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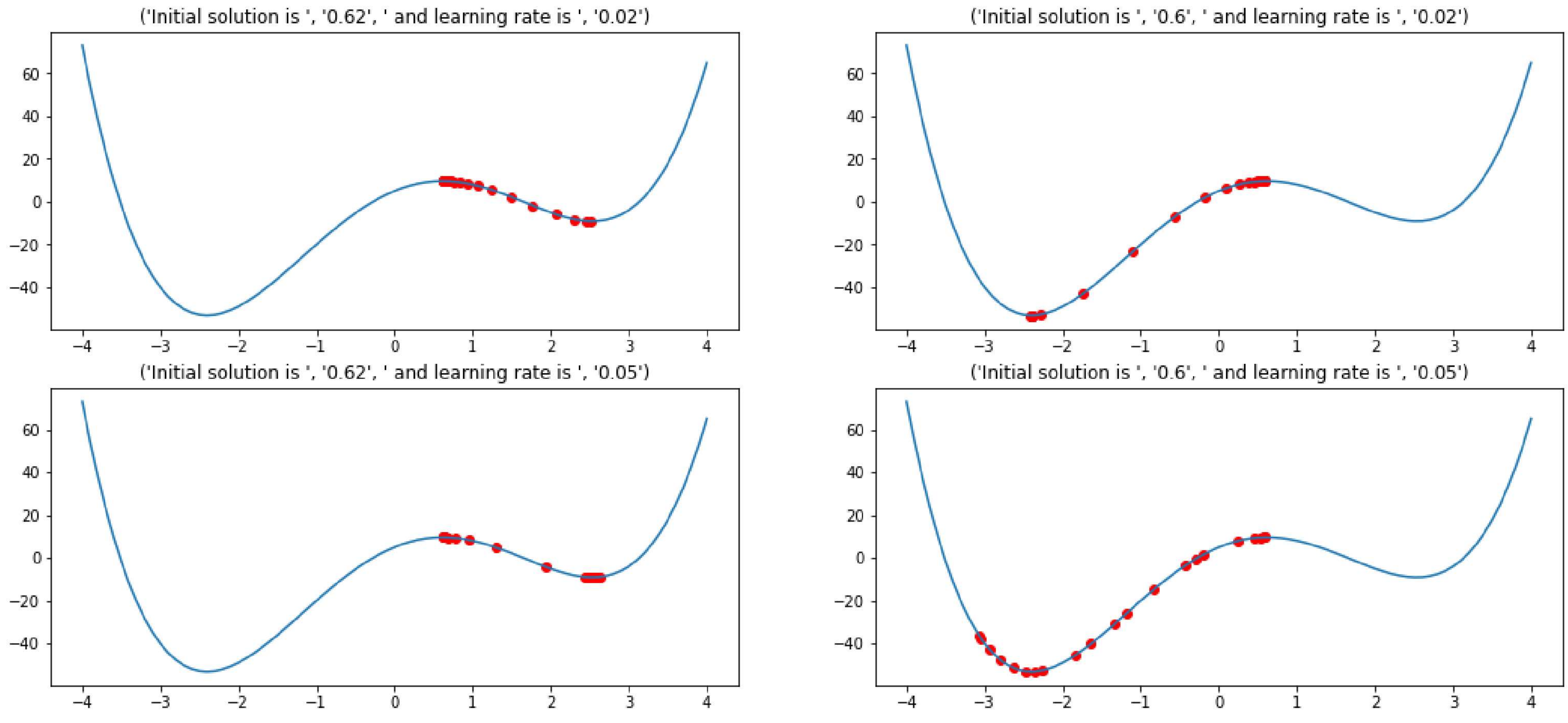
```
import numpy as np
import matplotlib.pyplot as plt
fig,ax = plt.subplots(2,2,figsize=(18,8))
def f(x):
    w = np.array([1,-1,-12,15,5])
    M = np.size(w)-1
    return np.sum([x**i*w[M-i] for i in range(0,M+1)],axis=0)
def g(x):
    w = np.array([1,-1,-12,15,5])
    M = np.size(w)-1
    return np.sum([i*x**(i-1)*w[M-i] for i in range(0,M+1)],axis=0)
alphaList = [0.02,0.05]
xList = [0.62,0.6]
for j in range(4):
    alpha = alphaList[j//2]
    x = xList[j%2]
    title = "Initial solution is ",str(x)," and learning rate is ",str(alpha)
    x_hist = np.array(x)
    fx_hist = np.array(f(x))
    for i in range(20):
        x = x-alpha*g(x)
        x_hist = np.append(x_hist,x)
        fx_hist = np.append(fx_hist,f(x))
    print('x = ',x, 'f(x) = ' ,f(x))

    delta = 0.1
    x_ = np.arange(-4,4+delta,delta)

    ax[j//2,j%2].plot(x_,f(x_))
    ax[j//2,j%2].set_title(title)
    ax[j//2,j%2].scatter(x_hist,fx_hist,c='r')
```

```
x =  2.5104174088324025 f(x) =  -9.073558171240812
x =  -2.4003994283530288 f(x) =  -53.11840483760499
x =  2.5083884414285142 f(x) =  -9.071713647395654
x =  -0.29497479850285213 f(x) =  -0.43550699945570187
```




```
from scipy.optimize import fsolve
from scipy.optimize import minimize
x0 = 0.6
root = fsolve(g,x0)
print(root)
minimum = minimize(f,x0)
print(minimum)
```

```
[0.61654501]
      fun: -53.1184048380149
 hess_inv: array([[0.01680084]])
      jac: array([-2.38418579e-06])
  message: 'Optimization terminated successfully.'
```

```
          nfev: 30
           nit: 3
          njev: 10
        status: 0
       success: True
             x: array([-2.40040317])
```

```
import numpy as np
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import cifar10 , mnist

( x_train,y_train ),( x_test,y_test ) = cifar10.load_data ( )
# ( x_train , y_train ),( x_test , y_test ) = mnist.load_data ( )
print ( " x_train => " , x_train.shape )

Ntr = x_train.shape [ 0 ]
Nte = x_test.shape [ 0 ]
Din = 3072 # CIFAR10
# Din = 784 # MINIST
x_train = x_train [ range ( Ntr ) , : ]
x_test = x_test [ range ( Nte ) , : ]
y_train = y_train [ range ( Ntr ) ]
y_test = y_test [ range ( Nte ) ]

K = len(np.unique(y_train))
y_train = tf.keras.utils.to_categorical(y_train,num_classes=K)
y_test= tf.keras.utils.to_categorical(y_test,num_classes=K)
x_train = np.reshape(x_train,(Ntr,Din))
x_test= np.reshape(x_test,(Nte,Din))
x_train=x_train.astype(np.float32)
x_test = x_test.astype(np.float32)
x_train /= 255.
x_test /=255.
```

```
x_train =>  (50000, 32, 32, 3)
```

```
# Utility function for diaplaying
def display(y_train, y_test, y_train_pred, y_test_pred, loss_history, w, showim = True):
    plt.plot(loss_history)
    # For diapaying the weights matrix w as an image. 32*32*3 assumption is␣↪there
    if showim:
        f, axarr = plt.subplots(2, 5)
        f.set_size_inches(16, 6)
        for i in range(10):
            img = w[:, i].reshape(32, 32, 3)# CIFAR10
            # img = w1[:, i].reshape(28, 28)# MNIST
            img = (img - np.amin(img))/(np.amax(img) - np.amin(img))
            axarr[i//5, i%5].imshow(img)
        plt.show()
    train_acc = np.mean(np.abs(np.argmax(y_train, axis=1) == np.argmax(y_train_pred, axis=1)))
    print("train_acc = ", train_acc)
    test_acc = np.mean(np.abs(np.argmax(y_test, axis=1) == np.argmax(y_test_pred, axis=1)))
    print("test_acc = ", test_acc)
```

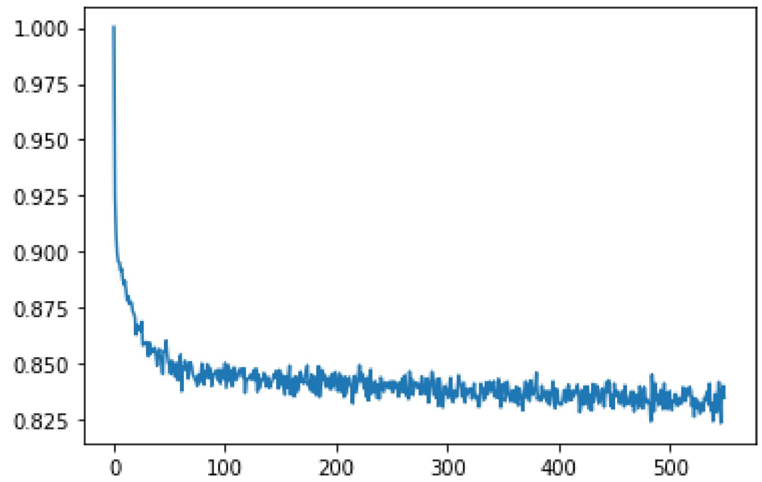
```
std =1e-5
w = std*np.random.randn(Din,K)
b = np.zeros(K)
lr = 1e-3
lr_decay=0.1
epochs =11
batch_size=1000
loss_history = []
rng = np.random.default_rng(seed=0)
for e in range(epochs):
    indices = np.arange(Ntr)
    rng.shuffle(indices)
    for batch in range(Ntr//batch_size):
        batch_indices = indices[batch*batch_size:(batch+1)*batch_size]
        x =x_train[batch_indices]#Extract a batch of 100
        y = y_train[batch_indices]
        #Forward pass
        y_pred = x@w+b
        loss=1./batch_size*np.square(y_pred-y).sum()
        loss_history.append(loss)
```

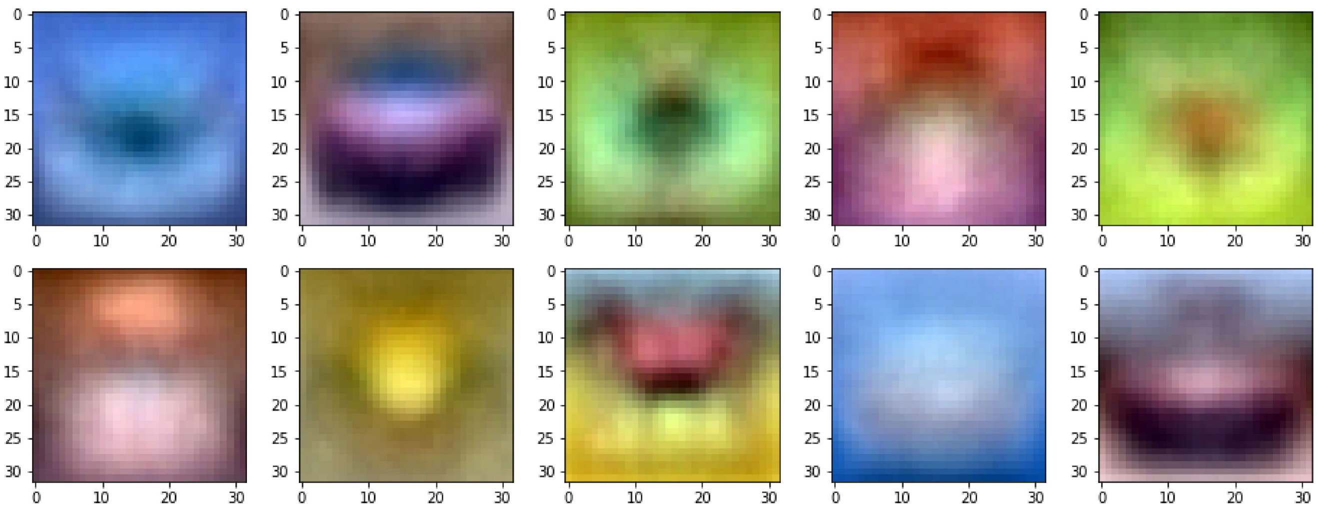
```
        #backward pass
        dy_pred =1./batch_size*2.0*(y_pred-y)
        dw = x.T @ dy_pred
        db = dy_pred.sum(axis=0)*1
        w=w-lr*dw
        b = b-lr*db

    if e % 5==0:
        print("Iteration %d / %d: loss %f"%(e,epochs,loss))
    if e % 10==0:
        lr *= lr_decay
```

```
Iteration 0 / 11: loss 0.850470
Iteration 5 / 11: loss 0.836772
Iteration 10 / 11: loss 0.834915
```

```
y_train_pred = x_train.dot(w)+b
y_test_pred = x_test.dot(w)+b
display(y_train,y_test,y_train_pred,y_test_pred,loss_history,w,showim=True)
```



```
train_acc =  0.33578
test_acc =  0.3353
```

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