# 20.duel-curiosity-q-learning-agent

September 29, 2021

```python
[1]: import numpy as np
     import pandas as pd
     import tensorflow as tf
     import matplotlib.pyplot as plt
     import seaborn as sns
     sns.set()
```

```python
[2]: df = pd.read_csv('../dataset/GOOG-year.csv')
     df.head()
```

```
[2]:         Date        Open        High         Low       Close   Adj Close  \
     0  2016-11-02  778.200012  781.650024  763.450012  768.700012  768.700012
     1  2016-11-03  767.250000  769.950012  759.030029  762.130005  762.130005
     2  2016-11-04  750.659973  770.359985  750.560974  762.020020  762.020020
     3  2016-11-07  774.500000  785.190002  772.549988  782.520020  782.520020
     4  2016-11-08  783.400024  795.632996  780.190002  790.510010  790.510010

         Volume
     0  1872400
     1  1943200
     2  2134800
     3  1585100
     4  1350800
```

```python
[3]: from collections import deque
     import random

     class Agent:

         LEARNING_RATE = 0.003
         BATCH_SIZE = 32
         LAYER_SIZE = 500
         OUTPUT_SIZE = 3
         EPSILON = 0.5
         DECAY_RATE = 0.005
         MIN_EPSILON = 0.1
         GAMMA = 0.99
```

```python
    MEMORIES = deque()
    COPY = 1000
    T_COPY = 0
    MEMORY_SIZE = 300

    def __init__(self, state_size, window_size, trend, skip):
        self.state_size = state_size
        self.window_size = window_size
        self.half_window = window_size // 2
        self.trend = trend
        self.skip = skip
        tf.reset_default_graph()
        self.X = tf.placeholder(tf.float32, (None, self.state_size))
        self.Y = tf.placeholder(tf.float32, (None, self.state_size))
        self.ACTION = tf.placeholder(tf.float32, (None))
        self.REWARD = tf.placeholder(tf.float32, (None))
        self.batch_size = tf.shape(self.ACTION)[0]

        with tf.variable_scope('curiosity_model'):
            action = tf.reshape(self.ACTION, (-1,1))
            state_action = tf.concat([self.X, action], axis=1)
            save_state = tf.identity(self.Y)

            feed = tf.layers.dense(state_action, 32, activation=tf.nn.relu)
            self.curiosity_logits = tf.layers.dense(feed, self.state_size)
            self.curiosity_cost = tf.reduce_sum(tf.square(save_state - self.
→curiosity_logits), axis=1)

            self.curiosity_optimizer = tf.train.RMSPropOptimizer(self.
→LEARNING_RATE)\
            .minimize(tf.reduce_mean(self.curiosity_cost))

        total_reward = tf.add(self.curiosity_cost, self.REWARD)

        with tf.variable_scope("q_model"):
            with tf.variable_scope("eval_net"):
                x_action = tf.layers.dense(self.X, 128, tf.nn.relu)
                tensor_action, tensor_validation = tf.split(x_action,2,1)
                feed_action = tf.layers.dense(tensor_action, self.OUTPUT_SIZE)
                feed_validation = tf.layers.dense(tensor_validation, 1)
                self.logits = feed_validation + \
                tf.subtract(feed_action,tf.
→reduce_mean(feed_action,axis=1,keep_dims=True))

            with tf.variable_scope("target_net"):
                y_action = tf.layers.dense(self.Y, 128, tf.nn.relu)
                tensor_action, tensor_validation = tf.split(y_action,2,1)
```

```python
            feed_action = tf.layers.dense(tensor_action, self.OUTPUT_SIZE)
            feed_validation = tf.layers.dense(tensor_validation, 1)
            y_q = feed_validation + \
            tf.subtract(feed_action,tf.
→reduce_mean(feed_action,axis=1,keep_dims=True))

        q_target = total_reward + self.GAMMA * tf.reduce_max(y_q, axis=1)
        action = tf.cast(self.ACTION, tf.int32)
        action_indices = tf.stack([tf.range(self.batch_size, dtype=tf.
→int32), action], axis=1)
        q = tf.gather_nd(params=self.logits, indices=action_indices)
        self.cost = tf.losses.mean_squared_error(labels=q_target,␣
→predictions=q)
        self.optimizer = tf.train.RMSPropOptimizer(self.LEARNING_RATE).
→minimize(
        self.cost, var_list=tf.get_collection(tf.GraphKeys.
→TRAINABLE_VARIABLES, "q_model/eval_net"))

    t_params = tf.get_collection(tf.GraphKeys.GLOBAL_VARIABLES,␣
→scope='q_model/target_net')
    e_params = tf.get_collection(tf.GraphKeys.GLOBAL_VARIABLES,␣
→scope='q_model/eval_net')
    self.target_replace_op = [tf.assign(t, e) for t, e in zip(t_params,␣
→e_params)]

    self.sess = tf.InteractiveSession()
    self.sess.run(tf.global_variables_initializer())

def _memorize(self, state, action, reward, new_state, done):
    self.MEMORIES.append((state, action, reward, new_state, done))
    if len(self.MEMORIES) > self.MEMORY_SIZE:
        self.MEMORIES.popleft()

def get_state(self, t):
    window_size = self.window_size + 1
    d = t - window_size + 1
    block = self.trend[d : t + 1] if d >= 0 else -d * [self.trend[0]] +␣
→self.trend[0 : t + 1]
    res = []
    for i in range(window_size - 1):
        res.append(block[i + 1] - block[i])
    return np.array(res)

def predict(self, inputs):
    return self.sess.run(self.logits, feed_dict={self.X:inputs})
```

```python
    def get_predicted_action(self, sequence):
        prediction = self.predict(np.array(sequence))[0]
        return np.argmax(prediction)

    def _select_action(self, state):
        if np.random.rand() < self.EPSILON:
            action = np.random.randint(self.OUTPUT_SIZE)
        else:
            action = self.get_predicted_action([state])
        return action

    def _construct_memories(self, replay):
        states = np.array([a[0] for a in replay])
        actions = np.array([a[1] for a in replay])
        rewards = np.array([a[2] for a in replay])
        new_states = np.array([a[3] for a in replay])
        if (self.T_COPY + 1) % self.COPY == 0:
            self.sess.run(self.target_replace_op)

        cost, _ = self.sess.run([self.cost, self.optimizer], feed_dict = {
            self.X: states, self.Y: new_states, self.ACTION: actions, self.
→REWARD: rewards
        })

        if (self.T_COPY + 1) % self.COPY == 0:
            self.sess.run(self.curiosity_optimizer, feed_dict = {
                self.X: states, self.Y: new_states, self.ACTION: actions, self.
→REWARD: rewards
            })
        return cost

    def buy(self, initial_money):
        starting_money = initial_money
        states_sell = []
        states_buy = []
        inventory = []
        state = self.get_state(0)
        for t in range(0, len(self.trend) - 1, self.skip):
            action = self._select_action(state)
            next_state = self.get_state(t + 1)

            if action == 1 and initial_money >= self.trend[t]:
                inventory.append(self.trend[t])
                initial_money -= self.trend[t]
                states_buy.append(t)
                print('day %d: buy 1 unit at price %f, total balance %f'% (t,
→self.trend[t], initial_money))
```

```python
            elif action == 2 and len(inventory):
                bought_price = inventory.pop(0)
                initial_money += self.trend[t]
                states_sell.append(t)
                try:
                    invest = ((close[t] - bought_price) / bought_price) * 100
                except:
                    invest = 0
                print(
                    'day %d, sell 1 unit at price %f, investment %f %%, total␣
↪balance %f,'
                    % (t, close[t], invest, initial_money)
                )

            state = next_state
        invest = ((initial_money - starting_money) / starting_money) * 100
        total_gains = initial_money - starting_money
        return states_buy, states_sell, total_gains, invest

    def train(self, iterations, checkpoint, initial_money):
        for i in range(iterations):
            total_profit = 0
            inventory = []
            state = self.get_state(0)
            starting_money = initial_money
            for t in range(0, len(self.trend) - 1, self.skip):

                action = self._select_action(state)
                next_state = self.get_state(t + 1)

                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) > 0:
                    bought_price = inventory.pop(0)
                    total_profit += self.trend[t] - bought_price
                    starting_money += self.trend[t]

                invest = ((starting_money - initial_money) / initial_money)

                self._memorize(state, action, invest, next_state,␣
↪starting_money < initial_money)
                batch_size = min(len(self.MEMORIES), self.BATCH_SIZE)
                state = next_state
                replay = random.sample(self.MEMORIES, batch_size)
```

```
                cost = self._construct_memories(replay)
                self.T_COPY += 1
                self.EPSILON = self.MIN_EPSILON + (1.0 - self.MIN_EPSILON) * np.
→exp(-self.DECAY_RATE * i)
            if (i+1) % checkpoint == 0:
                print('epoch: %d, total rewards: %f.3, cost: %f, total money:␣
→%f'%(i + 1, total_profit, cost,
                                                                            ␣
→    starting_money))
```

[4]:
```
close = df.Close.values.tolist()
initial_money = 10000
window_size = 30
skip = 1
batch_size = 32
agent = Agent(state_size = window_size,
              window_size = window_size,
              trend = close,
              skip = skip)
agent.train(iterations = 200, checkpoint = 10, initial_money = initial_money)
```

WARNING:tensorflow:From <ipython-input-3-e49b5b607a66>:53: calling reduce_mean
(from tensorflow.python.ops.math_ops) with keep_dims is deprecated and will be
removed in a future version.
Instructions for updating:
keep_dims is deprecated, use keepdims instead
epoch: 10, total rewards: 698.460085.3, cost: 596251.000000, total money:
10698.460085
epoch: 20, total rewards: 1683.164917.3, cost: 5890915.500000, total money:
6720.204895
epoch: 30, total rewards: 1686.875004.3, cost: 75077.554688, total money:
6721.424992
epoch: 40, total rewards: 541.999876.3, cost: 2707843.750000, total money:
9525.359861
epoch: 50, total rewards: 1668.824950.3, cost: 32719.388672, total money:
7666.774900
epoch: 60, total rewards: 751.654909.3, cost: 1165742.750000, total money:
8743.134889
epoch: 70, total rewards: 1637.889772.3, cost: 325201.937500, total money:
6669.909730
epoch: 80, total rewards: 587.055053.3, cost: 1527037.250000, total money:
892.705077
epoch: 90, total rewards: 2170.969727.3, cost: 122936.546875, total money:
8204.549683
epoch: 100, total rewards: 1565.850155.3, cost: 844705.187500, total money:
19.270138
epoch: 110, total rewards: 1733.244930.3, cost: 557043.125000, total money:
```

```
6744.174861
epoch: 120, total rewards: 1282.489866.3, cost: 3785043.750000, total money:
8328.149839
epoch: 130, total rewards: 1260.559873.3, cost: 596946.312500, total money:
6319.639890
epoch: 140, total rewards: 1346.769778.3, cost: 26543662.000000, total money:
10330.129763
epoch: 150, total rewards: 2415.594848.3, cost: 851761.625000, total money:
9467.174865
epoch: 160, total rewards: 1033.800112.3, cost: 3596937.500000, total money:
9044.600099
epoch: 170, total rewards: 1597.439823.3, cost: 511038.375000, total money:
93.789859
epoch: 180, total rewards: 1736.860354.3, cost: 3795484.000000, total money:
1011.990359
epoch: 190, total rewards: 1682.540215.3, cost: 657330.250000, total money:
8675.460198
epoch: 200, total rewards: 875.094668.3, cost: 30907612.000000, total money:
10875.094668
```

[5]:
```python
states_buy, states_sell, total_gains, invest = agent.buy(initial_money =␣
 ↪initial_money)
```

```
day 3: buy 1 unit at price 782.520020, total balance 9217.479980
day 4: buy 1 unit at price 790.510010, total balance 8426.969970
day 5: buy 1 unit at price 785.309998, total balance 7641.659972
day 6: buy 1 unit at price 762.559998, total balance 6879.099974
day 7: buy 1 unit at price 754.020020, total balance 6125.079954
day 9: buy 1 unit at price 758.489990, total balance 5366.589964
day 10, sell 1 unit at price 764.479980, investment -2.305377 %, total balance
6131.069944,
day 11: buy 1 unit at price 771.229980, total balance 5359.839964
day 13: buy 1 unit at price 769.200012, total balance 4590.639952
day 15: buy 1 unit at price 760.989990, total balance 3829.649962
day 16: buy 1 unit at price 761.679993, total balance 3067.969969
day 17: buy 1 unit at price 768.239990, total balance 2299.729979
day 19: buy 1 unit at price 758.039978, total balance 1541.690001
day 21: buy 1 unit at price 750.500000, total balance 791.190001
day 22, sell 1 unit at price 762.520020, investment -3.540751 %, total balance
1553.710021,
day 23, sell 1 unit at price 759.109985, investment -3.336264 %, total balance
2312.820006,
day 24: buy 1 unit at price 771.190002, total balance 1541.630004
day 25, sell 1 unit at price 776.419983, investment 1.817560 %, total balance
2318.049987,
day 27, sell 1 unit at price 789.270020, investment 4.674942 %, total balance
3107.320007,
day 29, sell 1 unit at price 797.070007, investment 5.086424 %, total balance
```

3904.390014,
day 30, sell 1 unit at price 797.849976, investment 3.451629 %, total balance 4702.239990,
day 32: buy 1 unit at price 794.200012, total balance 3908.039978
day 33, sell 1 unit at price 796.419983, investment 3.538738 %, total balance 4704.459961,
day 34, sell 1 unit at price 794.559998, investment 4.411360 %, total balance 5499.019959,
day 38: buy 1 unit at price 785.049988, total balance 4713.969971
day 39, sell 1 unit at price 782.789978, investment 2.771503 %, total balance 5496.759949,
day 40, sell 1 unit at price 771.820007, investment 0.466002 %, total balance 6268.579956,
day 41: buy 1 unit at price 786.140015, total balance 5482.439941
day 45: buy 1 unit at price 806.650024, total balance 4675.789917
day 47, sell 1 unit at price 807.909973, investment 6.578808 %, total balance 5483.699890,
day 50: buy 1 unit at price 804.609985, total balance 4679.089905
day 51, sell 1 unit at price 806.070007, investment 7.404398 %, total balance 5485.159912,
day 52, sell 1 unit at price 802.174988, investment 4.017815 %, total balance 6287.334900,
day 53: buy 1 unit at price 805.020020, total balance 5482.314880
day 54, sell 1 unit at price 819.309998, investment 3.161670 %, total balance 6301.624878,
day 56: buy 1 unit at price 835.669983, total balance 5465.954895
day 58, sell 1 unit at price 823.309998, investment 4.873576 %, total balance 6289.264893,
day 59, sell 1 unit at price 802.320007, investment 2.058157 %, total balance 7091.584900,
day 60: buy 1 unit at price 796.789978, total balance 6294.794922
day 61, sell 1 unit at price 795.695007, investment -1.358088 %, total balance 7090.489929,
day 62, sell 1 unit at price 798.530029, investment -0.755640 %, total balance 7889.019958,
day 63, sell 1 unit at price 801.489990, investment -0.438502 %, total balance 8690.509948,
day 66: buy 1 unit at price 808.380005, total balance 7882.129943
day 67, sell 1 unit at price 809.559998, investment -3.124437 %, total balance 8691.689941,
day 68: buy 1 unit at price 813.669983, total balance 7878.019958
day 69, sell 1 unit at price 819.239990, investment 2.817557 %, total balance 8697.259948,
day 70, sell 1 unit at price 820.450012, investment 1.493111 %, total balance 9517.709960,
day 72, sell 1 unit at price 824.159973, investment 1.289219 %, total balance 10341.869933,
day 73: buy 1 unit at price 828.070007, total balance 9513.799926

day 74, sell 1 unit at price 831.659973, investment 0.433534 %, total balance 10345.459899,
day 75: buy 1 unit at price 830.760010, total balance 9514.699889
day 76: buy 1 unit at price 831.330017, total balance 8683.369872
day 78: buy 1 unit at price 829.280029, total balance 7854.089843
day 79: buy 1 unit at price 823.210022, total balance 7030.879821
day 80: buy 1 unit at price 835.239990, total balance 6195.639831
day 81, sell 1 unit at price 830.630005, investment -0.015649 %, total balance 7026.269836,
day 82, sell 1 unit at price 829.080017, investment -0.270651 %, total balance 7855.349853,
day 84, sell 1 unit at price 831.909973, investment 0.317136 %, total balance 8687.259826,
day 85: buy 1 unit at price 835.369995, total balance 7851.889831
day 86: buy 1 unit at price 838.679993, total balance 7013.209838
day 88: buy 1 unit at price 845.539978, total balance 6167.669860
day 89: buy 1 unit at price 845.619995, total balance 5322.049865
day 90, sell 1 unit at price 847.200012, investment 2.914200 %, total balance 6169.249877,
day 91: buy 1 unit at price 848.780029, total balance 5320.469848
day 92: buy 1 unit at price 852.119995, total balance 4468.349853
day 93, sell 1 unit at price 848.400024, investment 1.575599 %, total balance 5316.749877,
day 94: buy 1 unit at price 830.460022, total balance 4486.289855
day 95: buy 1 unit at price 829.590027, total balance 3656.699828
day 96, sell 1 unit at price 817.580017, investment -2.129593 %, total balance 4474.279845,
day 97: buy 1 unit at price 814.429993, total balance 3659.849852
day 98, sell 1 unit at price 819.510010, investment -2.285733 %, total balance 4479.359862,
day 100: buy 1 unit at price 831.409973, total balance 3647.949889
day 101, sell 1 unit at price 831.500000, investment -1.660475 %, total balance 4479.449889,
day 103: buy 1 unit at price 838.549988, total balance 3640.899901
day 104: buy 1 unit at price 834.570007, total balance 2806.329894
day 105, sell 1 unit at price 831.409973, investment -1.680426 %, total balance 3637.739867,
day 106: buy 1 unit at price 827.880005, total balance 2809.859862
day 108: buy 1 unit at price 824.729980, total balance 1985.129882
day 109: buy 1 unit at price 823.349976, total balance 1161.779906
day 110: buy 1 unit at price 824.320007, total balance 337.459899
day 112, sell 1 unit at price 837.169983, investment -1.367851 %, total balance 1174.629882,
day 113: buy 1 unit at price 836.820007, total balance 337.809875
day 115, sell 1 unit at price 841.650024, investment -1.228697 %, total balance 1179.459899,
day 116, sell 1 unit at price 843.190002, investment 1.532883 %, total balance 2022.649901,

day 117, sell 1 unit at price 862.760010, investment 3.998358 %, total balance 2885.409911,

day 118: buy 1 unit at price 872.299988, total balance 2013.109923

day 119, sell 1 unit at price 871.729980, investment 7.035594 %, total balance 2884.839903,

day 120, sell 1 unit at price 874.250000, investment 5.152696 %, total balance 3759.089903,

day 123, sell 1 unit at price 916.440002, investment 9.288655 %, total balance 4675.529905,

day 124: buy 1 unit at price 927.039978, total balance 3748.489927

day 126, sell 1 unit at price 927.130005, investment 11.090741 %, total balance 4675.619932,

day 127, sell 1 unit at price 934.299988, investment 12.854518 %, total balance 5609.919920,

day 128, sell 1 unit at price 932.169983, investment 13.027294 %, total balance 6542.089903,

day 129: buy 1 unit at price 928.780029, total balance 5613.309874

day 133, sell 1 unit at price 943.000000, investment 14.532098 %, total balance 6556.309874,

day 137, sell 1 unit at price 941.859985, investment 14.259023 %, total balance 7498.169859,

day 140, sell 1 unit at price 969.539978, investment 15.860038 %, total balance 8467.709837,

day 141: buy 1 unit at price 971.469971, total balance 7496.239866

day 142, sell 1 unit at price 975.880005, investment 11.874357 %, total balance 8472.119871,

day 143, sell 1 unit at price 964.859985, investment 4.079652 %, total balance 9436.979856,

day 144, sell 1 unit at price 966.950012, investment 4.109690 %, total balance 10403.929868,

day 145, sell 1 unit at price 975.599976, investment 0.425129 %, total balance 11379.529844,

day 147: buy 1 unit at price 976.570007, total balance 10402.959837

day 148: buy 1 unit at price 980.940002, total balance 9422.019835

day 149, sell 1 unit at price 983.409973, investment 0.700407 %, total balance 10405.429808,

day 150: buy 1 unit at price 949.830017, total balance 9455.599791

day 151, sell 1 unit at price 942.900024, investment -3.877911 %, total balance 10398.499815,

day 152, sell 1 unit at price 953.400024, investment 0.375857 %, total balance 11351.899839,

day 153: buy 1 unit at price 950.760010, total balance 10401.139829

day 155, sell 1 unit at price 939.780029, investment -1.154864 %, total balance 11340.919858,

day 156: buy 1 unit at price 957.369995, total balance 10383.549863

day 157: buy 1 unit at price 950.630005, total balance 9432.919858

day 158: buy 1 unit at price 959.450012, total balance 8473.469846

day 159, sell 1 unit at price 957.090027, investment -0.029243 %, total balance

9430.559873,
day 160: buy 1 unit at price 965.590027, total balance 8464.969846
day 162, sell 1 unit at price 927.330017, investment -2.451005 %, total balance 9392.299863,
day 163: buy 1 unit at price 940.489990, total balance 8451.809873
day 164: buy 1 unit at price 917.789978, total balance 7534.019895
day 165: buy 1 unit at price 908.729980, total balance 6625.289915
day 166, sell 1 unit at price 898.700012, investment -6.331752 %, total balance 7523.989927,
day 167, sell 1 unit at price 911.710022, investment -5.580008 %, total balance 8435.699949,
day 169: buy 1 unit at price 918.590027, total balance 7517.109922
day 170: buy 1 unit at price 928.799988, total balance 6588.309934
day 171: buy 1 unit at price 930.090027, total balance 5658.219907
day 172: buy 1 unit at price 943.830017, total balance 4714.389890
day 173: buy 1 unit at price 947.159973, total balance 3767.229917
day 175: buy 1 unit at price 953.419983, total balance 2813.809934
day 177: buy 1 unit at price 970.890015, total balance 1842.919919
day 178, sell 1 unit at price 968.150024, investment 2.941024 %, total balance 2811.069943,
day 179: buy 1 unit at price 972.919983, total balance 1838.149960
day 180: buy 1 unit at price 980.340027, total balance 857.809933
day 187, sell 1 unit at price 930.390015, investment 1.372867 %, total balance 1788.199948,
day 189, sell 1 unit at price 927.960022, investment 2.116145 %, total balance 2716.159970,
day 190, sell 1 unit at price 929.359985, investment 1.172444 %, total balance 3645.519955,
day 191, sell 1 unit at price 926.789978, investment -0.216409 %, total balance 4572.309933,
day 192, sell 1 unit at price 922.900024, investment -0.773044 %, total balance 5495.209957,
day 193: buy 1 unit at price 907.239990, total balance 4587.969967
day 196, sell 1 unit at price 922.219971, investment -2.289612 %, total balance 5510.189938,
day 197, sell 1 unit at price 926.960022, investment -2.132686 %, total balance 6437.149960,
day 198, sell 1 unit at price 910.979980, investment -4.451344 %, total balance 7348.129940,
day 200, sell 1 unit at price 906.659973, investment -6.615584 %, total balance 8254.789913,
day 201: buy 1 unit at price 924.690002, total balance 7330.099911
day 202: buy 1 unit at price 927.000000, total balance 6403.099911
day 204: buy 1 unit at price 915.890015, total balance 5487.209896
day 205: buy 1 unit at price 913.809998, total balance 4573.399898
day 206: buy 1 unit at price 921.289978, total balance 3652.109920
day 207: buy 1 unit at price 929.570007, total balance 2722.539913
day 208: buy 1 unit at price 939.330017, total balance 1783.209896

day 209: buy 1 unit at price 937.340027, total balance 845.869869
day 210, sell 1 unit at price 928.450012, investment -4.570774 %, total balance
1774.319881,
day 211: buy 1 unit at price 927.809998, total balance 846.509883
day 215, sell 1 unit at price 932.070007, investment -4.923804 %, total balance
1778.579890,
day 218: buy 1 unit at price 920.289978, total balance 858.289912
day 219, sell 1 unit at price 915.000000, investment 0.855343 %, total balance
1773.289912,
day 220, sell 1 unit at price 921.809998, investment -0.311456 %, total balance
2695.099910,
day 221, sell 1 unit at price 931.580017, investment 0.494069 %, total balance
3626.679927,
day 223: buy 1 unit at price 928.530029, total balance 2698.149898
day 225, sell 1 unit at price 924.859985, investment 0.979372 %, total balance
3623.009883,
day 228: buy 1 unit at price 959.109985, total balance 2663.899898
day 230, sell 1 unit at price 957.789978, investment 4.812814 %, total balance
3621.689876,
day 231, sell 1 unit at price 951.679993, investment 3.298637 %, total balance
4573.369869,
day 232, sell 1 unit at price 969.960022, investment 4.345021 %, total balance
5543.329891,
day 233, sell 1 unit at price 978.890015, investment 4.211512 %, total balance
6522.219906,
day 234, sell 1 unit at price 977.000000, investment 4.231119 %, total balance
7499.219906,
day 235, sell 1 unit at price 972.599976, investment 4.827495 %, total balance
8471.819882,
day 236, sell 1 unit at price 989.250000, investment 7.493293 %, total balance
9461.069882,
day 239: buy 1 unit at price 992.000000, total balance 8469.069882
day 240, sell 1 unit at price 992.179993, investment 6.854917 %, total balance
9461.249875,
day 242, sell 1 unit at price 984.450012, investment 2.642036 %, total balance
10445.699887,
day 243: buy 1 unit at price 988.200012, total balance 9457.499875
day 245, sell 1 unit at price 970.539978, investment -2.163309 %, total balance
10428.039853,
day 246, sell 1 unit at price 973.330017, investment -1.504756 %, total balance
11401.369870,

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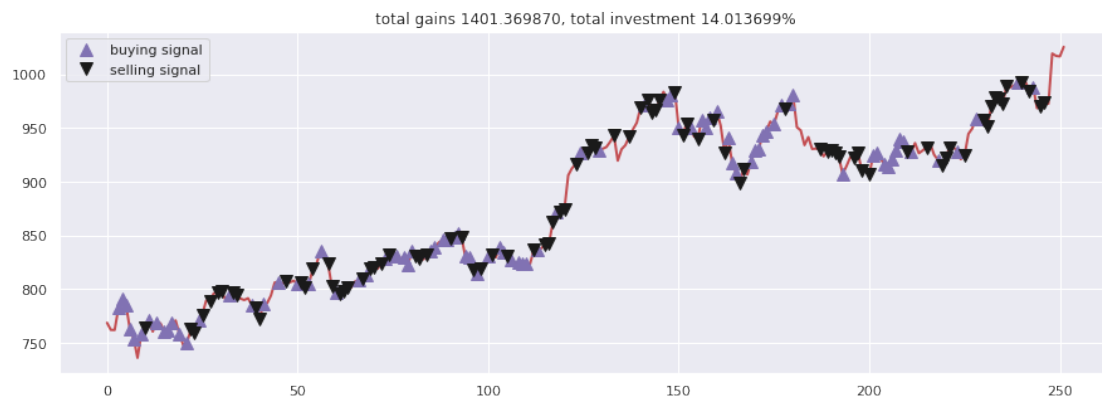[6]: fig = plt.figure(figsize = (15,5))
     plt.plot(close, color='r', lw=2.)
     plt.plot(close, '^', markersize=10, color='m', label = 'buying signal',␣
      ↪markevery = states_buy)
```

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

total gains 1401.369870, total investment 14.013699%



[ ]: