Automatic Synthesis of Trading Systems

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The process of developing mechanical trading systems often leads to frustration and to a financial disaster if the systems do not perform as expected. The majority of those who attempt to develop mechanical trading systems quit sooner or later and if they decide to continue trading adopt an alternative style. As it turns out, developing a winning trading system is an art and a science and requires both quantitative skills and experience with the operation of the markets. To succeed, it is not enough purchasing a fast computer, getting a high speed Internet connection, reading a few good books on technical analysis and attending a few seminars. It is also required that traders invest personal time and go through the learning process of system development. Very few make it to the end of the road and, of course, the end is not the "Holy Grail" but a trading system with an acceptable performance.

An alternative to developing a system is getting a black box that advertises huge monthly returns. However, most traders do not trust black-box systems because they have a poor record of meeting expectations and prefer to develop their own using one of those sophisticated software programs for trading system development and analysis. There is at least a dozen or more such program available in the marketplace at a moderate price. Some are even offered at no extra cost to those that open an account with a broker. These programs have a high-level programming language for implementing and testing trading system and advanced capabilities for statistical analysis of the results. There are at least two problems with the use of such programs. The first problem is that implementing even a simple trading system requires knowledge of programming. The presence of high-level language eases but does not eliminate completely this requirement. The second problem is more fundamental and it has to do with the fact that these "back-testing" programs do not offer a clue of how to come up with a winning trading system in the first place -- all you can do with them is to test it after you find it. The burden of finding a system is on the user and this must be done before it is implemented in these programs.

Just a small fraction of traders have the skills and the experience to develop a system suitable for mechanical trading and some of them are very successful indeed and end up making a lots of money trading the markets. Having a winning trading system and the discipline to follow its signals is like a license to print your own money. This is the main reason traders are so persistent in their search for winning systems. For those that do not succeed in finding a good system using the conventional methodology discussed above there is an alternative method: develop a program that automatically discovers trading systems.

In principle, the idea of automatic discovery of trading system is simple. You let the computer do the work based on a set of rules of what constitutes a winning trading system. The computer will search for profitable trading systems that fulfill the user criteria and requirements. The trader is not required to do any work, just inspect the results and see whether the computer did a good job. Since computers do not take coffee break, do not plan for vacation, take no maternity leave and can work three shifts a day, etc., the efficiency of such process can be extremely high. The trader can concentrate on other productive tasks and let the computer search for winning trading systems. This is at least theoretically sound and also an appealing concept but it requires an essential ingredient to be practical: a program that can do the job. The problem is then developing such a program.

"Trading System Synthesis" is a method developed by this author in mid 90's (see references) for solving the problem just defined, i.e. the problem of developing a program for the automatic discovery of trading systems. The term *synthesis* is used here as opposed to the term *analysis*. As far as trading system development is concerned, the distinction adopted here is as follows: "Analysis" refers to a process by means of which a trading system based on a set of pre-defined rules is tested to determine if it generates acceptable results in a given historical time period. On the other hand, "synthesis" refers to a process by means of which the desired performance of the system is specified in advance and based on that the rules, or code, that completely defines the system are discovered by some mechanical means. This guarantees that the historical performance of the trading system matches or exceeds expectations in a specified period of time.

Analysis of trading systems

Before we describe how the process of synthesis works, let us first take a look at the traditional analysis methodology, which is outlined in Figure 1. When a trading system is available, it is coded using a computer language, usually a high-level language. Back testing the trading system involves determination of exact market entry and exit signals followed by a calculation of a set of performance statistics, such as the success rate or profitability, the profit factor, the number of winning and losing trades, the maximum intraday drawdown, etc. The results are then analyzed using various statistical measures in order to determine whether the trading system is acceptable.

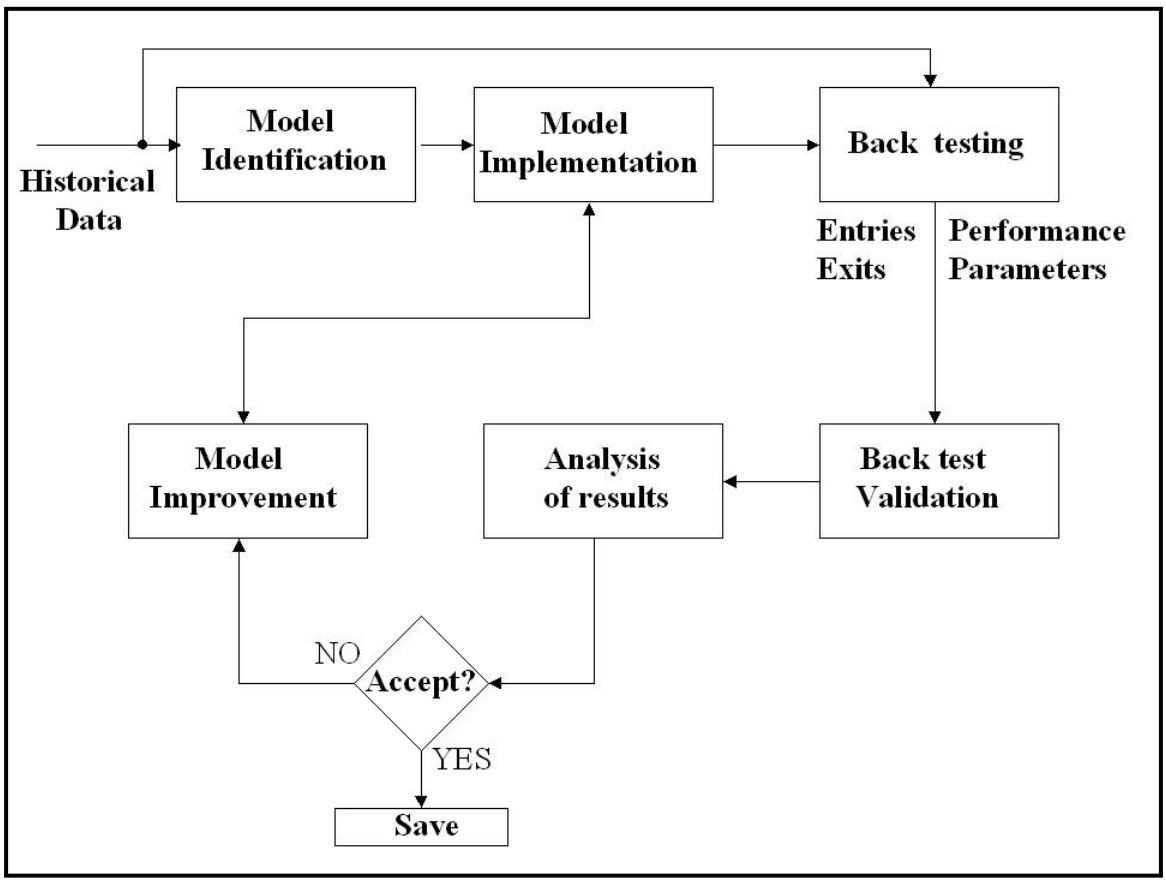

Figure 1. Development of trading systems using analysis

The trading system code may be modified for the purpose of improving performance and the process of analysis is repeated. This is a trial-and-error method for trading system development and it is based one an advanced description of the system and on historical back testing.

Synthesis of trading systems

We now turn our attention to an alternative method of trading systems development we call "synthesis" as outlined in Figure 2. This method involves a model identification algorithm. The algorithm requires as input the general description of the trading systems that are considered during the synthesis. The other input to the algorithm is the historical data and its output is the code (model) of each candidate trading system to back test. The back testing involves calculation of a set of performance statistics of each candidate trading system. An analysis of the performance statistics determines whether the criteria specified in advance by the user are satisfied. This is all done automatically. If the performance matches or exceeds expectations, then the code of the trading system is saved in a database, otherwise it is rejected and the process continuous with the next identified trading system and terminates when there are no more trading systems to back test and analyze.

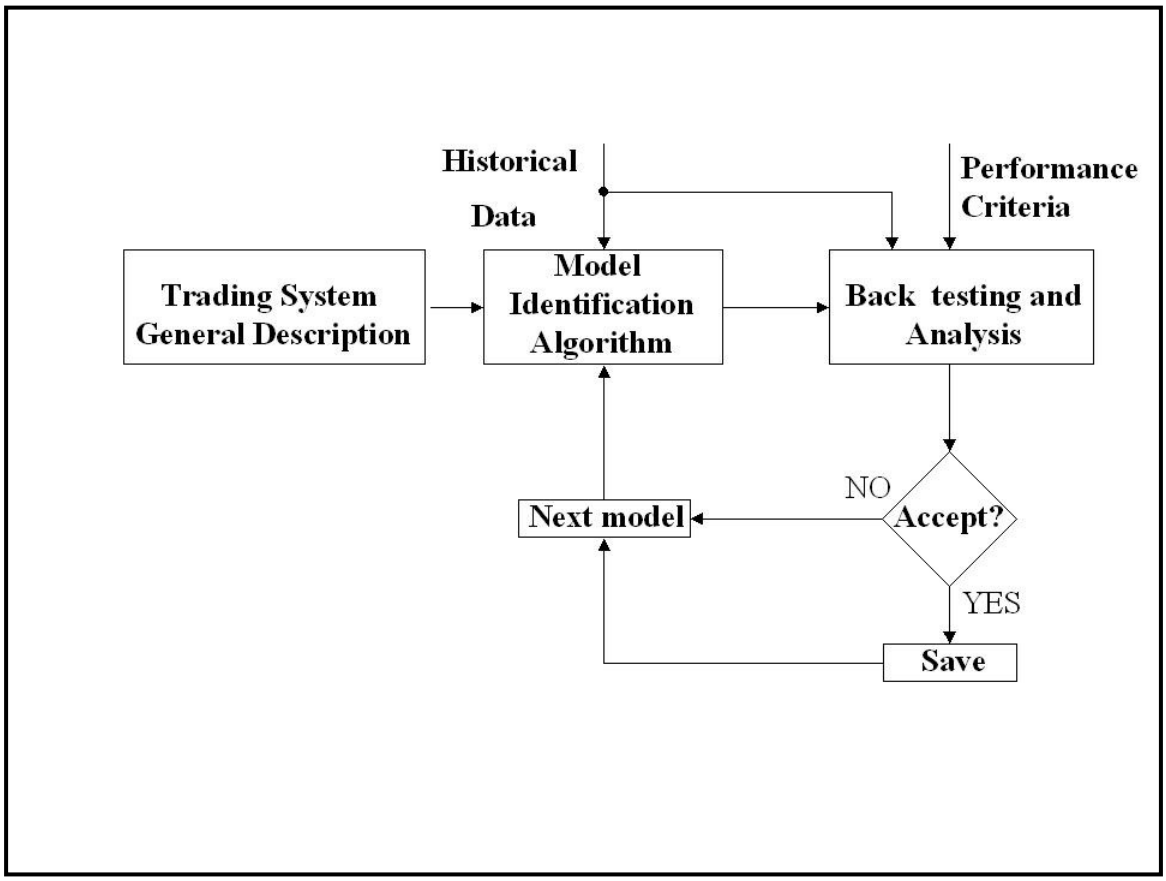

Figure 2. Development of trading systems using Synthesis

We will now take a closer look at each of the steps shown in Figure 2.

Trading System General Description

This part of the synthesis process describes the general structure of the trading system that can be identified. Searching for trading systems is only made possible if there are established guidelines regarding their general structure. The general description does not imply knowledge of the trading system code. The determination of the code (model) given the general descriptions is the task of the model identification algorithm.

Model Identification Algorithm

The general description of trading systems is one of the inputs to the model identification algorithm. The other input is historical data. The output of the algorithm is the code of trading systems that are candidates for meeting the performance criteria specified by the user in advance. Trading systems that do not fulfill some of the performance criteria, such as a minimum number of trades over the test period, for example, may be rejected before the back-testing step. This speeds up the process significantly.

It is evident that as general descriptions get more complex this places an additional burden on the process and the probability of finding trading systems that fulfill the performance criteria decreases. Efficient synthesis of trading systems requires a fine balance between what is defined in advance in terms of general descriptions and what is to be identified in order to determine precise code one can use in actual trading. Theoretically, a general identification algorithm is possible but practically such algorithm is very difficult if not impossible to implement. Custom identification algorithms that work with a specific class of general descriptions offer the highest a potential for good results at reasonable execution speed.

Back Testing and Analysis

The trading systems generated by the Model Identification Algorithm are back tested using historical data and this step allows calculation of a set of performance parameters. The parameters that are used to select trading systems must be specified in advance. As the number of the parameters considered increases, the probability of finding trading systems that meet or exceed the performance criteria decreases significantly. A minimal set of parameters may include the percent profitability, number of historical trades and maximum consecutive losers. As more parameters are added to the set, the complexity of the synthesis process increases with the risk of rejecting all candidate systems. In order to reduce the complexity, the performance criteria must be selected carefully based on the intended application of the trading systems.

Back testing and analysis acts essential as a filter to reject trading systems with unacceptable performance. The code of trading systems with performance that matches or exceeds expectations is stored in a database and the process continuous until there are no more trading systems to back-test and analyze.

Table 1 is a comparison table of analysis and synthesis of trading systems.

Operation	Analysis	Synthesis
Trading system code	Available in advance	Automatic Search
Trading system structure	General	Class of systems
System improvement possible?	Yes	No
Performance analysis	Manual	Automatic (included)

Table 1. Analysis versus synthesis

It may be seen from table 1 that the main advantages of synthesis are gained at the expense of a generality. However, analysis is useless unless specific code is available in advance. Although the automation of the trading system discovery process results in loss of generality, the method is very powerful and efficient when a specific class of trading systems is targeted.

The next step in mechanical trading

Automatic discovery of trading systems is the next step in mechanical trading. Going to this next step does not mean that discovering profitable trading system is now a trivial exercise. The main new difficulty now is designing an algorithm that will search for a broad class of trading systems in an efficient way. As already mentioned the gains realized from using automatic discovery of trading system come with a loss of generality of the class of trading systems the algorithm is able to search for. Regardless of the method used to discover and develop trading systems, all traders should remember that trading, especially intraday and short-term involves substantial financial risks and can result in total loss of capital.

References

Profitability and Systematic Trading (Wiley, 2009). For more details see:

http://www.wiley.com/WileyCDA/WileyTitle/productCd-047022908X.html

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