalization properties which allow them to be applied successfully to a broad range of problems within computational finance. I also suggest further ideas and directions of research for the specific problems and suggested heuristic methods.

These results contribute significantly to making financial computing faster and more reliable for financial institutions, which has an impact on the efficiency of the banking system and thus benefit society as a whole.