Monte Carlo Simulations and System Trading

Opportunity Assessment, Risk Analysis and Validation of Mechanical Trading Systems

System trading with mechanical trading systems makes up an ever-growing portion of the global exchange activity of professional as well as private traders. Unfortunately, the current success rate of systematic trading, i.e. the ability to work profitably on a middle- to long-term basis, has not been able to keep pace with the method's increased popularity. The reasons are among other things, unsatisfactory development processes as well as inadequately tested systems. The application of Monte Carlo simulations during system development and testing can lead to a qualitative enhancement in the evaluation of opportunity, risk analysis and validation of mechanical trading systems.

An important fundamental principle of systematic trading with mechanical trading systems is the analysis of price data with the goal of generating buy and sell signals for execution in the financial markets. The user spectrum for these types of systems spans a range from large institutional banks and traders, commercial vendors of trading systems and the services that go with them, to professional and semi-professional developers and traders. However, many of these groups of users have made similar experiences with these systems' applications. The optimised trading systems, often in use for longer periods of time, function over a certain time span and then suddenly stop working. Some users have made much worse experiences, for example, when a successfully back-tested or paper-traded system fails in its first application to real markets using up the trading account faster than anticipated. Reason enough to look for ways to improve the development of mechanical trading systems.

This is where the Monte Carlo simulation comes into play. The method involves inserting a random component into a certain fundamental model and then conducting enough simulations in order to generate realistic scenarios spanning as much of the best and worst case spectrum as possible.

Within the realm of developing and testing mechanical trading systems, the Monte Carlo simulation can deliver valuable information about both the expected profit opportunity as well as the risk of a specific trading approach. In addition, using this method to create alternative synthetic data can be decisive in supporting the development and testing of robust mechanical trading systems.

Recently, Monte Carlo simulations as effective tools for system traders and developers has been widely discussed in literature and the press (e.g.*TRADERS´*) and mentioned by well-known international authors (Mandelbrot, Taleb).

Nevertheless, the importance of Monte Carlo simulation techniques for improving and validating mechanical trading systems continues to be underestimated. This article will attempt to explain pragmatically the essential components, which are system-simulation and data-simulation and organise these processes into the system's development process.

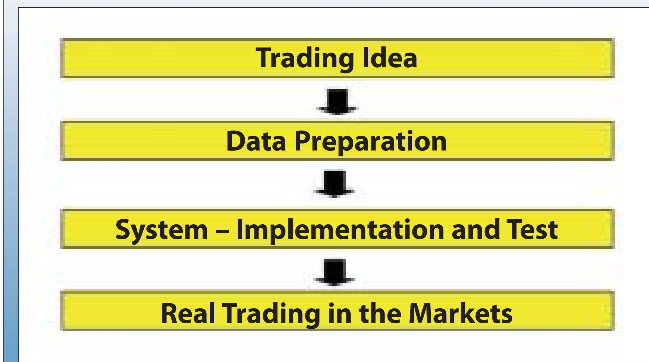
Conventional Systems Development

Conventional systems development processes as related to the development of mechanical trading systems can be diagrammed as shown in Figure 1. The goal of these processes is to find a profitable low-risk trading system for various market conditions, which also can be traded with a certain amount of available capital within a reasonable period of time. Initially, that may seem simple. However, in the real world, systems fulfilling all of the above mentioned requirements are very rare indeed.

This author sees two essential shortcomings in today's standard development of mechanical trading systems. On one hand, the inadequate assessment of a system's potential profit opportunity as well as potential risk (drawdown), and on the other hand, failure to properly validate system robustness. The nearly exclusive use of so-called "best" system reports as a basis for evaluating systems and the consequential decision to take part in real trading based on those reports, ignores immanent system volatility in these key areas. In addition, the decision to trade is often based only on system tests using original historical data of the security or instrument to be traded and the market conditions associated with that data. This ignores the possibility that different market conditions may develop.

Naturally, there are approaches to improve the quality of these system development processes using conventional means (e.g. dividing between system tests and out-of-sample tests, walk-forward data extrapolations, or the use of data from various markets, etc). Generally, however, these methods fail to achieve the desired goal of assessing a system's potential range of profitability based on an observed unit of time. They also do not deliver a realistic estimation of maximum account drawdown, nor do they allow an estimate of system behaviour under various market conditions. For meaningful stress and robustness tests, you need a test scenario with an adequately large quantity structure, which is usually not sufficiently available in conventional test scenarios. However, system and data simulations based on the Monte Carlo simulation technique, introduced in detail below, do in fact allow these considerations!

F1) Conventional Systems Development Process



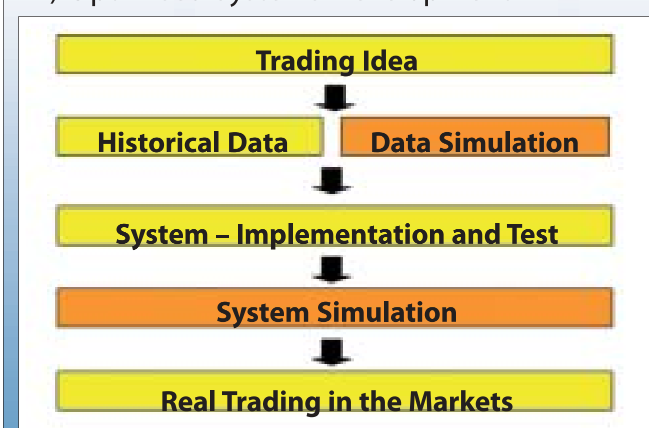
This shows a standard development process, which essentially consists of using original data for system development and system tests.

Optimised System Development Processes

Supplementing conventional system development processes with the above described Monte Carlo simulation method or system and data simulation techniques respectively, leads to an optimised systems development process (Figure 2).

An additional process step – the system simulation – allows a differentiated analysis of the opportunities and risks of system application under the influence of random components. If the system simulation is positive, then the next process step – data simulation – goes beyond available historical data and uses additional synthetic data for testing. These two simulation techniques should be understood as a two-step concept for the purpose of developer

F2) Optimised Systems Development



An optimised process contains the additional steps of data simulation and system simulation.

F3) System Simulation, Input/Output

This shows the necessary input data for a system simulation based on the Monte Carlo method, which better indicates potential swings in profit and loss results.

Source: www.zentrader.de

F4) Profits and Drawdowns in a System Simulation

Figure 4 shows the distribution of profits and drawdowns generated by the testing software.

Source: www.zentrader.de

productivity. Data simulation is really only necessary after the trading system has passed the system simulation step. However, many systems usually fail at that point.

System Simulation

What is system simulation? A system simulation allows a system to be stress-tested. Input data used is available from already conducted system reports such as the number of profitable trades, the number of losing trades, the average profit per winning trade, average loss per losing trade as well as other data.

Simulation-specific input data for the testing software is also needed. This might include the number of trades per simulation run or the total number of total simulation runs. Variables for risk control such as value-at-risk parameters could also be entered. Figure 3 shows the input data as well as the result of a system simulation. Figure 4 shows the distribution of profits and drawdowns generated by the testing software.

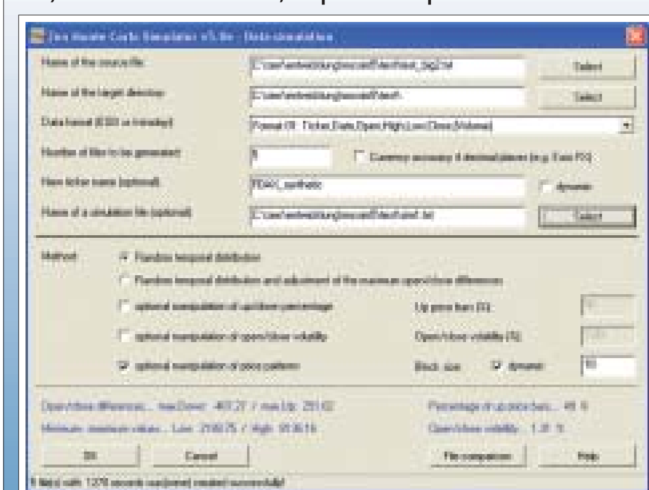
In the example, a Monte Carlo simulation-based stress-test of 3.7 million trades was conducted on a profitable FDAX system utilising one contract. The original system test showed a yearly profit of €21,000 and a maximum drawdown of €-1,300 in back-testing. In contrast, the opportunity assessment based on the system simulation showed a potential profit range of €3,000 to €41,000. The simulation also showed a maximum account drawdown of €-23,000. Among other things, this is a first indication of the necessary account size for this trading system, which should be between €30,000 and €40,000 when considering Eurex margin requirements. Thus the system simulation delivers a differentiated statement about the FDAX system's assumed profit bandwidth within defined time limits as well as an eye-opening risk analysis showing a much greater potential drawdown than was the case with the original one dimensional system test.

However, the system simulation only used historical data in this instance, thus showing potential performance and risk under the assumption that market conditions remain the same. In order to introduce changed market conditions into the development process, a data simulation must be added as an additional test component.

Data Simulation

Data simulation, also known as data scrambling, is a technique that creates new data based on the characteristics of the original historical data and the inclusion of a random component based on the Monte Carlo simulation. Additional optional configurations and parameterisation can also be used. The new data is then available for additional system testing, helping to avoid a main source of error in

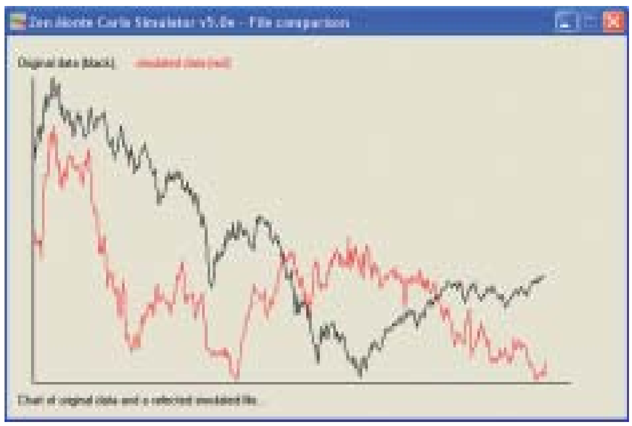
F5) Data Simulation, Input/Output



This shows the necessary parameters for the generation of synthetic data in a data simulation.

Source: www.zentrader.de

F6) Simulated Price Movement



This chart shows a comparison of synthetically generated simulation data in red with actual historical data in black.

Source: www.zentrader.de

conventional system development – namely over-optimisation or curve fitting. Figure 5 shows possible configurations for this type of data simulation. Figure 6 is an exemplary graphical comparison of an original historical data series and a randomly chosen synthetic data series.

The advantage of applying data simulation techniques to an optimised system development process is that potentially varying market conditions can be simulated with nearly as many different price series as desired. Thus, system tests can be conducted in as many different imaginable scenarios as needed and over-optimisation in the development and testing phase is largely avoided. As opposed to the alternative of testing with price data from different markets, data simulation allows maintaining typical price characteristics associated with the market to be traded. However, there are caveats. You should not assume to be able to completely simulate complex markets or future market behaviour using a test model. Even if that is not intended, the already present diversity involves a rather substantial test effort. Even if these methods and techniques can never guarantee a Holy Grail, system simulation and data simulation can vastly improve opportunity assessment, risk analysis and validation of mechanical trading systems. In addition, there is software available requiring only minimal data input in order to attain informative simulation and test results enhancing the productivity of trading system developers and system traders.

However, traders that use purchased systems can also use the described techniques to check their mostly black box systems. The requirement here of course is that system vendors make the applicable system-report results available and if possible provide a so-called black box system tester for your system in order to verify system performance with alternative data.

System simulations are already partially integrated in well-known trading system development environments (e.g. Investoxx, Tradesim, etc.). However, data simulation is still in the early stages of development. Continued development of data simulation methods as well as an improved integration in available system-test and system-development software would be desirable goals for the future.

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