

# evolution-strategy-bayesian-agent

September 29, 2021

```
[1]: !pip3 install bayesian-optimization==0.6 --user
```

```
Requirement already satisfied: bayesian-optimization==0.6 in
/home/husein/.local/lib/python3.6/site-packages (0.6.0)
Requirement already satisfied: scikit-learn>=0.18.0 in
/usr/local/lib/python3.6/dist-packages (from bayesian-optimization==0.6)
(0.19.1)
Requirement already satisfied: scipy>=0.14.0 in /usr/local/lib/python3.6/dist-
packages (from bayesian-optimization==0.6) (1.2.0)
Requirement already satisfied: numpy>=1.9.0 in /usr/local/lib/python3.6/dist-
packages (from bayesian-optimization==0.6) (1.14.5)
You are using pip version 18.1, however version 19.0.3 is available.
```

You should consider upgrading via the 'pip install --upgrade pip' command.

I use bayesian-optimization==0.6, my backend pretty much stick with this version, so migrating will break the code.

```
[2]: import numpy as np
import pandas as pd
import time
import matplotlib.pyplot as plt
import seaborn as sns
import random
from bayes_opt import BayesianOptimization
sns.set()
```

```
[3]: import pkg_resources
import types

def get_imports():
    for name, val in globals().items():
        if isinstance(val, types.ModuleType):
            name = val.__name__.split('.')[0]
        elif isinstance(val, type):
            name = val.__module__.split('.')[0]
    poorly_named_packages = {'PIL': 'Pillow', 'sklearn': 'scikit-learn'}
    if name in poorly_named_packages.keys():
```

```

        name = poorly_named_packages[name]
    yield name

imports = list(set(get_imports()))
requirements = []
for m in pkg_resources.working_set:
    if m.project_name in imports and m.project_name != 'pip':
        requirements.append((m.project_name, m.version))

for r in requirements:
    print('{}=={}'.format(*r))

```

```

seaborn==0.9.0
pandas==0.23.4
numpy==1.14.5
matplotlib==3.0.2

```

```

[4]: def get_state(data, t, n):
      d = t - n + 1
      block = data[d : t + 1] if d >= 0 else -d * [data[0]] + data[0 : t + 1]
      res = []
      for i in range(n - 1):
          res.append(block[i + 1] - block[i])
      return np.array([res])

```

TSLA Time Period: **Mar 23, 2018 - Mar 23, 2019**

```

[5]: df = pd.read_csv('../dataset/TSLA.csv')
      df.head()

```

```

[5]:
      Date      Open      High      Low      Close  Adj Close  \
0  2018-03-23  311.250000  311.250000  300.450012  301.540009  301.540009
1  2018-03-26  307.339996  307.589996  291.359985  304.179993  304.179993
2  2018-03-27  304.000000  304.269989  277.179993  279.179993  279.179993
3  2018-03-28  264.579987  268.679993  252.100006  257.779999  257.779999
4  2018-03-29  256.489990  270.959991  248.210007  266.130005  266.130005

      Volume
0    6654900
1    8375200
2   13872000
3   21001400
4   15170700

```

```

[6]: close = df.Close.values.tolist()
      window_size = 30

```

```

skip = 5
l = len(close) - 1

```

```

[7]: class Deep_Evolution_Strategy:

    inputs = None

    def __init__(
        self, weights, reward_function, population_size, sigma, learning_rate
    ):
        self.weights = weights
        self.reward_function = reward_function
        self.population_size = population_size
        self.sigma = sigma
        self.learning_rate = learning_rate

    def _get_weight_from_population(self, weights, population):
        weights_population = []
        for index, i in enumerate(population):
            jittered = self.sigma * i
            weights_population.append(weights[index] + jittered)
        return weights_population

    def get_weights(self):
        return self.weights

    def train(self, epoch = 100, print_every = 1):
        lasttime = time.time()
        for i in range(epoch):
            population = []
            rewards = np.zeros(self.population_size)
            for k in range(self.population_size):
                x = []
                for w in self.weights:
                    x.append(np.random.randn(*w.shape))
                population.append(x)
            for k in range(self.population_size):
                weights_population = self._get_weight_from_population(
                    self.weights, population[k]
                )
                rewards[k] = self.reward_function(weights_population)
            rewards = (rewards - np.mean(rewards)) / np.std(rewards)
            for index, w in enumerate(self.weights):
                A = np.array([p[index] for p in population])
                self.weights[index] = (
                    w
                    + self.learning_rate

```

```

        / (self.population_size * self.sigma)
        * np.dot(A.T, rewards).T
    )
    if (i + 1) % print_every == 0:
        print(
            'iter %d. reward: %f'
            % (i + 1, self.reward_function(self.weights))
        )
    print('time taken to train:', time.time() - lasttime, 'seconds')

class Model:
    def __init__(self, input_size, layer_size, output_size):
        self.weights = [
            np.random.randn(input_size, layer_size),
            np.random.randn(layer_size, output_size),
            np.random.randn(layer_size, 1),
            np.random.randn(1, layer_size),
        ]

    def predict(self, inputs):
        feed = np.dot(inputs, self.weights[0]) + self.weights[-1]
        decision = np.dot(feed, self.weights[1])
        buy = np.dot(feed, self.weights[2])
        return decision, buy

    def get_weights(self):
        return self.weights

    def set_weights(self, weights):
        self.weights = weights

```

```

[8]: class Agent:
    def __init__(
        self,
        population_size,
        sigma,
        learning_rate,
        model,
        money,
        max_buy,
        max_sell,
        skip,
        window_size,
    ):
        self.window_size = window_size
        self.skip = skip

```

```

self.POPULATION_SIZE = population_size
self.SIGMA = sigma
self.LEARNING_RATE = learning_rate
self.model = model
self.initial_money = money
self.max_buy = max_buy
self.max_sell = max_sell
self.es = Deep_Evolution_Strategy(
    self.model.get_weights(),
    self.get_reward,
    self.POPULATION_SIZE,
    self.SIGMA,
    self.LEARNING_RATE,
)

def act(self, sequence):
    decision, buy = self.model.predict(np.array(sequence))
    return np.argmax(decision[0]), int(buy[0])

def get_reward(self, weights):
    initial_money = self.initial_money
    starting_money = initial_money
    self.model.weights = weights
    state = get_state(close, 0, self.window_size + 1)
    inventory = []
    quantity = 0
    for t in range(0, 1, self.skip):
        action, buy = self.act(state)
        next_state = get_state(close, t + 1, self.window_size + 1)
        if action == 1 and initial_money >= close[t]:
            if buy < 0:
                buy = 1
            if buy > self.max_buy:
                buy_units = self.max_buy
            else:
                buy_units = buy
            total_buy = buy_units * close[t]
            initial_money -= total_buy
            inventory.append(total_buy)
            quantity += buy_units
        elif action == 2 and len(inventory) > 0:
            if quantity > self.max_sell:
                sell_units = self.max_sell
            else:
                sell_units = quantity
            quantity -= sell_units
            total_sell = sell_units * close[t]

```

```

        initial_money += total_sell

        state = next_state
    return ((initial_money - starting_money) / starting_money) * 100

def fit(self, iterations, checkpoint):
    self.es.train(iterations, print_every = checkpoint)

def buy(self):
    initial_money = self.initial_money
    state = get_state(close, 0, self.window_size + 1)
    starting_money = initial_money
    states_sell = []
    states_buy = []
    inventory = []
    quantity = 0
    for t in range(0, 1, self.skip):
        action, buy = self.act(state)
        next_state = get_state(close, t + 1, self.window_size + 1)
        if action == 1 and initial_money >= close[t]:
            if buy < 0:
                buy = 1
            if buy > self.max_buy:
                buy_units = self.max_buy
            else:
                buy_units = buy
            total_buy = buy_units * close[t]
            initial_money -= total_buy
            inventory.append(total_buy)
            quantity += buy_units
            states_buy.append(t)
            print(
                'day %d: buy %d units at price %f, total balance %f'
                % (t, buy_units, total_buy, initial_money)
            )
        elif action == 2 and len(inventory) > 0:
            bought_price = inventory.pop(0)
            if quantity > self.max_sell:
                sell_units = self.max_sell
            else:
                sell_units = quantity
            if sell_units < 1:
                continue
            quantity -= sell_units
            total_sell = sell_units * close[t]
            initial_money += total_sell
            states_sell.append(t)

```

```

        try:
            invest = ((total_sell - bought_price) / bought_price) * 100
        except:
            invest = 0
        print(
            'day %d, sell %d units at price %f, investment %f %%, total_
→balance %f,'
            % (t, sell_units, total_sell, invest, initial_money)
        )
        state = next_state

    invest = ((initial_money - starting_money) / starting_money) * 100
    print(
        '\ntotal gained %f, total investment %f %%'
        % (initial_money - starting_money, invest)
    )
    plt.figure(figsize = (20, 10))
    plt.plot(close, label = 'true close', c = 'g')
    plt.plot(
        close, 'X', label = 'predict buy', markevery = states_buy, c = 'b'
    )
    plt.plot(
        close, 'o', label = 'predict sell', markevery = states_sell, c = 'r'
    )
    plt.legend()
    plt.show()

```

```

[9]: def best_agent(
    window_size, skip, population_size, sigma, learning_rate, size_network
):
    model = Model(window_size, size_network, 3)
    agent = Agent(
        population_size,
        sigma,
        learning_rate,
        model,
        10000,
        5,
        5,
        skip,
        window_size,
    )
    try:
        agent.fit(100, 1000)
        return agent.es.reward_function(agent.es.weights)
    except:
        return 0

```

```
[10]: def find_best_agent(
    window_size, skip, population_size, sigma, learning_rate, size_network
):
    global accbest
    param = {
        'window_size': int(np.around(window_size)),
        'skip': int(np.around(skip)),
        'population_size': int(np.around(population_size)),
        'sigma': max(min(sigma, 1), 0.0001),
        'learning_rate': max(min(learning_rate, 0.5), 0.000001),
        'size_network': int(np.around(size_network)),
    }
    print('\nSearch parameters %s' % (param))
    investment = best_agent(**param)
    print('stop after 100 iteration with investment %f' % (investment))
    if investment > accbest:
        costbest = investment
    return investment
```

```
[11]: accbest = 0.0
NN_BAYESIAN = BayesianOptimization(
    find_best_agent,
    {
        'window_size': (2, 50),
        'skip': (1, 15),
        'population_size': (1, 50),
        'sigma': (0.01, 0.99),
        'learning_rate': (0.000001, 0.49),
        'size_network': (10, 1000),
    },
)
NN_BAYESIAN.maximize(init_points = 30, n_iter = 50, acq = 'ei', xi = 0.0)
```

### Initialization

```
Step | Time | Value | learning_rate | population_size | sigma |
size_network | skip | window_size |
```

```
Search parameters {'window_size': 32, 'skip': 4, 'population_size': 14, 'sigma':
0.6924932742559208, 'learning_rate': 0.4506746405913942, 'size_network': 903}
```

```
time taken to train: 3.6314964294433594 seconds
```

```
stop after 100 iteration with investment 45.469898
```

```
1 | 00m03s | 45.46990 | 0.4507 |
14.1205 | 0.6925 | 903.2810 | 3.8596
| 32.0389 |
```



Search parameters {'window\_size': 9, 'skip': 2, 'population\_size': 40, 'sigma': 0.6314318303690627, 'learning\_rate': 0.2665435889829382, 'size\_network': 418}  
time taken to train: 6.387232542037964 seconds  
stop after 100 iteration with investment 46.435302  
2 | 00m06s | 46.43530 | 0.2665 |  
40.1437 | 0.6314 | 417.6211 | 2.4864  
| 8.5411 |

Search parameters {'window\_size': 15, 'skip': 14, 'population\_size': 19, 'sigma': 0.08278555353887103, 'learning\_rate': 0.28395843327770764, 'size\_network': 121}  
stop after 100 iteration with investment 0.000000  
3 | 00m00s | 0.00000 | 0.2840 | 19.2441 | 0.0828 |  
121.0415 | 13.7214 | 15.4565 |

Search parameters {'window\_size': 20, 'skip': 3, 'population\_size': 17, 'sigma': 0.9721007155778852, 'learning\_rate': 0.2755723397763024, 'size\_network': 777}  
/usr/local/lib/python3.6/dist-packages/ipykernel\_launcher.py:39: RuntimeWarning:  
invalid value encountered in true\_divide  
time taken to train: 3.6136224269866943 seconds  
stop after 100 iteration with investment 20.886098  
4 | 00m03s | 20.88610 | 0.2756 | 16.9868 | 0.9721 |  
776.5696 | 2.8687 | 19.7415 |

Search parameters {'window\_size': 10, 'skip': 10, 'population\_size': 12, 'sigma': 0.9587684522335657, 'learning\_rate': 0.3107466445720601, 'size\_network': 196}  
time taken to train: 0.47393083572387695 seconds  
stop after 100 iteration with investment 15.384199  
5 | 00m00s | 15.38420 | 0.3107 | 12.0360 | 0.9588 |  
196.2702 | 10.3654 | 9.5100 |

Search parameters {'window\_size': 16, 'skip': 15, 'population\_size': 16, 'sigma': 0.9424607807175174, 'learning\_rate': 0.4304065851197905, 'size\_network': 101}  
time taken to train: 0.4492471218109131 seconds  
stop after 100 iteration with investment 10.937500  
6 | 00m00s | 10.93750 | 0.4304 | 15.7218 | 0.9425 |  
101.4025 | 14.7170 | 16.4290 |

Search parameters {'window\_size': 44, 'skip': 14, 'population\_size': 9, 'sigma': 0.5515595926157524, 'learning\_rate': 0.1058658719049542, 'size\_network': 448}  
time taken to train: 1.143993616104126 seconds  
stop after 100 iteration with investment 14.495498  
7 | 00m01s | 14.49550 | 0.1059 | 8.6050 | 0.5516 |

447.5149 | 14.1363 | 43.8864 |

Search parameters {'window\_size': 11, 'skip': 9, 'population\_size': 13, 'sigma': 0.3095428607448544, 'learning\_rate': 0.04079037201287228, 'size\_network': 900}

time taken to train: 1.3032267093658447 seconds

stop after 100 iteration with investment 6.128101

8 | 00m01s | 6.12810 | 0.0408 | 12.8935 | 0.3095 |  
900.3144 | 8.7717 | 10.8557 |

Search parameters {'window\_size': 17, 'skip': 6, 'population\_size': 19, 'sigma': 0.6364998429932328, 'learning\_rate': 0.29209145932218566, 'size\_network': 535}

time taken to train: 1.9795026779174805 seconds

stop after 100 iteration with investment 23.538000

9 | 00m01s | 23.53800 | 0.2921 | 18.8682 | 0.6365 |  
535.3654 | 6.1929 | 16.9913 |

Search parameters {'window\_size': 2, 'skip': 8, 'population\_size': 45, 'sigma': 0.23630620909949168, 'learning\_rate': 0.2469324378001854, 'size\_network': 483}

time taken to train: 2.0241739749908447 seconds

stop after 100 iteration with investment 7.828999

10 | 00m02s | 7.82900 | 0.2469 | 44.5681 | 0.2363 |  
482.7787 | 8.1918 | 2.4514 |

Search parameters {'window\_size': 3, 'skip': 8, 'population\_size': 6, 'sigma': 0.3690419820520124, 'learning\_rate': 0.2500034872048501, 'size\_network': 66}

time taken to train: 0.1856238842010498 seconds

stop after 100 iteration with investment 6.033901

11 | 00m00s | 6.03390 | 0.2500 | 5.7217 | 0.3690 |  
66.4484 | 8.4349 | 2.6576 |

Search parameters {'window\_size': 5, 'skip': 13, 'population\_size': 21, 'sigma': 0.7845492963667585, 'learning\_rate': 0.18249610602293675, 'size\_network': 682}

time taken to train: 1.0442640781402588 seconds

stop after 100 iteration with investment 3.329900

12 | 00m01s | 3.32990 | 0.1825 | 20.7766 | 0.7845 |  
681.5072 | 13.4947 | 5.0838 |

Search parameters {'window\_size': 9, 'skip': 8, 'population\_size': 31, 'sigma': 0.584901850128559, 'learning\_rate': 0.262432628184034, 'size\_network': 455}

time taken to train: 1.8967516422271729 seconds

stop after 100 iteration with investment 16.867999

13 | 00m01s | 16.86800 | 0.2624 | 31.0438 | 0.5849 |  
454.5904 | 7.7382 | 9.0253 |

Search parameters {'window\_size': 5, 'skip': 5, 'population\_size': 21, 'sigma': 0.26583128202542755, 'learning\_rate': 0.17776810195709006, 'size\_network': 367}

time taken to train: 1.3621792793273926 seconds

stop after 100 iteration with investment 29.612498

14		00m01s		29.61250		0.1778		20.7062		0.2658
367.4264		4.5233		5.0714						

Search parameters {'window\_size': 21, 'skip': 3, 'population\_size': 23, 'sigma': 0.5312612811941403, 'learning\_rate': 0.25789044017589463, 'size\_network': 155}

time taken to train: 2.652163505554199 seconds

stop after 100 iteration with investment 37.225500

15		00m02s		37.22550		0.2579		22.7385		0.5313
155.3037		2.5507		21.2792						

Search parameters {'window\_size': 4, 'skip': 1, 'population\_size': 14, 'sigma': 0.7564163325071124, 'learning\_rate': 0.40307249149418684, 'size\_network': 379}

time taken to train: 3.518620729446411 seconds

stop after 100 iteration with investment 62.153502

16		00m03s		62.15350		0.4031				
13.5794		0.7564		379.4240		1.4926				
		3.5441								

Search parameters {'window\_size': 50, 'skip': 2, 'population\_size': 43, 'sigma': 0.2197222083454031, 'learning\_rate': 0.4674263070099041, 'size\_network': 760}

time taken to train: 19.268061637878418 seconds

stop after 100 iteration with investment 72.960099

17		00m19s		72.96010		0.4674				
42.8796		0.2197		759.9597		1.9957				
		49.5908								

Search parameters {'window\_size': 26, 'skip': 12, 'population\_size': 48, 'sigma': 0.4952569660825247, 'learning\_rate': 0.3424567460907903, 'size\_network': 900}

time taken to train: 7.226728439331055 seconds

stop after 100 iteration with investment 14.478001

18		00m07s		14.47800		0.3425		47.5428		0.4953
899.7087		11.8071		25.6620						

Search parameters {'window\_size': 38, 'skip': 11, 'population\_size': 6, 'sigma': 0.8568025149071787, 'learning\_rate': 0.3517351727084189, 'size\_network': 980}

time taken to train: 1.3971071243286133 seconds

stop after 100 iteration with investment 14.713399

19		00m01s		14.71340		0.3517		5.6559		0.8568
980.1978		11.1964		37.5201						

Search parameters {'window\_size': 16, 'skip': 9, 'population\_size': 31, 'sigma': 0.04116018942639576, 'learning\_rate': 0.4462154885816546, 'size\_network': 872}

stop after 100 iteration with investment 0.000000

20		00m00s		0.00000		0.4462		31.2642		0.0412
871.7114		9.4960		15.9637						

Search parameters {'window\_size': 19, 'skip': 11, 'population\_size': 32, 'sigma': 0.47272286939193925, 'learning\_rate': 0.2110219583380834, 'size\_network': 281}  
time taken to train: 1.7874493598937988 seconds  
stop after 100 iteration with investment 15.373998  
21 | 00m01s | 15.37400 | 0.2110 | 31.8644 | 0.4727 |  
280.6654 | 11.2746 | 19.3018 |

Search parameters {'window\_size': 26, 'skip': 7, 'population\_size': 3, 'sigma': 0.6844687524887009, 'learning\_rate': 0.0944715663501871, 'size\_network': 914}  
time taken to train: 0.5886580944061279 seconds  
stop after 100 iteration with investment 12.319299  
22 | 00m00s | 12.31930 | 0.0945 | 3.0635 | 0.6845 |  
914.2091 | 6.7413 | 25.7872 |

Search parameters {'window\_size': 28, 'skip': 3, 'population\_size': 12, 'sigma': 0.5125345048920551, 'learning\_rate': 0.21801331961507173, 'size\_network': 558}  
time taken to train: 2.5648751258850098 seconds  
stop after 100 iteration with investment 33.169600  
23 | 00m02s | 33.16960 | 0.2180 | 11.8223 | 0.5125 |  
557.5803 | 3.0897 | 27.7219 |

Search parameters {'window\_size': 5, 'skip': 4, 'population\_size': 45, 'sigma': 0.1265470327238655, 'learning\_rate': 0.48218855938970684, 'size\_network': 525}  
time taken to train: 3.909914493560791 seconds  
stop after 100 iteration with investment 21.085901  
24 | 00m03s | 21.08590 | 0.4822 | 45.2744 | 0.1265 |  
524.8536 | 4.4636 | 4.5786 |

Search parameters {'window\_size': 9, 'skip': 2, 'population\_size': 29, 'sigma': 0.9049065403007066, 'learning\_rate': 0.38962121170124975, 'size\_network': 204}  
time taken to train: 3.9239423274993896 seconds  
stop after 100 iteration with investment 40.901604  
25 | 00m03s | 40.90160 | 0.3896 | 28.8579 | 0.9049 |  
204.2013 | 1.9670 | 8.7195 |

Search parameters {'window\_size': 38, 'skip': 3, 'population\_size': 41, 'sigma': 0.3113494369250888, 'learning\_rate': 0.42379002609601546, 'size\_network': 614}  
time taken to train: 10.965286254882812 seconds  
stop after 100 iteration with investment 54.670205  
26 | 00m10s | 54.67021 | 0.4238 | 40.6576 | 0.3113 |  
614.1548 | 2.5591 | 37.7406 |

Search parameters {'window\_size': 38, 'skip': 1, 'population\_size': 34, 'sigma': 0.33251817501018216, 'learning\_rate': 0.28025378213533453, 'size\_network': 601}  
time taken to train: 19.4577956199646 seconds  
stop after 100 iteration with investment 90.161499

27		00m19s		90.16150		0.2803	
34.1475		0.3325		600.7703		1.2320	
		37.7156					

Search parameters {'window\_size': 23, 'skip': 2, 'population\_size': 15, 'sigma': 0.25337476478163296, 'learning\_rate': 0.4721917822578962, 'size\_network': 777}  
time taken to train: 4.5063018798828125 seconds  
stop after 100 iteration with investment 35.491501

28		00m04s		35.49150		0.4722		15.0837		0.2534	
777.1621		2.1678		22.5169							

Search parameters {'window\_size': 37, 'skip': 1, 'population\_size': 29, 'sigma': 0.8732198087436757, 'learning\_rate': 0.021617376925168078, 'size\_network': 834}  
time taken to train: 18.457762718200684 seconds  
stop after 100 iteration with investment 0.367701

29		00m18s		0.36770		0.0216		29.2968		0.8732	
834.4437		1.2878		37.4394							

Search parameters {'window\_size': 22, 'skip': 10, 'population\_size': 34, 'sigma': 0.931415927507302, 'learning\_rate': 0.1502122497456846, 'size\_network': 377}  
time taken to train: 2.5566844940185547 seconds  
stop after 100 iteration with investment 11.250799

30		00m02s		11.25080		0.1502		34.2506		0.9314	
376.8366		10.3104		22.3349							

### Bayesian Optimization

Step		Time		Value		learning_rate		population_size		sigma	
size_network				skip		window_size					

Search parameters {'window\_size': 39, 'skip': 2, 'population\_size': 32, 'sigma': 0.934251078387382, 'learning\_rate': 0.23986973695035896, 'size\_network': 602}  
time taken to train: 11.161960363388062 seconds  
stop after 100 iteration with investment 45.801800

31		00m12s		45.80180		0.2399		31.7850		0.9343	
602.4628		1.6398		38.7034							

Search parameters {'window\_size': 48, 'skip': 11, 'population\_size': 5, 'sigma': 0.82819865732244, 'learning\_rate': 0.258973848167657, 'size\_network': 513}  
time taken to train: 0.8257131576538086 seconds  
stop after 100 iteration with investment 11.031597

32		00m01s		11.03160		0.2590		5.0252		0.8282	
513.0593		11.1859		47.8048							

Search parameters {'window\_size': 10, 'skip': 10, 'population\_size': 39,

```

'sigma': 0.952082073395817, 'learning_rate': 0.05084755823239097,
'size_network': 760}
time taken to train: 2.986116886138916 seconds
stop after 100 iteration with investment 1.604099
  33 | 00m03s |    1.60410 |          0.0508 |          38.5205 |    0.9521 |
760.2650 |    9.5442 |          9.7626 |

Search parameters {'window_size': 49, 'skip': 4, 'population_size': 31, 'sigma':
0.7123005097916996, 'learning_rate': 0.08936228401608749, 'size_network': 689}
time taken to train: 9.168430089950562 seconds
stop after 100 iteration with investment 23.429304
  34 | 00m10s |    23.42930 |          0.0894 |          30.9345 |    0.7123 |
688.9225 |    3.6114 |          49.4008 |

Search parameters {'window_size': 11, 'skip': 7, 'population_size': 44, 'sigma':
0.6914780569033353, 'learning_rate': 0.4260041398991975, 'size_network': 406}
time taken to train: 2.953139543533325 seconds
stop after 100 iteration with investment 22.639500
  35 | 00m03s |    22.63950 |          0.4260 |          43.6345 |    0.6915 |
406.0963 |    7.1675 |          11.4653 |

Search parameters {'window_size': 9, 'skip': 4, 'population_size': 11, 'sigma':
0.31584827212577704, 'learning_rate': 0.30732453983094393, 'size_network': 179}
time taken to train: 0.8408491611480713 seconds
stop after 100 iteration with investment 34.574998
  36 | 00m01s |    34.57500 |          0.3073 |          11.2473 |    0.3158 |
178.8690 |    3.7974 |          8.7130 |

Search parameters {'window_size': 32, 'skip': 5, 'population_size': 7, 'sigma':
0.7215504733844512, 'learning_rate': 0.2536350848590793, 'size_network': 788}
time taken to train: 1.5779805183410645 seconds
stop after 100 iteration with investment 35.942901
  37 | 00m02s |    35.94290 |          0.2536 |          7.2798 |    0.7216 |
788.0273 |    5.3914 |          32.2254 |

Search parameters {'window_size': 30, 'skip': 7, 'population_size': 3, 'sigma':
0.13212271540650566, 'learning_rate': 0.22355084099626585, 'size_network': 715}
stop after 100 iteration with investment 0.000000
  38 | 00m01s |    0.00000 |          0.2236 |          2.6159 |    0.1321 |
715.3900 |    7.2454 |          30.0190 |

Search parameters {'window_size': 38, 'skip': 3, 'population_size': 36, 'sigma':
0.3234773477207441, 'learning_rate': 0.14336537507276517, 'size_network': 600}
time taken to train: 9.481030225753784 seconds
stop after 100 iteration with investment 46.123005
  39 | 00m10s |    46.12301 |          0.1434 |          35.5993 |    0.3235 |
600.2903 |    2.9762 |          37.5038 |

```

Search parameters {'window\_size': 45, 'skip': 9, 'population\_size': 28, 'sigma': 0.4850038120889745, 'learning\_rate': 0.0558956221483831, 'size\_network': 304}  
time taken to train: 3.2149434089660645 seconds

stop after 100 iteration with investment 14.373000

40		00m04s		14.37300		0.0559		27.6985		0.4850	
303.9253		9.4846		45.4310							

Search parameters {'window\_size': 22, 'skip': 15, 'population\_size': 27, 'sigma': 0.892154361425812, 'learning\_rate': 0.11103204478310967, 'size\_network': 720}

time taken to train: 2.9948313236236572 seconds

stop after 100 iteration with investment 2.085701

41		00m04s		2.08570		0.1110		26.7859		0.8922	
719.9819		14.6931		21.9758							

Search parameters {'window\_size': 28, 'skip': 11, 'population\_size': 29, 'sigma': 0.182839958629257, 'learning\_rate': 0.4152058364378557, 'size\_network': 414}

stop after 100 iteration with investment 0.000000

42		00m03s		0.00000		0.4152		29.1302		0.1828	
414.2307		10.6240		27.6846							

Search parameters {'window\_size': 6, 'skip': 11, 'population\_size': 8, 'sigma': 0.3107794826020311, 'learning\_rate': 0.02994227973133117, 'size\_network': 706}  
time taken to train: 0.47510623931884766 seconds

stop after 100 iteration with investment 10.840799

43		00m01s		10.84080		0.0299		7.7921		0.3108	
705.7487		11.4479		6.4711							

Search parameters {'window\_size': 33, 'skip': 6, 'population\_size': 23, 'sigma': 0.18897818948672943, 'learning\_rate': 0.48092906089670234, 'size\_network': 420}  
time taken to train: 3.241325616836548 seconds

stop after 100 iteration with investment 15.043197

44		00m04s		15.04320		0.4809		23.2099		0.1890	
420.3809		6.2120		32.9792							

Search parameters {'window\_size': 17, 'skip': 3, 'population\_size': 32, 'sigma': 0.06697003222307954, 'learning\_rate': 0.4646900168899678, 'size\_network': 546}  
stop after 100 iteration with investment 0.000000

45		00m03s		0.00000		0.4647		32.4220		0.0670	
546.1121		3.0166		16.6439							

Search parameters {'window\_size': 13, 'skip': 10, 'population\_size': 31, 'sigma': 0.7861817735301436, 'learning\_rate': 0.24402019776924927, 'size\_network': 482}

time taken to train: 2.0156164169311523 seconds

stop after 100 iteration with investment 17.416799

46		00m03s		17.41680		0.2440		30.8409		0.7862	
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481.8969 | 10.3213 | 12.9426 |

Search parameters {'window\_size': 45, 'skip': 8, 'population\_size': 40, 'sigma': 0.6965006558869755, 'learning\_rate': 0.45589740049481137, 'size\_network': 900}  
time taken to train: 10.297287225723267 seconds

stop after 100 iteration with investment 24.141198

47		00m11s		24.14120		0.4559		40.3615		0.6965	
900.4400		8.2389		45.1515							

Search parameters {'window\_size': 18, 'skip': 14, 'population\_size': 2, 'sigma': 0.04039851162238903, 'learning\_rate': 0.22501631948214842, 'size\_network': 723}  
stop after 100 iteration with investment 0.000000

48		00m01s		0.00000		0.2250		2.2811		0.0404	
723.0895		13.6784		18.3855							

Search parameters {'window\_size': 31, 'skip': 8, 'population\_size': 14, 'sigma': 0.454631410056508, 'learning\_rate': 0.24625843061415703, 'size\_network': 74}  
time taken to train: 0.7722418308258057 seconds

stop after 100 iteration with investment 18.272197

49		00m02s		18.27220		0.2463		14.1262		0.4546	
74.3288		7.5932		30.7744							

Search parameters {'window\_size': 15, 'skip': 6, 'population\_size': 27, 'sigma': 0.15621515707814737, 'learning\_rate': 0.1193213493313695, 'size\_network': 634}  
time taken to train: 3.032594919204712 seconds

stop after 100 iteration with investment 26.547500

50		00m04s		26.54750		0.1193		26.8286		0.1562	
633.9069		6.2033		14.6754							

Search parameters {'window\_size': 29, 'skip': 12, 'population\_size': 42, 'sigma': 0.6697896535290164, 'learning\_rate': 0.4745180059332752, 'size\_network': 349}

time taken to train: 3.507105827331543 seconds

stop after 100 iteration with investment 17.257600

51		00m04s		17.25760		0.4745		41.9340		0.6698	
349.1451		12.2459		28.8649							

Search parameters {'window\_size': 30, 'skip': 10, 'population\_size': 6, 'sigma': 0.36634648134375375, 'learning\_rate': 0.012531352066896569, 'size\_network': 627}  
time taken to train: 0.8845171928405762 seconds

stop after 100 iteration with investment 9.192099

52		00m01s		9.19210		0.0125		6.3290		0.3663	
626.6453		9.9106		30.4519							

Search parameters {'window\_size': 41, 'skip': 10, 'population\_size': 20, 'sigma': 0.7232212850756303, 'learning\_rate': 0.05422750825215879, 'size\_network': 77}

time taken to train: 1.018505334854126 seconds



stop after 100 iteration with investment 10.100899  
 53 | 00m02s | 10.10090 | 0.0542 | 20.3173 | 0.7232 |  
 77.1594 | 9.8805 | 40.7962 |

Search parameters {'window\_size': 46, 'skip': 2, 'population\_size': 13, 'sigma': 0.7461784153297715, 'learning\_rate': 0.18026891305088624, 'size\_network': 748}  
 time taken to train: 5.579480409622192 seconds  
 stop after 100 iteration with investment 45.839198  
 54 | 00m06s | 45.83920 | 0.1803 | 13.2481 | 0.7462 |  
 748.2901 | 2.1922 | 45.9253 |

Search parameters {'window\_size': 12, 'skip': 7, 'population\_size': 21, 'sigma': 0.12757225010664022, 'learning\_rate': 0.4720147812316741, 'size\_network': 478}  
 stop after 100 iteration with investment 0.000000  
 55 | 00m02s | 0.00000 | 0.4720 | 21.3350 | 0.1276 |  
 477.9011 | 6.7735 | 12.1196 |

Search parameters {'window\_size': 29, 'skip': 4, 'population\_size': 37, 'sigma': 0.6847804984410423, 'learning\_rate': 0.3799327602962851, 'size\_network': 450}  
 time taken to train: 6.137412786483765 seconds  
 stop after 100 iteration with investment 39.676200  
 56 | 00m07s | 39.67620 | 0.3799 | 36.7378 | 0.6848 |  
 449.9529 | 4.2075 | 28.9233 |

Search parameters {'window\_size': 34, 'skip': 11, 'population\_size': 14, 'sigma': 0.8010607500809694, 'learning\_rate': 0.23083060941714112, 'size\_network': 757}  
 time taken to train: 2.378453493118286 seconds  
 stop after 100 iteration with investment 13.318699  
 57 | 00m03s | 13.31870 | 0.2308 | 14.2680 | 0.8011 |  
 757.3544 | 10.8331 | 34.4581 |

Search parameters {'window\_size': 10, 'skip': 7, 'population\_size': 28, 'sigma': 0.5713362277179944, 'learning\_rate': 0.04831456297103356, 'size\_network': 593}  
 time taken to train: 2.1748082637786865 seconds  
 stop after 100 iteration with investment 12.414400  
 58 | 00m03s | 12.41440 | 0.0483 | 27.5151 | 0.5713 |  
 592.7145 | 7.0072 | 10.1533 |

Search parameters {'window\_size': 16, 'skip': 13, 'population\_size': 45, 'sigma': 0.4706884846581156, 'learning\_rate': 0.034235641925639194, 'size\_network': 443}  
 time taken to train: 2.8119874000549316 seconds  
 stop after 100 iteration with investment 0.959402  
 59 | 00m04s | 0.95940 | 0.0342 | 45.2785 | 0.4707 |  
 443.1858 | 13.4948 | 16.3061 |

Search parameters {'window\_size': 15, 'skip': 2, 'population\_size': 30, 'sigma':

0.6549664938594614, 'learning\_rate': 0.20784803825055315, 'size\_network': 872}  
time taken to train: 7.9712584018707275 seconds  
stop after 100 iteration with investment 44.488004  
60 | 00m09s | 44.48800 | 0.2078 | 30.0239 | 0.6550 |  
871.5196 | 2.1500 | 14.9509 |

Search parameters {'window\_size': 10, 'skip': 15, 'population\_size': 24,  
'sigma': 0.8533447765395747, 'learning\_rate': 0.3191278111563541,  
'size\_network': 641}  
time taken to train: 1.436133623123169 seconds  
stop after 100 iteration with investment 11.594501  
61 | 00m02s | 11.59450 | 0.3191 | 23.6787 | 0.8533 |  
640.9846 | 14.7180 | 9.6982 |

Search parameters {'window\_size': 44, 'skip': 9, 'population\_size': 36, 'sigma':  
0.463919314907331, 'learning\_rate': 0.1936992237562697, 'size\_network': 941}  
time taken to train: 9.152456760406494 seconds  
stop after 100 iteration with investment 20.351601  
62 | 00m10s | 20.35160 | 0.1937 | 36.1552 | 0.4639 |  
940.5797 | 9.1233 | 44.4202 |

Search parameters {'window\_size': 37, 'skip': 1, 'population\_size': 33, 'sigma':  
0.36295005827770077, 'learning\_rate': 0.47908981350049923, 'size\_network': 602}  
time taken to train: 18.611863613128662 seconds  
stop after 100 iteration with investment 118.454998  
63 | 00m19s | 118.45500 | 0.4791 |  
33.3752 | 0.3630 | 601.8918 | 1.3983  
| 37.0267 |

Search parameters {'window\_size': 16, 'skip': 5, 'population\_size': 16, 'sigma':  
0.09646575043468991, 'learning\_rate': 0.2729165143295437, 'size\_network': 58}  
stop after 100 iteration with investment 0.000000  
64 | 00m01s | 0.00000 | 0.2729 | 16.4097 | 0.0965 |  
57.8640 | 4.9026 | 16.2834 |

Search parameters {'window\_size': 30, 'skip': 6, 'population\_size': 7, 'sigma':  
0.7289102584243544, 'learning\_rate': 0.12484596802107553, 'size\_network': 185}  
time taken to train: 0.5961647033691406 seconds  
stop after 100 iteration with investment 15.445500  
65 | 00m02s | 15.44550 | 0.1248 | 7.3242 | 0.7289 |  
185.1033 | 6.4609 | 30.1676 |

Search parameters {'window\_size': 49, 'skip': 7, 'population\_size': 33, 'sigma':  
0.5581064171753295, 'learning\_rate': 0.48357752208712235, 'size\_network': 124}  
time taken to train: 2.7921245098114014 seconds  
stop after 100 iteration with investment 30.849402  
66 | 00m04s | 30.84940 | 0.4836 | 33.2937 | 0.5581 |

124.2780 | 6.8382 | 49.4273 |

Search parameters {'window\_size': 26, 'skip': 10, 'population\_size': 24, 'sigma': 0.24577665028491352, 'learning\_rate': 0.4231196805573851, 'size\_network': 454}

stop after 100 iteration with investment 0.000000

67		00m03s		0.00000		0.4231		23.8407		0.2458	
453.9105		10.4039		25.7967							

Search parameters {'window\_size': 25, 'skip': 14, 'population\_size': 15, 'sigma': 0.8651996621858432, 'learning\_rate': 0.46975452925924466, 'size\_network': 375}

time taken to train: 1.1424753665924072 seconds

stop after 100 iteration with investment 11.169699

68		00m02s		11.16970		0.4698		15.4829		0.8652	
375.0137		13.9859		25.0451							

Search parameters {'window\_size': 9, 'skip': 13, 'population\_size': 12, 'sigma': 0.3524741428994743, 'learning\_rate': 0.3886982495816039, 'size\_network': 175}

stop after 100 iteration with investment 0.000000

69		00m02s		0.00000		0.3887		11.7058		0.3525	
174.7174		12.9577		8.5275							

Search parameters {'window\_size': 5, 'skip': 12, 'population\_size': 6, 'sigma': 0.8007659832230785, 'learning\_rate': 0.27630041062284755, 'size\_network': 154}

time taken to train: 0.17244505882263184 seconds

stop after 100 iteration with investment 6.806999

70		00m01s		6.80700		0.2763		5.7301		0.8008	
154.3186		12.0720		4.5087							

Search parameters {'window\_size': 11, 'skip': 10, 'population\_size': 37, 'sigma': 0.05355815832861388, 'learning\_rate': 0.2366377480881774, 'size\_network': 303}

stop after 100 iteration with investment 0.000000

71		00m02s		0.00000		0.2366		37.4679		0.0536	
302.7305		9.5728		10.6437							

Search parameters {'window\_size': 10, 'skip': 4, 'population\_size': 7, 'sigma': 0.08748548532444651, 'learning\_rate': 0.18131358696548933, 'size\_network': 756}

stop after 100 iteration with investment 0.000000

72		00m02s		0.00000		0.1813		7.2251		0.0875	
756.4472		4.3724		10.1733							

Search parameters {'window\_size': 23, 'skip': 3, 'population\_size': 47, 'sigma': 0.2069924002582705, 'learning\_rate': 0.2339565390615853, 'size\_network': 748}

time taken to train: 10.470397710800171 seconds

stop after 100 iteration with investment 41.974299

73		00m12s		41.97430		0.2340		46.5060		0.2070	
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747.5559 | 3.2126 | 22.9940 |

Search parameters {'window\_size': 18, 'skip': 4, 'population\_size': 15, 'sigma': 0.096468529225561, 'learning\_rate': 0.24318988867713998, 'size\_network': 719}

time taken to train: 2.4836621284484863 seconds

stop after 100 iteration with investment 4.511399

74 | 00m04s | 4.51140 | 0.2432 | 15.1338 | 0.0965 |  
719.0122 | 4.1038 | 17.6563 |

Search parameters {'window\_size': 39, 'skip': 13, 'population\_size': 23, 'sigma': 0.20501017884787212, 'learning\_rate': 0.4093471252831627, 'size\_network': 470}

stop after 100 iteration with investment 0.000000

75 | 00m02s | 0.00000 | 0.4093 | 22.8299 | 0.2050 |  
470.4530 | 12.6440 | 38.6439 |

Search parameters {'window\_size': 9, 'skip': 11, 'population\_size': 32, 'sigma': 0.873932761251215, 'learning\_rate': 0.1969100795960079, 'size\_network': 607}

time taken to train: 1.9335334300994873 seconds

stop after 100 iteration with investment 7.525198

76 | 00m03s | 7.52520 | 0.1969 | 32.1473 | 0.8739 |  
606.6092 | 10.5312 | 8.5077 |

Search parameters {'window\_size': 27, 'skip': 2, 'population\_size': 29, 'sigma': 0.22134396177855, 'learning\_rate': 0.40153464213790957, 'size\_network': 915}

time taken to train: 10.16161847114563 seconds

stop after 100 iteration with investment 36.609398

77 | 00m12s | 36.60940 | 0.4015 | 29.4131 | 0.2213 |  
914.7459 | 2.1501 | 26.9411 |

Search parameters {'window\_size': 8, 'skip': 2, 'population\_size': 43, 'sigma': 0.2028727427873136, 'learning\_rate': 0.4726119214341495, 'size\_network': 915}

time taken to train: 8.813605308532715 seconds

stop after 100 iteration with investment 54.560602

78 | 00m11s | 54.56060 | 0.4726 | 42.8794 | 0.2029 |  
915.4439 | 1.9333 | 8.1425 |

Search parameters {'window\_size': 29, 'skip': 8, 'population\_size': 13, 'sigma': 0.19122254845668435, 'learning\_rate': 0.185498852537461, 'size\_network': 737}

time taken to train: 2.1560752391815186 seconds

stop after 100 iteration with investment 10.917298

79 | 00m03s | 10.91730 | 0.1855 | 12.5186 | 0.1912 |  
736.6909 | 8.3923 | 28.8096 |

Search parameters {'window\_size': 38, 'skip': 11, 'population\_size': 2, 'sigma': 0.5976383670876801, 'learning\_rate': 0.3717027673547307, 'size\_network': 603}

stop after 100 iteration with investment 0.000000

80 | 00m02s | 0.00000 | 0.3717 | 1.9506 | 0.5976 |

603.2334 | 11.1509 | 38.3818 |

```
[12]: print('Best AGENT accuracy value: %f' % NN_BAYESIAN.res['max']['max_val'])
      print('Best AGENT parameters: ', NN_BAYESIAN.res['max']['max_params'])
```

Best AGENT accuracy value: 118.454998

Best AGENT parameters: {'window\_size': 37.026745406700485, 'skip': 1.398295139557024, 'population\_size': 33.375200286661, 'sigma': 0.36295005827770077, 'learning\_rate': 0.47908981350049923, 'size\_network': 601.8917542486957}

My selected parameters

```
[13]: best_agent(
      window_size = 30,
      skip = 1,
      population_size = 15,
      sigma = 0.1,
      learning_rate = 0.03,
      size_network = 500
    )
```

time taken to train: 7.432262897491455 seconds

```
[13]: 60.713309930000004
```

bayesian parameters

```
[14]: best_agent(
      window_size = int(np.around(NN_BAYESIAN.
      ↪res['max']['max_params']['window_size'])),
      skip = int(np.around(NN_BAYESIAN.res['max']['max_params']['skip'])),
      population_size = int(np.around(NN_BAYESIAN.
      ↪res['max']['max_params']['population_size'])),
      sigma = NN_BAYESIAN.res['max']['max_params']['sigma'],
      learning_rate = NN_BAYESIAN.res['max']['max_params']['learning_rate'],
      size_network = int(np.around(NN_BAYESIAN.
      ↪res['max']['max_params']['size_network'])))
    )
```

time taken to train: 18.46750020980835 seconds

```
[14]: 105.43940030999998
```

My selected parameters

```
[18]: model = Model(input_size = 30,
                    layer_size = 500,
                    output_size = 3)
```

```

agent = Agent(population_size = 15,
              sigma = 0.1,
              learning_rate = 0.03,
              model = model,
              money = 10000,
              max_buy = 5,
              max_sell = 5,
              skip = 1,
              window_size = 30)
agent.fit(500, 100)
agent.buy()

```

```

iter 100. reward: 78.018904
iter 200. reward: 104.486503
iter 300. reward: 111.254201
iter 400. reward: 112.303196
iter 500. reward: 117.427600
time taken to train: 35.953824043273926 seconds
day 2: buy 5 units at price 1395.899965, total balance 8604.100035
day 3: buy 5 units at price 1288.899995, total balance 7315.200040
day 4: buy 5 units at price 1330.650025, total balance 5984.550015
day 5: buy 5 units at price 1262.399980, total balance 4722.150035
day 6: buy 1 units at price 267.529999, total balance 4454.620036
day 8, sell 5 units at price 1528.600005, investment 9.506415 %, total balance
5983.220041,
day 11, sell 5 units at price 1523.500060, investment 18.201572 %, total balance
7506.720101,
day 12, sell 5 units at price 1504.649965, investment 13.076311 %, total balance
9011.370066,
day 14, sell 5 units at price 1501.699980, investment 18.955957 %, total balance
10513.070046,
day 15, sell 1 units at price 291.209991, investment 8.851341 %, total balance
10804.280037,
day 16: buy 5 units at price 1438.450010, total balance 9365.830027
day 18, sell 5 units at price 1500.399935, investment 4.306714 %, total balance
10866.229962,
day 23: buy 5 units at price 1427.400055, total balance 9438.829907
day 24: buy 5 units at price 1470.399935, total balance 7968.429972
day 25: buy 5 units at price 1469.499970, total balance 6498.930002
day 28: buy 1 units at price 284.450012, total balance 6214.479990
day 31: buy 5 units at price 1509.850005, total balance 4704.629985
day 32: buy 1 units at price 306.850006, total balance 4397.779979
day 34, sell 5 units at price 1505.299990, investment 5.457470 %, total balance
5903.079969,
day 35: buy 5 units at price 1459.850005, total balance 4443.229964
day 37, sell 5 units at price 1432.400055, investment -2.584323 %, total balance
5875.630019,

```

day 38: buy 5 units at price 1422.700045, total balance 4452.929974  
 day 41: buy 5 units at price 1375.050050, total balance 3077.879924  
 day 42: buy 1 units at price 279.070007, total balance 2798.809917  
 day 44, sell 5 units at price 1394.250030, investment -5.120785 %, total balance 4193.059947,  
 day 47: buy 5 units at price 1423.650055, total balance 2769.409892  
 day 48: buy 1 units at price 291.820007, total balance 2477.589885  
 day 49: buy 5 units at price 1483.699950, total balance 993.889935  
 day 50: buy 5 units at price 1455.650025, total balance -461.760090  
 day 56, sell 5 units at price 1723.899995, investment 506.046730 %, total balance 1262.139905,  
 day 57, sell 5 units at price 1788.600005, investment 18.462099 %, total balance 3050.739910,  
 day 58, sell 5 units at price 1790.850065, investment 483.623930 %, total balance 4841.589975,  
 day 59, sell 5 units at price 1854.149935, investment 27.009619 %, total balance 6695.739910,  
 day 60, sell 5 units at price 1762.749940, investment 23.901728 %, total balance 8458.489850,  
 day 62, sell 5 units at price 1737.550050, investment 26.362677 %, total balance 10196.039900,  
 day 63: buy 5 units at price 1668.150025, total balance 8527.889875  
 day 64: buy 1 units at price 333.010010, total balance 8194.879865  
 day 65, sell 5 units at price 1710.000000, investment 512.749474 %, total balance 9904.879865,  
 day 66, sell 5 units at price 1722.500000, investment 20.991812 %, total balance 11627.379865,  
 day 68, sell 5 units at price 1714.750060, investment 487.605380 %, total balance 13342.129925,  
 day 75: buy 5 units at price 1594.799955, total balance 11747.329970  
 day 76: buy 1 units at price 316.709991, total balance 11430.619979  
 day 78: buy 5 units at price 1550.500030, total balance 9880.119949  
 day 79, sell 5 units at price 1613.450010, investment 1.169429 %, total balance 11493.569959,  
 day 81, sell 5 units at price 1601.150055, investment 405.557166 %, total balance 13094.720014,  
 day 82: buy 5 units at price 1567.899935, total balance 11526.820079  
 day 83: buy 5 units at price 1516.000060, total balance 10010.820019  
 day 84: buy 5 units at price 1487.149965, total balance 8523.670054  
 day 85: buy 5 units at price 1543.699950, total balance 6979.970104  
 day 88: buy 5 units at price 1450.850065, total balance 5529.120039  
 day 89: buy 5 units at price 1490.700075, total balance 4038.419964  
 day 90: buy 5 units at price 1504.199980, total balance 2534.219984  
 day 91, sell 5 units at price 1747.700045, investment 12.718479 %, total balance 4281.920029,  
 day 92, sell 5 units at price 1740.850065, investment 11.030687 %, total balance 6022.770094,  
 day 93, sell 5 units at price 1709.949950, investment 12.793528 %, total balance

7732.720044,  
 day 94, sell 5 units at price 1897.850035, investment 27.616587 %, total balance 9630.570079,  
 day 95, sell 5 units at price 1851.699980, investment 19.952066 %, total balance 11482.270059,  
 day 96, sell 5 units at price 1762.250060, investment 21.463279 %, total balance 13244.520119,  
 day 98, sell 5 units at price 1782.050020, investment 19.544505 %, total balance 15026.570139,  
 day 99, sell 1 units at price 347.640015, investment -76.888710 %, total balance 15374.210154,  
 day 103: buy 5 units at price 1542.200010, total balance 13832.010144  
 day 105, sell 5 units at price 1608.200075, investment 4.279605 %, total balance 15440.210219,  
 day 106: buy 1 units at price 320.100006, total balance 15120.110213  
 day 108, sell 1 units at price 319.269989, investment -0.259299 %, total balance 15439.380202,  
 day 109: buy 5 units at price 1559.299925, total balance 13880.080277  
 day 111: buy 1 units at price 303.149994, total balance 13576.930283  
 day 112: buy 5 units at price 1508.300020, total balance 12068.630263  
 day 114: buy 5 units at price 1403.699950, total balance 10664.930313  
 day 115: buy 5 units at price 1404.750060, total balance 9260.180253  
 day 118: buy 5 units at price 1397.200010, total balance 7862.980243  
 day 121, sell 5 units at price 1476.000060, investment -5.342132 %, total balance 9338.980303,  
 day 122, sell 5 units at price 1474.199980, investment 386.293917 %, total balance 10813.180283,  
 day 124: buy 5 units at price 1495.099945, total balance 9318.080338  
 day 125: buy 1 units at price 298.329987, total balance 9019.750351  
 day 127: buy 1 units at price 299.679993, total balance 8720.070358  
 day 128: buy 5 units at price 1504.949950, total balance 7215.120408  
 day 129, sell 5 units at price 1547.899935, investment 2.625467 %, total balance 8763.020343,  
 day 131: buy 5 units at price 1323.849945, total balance 7439.170398  
 day 132, sell 5 units at price 1553.500060, investment 10.671804 %, total balance 8992.670458,  
 day 134, sell 5 units at price 1473.999940, investment 4.929694 %, total balance 10466.670398,  
 day 135: buy 5 units at price 1409.149935, total balance 9057.520463  
 day 136: buy 5 units at price 1309.750060, total balance 7747.770403  
 day 137: buy 1 units at price 250.559998, total balance 7497.210405  
 day 138: buy 5 units at price 1313.999940, total balance 6183.210465  
 day 139: buy 5 units at price 1284.400025, total balance 4898.810440  
 day 141: buy 5 units at price 1293.899995, total balance 3604.910445  
 day 142: buy 5 units at price 1297.949980, total balance 2306.960465  
 day 143: buy 1 units at price 276.589996, total balance 2030.370469  
 day 144: buy 5 units at price 1358.899995, total balance 671.470474  
 day 146, sell 5 units at price 1300.000000, investment -6.956771 %, total

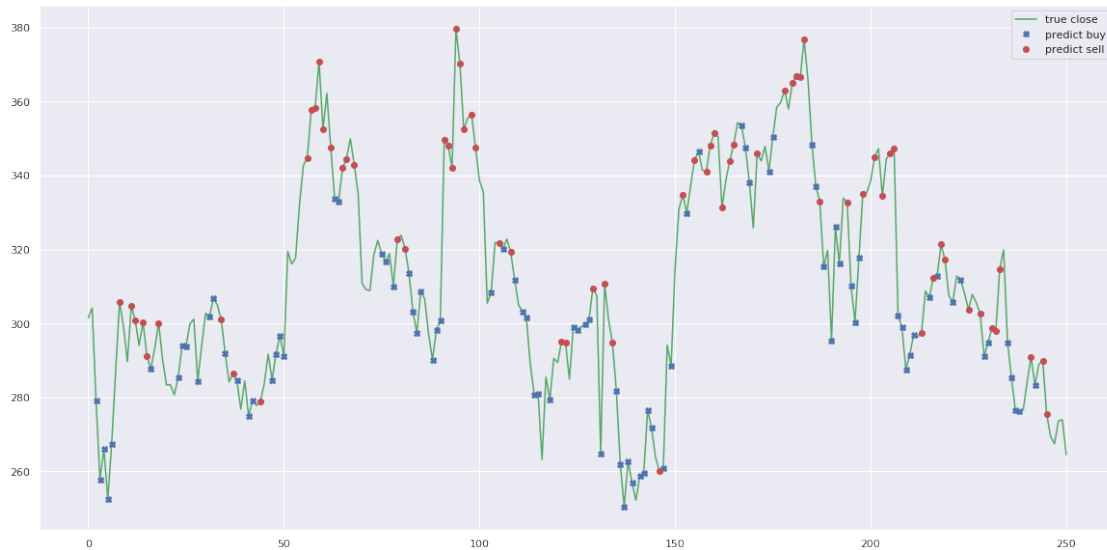


balance 1971.470474,  
 day 147: buy 5 units at price 1304.750060, total balance 666.720414  
 day 149: buy 5 units at price 1442.500000, total balance -775.779586  
 day 152, sell 5 units at price 1674.250030, investment 11.982482 %, total  
 balance 898.470444,  
 day 153: buy 1 units at price 329.899994, total balance 568.570450  
 day 155, sell 5 units at price 1721.399995, investment 477.012057 %, total  
 balance 2289.970445,  
 day 156: buy 5 units at price 1732.050020, total balance 557.920425  
 day 158, sell 5 units at price 1705.299990, investment 469.040320 %, total  
 balance 2263.220415,  
 day 159, sell 5 units at price 1740.800020, investment 15.671622 %, total  
 balance 4004.020435,  
 day 160, sell 5 units at price 1756.999970, investment 32.718967 %, total  
 balance 5761.020405,  
 day 162, sell 5 units at price 1656.399995, investment 17.546043 %, total  
 balance 7417.420400,  
 day 164, sell 5 units at price 1720.000000, investment 31.322766 %, total  
 balance 9137.420400,  
 day 165, sell 5 units at price 1742.200010, investment 595.322487 %, total  
 balance 10879.620410,  
 day 167: buy 1 units at price 353.470001, total balance 10526.150409  
 day 168: buy 1 units at price 347.489990, total balance 10178.660419  
 day 169: buy 1 units at price 338.190002, total balance 9840.470417  
 day 171, sell 5 units at price 1730.000000, investment 31.659062 %, total  
 balance 11570.470417,  
 day 174: buy 1 units at price 341.170013, total balance 11229.300404  
 day 175: buy 1 units at price 350.480011, total balance 10878.820393  
 day 178, sell 5 units at price 1815.299990, investment 41.334472 %, total  
 balance 12694.120383,  
 day 180, sell 5 units at price 1825.749970, investment 41.104411 %, total  
 balance 14519.870353,  
 day 181, sell 5 units at price 1833.800050, investment 41.284339 %, total  
 balance 16353.670403,  
 day 182, sell 5 units at price 1833.000030, investment 562.713784 %, total  
 balance 18186.670433,  
 day 183, sell 5 units at price 1883.950045, investment 38.637873 %, total  
 balance 20070.620478,  
 day 185: buy 1 units at price 348.420013, total balance 19722.200465  
 day 186: buy 1 units at price 337.029999, total balance 19385.170466  
 day 187, sell 3 units at price 998.910003, investment -23.440509 %, total  
 balance 20384.080469,  
 day 188: buy 5 units at price 1576.900025, total balance 18807.180444  
 day 190: buy 5 units at price 1476.950075, total balance 17330.230369  
 day 191: buy 1 units at price 326.089996, total balance 17004.140373  
 day 192: buy 5 units at price 1580.650025, total balance 15423.490348  
 day 194, sell 5 units at price 1663.999940, investment 15.355282 %, total  
 balance 17087.490288,

day 195: buy 5 units at price 1550.599975, total balance 15536.890313  
 day 196: buy 1 units at price 300.359985, total balance 15236.530328  
 day 197: buy 5 units at price 1588.450010, total balance 13648.080318  
 day 198, sell 5 units at price 1674.799955, investment 407.668986 %, total  
 balance 15322.880273,  
 day 201, sell 5 units at price 1724.850005, investment -0.415693 %, total  
 balance 17047.730278,  
 day 203, sell 5 units at price 1671.999970, investment 373.024575 %, total  
 balance 18719.730248,  
 day 205, sell 5 units at price 1730.249940, investment 397.927995 %, total  
 balance 20449.980188,  
 day 206, sell 2 units at price 694.619996, investment 105.393416 %, total  
 balance 21144.600184,  
 day 207: buy 5 units at price 1511.300050, total balance 19633.300134  
 day 208: buy 1 units at price 298.920013, total balance 19334.380121  
 day 209: buy 5 units at price 1437.949980, total balance 17896.430141  
 day 210: buy 5 units at price 1457.550050, total balance 16438.880091  
 day 211: buy 5 units at price 1485.200045, total balance 14953.680046  
 day 213, sell 5 units at price 1487.299955, investment 335.940997 %, total  
 balance 16440.980001,  
 day 215: buy 5 units at price 1535.099945, total balance 14905.880056  
 day 216, sell 5 units at price 1561.049955, investment 345.403420 %, total  
 balance 16466.930011,  
 day 217: buy 1 units at price 312.890015, total balance 16154.039996  
 day 218, sell 5 units at price 1606.750030, investment 361.153197 %, total  
 balance 17760.790026,  
 day 219, sell 5 units at price 1586.100005, investment 370.610928 %, total  
 balance 19346.890031,  
 day 221: buy 5 units at price 1528.999940, total balance 17817.890091  
 day 223: buy 5 units at price 1559.049990, total balance 16258.840101  
 day 225, sell 5 units at price 1518.849945, investment -3.681278 %, total  
 balance 17777.690046,  
 day 228, sell 5 units at price 1512.799990, investment 2.427294 %, total balance  
 19290.490036,  
 day 229: buy 5 units at price 1456.150055, total balance 17834.339981  
 day 230: buy 1 units at price 294.709991, total balance 17539.629990  
 day 231, sell 5 units at price 1493.849945, investment 358.109713 %, total  
 balance 19033.479935,  
 day 232, sell 5 units at price 1489.299925, investment -5.779274 %, total  
 balance 20522.779860,  
 day 233, sell 3 units at price 944.219970, investment -39.106153 %, total  
 balance 21466.999830,  
 day 235: buy 5 units at price 1473.950045, total balance 19993.049785  
 day 236: buy 1 units at price 285.359985, total balance 19707.689800  
 day 237: buy 5 units at price 1382.700045, total balance 18324.989755  
 day 238: buy 1 units at price 276.239990, total balance 18048.749765  
 day 241, sell 5 units at price 1454.600065, investment 384.285570 %, total  
 balance 19503.349830,

day 242: buy 1 units at price 283.359985, total balance 19219.989845  
day 244, sell 5 units at price 1449.799955, investment -8.728638 %, total balance 20669.789800,  
day 245, sell 3 units at price 826.289979, investment -45.325882 %, total balance 21496.079779,

total gained 11496.079779, total investment 114.960798 %



### bayesian parameters

```
[19]: model = Model(input_size = int(np.around(NN_BAYESIAN.
↳res['max']['max_params']['window_size'])),
        layer_size = int(np.around(NN_BAYESIAN.
↳res['max']['max_params']['size_network'])),
        output_size = 3)
agent = Agent(population_size = int(np.around(NN_BAYESIAN.
↳res['max']['max_params']['population_size'])),
        sigma = NN_BAYESIAN.res['max']['max_params']['sigma'],
        learning_rate = NN_BAYESIAN.
↳res['max']['max_params']['learning_rate'],
        model = model,
        money = 10000,
        max_buy = 5,
        max_sell = 5,
        skip = int(np.around(NN_BAYESIAN.
↳res['max']['max_params']['skip'])),
        window_size = int(np.around(NN_BAYESIAN.
↳res['max']['max_params']['window_size'])))
agent.fit(500, 100)
```

```
agent.buy()
```

```
iter 100. reward: 115.522302
iter 200. reward: 122.923396
iter 300. reward: 128.013799
iter 400. reward: 129.764900
iter 500. reward: 133.173699
time taken to train: 93.03121662139893 seconds
day 2: buy 5 units at price 1395.899965, total balance 8604.100035
day 3: buy 5 units at price 1288.899995, total balance 7315.200040
day 4: buy 5 units at price 1330.650025, total balance 5984.550015
day 5: buy 5 units at price 1262.399980, total balance 4722.150035
day 6: buy 5 units at price 1337.649995, total balance 3384.500040
day 7: buy 5 units at price 1434.700010, total balance 1949.800030
day 11, sell 5 units at price 1523.500060, investment 9.141063 %, total balance
3473.300090,
day 12: buy 1 units at price 300.929993, total balance 3172.370097
day 13, sell 5 units at price 1470.399935, investment 14.081771 %, total balance
4642.770032,
day 14, sell 5 units at price 1501.699980, investment 12.854616 %, total balance
6144.470012,
day 15, sell 5 units at price 1456.049955, investment 15.339827 %, total balance
7600.519967,
day 18, sell 5 units at price 1500.399935, investment 12.166855 %, total balance
9100.919902,
day 19: buy 1 units at price 290.239990, total balance 8810.679912
day 20: buy 5 units at price 1416.849975, total balance 7393.829937
day 21, sell 5 units at price 1417.299955, investment -1.212801 %, total balance
8811.129892,
day 22: buy 5 units at price 1403.450010, total balance 7407.679882
day 23: buy 1 units at price 285.480011, total balance 7122.199871
day 25: buy 5 units at price 1469.499970, total balance 5652.699901
day 28: buy 1 units at price 284.450012, total balance 5368.249889
day 29: buy 1 units at price 294.089996, total balance 5074.159893
day 30: buy 1 units at price 302.769989, total balance 4771.389904
day 32, sell 5 units at price 1534.250030, investment 409.836196 %, total
balance 6305.639934,
day 33, sell 5 units at price 1525.099945, investment 425.461686 %, total
balance 7830.739879,
day 34, sell 5 units at price 1505.299990, investment 6.242723 %, total balance
9336.039869,
day 35: buy 1 units at price 291.970001, total balance 9044.069868
day 36: buy 5 units at price 1420.899965, total balance 7623.169903
day 37: buy 1 units at price 286.480011, total balance 7336.689892
day 38: buy 5 units at price 1422.700045, total balance 5913.989847
day 39: buy 5 units at price 1384.100035, total balance 4529.889812
day 40: buy 5 units at price 1422.449950, total balance 3107.439862
```

day 41: buy 5 units at price 1375.050050, total balance 1732.389812  
 day 43: buy 5 units at price 1389.250030, total balance 343.139782  
 day 45: buy 5 units at price 1418.800050, total balance -1075.660268  
 day 52, sell 5 units at price 1580.449980, investment 12.611776 %, total balance 504.789712,  
 day 54: buy 5 units at price 1660.500030, total balance -1155.710318  
 day 55, sell 5 units at price 1713.849945, investment 500.339736 %, total balance 558.139627,  
 day 56, sell 5 units at price 1723.899995, investment 17.312013 %, total balance 2282.039622,  
 day 57, sell 5 units at price 1788.600005, investment 528.792382 %, total balance 4070.639627,  
 day 58, sell 5 units at price 1790.850065, investment 508.946271 %, total balance 5861.489692,  
 day 59, sell 5 units at price 1854.149935, investment 512.395549 %, total balance 7715.639627,  
 day 60, sell 5 units at price 1762.749940, investment 503.743513 %, total balance 9478.389567,  
 day 61, sell 5 units at price 1811.100005, investment 27.461472 %, total balance 11289.489572,  
 day 62: buy 5 units at price 1737.550050, total balance 9551.939522  
 day 63, sell 5 units at price 1668.150025, investment 482.291944 %, total balance 11220.089547,  
 day 64: buy 5 units at price 1665.050050, total balance 9555.039497  
 day 65, sell 5 units at price 1710.000000, investment 20.193994 %, total balance 11265.039497,  
 day 66, sell 5 units at price 1722.500000, investment 24.449097 %, total balance 12987.539497,  
 day 68, sell 3 units at price 1028.850036, investment -27.670563 %, total balance 14016.389533,  
 day 70: buy 5 units at price 1554.299925, total balance 12462.089608  
 day 72: buy 5 units at price 1544.499970, total balance 10917.589638  
 day 73: buy 5 units at price 1592.550050, total balance 9325.039588  
 day 76: buy 5 units at price 1583.549955, total balance 7741.489633  
 day 78: buy 5 units at price 1550.500030, total balance 6190.989603  
 day 80, sell 5 units at price 1619.250030, investment 17.759352 %, total balance 7810.239633,  
 day 82, sell 5 units at price 1567.899935, investment 12.859449 %, total balance 9378.139568,  
 day 83: buy 5 units at price 1516.000060, total balance 7862.139508  
 day 85: buy 1 units at price 308.739990, total balance 7553.399518  
 day 86: buy 5 units at price 1533.249970, total balance 6020.149548  
 day 87: buy 5 units at price 1485.899965, total balance 4534.249583  
 day 88: buy 5 units at price 1450.850065, total balance 3083.399518  
 day 90: buy 5 units at price 1504.199980, total balance 1579.199538  
 day 92, sell 5 units at price 1740.850065, investment 22.698760 %, total balance 3320.049603,  
 day 93, sell 5 units at price 1709.949950, investment 2.978014 %, total balance

5029.999553,  
 day 94, sell 5 units at price 1897.850035, investment 9.225633 %, total balance  
 6927.849588,  
 day 95, sell 5 units at price 1851.699980, investment 11.209869 %, total balance  
 8779.549568,  
 day 96, sell 5 units at price 1762.250060, investment 13.379022 %, total balance  
 10541.799628,  
 day 98, sell 5 units at price 1782.050020, investment 15.380386 %, total balance  
 12323.849648,  
 day 99, sell 5 units at price 1738.200075, investment 9.145711 %, total balance  
 14062.049723,  
 day 100, sell 5 units at price 1693.450010, investment 6.940107 %, total balance  
 15755.499733,  
 day 101, sell 1 units at price 335.450012, investment -78.365043 %, total  
 balance 16090.949745,  
 day 102: buy 1 units at price 305.500000, total balance 15785.449745  
 day 105: buy 5 units at price 1608.200075, total balance 14177.249670  
 day 106: buy 1 units at price 320.100006, total balance 13857.149664  
 day 108, sell 5 units at price 1596.349945, investment 5.300124 %, total balance  
 15453.499609,  
 day 110: buy 5 units at price 1525.050050, total balance 13928.449559  
 day 111, sell 5 units at price 1515.749970, investment 390.947081 %, total  
 balance 15444.199529,  
 day 112: buy 5 units at price 1508.300020, total balance 13935.899509  
 day 113: buy 5 units at price 1444.750060, total balance 12491.149449  
 day 115: buy 5 units at price 1404.750060, total balance 11086.399389  
 day 116: buy 5 units at price 1316.199950, total balance 9770.199439  
 day 118: buy 5 units at price 1397.200010, total balance 8372.999429  
 day 119: buy 5 units at price 1452.700045, total balance 6920.299384  
 day 120, sell 5 units at price 1447.299955, investment -5.605741 %, total  
 balance 8367.599339,  
 day 122: buy 1 units at price 294.839996, total balance 8072.759343  
 day 123: buy 5 units at price 1424.799955, total balance 6647.959388  
 day 124, sell 5 units at price 1495.099945, investment 0.619152 %, total balance  
 8143.059333,  
 day 125, sell 5 units at price 1491.649935, investment 2.812136 %, total balance  
 9634.709268,  
 day 126, sell 5 units at price 1495.500030, investment -0.578377 %, total  
 balance 11130.209298,  
 day 128, sell 5 units at price 1504.949950, investment 392.618642 %, total  
 balance 12635.159248,  
 day 129, sell 5 units at price 1547.899935, investment -3.749542 %, total  
 balance 14183.059183,  
 day 131: buy 5 units at price 1323.849945, total balance 12859.209238  
 day 132, sell 5 units at price 1553.500060, investment 385.317098 %, total  
 balance 14412.709298,  
 day 133: buy 5 units at price 1505.099945, total balance 12907.609353  
 day 135: buy 5 units at price 1409.149935, total balance 11498.459418

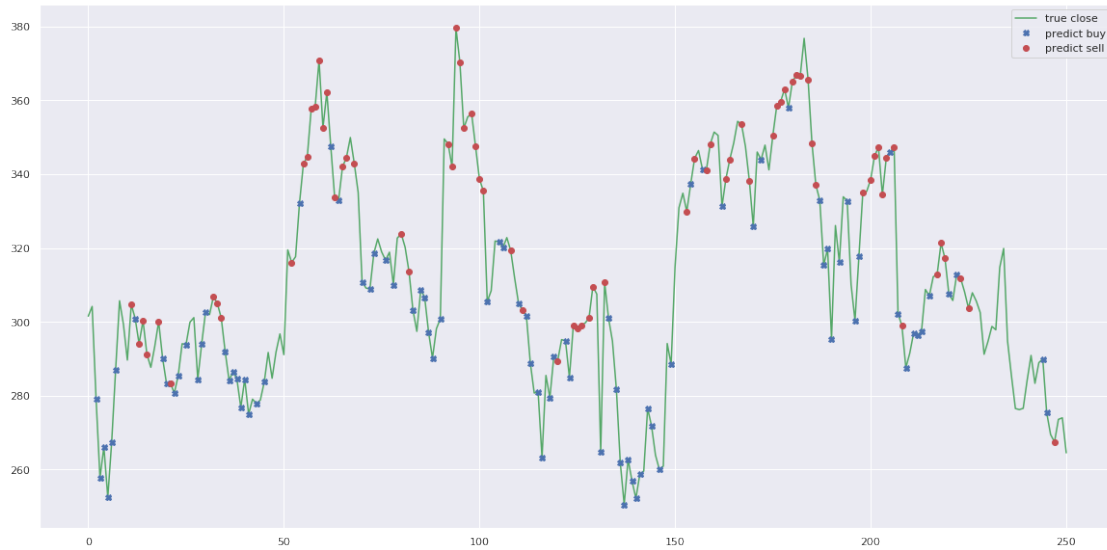
day 136: buy 5 units at price 1309.750060, total balance 10188.709358  
 day 137: buy 1 units at price 250.559998, total balance 9938.149360  
 day 138: buy 5 units at price 1313.999940, total balance 8624.149420  
 day 139: buy 5 units at price 1284.400025, total balance 7339.749395  
 day 140: buy 5 units at price 1261.149980, total balance 6078.599415  
 day 141: buy 5 units at price 1293.899995, total balance 4784.699420  
 day 143: buy 5 units at price 1382.949980, total balance 3401.749440  
 day 144: buy 5 units at price 1358.899995, total balance 2042.849445  
 day 146: buy 5 units at price 1300.000000, total balance 742.849445  
 day 149: buy 5 units at price 1442.500000, total balance -699.650555  
 day 153, sell 5 units at price 1649.499970, investment 8.160383 %, total balance 949.849415,  
 day 154: buy 5 units at price 1686.600035, total balance -736.750620  
 day 155, sell 5 units at price 1721.399995, investment 14.128487 %, total balance 984.649375,  
 day 157: buy 5 units at price 1706.999970, total balance -722.350595  
 day 158, sell 5 units at price 1705.299990, investment 18.034256 %, total balance 982.949395,  
 day 159, sell 5 units at price 1740.800020, investment 23.922402 %, total balance 2723.749415,  
 day 162: buy 5 units at price 1656.399995, total balance 1067.349420  
 day 163, sell 5 units at price 1693.650055, investment 28.677262 %, total balance 2760.999475,  
 day 164, sell 5 units at price 1720.000000, investment 23.103349 %, total balance 4480.999475,  
 day 167, sell 5 units at price 1767.350005, investment 21.659665 %, total balance 6248.349480,  
 day 169, sell 5 units at price 1690.950010, investment 473.514460 %, total balance 7939.299490,  
 day 170: buy 5 units at price 1629.149935, total balance 6310.149555  
 day 172: buy 1 units at price 343.920013, total balance 5966.229542  
 day 175, sell 5 units at price 1752.400055, investment 22.992708 %, total balance 7718.629597,  
 day 176, sell 5 units at price 1792.449950, investment 35.396761 %, total balance 9511.079547,  
 day 177, sell 5 units at price 1798.500060, investment 19.493730 %, total balance 11309.579607,  
 day 178, sell 5 units at price 1815.299990, investment 28.822345 %, total balance 13124.879597,  
 day 179: buy 1 units at price 357.970001, total balance 12766.909596  
 day 180, sell 5 units at price 1825.749970, investment 39.396823 %, total balance 14592.659566,  
 day 181, sell 5 units at price 1833.800050, investment 631.880613 %, total balance 16426.459616,  
 day 182, sell 5 units at price 1833.000030, investment 39.497726 %, total balance 18259.459646,  
 day 184, sell 5 units at price 1828.549955, investment 42.366079 %, total balance 20088.009601,

day 185, sell 5 units at price 1742.100065, investment 38.135836 %, total balance 21830.109666,  
 day 186, sell 1 units at price 337.029999, investment -73.952392 %, total balance 22167.139665,  
 day 187: buy 1 units at price 332.970001, total balance 21834.169664  
 day 188: buy 5 units at price 1576.900025, total balance 20257.269639  
 day 189: buy 5 units at price 1598.849945, total balance 18658.419694  
 day 190: buy 5 units at price 1476.950075, total balance 17181.469619  
 day 192: buy 5 units at price 1580.650025, total balance 15600.819594  
 day 194: buy 1 units at price 332.799988, total balance 15268.019606  
 day 196: buy 5 units at price 1501.799925, total balance 13766.219681  
 day 197: buy 5 units at price 1588.450010, total balance 12177.769671  
 day 198, sell 5 units at price 1674.799955, investment 21.103437 %, total balance 13852.569626,  
 day 200, sell 5 units at price 1692.649995, investment 24.560306 %, total balance 15545.219621,  
 day 201, sell 5 units at price 1724.850005, investment 32.680770 %, total balance 17270.069626,  
 day 202, sell 5 units at price 1736.300050, investment 20.367421 %, total balance 19006.369676,  
 day 203, sell 5 units at price 1671.999970, investment -0.865651 %, total balance 20678.369646,  
 day 204, sell 5 units at price 1722.149965, investment 0.887522 %, total balance 22400.519611,  
 day 205: buy 5 units at price 1730.249940, total balance 20670.269671  
 day 206, sell 5 units at price 1736.549990, investment 4.838807 %, total balance 22406.819661,  
 day 207: buy 5 units at price 1511.300050, total balance 20895.519611  
 day 208, sell 5 units at price 1494.600065, investment -8.258900 %, total balance 22390.119676,  
 day 209: buy 1 units at price 287.589996, total balance 22102.529680  
 day 211: buy 5 units at price 1485.200045, total balance 20617.329635  
 day 212: buy 5 units at price 1481.900025, total balance 19135.429610  
 day 213: buy 5 units at price 1487.299955, total balance 17648.129655  
 day 215: buy 1 units at price 307.019989, total balance 17341.109666  
 day 217, sell 5 units at price 1564.450075, investment 354.887769 %, total balance 18905.559741,  
 day 218, sell 5 units at price 1606.750030, investment 348.850469 %, total balance 20512.309771,  
 day 219, sell 5 units at price 1586.100005, investment 376.349221 %, total balance 22098.409776,  
 day 220: buy 5 units at price 1537.550050, total balance 20560.859726  
 day 222: buy 1 units at price 312.839996, total balance 20248.019730  
 day 223, sell 5 units at price 1559.049990, investment -1.131970 %, total balance 21807.069720,  
 day 225, sell 5 units at price 1518.849945, investment -5.003597 %, total balance 23325.919665,  
 day 244: buy 1 units at price 289.959991, total balance 23035.959674



day 245: buy 1 units at price 275.429993, total balance 22760.529681  
day 247, sell 2 units at price 534.940002, investment 84.487522 %, total balance 23295.469683,

total gained 13295.469683, total investment 132.954697 %



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