Financial Informatics: Financial Fuzzy Logic Based Systems

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Fuzzy Financial Systems

The behaviour of the stakeholders in a market is an interesting avenue of study. The reaction to change is one of the key areas of interest here; the manner in which change is anticipated varies from person to person, but there are some generalizations are beginning to appear.

For instance, investors appear to have heuristics that underline their behaviour:

(1) IF there is greater than average price movement on the (reversal) day THEN I look for the price to exceed its normal daily price range [...].
(2) IF a Stock price that is heavily overbought or oversold THEN I look for the price to accelerate away [...].

http://www.streetdirectory.com/travel_guide/36574/investment/candlestick_charting___a_peek_into_market_psychology.html
Now, when we wish to know how a stock, commodity, currency, or an entire market is behaving, we tend to find the 'price' of the instrument. Usually we get a single number for an entire period, trading period. Typically, the price quoted for the instrument at the end of a trading (fractional) hour, day, week and so on, but in reality, the prices are changing during a trading period, going through highs and lows – reversal are quite common within a period.
Fuzzy Financial Systems

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Fuzzy Financial Systems:
Observing change through candlesticks

The behaviour of financial instruments over a period of time shows that there is an inherent fuzziness in this behaviour. The behaviour shows characteristic patterns – captured by the so-called candlestick patterns used to display the full range of behaviour during the period of time. The range includes the value of the instrument at the beginning and end of the trading period (called open and close), and the highest and the lowest values during trading (called high and low). Usually, only the closing value of the instrument is cited.

Fuzzy Financial Systems:
Observing change through line breaks

Three line break
The three line break chart is similar in concept to point and figure charts. The decision criteria for determining "reversals" are somewhat different. The three-line break chart looks like a series of rising and falling lines of varying heights. Using closing prices (or highs and lows), a new rising line is drawn if the previous high is exceeded. A new falling line is drawn if the price hits a new low.

Fuzzy Financial Systems

Data mining perhaps is one of the most important areas where fuzzy logic based systems will see considerable usage.

Traditionally, business analysts have performed the task of extracting useful information from recorded data, but the increasing volume of data in modern business and science calls for computer-based approaches.

Data mining involves the application of intelligent programs for extracting information from recorded data.


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Fuzzy Financial Systems:
Recognizing patterns of change

We can use the candlestick patterns – a collection of candle sticks - to speculate about the reversals (or otherwise) of the instrument over a given period of time.

Candlesticks and Technical Analysis (Compressed over a day)

Fuzzy Financial Systems:
Recognizing patterns of change

We can use the candlestick patterns – a collection of candle sticks - to speculate about the reversals (or otherwise) of the instrument over a given period of time: will our strategy may change depending our time horizons?

Candlesticks and Technical Analysis (10 minute compression)
### Description Patterns

<table>
<thead>
<tr>
<th>Description</th>
<th>Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long body candlesticks indicate intense buying and selling pressure</td>
<td><img src="image" alt="Long candlestick pattern" /></td>
</tr>
<tr>
<td>Short body candlesticks indicate little or no change in price and perhaps consolidation.</td>
<td><img src="image" alt="Short candlestick pattern" /></td>
</tr>
</tbody>
</table>

### More on candlestick patterns

<table>
<thead>
<tr>
<th>Description</th>
<th>Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abandoned Baby: A rare reversal pattern characterized by a gap followed by a Doji, which is then followed by another gap in the opposite direction.</td>
<td><img src="image" alt="Abandoned Baby pattern" /></td>
</tr>
<tr>
<td>Rising Three Methods: A bullish continuation pattern in which a long white body is followed by three small body days, each fully contained within the range of the high and low of the first day. The fifth day closes at a new high.</td>
<td><img src="image" alt="Rising Three Methods pattern" /></td>
</tr>
</tbody>
</table>

[Link to Chart School](http://stockcharts.com/school/doku.php?id=chart_school:chart_analysis:introduction_to_candlesticks)
Fuzzy Financial Systems:
More on candlestick patterns

Prior Trend Reversal
Bullish reversals require a preceding downtrend and bearish reversals require a prior uptrend. The direction of the trend can be determined using trend lines, moving averages, peak/trough analysis or other aspects of technical analysis. A downtrend might exist as long as the security was trading below its down trend line, below its previous reaction high or below a specific moving average. The length and duration will depend on individual preferences.

Long Shadow Reversal
There are two pairs of single candlestick reversal patterns made up of a small real body, one long shadow and one short or non-existent shadow.
Fuzzy Financial Systems:
More on candlestick patterns

We see a variety of patterns in the behaviour of prices (open/high/low/close) over a period of time. The patterns have a characteristic shape: Bullish engulfing, shooting star.

• There is a belief that the study of patterns for identifying reversals and turning points can be conducted using candlestick patterns, line breaks and so on.
• These methods are empirical and perhaps throw some light on investor psychology.
• The emphasis here is on what the investors/traders/brokers do and need, rather than what the modelers and scholars think how the markets and people behave.
Fuzzy Financial Systems: Systems for recognizing patterns?

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What is required is a good knowledge representation method for representing the knowledge of how to relate a candlestick pattern to the movement of the instrument/market.

Fuzzy logic based systems have been recently developed for using candlestick data for acquiring and deploying knowledge of financial prediction (Lee, Liu and Chen 2006). The rules acquired make the system transparent and the output highly visualisable. This is usually not the case of other methods like neural nets, stochastic modeling.
Fuzzy Financial Systems

The key notion here is that of a fuzzy time series: Imprecise data at equally spaced discrete time points are modeled as fuzzy variables.

For individual candlesticks, the rather imprecise notions of ‘length’ of the body part, length of the shadows (upper and lower) are formalised through the use of fuzzy sets and specifically through membership functions.

The linguistic variables for length are short, middle, and long.

Heuristic Note: These functions are described for the Taiwanese stock market in one important sense: ‘the varying percentages of the stock prices are limited to 14 percent in the Taiwanese stock market’ (Lee, Liu and Chen 2006:616).
Fuzzy Financial Systems

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The membership function of the length of the body and shadow.

Heuristic Note: These functions are described for the Taiwanese stock market in one important sense: 'the varying percentages of the stock prices are limited to 14 percent in the Taiwanese stock market' (Lee, Liu and Chen 2006:616). So a candlestick has definitely has SHORT length or body if the percentage change in the instrument was between 0.5 and 1.5; the evidence that the length was SHORT when the change was 2% is 0.5, and any change above 2.5% cannot be regarded as SHORT. Similarly, any change change in the length or body above 5% is definitely LONG.

Fuzzy Financial Systems

The key notion here is that of a fuzzy time series: Imprecise data at equally spaced discrete time points are modeled as fuzzy variables.

Candlestick patterns involve more than two patterns. It is the relative lengths of these patterns that result in idiosyncratic patterns. Linguistic variables are defined to capture the essence of the comparative nature of the patterns at the opening and closing.
Fuzzy Financial Systems

For candlestick patterns that involve more than two patterns. It is the relative lengths of these patterns that result in idiosyncratic patterns. Linguistic variables are defined to capture the essence of the comparative nature of the patterns at the opening and closing. There are five linguistic variables for open and close respectively: low, equal, low, equal, equal, high, and high.

“The related positions of the open and close price to the previous candlestick line are used to model the open style and the close style.” (ibid:617)

The colour of the body can be assigned in relation to their aggressive behaviour (bullish) or passive behaviour (bearish).

The candlesticks can be assigned the label bullish and bearish. And, hedged in relation to the quality of behaviour: NORMAL_BULLISH, WEAK_BULLISH, STRONG_BULLISH, or EXTREME_BULLISH. Similarly for BEARISH.

If the open value is greater than the closing value, then the body colour is BEARISH.

If the open value is smaller than the closing value, then the body colour is BULLISH.

If the open value is approx. equal to the closing value, then the variable is CROSS.

For candlestick patterns that involve more than two patterns. We also have to define the degree of variation between two candlesticks: whether the variation showed increase or decrease in the lengths or the body, and whether or not the increase or decrease was large, small, normal or extreme.

Lee et al’s prototype used a trading variation divided into 7 or 8 intervals ranging from the minimum change \( I_{\text{min}} \) to a maximum change \( I_{\text{max}} \) and then creating \( m \) intervals.

So the set \( A_1 \) is a set of the largest decrements together with some elements of normal decrement. Conversely, \( A_7 \) has the largest increments and some elements of normal increments.
Fuzzy Financial Systems

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Lee et al.’s prototype used a trading variation divided into 7 or 8 intervals ranging from the minimum change $I_{min}$ to a maximum change $I_{max}$ and then creating $m$ intervals.

$u_1 = [-6, -4]$ ..........................  
$u_2 = [6, 8]$;

So the set $A_1$ is a set of the largest decrements together with some elements of normal decrement. Conversely, $A_7$ has the largest increments and some elements of normal increments.

$A_1 = \{ \text{LARGE, DECREASE} \}$,  
$A_2 = \{ \text{NORMAL, DECREASE} \}$,  
$A_3 = \{ \text{SMALL, DECREASE} \}$,  
$A_4 = \{ \text{SMALL, INCREASE} \}$,  
$A_5 = \{ \text{NORMAL, INCREASE} \}$,  
$A_6 = \{ \text{LARGE, INCREASE} \}$,  
and  
$A_7 = \{ \text{EXTREME, INCREASE} \}$.

Then the fuzzy set $A_1$ to $A_7$ on the universe of discourse will be as follows:

$A_1 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
$A_2 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
$A_3 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
$A_4 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
$A_5 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
$A_6 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$,  
and  
$A_7 = \{ 0.5y_1 + 0.5y_2 + 0.5y_3 + 0.5y_4 + 0.5y_5 + 0.5y_6 + 0.5y_7 \}$.

**A candlestick pattern for a fuzzy time series:**

<table>
<thead>
<tr>
<th>Pattern description part</th>
<th>Pattern information part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous candle: Upward</td>
<td>Confirmation information:</td>
</tr>
<tr>
<td>Candle lines:</td>
<td>The open price after the pattern should not be higher than the open price of candle line 0.</td>
</tr>
<tr>
<td>Candle line 0:</td>
<td>Recognition rule: 1. A definite downward must be underway.</td>
</tr>
<tr>
<td>Open style: OPEN HIGH</td>
<td>3. The second day’s body must completely engulf the prior day’s body.</td>
</tr>
<tr>
<td>Close style: CLOSE LOW</td>
<td>3. The first day’s color should restore the normal black for a documented and white.</td>
</tr>
<tr>
<td>Upper shadow: null</td>
<td>Pattern explanation: The first day of theEngulfing pattern has a small body and the second day has a long real body. Because the second day’s price...</td>
</tr>
<tr>
<td>Body: ABOVE SHORT</td>
<td></td>
</tr>
<tr>
<td>Body color: WHITE</td>
<td></td>
</tr>
<tr>
<td>Lower shadow: null</td>
<td></td>
</tr>
<tr>
<td>Interests time period: DAY</td>
<td></td>
</tr>
</tbody>
</table>

Fuzzy Financial Systems

Lee et al’s system computes which of the variation sets a candlestick pattern belongs to:

TAIFX Data, Data Variation, and Fuzzy Sets

<table>
<thead>
<tr>
<th>Years</th>
<th>Open</th>
<th>Close</th>
<th>High</th>
<th>Low</th>
<th>One day variations</th>
<th>Fuzzy variations A_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004/1/2</td>
<td>5997.15</td>
<td>6041.56</td>
<td>6043.3</td>
<td>5997.15</td>
<td>1.59</td>
<td>A_i</td>
</tr>
<tr>
<td>2004/1/5</td>
<td>6080.18</td>
<td>6125.43</td>
<td>6137.91</td>
<td>6081.86</td>
<td>0.30</td>
<td>A_i</td>
</tr>
<tr>
<td>2004/1/6</td>
<td>6176.02</td>
<td>6144.01</td>
<td>6179.02</td>
<td>6110.69</td>
<td>-6.64</td>
<td>A_i</td>
</tr>
<tr>
<td>2004/1/7</td>
<td>6174.53</td>
<td>6141.22</td>
<td>6173.42</td>
<td>6180.55</td>
<td>0.42</td>
<td>A_i</td>
</tr>
<tr>
<td>2004/1/8</td>
<td>6180.26</td>
<td>6160.17</td>
<td>6180.4</td>
<td>6152.53</td>
<td>0.04</td>
<td>A_i</td>
</tr>
<tr>
<td>2004/1/9</td>
<td>6241.36</td>
<td>6226.98</td>
<td>6257.89</td>
<td>6207.69</td>
<td>-0.12</td>
<td>A_i</td>
</tr>
</tbody>
</table>

Some of the heuristics identified by Lee et al include:

1. If previous trend = STRONG BEARISH and open style = OPEN_LOW and upper shadow = EQUAL and body = CROSS and lower shadow = MIDDLE, then following trend = STRONG INCREASE.
2. If previous trend = EXTREME BEARISH and open style = OPEN_LOW and upper shadow = EQUAL and body = CROSS and lower shadow = LONG, then following trend = EXTREME INCREASE.

The investor can merge P1 and P2 by using the ABOVE fuzzy modifier as follows:

3. If previous trend = ABOVE STRONG BEARISH and open style = OPEN_LOW and upper shadow = EQUAL and body = CROSS and lower shadow = ABOVE MIDDLE, then following trend = ABOVE STRONG INCREASE.
Fuzzy Financial Systems

An initial evaluation of Taiwanese Stock Market data, used both for training and testing shows encouraging results.

The system is reportedly being used for teaching and learning.