

Introduction

Our project is designed to produce a model that classifies traffic signs to their classes.

For this purpose, we used logistic regression in the first step because it is a classification problem and with Softmax because it is more than two classes.

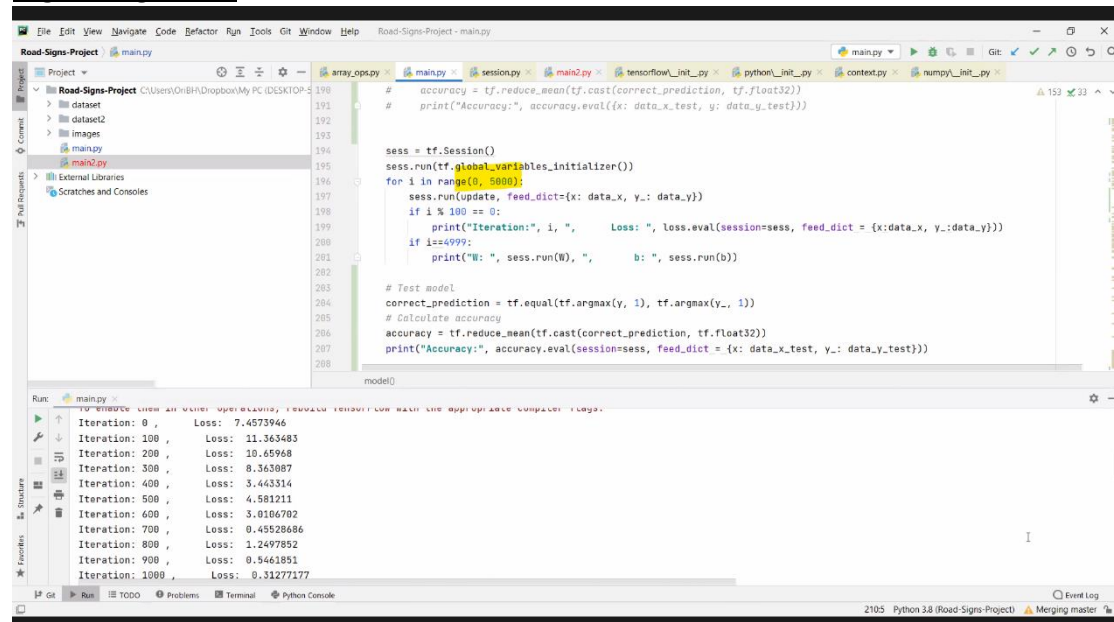
In the second step we used a neural network with one hidden layer and a Relu activation function in order to achieve a better result in the percentage of accuracy but surprisingly the results were less good than the model of the first stage (the simple logistic regression model).

In the third step we increased the amount of neurons of the hidden layer and the results were not as expected.

In the fourth step we added another hidden layer to the grid and we have not yet improved the model.

In the last step we used the "Adam optimizer" algorithm and we were able to achieve better results.

Logistic regression



The screenshot shows an IDE with a Python file named `main.py` and a Run console. The code implements a logistic regression model using TensorFlow. It includes a training loop that prints the loss at every 100 iterations and a test function to calculate the accuracy. The Run console shows the output of the training process, displaying the loss decreasing from approximately 7.45 to 0.31 over 1000 iterations.

```

190 # accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
191 # print("Accuracy:", accuracy.eval({x: data_x_test, y: data_y_test}))
192
193
194 sess = tf.Session()
195 sess.run(tf.global_variables_initializer())
196 for i in range(0, 5000):
197     sess.run(update, feed_dict={x: data_x, y_: data_y})
198     if i % 100 == 0:
199         print("Iteration:", i, "    Loss: ", loss.eval(session=sess, feed_dict = {x:data_x, y_:data_y}))
200     if i==4999:
201         print("W: ", sess.run(W), "    b: ", sess.run(b))
202
203 # Test model
204 correct_prediction = tf.equal(tf.argmax(y, 1), tf.argmax(y_, 1))
205 # Calculate accuracy
206 accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
207 print("Accuracy:", accuracy.eval(session=sess, feed_dict = {x: data_x_test, y_: data_y_test}))
208
209 model()

```

```

Run: main.py
Iteration: 0 ,      Loss: 7.4573946
Iteration: 100 ,   Loss: 11.363483
Iteration: 200 ,   Loss: 10.65968
Iteration: 300 ,   Loss: 8.363087
Iteration: 400 ,   Loss: 3.443314
Iteration: 500 ,   Loss: 4.581211
Iteration: 600 ,   Loss: 3.0106702
Iteration: 700 ,   Loss: 0.4528686
Iteration: 800 ,   Loss: 1.2497852
Iteration: 900 ,   Loss: 0.5461851
Iteration: 1000 ,  Loss: 0.3127177

```

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Iteration: 3000, Loss: 0.15029994
Iteration: 3100, Loss: 0.14554526
Iteration: 3200, Loss: 0.14095588
Iteration: 3300, Loss: 0.13665561
Iteration: 3400, Loss: 0.13272712
Iteration: 3500, Loss: 0.12915003
Iteration: 3600, Loss: 0.12587269
Iteration: 3700, Loss: 0.12291981
Iteration: 3800, Loss: 0.11963028
Iteration: 3900, Loss: 0.11896383
Iteration: 4000, Loss: 6.2284084
Iteration: 4100, Loss: 1.3192561
Iteration: 4200, Loss: 0.1510671
Iteration: 4300, Loss: 0.13603938
Iteration: 4400, Loss: 0.12716374
Iteration: 4500, Loss: 0.12094337
Iteration: 4600, Loss: 0.1162673
Iteration: 4700, Loss: 0.11253116
Iteration: 4800, Loss: 0.109385446
Iteration: 4900, Loss: 0.10663649
W: [[-1.7160467e-03 1.4583594e-03 -1.0727198e-03 1.3303999e-03]
[-1.5229911e-03 2.9751642e-03 -1.6030886e-03 1.5092343e-04]
[-2.2196465e-03 4.2229658e-03 -1.9234487e-03 -7.7867895e-05]
...
[-1.3698866e-03 -1.2469837e-04 1.9910142e-03 -4.9642840e-04]
[-3.2539957e-04 8.0176227e-04 1.2771935e-03 -1.7535563e-05]
[-4.2929380e-04 2.5972195e-03 -3.3685033e-03 -5.7921381e-05]], b: [-0.00024268 -0.00025399 -0.0003562 0.00085206]
Accuracy: 0.94930875
Process finished with exit code 0

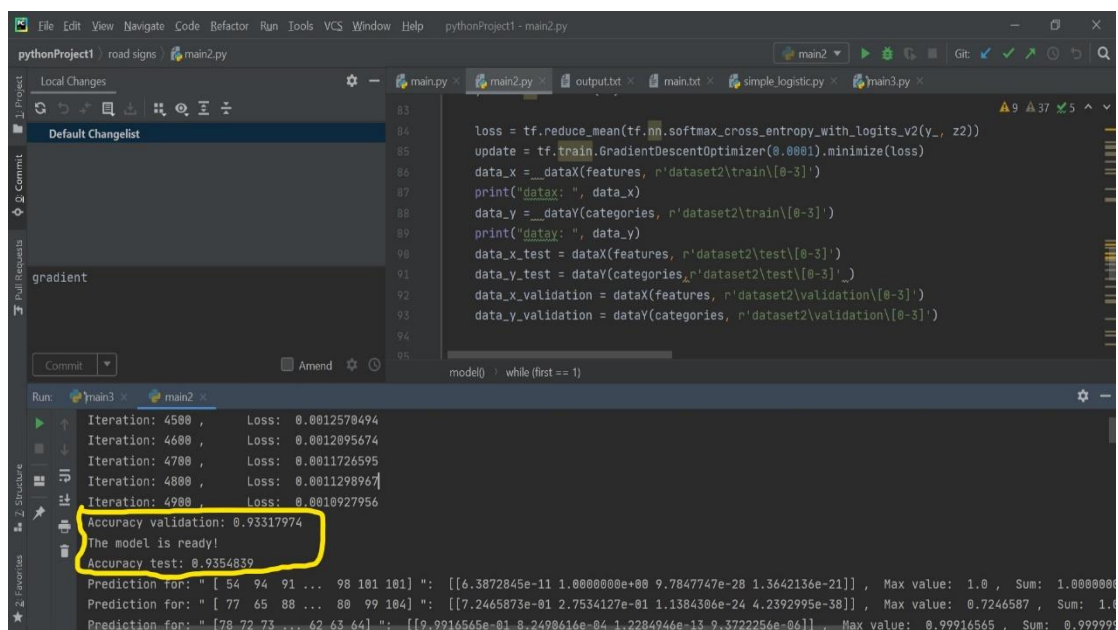
```

The accuracy of the test with 5000 iterations is 0.94930875

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Neural Network with one hidden layer



Neural Network with two hidden layers

```

72 hidden_layer_nodes_1 = 200
73 hidden_layer_nodes_2 = 100
74 x = tf.placeholder(tf.float32, [None, features])
75 y_ = tf.placeholder(tf.float32, [None, categories])
76 W1 = tf.Variable(tf.truncated_normal([features, hidden_layer_nodes_1], stddev=0.1))
77 b1 = tf.Variable(tf.constant(0.1, shape=[hidden_layer_nodes_1]))
78 z1 = tf.nn.relu(tf.matmul(x, W1) + b1)
79
80 W2 = tf.Variable(tf.truncated_normal([hidden_layer_nodes_1, hidden_layer_nodes_2], stddev=0.1))
81 b2 = tf.Variable(tf.constant(0.1, shape=[hidden_layer_nodes_2]))
82 z2 = tf.nn.relu(tf.matmul(z1, W2) + b2)
83 W3 = tf.Variable(tf.truncated_normal([hidden_layer_nodes_2, categories], stddev=0.1))
84 b3 = tf.Variable(tf.constant(0.1, shape=[categories]))
      model()

Run: main3
Iteration: 4700, Loss: 0.0007263486
Iteration: 4800, Loss: 0.0007044286
Iteration: 4900, Loss: 0.00068474544
Accuracy validation: 0.92235
The model is ready!
Accuracy test: 0.93202764
Prediction for: [ 54 94 91 ... 98 101 101 ]: [[9.9999857e-01 1.1910560e-06 3.0292494e-19 2.9004443e-07]], Max value: 0.99999857, Sum: 1.0
Prediction for: [ 77 65 88 ... 80 99 104 ]: [[9.6573514e-01 3.4264836e-02 7.4863456e-16 8.9270550e-32]], Max value: 0.96573514, Sum: 0.96573514
Prediction for: [ 78 72 73 ... 62 63 64 ]: [[9.9998116e-01 1.8888295e-05 1.4223391e-15 2.2881478e-17]], Max value: 0.9998116, Sum: 1.0000000
Prediction for: [ 90 88 83 ... 73 71 69 ]: [[9.9999702e-01 2.9593543e-06 1.1677237e-16 3.2369800e-15]], Max value: 0.999997, Sum: 0.9999997
Prediction for: [ 73 45 88 ... 60 62 47 ]: [[1.0000000e+00 3.969787e-14 0.0000000e+00 0.0000000e+00]], Max value: 1.0, Sum: 1.0000000

```

The result with Neural Network with two hidden layers (200 neurons in the first layer and 100 neurons in the second layer) and Gradient Descent algorithm after 5000 iterations.

Neural Network with Adam optimizer

The following tables represent the data shown in the three screenshots of the PyCharm IDE.

Screenshot 1 Data:

Iteration	Loss
0	8.594146e-05
100	0.00022708443
200	4.5000725e-05
300	8.86186e-05
400	2.8904407e-05
500	5.7780857e-05
600	1.6272152e-05
700	3.2587687e-05
800	1.167142e-05

Accuracy train: 1.0
Accuracy validation: 0.96428573

Screenshot 2 Data:

Iteration	Loss
0	2.8906366e-06
100	3.2604345e-07
200	6.11256e-08
300	1.2444787e-08
400	3.088323e-09
500	9.339755e-07

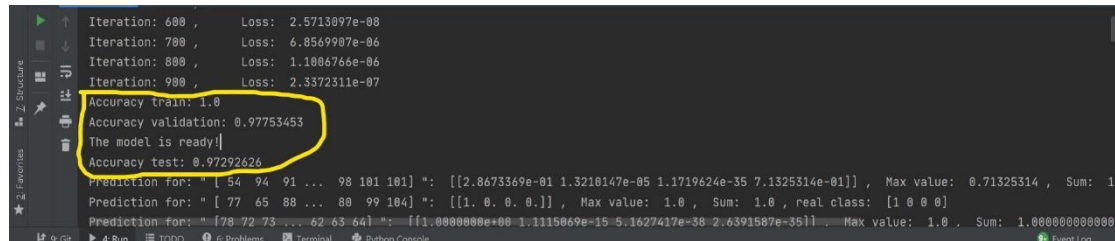
Accuracy train: 1.0
Accuracy validation: 0.97868663

Screenshot 3 Data:

Iteration	Loss
0	5.010621e-09
100	1.6013526e-09
200	1.9206157e-06
300	4.7411825e-07
400	7.933507e-08
500	6.7256782e-09
600	1.5580945e-05
700	1.3757056e-06
800	2.2452622e-07
900	3.9438913e-08

Accuracy train: 1.0
Accuracy validation: 0.9758065

In the middle image the highest accuracy appears, then the accuracy begins to decrease.



```

Iteration: 600 , Loss: 2.5713097e-08
Iteration: 700 , Loss: 6.8569987e-06
Iteration: 800 , Loss: 1.1086766e-06
Iteration: 900 , Loss: 2.3372311e-07
Accuracy train: 1.0
Accuracy validation: 0.97753453
The model is ready!
Accuracy test: 0.97292626
Prediction for: " [ 54 94 91 ... 98 101 101] ": [[2.8673369e-01 1.3210147e-05 1.1719624e-35 7.1325314e-01]], Max value: 0.71325314 , Sum: 1.0
Prediction for: " [ 77 65 88 ... 80 99 104] ": [[1. 0. 0. 0.]], Max value: 1.0 , Sum: 1.0 , real class: [1 0 0]
Prediction for: " [78 72 73 ... 62 63 64] ": [[1.0000000e+00 1.1115069e-15 5.1627417e-38 2.6391587e-35]], Max value: 1.0 , Sum: 1.0000000000000000

```

The result with Neural Network with two hidden layers (200 neurons in the first layer and 100 neurons in the second layer) and Adam optimizer algorithm after 5000 iterations.