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A Guide to
FRACTAL FINANCE
“Patterns from Pieces”
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What is Fractal Finance?

A Fractal View

- Fractal Finance is a completely new way of looking at the markets.
- With the help of Chaos theory, it is possible to find hidden order in price data.
- Fractal attractors define price attraction ranges.
- Fractal Finance can identify these attractors and use them to trade.
- Fractal Finance makes very accurate predictions.
- Fractal Finance Toolkit contains the functions and indicators to do this.
Order and Randomness

- Chaos Theory is a way to describe or quantify nonlinear, apparently random events or systems.
- Analyze events or systems that are influenced by their own outcomes, taking on a life of their own.
- Order and randomness can coexist allowing predictability.
Market Applications of Chaos Theory and Fractal Analysis

- Market prices tend to seek natural levels or ranges of balance.
- These levels or ranges can be described as “attractors.”
- These ranges (attractors) are determinant.
- However, data within these ranges remains random (local randomness & global determinism.)
Fractal Attractor in IBM
Fractal Attractor (a different resolution)
Why Use Chaos Theory and Fractals in Trading?

- Markets are nonlinear
- Traditional technical analysis is linear and Euclidean
- Linear analysis techniques cannot quantify nonlinear noise
- Market reversals are also nonlinear events
- Technical Analysis is a poor indicator for the trend vs range trading decision
- Fractals quantify what Euclidian geometry cannot
Fractal Rulers – Measuring Chaos

- Markets are not random and are nonlinear.
- Chaos theory is the study of apparently random nonlinear systems. *This is exactly what we need for financial markets!*
- Fractals are the modern measuring tools of Chaos theory.
- Markets are man-made nonlinear dynamic systems.
- Would you measure an ocean wave with a ruler? You should if it is a “Fractal Ruler.”

[Image of a wave and a ruler]
Measuring Chaos

- Benoit Mandelbrot is considered the founder of fractal analysis.
- Mandelbrot measured England’s irregular, chaotic coastline more accurately by using a fractal ruler.
- The Koch Snowflake demonstrates how using infinitely finer fractals increases measurement accuracy.
- Mandelbrot applied these same nonlinear measuring techniques to the cotton market.
What is the Goal?

Given a time series \( \{x_t\} \), predict its future course, that is, \( x_{t+1}, x_{t+2}, \ldots \).
Traditional Forecasting Methods

- ARIMA ➞ but linearity assumption
- Neural Networks ➞ but large number of parameters and long training times
- Hidden Markov Models ➞ $O(N^2)$ in number of nodes $N$; also fixing $N$ is a problem
- Lag Plots
The Fractal Finance Method

- Based on the “Takens’ Theorem” [Takens/1981]
- which says that delay vectors can be used for predictive purposes
By Discovering the Fractal Attractor
We Go From This…

Given a time series \( \{x_t\} \), predict its future course, that is, \( x_{t+1}, x_{t+2}, \ldots \)
To That!
To This! (Prediction is Blue Line)
How do we do it?
Start with Lag Plots

Interpolate these…

Q0: Interpolation Method
Q1: Lag = ?
Q2: K = ?

To get the final prediction

Fractal Finance  11/16/2018
Find the Fractal Dimensions

FD = intrinsic dimensionality [Belussi/1995]

“Embedding” dimensionality = 3
Intrinsic dimensionality = 1

Points to note:

• FD can be a non-integer
• There are fast methods to compute it
Q1: Finding $L_{(opt)}$

- Use Fractal Dimensions to find the optimal lag length $L_{(opt)}$
Q2: Finding $k(\text{opt})$

- To find $k(\text{opt})$ also known as the optimum number of lag points
  
  - Conjecture: $k(\text{opt}) \sim O(f)$

We choose $k(\text{opt}) = 2*\text{f} + 1$

- $\text{f} = \text{the Fractal Dimension (FD)}$
Interpolate Prediction

Our Prediction from here

Value

Timesteps
Summary of Method

- Create a lag-plot of time series data
- Use the fractal dimension to find the optimal lag number
- Identify the nearest neighbors (NN)
- Use $K_{opt}$ to determine optimal number of nearest neighbors for prediction
- Interpolate new point using statistical methods to arrive at new prediction
Installation

Fractal Finance is designed for all styles and time frames of trading. Fractal Finance may be used with stocks, futures, and forex markets. The Fractal Finance tools may even be used for options trading.

The Fractal Finance Toolkit is what is commonly referred to as a, “gray box.” All of the module’s inputs are open to manipulation by the user.

In order for Fractal Finance to function properly, it must be imported into MultiCharts. There are two files that you must import. One is a Read-Only file (identified as Fractal Finance 1.0_a.sef). The other is a standard import file (identified as Fractal Finance 1.0_b.pla).

Please use the following steps to import Fractal Finance:

1) Open the PowerLanguage editor → select Import Read-Only
2) Browse to where you have saved Fractal Finance → Import Fractal Finance 1.0_a.sef
3) Open the PowerLanguage editor → select Import
4) Browse to where you have saved Fractal Finance → Import Fractal Finance 1.0_b.pla
5) Once imported, make sure that the files are all verified. You do this by clicking on Compile → All Uncompiled from the PowerLanguage editor drop down menu.
6) Fractal Finance will now be installed. The last item left is to enter your specific password key. This item will be provided to you from Fractal Finance Support. When you run Fractal Finance, a pop-up will appear requesting an activation key. Enter the key and activate.
7) Installation is complete and you are ready to use Fractal Finance.
The Fractal Finance Indicators

- Indicators are found in the Fractal Finance 1.0 Study.
- All inputs and indicators can be controlled from the Format Study Menu.
- The format study window lists the necessary variables and on/off switches under the Inputs tab.
- Style, Properties, Scaling, and Alerts allows you to customize visual and other features.
- The Indicator code is unprotected and can be changed.
Indicator Parameters Explained

1) Price – Price input used for the calculation of the prediction. Common selections: Open, High, Low, Close, (High+Low)/2, etc.

2) Rounding – Rounds the predictor to the nearest tick.

3) FracLength – Number of bars used to calculate the fractal dimension of the lag plot used in determining the prediction. A larger number uses more data, time, and may not improve results. It is recommended to use less than 100 unless you have found a specific application.

4) Lag – Represents the maximum number of the lag used for calculating the prediction. This number should not change results dramatically after a certain amount. This is due to the dynamic nature of the program. It automatically searches for the ideal lag length under this number. Experience dictates that a lag no greater than 10 will work in most cases.

5) Plot_Lag – Plots the dynamic lag length used for the prediction. This changes dynamically as the fractal dimension of the lag plot changes.

6) Plot_FD – Plots the fractal dimension of the underlying lag plot. Used to determine the optimum lag for predictor performance.

7) Plot_FDavg – Average value of the FD. This value determines when the fractal dimension begins flattening out. Used in the optimum lag discovery process. Numbers between 3 – 10 should work well in most cases.

8) Plot_Lopt – Displays the changing optimum lag length. Will never be greater than the Lag input.

9) Plot_Kopt – Optimum number of nearest neighbors used in the prediction.

10) Plot_Predict – Plots the predictor as calculated from the input variables.

11) Steps2Predict – Selects the number of steps ahead to predict. If the number is less than one, the input will default to one. For example, if Steps2Predict = 0, the first bar will be predicted. If Steps2Predict = 1, the first bar will be predicted. If Steps2Predict = 2, the second bar will be predicted.
Indicator Parameters (Continued)

12) Predictavg – Calculates and displays an average of the predictor based on the input value. This number **MUST** be set to one (1) to predict with no average or lag.

13) Plot_Zero – Plots a zero line on the indicator selected.

14) Plot_Accuracy – A special indicator that measures the accuracy of the prediction. When the indicator is equal to zero, the prediction is perfect. Typically used to optimize inputs for different markets. Number displayed is the difference (plus or minus) of the prediction from the actual price.

15) AccuAvg – Calculates an average of the Plot_Accuracy based on the input value. This number **MUST** be set to one (1) to calculate with no average or lag.

16) Plot_Bands – Plots a positive and negative band in an indicator. Typically used with the Accuracy indicator and Zero plot to measure accuracy range.

17) Bands – Value (plus and minus) of the bands.

18) Plot_FFForward – Plots the Fractal Forward indicator. This special indicator makes a calculation of predictor strength by comparing the high, low, and close predictions. A number from nine to negative nine (9 to -9) displays the composite direction. Nine represents that all predictions are moving in the same upward direction. Negative nine represents the opposite. All variations in-between are also displayed.
The Functions

Fractal Finance Toolkit contains a number of special indicators. Most of these are unlike any you have seen in previous trading tools. At the core of these indicators is the Fractal Finance functions. To fully unlock the power of Fractal Finance, you should have a basic understanding of these functions and the methodology behind them. If you have not read the section: “The Fractal Finance Method,” it is recommended that you pause here and read that section now.

Each indicator listed below has a corresponding function that you can use in your code. These functions can be easily called to create custom indicators, functions, and systems. The input variables for each function will be explained with the description.

In this section, the indicators that use functions will be listed as they are found in the Format Study box. There is no particular reason for this, except to provide consistency.

1) ***Plot_Lag*** – When this graph is displayed, you will see a composite of the various optimal lag plot prices that will be used in the prediction. The lag used for this plot will never be higher than the lag input. This data is determined with the fractal dimension in conjunction with the lag prices in the chart. Once the fractal dimension “flattens out” the price data in the lag plot data is no longer contributing to forecast improvement. This method makes it faster and easier to determine which price lag should be included in the prediction. You will probably not use this for trading, but you may be able to find new applications.

   Quick Reference: Indicator Name → Plot_Lag (True/False)   
   Function Name → FractalFinance_LagPlot_1.0(Price,Lag)   
   Inputs → Price – Price used for analysis (O, H, L, C)  
   Lag – The lagging bar on the chart (Numeric)

2) ***Plot_FD*** – The fractal dimension of the lag plot prices is calculated and graphed. Because the lag plot is dynamic, the plotted fractal dimension will also be dynamic and match the lag prices. If you wish to calculate the fractal dimension of the current price only, set the lag input of the function to zero. A set of price data must be used to calculate the fractal dimension. The amount of price data is determined by the FracLength input. You will probably not use this for trading, but you may be able to find new applications.

   Quick Reference: Indicator Name → Plot_FD (True/False)   
   Function Name → FractalFinance_FD_1.0(Price,Lag,FracLength)   
   Inputs → Price – Price used for analysis (O, H, L, C)  
   Lag – The lagging bar on the chart (Numeric)  
   FracLength – Bars used to calculate the fractal dimension (Numeric)
3) **Plot_Lopt** – Used to plot the ideal lag number used to make the optimal prediction. When this is graphed, you will see the lag number used for a specific bar to calculate the lag plot. This number will never be higher than the lag input. You will probably not use this for trading, but you may be able to find new applications.

   Quick Reference: Indicator Name → Plot_Lopt (True/False)  
   Function Name → FractalFinance_LagPlot_1.0(Price,Lag,FracLength,FDavg)  
   Inputs → Price – Price used for analysis (O,H,L,C)  
   Lag – The lagging bar on the chart (Numeric)  
   FracLength – Bars used to calculate the fractal dimension (Numeric)  
   FDavg – An average of the fractal dimension used to determine the flattening period of the maximum lag. Set to 1 for none. (Numeric)

4) **Plot_Kopt** – Before the predictor can make a forecast, the ideal number of nearest neighbors (NN) must be determined for interpolation. By using a known formula used for this purpose, the optimum number of NN is calculated. This number does not change much, but may do so when unexpected price fluctuations take place. Kopt is used in the predictor function to calculate the prediction. You will probably not use this for trading, but you may be able to find new applications.

   Quick Reference: Indicator Name → Plot_Kopt (True/False)  
   Function Name → FractalFinance_Kopt_1.0(Price,Lag,FracLength)  
   Inputs → Price – Price used for analysis (O,H,L,C)  
   Lag – The lagging bar on the chart (Numeric)  
   FracLength – Bars used to calculate the fractal dimension (Numeric)  
   FDavg – An average of the fractal dimension used to determine the flattening period of the maximum lag. Set to 1 for none. (Numeric)
5) **Plot_Predict** – This is the heart of the toolkit and it plots the predictor on the chart. The primary inputs for the predictor are the Steps2Predict and PredictAvg. The Steps2Predict determines the number of steps ahead to predict. The PredictAvg determines if the predictor will be averaged (value greater than 1) or not averaged (value of 1). Other inputs include Lag, FracLength, FDavg, and Prediction. Because of the importance of the predictor function, a separate section is dedicated to it later.

Quick Reference: Indicator Name → Plot_Predict (True/False)  
Visual Reference → page 24, 36  
Function Name → FractalFinance_Predictor_1.0(Price,Lag,FracLength,FDavg,Prediction)  
Inputs → Price – Price used for analysis (O,H,L,C)  
Lag – The lagging bar on the chart (Numeric)  
FracLength – Bars used to calculate the fractal dimension (Numeric)  
FDavg – An average of the fractal dimension used to determine the flattening period of the maximum lag. Set to 1 for none. (Numeric)  
Prediction – The number of steps (bars) to predict ahead (Numeric)

6) **Plot_FForward** – A special indicator and function known as, “Fractal Forward.” The purpose of the indicator is to quantify the high, low, and close predictions using one number. It works by assigning a value of (1, 0, -1) to each prediction based on increasing or decreasing forecasts. Increasing is a 1, neutral is a 0, and decreasing is a -1. This will assign a number from (3 to -3) to each (high, low, close). When these three are added together, it generates a value from (9 to -9). To clarify use of the indicator, a separate section is dedicated to it later.

Quick Reference: Indicator Name → Plot_Fforward (True/False)  
Visual Reference → page 38  
Function Name → FractalFinance_Forward_1.0(Lag,FracLength,FDavg,Prediction)  
Inputs → Lag – The lagging bar on the chart (Numeric)  
FracLength – Bars used to calculate the fractal dimension (Numeric)  
FDavg – An average of the fractal dimension used to determine the flattening period of the maximum lag. Set to 1 for none. (Numeric)  
Prediction – The number of steps (bars) to predict ahead (Numeric)
Writing the Code

The functions in Fractal Finance are easy to manipulate with MultiCharts PowerLanguage. Simply call the functions with the names specified in this manual, include the inputs, and write the instructions. Below is a snippet of code from the source code in the Fractal Finance indicator. You can see how the indicators were easily created and plotted. Feel free to use the open source code for your own modifications or purposes.

BEGIN

Value1 = FractalFinance_Lopt_1.0(Price,Lag,FracLength,FDavg);
Value2 = FractalFinance_LagPlot_1.0(Price,Value1);
Value3 = FractalFinance_FD_1.0(Price,Value1,FracLength);
Value4 = Average((FractalFinance_FD_1.0(Price,Value1,FracLength)),FDavg);
Value5 = FractalFinance_Kopt_1.0(Price,Lag,FracLength,FDavg);
If Rounding = True then Value6 = Round2Fraction(FractalFinance_Predictor_1.0(Price,Lag,FracLength,FDavg,Steps));
If Rounding = False then Value6 = FractalFinance_Predictor_1.0(Price,Lag,FracLength,FDavg,Steps);
Value7 = AveragePC(Value6, PredictAvg);
Value8 = Average((Price - Value7),AccuAvg);
Direction = FractalFinance_Forward_1.0(Lag,FracLength,FDavg,Steps2Predict);

END;

If Plot_Lopt = True then Plot1(Value1,"Lopt");
If Plot_Lag = True then Plot2(Value2,"Lag");
If Plot_FD = True then Plot3(Value3,"FD");
If Plot_FDavg = True then Plot4(Value4,"FDavg");
If Plot_Kopt = True then Plot5(Value5,"Kopt");
If Plot_Predict = True then Plot6(-fdctOffset)(Value7,"FDCT");
If Plot_Zero = True then Plot8(0,"Zero");
If Plot_Accuracy = True then Plot9(Value8,"Error");
If Plot_Bands = True then Plot10(Bands,"+ Band");
If Plot_Bands = True then Plot11(-Bands,"- Band");
If Plot_FForward = True then Plot12(Direction,"Direction");
If Plot_FForward = True then Plot13(Direction1,"Direction 2");
If Plot_FForward = True then Plot14(9,"High");
If Plot_FForward = True then Plot15(-9,"Low");
Sample Trading System Code

Fractal Finance comes with a sample trading system. The code is open for this system and you can modify it for your own purposes. You can see that it is not necessary to write a long series of code to create a winning system with Fractal Finance. In this system two moving averages of the predictor are used to trigger entries and reversals. This system is designed for the e-mini S&P 500 futures contract.

```plaintext
If Use_Timer = True and time >= StartTime and time < EndTime and (barssinceexit(1)>0 or totaltrades=0) then Begin
    If Value2 crosses above Value3 then Buy ("1B_Entry_Timer") this bar;
    If Value2 crosses below Value3 then Sellshort ("1S_Entry_Timer") this bar;
End;

If Use_Timer = False and (barssinceexit(1)>0 or totaltrades=0) then Begin
    If Value2 crosses above Value3 then Buy ("1B_Entry_NoTime") this bar;
    If Value2 crosses below Value3 then Sellshort ("1S_Entry_NoTime") this bar;
End;

If Use_Timer = True then begin
    If Time >= EndTime and MarketPosition(0) = -1 then Buytocover ("EODX_S") this bar
    else
    If Time >= EndTime and MarketPosition(0) = 1 then Sell ("EODX_I") this bar;
end;
```
The Predictor

Plot_Predict – This is the heart of the toolkit and it plots the predictor on the chart. The Predictor uses all of the functions in Fractal Finance to generate a forecast. The forecast will always be based on the Price input. For example, if Close is the Price input, the close price will be forecasted. The same holds true for Open, High, Low, Close. In addition to these inputs, you can also use any type of price data. You may want to forecast a volatility indicator or maybe an average such as ((High + Low)/2). This flexibility makes Fractal Finance a powerful trading tool.

The predictor is already designed to function as a moving average of the predicted price. By changing the FDavg input parameter, you can turn the predictor into a moving average of the predictor. For example, when FDavg is set to the default of 1, no average is calculated and the prediction functions normally. However, if a 10 is the input, a 10 bar average of the predictor will be plotted on the chart. This may be used for a number of different strategies and indicators. Particularly, when smoothing the data is important.

The Fractal Finance Predictor is capable of forecasting an unlimited number of steps ahead. Unfortunately, because of the physical laws associated with chaotic systems, prediction accuracy breaks down rapidly with further steps. This is logical, because every minor prediction error is magnified exponentially for each step. For this reason, it is recommended that you do not forecast more than four steps ahead.

More than one Predictor can be used on the same chart. The limit is really your imagination. You may plot a one step prediction with a three step or plot the predicted High, Low, and Close on the same chart. Maybe you would rather combine moving averages of the predictor. All of this is possible by inserting more than one Fractal Finance indicator on the same chart. You also have the ability to access the code used in the indicator toolbox and modify it. If you are interested in turning the predictor into a stochastic indicator or perhaps an MACD, it is easy to do with the functions. If you have programming requirements that you are not capable of performing yourself, Quant Trade is available to help you. Simply contact us for a free consultation and we will return a quote for your new project.

One note should be made regarding calculation time. Fractal Finance uses some very sophisticated algorithms that are divided between several functions. While the algorithms were designed as efficiently as possible, there is still a calculation delay. The more data that you are analyzing, the greater the calculation time. You may need to wait as long as a minute or more before your see the indicators appear. Please keep this in mind. If you see the calculating notice, you can feel comfortable in knowing that everything is working. Once the data is crunched, the predictions occur vary quickly per bar. You will not see any lag in the indicator that will affect your trading or trading system.
Two Predictors with Different Settings
The Fractal Forward Indicator

Plot_FForward – This indicator uses the predictor to gauge the strength and direction of the market. Technically, the indicator is meant to determine if the predictions (High, Low, Close) are predicting in the same direction (up, down) or some variation in-between. In practice, three predictions are made for each type of price (High, Low, Close) over the last three bars. Three bars are used, because that is the minimum number of points necessary to plot a trend. Every time a prediction is higher than a previous prediction, a value of positive one (+1) is assigned. Every time a prediction is lower than a previous prediction, a value of negative one (-1) is assigned. When all of these numbers are totaled for each price type (High, Low, Close), a total of positive nine to negative nine (+9 to -9) is possible on the indicator. For example, if the indicator is positive nine (+9), all three predictions over three bars over all price types (High, Low, Close) are going sequentially higher. The opposite is true for a negative nine (-9).

This indicator can be used in conjunction with Plot_Bands to add a marker to the indicator. A screenshot on the next page demonstrates this as a band from positive three to negative three (+3 to -3). The number chosen was arbitrary, but may be useful for gauging the strength of the prediction combination. A zero (0) is also visible. This was added to the indicator with the Plot_Zero option.

In the plot, there is one lagging mirror image plot of the same indicator. This is visible as a dark orange line on the indicator in the screenshot. The light blue line is the real-time indicator. The lagging plot is intended to be a reference point for when a change in indicator direction takes place.

In summary, the Fractal Forward is meant to do the following:

1. Act as a bullish, bearish, or neutral sentiment of the three most recent high, low, and close predictions.
2. The indicator is comparing the three most recent predictions to establish a prediction trend.
3. Used as a proxy for trend strength, trend direction, or trend purity.
4. Indicate a potential change in trend direction. Example: When reversing direction from an extreme (9 or -9) the price will often follow.

The function is built with three predictor functions. Each is predicting a different price. You can easily duplicate the results in your own indicator or make changes in the logic by using the FractalFinance_Predictor_1.0 function. You can also incorporate the Fractal Forward indicator in your systems by using the FractalFinance_Forward_1.0 function. The inputs for the function were explained in the functions section of this guide.
Fractal Forward Indicator
Fractal Finance Screenshots

- This section lists screenshots of the indicators.
- Indicators are found in the Fractal Finance 1.0 Study.
- The following indicators are included:
  - Plot_Lag
  - Plot_FD
  - Plot_FDavg
  - Plot_Lopt
  - Plot_Kopt
  - Plot_Predict
  - PredictAvg
  - Plot_Accuracy
  - Plot_FForward
Plot_Lag = Lag Plot
Plot\_FD = Fractal Dimension
Plot_Fdavg = Average Fractal Dimension
Plot_Lopt = Optimal Lag
Plot_Kopt = Optimal Nearest Neighbors NN
Plot_Predict = Predictor
PredictAvg = Average of Predictor (10)
Plot_Accuracy = Predictor Accuracy
Plot_FForward = Fractal Forward
The **FRACTAL FINANCE** Toolkit

The Fractal Predictor forecasting one step ahead (BLUE LINE)
The **FRACTAL FINANCE** Toolkit

Fractal Predictor with 10 Bar Average of Predictor and Fractal Forward Indicator on the Bottom
The **Fractal Finance** Toolkit

Equity Curve of a Fractal Finance System

**Equity Curve Close To Close With Drawdown**

- **Equity ($)**
  - 50,000
  - 52,000
  - 54,000
  - 56,000

- **Drawdown (%)**
  - -1.5
  - -1.0
  - -0.5

- **Trade Number**
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60
  - 70
  - 80
  - 90
  - 100
  - 110
  - 120
  - 130
  - 140
  - 150
  - 160

Legend:
- Net Profit
- Peaks
- Close To Close Drawdown
- Close To Close Drawdown (%)
The **FRACTAL FINANCE** Toolkit

**Includes:**
- Fractal Predictor
- Fractal Predictive Moving Average
- Fractal Forward indicator
- Accuracy indicator
- All available functions
- Sample trading system
- Available at: www.fractalfinance.com
- Contact Us: info@fractalfinance.com
Pioneers in the fractal exploration of financial markets!

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