Algorithmic trading and high frequency trading

Balling Band algo trading system

Algorithmic Trading System

Balling Band algo trading system is an offline trading simulator platform that we developed. This platform includes the whole process of an algorithmic investing and trading such as trading strategy implement, pre-trade analysis, trade execution, position management and PnL analysis.

1.Investment Strategies. Balling Band implements six technical investment strategies – Pairs Trading, ACOscillator, CCI Correction, DM RSI ADX, MACD Stochastic, Breakouts Swing, and Oscillator3-13 - on six HSI Index Futures contracts and HSI components. The filter is built in the strategy file, and each strategy will generate a series of trading signal. User can arbitrarily select strategy from the strategies pool.

2.Trade Execution and Position Management. we simulated the trade execution process. Firstly, we use position management method to determine each trade quantity based on our capital balance and market volume. Secondly, after generating the trading quantity, we will slice our orders to minimize our transaction cost.

3.Performance Report (PnL). After execution of all trades, a PnL report will be generated for further analysis on the investment strategy and trading process.

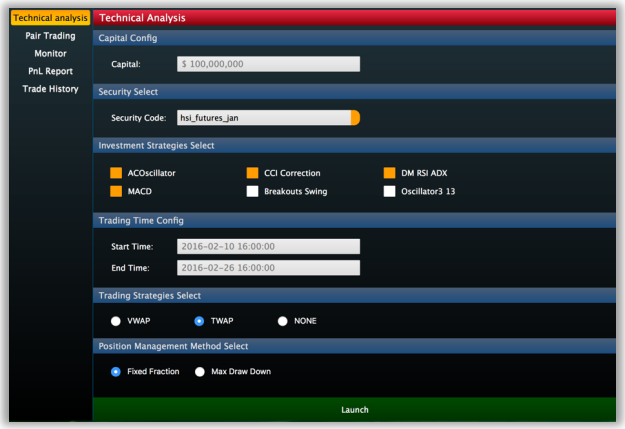

Figure 1 Technical Analysis Module

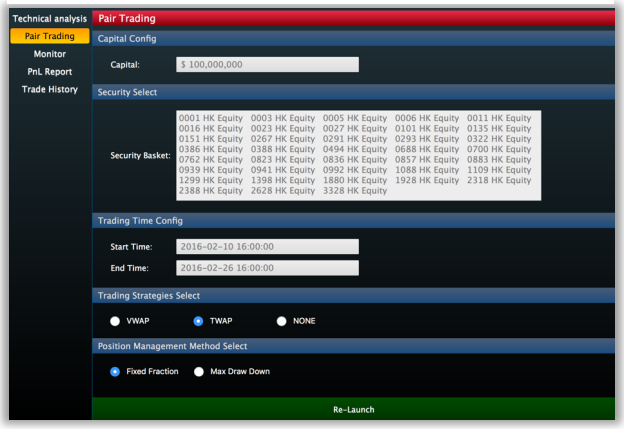

Figure 2 Pairs Trading Module

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Module Structure

Balling Band contains five main modules – Technical analysis, Pairs Trading, Monitor, PnL Report and Trade History.

Module 1 Technical Analysis Module (Figure 1): This module contains 6 parts – Capital Config, Security Select, Investment Strategies Select, Trading Time Config, Trading Strategies Select and Position Management Method Select.

The initial capital is set to $ 100,000,000. And we can select several HSI Futures contracts in the pool including 15Oct, 15Nov, 15Dec, 16Jan and 16Feb contract. After decide which contract we want to analyze and trade, we can select different technical strategies in the strategies pool.

Figure 3 Monitor Module

Monitor Module includes two parts – "Signals Plots" and "All Signals". "Signals Plots" directly shows the suggestion of trading action and time for the specific security. And "All Signals" shows a corresponding signal table.

For instance, Figure 3 shows a four trading signals for each stock in the pair selected by the system. "All Signals" table

suggests we should long 1 unit of 0267 HK Equity and short 3 units of 2318 HK Equity at 2015-11-11 11:45:00.

Module 4 PnL Report Module (Figure 4): This module displays the holding-period performance of each technical strategy. The report includes Realized PnL, Return, Annul Return, Volatility, Sharpe Ratio and Maximum Draw Down.

Figure 5 Trade History Module

For example, we can simultaneously select CCI Correction, MACD Stochastic, Breakouts Swing and Oscillator3_13 strategies. Initial capital will be equally allocated to each strategy. After investment strategy selection, we can select trading strategy "TWAP" and position management method "Fixed Fraction" and launch trade by click "Launch" button.

Module 2 Pairs Trading Module (Figure 2): This module is similar to Technical Analysis Module. Instead, the system will automatically select the best trading pairs by searching in security basket.

Module 3 Monitor Module (Figure 3): This module shows the trading signal after launch the trade in Module 1 and Module 2.

Figure 4 PnL Report Module

Module 5 Trade History Module (Figure 5): This module displays a complete trade history for each strategy we chose. The table includes information of Code, Time, Action, Qnt, Occpy, Price, PnL, Equity and Strategy.

For example, the table in Figure 5 shows the trade history of strategy CCI Correction on HSI Futures. This table shows "realized" trade. So the trading time and quantity are not necessarily as those in signal table.

Also, the table contains the information of Occupy. This is the percentage of each trade quantity to the market volume. The slicing method implement will base on this data.

Investment Strategies

We implemented six technical strategies - ACOscillator, CCI Correction, DM RSI ADX, MACD Stochastic, Breakouts Swing, and Oscillator3-13 – on six HSI Index Futures contracts. For convenience, we use 15Oct, 15Nov, 15Dec, 16Jan and 16Feb for back-testing. Each strategy is briefly introduced as following:

1.CCI Correction

Indicator: Commodity Channel Index (CCI)

Filter: Daily CCI could dictate the trading bias and function as a filter. Once the trading bias is set, 5-min CCI is used to generate trading signals.

Idea:

a. Define the bigger trend and trading bias.

Daily CCI > +100: an uptrend is emerging and a bullish trading bias is adopted.

Daily CCI < -100: a downtrend is emerging and a bearish trading bias is adopted.

b. Wait for a smaller counter trend movement.

In bullish bias: 5-min CCI < -100 indicates an overbought pullback.

In bearish bias: 5-min CCI > +100 indicates an oversold bounce.

c. Look a reversal of this counter trend movement.

When the trading bias is bullish and 5-min CCI moves below -100, a surge back into positive territory signals a reversal of the pullback. This indicates that the bigger uptrend is also resuming and its time to buy the stock. When the trading bias is bearish and 5-min CCI moves above +100, a plunge into negative territory signals a reversal of the bounce. This indicates that the bigger downtrend is resuming and its time for short selling.

In addition, stop-losses and take-profits are used to control risks and provide appropriate timing of exiting.

2. Breakouts Swing

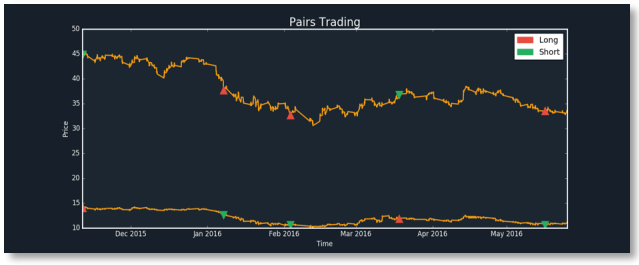
Filter: the open price gives information about the market's trending direction if it moves outside the prior days' range.

Idea:

1. market open higher that previous 3-day high: a bullish trading bias is adopted and a buy signal is triggered.

2. market open lower than previous 3-day low: a bearish trading bias is adopted and a sell signal is triggered.

In addition, stop-losses and take-profits are used to control risks and provide appropriate timing of exiting.



3. DM_RSI_ADX

Idea: When the +DMI is dominant and rising, price direction is up. When the -DMI is dominant and rising, price direction is down. The trend strength is then indicated by ADX and we use RSI to confirm the trend.

We use 14 days –DMI +DMI ADX and RSI

Generating signals

- Bullish cross
  1. ADX must be over 20 which indicates the trend strength
  2 . +DMI > -DMI indicates an uptrend,
  3. RSI< 50 to confirm we are not in a downtrend
  4. Profit taking for 3%, Stop loss when lose 4%
- Bearish cross
  2. ADX must be over 20 which indicates the trend strength
  3 +DMI < -DMI indicates a downtrend,
  5. RSI> 50 to confirm we are not in a downtrend
  6. Profit taking for 3%, Stop loss when lose 4%

4. ACOscillator

Idea: The accelerator oscillator has been developed by Bill Williams as the development of the awesome Oscillator, representing the difference between the Awesome Oscillator and the 5-period moving average which is to seek trend reversal.

To calculate the accelerator oscillator

1. Awesome Oscillator(AO): difference of 40 and 5 days' moving average
2. Accelerator Oscillator(AC) = the difference of AO and its 5-period moving average
3. Get a 5 day moving Average AC to get a smooth trend

Generating signals:

- Bullish:
  1. When 5 day moving Average AC is rising and ADX> 20, then it indicates an uptrend
  2. Profit taking when win 3%, Stop loss when lose 4%
- Bearish:
  3. When 5 day moving Average AC is decreasing and ADX> 20, then it indicates a down trend
  4. Profit taking when win 3%, Stop loss when lose 4%

5. Oscilator3_13

Idea: We adopt MACD to identify the security's momentum, as well as trend direction and duration.

Major components in MACD:

1. The MACD line: difference between 3 and 13 periods' exponential moving average
2. The signal line: an EMA of the MACD line
3. MACD histogram: the difference between MACD line and the signal line

Generating signals

- Bullish
  1. When MACD >0 and histogram is increasing and ADX >20, it indicates an up trend
  2. Profit taking when win 3%, Stop loss when lose 4%
- Bullish
  1. When MACD <0 and histogram is decreasing and ADX >20, it indicates an down trend
  2. Profit taking when win 3%, Stop loss when lose 4%

6.Pair trading strategies:

Trading pool:

HSI Component stocks, SPX Component stocks, futures with different maturity date

Filters steps:

1. Liquidity (easy to long and short, CSI 300 component stock is hard to short)
2. Correlation >0.8

3. Co-integration: P^A and P^B is the price for A and B, and we do log regression between them

$$s_t = \log(P_t^A) - \beta \cdot \log(P_t^B)$$

Then we normalize the price difference

$$\tilde{s}_t = (s_t - \mu) / \sigma$$

4. select the pairs converge quickly and have more crossing historically

Trading converging pairs strategies:

SMA(St,7)// We want to create a position when it already started to converge

If abs(St) >3, Select another pair

If abs(St)<3:

If St >1and St< SMA short 1 A and long beta*B

Exit when St<0.1

Stop loss when St>3

If St <-1 and St< SMA long 1 A and short beta*B

Exit when St>-0.1

Stop loss when St<-3

Figure 6 Pairs Trading Signals

Trade Execution and Position Management

In ***Balling Band***, every trading quantity is automatically decided by the position management methods – Fixed Fraction or Max-Drawdown. After determined trading quantity, we implemented VWAP and TWAP trading slicing method to cut our large volume of orders into comparatively smaller slice in order to reduce our transaction cost.

Figure 7 (a) Fixed Fraction + No slicing (b) Fixed Fraction + TWAP

1. Position Management

We implemented two basic position management methods – Fixed Fraction and Max-Drawdown. By applying these methods, we can well manage our trading volume each time. Also, position management methods can help us better control our trading risk.

Fixed Fraction is calculated as following:

$$Number\ of\ Contracts = Fraction * Equity / |Trade\ Risk|$$

The Fraction in our trading system is set to 0.15. Trade Risk is max drawdown of the specific security. Equity is allocated money for each investment strategy.

For Max Drawdown method, equity will be allocated for each trading contract. For example, each contract will be allocated:

$$Max\ Historical\ Drawdown * 1.5 + Margin\ Requirement$$

Every time the profit is greater than this value, one contract will be added. This method gave us 1.5 times of MDD buffer to control our risk.

2. Trading Execution

After generating appropriate trading quantity, we have to do pre-trade analysis to minimize our transaction cost. We applied VWAP and TWAP. Also, there is a option "None" which is to generate original trade book for analysis.

For VWAP, tried to splice the orders by constant time, which based on the time interval of the tick orders input since we required some historical data for reference. The main reason behind this is that we pay an effort to hide our total trading orders from the market participants so that they do not realize or identify our large order size on building our positions in the asset. Therefore, to achieve this, we take advantage of the historical data to calculate the average traded volume for fixed time intervals.

Hence, in our VWAP algorithm, in order to split a large order on a day, we make use of the previous week trading volume data as a reference for computing the average trading volume in certain time intervals. For example, as we obtained some 15-minutes data of HSI futures, to make everything simple we implemented to splice our orders in 15 minutes so that we can easily find out the historical trading volume data for computing our order data.

The calculation:

$$average\ trading\ volume\ of\ each\ time\ interval\ i = \frac{vAi + vBi + vCi + \cdots + vGi}{7}$$

where vAi, vBi, … vGi represented the 1st day (A) to 7th day (G) 's time interval i's trading volume

After that, we also calculate the percentage of the average trading volume of 1 interval a 1 day:

$$percentage = \frac{avgVix}{avgVi1 + avgVi2 + \cdots + avgVn}$$

,where x (x=1,2,…n) is the time interval number and avgVix is the average trading volume of time interval x.

Finally, we can use the percentage as the reference to decide the maximum percentage of time interval volume we can trade in a certain time frame. Based on these statistical data we can split our large order logically and form a list of small orders for trading part.

For TWAP, the algorithm will search through the past record and find out the time-weighted average price (TWAP) of the stock in the past 7 days. That price will be used as the target price for each individual order. The target price will be updated continuously as the time passes through intervals. The order will be executed if the current price equals or better than the TWAP of the stock.

After executing all orders, the algorithm will check if the executed quantity equals target quantity, since target quantity may not be fully executed, if the market volume is less than the lot size. If executed quantity is less than target quantity, the algorithm will issue more orders will the same lot size, such that the target quantity can be fully purchased or sold.

PnL Report (Back-testing Result)

For each strategy, we calculate the following things to measure its performance after trade execution.

1. Profit and loss (PnL)

The realized profit and loss is calculated as the total amount of money we earn or lose during a specified period given the cash flows of each trade.

2. Return

The return is calculated as the realized PnL divided by the capital of the strategy.

3. Annualized return

The annualized return incorporates the trading period into the return calculated above so that trading performance with different time period could be compared reasonably.

4. Volatility

Volatility is calculated using the standard deviation of the strategy's annualized return. Volatility refers to the risk of the strategy's return, which is the value variation of the stock we are trading. Different strategies would show different volatilities. We prefer lower volatility, which means our return does not fluctuate dramatically. High volatility needs to be watched out since it implies high risk with that strategy.

5. Sharpe Ratio

The Sharpe ratio is a measure for calculating risk-adjusted return. It takes account of both return and volatility, so gives a fairly reasonable indication of the trading performance. The Sharpe ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk. Subtracting the risk-free rate from the mean return, the performance associated with risk-taking activities can be isolated. For risk-free interest rate we use the 10-year Hong Kong Treasury bond. Generally, the higher the value of the Sharpe ratio, the better performance it indicates. The following formulation is what we implement in our codes:

$$\text{Sharpe ratio} = (\text{Mean portfolio return} - \text{Risk-free rate}) / \text{Standard deviation of portfolio return}$$

6. Maximum Drawdown (MDD)

Maximum drawdown is the maximum loss from a peak to a trough of a portfolio. It indicates the downside risk of the strategy during the period. MDD is calculated using the following formulation:

$$(\text{Trough Value} - \text{Peak Value}) \div \text{Peak Value}$$

MDD is relatively small in our system because we are cautious in controlling the loss and risk.

Back-testing Result

Figure 8 No slicing

Figure 9 TWAP slicing

Figure 8 displays the performance of no slicing and Figure 9 displays the performance of TWAP slicing. As is shown, the performance after slicing is better than that of no slicing. Although the realized PnL is basically same. But the volatility of our PnL decreases. In turn, the Sharpe Ratio is better.