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Portfolio Back-Testing with Portfolio Maestro: Optimization

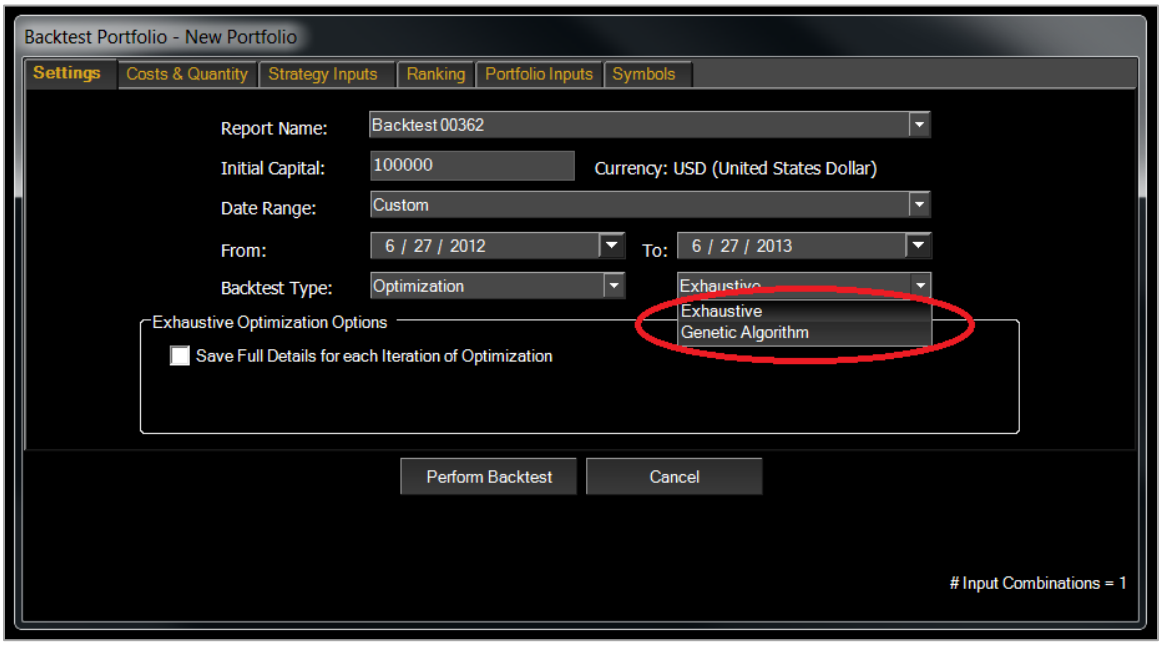
Frederic Palmliden, CMT
Senior Quantitative Analyst
TSLabs@TradeStation.com

Summary

Portfolio Maestro offers advanced functionality that allows users to back-test a portfolio of symbols on one or more strategies, based on user-specified criteria. In this fourth installment of our white paper series on Portfolio Maestro, we analyze the three types of optimization in the program – Exhaustive, Genetic, and Walk Forward – and explore some practical examples.

Exhaustive optimization tests every possible combination of strategy inputs and ranking values according to user-specified ranges. Genetic optimization uses a genetic algorithm to minimize the total number of tests required to produce a statistically valid back-test. Walk-forward optimization attempts to reduce the chance of over-fitting strategies by testing them against out-of-sample data.

Figure 1: Optimization Options



Exhaustive Optimization Background

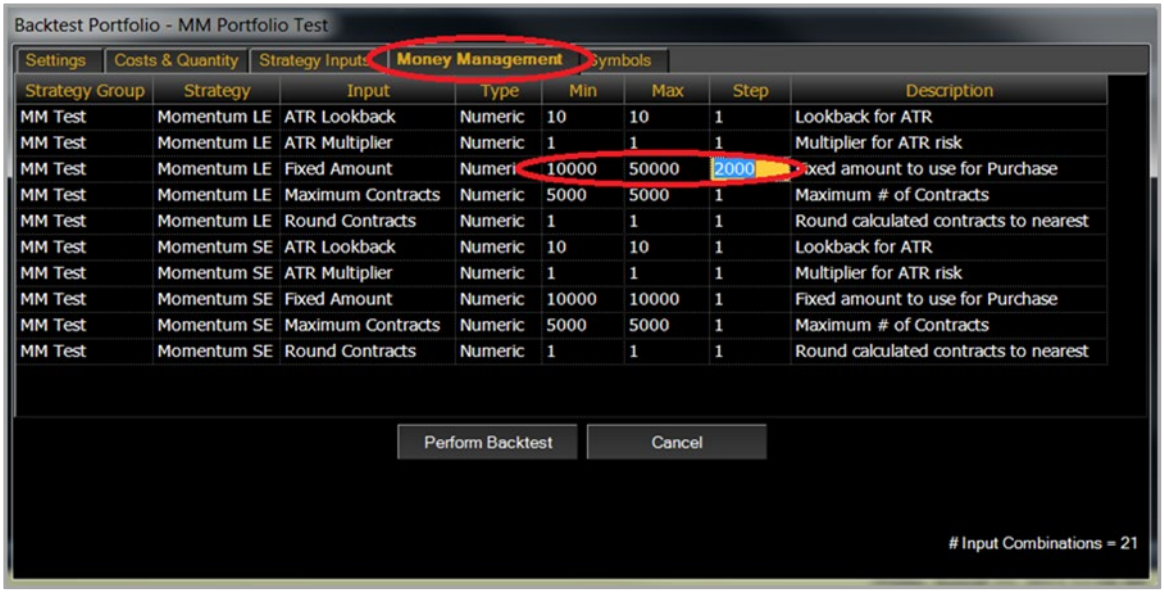
Exhaustive optimization runs multiple tests by varying the specified strategy input and ranking values over a defined time period. As the name implies, the key to exhaustive optimization is that this approach is designed to be comprehensive or exhaustive in nature, which can be a great advantage for traders who want to see the impact of all strategy input adjustments. A minimum and maximum setting (i.e., Min and Max setting) determine the range of values to test, while the Step setting dictates how much to increment the value for each test (see the highlighted area in the top portion of figure 2 below).

Figure 2: Strategy Input Optimization Ranges

The total number of back-tests needed to perform the exhaustive optimization can be found in the lower right corner of the Backtest Portfolio dialog (highlighted area in the lower portion of figure 2 above). Keep in mind that the number of combinations is the number of tests per symbol within the portfolio.

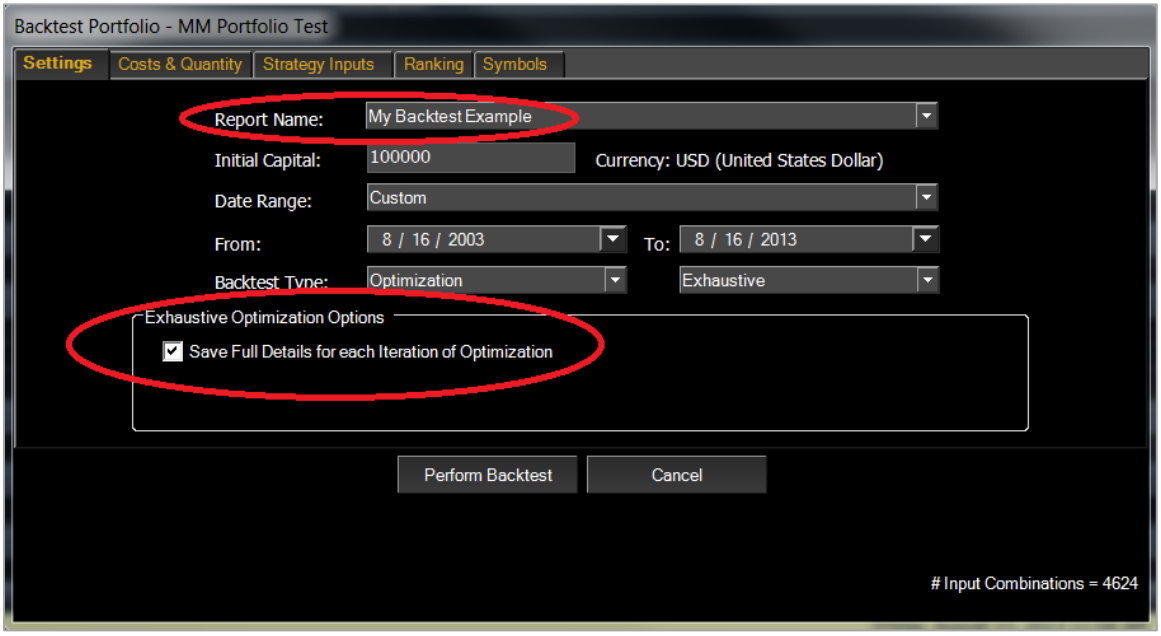
The exhaustive back-test is not limited to strategy inputs. The back-test can also include portfolio inputs if constraints or portfolio stops are being used, as well as money-management and ranking inputs (see figure 3 below).

Figure 3: Money-Management Exhaustive Optimization Inputs



To access the exhaustive optimization options, first select a portfolio to back-test using the Manage Portfolio icon. Then click on the Backtest icon on the top right corner of the screen, which will open the Backtest Portfolio dialog. In the Settings tab, select Optimization and Exhaustive as the Backtest Type (see figure 1). Then select the input ranges to include in the back-test using the appropriate tab (e.g., Strategy Inputs tab). To see the full details for each iteration of optimization versus the standard optimization report, select the box in the Exhaustive Optimization Options section (see figure 4 below). Finally, click on Perform Backtest in the lower portion of the dialog to start the exhaustive back-test.

Figure 4: Exhaustive Optimization Options

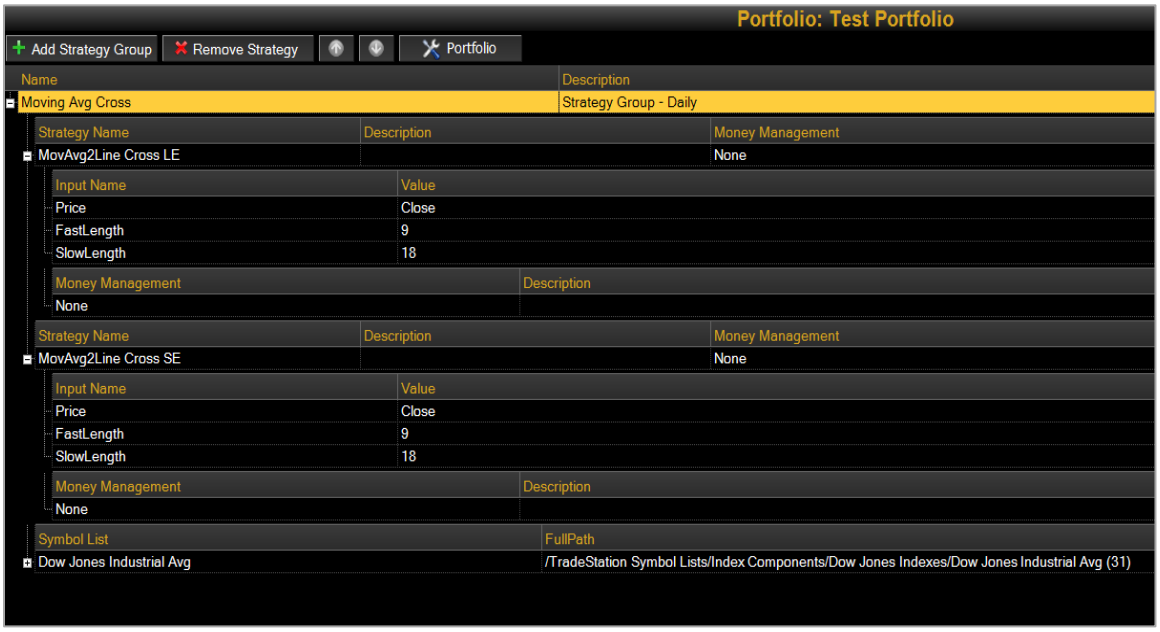


Once the exhaustive optimization is complete, a report is available to view immediately or it can be saved for later viewing. The report is saved automatically and the name of the report can be specified prior to running the optimization (see the Report Name field in Figure 4 above). The optimization report will be analyzed more closely in the next section.

Exhaustive Optimization Example

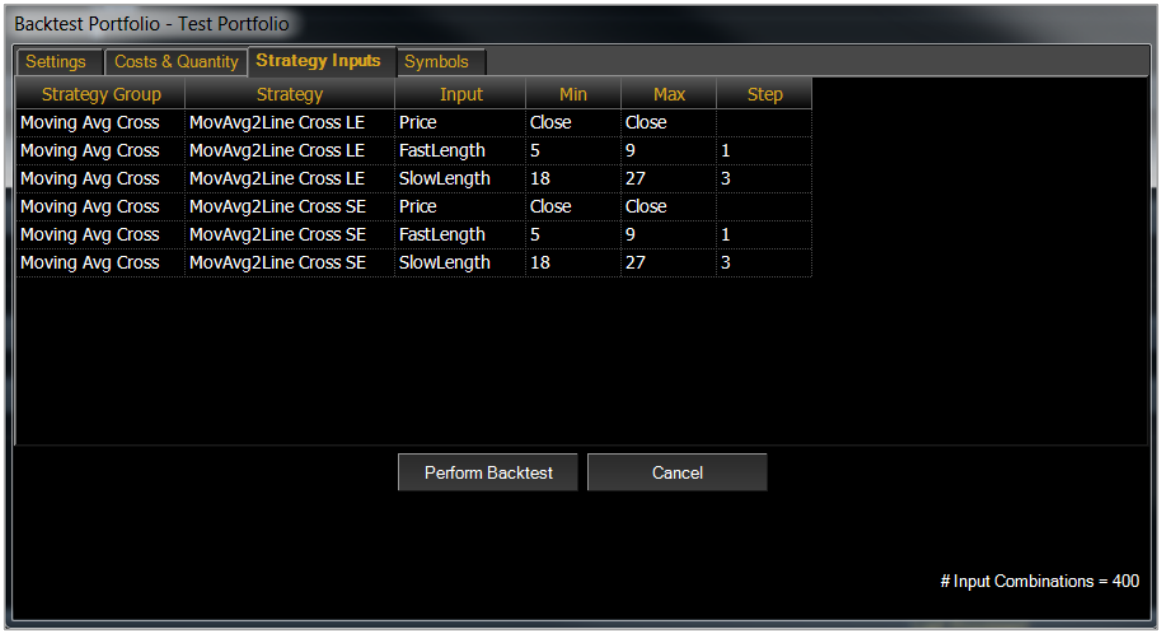
In the following example, a new Strategy Group is created with a two moving average cross trading system by including both the MovAvg2Line Cross LE and the MovAvg2Line Cross SE strategy components on the Dow Jones Industrial Average index components (see figure 5 below). For step-by-step instructions on how to create and set up a Strategy Group and a Portfolio, please refer to the previous white papers in the series. A complete reference to the previous white papers in the series is found at the end of this paper.

Figure 5: Two Moving Average Cross Strategy Group and Portfolio Example



The newly created Strategy Group is then added to a new Portfolio, which is ready to back-test using the exhaustive optimization. The different settings for the exhaustive optimization are highlighted in figure 6 below. The ranges purposely include a shorter-length moving average with a longer length for both strategy components with no overlap for a total of 400 combinations. For this example, a look-back of two years of daily data is used in the Settings tab. Keep in mind also that commissions, slippage and order quantity amounts (e.g., fixed shares amount or fixed dollars amount) can be specified if needed.

Figure 6: Exhaustive Optimization Settings Example



Once the back-test is complete, the optimization report is available for viewing (see figure 7 below). Notice that basic information (e.g., Total Return, Number of Trades) is available and the report displays the information line by line. Each line in the optimization report corresponds to a combination of inputs tested on the portfolio. Also, the data can be sorted by selecting a particular column in ascending or descending order. For example, the data in figure 7 is sorted using the Total Return field. Therefore, the maximum and minimum outcomes are viewable, as are all the outcomes in between, according to a selected field (e.g., Total Return). In this case, a fast length of 5 and a slow length of 18 for long entries, and a fast length of 9

and a slow length of 18, generated the highest total return. Once a particular combination of inputs of interest is found, additional analysis can be performed using that particular combination, such as running a standard back-test or running a walk-forward optimization report.

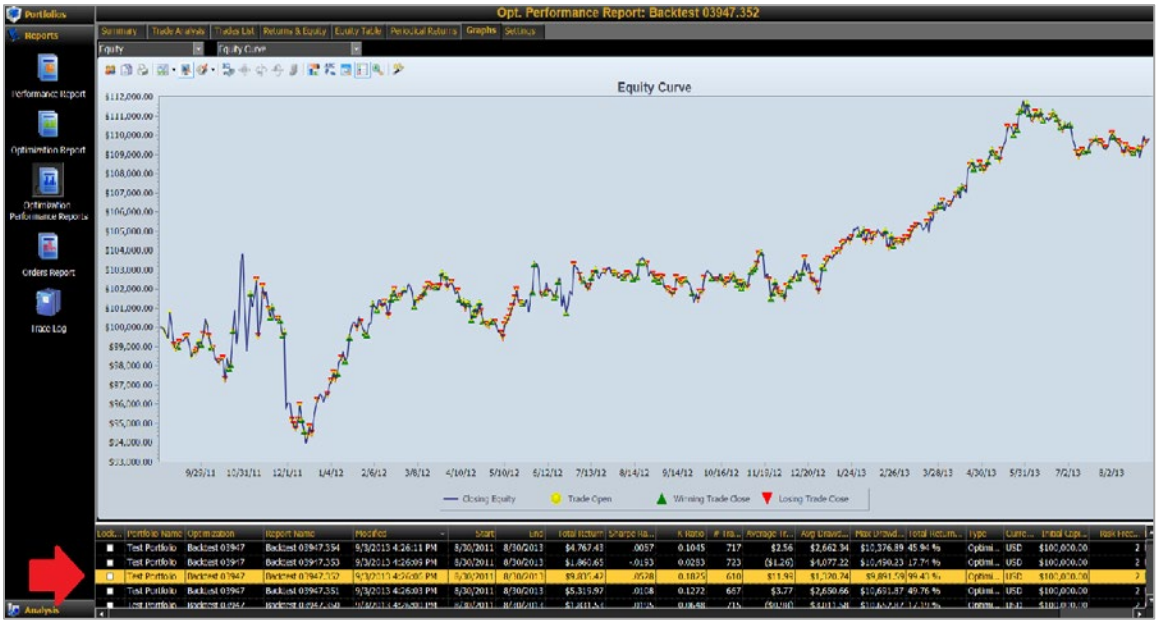
Figure 7: Exhaustive Optimization Report Example

Opt. Performance Report: Backtest 02971

Test	Total Return	Trades	Avg Trade	Avg Drawdown	Max Drawdown	Sharpe Ratio	K-Ratio	Total Return / Max Drawdown	Inputs
017	$25,412.00	767	$27.35	$2,052.43	$15,083.00	0.1071	0.1497	168.48 %	FastLength=5,SlowLength=18;FastLength=9,SlowLength=18
097	$22,984.00	773	$23.45	$2,268.05	$14,331.00	0.0925	0.1349	160.38 %	FastLength=6,SlowLength=18;FastLength=9,SlowLength=18
013	$22,000.00	782	$21.87	$1,813.92	$17,695.00	0.0867	0.1073	124.33 %	FastLength=5,SlowLength=18;FastLength=8,SlowLength=18
177	$21,304.00	796	$19.62	$2,415.35	$14,251.00	0.0835	0.1571	149.49 %	FastLength=7,SlowLength=18;FastLength=9,SlowLength=18
093	$20,486.00	787	$19.19	$2,252.62	$16,066.00	0.0790	0.1375	127.51 %	FastLength=6,SlowLength=18;FastLength=8,SlowLength=18
092	$19,815.00	620	$26.01	$2,206.26	$17,530.00	0.0784	0.1386	113.03 %	FastLength=6,SlowLength=18;FastLength=7,SlowLength=27
012	$18,733.00	624	$24.76	$2,059.10	$18,606.00	0.0722	0.1206	100.68 %	FastLength=5,SlowLength=18;FastLength=7,SlowLength=27
014	$18,462.00	723	$21.18	$2,121.96	$19,310.00	0.0675	0.1351	95.61 %	FastLength=5,SlowLength=18;FastLength=8,SlowLength=21
015	$18,305.00	657	$25.15	$2,379.10	$18,552.00	0.0686	0.1248	98.67 %	FastLength=5,SlowLength=18;FastLength=8,SlowLength=24
257	$18,227.00	822	$14.89	$2,220.56	$14,702.00	0.0679	0.1219	123.98 %	FastLength=8,SlowLength=18;FastLength=9,SlowLength=18
094	$17,078.00	728	$18.55	$2,639.44	$17,944.00	0.0608	0.1393	95.17 %	FastLength=6,SlowLength=18;FastLength=8,SlowLength=21
095	$16,155.00	661	$20.95	$2,706.44	$18,876.00	0.0576	0.1165	85.58 %	FastLength=6,SlowLength=18;FastLength=8,SlowLength=24
098	$15,305.00	692	$17.94	$2,377.84	$16,588.00	0.0522	0.1277	92.27 %	FastLength=6,SlowLength=18;FastLength=9,SlowLength=21
033	$15,220.00	742	$12.92	$2,743.00	$16,820.00	0.0554	0.1129	90.49 %	FastLength=5,SlowLength=21;FastLength=8,SlowLength=18
037	$14,919.00	728	$12.12	$3,381.69	$15,762.00	0.0558	0.1052	94.65 %	FastLength=5,SlowLength=21;FastLength=9,SlowLength=18
099	$14,677.00	639	$19.25	$2,888.64	$17,152.00	0.0531	0.1065	85.57 %	FastLength=6,SlowLength=18;FastLength=9,SlowLength=24
096	$14,376.00	609	$19.33	$2,571.53	$18,736.00	0.0504	0.1106	76.73 %	FastLength=6,SlowLength=18;FastLength=8,SlowLength=27
032	$14,364.00	623	$16.00	$2,629.14	$18,168.00	0.0525	0.1054	79.06 %	FastLength=5,SlowLength=21;FastLength=7,SlowLength=27
100	$14,264.00	589	$20.22	$2,896.93	$19,178.00	0.0506	0.1155	74.38 %	FastLength=6,SlowLength=18;FastLength=9,SlowLength=27
009	$13,817.00	817	$10.31	$2,629.07	$19,575.00	0.0460	0.0753	70.58 %	FastLength=5,SlowLength=18;FastLength=7,SlowLength=18
035	$13,421.00	659	$16.01	$2,598.75	$18,114.00	0.0467	0.1098	74.09 %	FastLength=5,SlowLength=21;FastLength=8,SlowLength=24
029	$13,118.00	771	$8.64	$3,119.67	$18,051.00	0.0452	0.0722	72.67 %	FastLength=5,SlowLength=21;FastLength=7,SlowLength=18
008	$13,080.00	660	$13.90	$2,665.94	$21,010.00	0.0422	0.0818	62.26 %	FastLength=5,SlowLength=18;FastLength=6,SlowLength=27
088	$12,908.00	656	$13.09	$3,008.77	$19,934.00	0.0413	0.0869	64.75 %	FastLength=6,SlowLength=18;FastLength=6,SlowLength=27
018	$12,888.00	690	$15.25	$2,041.74	$16,008.00	0.0425	0.1256	80.51 %	FastLength=5,SlowLength=18;FastLength=9,SlowLength=21
016	$12,686.00	613	$17.28	$2,961.62	$19,812.00	0.0417	0.0965	64.03 %	FastLength=5,SlowLength=18;FastLength=8,SlowLength=27
089	$12,681.00	841	$8.48	$2,745.14	$17,515.00	0.0408	0.0918	72.40 %	FastLength=6,SlowLength=18;FastLength=7,SlowLength=18
172	$12,633.00	617	$14.23	$2,923.69	$17,866.00	0.0431	0.1150	70.71 %	FastLength=7,SlowLength=18;FastLength=7,SlowLength=27

Also, for a more comprehensive optimization report, select Save Full Details for each Iteration of optimization in the Settings tab before performing the optimization. The lower portion of the optimization performance report screen displays the list of optimization tests, where each line corresponds to a particular combination of inputs. To view the performance report for a particular combination of inputs, select the desired line (see red arrow in figure 8 below). The layout of the optimization performance report is identical to the performance report generated from a regular back-test, including multiple tabs with different options (e.g., Summary, Trade Analysis and Graphs).

Figure 8: Optimization Performance Report Equity Curve Example



Optimization reports are available for later viewing by clicking on Report in the Shortcut Bar and selecting either the Optimization Report icon or the Optimization Performance Reports icon. Keep in mind that each report can be named in the Settings tab prior to being performed for convenient future access.

One of the main advantages of running exhaustive optimization with Portfolio Maestro is that the process is vertical versus horizontal, just like a standard back-test. Therefore, instead of testing each symbol within the portfolio using a range of inputs, the entire portfolio is tested at the same time using all positions with a particular combination of inputs in order to perform a back-test that is closer to a real trading experience.

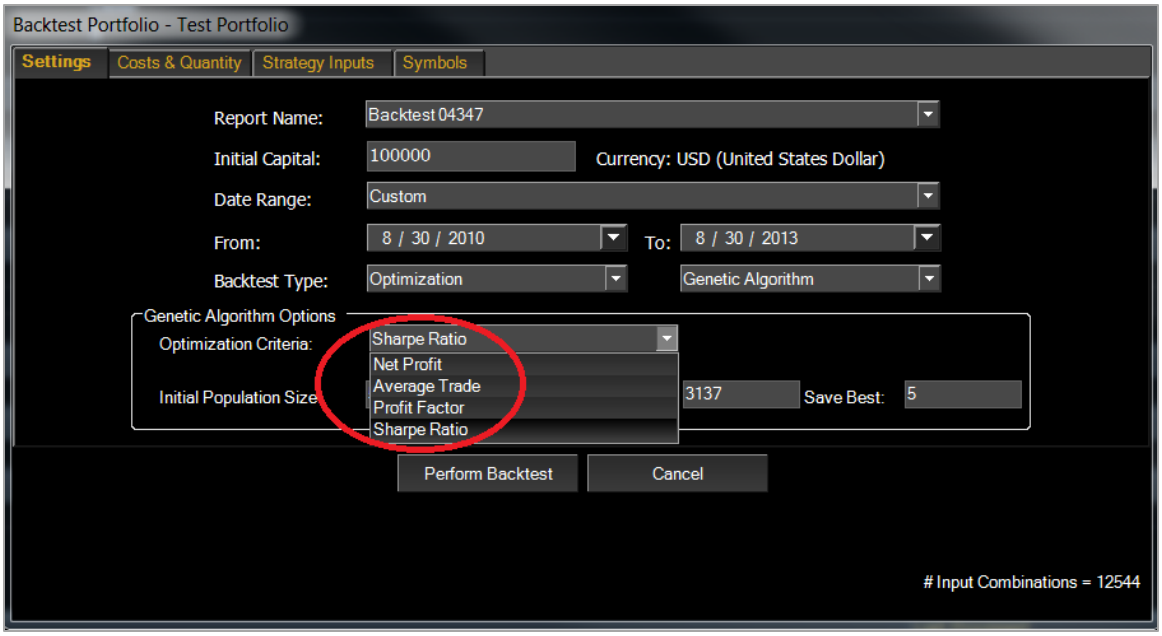
Several factors affect the back-testing speed, including the number of intervals per day, the number of days of history, the number of symbols and the number of input combinations. A larger number of parameters means a lengthier amount of time to complete an exhaustive optimization. The key to understanding sizing considerations is to understand what is being requested (i.e., understanding how many bars will be processed and how many action signals will be evaluated). Back-testing speed quickly becomes an issue when more complex strategy components are analyzed with a longer look-back period. The usual solution is to turn to genetic optimization.

Genetic Optimization Background

Genetic optimization provides a sharp contrast to an exhaustive approach. A genetic algorithm helps to minimize the total number of tests required to perform an optimization, which is especially beneficial when the number of combinations in an exhaustive optimization is very large. The genetic optimization process starts with a population of randomly selected individuals (i.e., Initial Population Size), where the population in each iteration is called a generation. For each generation, the Optimization Criteria, also called fitness, of every individual in the population is evaluated. Individuals that demonstrate fitness are selected and the individual's parameters are then randomly modified to form a new generation. The new generation is then used in the next iteration of the algorithm. The genetic algorithm terminates when a specified maximum number of generations has been produced (source: Wikipedia 2013).

There are currently four different factors to choose from as the Optimization Criteria: Net Profit, Average Trade, Profit Factor, and Sharpe Ratio (see figure 9 below). Notice also that once the input ranges have been specified for the optimization, recommended settings in the Settings tab will populate (i.e., Initial Population Size, Maximum Generations and Save Best), but the fields can also be manually specified.

Figure 9: Optimization Criteria within the Genetic Optimization



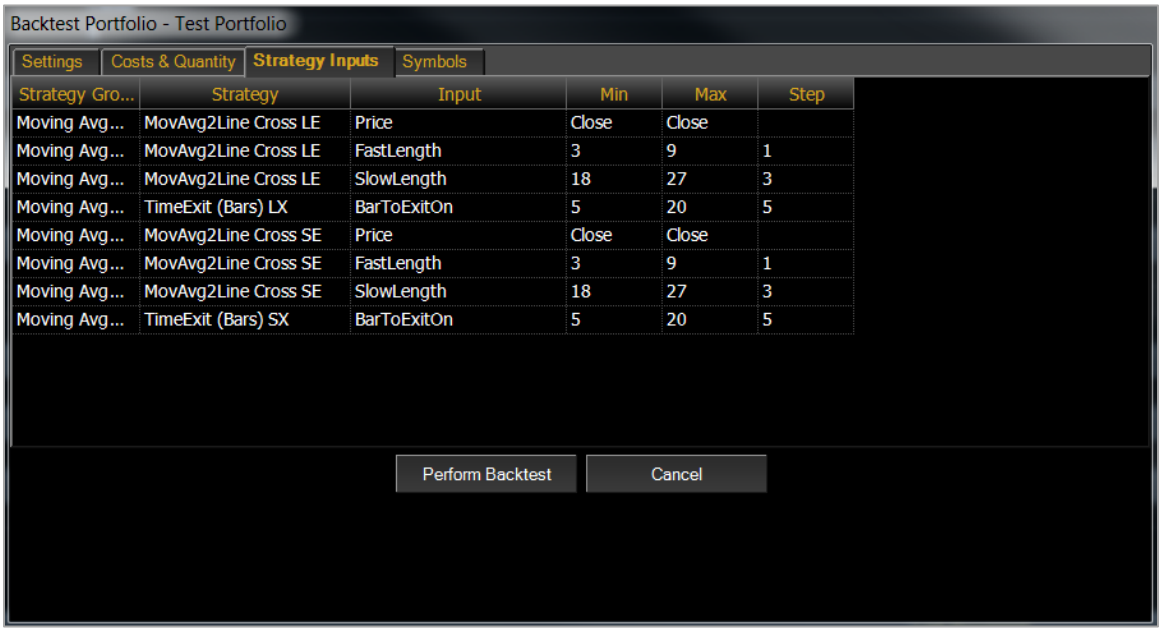
Genetic Optimization Example

The following example builds on the previous example. The same strategy components are used as before with the addition of strategy exits based on time (i.e., TimeExit (Bars) LX and TimeExit (Bars) SX). A total of six different strategy inputs are optimized (see figure 10 below) on the 30 index components of the Dow Jones Industrial Average, which dramatically increases the number of combinations to 12,544 in this case, prompting the need to use the genetic optimization approach.

Moreover, in order to reflect a more real-life trading example, the default trade size of 100 shares is adjusted to $3,000.00 rounded down to the nearest share using the Costs & Quantity tab. Otherwise, high-priced securities would have an overly influential impact on the overall portfolio.

In this case, the genetic optimization is run on three years of data using $100,000.00 in initial capital and the Total Return is selected as the Optimization Criteria.

Figure 10: Optimization



Once the genetic optimization completes, the optimization performance report is available for viewing (and can also be saved for later viewing). The specified number in the Save Best field in the Settings tab dictates the number of tests available for viewing in the report. For this example, the best 20 tests are displayed in figure 11 below.

Notice that each line corresponds to a distinct test with the particular set of strategy inputs listed in the far right column. By default, the report is sorted by the Test column, but the data can be easily sorted a different way by clicking on another column heading. The different columns can be rearranged if needed by clicking and dragging a column heading to a different position within the report.

The report can be exported to Microsoft Excel by clicking on the Export to Excel button in the top portion of the screen.

Keep in mind that the tests displayed in the optimization performance report using genetic optimization may not necessarily be the top set of combinations using an exhaustive approach. While this may be a disadvantage at times, it can also help prevent using a peak set of strategy inputs that just happened to perform well historically. This is one of the main reasons why genetic optimization helps to avoid over-fitting a trading strategy.

Figure 11: Optimization Performance Report Example Using Genetic Optimization

Opt. Performance Report: Backtest 04347

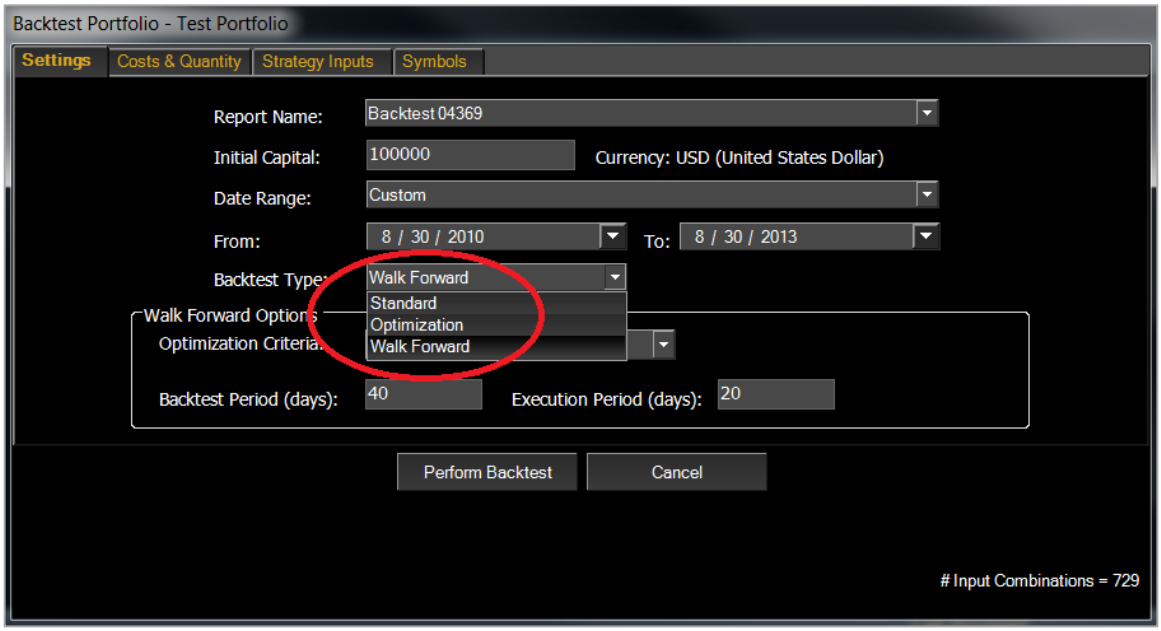
Test	Total Return	Trades	Avg Trade	Avg Drawdown	Max Drawdown	Sharpe Ratio	K-Ratio	Total Return / Max Drawdown	Inputs
01	$23,386.42	1263	$18.00	$1,078.67	$6,478.98	0.1216	0.3010	360.96 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=11
02	$23,003.43	1257	$17.58	$1,080.18	$6,859.14	0.1177	0.2929	335.37 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=12
03	$22,405.18	1265	$17.19	$1,196.37	$6,478.98	0.1136	0.2862	345.81 %	FastLength=6,SlowLength=18;BarToExitOn=19;FastLength=9,SlowLength=18;BarToExitOn=11
04	$22,299.58	1269	$17.05	$1,292.77	$6,478.98	0.1131	0.2699	344.18 %	FastLength=6,SlowLength=18;BarToExitOn=18;FastLength=9,SlowLength=18;BarToExitOn=11
05	$22,275.06	1264	$17.09	$903.63	$6,423.39	0.1126	0.2838	346.78 %	FastLength=7,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=10
06	$22,063.84	1088	$19.34	$1,010.46	$8,433.29	0.1044	0.2815	261.63 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=8,SlowLength=25;BarToExitOn=13
07	$22,022.19	1259	$16.77	$1,110.44	$6,859.14	0.1097	0.2772	321.06 %	FastLength=6,SlowLength=18;BarToExitOn=19;FastLength=9,SlowLength=18;BarToExitOn=12
08	$21,832.43	1267	$16.70	$911.68	$6,406.58	0.1091	0.2783	340.78 %	FastLength=7,SlowLength=18;BarToExitOn=19;FastLength=9,SlowLength=18;BarToExitOn=10
09	$21,812.43	1263	$16.55	$1,246.20	$6,859.14	0.1085	0.2615	318.01 %	FastLength=6,SlowLength=18;BarToExitOn=18;FastLength=9,SlowLength=18;BarToExitOn=12
10	$21,785.48	1101	$19.68	$900.39	$7,428.28	0.1122	0.2873	293.28 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=8,SlowLength=25;BarToExitOn=6
11	$21,779.33	1265	$16.74	$1,005.38	$6,195.80	0.1123	0.2909	351.52 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=10
12	$21,772.98	1260	$16.55	$1,199.37	$6,910.77	0.1072	0.2713	315.06 %	FastLength=7,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=12
13	$21,605.33	1264	$16.56	$1,036.68	$6,800.46	0.1071	0.2821	317.70 %	FastLength=7,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=11
14	$21,539.57	1253	$16.32	$1,086.93	$7,355.83	0.1060	0.2822	292.82 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=13
15	$21,491.16	1107	$18.66	$1,178.83	$8,984.85	0.0994	0.2549	239.19 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=8,SlowLength=24;BarToExitOn=13
16	$21,455.99	1275	$16.57	$1,005.25	$5,964.84	0.1125	0.2933	359.71 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=8
17	$21,434.74	1273	$16.25	$1,276.03	$7,316.40	0.1058	0.2737	292.97 %	FastLength=5,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=12
18	$21,424.24	1277	$16.43	$1,180.55	$6,887.88	0.1086	0.2752	311.04 %	FastLength=5,SlowLength=18;BarToExitOn=20;FastLength=9,SlowLength=18;BarToExitOn=11
19	$21,418.82	1116	$19.09	$898.29	$6,895.95	0.1100	0.2678	310.60 %	FastLength=6,SlowLength=18;BarToExitOn=18;FastLength=8,SlowLength=25;BarToExitOn=6
20	$21,391.47	1265	$16.21	$1,193.29	$6,800.82	0.1077	0.2869	314.54 %	FastLength=6,SlowLength=18;BarToExitOn=20;FastLength=8,SlowLength=18;BarToExitOn=11

In this case, on a positive note, the strategy inputs that are common to the previous example and that generated the highest total return are closely related to those of the best-performing test using the exhaustive approach (i.e., lengths of 5-18 and 9-18, versus 6-18 and 9-18). Once a particular combination of inputs of interest is found, additional analysis can then be performed using that particular combination, such as running a standard back-test or running a walk-forward optimization report.

Walk-Forward Optimization Background

The walk-forward optimization – also known as out-of-sample testing – helps reduce the chance of over-fitting strategies when developing a trading strategy. The main concept behind walk-forward optimization is the use of two period types: an optimization period and a holding period. Strategy inputs are optimized during the optimization period and a selected set of inputs is applied in the holding period. The process is then repeated again and again for the entire look-back period to generate a set of out-of-sample data. The walk-forward optimization process helps to answer the question, what would the results look like if I had optimized a certain parameter in the past at a certain frequency?

Figure 12: Walk-Forward Optimization Selection

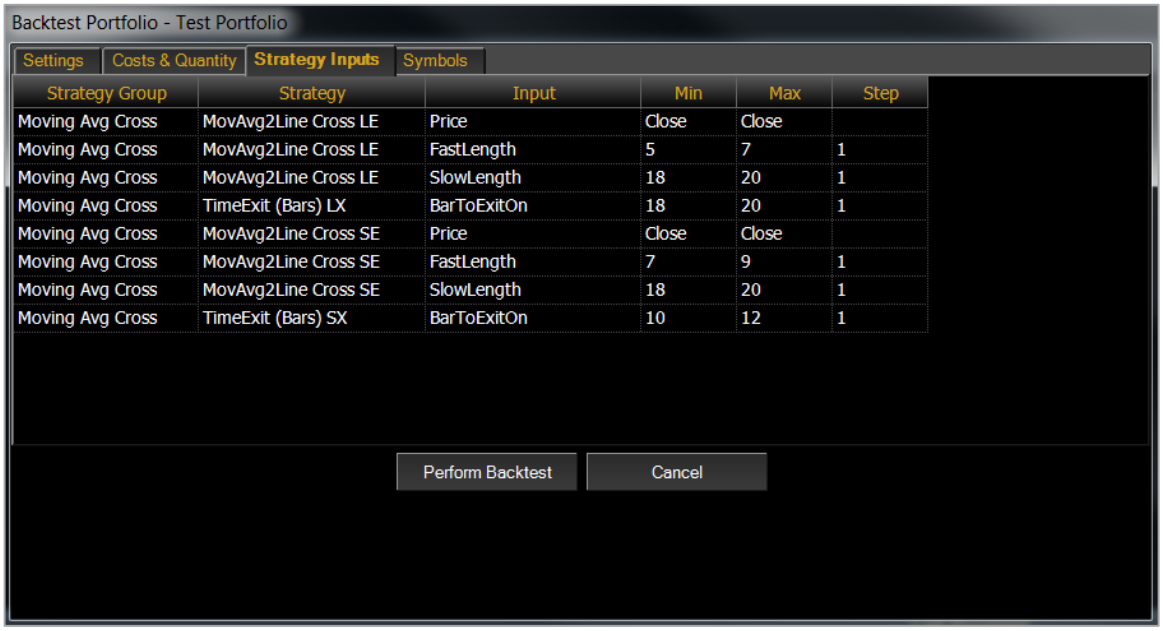


To access the walk-forward functionality, click on the Settings tab within the Backtest Portfolio dialog and select Walk Forward as the Backtest Type (see figure 12 above). Once selected, the Walk Forward Options fields will populate with the Optimization Criteria, Backtest Period (days), and the Execution Period (days). The last two fields dictate the proportion of in-sample to out-of-sample periods. Each field within the Walk Forward Options will populate automatically, but keep in mind that the values can be overwritten.

Walk-Forward Optimization Example

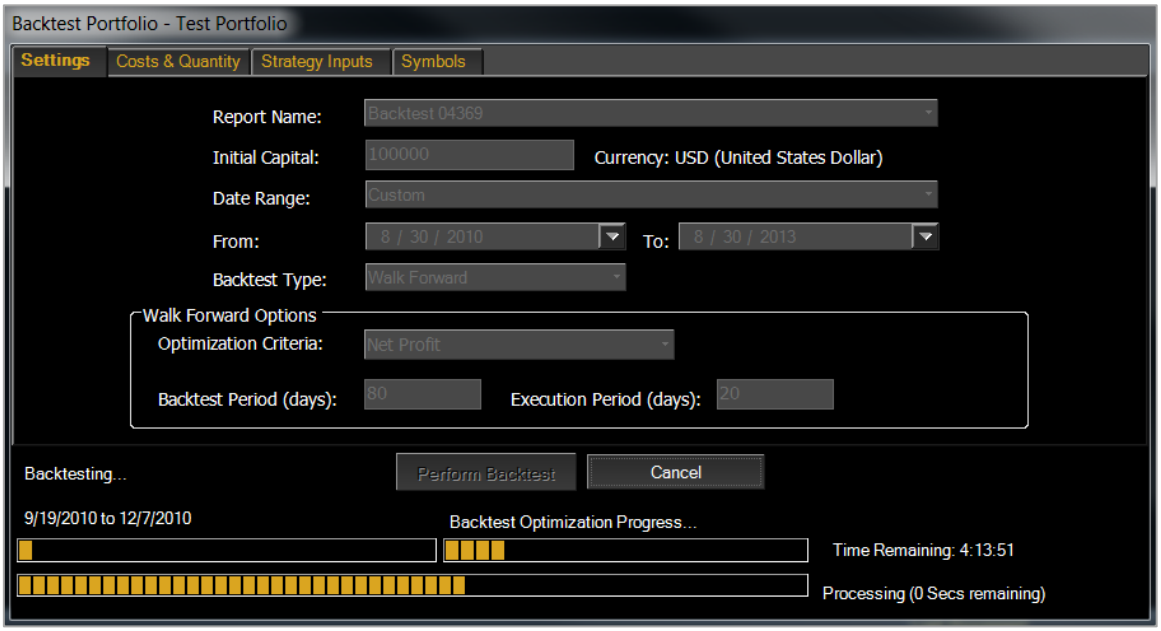
The following example continues to build on the previous example. The strategy components from the previous example are utilized again, but the back-test type is now Walk Forward versus Genetic Optimization. The different settings will be based on the results from the completed genetic optimization and are found in figure 13 below. Also, the Backtest Period and the Execution Period fields are adjusted to 80 and 20, respectively, and the back-test will include three years of data.

Figure 13: Walk-Forward Optimization Example



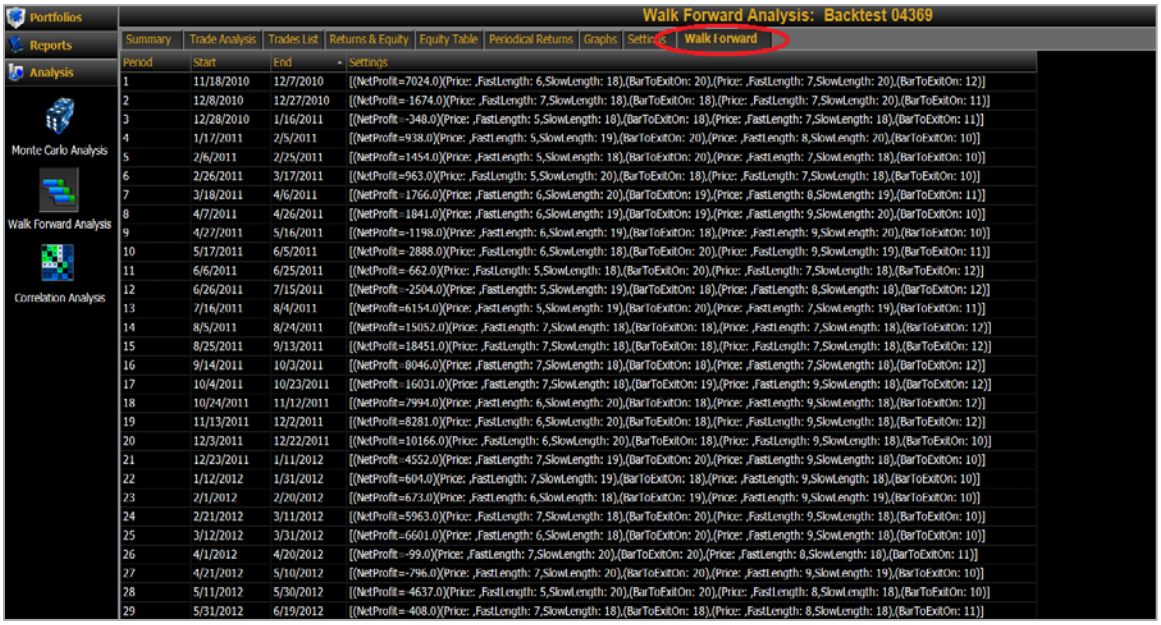
Once the back-test is started, the walk-forward optimization progress can be monitored (see figure 14 below). The different periods tested will be displayed in the lower left side of the dialog box. Notice also the estimated Time Remaining field that appears on the right side of the window. The back-testing speed will be affected by a number of factors, in line with the factors affecting an exhaustive optimization. In general, walk-forward optimization back-testing tends to take longer than exhaustive optimization, mainly because the data is broken up into different parts during the look-back period.

Figure 14: Walk-Forward Optimization Progress



Once the optimization is complete, the Walk Forward Analysis report is available to view. While the calculations to generate the report are complex, the information provided in the report is easy to understand. Notice that the layout of the report is very similar to that of a regular strategy performance report with multiple tabs, including Summary, Trade Analysis and Trades List tabs. The main difference in the report layout is the inclusion of a Walk Forward tab (see figure 15 below).

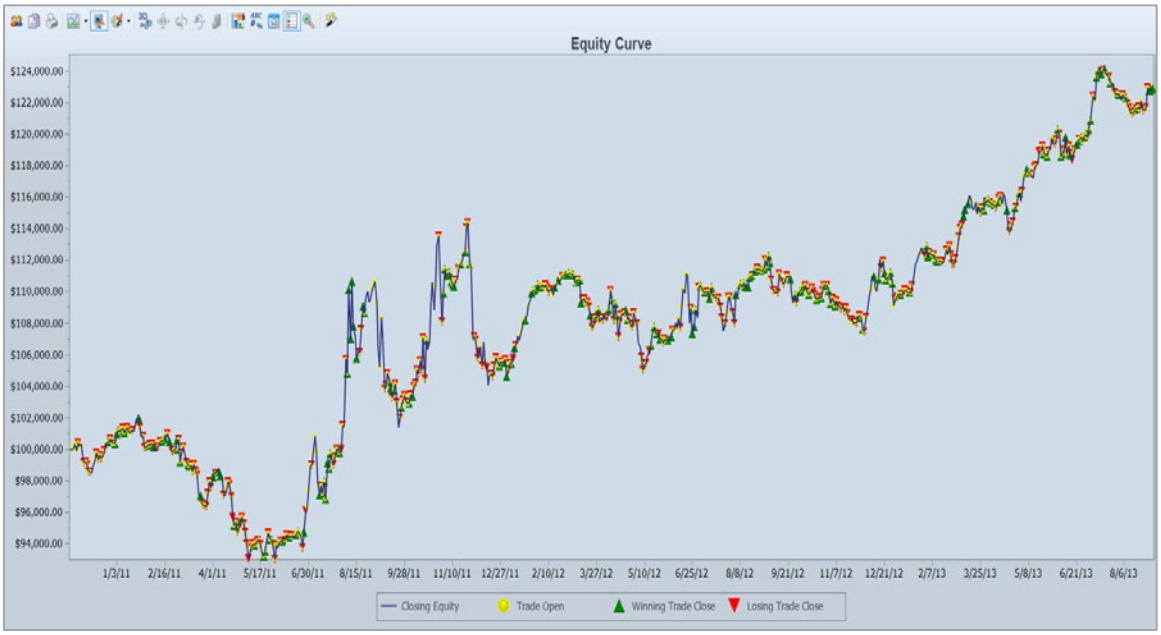
Figure 15: Walk-Forward Analysis Example



The Walk Forward tab lists the different out-of-sample periods in chronological order. In this case, each line corresponds to a period of 20 calendar days where optimized parameters are applied. In this example, the settings were to optimize the strategy inputs for 80 days at a time (i.e., Backtest Period) and apply the optimized parameters for the following 20 days (i.e., Execution Period). Therefore, the Walk Forward tab is the complete collection of all the different out-of-sample periods put together back to back. Notice how the strategy inputs change every 20 days in the Settings column in figure 15 above.

The other tabs in the report reflect the portfolio performance with the changing strategy inputs for the entire back-tested period. For instance, the Equity Curve graph reflects the performance of the portfolio with the dynamic strategy inputs (see figure 16 below). Keep in mind that the purpose of the report is to answer the question, what would the portfolio performance look like if strategy inputs were optimized for a given period and then applied going forward?

Figure 16: Walk-Forward Analysis Equity Curve Example



If the report needs to be accessed at a later time, it can be accessed by clicking on Analysis in the Shortcut Bar and then by selecting the Walk Forward Analysis icon (see figure 15). The different Walk Forward Analysis reports are listed in the Selection Panel in the lower portion of the screen.

Conclusion

Portfolio Maestro offers multiple optimization tools for use in portfolio back-testing. Each type of optimization has a distinct purpose in the portfolio strategy trading development process. The exhaustive approach is more of a brute-force approach, testing every combination of strategy inputs given a set of parameters, whereas the genetic approach helps to minimize the number of tests as well as the danger of over-fitting strategies. Finally, the walk-forward approach helps to test parameters on unseen data, attempting to provide a more realistic picture of what results might look like in real-world trading scenarios. Back-testing these advanced features in a simulated environment – without risking capital – is a major benefit of Portfolio Maestro.

For more information about Portfolio Maestro's basic functionality, please see the first installment of the series, "Portfolio Back-Testing with Portfolio Maestro: An Introduction to Portfolio Back-Testing." For more information about Portfolio Maestro's other advanced features, please see the second and third installments of the series, entitled "Portfolio Back-Testing with Portfolio Maestro: Ranking and Money Management" and "Portfolio Back-Testing with Portfolio Maestro: Constraints and Portfolio Stops," respectively.

Works Cited

Wikipedia. Genetic Algorithm. September 4, 2013. http://en.wikipedia.org/wiki/Genetic_algorithm (accessed September 4, 2013).

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