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	Volume
0	2018-03-23	311.250000	311.250000	300.450012	301.540009	301.540009	6654900
1	2018-03-26	307.339996	307.589996	291.359985	304.179993	304.179993	8375200
2	2018-03-27	304.000000	304.269989	277.179993	279.179993	279.179993	13872000
3	2018-03-28	264.579987	268.679993	252.100006	257.779999	257.779999	21001400
4	2018-03-29	256.489990	270.959991	248.210007	266.130005	266.130005	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, l, 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, l, 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 |
```

```
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 |
```

```
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]:
```
60.71330993000004
```

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
```

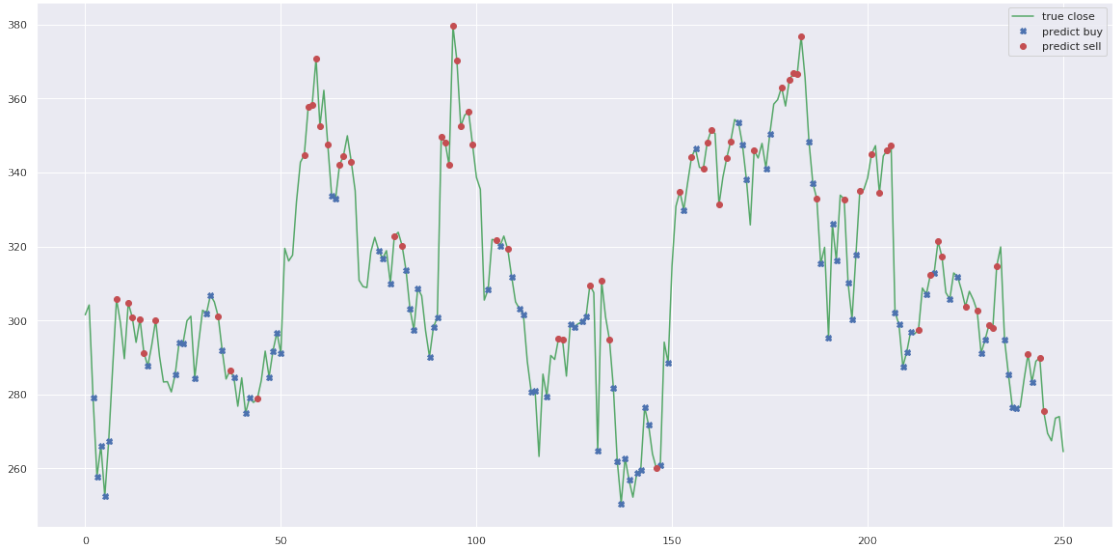
7732.720044,
day 94, sell 5 units at price 1897.850035, investment 27.616587 %, total balance 9630.570079,
day 95, sell 5 units at price 1851.699980, investment 19.952066 %, total balance 11482.270059,
day 96, sell 5 units at price 1762.250060, investment 21.463279 %, total balance 13244.520119,
day 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
```

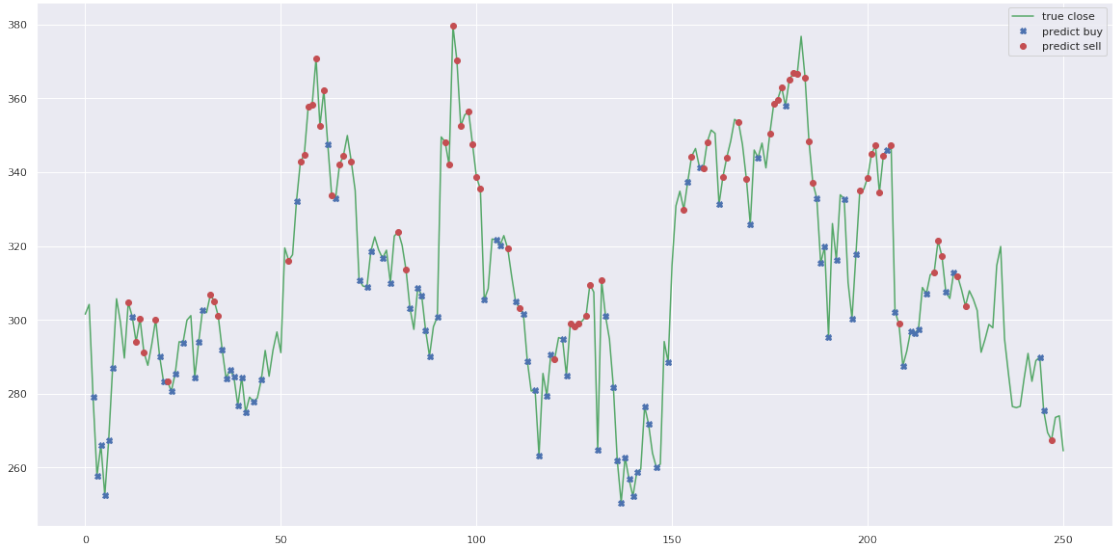
5029.999553,
day 94, sell 5 units at price 1897.850035, investment 9.225633 %, total balance
6927.849588,
day 95, sell 5 units at price 1851.699980, investment 11.209869 %, total balance
8779.549568,
day 96, sell 5 units at price 1762.250060, investment 13.379022 %, total balance
10541.799628,
day 98, 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 %
```



[ ]: