COMP6560

Computational Intelligence in Business, Economics and Finance
Assignment

Optimising trading strategies based on technical analysis

Deliverables: zip file with project and other files on results, summary statistics, and presentation (project can be in Java or another language of your preference; you can use BlueJ or any other IDE you like)

Deadline: **23:55 on Wednesday, December 15 2021 (Week 20)**

Your task is to implement a Genetic Algorithm (GA) to optimise a trading strategy based on technical indicators. You will need to first calculate the value of different technical indicators and trading signals. Then, you will use a GA to combine their recommendations (BUY, HOLD and SELL signals) to create a trading strategy.

For this assessment, you should use the Unilever.csv file as the source of prices – available on Moodle.

Part A: Implementing technical indicators and trading signals

For this part, update the Unilever.csv file to include the information of technical indicators and trading signals.

Task 1: Technical Indicators (10%)

Task 1a

The Exponential Moving Average (EMA) is a type of moving average that puts more emphasis on recent price data, while the standard moving average uses the same weight for all prices observations. The formula to calculate the EMA is given below:

$$EMA(L,t) = \left(P_t * \left(\frac{smoothing}{1+L}\right)\right) + \left(EMA(L,t-1) * \left(1 - \frac{smoothing}{1+L}\right)\right)$$

where P_t is the price at the day t, L is the period length (number of days) and the $smoothing$ factor is equal to 2. In other words, the EMA for the t-th day is the price at t multiplied by the smoothing term plus the EMA value of the previous day (t – 1) multiplied by the smoothing term. To calculate the EMA for the first day after the interval L (e.g., EMA at the 12th day for an 12-day interval), we use the value of the Simple Moving Average (SMA) as the EMA:

$$SMA(L,\ t) = \frac{\sum_{i=1}^{L} P_{t-i}}{L}$$

For example, if we are interested in calculating the 12-day EMA, we will first calculate the 12-day SMA as the EMA on the 12th day; then use this value to calculate the EMA for the 13th day and so forth.

Using the formulation above, calculate the 12-day and 26-day EMA.

Task 1b

Calculate the 24-day trade break out rule (TBR), given the formula below.

$$TBR(L,t) = \frac{P_t - \max\{P_{t-1}, \dots, P_{t-L}\}}{\max\{P_{t-1}, \dots, P_{t-L}\}}$$

where P_t is the price at the day t, L is the period length (24 days), and max{…} returns the maximum price observed in the days $\{t-1, \dots, t-L\}$ – i.e., the highest price in the 24 past days.

Task 1c

Calculate the 29-day volatility (VOL), given the formula below.

$$Vol(L,t) = \frac{\sigma(P_{t-1}, \dots, P_{t-L})}{SMA(L,t)}$$

where σ is the standard deviation for the prices in the given range, P_t is the price at the day t and L is the period length (29 days).

Task 1d

Calculate the 25-day momentum (MOM), give the formula below.

$$MOM(x,\ t) = P_t - P_{t-x}$$

where P_t is the price at the day t and P_{t-x} is the price at previous x-th day (e.g., price at the $t-x$ day).

Task 2: Trading signals (10%)

Task 2a

Use the two EMA indicators from above to generate buy and sell signals. For each indicator entry, you should compare 12-day EMA to 26-day EMA, and generate signals in the following manner:

If *12-day EMA* **>** *26-day EMA* **=>** 1 (buy)
If *12-day EMA* **<** *26-day EMA* **=>** 2 (sell)
If *12-day EMA* **=** *26-day EMA* **=>** 0 (hold)

Task 2b
Use the TBR indicator above to generate signals in the following manner:

If *24-day TBR* **>** −0.02 **=>** 2 (sell)
If *24-day TBR* **<** −0.02 **=>** 1 (buy)
If *24-day TBR* **=** −0.02 **=>** 0 (hold)

Task 2c
Use the VOL indicator above to generate signals in the following manner:

If *29-day VOL* **>** 0.02 **=>** 1 (buy)
If *29-day VOL* **<** 0.02 **=>** 2 (sell)
If *29-day VOL* **=** 0.02 **=>** 0 (hold)

Task 2d
Use the MOM indicator above to generate signals in the following manner:

If *25-day MOM* **>** 0 **=>** 1 (buy)
If *25-day MOM* **<** 0 **=>** 2 (sell)
If *25-day MOM* **=** 0 **=>** 0 (hold)

PART B: Genetic Algorithm

Task 1 (40%)
Use a GA to combine the output of the trading signals from Task 2a–2d. For example, the indicator may generate the following signals:

Task 2a => BUY
Task 2b => BUY
Task 2c => HOLD
Task 2d => SELL

In this case, you could choose to BUY since the majority of trading signals are recommending this action. We say that all signals have the same weight in this case.

Your task is to implement a GA to evolve a set of weights (one for each trading signal) to determine an optimal trading action. Your individual representation should associate a numeric weight (between 0 and 1) to each trading signal:

0.4 x Task 2a => BUY
0.2 x Task 2b => BUY
0.1 x Task 2c => HOLD
0.8 x Task 2d => SELL

In this case, the strategy decides to SELL, giving that it is the signal associate with the highest weight: BUY = 0.4 + 0.2, HOLD = 0.1 and SELL = 0.8. Your implementation should include:

- **individual representation [10%]**: for correct representation, one weight value between 0 and 1 per trading signal; the population should be randomly initialized with values between [0, 1];

- **fitness function [15%]**: for correct evaluation of candidate solutions. The fitness function should operate with an initial budget of £3000 and stock amount of 0. For each value on the training data, it should generate a trading signal. Every BUY action should deduct the amount from the budget and only be performed if there is sufficient budget, and increase the stock amount; every SELL action should deduct the stock amount and only be performed if there is sufficient stocks, and increase the budget accordingly; HOLD actions have no effect. The fitness of a solution is the total cash balance at the end of trading (budget + stock), where the stocks should be converted to cash using the last value of the training period;

- **selection method [5%]**: the GA should use tournament selection;

- **genetic operators [5%]**: the GA should use one mutation and one crossover operator of your choice. The mutation operator should only generate new real values between 0 and 1;

- **termination criteria [5%]**: a maximum number of generations should indicate the end of the evolutionary process.

At the end of the evolutionary process, the best weight configuration should be returned.

Task 2 (20%)

Modify your GA to include a gene in the individual representation to encode the amount to be traded in terms of stock (as an integer number): for BUY actions, this would be the maximum amount that you buy (as long as there is budget); for SELL actions, this would be the amount that you sell (as long as there are stocks to sell). You will need to modify the way the individuals are initialised, the fitness function and the mutation operator – the latter will need to generate a valid value when mutating the gene representing the amount.

PART C: Presentation

Task 1 (20%)

Prepare powerpoint slides to make a 5-minute presentation discussing your implementation and results. Topics you should cover in your slides:

- How much you managed to achieve in terms of the given tasks.
- Difficulties during your implementation: what has gone well, what has gone wrong.
- Would you do anything differently if you had to re-do the assignment.

- Report on your experimental results, including summary statistics from multiple runs. If you haven't obtained any results yet, that is fine, but you should still mention that you don't have any results.
- Report on different GA parameters that you might have used, and how/if they affected the performance of the algorithm. If you've tried different parameters, you should also present statistical analysis to support your argument.
- Anything else you consider useful to mention, e.g., any additional methods implementation you decided to implement.

Submission

Electronic version (zip file) of the project, along with any results files, statistical analysis, and powerpoint slides. The zip file should be submitted via Moodle before the deadline, no later than **23:55 on Wednesday, December 15 2021 (Week 20)**. Any other form of submission will not be accepted. Note that the submission link will not be available after the deadline.

Plagiarism and duplication of material

• Late or non submission of coursework

The penalty for late or non submission of coursework is normally that a mark of zero is awarded for the missing piece of work and the final mark for the module is calculated accordingly.

• Plagiarism and Duplication of Material

Senate has agreed the following definition of plagiarism: "Plagiarism is the act of repeating the ideas or discoveries of another as one's own. To copy sentences, phrases or even striking expressions without acknowledgement in a manner that may deceive the reader as to the source is plagiarism; to paraphrase in a manner that may deceive the reader is likewise plagiarism. Where such copying or close paraphrase has occurred the mere mention of the source in a bibliography will not be deemed sufficient acknowledgement; in each such instance it must be referred specifically to its source. Verbatim quotations must be directly acknowledged either in inverted commas or by indenting." The work you submit must be your own, except where its original author is clearly referenced. We reserve the right to run checks on all submitted work in an effort to identify possible plagiarism, and take disciplinary action against anyone found to have committed plagiarism. When you use other peoples' material, you must clearly indicate the source of the material using the Harvard style
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