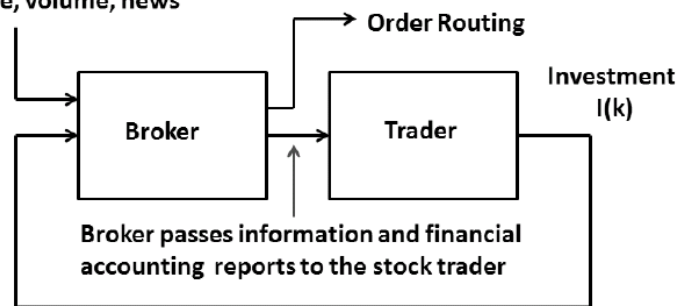


Opportunities for Control Theory in Stock Trading Research

In the world of stock trading, *technical analysis* generally refers to a class of strategies and indicators that are based on the use of price and volume data. Despite the heavy use of technical analysis by many professional market managers on Wall Street and individual investors alike, such strategies are one of the most controversial subjects in the area of finance. Although proponents of the Efficient Market Hypothesis have long claimed that technical analysis has little to no theoretical justification, there is an increasing body of literature to the contrary. Based on statistical analysis of back-tests using empirical data, numerous authors have argued that many technical analysis methods have significant validity. This dichotomy between theory and statistics is being addressed by ongoing research in the control community that models these popular methods from a feedback control perspective. In the process, this research opens the door to a rigorous new framework for theoretical analysis that is lacking in the existing finance literature.

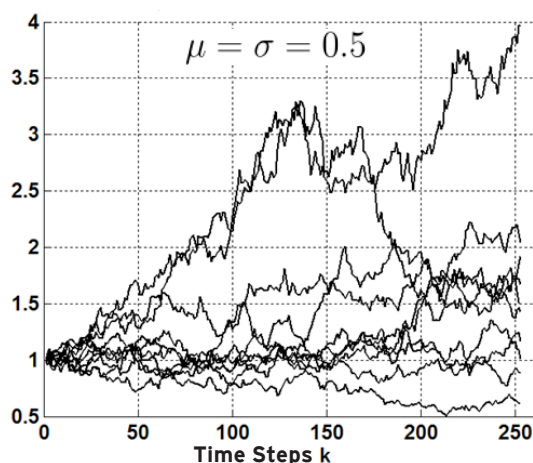


Broker gathers information such as price, volume, news



On Stock Trading Without a Model

In its “purest” form, technical analysis involves little or no reliance on an underlying model for stock prices. Instead, price patterns or other patterns such as those of gains and losses or trading volume are used to determine how an investment should be modulated over time. Many refer to this approach as “model free” or “reactive”; that is, the controller determines the investment level by reacting to the observed pattern without regard to an explicit prediction of future prices. This method is consistent with the viewpoint of robusticians in the control field (i.e., distrust of the underlying price model dictates the development of strategies along these lines).



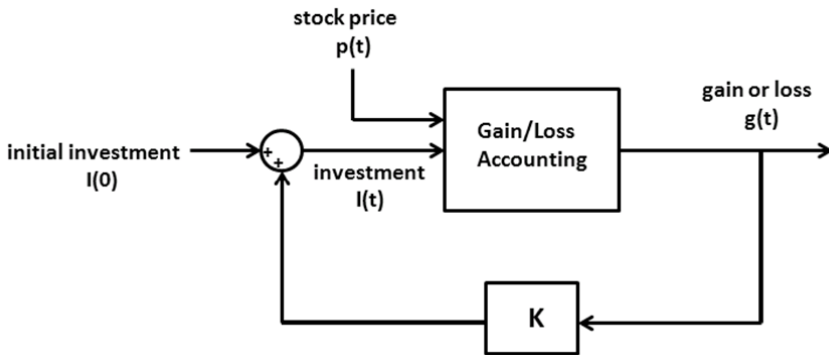
Brownian motion sample paths for price

Benchmarking Considerations for Control-Based Stock Trading Strategies

Analogous to performance evaluation standards used for algorithms in nonlinear optimization, stock trading strategies should “prove their worth” via back-tests using a sufficiently diverse group of benchmark price classes. Such classes include geometric Brownian motion (shown left), historical data for both stocks and sectors, and various other classes of stochastic processes. From a practical perspective, a theory, however elegant, is only as good as its back-tested performance. To this end, a focal point of ongoing research is the development of new benchmark stock price classes to serve as “proving grounds” for technically based control strategies in conjunction with several metrics for evaluating risk and return.

Contributors: James A. Primbs, California State University, Fullerton, USA, and B. Ross Barmish, University of Wisconsin-Madison, USA

Considerations Particular to Feedback-Based Stock Trading



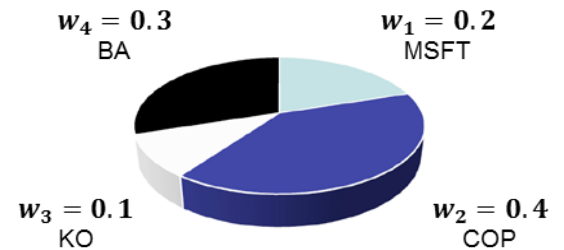
Reformulation of stock trading as a control system with feedback K and input $p(t)$

Modeling Technical Analysis via Feedback

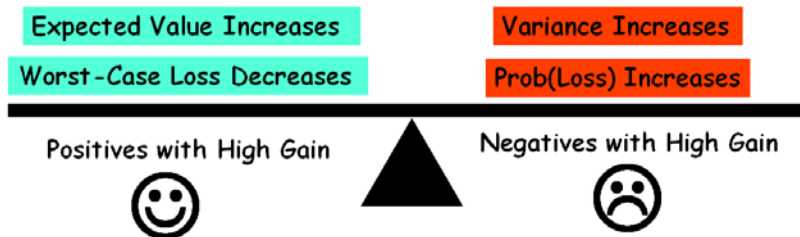
Many popular technical analysis strategies are modeled naturally as feedback loops. For example, the key characteristics of many pyramid-style trend-following strategies, as espoused by legendary traders such as Jesse Livermore and William O'Neil, can be captured via a model involving a simple proportional feedback mapping on cumulative trading gains and losses. The block diagram at left with a feedback control gain K corresponds to such a strategy and allows researchers to carry out a rigorous mathematical analysis of various performance-related quantities such as profits and losses. In this setting, the terminology "control specific risk" is used when studying the effects of K on performance.

Open Research Problem: Portfolio Balancing and Feedback-Based Technical Analysis

A *portfolio* is a collection of assets consisting of stocks, bonds, and cash. Modern portfolio theory deals largely with how to allocate wealth among these assets. The figure at right depicts this process for a portfolio consisting of Microsoft (MSFT), Conoco Phillips (COP), Coca-Cola (KO), and Boeing (BA). The i -th weight indicates the percentage of the wealth allocated to the i -th asset. Over time, portfolios are typically rebalanced based on market conditions; that is, as time evolves, various criteria are used to change the portfolio weights. An open research problem involves the development of new model-free technical analysis methods aimed at rebalancing a portfolio based on feedback control.



Example of portfolio weights



Tuning feedback gain K is a balancing act.

Challenges in Selection of Feedback Gains

Strategies based on feedback exhibit highly non-Gaussian return characteristics. Thus, the use of traditional measures of performance and risk are rendered unsuitable. Choosing appropriate feedback gains in a stock trading setting is a balancing act involving different aspects of the profit and loss distribution. One particular challenge is to formulate and solve new classes of optimization problems with many more parameters than the simple illustration at top left. In a portfolio context, there may be many stocks, each with its own feedback gain. In addition, the formulation and analysis of new optimization problems should include consideration of control-specific risk as described above.