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The Main Ingredients of Simple Trading Models for Use in Genetic Algorithm Optimization

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1 Introduction

The purpose of this paper is to analyze the different ingredients that constitute the basis of a trading model in order to be able to reformulate them in terms of simple quantities to be used in conjunction with a genetic algorithm.

Before entering into the details, let us first state that a real trading model can be quite complicated and can imply many different rules that also depend on the model own trading history. Here we shall limit ourselves to simpler models that depend essentially on a set of indicators that are pure function of the price history or of the current return. This limitation is not only done to simplify our first attempt but also because our purpose is to study indicators.

The basic rule of a simple trading model with possible contrarian strategy is as follows,

```
IF |M| > K THEN G := sign(I) * sign(C) ELSE G := 0
```

where `M` is an indicator that may be a function of two other ones: `I` an indicator that gives the direction of the position and `C` an indicator that gives the strategy (trend following or contrarian), `K` is a constant and `G` the gearing[1]. A trading model might be a combination of this type of rules with `AND` and `OR` using different indicators to give rise to a more complex model using many rules. The representation of these rules can be done using a binary tree approach for the mapping.

2 Indicators

In various papers (Müller, 1989; Müller, 1991a; Müller, 1991b; Pictet et al., 1992), we have given different descriptions of indicators that have been used in conjunction with trading models. Here we would like to give some abstract classification of these indicators in order to be able to use them the proper way in combination with the genetic algorithm. For the time being, the indicators we use are function of the time series itself. In a later stage, we can envisage using as indicators for a particular time series a function of other time series, like, for instance, interest rate functions for studying FX-rates.

First, we define two general classes of indicators. The symmetric I_s and the antisymmetric I_a indicators:

$$I_s(x) = I_s(-x) \quad \text{and} \quad I_a(x) = -I_a(-x) \tag{2.1}$$

A typical antisymmetric indicator is a momentum (Pictet et al., 1992) of the logarithm of price[2] x. A typical symmetric indicator would be the momentum of the volatility of prices. The two classes will be used differently in the trading model. The antisymmetric indicators are the ones that give the dealing signal while the symmetric indicators *modulate* it. For instance, they may forbid the model to trade or may modulate the threshold values.

What are the indicator parameters ? We first describe the parameters that are common to both classes of indicators. Any indicator is composed from moving averages (MA) of different types so the first parameter is the *range* Δt_r of the moving average. The second is the weighting function w of the past. This function can be represented by two parameters (Müller, 1991b)

[1] For a good definition of the trading model terminology used here see (Pictet et al., 1992) or (Ward, 1992)

[2] We use here the same definition as in (Müller et al., 1990).

using the repeated application of the EMA (exponential moving average). The expression takes the following form:

$$MA_{x,w}(t_c) \equiv EMA_x^{(j,n)}(\Delta t_r, t_c) = \frac{1}{n+1-j} \sum_{i=j}^{n} EMA_x^{(i)}(\Delta t_r, t_c) \tag{2.2}$$

where $MA_{x,w}$ can, with this definition, model wide variety of moving averages of the series $x(t)$. The two parameters are j, n with $0 < j < n$ and $EMA_x^{(i)}$ is the *ith* application of the EMA operator. The moving average parameters are then : Δt_r, j, n. For all practical applications, the parameters j and n will not get above 10.

The indicator may be a momentum of various order. The momentum is defined as:

$$m_{x,w}(t_c) \equiv x(t_c) - MA_{x,w}(t_c) \ , \tag{2.3}$$

where t_c is the current time. The concept of momentum can be extended to the *first* momentum which is a difference of two moving averages with different ranges, and the *second* momentum which is a linear combination of three moving averages with different ranges with the property that this combination is equal to zero for a straight line; it indicates the overall curvature of the series for a certain depth in the past. The *order* of the momentum constitutes the fourth general parameter for indicators. This parameter can only take three values 0, 1 or 2.

For symmetric indicators, the number of parameters can be bigger because of the construction of the variable itself. For instance, the direction change indicator (Müller, 1991a) has an internal parameter Δx_{crit} that defines the direction change and a parameter to decide how many of relevant Δx_{crit} must be used. Another variable that might be used is the volatility as defined in (Müller, 1992). In this case the range over which the volatility is measured is also a parameter. So, in general, symmetric indicators mean some more parameters to the problem. Here we consider only two more.

Now the basic variable to the indicator can be either the logarithm of price x or the current return of the model r_c. An indicator using the current return can be used for programming stop losses or stop profit, or to compute the risk of an open position. One parameter is needed to determine what variable to use. Since the choice is limited to two variables, one bit would be enough to represent this information.

To make the indicator more adaptive, it should always contain a scaling or calibration factor in order to keep its variations within similar values for different currencies. One way of doing so is to use the scaling law (Müller et al., 1990). Unfortunately, this is not enough especially in very volatile situations like the EMS (European Monetary System) turmoil of September 92. In order to increase this adaptiveness, one can use a long term EMA of the indicator itself with a range depending on the indicator range. We suggest to use for the calibration factor the following function of the indicator range:

$$\Delta\vartheta_{calib} = 160.\Delta\vartheta_r^{0.47} \tag{2.4}$$

where the different times are given in days. Such a function would give an EMA range of 160 days for the calibration of a 1 day moving average and of 588 days for a 16 days moving average. The time scale used for this calculation, as for all indicator calculations, is the ϑ-scale that deseasonalizes the volatility (Dacorogna et al., 1993).

indicator	var.	ord.	$\Delta\vartheta_r$	j	n	other par.		total
Antisymmetric	1	2	8	3	3	–	–	17
Symmetric	1	2	8	3	3	8	8	33

Table 1: Summary of the parameters for one indicator and the estimated number of bits needed to describe them.

To illustrate the above explanation, we present here one example, the main indicator of the current 40 and 50 models running in the OIS. This indicator has the following antisymmetric form:

$$I_x \;=\; \frac{(x - EMA_x^{(2,4)})}{s(\Delta\vartheta_r, 2, 4)} \tag{2.5}$$

where $s(\Delta\vartheta_r, 2, 4)$ is a scaling factor that can be taken from the scaling law (Müller et al., 1990) or dynamically computed. The variable is the logarithm of the price. The typical ranges of this indicator are: 4 and 16 days. Here again, we used the ϑ-time scale.

In Table 1 the different parameters are shown also with their possible bit representation. This is only a first approximation but it gives a good picture of what is behind the concept of indicator in this context.

3 Operations on indicators

The operations on the indicators are essentially the four mathematical operations: +, -, *, /. In order to generate sensible trading models these operations must be performed following a set of rules. They must be implemented at the level of the mapping algorithm so the genetic algorithm generates the right genes. Here, we list a set of rules that should be followed:

- The division should only be used with a modified value of the indicator in order to avoid division by zero. One would never divide by I but by $I + sign(I) * \varepsilon$ where ε is a small positive constant. This constant can be chosen as, for instance 0.0001 always the same if the indicators are well scaled.
- For all the operations the problem of scaling is also present. In the case of the multiplication and the division because we have already constructed the indicators to be of order one, the scaling is not necessary. In the case of the addition and the subtraction, the result must be divided by $\sqrt{n}$ where n is the number of indicators in the summation.
- First, we shall assume that the *number of operations* allowed is limited and that we do not allow for weighted sums. This assumption is only for simplification. One can decide, at a later stage to expand the number of allowed operations. We suggest to limit it to three in the first attempts.

- In section 1, we saw that the trading model takes a position according to an antisymmetric indicator. So the result of the operations should always be an antisymmetric function. The rule is then to have an odd number of antisymmetric indicators with multiplications and divisions and to only add or subtract the same type of indicators.

Any combination of operations is allowed as long as their number is not above three. For instance I_1 alone is allowed as well as $I_1 + I_2$, or $I_1 + I_2 * I_3$, or $(I_1 - I_2) * I_3$. This insures that the simplest cases will also be tested by the genetic algorithm as well as the most complicated ones.

We have deliberately left out here a set of possible operations like $\sqrt{}$, power function or any *log* or *exp* functions for simplicity and also because we think that the chosen set is already wide enough to lead us to interesting results.

4 Constants and Gearings

The last elements to be discussed in the formula given in the introduction are the constants to test the indicators against and the gearing. The last is the amount of capital invested in the position. In the current implementation of the OIS (Olsen Information System), we allow for ± 1 and ± 0.5. Since we want here to keep the study as simple as possible, we should only allow for $G = \pm 1$. In a later stage, it is always possible to include this complication.

Concerning the constants to be used in the model, they are of course real numbers but the values these constants may take should be limited. We should be here as close as possible to our old optimization scheme. For instance, if the break level is looked at it should be allowed to vary from 0.1 to 1.0 in steps of 0.05. If the calibration of the indicator is well done this number would always be the same.

One last remark on this subject. It concerns the fact that to be fully complete with the trading model one need to consider the position of the model so we would have on top of the condition expressed in the introduction another condition as follows,

```
IF G ≠ 0 THEN K := A ELSE K := B
```

where the constant `K` may take different values according to the current position of the model. Such a rule would allow the model to use a hysteresis when it comes to taking a position.

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