

به نام خدا

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گزارش تمرین عملی شبکه عصبی

قدم اول

نیازی به بیان مطلبی نیست.

قدم دوم (جداسازی ۲۰۰ داده از مجموعه train) و اعمال feed_forwarding

عکس از چندین اجرا در حالت زیر می بینید که میانگین نزدیک به ۲۵ درصد است.

```
PROBLEMS OUTPUT TERMINAL DEBUG CONSOLE
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 24.5%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 24.0%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 29.0%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 22.0%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 19.5%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 23.5%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 26.0%
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe "c:/Users/ASUS/Documents/
University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
accuracy is 23.0%
```

قدم سوم (Backpropagation)

ابتدا فرمول های مشتقات جزئی را که از این [لینک](#) استفاده شد در زیر می بینیم.

The last layer

Weight

If we apply the chain rule, we can reach to the following formula:

$$\frac{\partial Cost}{\partial w_{jk}^{(3)}} = \frac{\partial Cost}{\partial a_j^{(3)}} \times \frac{\partial a_j^{(3)}}{\partial z_j^{(3)}} \times \frac{\partial z_j^{(3)}}{\partial w_{jk}^{(3)}}$$
$$\frac{\partial Cost}{\partial w_{jk}^{(3)}} = 2(a_j^{(3)} - y_j) \times \sigma'(z_j^{(3)}) \times a_k^{(2)}$$

Bias

$$\frac{\partial Cost}{\partial b_j^{(3)}} = \frac{\partial Cost}{\partial a_j^{(3)}} \times \frac{\partial a_j^{(3)}}{\partial z_j^{(3)}} \times \frac{\partial z_j^{(3)}}{\partial b_j^{(3)}}$$
$$\frac{\partial Cost}{\partial b_j^{(3)}} = 2(a_j^{(3)} - y_j) \times \sigma'(z_j^{(3)}) \times 1$$

Activation

We also need to calculate partial derivatives with respect to the activation output of the previous layer. It helps us for backpropagation as we see further.

$$\frac{\partial Cost}{\partial a_k^{(2)}} = \sum_{j=0}^9 \frac{\partial Cost}{\partial a_j^{(3)}} \times \frac{\partial a_j^{(3)}}{\partial z_j^{(3)}} \times \frac{\partial z_j^{(3)}}{\partial a_k^{(2)}}$$
$$\frac{\partial Cost}{\partial a_k^{(2)}} = \sum_{j=0}^9 (2(a_j^{(3)} - y_j) \times \sigma'(z_j^{(3)}) \times w_{jk}^{(3)})$$

3rd layer

Weight

$$\frac{\partial Cost}{\partial w_{km}^{(2)}} = \frac{\partial Cost}{\partial a_k^{(2)}} \times \frac{\partial a_k^{(2)}}{\partial z_k^{(2)}} \times \frac{\partial z_k^{(2)}}{\partial w_{km}^{(2)}}$$
$$\frac{\partial Cost}{\partial w_{km}^{(2)}} = \frac{\partial Cost}{\partial a_k^{(2)}} \times \sigma'(z_k^{(2)}) \times a_m^{(1)}$$

Bias

$$\frac{\partial Cost}{\partial b_k^{(2)}} = \frac{\partial Cost}{\partial a_k^{(2)}} \times \frac{\partial a_k^{(2)}}{\partial z_k^{(2)}} \times \frac{\partial z_k^{(2)}}{\partial b_k^{(2)}}$$
$$\frac{\partial Cost}{\partial b_k^{(2)}} = \frac{\partial Cost}{\partial a_k^{(2)}} \times \sigma'(z_k^{(2)}) \times 1$$

Activation

$$\frac{\partial Cost}{\partial a_m^{(1)}} = \sum_{k=0}^{15} \frac{\partial Cost}{\partial a_k^{(2)}} \times \frac{\partial a_k^{(2)}}{\partial z_k^{(2)}} \times \frac{\partial z_k^{(2)}}{\partial a_m^{(1)}}$$
$$\frac{\partial Cost}{\partial a_m^{(1)}} = \sum_{k=0}^{15} \left(\frac{\partial Cost}{\partial a_k^{(2)}} \times \sigma'(z_k^{(2)}) \times w_{km}^{(2)} \right)$$

2nd layer

Weight

$$\frac{\partial Cost}{\partial w_{mv}^{(1)}} = \frac{\partial Cost}{\partial a_m^{(1)}} \times \frac{\partial a_m^{(1)}}{\partial z_m^{(1)}} \times \frac{\partial z_m^{(1)}}{\partial w_{mv}^{(1)}}$$
$$\frac{\partial Cost}{\partial w_{mv}^{(1)}} = \frac{\partial Cost}{\partial a_m^{(1)}} \times \sigma'(z_m^{(1)}) \times \text{times } a_v^{(0)}$$

Bias

$$\frac{\partial Cost}{\partial b_m^{(1)}} = \frac{\partial Cost}{\partial a_m^{(1)}} \times \frac{\partial a_m^{(1)}}{\partial z_m^{(1)}} \times \frac{\partial z_m^{(1)}}{\partial b_m^{(1)}}$$
$$\frac{\partial Cost}{\partial b_m^{(1)}} = \frac{\partial Cost}{\partial a_m^{(1)}} \times \sigma'(z_m^{(1)}) \times 1$$

همچنین در شبه کد گفته شده در تابع main پیاده سازی شد.

لازم به ذکر است که این قسمت بدون استفاده از مفهوم Vectorization پیاده سازی شده است که سرعت اجرای بسیار پایین تری دارد. (با استفاده از حلقه‌ها)

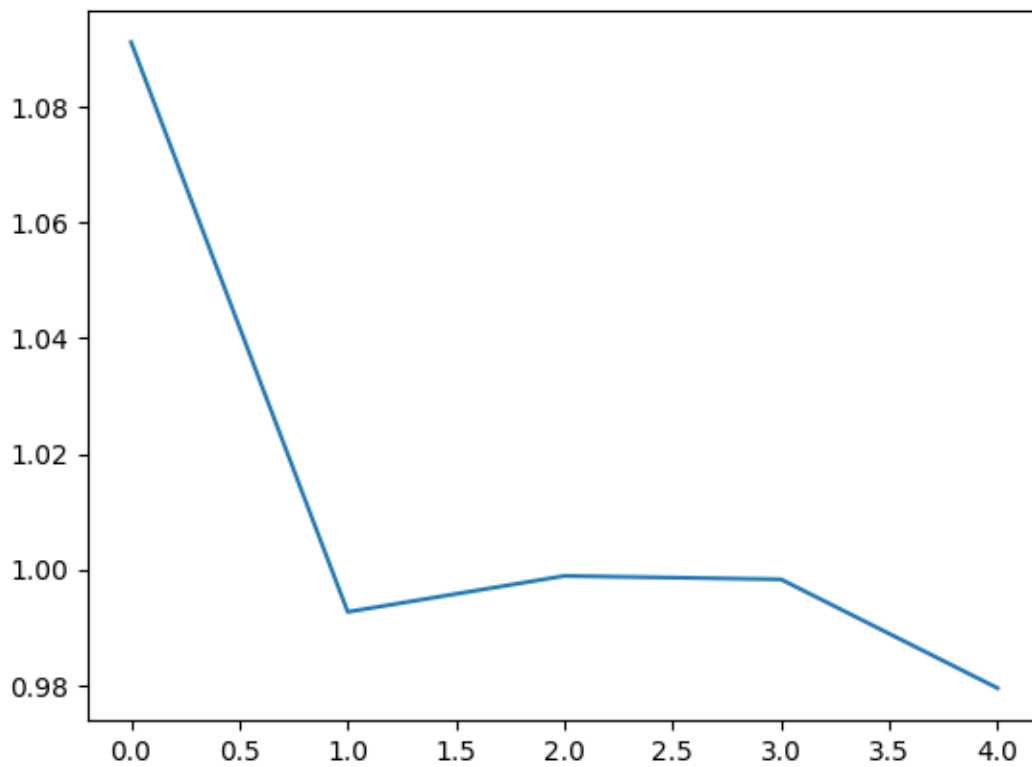
با توجه به مقادیر گفته شده در گزارش با پارامترهای زیر اجرا شد و نتیجه را در ادامه می‌بینیم.

```
main(part=2,epoch=5,batch_size=10,learning_rate=1)
```

زمان اجرا را در زیر می‌بینیم که تقریباً یک دقیقه بوده است.

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe "c:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN\src\main.py"
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 45.5%*****
*****accuracy is 62.5%*****
*****accuracy is 52.0%*****
*****accuracy is 47.0%*****
*****accuracy is 39.5%*****
Learning Process Time: 59.76878356933594
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

در زیر نمودار هزینه را می‌بینیم که تقریباً نزولی بوده است (اجراهایی نیز بود که نزولی اکید باشد).



قدم چهارم (Vectorization)

قسمت اول: آموزش ۲۰۰ عکس با پارامترهای زیر جهت مقایسه با قدم قبل

```
main(part=3,epoch=20,batch_size=10,learning_rate=1)
```

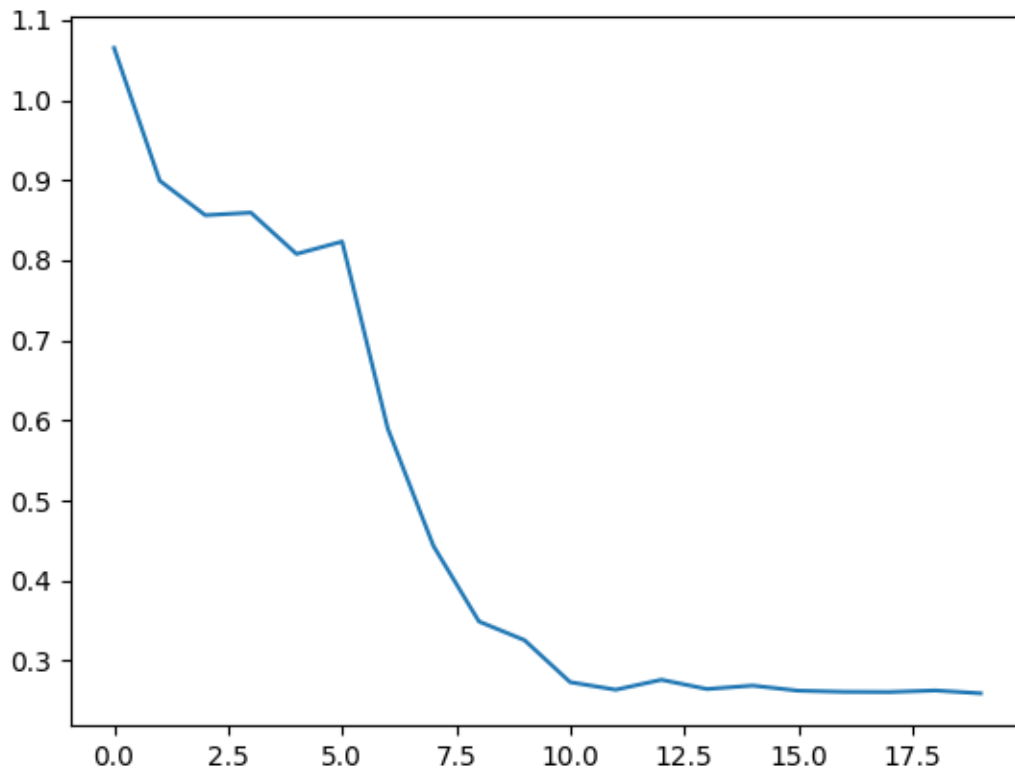
خروجی را در زیر می بینیم که در حدود ۱.۵ ثانیه انجام شد.

```

PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe "c:/Users/ASUS/Documents/University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 27.5%*****
*****accuracy is 48.5%*****
*****accuracy is 22.5%*****
*****accuracy is 69.5%*****
*****accuracy is 22.5%*****
*****accuracy is 47.0%*****
*****accuracy is 64.0%*****
*****accuracy is 74.5%*****
*****accuracy is 73.5%*****
*****accuracy is 74.5%*****
*****accuracy is 74.5%*****
*****accuracy is 74.0%*****
*****accuracy is 74.5%*****
*****accuracy is 74.5%*****
*****accuracy is 73.5%*****
*****accuracy is 74.5%*****
*****accuracy is 74.5%*****
*****accuracy is 74.0%*****
*****accuracy is 74.5%*****
*****accuracy is 74.5%*****
Learning Process Time: 1.5759103298187256
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN

```

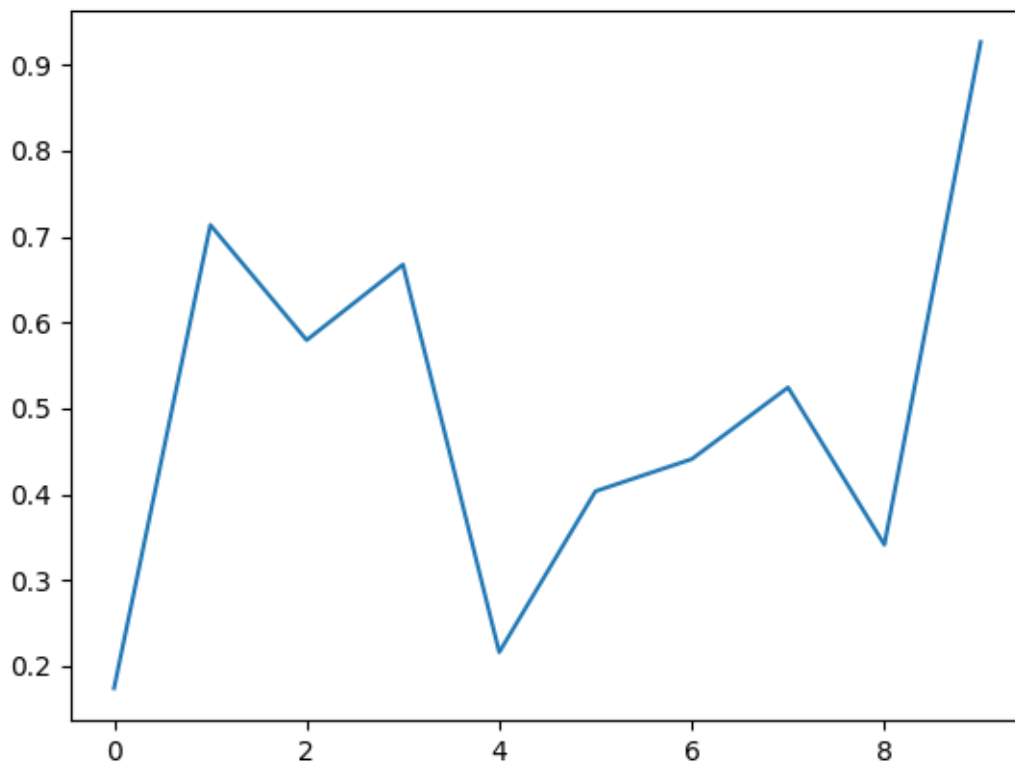
نمودار هزینه‌ها نیز در زیر قابل مشاهده هستند.



قسمت دوم: تنظیم ۱۰ بار اجرای کد

زمان اجرای ۱۰ بار حدود ۱۳ ثانیه طول کشید.

همچنین نمودار میانگین هزینه هر بار اجرا در زیر آمده است. که باید توجه شود که هر اجرا کاملاً مستقل از دیگری است.



قدم پنجم (Test)

قسمت اول: آموزش ۱۹۶۲ عکس با پارامترهای زیر جهت مقایسه با قدم قبل

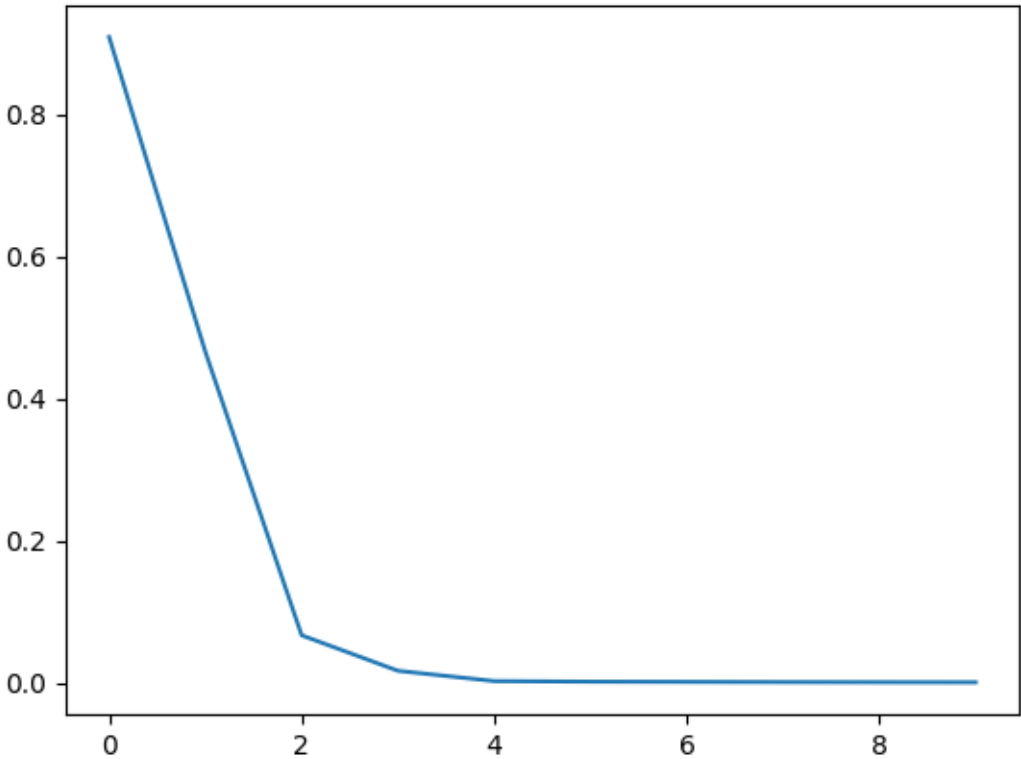
اجرا با پارامترهای زیر

```
main(part=4,epoch=10,batch_size=10,learning_rate=1)
```

زمان اجرای کد در زیر حدود ۶.۲ ثانیه است و دقت هر دو مجموعه ۱۰۰ درصد است.

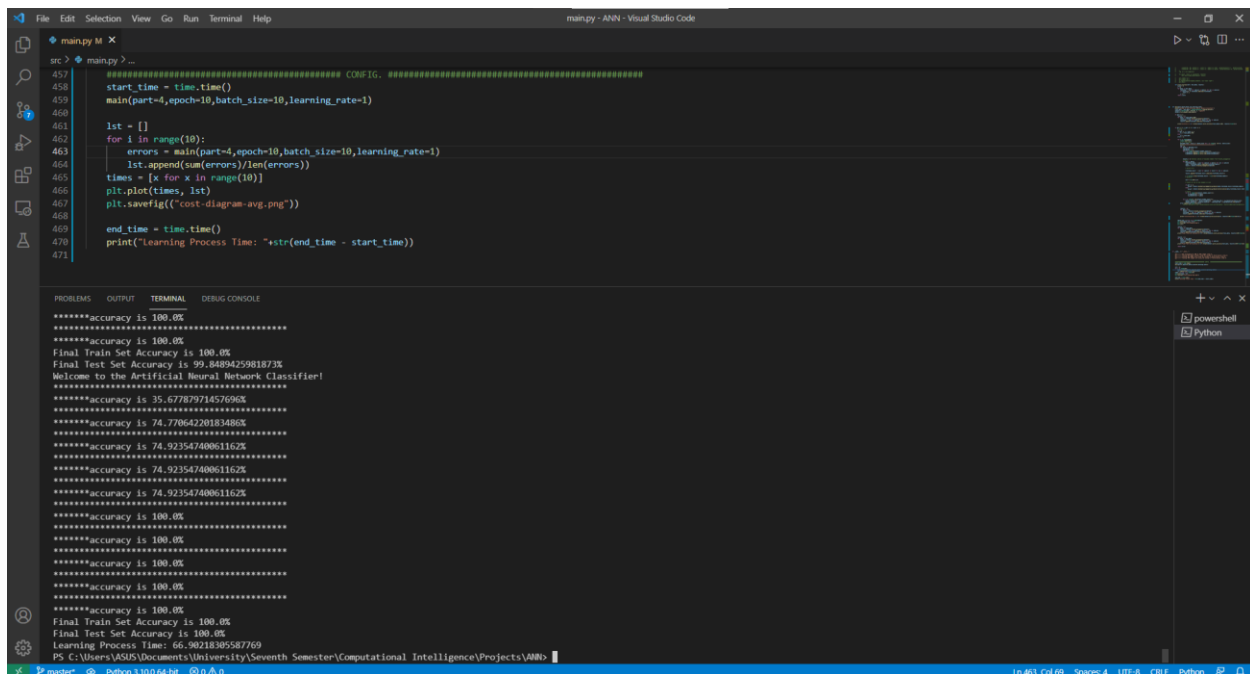
```
C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe -c:/Users/ASUS/Documents/University/Seventh Semes
ter/Computational Intelligence/Projects/ANN/src/main.py
Welcome to the Artificial Neural Network Classifier!
*****
*****accuracy is 47.14576962833846%
*****
*****accuracy is 99.74515800203874%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 100.0%
Learning Process Time: 6.213231801986694
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

همچنین در نمودار زیر نمودار کاهش هزینه‌ها برای مجموعه آموزشی را مشاهده می‌کنیم.



قسمت دوم: تنظیم ۱۰ بار اجرای کد

زمان اجرای ۱۰ بار کد حدود ۶۷ ثانیه طول کشید.



The screenshot shows a Visual Studio Code editor with a Python file named 'main.py' open. The code defines a function 'main' that takes 'part', 'epoch', 'batch_size', and 'learning_rate' as arguments. It calculates accuracy over 10 epochs and saves a cost diagram. The terminal output shows the execution results for three different parts (1, 2, and 3).

```
src > main.py > ...
457 ##### CONFIG: #####
458 start_time = time.time()
459 main(part=1, epoch=10, batch_size=10, learning_rate=1)
460
461 lst = []
462 for i in range(10):
463     errors = main(part=1, epoch=10, batch_size=10, learning_rate=1)
464     lst.append(sum(errors)/len(errors))
465 times = [x for x in range(10)]
466 plt.plot(times, lst)
467 plt.savefig('cost-diagram-avg.png')
468
469 end_time = time.time()
470 print("Learning Process Time: "+str(end_time - start_time))
471
```

Terminal Output:

```
*****accuracy is 100.0%
*****accuracy is 100.0%
*****accuracy is 100.0%
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 99.8489425981873%
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 35.67787971457690%
*****accuracy is 74.77064220183480%
*****accuracy is 74.92354740061162%
*****accuracy is 74.92354740061162%
*****accuracy is 74.92354740061162%
*****accuracy is 100.0%
*****accuracy is 100.0%
*****accuracy is 100.0%
*****accuracy is 100.0%
*****accuracy is 100.0%
*****accuracy is 100.0%
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 100.0%
Learning Process Time: 66.90218305587769
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

همچنین خروجی تولید شده از دقت نهایی مدل در زیر مشاهده می‌شود.

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 99.8489425981873%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 99.24471299093656%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 99.8489425981873%

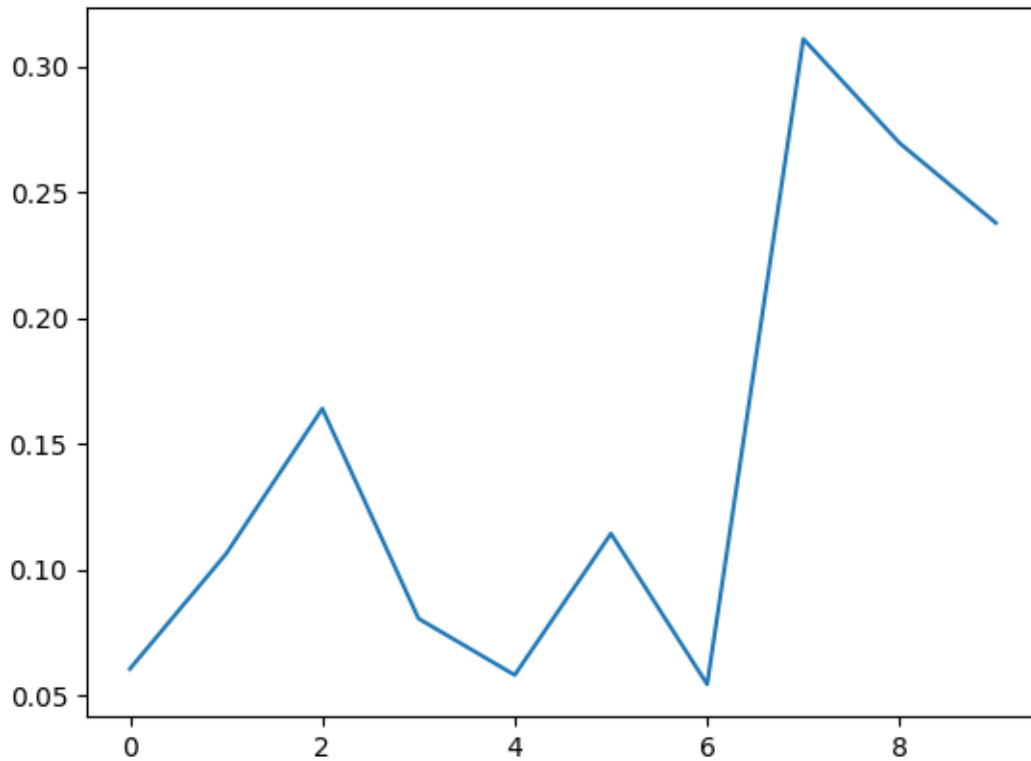
Welcome to the Artificial Neural Network Classifier!

Final Train Set Accuracy is 100.0%

Final Test Set Accuracy is 100.0%

Learning Process Time: 66.90218305587769

همچنین میانگین هزینه‌های داده‌های آموزشی در زیر قابل مشاهده است.



امتیازی

سوال اول)

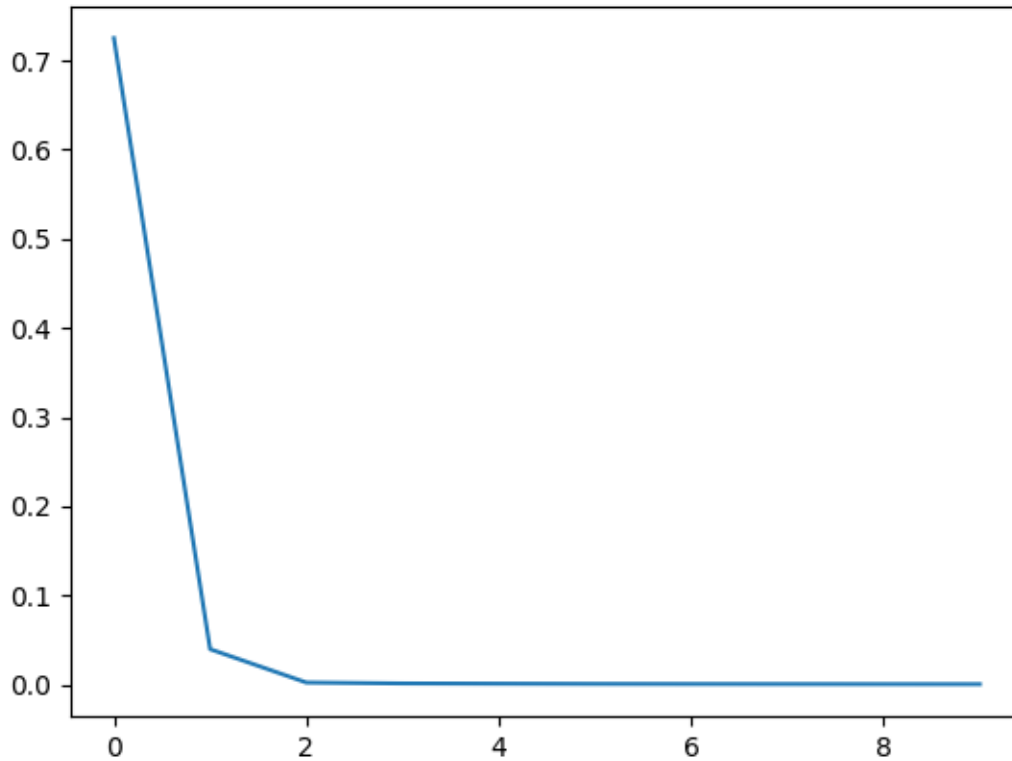
در ابتدا با مقادیر ذکر شده در قسمت اول قدم آخر شروع می‌کنیم. بدین صورت که ابتدا چند نرخ یادگیری را تست می‌کنیم. سپس به `batch_size` و بعد هم به سراغ `epoch` می‌رویم.

نرخ یادگیری ۱ را قبلاً دیدیم.

با نرخ یادگیری ۰.۵ تست می‌کنیم.


```
main(part=4,epoch=10,batch_size=5,learning_rate=1)
```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> && C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe -c:"C:/Users/ASUS/Documents/University/Seventh Semes-  
ter/Computational Intelligence/Projects/ANN/src/main.py"  
Welcome to the Artificial Neural Network Classifier!  
*****accuracy is 96.9928642405709%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
*****accuracy is 100.0%  
*****  
Final Train Set Accuracy is 100.0%  
Final Test Set Accuracy is 100.0%  
Learning Process Time: 6.476106405258179  
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

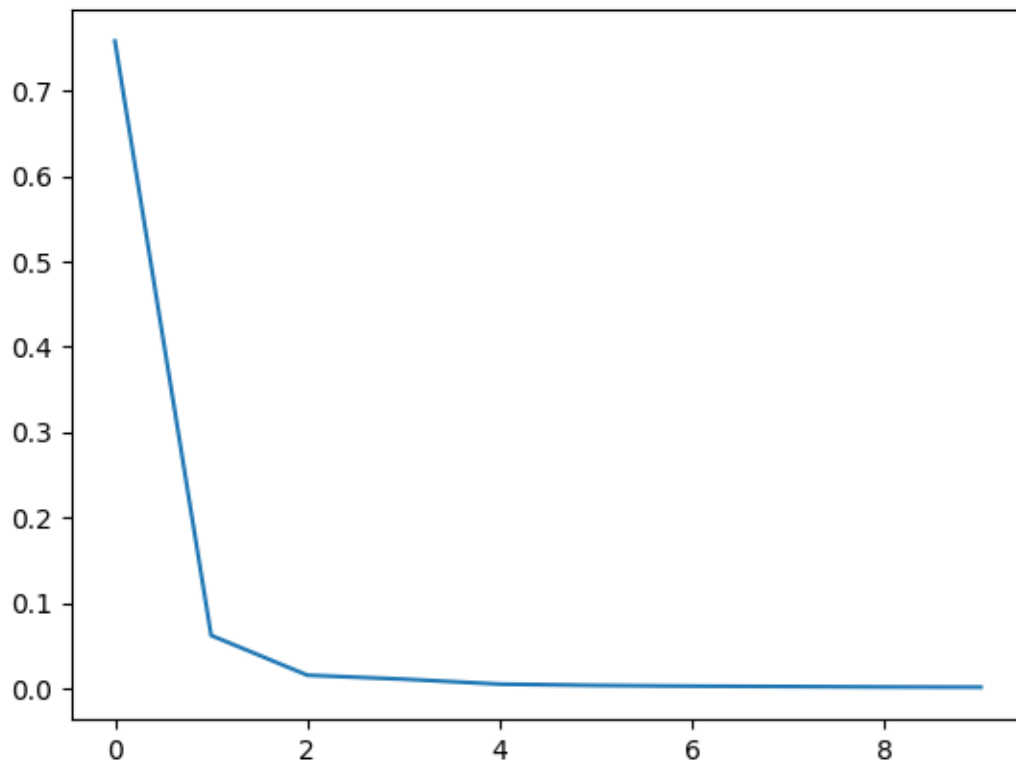


```
main(part=4,epoch=10,batch_size=20,learning_rate=1)
```

```

PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe "c:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN\src/main.py"
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 87.56371049949031%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 100.0%
Learning Process Time: 6.050006628036499

```



```

main(part=4,epoch=10,batch_size=50,learning_rate=1)

```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN0 & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe -c:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN0\src/main.py
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 25.229357788165136%*****
*****accuracy is 60.040774719673886%*****
*****accuracy is 49.94903168040773%*****
*****accuracy is 60.34658511722732%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
*****accuracy is 75.02548419979613%*****
Final Train Set Accuracy is 75.02548419979613%
Final Test Set Accuracy is 74.92447129909366%
Learning Process Time: 5.992336750830518
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN0
```

```
main(part=4,epoch=10,batch_size=30,learning_rate=1)
```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe "c:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN\src/main.py"
Welcome to the Artificial Neural Network Classifier!
*****
*****accuracy is 45.61671763586626%
*****
*****accuracy is 49.94983160048775%
*****
*****accuracy is 75.02548419979613%
*****
*****accuracy is 99.84709480122324%
*****
*****accuracy is 99.94983160048775%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
*****accuracy is 100.0%
*****
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 100.0%
Learning Process Time: 6.013535499572754
```

```
main(part=4,epoch=10,batch_size=35,learning_rate=1)
```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:\Users\ASUS\AppData\Local\Programs\Python\Python310\python.exe -c "C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN\src\main.py"
Welcome to the Artificial Neural Network Classifier!
*****accuracy is 24.974515800203875%*****
*****accuracy is 78.54230377166157%*****
*****accuracy is 99.94903160040775%*****
*****accuracy is 99.898063200815%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
*****accuracy is 100.0%*****
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 99.67280519637463%
Learning Process Time: 6.210007667541504
```

همانطور که مشاهده شد، با افزایش سایز بچ، زمان اجرا و دقت مدل کاهش می‌یابد. لذا یک مصالحه‌ای اینجا وجود دارد که ما با تست‌های مختلف به سایز ۳۰ رسیدیم.

حال به سراغ epoch می‌رویم. با افزایش آن مدت زمان اجرا و دقت مدل افزایش می‌یابد. پس اینجا نیز مصالحه‌ای وجود دارد که آن را بررسی می‌کنیم. الان ما epoch=10 دقت ۱۰۰ درصد را داریم پس مقادیر کمتر آن را بررسی می‌کنیم.

```
main(part=4,epoch=5,batch_size=32,learning_rate=1)
```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe -c "C:/Users/ASUS/Documents/University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
*****
*****accuracy is 24.974515800703875%
*****
*****accuracy is 72.98674821610681%
*****
*****accuracy is 100.0%
*****
*****accuracy is 99.84709488122324%
*****
*****accuracy is 100.0%
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 100.0%
Learning Process Time: 3.2125165462493896
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

```
main(part=4,epoch=4,batch_size=32,learning_rate=1)
```

```
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN> & C:/Users/ASUS/AppData/Local/Programs/Python/Python310/python.exe -c "C:/Users/ASUS/Documents/University/Seventh Semester/Computational Intelligence/Projects/ANN/src/main.py"
Welcome to the Artificial Neural Network Classifier!
*****
*****accuracy is 55.147888358817535%
*****
*****accuracy is 98.11416921588665%
*****
*****accuracy is 98.62385321100918%
*****
*****accuracy is 100.0%
Final Train Set Accuracy is 100.0%
Final Test Set Accuracy is 98.94259818731118%
Learning Process Time: 2.635472536087036
PS C:\Users\ASUS\Documents\University\Seventh Semester\Computational Intelligence\Projects\ANN>
```

همچنین با توجه به دو تست انجام شده ما epoch=5 را انتخاب می‌کنیم.

پس در نهایت با پارامترهای زیر مقدار مناسبی دست پیدا کردیم.

```
main(part=4,epoch=4,batch_size=32,learning_rate=1)
```

سوال دوم)

می‌توان با ارائه یک مقدار مومنتوم از گیرکردن تابع هزینه در یک حداقل محلی جلوگیری کنیم. بنابراین، یک مقدار مومنتوم به تابع کمک می‌کند تا از حداقل های محلی جلوگیری کند.

درواقع ایده این است که از گرادیان دقیق استفاده نکنیم، بلکه از یک برآورد نویزدار از گرادیان استفاده کنیم، یک گرادیان تصادفی که مقدار مورد انتظار آن گرادیان واقعی است، در این صورت می‌توانیم در جهت هایی حرکت کنیم که با گرادیان متفاوت است. این گاهی اوقات ما را از حداقل محلی نزدیک می‌برد و می‌تواند مانع از به دام افتادن ما در حداقل محلی کوچک شود.

استفاده از بچ

با محاسبه یک برآیند گرادیان با در نظر گرفتن تعدادی از داده‌های آموزشی، می‌توانیم به‌طور کارآمدتر تخمینی نویزدار از گرادیان تولید کنیم.