realtime-evolution-strategy

September 29, 2021

[1]:

```python
from sklearn.preprocessing import MinMaxScaler
import os
import numpy as np
import pandas as pd
import time
import random

import matplotlib.pyplot as plt
import seaborn as sns
sns.set()
```

[2]:

```python
def softmax(z):
    assert len(z.shape) == 2
    s = np.max(z, axis=1)
    s = s[:, np.newaxis]
    e_x = np.exp(z - s)
    div = np.sum(e_x, axis=1)
    div = div[:, np.newaxis]
    return e_x / div
```

[3]:

```python
df = pd.read_csv('FB.csv')
df.head()
```

[3]:

```
         Date        Open        High         Low       Close   Adj Close  \
0  2018-05-23  182.500000  186.910004  182.179993  186.899994  186.899994
1  2018-05-24  185.880005  186.800003  185.029999  185.929993  185.929993
2  2018-05-25  186.020004  186.330002  184.449997  184.919998  184.919998
3  2018-05-29  184.339996  186.809998  183.710007  185.740005  185.740005
4  2018-05-30  186.539993  188.000000  185.250000  187.669998  187.669998

     Volume
0  16628100
1  12354700
2  10965100
3  16398900
4  13736900
```

[4]:

```
parameters = [df['Close'].tolist(), df['Volume'].tolist()]
```

[5]:

```
def get_state(parameters, t, window_size = 20):
    outside = []
    d = t - window_size + 1
    for parameter in parameters:
        block = (
            parameter[d : t + 1]
            if d >= 0
            else -d * [parameter[0]] + parameter[0 : t + 1]
        )
        res = []
        for i in range(window_size - 1):
            res.append(block[i + 1] - block[i])
        for i in range(1, window_size, 1):
            res.append(block[i] - block[0])
        outside.append(res)
    return np.array(outside).reshape((1, -1))
```

Our output size from `get_state` is 38. In this notebook, I only use `Close` and `Volume` parameters, you can choose any parameters you want from your DataFrame.

After that, I want to add another parameters, my `inventory` size, mean of `inventory` and `capital`.

Let say for an example,

```
inventory_size = 1
mean_inventory = 0.5
capital = 2
last_state = 0
```

We have 3 actions,

1. `0` for do nothing.
2. `1` for buy.
3. `2` for sell.

[6]:

```
inventory_size = 1
mean_inventory = 0.5
capital = 2
concat_parameters = np.concatenate([get_state(parameters, 20), [[inventory_size,
                                                                 mean_inventory,
                                                                 capital]]],␣
 ↪axis = 1)
```

[7]:

```
input_size = concat_parameters.shape[1]
input_size
```

[7]:

```
79
```

[8]:

```
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) + 1e-7)
            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.rand(input_size, layer_size)
            * np.sqrt(1 / (input_size + layer_size)),
            np.random.rand(layer_size, output_size)
            * np.sqrt(1 / (layer_size + output_size)),
            np.zeros((1, layer_size)),
            np.zeros((1, output_size)),
        ]

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

    def get_weights(self):
        return self.weights

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

[9]:

```
class Agent:

    POPULATION_SIZE = 15
    SIGMA = 0.1
    LEARNING_RATE = 0.03

    def __init__(self, model, timeseries, skip, initial_money, real_trend,␣
 ↪minmax):
        self.model = model
        self.timeseries = timeseries
        self.skip = skip
        self.real_trend = real_trend
        self.initial_money = initial_money
        self.es = Deep_Evolution_Strategy(
            self.model.get_weights(),
            self.get_reward,
            self.POPULATION_SIZE,
            self.SIGMA,
            self.LEARNING_RATE,
        )
        self.minmax = minmax
        self._initiate()

    def _initiate(self):
        # i assume first index is the close value
        self.trend = self.timeseries[0]
        self._mean = np.mean(self.trend)
        self._std = np.std(self.trend)
        self._inventory = []
        self._capital = self.initial_money
        self._queue = []
        self._scaled_capital = self.minmax.transform([[self._capital, 2]])[0, 0]

    def reset_capital(self, capital):
        if capital:
            self._capital = capital
        self._scaled_capital = self.minmax.transform([[self._capital, 2]])[0, 0]
        self._queue = []
        self._inventory = []

    def trade(self, data):
        """
        you need to make sure the data is [close, volume]
        """
        scaled_data = self.minmax.transform([data])[0]
        real_close = data[0]
        close = scaled_data[0]
        if len(self._queue) >= window_size:
            self._queue.pop(0)
        self._queue.append(scaled_data)
        if len(self._queue) < window_size:
            return {
                'status': 'data not enough to trade',
                'action': 'fail',
                'balance': self._capital,
                'timestamp': str(datetime.now()),
            }
        state = self.get_state(
            window_size - 1,
            self._inventory,
            self._scaled_capital,
            timeseries = np.array(self._queue).T.tolist(),
        )
        action, prob = self.act_softmax(state)
        print(prob)
        if action == 1 and self._scaled_capital >= close:
            self._inventory.append(close)
            self._scaled_capital -= close
            self._capital -= real_close
            return {
                'status': 'buy 1 unit, cost %f' % (real_close),
                'action': 'buy',
                'balance': self._capital,
                'timestamp': str(datetime.now()),
            }
        elif action == 2 and len(self._inventory):
            bought_price = self._inventory.pop(0)
            self._scaled_capital += close
            self._capital += real_close
            scaled_bought_price = self.minmax.inverse_transform(
                [[bought_price, 2]]
            )[0, 0]
            try:
                invest = (
                    (real_close - scaled_bought_price) / scaled_bought_price
                ) * 100
            except:
                invest = 0
            return {
                'status': 'sell 1 unit, price %f' % (real_close),
                'investment': invest,
                'gain': real_close - scaled_bought_price,
                'balance': self._capital,
                'action': 'sell',
                'timestamp': str(datetime.now()),
            }
        else:
            return {
                'status': 'do nothing',
                'action': 'nothing',
                'balance': self._capital,
                'timestamp': str(datetime.now()),
            }

    def change_data(self, timeseries, skip, initial_money, real_trend, minmax):
        self.timeseries = timeseries
        self.skip = skip
        self.initial_money = initial_money
        self.real_trend = real_trend
        self.minmax = minmax
        self._initiate()
    def act(self, sequence):
        decision = self.model.predict(np.array(sequence))

        return np.argmax(decision[0])

    def act_softmax(self, sequence):
        decision = self.model.predict(np.array(sequence))

        return np.argmax(decision[0]), softmax(decision)[0]

    def get_state(self, t, inventory, capital, timeseries):
        state = get_state(timeseries, t)
        len_inventory = len(inventory)
        if len_inventory:
            mean_inventory = np.mean(inventory)
        else:
            mean_inventory = 0
        z_inventory = (mean_inventory - self._mean) / self._std
        z_capital = (capital - self._mean) / self._std
        concat_parameters = np.concatenate(
            [state, [[len_inventory, z_inventory, z_capital]]], axis = 1
        )
        return concat_parameters

    def get_reward(self, weights):
        initial_money = self._scaled_capital
        starting_money = initial_money
        invests = []
        self.model.weights = weights
        inventory = []
        state = self.get_state(0, inventory, starting_money, self.timeseries)

        for t in range(0, len(self.trend) - 1, self.skip):
            action = self.act(state)
            if action == 1 and starting_money >= self.trend[t]:
                inventory.append(self.trend[t])
                starting_money -= self.trend[t]

            elif action == 2 and len(inventory):
                bought_price = inventory.pop(0)
                starting_money += self.trend[t]
                invest = ((self.trend[t] - bought_price) / bought_price) * 100
                invests.append(invest)

            state = self.get_state(
                t + 1, inventory, starting_money, self.timeseries
            )
        invests = np.mean(invests)
        if np.isnan(invests):
            invests = 0
        score = (starting_money - initial_money) / initial_money * 100
        return invests * 0.7 + score * 0.3

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

    def buy(self):
        initial_money = self._scaled_capital
        starting_money = initial_money

        real_initial_money = self.initial_money
        real_starting_money = self.initial_money
        inventory = []
        real_inventory = []
        state = self.get_state(0, inventory, starting_money, self.timeseries)
        states_sell = []
        states_buy = []

        for t in range(0, len(self.trend) - 1, self.skip):
            action, prob = self.act_softmax(state)
            print(t, prob)

            if action == 1 and starting_money >= self.trend[t] and t <␣
 ↪(len(self.trend) - 1 - window_size):
                inventory.append(self.trend[t])
                real_inventory.append(self.real_trend[t])
                real_starting_money -= self.real_trend[t]
                starting_money -= self.trend[t]
                states_buy.append(t)
                print(
                    'day %d: buy 1 unit at price %f, total balance %f'
                    % (t, self.real_trend[t], real_starting_money)
                )

            elif action == 2 and len(inventory):
                bought_price = inventory.pop(0)
                real_bought_price = real_inventory.pop(0)
                starting_money += self.trend[t]
                real_starting_money += self.real_trend[t]
                states_sell.append(t)
                try:
                    invest = (
                        (self.real_trend[t] - real_bought_price)
                        / real_bought_price
                    ) * 100
                except:
                    invest = 0
                print(
                    'day %d, sell 1 unit at price %f, investment %f %%, total␣
 ↪balance %f,'
                    % (t, self.real_trend[t], invest, real_starting_money)
                )
            state = self.get_state(
                t + 1, inventory, starting_money, self.timeseries
            )

        invest = (
            (real_starting_money - real_initial_money) / real_initial_money
        ) * 100
        total_gains = real_starting_money - real_initial_money
        return states_buy, states_sell, total_gains, invest
```

[10]:

```
stocks = [i for i in os.listdir(os.getcwd()) if '.csv' in i and not 'TWTR' in i]
stocks
```

[10]:

```
['CPRT.csv',
 'AMD.csv',
 'GWR.csv',
 'MTDR.csv',
 'GOOG.csv',
 'TSLA.csv',
 'FSV.csv',
 'LB.csv',
 'FB.csv',
 'SINA.csv',
 'LYFT.csv']
```

I want to train on all stocks I downloaded except for Twitter. I want to use Twitter for testing.

[11]:

```
skip = 1
layer_size = 500
output_size = 3
window_size = 20
```

[12]:

```
model = Model(input_size = input_size, layer_size = layer_size, output_size =␣
 ↪output_size)
agent = None

for no, stock in enumerate(stocks):
    print('training stock %s'%(stock))
    df = pd.read_csv(stock)
    real_trend = df['Close'].tolist()
    parameters = [df['Close'].tolist(), df['Volume'].tolist()]
    minmax = MinMaxScaler(feature_range = (100, 200)).fit(np.array(parameters).
↪T)
    scaled_parameters = minmax.transform(np.array(parameters).T).T.tolist()
    initial_money = np.max(parameters[0]) * 2

    if no == 0:
        agent = Agent(model = model,
                      timeseries = scaled_parameters,
                      skip = skip,
                      initial_money = initial_money,
                      real_trend = real_trend,
                      minmax = minmax)
    else:
        agent.change_data(timeseries = scaled_parameters,
                          skip = skip,
                          initial_money = initial_money,
                          real_trend = real_trend,
                          minmax = minmax)

    agent.fit(iterations = 100, checkpoint = 10)
    print()
```

```
training stock CPRT.csv
iter 10. reward: -1.247987
iter 20. reward: 6.464369
iter 30. reward: 20.931005
iter 40. reward: 17.746705
iter 50. reward: 18.576328
iter 60. reward: 21.053296
iter 70. reward: 19.513437
iter 80. reward: 34.468159
iter 90. reward: 18.841612
iter 100. reward: 30.144099
time taken to train: 17.304582357406616 seconds

training stock AMD.csv
iter 10. reward: 36.286963
iter 20. reward: 43.994438
iter 30. reward: 36.426547
iter 40. reward: 40.952264
iter 50. reward: 42.701169
iter 60. reward: 46.964220
iter 70. reward: 50.213138
iter 80. reward: 47.108041
iter 90. reward: 52.502404
iter 100. reward: 55.356372
time taken to train: 18.030934810638428 seconds

training stock GWR.csv
iter 10. reward: 21.827143
iter 20. reward: 26.996406
iter 30. reward: 28.478715
iter 40. reward: 24.769332
iter 50. reward: 32.276361
iter 60. reward: 29.583129
iter 70. reward: 32.912309
iter 80. reward: 33.685202
iter 90. reward: 35.657235
iter 100. reward: 33.971033
time taken to train: 17.878694772720337 seconds

training stock MTDR.csv
iter 10. reward: 6.588120
iter 20. reward: 9.963038
iter 30. reward: 6.995521
iter 40. reward: 11.924601
iter 50. reward: 12.691655
iter 60. reward: 13.768439
iter 70. reward: 13.757468
iter 80. reward: 17.086748
iter 90. reward: 18.127015
iter 100. reward: 17.695863
time taken to train: 16.625855445861816 seconds

training stock GOOG.csv
iter 10. reward: 14.863618
iter 20. reward: 17.537896
iter 30. reward: 18.676808
iter 40. reward: 22.530143
iter 50. reward: 24.339954
iter 60. reward: 25.471286
iter 70. reward: 27.379953
iter 80. reward: 26.651974
iter 90. reward: 26.503188
iter 100. reward: 28.608727
time taken to train: 18.292449712753296 seconds

training stock TSLA.csv
iter 10. reward: -1.988759
iter 20. reward: 3.583594
iter 30. reward: 6.227101
iter 40. reward: 7.969605
iter 50. reward: 13.373963
iter 60. reward: 18.205339
iter 70. reward: 19.686566
iter 80. reward: 19.667429
iter 90. reward: 20.270016
iter 100. reward: 22.427184
time taken to train: 17.09872031211853 seconds

training stock FSV.csv
iter 10. reward: 18.520624
iter 20. reward: 22.422610
iter 30. reward: 23.608830
iter 40. reward: 23.608830
iter 50. reward: 23.507973
iter 60. reward: 24.019357
iter 70. reward: 24.429757
iter 80. reward: 25.059607
iter 90. reward: 25.248546
iter 100. reward: 25.237088
time taken to train: 17.251641750335693 seconds

training stock LB.csv
iter 10. reward: -4.582982
iter 20. reward: -4.592372
iter 30. reward: -3.883796
iter 40. reward: -3.076274
iter 50. reward: -2.990688
iter 60. reward: -0.984809
iter 70. reward: -0.301800
iter 80. reward: 1.037189
iter 90. reward: 1.035139
iter 100. reward: 1.982279
time taken to train: 17.05810546875 seconds

training stock FB.csv
iter 10. reward: -28.704470
iter 20. reward: -17.753076
iter 30. reward: -18.305663
iter 40. reward: -17.788208
iter 50. reward: -17.444941
iter 60. reward: -17.783883
iter 70. reward: -18.965700
iter 80. reward: -18.308042
iter 90. reward: -17.689998
iter 100. reward: -17.506858
time taken to train: 16.90356683731079 seconds

training stock SINA.csv
iter 10. reward: -4.434994
iter 20. reward: 1.403997
iter 30. reward: 2.220121
iter 40. reward: 4.055608
iter 50. reward: 3.661211
iter 60. reward: 4.540796
iter 70. reward: 6.477745
iter 80. reward: 6.597851
iter 90. reward: 6.701629
iter 100. reward: 6.760706
time taken to train: 16.092115879058838 seconds

training stock LYFT.csv
iter 10. reward: 3.374927
iter 20. reward: 10.456719
iter 30. reward: 10.456719
iter 40. reward: 10.456719
iter 50. reward: 10.456719
iter 60. reward: 10.456719
iter 70. reward: 10.456719
iter 80. reward: 10.456719
iter 90. reward: 10.456719
iter 100. reward: 10.456719
time taken to train: 4.763254642486572 seconds
```

0.0.1 If you saw the whole training session on certain stocks are negatives (like FB), means that, that stock markets are losing very bad

[13]:

```
df = pd.read_csv('GOOG.csv')
real_trend = df['Close'].tolist()
parameters = [df['Close'].tolist(), df['Volume'].tolist()]
minmax = MinMaxScaler(feature_range = (100, 200)).fit(np.array(parameters).T)
scaled_parameters = minmax.transform(np.array(parameters).T).T.tolist()
initial_money = np.max(parameters[0]) * 2


agent.change_data(timeseries = scaled_parameters,
                  skip = skip,
                  initial_money = initial_money,
                  real_trend = real_trend,
                  minmax = minmax)
```

[14]:

```
states_buy, states_sell, total_gains, invest = agent.buy()
```

```
0 [0. 0. 1.]
1 [0. 0. 1.]
2 [0. 0. 1.]
3 [1. 0. 0.]
```

```
4 [0. 0. 1.]
5 [2.88041485e-42 1.00000000e+00 0.00000000e+00]
day 5: buy 1 unit at price 1084.989990, total balance 1490.169922
6 [1. 0. 0.]
7 [0. 0. 1.]
day 7, sell 1 unit at price 1139.290039, investment 5.004659 %, total balance
2629.459961,
8 [0. 0. 1.]
9 [0. 0. 1.]
10 [0. 0. 1.]
11 [0. 0. 1.]
12 [0. 0. 1.]
13 [0. 0. 1.]
14 [0.0000000e+00 1.0000000e+00 1.7139084e-34]
day 14: buy 1 unit at price 1134.790039, total balance 1494.669922
15 [0. 0. 1.]
day 15, sell 1 unit at price 1152.119995, investment 1.527151 %, total balance
2646.789917,
16 [0.00000000e+000 3.38086219e-109 1.00000000e+000]
17 [0. 0. 1.]
18 [0. 1. 0.]
day 18: buy 1 unit at price 1168.060059, total balance 1478.729858
19 [0. 0. 1.]
day 19, sell 1 unit at price 1169.839966, investment 0.152381 %, total balance
2648.569824,
20 [0. 1. 0.]
day 20: buy 1 unit at price 1157.660034, total balance 1490.909790
21 [0. 1. 0.]
day 21: buy 1 unit at price 1155.479980, total balance 335.429810
22 [0. 1. 0.]
day 22: buy 1 unit at price 1124.810059, total balance -789.380249
23 [0. 1. 0.]
day 23: buy 1 unit at price 1118.459961, total balance -1907.840210
24 [7.52059788e-254 1.00000000e+000 0.00000000e+000]
25 [1. 0. 0.]
26 [1. 0. 0.]
27 [1. 0. 0.]
28 [0. 1. 0.]
29 [0. 1. 0.]
30 [0. 1. 0.]
31 [0.00000000e+00 1.00000000e+00 2.51869099e-15]
32 [0. 0. 1.]
day 32, sell 1 unit at price 1152.839966, investment -0.416363 %, total balance
-755.000244,
33 [1. 0. 0.]
34 [0. 0. 1.]
day 34, sell 1 unit at price 1183.479980, investment 2.423235 %, total balance
428.479736,
35 [1. 0. 0.]
36 [1. 0. 0.]
37 [1. 0. 0.]
38 [1. 0. 0.]
39 [1. 0. 0.]
40 [1. 0. 0.]
41 [1. 0. 0.]
42 [1. 0. 0.]
43 [0. 1. 0.]
day 43: buy 1 unit at price 1263.699951, total balance -835.220215
44 [0. 1. 0.]
45 [0. 1. 0.]
46 [0. 1. 0.]
47 [0. 1. 0.]
48 [0. 1. 0.]
49 [0. 1. 0.]
50 [0. 1. 0.]
51 [0. 1. 0.]
52 [0. 1. 0.]
53 [0. 1. 0.]
54 [0. 1. 0.]
55 [0. 0. 1.]
day 55, sell 1 unit at price 1237.609985, investment 10.028353 %, total balance
402.389770,
56 [1. 0. 0.]
57 [0. 1. 0.]
day 57: buy 1 unit at price 1242.099976, total balance -839.710206
58 [0. 1. 0.]
59 [0. 1. 0.]
60 [1. 0. 0.]
61 [1. 0. 0.]
62 [1. 0. 0.]
63 [1. 0. 0.]
64 [1. 0. 0.]
65 [0. 1. 0.]
66 [0. 1. 0.]
67 [1. 0. 0.]
68 [1. 0. 0.]
69 [1. 0. 0.]
70 [0. 0. 1.]
day 70, sell 1 unit at price 1218.189941, investment 8.916723 %, total balance
378.479735,
71 [1. 0. 0.]
72 [1. 0. 0.]
73 [1. 0. 0.]
74 [1. 0. 0.]
75 [0. 0. 1.]
day 75, sell 1 unit at price 1164.640015, investment -7.838881 %, total balance
```

```
1543.119750,
76 [0. 0. 1.]
day 76, sell 1 unit at price 1177.359985, investment -5.212140 %, total balance
2720.479735,
77 [1.00000000e+000 1.71349693e-284 0.00000000e+000]
78 [0. 0. 1.]
79 [0. 1. 0.]
day 79: buy 1 unit at price 1172.530029, total balance 1547.949706
80 [0. 0. 1.]
day 80, sell 1 unit at price 1156.050049, investment -1.405506 %, total balance
2703.999755,
81 [0. 0. 1.]
82 [0. 0. 1.]
83 [0. 0. 1.]
84 [0. 0. 1.]
85 [0. 0. 1.]
86 [0. 0. 1.]
87 [1. 0. 0.]
88 [0. 0. 1.]
89 [1. 0. 0.]
90 [0. 0. 1.]
91 [0. 0. 1.]
92 [0. 0. 1.]
93 [0. 1. 0.]
day 93: buy 1 unit at price 1168.189941, total balance 1535.809814
94 [1. 0. 0.]
95 [0. 1. 0.]
day 95: buy 1 unit at price 1148.969971, total balance 386.839843
96 [0. 1. 0.]
day 96: buy 1 unit at price 1138.819946, total balance -751.980103
97 [0. 1. 0.]
day 97: buy 1 unit at price 1081.219971, total balance -1833.200074
98 [2.58002336e-293 0.00000000e+000 1.00000000e+000]
day 98, sell 1 unit at price 1079.319946, investment -7.607495 %, total balance
-753.880128,
99 [0. 1. 0.]
day 99: buy 1 unit at price 1110.079956, total balance -1863.960084
100 [0. 1. 0.]
101 [0. 0. 1.]
day 101, sell 1 unit at price 1121.280029, investment -2.409980 %, total balance
-742.680055,
102 [0. 0. 1.]
day 102, sell 1 unit at price 1115.689941, investment -2.031050 %, total balance
373.009886,
103 [1. 0. 0.]
104 [0. 0. 1.]
day 104, sell 1 unit at price 1096.459961, investment 1.409518 %, total balance
1469.469847,
105 [0. 0. 1.]
day 105, sell 1 unit at price 1101.160034, investment -0.803539 %, total balance
2570.629881,
106 [0. 0. 1.]
107 [0. 0. 1.]
108 [0. 0. 1.]
109 [0. 0. 1.]
110 [1. 0. 0.]
111 [0. 0. 1.]
112 [1. 0. 0.]
113 [0. 0. 1.]
114 [0. 0. 1.]
115 [0. 0. 1.]
116 [0. 1. 0.]
day 116: buy 1 unit at price 1055.810059, total balance 1514.819822
117 [0. 1. 0.]
day 117: buy 1 unit at price 1093.390015, total balance 421.429807
118 [0. 0. 1.]
day 118, sell 1 unit at price 1082.400024, investment 2.518442 %, total balance
1503.829831,
119 [0. 0. 1.]
day 119, sell 1 unit at price 1066.150024, investment -2.491333 %, total balance
2569.979855,
120 [1. 0. 0.]
121 [0. 0. 1.]
122 [0. 0. 1.]
123 [0. 0. 1.]
124 [1. 0. 0.]
125 [1. 0. 0.]
126 [1. 0. 0.]
127 [1. 0. 0.]
128 [1. 0. 0.]
129 [1. 0. 0.]
130 [1. 0. 0.]
131 [1. 0. 0.]
132 [0. 0. 1.]
133 [0. 0. 1.]
134 [1. 0. 0.]
135 [0. 1. 0.]
day 135: buy 1 unit at price 1050.819946, total balance 1519.159909
136 [1. 0. 0.]
137 [0. 0. 1.]
day 137, sell 1 unit at price 1036.579956, investment -1.355131 %, total balance
2555.739865,
138 [0. 0. 1.]
139 [0. 0. 1.]
140 [0. 1. 0.]
day 140: buy 1 unit at price 1063.680054, total balance 1492.059811
```

```
141 [0. 0. 1.]
day 141, sell 1 unit at price 1061.900024, investment -0.167346 %, total balance
2553.959835,
142 [0. 0. 1.]
143 [0. 0. 1.]
144 [0. 1. 0.]
day 144: buy 1 unit at price 1028.709961, total balance 1525.249874
145 [1. 0. 0.]
146 [0. 1. 0.]
day 146: buy 1 unit at price 1009.409973, total balance 515.839901
147 [0. 0. 1.]
day 147, sell 1 unit at price 979.539978, investment -4.779771 %, total balance
1495.379879,
148 [1. 0. 0.]
149 [0. 1. 0.]
day 149: buy 1 unit at price 1039.459961, total balance 455.919918
150 [1. 0. 0.]
151 [0. 0. 1.]
day 151, sell 1 unit at price 1037.079956, investment 2.741204 %, total balance
1492.999874,
152 [1. 0. 0.]
153 [0. 0. 1.]
day 153, sell 1 unit at price 1045.849976, investment 0.614744 %, total balance
2538.849850,
154 [0. 0. 1.]
155 [0. 0. 1.]
156 [1. 0. 0.]
157 [0. 0. 1.]
158 [0. 0. 1.]
159 [0. 0. 1.]
160 [0. 0. 1.]
161 [1. 0. 0.]
162 [1. 0. 0.]
163 [1. 0. 0.]
164 [1. 0. 0.]
165 [1. 0. 0.]
166 [1. 0. 0.]
167 [0. 1. 0.]
day 167: buy 1 unit at price 1075.569946, total balance 1463.279904
168 [1. 0. 0.]
169 [1. 0. 0.]
170 [0. 1. 0.]
day 170: buy 1 unit at price 1070.079956, total balance 393.199948
171 [1. 0. 0.]
172 [0. 1. 0.]
day 172: buy 1 unit at price 1089.060059, total balance -695.860111
173 [0. 1. 0.]
day 173: buy 1 unit at price 1116.369995, total balance -1812.230106
```

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174 [1. 0. 0.]
175 [1. 0. 0.]
176 [1. 0. 0.]
177 [1. 0. 0.]
178 [0. 1. 0.]
179 [0. 1. 0.]
180 [0. 1. 0.]
181 [0. 1. 0.]
182 [0. 0. 1.]
day 182, sell 1 unit at price 1120.160034, investment 4.145717 %, total balance
-692.070072,
183 [0. 0. 1.]
day 183, sell 1 unit at price 1121.670044, investment 4.821143 %, total balance
429.599972,
184 [0. 1. 0.]
day 184: buy 1 unit at price 1113.650024, total balance -684.050052
185 [0. 1. 0.]
day 185: buy 1 unit at price 1118.560059, total balance -1802.610111
186 [0.0000000e+00 1.0000000e+00 3.9040329e-80]
187 [0. 1. 0.]
188 [0. 0. 1.]
day 188, sell 1 unit at price 1110.369995, investment 1.956727 %, total balance
-692.240116,
189 [0. 1. 0.]
day 189: buy 1 unit at price 1109.400024, total balance -1801.640140
190 [0. 1. 0.]
191 [1. 0. 0.]
192 [1. 0. 0.]
193 [0. 1. 0.]
194 [1. 0. 0.]
195 [1. 0. 0.]
196 [1. 0. 0.]
197 [1. 0. 0.]
198 [0. 1. 0.]
199 [0. 1. 0.]
200 [1. 0. 0.]
201 [1.00000000e+00 0.00000000e+00 1.11009789e-17]
202 [0. 0. 1.]
day 202, sell 1 unit at price 1185.550049, investment 6.196875 %, total balance
-616.090091,
203 [0. 1. 0.]
day 203: buy 1 unit at price 1184.459961, total balance -1800.550052
204 [0. 1. 0.]
205 [0. 1. 0.]
206 [0. 1. 0.]
207 [0. 1. 0.]
208 [0. 1. 0.]
209 [0. 1. 0.]
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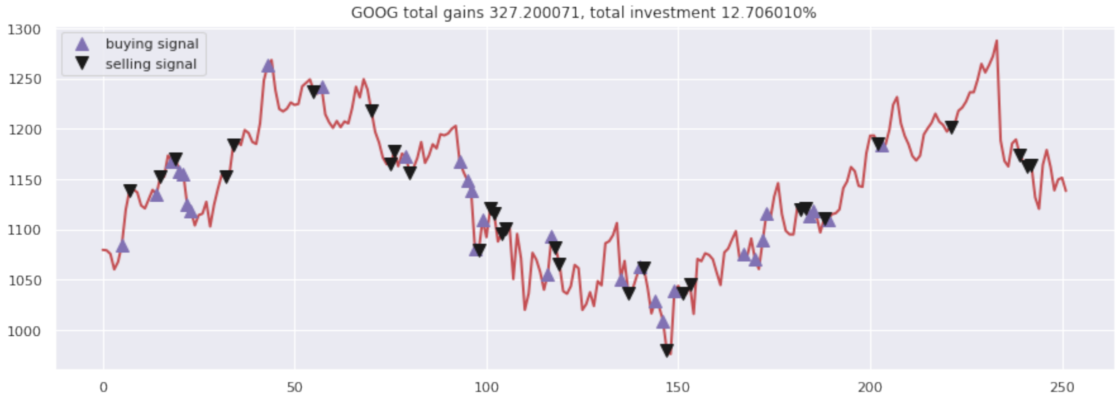
210 [0. 1. 0.]
211 [0. 1. 0.]
212 [0. 1. 0.]
213 [0. 1. 0.]
214 [0. 1. 0.]
215 [0. 1. 0.]
216 [0. 1. 0.]
217 [0. 1. 0.]
218 [0. 1. 0.]
219 [1. 0. 0.]
220 [1. 0. 0.]
221 [0. 0. 1.]
day 221, sell 1 unit at price 1202.160034, investment 7.947740 %, total balance
-598.390018,
222 [1. 0. 0.]
223 [1. 0. 0.]
224 [1. 0. 0.]
225 [1. 0. 0.]
226 [1. 0. 0.]
227 [1. 0. 0.]
228 [1. 0. 0.]
229 [1. 0. 0.]
230 [1. 0. 0.]
231 [0. 1. 0.]
232 [0. 1. 0.]
233 [0. 1. 0.]
234 [1. 0. 0.]
235 [1. 0. 0.]
236 [0. 1. 0.]
237 [0. 1. 0.]
238 [0. 1. 0.]
239 [0. 0. 1.]
day 239, sell 1 unit at price 1174.099976, investment 4.965305 %, total balance
575.709958,
240 [0. 1. 0.]
241 [0. 0. 1.]
day 241, sell 1 unit at price 1162.380005, investment 4.775553 %, total balance
1738.089963,
242 [0. 0. 1.]
day 242, sell 1 unit at price 1164.270020, investment -1.704569 %, total balance
2902.359983,
243 [0. 1. 0.]
244 [0. 0. 1.]
245 [0. 0. 1.]
246 [0. 0. 1.]
247 [0. 0. 1.]
248 [0. 0. 1.]
249 [1. 0. 0.]
```

```
250 [0. 0. 1.]
```

[15]:
```
fig = plt.figure(figsize = (15, 5))
plt.plot(df['Close'], color='r', lw=2.)
plt.plot(df['Close'], '^', markersize=10, color='m', label = 'buying signal',␣
 ↪markevery = states_buy)
plt.plot(df['Close'], 'v', markersize=10, color='k', label = 'selling signal',␣
 ↪markevery = states_sell)
plt.title('GOOG total gains %f, total investment %f%%'%(total_gains, invest))
plt.legend()
plt.show()
```



[16]:
```
df = pd.read_csv('TWTR.csv')
real_trend = df['Close'].tolist()
parameters = [df['Close'].tolist(), df['Volume'].tolist()]
minmax = MinMaxScaler(feature_range = (100, 200)).fit(np.array(parameters).T)
scaled_parameters = minmax.transform(np.array(parameters).T).T.tolist()
initial_money = np.max(parameters[0]) * 2

agent.change_data(timeseries = scaled_parameters,
                  skip = skip,
                  initial_money = initial_money,
                  real_trend = real_trend,
                  minmax = minmax)

states_buy, states_sell, total_gains, invest = agent.buy()
```

```
0 [0. 0. 1.]
1 [0. 0. 1.]
2 [0. 0. 1.]
3 [0. 0. 1.]
4 [0. 0. 1.]
5 [0. 0. 1.]
```

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6 [0. 0. 1.]
7 [0. 0. 1.]
8 [0. 0. 1.]
9 [1. 0. 0.]
10 [1. 0. 0.]
11 [0. 1. 0.]
day 11: buy 1 unit at price 41.209999, total balance 52.309997
12 [0. 1. 0.]
day 12: buy 1 unit at price 41.419998, total balance 10.889999
13 [0. 0. 1.]
day 13, sell 1 unit at price 43.490002, investment 5.532645 %, total balance
54.380001,
14 [0. 0. 1.]
day 14, sell 1 unit at price 44.070000, investment 6.397881 %, total balance
98.450001,
15 [0. 1. 0.]
day 15: buy 1 unit at price 46.759998, total balance 51.690003
16 [0. 0. 1.]
day 16, sell 1 unit at price 45.799999, investment -2.053035 %, total balance
97.490002,
17 [0. 0. 1.]
18 [0. 1. 0.]
day 18: buy 1 unit at price 44.950001, total balance 52.540001
19 [0. 1. 0.]
day 19: buy 1 unit at price 46.130001, total balance 6.410000
20 [0. 1. 0.]
21 [0. 1. 0.]
22 [0. 1. 0.]
23 [0. 1. 0.]
24 [0. 1. 0.]
25 [0. 1. 0.]
26 [0. 1. 0.]
27 [1. 0. 0.]
28 [1. 0. 0.]
29 [0. 1. 0.]
30 [0. 1. 0.]
31 [4.84761617e-08 9.99999952e-01 0.00000000e+00]
32 [1. 0. 0.]
33 [0. 1. 0.]
34 [1. 0. 0.]
35 [1. 0. 0.]
36 [0. 0. 1.]
day 36, sell 1 unit at price 44.259998, investment -1.535046 %, total balance
50.669998,
37 [0. 1. 0.]
day 37: buy 1 unit at price 44.709999, total balance 5.959999
38 [0. 0. 1.]
day 38, sell 1 unit at price 43.340000, investment -6.048127 %, total balance
```

```
49.299999,
39 [0. 0. 1.]
day 39, sell 1 unit at price 43.439999, investment -2.840528 %, total balance
92.739998,
40 [0. 1. 0.]
day 40: buy 1 unit at price 43.419998, total balance 49.320000
41 [1. 0. 0.]
42 [1. 0. 0.]
43 [0. 0. 1.]
day 43, sell 1 unit at price 44.220001, investment 1.842476 %, total balance
93.540001,
44 [0. 0. 1.]
45 [1. 0. 0.]
46 [1. 0. 0.]
47 [0. 1. 0.]
day 47: buy 1 unit at price 31.870001, total balance 61.670000
48 [1. 0. 0.]
49 [0. 0. 1.]
day 49, sell 1 unit at price 32.820000, investment 2.980857 %, total balance
94.490000,
50 [1. 0. 0.]
51 [0. 0. 1.]
52 [0. 0. 1.]
53 [0. 0. 1.]
54 [0. 0. 1.]
55 [0. 0. 1.]
56 [0. 0. 1.]
57 [0. 0. 1.]
58 [0. 0. 1.]
59 [0. 0. 1.]
60 [0. 0. 1.]
61 [0. 0. 1.]
62 [1. 0. 0.]
63 [0. 0. 1.]
64 [1. 0. 0.]
65 [1. 0. 0.]
66 [1. 0. 0.]
67 [1. 0. 0.]
68 [1.00000000e+000 0.00000000e+000 5.88236875e-246]
69 [0.         0.30331368 0.69668632]
70 [1. 0. 0.]
71 [1. 0. 0.]
72 [1. 0. 0.]
73 [0. 1. 0.]
day 73: buy 1 unit at price 30.809999, total balance 63.680001
74 [0. 1. 0.]
day 74: buy 1 unit at price 30.490000, total balance 33.190001
75 [1. 0. 0.]
```

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76 [0. 1. 0.]
day 76: buy 1 unit at price 30.889999, total balance 2.300002
77 [0. 1. 0.]
78 [0. 1. 0.]
79 [0. 1. 0.]
80 [0. 0. 1.]
day 80, sell 1 unit at price 28.860001, investment -6.329108 %, total balance
31.160003,
81 [0.00000000e+000 1.00000000e+000 8.40150266e-172]
day 81: buy 1 unit at price 29.219999, total balance 1.940004
82 [0. 0. 1.]
day 82, sell 1 unit at price 29.520000, investment -3.181371 %, total balance
31.460004,
83 [1.00000000e+000 0.00000000e+000 1.68749158e-251]
84 [0. 0. 1.]
day 84, sell 1 unit at price 28.500000, investment -7.737129 %, total balance
59.960004,
85 [0. 0. 1.]
day 85, sell 1 unit at price 28.600000, investment -2.121831 %, total balance
88.560004,
86 [0. 0. 1.]
87 [0. 0. 1.]
88 [0. 0. 1.]
89 [1. 0. 0.]
90 [0. 0. 1.]
91 [1. 0. 0.]
92 [1. 0. 0.]
93 [1. 0. 0.]
94 [1. 0. 0.]
95 [0. 0. 1.]
96 [1.49596746e-208 0.00000000e+000 1.00000000e+000]
97 [0. 0. 1.]
98 [0. 0. 1.]
99 [1. 0. 0.]
100 [0. 0. 1.]
101 [0. 0. 1.]
102 [0. 0. 1.]
103 [1. 0. 0.]
104 [0. 0. 1.]
105 [0. 0. 1.]
106 [0. 0. 1.]
107 [0. 0. 1.]
108 [1. 0. 0.]
109 [1. 0. 0.]
110 [0. 0. 1.]
111 [0. 0. 1.]
112 [0. 1. 0.]
day 112: buy 1 unit at price 34.750000, total balance 53.810004
```

```
113 [0. 1. 0.]
day 113: buy 1 unit at price 34.619999, total balance 19.190005
114 [0. 0. 1.]
day 114, sell 1 unit at price 34.299999, investment -1.294967 %, total balance
53.490004,
115 [0. 0. 1.]
day 115, sell 1 unit at price 34.020000, investment -1.733099 %, total balance
87.510004,
116 [0. 1. 0.]
day 116: buy 1 unit at price 34.419998, total balance 53.090006
117 [0. 1. 0.]
day 117: buy 1 unit at price 34.990002, total balance 18.100004
118 [0. 1. 0.]
119 [0. 1. 0.]
120 [0. 1. 0.]
121 [0. 1. 0.]
122 [0. 1. 0.]
123 [0. 1. 0.]
124 [0. 1. 0.]
125 [0. 1. 0.]
126 [0. 1. 0.]
127 [1. 0. 0.]
128 [1. 0. 0.]
129 [1.00000000e+000 3.87913053e-131 0.00000000e+000]
130 [1. 0. 0.]
131 [1. 0. 0.]
132 [1. 0. 0.]
133 [1. 0. 0.]
134 [0. 0. 1.]
day 134, sell 1 unit at price 33.660000, investment -2.208013 %, total balance
51.760004,
135 [1. 0. 0.]
136 [0. 0. 1.]
day 136, sell 1 unit at price 32.959999, investment -5.801666 %, total balance
84.720003,
137 [0. 0. 1.]
138 [0. 0. 1.]
139 [0. 0. 1.]
140 [0. 0. 1.]
141 [1.00000000e+000 2.08795633e-032 2.67176100e-180]
142 [0. 0. 1.]
143 [0. 0. 1.]
144 [0. 0. 1.]
145 [0. 1. 0.]
day 145: buy 1 unit at price 32.930000, total balance 51.790003
146 [1. 0. 0.]
147 [0. 1. 0.]
day 147: buy 1 unit at price 27.309999, total balance 24.480004
```

```
148 [0. 1. 0.]
day 148: buy 1 unit at price 26.450001, total balance -1.969997
149 [0. 1. 0.]
150 [0. 0. 1.]
day 150, sell 1 unit at price 28.680000, investment -12.906165 %, total balance
26.710003,
151 [0. 1. 0.]
day 151: buy 1 unit at price 28.430000, total balance -1.719997
152 [0. 1. 0.]
153 [0. 0. 1.]
day 153, sell 1 unit at price 28.809999, investment 5.492494 %, total balance
27.090002,
154 [0. 0. 1.]
day 154, sell 1 unit at price 27.990000, investment 5.822302 %, total balance
55.080002,
155 [0. 0. 1.]
day 155, sell 1 unit at price 29.950001, investment 5.346469 %, total balance
85.030003,
156 [0. 0. 1.]
157 [0. 0. 1.]
158 [0. 0. 1.]
159 [0. 0. 1.]
160 [1. 0. 0.]
161 [1. 0. 0.]
162 [1.00000000e+00 0.00000000e+00 1.18347919e-79]
163 [0. 0. 1.]
164 [1. 0. 0.]
165 [1. 0. 0.]
166 [0. 1. 0.]
day 166: buy 1 unit at price 32.250000, total balance 52.780003
167 [0. 1. 0.]
day 167: buy 1 unit at price 30.969999, total balance 21.810004
168 [1.00000000e+000 3.75718032e-277 0.00000000e+000]
169 [0. 1. 0.]
day 169: buy 1 unit at price 32.900002, total balance -11.089998
170 [0. 1. 0.]
171 [0. 1. 0.]
172 [0. 1. 0.]
173 [0. 1. 0.]
174 [0. 1. 0.]
175 [0. 1. 0.]
176 [0. 1. 0.]
177 [0. 0. 1.]
day 177, sell 1 unit at price 34.160000, investment 5.922481 %, total balance
23.070002,
178 [1. 0. 0.]
179 [1. 0. 0.]
180 [0. 1. 0.]
```

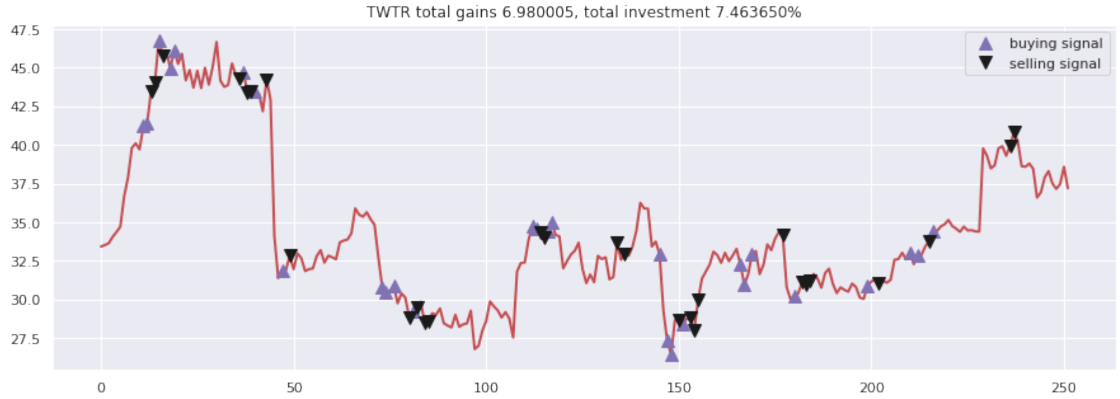
```
day 180: buy 1 unit at price 30.230000, total balance -7.159998
181 [0. 1. 0.]
182 [0. 0. 1.]
day 182, sell 1 unit at price 31.120001, investment 0.484346 %, total balance
23.960003,
183 [0. 0. 1.]
day 183, sell 1 unit at price 30.959999, investment -5.896665 %, total balance
54.920002,
184 [0. 0. 1.]
day 184, sell 1 unit at price 31.230000, investment 3.307972 %, total balance
86.150002,
185 [0. 0. 1.]
186 [0. 0. 1.]
187 [0. 0. 1.]
188 [0. 0. 1.]
189 [0. 0. 1.]
190 [0. 0. 1.]
191 [0. 0. 1.]
192 [0. 0. 1.]
193 [1. 0. 0.]
194 [0. 0. 1.]
195 [0. 0. 1.]
196 [1. 0. 0.]
197 [1. 0. 0.]
198 [1. 0. 0.]
199 [0. 1. 0.]
day 199: buy 1 unit at price 30.870001, total balance 55.280001
200 [1. 0. 0.]
201 [1. 0. 0.]
202 [0. 0. 1.]
day 202, sell 1 unit at price 31.030001, investment 0.518303 %, total balance
86.310002,
203 [0. 0. 1.]
204 [0. 0. 1.]
205 [0. 0. 1.]
206 [1.00000000e+000 3.78767981e-200 0.00000000e+000]
207 [1. 0. 0.]
208 [0. 0. 1.]
209 [1. 0. 0.]
210 [0. 1. 0.]
day 210: buy 1 unit at price 33.060001, total balance 53.250001
211 [1. 0. 0.]
212 [0. 1. 0.]
day 212: buy 1 unit at price 32.869999, total balance 20.380002
213 [1. 0. 0.]
214 [0. 1. 0.]
215 [0. 0. 1.]
day 215, sell 1 unit at price 33.750000, investment 2.087111 %, total balance
```

```
54.130002,
216 [0. 1. 0.]
day 216: buy 1 unit at price 34.380001, total balance 19.750001
217 [0. 1. 0.]
218 [0. 1. 0.]
219 [0. 1. 0.]
220 [0. 1. 0.]
221 [0. 1. 0.]
222 [0. 1. 0.]
223 [0. 1. 0.]
224 [0. 1. 0.]
225 [1. 0. 0.]
226 [1.00000000e+000 1.79166683e-113 0.00000000e+000]
227 [1. 0. 0.]
228 [0. 1. 0.]
229 [1. 0. 0.]
230 [1. 0. 0.]
231 [0. 1. 0.]
232 [0. 1. 0.]
233 [0. 1. 0.]
234 [0. 1. 0.]
235 [0. 1. 0.]
236 [0. 0. 1.]
day 236, sell 1 unit at price 39.950001, investment 21.539404 %, total balance
59.700002,
237 [0.00000000e+000 3.52341905e-242 1.00000000e+000]
day 237, sell 1 unit at price 40.799999, investment 18.673641 %, total balance
100.500001,
238 [0. 1. 0.]
239 [1. 0. 0.]
240 [0. 1. 0.]
241 [0. 1. 0.]
242 [0. 1. 0.]
243 [0. 1. 0.]
244 [0. 1. 0.]
245 [0. 1. 0.]
246 [0. 1. 0.]
247 [0. 1. 0.]
248 [1. 0. 0.]
249 [1. 0. 0.]
250 [0. 1. 0.]
```

[17]:

```
fig = plt.figure(figsize = (15, 5))
plt.plot(df['Close'], color='r', lw=2.)
plt.plot(df['Close'], '^', markersize=10, color='m', label = 'buying signal',␣
 ↪markevery = states_buy)
```

```
plt.plot(df['Close'], 'v', markersize=10, color='k', label = 'selling signal',␣
 ↪markevery = states_sell)
plt.title('TWTR total gains %f, total investment %f%%'%(total_gains, invest))
plt.legend()
plt.show()
```



[18]:
```
from datetime import datetime

volume = df['Volume'].tolist()

for i in range(100):
    print(agent.trade([real_trend[i], volume[i]]))
```

```
{'status': 'data not enough to trade', 'action': 'fail', 'balance':
93.51999599999999, 'timestamp': '2019-08-31 02:39:42.247020'}
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[19]:

```
import copy
import pickle

copy_model = copy.deepcopy(agent.model)

with open('model.pkl', 'wb') as fopen:
    pickle.dump(copy_model, fopen)
```

[ ]:

```
```