به نام خدا

گزارش پروژه دوم درس یادگیری عمیق

دکتر سید ابوالقاسم میرروشندل

تاریخ تحویل: ۱۴۰۱/۰۱/۳۱

نام و نام خانوادگی	فاطمه کمانی
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- **بررسی دیتاست (تعداد داده‌ها، توزیع داده‌های هر کلاس و سایر تحلیل‌ها)**

این دیتاست شامل ۴۸۰ نمونه داده از اطلاعات دانش آموزان است.

شامل ۱۷ ستون که ۱۶ ستون آن به عنوان ویژگی و ستون کلاس به عنوان لیبل مدل انتخاب شدند.

تحلیل داده‌ها به شرح زیر است، شما می‌توانید توزیع داده و مقادیر داده را در عکس زیر مشاهده کنید:

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1. Gender column: ['F' 'M']  F:64%, M:36%  Encoded as 0s and 1s

2. NationalITy column: ['Egypt' 'Iran' 'Iraq' 'Jordan' 'KW' 'Lybia' 'Morocco' 'Palestine'
 'SaudiArabia' 'Syria' 'Tunis' 'USA' 'lebanon' 'venzuela']              Encoded as 0 to 13

3. PlaceofBirth column: ['Egypt' 'Iran' 'Iraq' 'Jordan' 'KuwaIT' 'Lybia' 'Morocco' 'Palestine'
 'SaudiArabia' 'Syria' 'Tunis' 'USA' 'lebanon' 'venzuela']              Encoded as 0 to 13

4. StageID column: ['HighSchool' 'MiddleSchool' 'lowerlevel']  H:7%, M:52%, l:41%  Encoded as 0 to 2

5. GradeID column: ['G-02' 'G-04' 'G-05' 'G-06' 'G-07' 'G-08' 'G-09' 'G-10' 'G-11' 'G-12']      Encoded as 0 to 9

6. SectionID column: ['A' 'B' 'C'] A:59%, B:35%, C:6%   Encoded as 0 to 2

7. Topic column: ['Arabic' 'Biology' 'Chemistry' 'English' 'French' 'Geology' 'History'
 'IT' 'Math' 'Quran' 'Science' 'Spanish']               Encoded as 0 to 11

8. Semester column: ['F' 'S'] F:51%, S:49%  Encoded as 0s and 1s

9. Relation column: ['Father' 'Mum']  Father:59%, Mother:41%  Encoded as 0s and 1s

10. raisedhands column: [  0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17
  18  19  20  21  22  23  24  25  27  28  29  30  32  33  35  36  39  40
  41  42  45  49  50  51  52  53  55  57  59  60  61  62  65  66  67  69
  70  71  72  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87
  88  89  90  92  95  96  97  98  99 100]       Not Encoded

11. VisITedResources column: [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 24
 25 26 27 28 29 30 31 33 34 35 36 38 39 40 41 42 43 44 48 50 51 52 54 55
 57 58 59 60 61 62 63 64 65 66 68 69 70 71 72 74 75 76 77 78 79 80 81 82
 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99]    Not Encoded

12. AnnouncementsView column: [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
 24 25 26 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 48 49
 50 51 52 53 54 55 56 57 58 59 60 62 63 64 65 66 67 69 70 71 72 73 74 75
 76 77 78 79 80 82 83 85 86 87 88 89 91 93 95 98]       Not Encoded
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13. Discussion column: [ 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 19 20 21 22 23 24 25
 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 43 44 45 46 48 49 50 51
 53 55 57 58 59 60 61 62 63 64 65 66 68 69 70 71 72 73 74 75 76 77 79 80
 81 82 83 84 85 86 88 89 90 91 92 93 94 95 96 97 98 99]        Not Encoded

14. ParentAnsweringSurvey column: ['No' 'Yes']  No:44%, Yes:56%,  Encoded as 0s and 1s

15. ParentschoolSatisfaction column: ['Bad' 'Good']   Bad:39% Good:61%,  Encoded as 0 and1

16. StudentAbsenceDays column: ['Above-7' 'Under-7']   Above-7:60%, Under-7:40%  Encoded as 0s and 1s

17. Class column: ['H' 'L' 'M']   H:30, L:26, M:44  Encoded as 0 t0 2
```

با استفاده از label encoder این مقادیر به صورت عددی در آمدند. و با استفاده از Standard Scaler به صورت نرمال تری برای محاسبه در مدل در آمدند.

در جدول زیر مدل‌های ۳، ۴ و ۵ لایه با معماری‌های مختلف مشاهده می‌شود که در نهایت سه معماری بهتری یعنی:

[۳ ,۲۰ ,۳۲ ,۲۰ ,۱۶]

[۳ ,۳۰ ,۵۰ ,۴۰ ,۲۰ ,۱۶]

[۳ ,۲۰ ,۳۰ ,۴۰ ,۳۰ ,۲۰ ,۱۶]

انتخاب شدند.

Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
3: [16, 20, 32, 20, 3]	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.4321269690990448	(epoch index:7) Accuracy: 0.8645833134651184 Loss: 0.393481582403183	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.4321269690990448	(epoch index:2) Accuracy: 0.8645833134651184 Loss: 0.41615280508995056
3: [16, 32, 48, 8, 3]	(epoch index:15) Accuracy: 0.9192708134651184 Loss: 0.2297326922416687	(epoch index:15) Accuracy: 0.8645833134651184 Loss: 0.381051629781723	(epoch index:14) Accuracy: 0.9270833134651184 Loss: 0.24726463854312897	(epoch index:15) Accuracy: 0.8645833134651184 Loss: 0.381051629781723
3: [16, 40, 50, 20, 3]	(epoch index:6) Accuracy: 0.8385416865348816 Loss: 0.4038710296154022	(epoch index:6) Accuracy: 0.8333333134651184 Loss: 0.4375535547733307	(epoch index:6) Accuracy: 0.8385416865348816 Loss: 0.4038710296154022	(epoch index:2) Accuracy: 0.8333333134651184 Loss: 0.45510196685791016
4: [16, 20, 40, 50, 30, 3]	(epoch index:9) Accuracy: 0.8333333134651184 Loss: 0.3998267650604248	(epoch index:6) Accuracy: 0.8020833134651184 Loss: 0.4033297300338745	(epoch index:7) Accuracy: 0.8385416865348816 Loss: 0.4113585650920868	(epoch index:1) Accuracy: 0.8541666865348816 Loss: 0.42668578028678894
4: [16, 30, 50, 40, 10, 3]	(epoch index:9) Accuracy: 0.8723958134651184 Loss: 0.3451025187969208	(epoch index:6) Accuracy: 0.8020833134651184 Loss: 0.44904252886772156	(epoch index:9) Accuracy: 0.8723958134651184 Loss: 0.3451025187969208	(epoch index:9) Accuracy: 0.8229166865348816 Loss: 0.4716469347476959
4: [16, 32, 40, 12, 8, 3]	(epoch index:5) Accuracy: 0.8020833134651184 Loss: 0.4955822229385376	(epoch index:2) Accuracy: 0.8125 Loss: 0.47458982467651367	(epoch index:5) Accuracy: 0.8020833134651184 Loss: 0.4955822229385376	(epoch index:1) Accuracy: 0.8333333134651184 Loss: 0.5218788981437683
5: [16, 100, 200, 500, 200, 50, 3]	(epoch index:20) Accuracy: 0.7473958134651184 Loss: 0.5318569540977478	(epoch index:24) Accuracy: 0.8020833134651184 Loss: 0.44812262058258057	(epoch index:22) Accuracy: 0.7682291865348816 Loss: 0.5413220524787903	(epoch index:21) Accuracy: 0.8020833134651184 Loss: 0.4885505735874176
5: [16, 20, 30, 40, 30, 20, 3]	(epoch index:7) Accuracy: 0.8203125 Loss: 0.4500597417354584	(epoch index:5) Accuracy: 0.8333333134651184 Loss: 0.3907705247402191	(epoch index:7) Accuracy: 0.8203125 Loss: 0.4500597417354584	(epoch index:2) Accuracy: 0.84375 Loss: 0.41658636927604675
5: [16, 32, 36, 40, 30, 10, 3]	(epoch index:9) Accuracy: 0.8385416865348816 Loss: 0.43332552909851074	(epoch index:9) Accuracy: 0.8125 Loss: 0.44865354895591736	(epoch index:9) Accuracy: 0.8385416865348816 Loss: 0.43332552909851074	(epoch index:8) Accuracy: 0.8229166865348816 Loss: 0.4713158905506134

- **یک شبکه عصبی با n لایه میانی**
  - **سایر معیارهای ارزیابی:**

در این بخش شبکه‌های ۳،۴ و ۵ لایه‌ی میانی با انواع optimizer ها و اکتیویشن فانکشن‌ها تست شدند.

- **سه لایه میانی:**

Three hidden layer models:

alpha = 0.01

Model Parameters	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Adam-tanh	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.4321269690990448	(epoch index:7) Accuracy: 0.8645833134651184 Loss: 0.393481582403183	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.4321269690990448	(epoch index:2) Accuracy: 0.8645833134651184 Loss: 0.41615280508995056
Adam-relu	(epoch index:4) Accuracy: 0.7734375 Loss: 0.46318745613098145	(epoch index:4) Accuracy: 0.78125 Loss: 0.44162535667419434	(epoch index:4) Accuracy: 0.7734375 Loss: 0.46318745613098145	(epoch index:2) Accuracy: 0.8020833134651184 Loss: 0.44247743487358093
Adam-sigmoid	(epoch index:27) Accuracy: 0.8229166865348816 Loss: 0.46017542481422424	(epoch index:27) Accuracy: 0.8229166865348816 Loss: 0.40406718850135803	(epoch index:27) Accuracy: 0.8229166865348816 Loss: 0.46017542481422424	(epoch index:10) Accuracy: 0.8333333134651184 Loss: 0.42308297753334045
RMSprop-tanh	(epoch index:10) Accuracy: 0.8463541865348816 Loss: 0.4054217040538788	(epoch index:7) Accuracy: 0.8541666865348816 Loss: 0.3797050416469574	(epoch index:10) Accuracy: 0.8463541865348816 Loss: 0.4054217040538788	(epoch index:5) Accuracy: 0.8645833134651184 Loss: 0.41148242354393005
RMSprop-relu	(epoch index:9) Accuracy: 0.8385416865348816 Loss: 0.334501713514328	(epoch index:2) Accuracy: 0.8125 Loss: 0.46497800946235657	(epoch index:8) Accuracy: 0.8411458134651184 Loss: 0.3582023084163666	(epoch index:2) Accuracy: 0.8125 Loss: 0.46497800946235657
RMSprop-sigmoid	(epoch index:59) Accuracy: 0.875 Loss: 0.3811340034008026	(epoch index:57) Accuracy: 0.8229166865348816 Loss: 0.39502573013305664	(epoch index:59) Accuracy: 0.875 Loss: 0.3811340034008026	(epoch index:16) Accuracy: 0.84375 Loss: 0.40563496947288513
SGD-tanh	(epoch index:99) Accuracy: 0.7994791865348816 Loss: 0.5121402144432068	(epoch index:99) Accuracy: 0.84375 Loss: 0.41627392172813416	(epoch index:97) Accuracy: 0.8020833134651184 Loss: 0.5142480731010437	(epoch index:89) Accuracy: 0.8541666865348816 Loss: 0.4223890006542206
SGD-relu	(epoch index:99) Accuracy: 0.8046875 Loss: 0.46763500571250916	(epoch index:99) Accuracy: 0.8125 Loss: 0.4244281053543091	(epoch index:97) Accuracy: 0.8072916865348816 Loss: 0.4699944257736206	(epoch index:93) Accuracy: 0.8229166865348816 Loss: 0.4272530972957611
SGD-sigmoid	(epoch index:2) Accuracy: 0.4348958432674408 Loss: 1.1045570373535156	(epoch index:2) Accuracy: 0.4583333432674408 Loss: 1.1076233386993408	(epoch index:0) Accuracy: 0.4348958432674408 Loss: 1.1495647430419922	(epoch index:0) Accuracy: 0.4583333432674408 Loss: 1.1452230215072632

- **شکل خروجی کد مجموعه آموزش**

- **شکل خروجی کد مجموعه ارزیابی**

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 8/8 [00:01<00:00, 6.86epoch/s, loss=0.432, accuracy=0.823, val_loss=0.393, val_accuracy=0.865]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 5/5 [00:02<00:00, 2.37epoch/s, loss=0.463, accuracy=0.773, val_loss=0.442, val_accuracy=0.781]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 28/28 [00:03<00:00, 13.32epoch/s, loss=0.46, accuracy=0.823, val_loss=0.404, val_accuracy=0.823]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 11/11 [00:02<00:00, 8.05epoch/s, loss=0.405, accuracy=0.846, val_loss=0.422, val_accuracy=0.844]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 10/10 [00:02<00:00, 9.43epoch/s, loss=0.335, accuracy=0.839, val_loss=0.562, val_accuracy=0.792]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 60/60 [00:04<00:00, 18.18epoch/s, loss=0.381, accuracy=0.875, val_loss=0.405, val_accuracy=0.823]

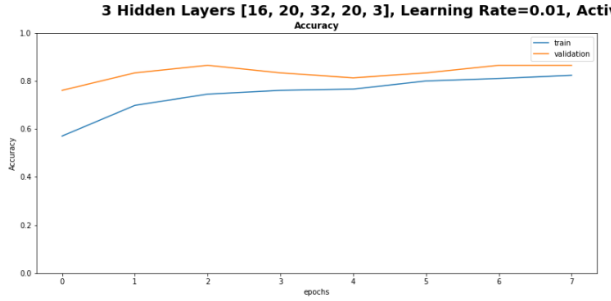
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 100/100 [00:05<00:00, 20.52epoch/s, loss=0.512, accuracy=0.799, val_loss=0.416, val_accuracy=0.844]

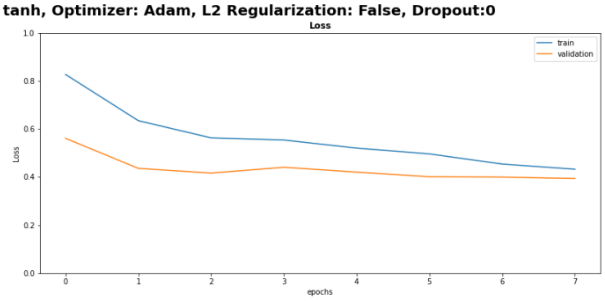
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 100/100 [00:05<00:00, 20.77epoch/s, loss=0.468, accuracy=0.805, val_loss=0.424, val_accuracy=0.812]

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 3/3 [00:00<00:00, 1.93epoch/s, loss=1.1, accuracy=0.435, val_loss=1.11, val_accuracy=0.458]

- نمودار تغییر Loss مجموعه آموزش
- نمودار تغییر Loss مجموعه ارزیابی
- نمودار تغییر Accuracy مجموعه آموزش
- نمودار تغییر Accuracy مجموعه ارزیابی

3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0





	precision	recall	f1-score	support
0	0.905	0.792	0.844	24
1	0.923	0.857	0.889	28
2	0.816	0.909	0.860	44
accuracy			0.865	96
macro avg	0.881	0.853	0.865	96
weighted avg	0.870	0.865	0.865	96

- **چهار لایه میانی:**

Four hidden layer models:

alpha = 0.01

Model Parameters	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Adam-tanh	(epoch index:6) Accuracy: 0.8125 Loss: 0.45681023597717285	(epoch index:6) Accuracy: 0.8020833134651184 Loss: 0.4033297300338745	(epoch index:6) Accuracy: 0.8125 Loss: 0.45681023597717285	(epoch index:1) Accuracy: 0.8541666865348816 Loss: 0.42668578028678894
Adam-relu	(epoch index:5) Accuracy: 0.8125 Loss: 0.4379318952560425	(epoch index:5) Accuracy: 0.8229166865348816 Loss: 0.3893572986125946	(epoch index:5) Accuracy: 0.8125 Loss: 0.4379318952560425	(epoch index:2) Accuracy: 0.8229166865348816 Loss: 0.41702958941459656
Adam-sigmoid	(epoch index:44) Accuracy: 0.8671875 Loss: 0.38616347312927246	(epoch index:12) Accuracy: 0.8333333134651184 Loss: 0.4175945818424225	(epoch index:41) Accuracy: 0.8723958134651184 Loss: 0.394702672958374	(epoch index:17) Accuracy: 0.84375 Loss: 0.4179975092411041
RMSprop-tanh	(epoch index:10) Accuracy: 0.8229166865348816 Loss: 0.43792375922203064	(epoch index:6) Accuracy: 0.7916666865348816 Loss: 0.4314236342906952	(epoch index:10) Accuracy: 0.8229166865348816 Loss: 0.43792375922203064	(epoch index:7) Accuracy: 0.8333333134651184 Loss: 0.4317041337490082
RMSprop-relu	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.42775723338127136	(epoch index:7) Accuracy: 0.8125 Loss: 0.4161432683467865	(epoch index:7) Accuracy: 0.8229166865348816 Loss: 0.42775723338127136	(epoch index:2) Accuracy: 0.8125 Loss: 0.4494068920612335
RMSprop-sigmoid	(epoch index:69) Accuracy: 0.8802083134651184 Loss: 0.3525955379009247	(epoch index:59) Accuracy: 0.8541666865348816 Loss: 0.3597206771373749	(epoch index:65) Accuracy: 0.8854166865348816 Loss: 0.36473289132118225	(epoch index:68) Accuracy: 0.875 Loss: 0.39910945296287537
SGD-tanh	(epoch index:114) Accuracy: 0.7916666865348816 Loss: 0.4814335107803345	(epoch index:113) Accuracy: 0.8229166865348816 Loss: 0.4129005968570709	(epoch index:93) Accuracy: 0.7942708134651184 Loss: 0.5015235543251038	(epoch index:61) Accuracy: 0.8541666865348816 Loss: 0.42910143733024597
SGD-relu	(epoch index:139) Accuracy: 0.8098958134651184 Loss: 0.44104132056236267	(epoch index:138) Accuracy: 0.78125 Loss: 0.4282194674015045	(epoch index:138) Accuracy: 0.8098958134651184 Loss: 0.4416213929653168	(epoch index:65) Accuracy: 0.8125 Loss: 0.48568376898765564
SGD-sigmoid	(epoch index:8) Accuracy: 0.4348958432674408 Loss: 1.0752904415130615	(epoch index:9) Accuracy: 0.4583333432674408 Loss: 1.0744620561599731	(epoch index:1) Accuracy: 0.4348958432674408 Loss: 1.113796591758728	(epoch index:0) Accuracy: 0.4583333432674408 Loss: 1.1555230617523193

- **شکل خروجی کد مجموعه آموزش**
- **شکل خروجی کد مجموعه ارزیابی**

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 7/7 [00:01<00:00, 9.86epoch/s, loss=0.457, accuracy=0.812, val_loss=0.403, val_accuracy=0.802]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: relu, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 6/6 [00:00<00:00, 7.26epoch/s, loss=0.438, accuracy=0.812, val_loss=0.389, val_accuracy=0.823]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 45/45 [00:03<00:00, 16.23epoch/s, loss=0.386, accuracy=0.867, val_loss=0.487, val_accuracy=0.802]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: tanh, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 11/11 [00:01<00:00, 10.92epoch/s, loss=0.438, accuracy=0.823, val_loss=0.449, val_accuracy=0.833]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: relu, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 8/8 [00:01<00:00, 8.67epoch/s, loss=0.428, accuracy=0.823, val_loss=0.416, val_accuracy=0.812]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 70/70 [00:04<00:00, 16.75epoch/s, loss=0.353, accuracy=0.88, val_loss=0.409, val_accuracy=0.844]

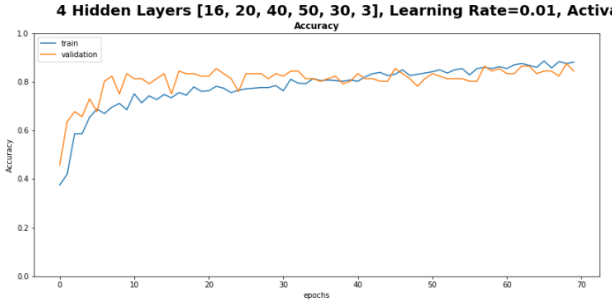
4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 115/115 [00:06<00:00, 18.88epoch/s, loss=0.481, accuracy=0.792, val_loss=0.413, val_accuracy=0.823]

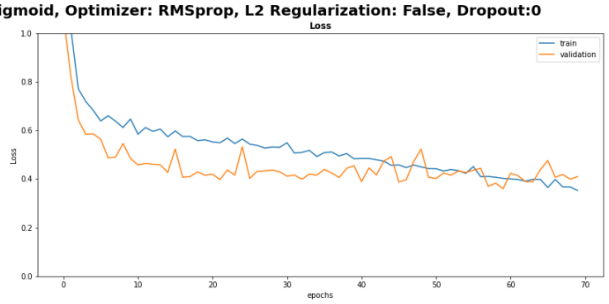
4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: relu, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 140/140 [00:07<00:00, 20.23epoch/s, loss=0.441, accuracy=0.81, val_loss=0.432, val_accuracy=0.781]

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 10/10 [00:01<00:00, 11.79epoch/s, loss=1.08, accuracy=0.435, val_loss=1.07, val_accuracy=0.458]

- نمودار تغییر Loss مجموعه آموزش
- نمودار تغییر Loss مجموعه ارزیابی
- نمودار تغییر Accuracy مجموعه آموزش
- نمودار تغییر Accuracy مجموعه ارزیابی

4 Hidden Layers [16, 20, 40, 50, 30, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: RMSprop, L2 Regularization: False, Dropout:0





	precision	recall	f1-score	support
0	0.864	0.792	0.826	24
1	0.920	0.821	0.868	28
2	0.796	0.886	0.839	44
accuracy			0.844	96
macro avg	0.860	0.833	0.844	96
weighted avg	0.849	0.844	0.844	96

- **پنج لایه میانی:**

Five hidden layer models:

alpha = 0.01

Model Parameters	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Adam-tanh	(epoch index:19) Accuracy: 0.9140625 Loss: 0.22287213802337646	(epoch index:8) Accuracy: 0.8333333134651184 Loss: 0.3885890245437622	(epoch index:19) Accuracy: 0.9140625 Loss: 0.22287213802337646	(epoch index:2) Accuracy: 0.84375 Loss: 0.41658636927604675
Adam-relu	(epoch index:9) Accuracy: 0.8776041865348816 Loss: 0.3136431872844696	(epoch index:3) Accuracy: 0.8541666865348816 Loss: 0.4337378442287445	(epoch index:9) Accuracy: 0.8776041865348816 Loss: 0.3136431872844696	(epoch index:3) Accuracy: 0.8541666865348816 Loss: 0.4337378442287445
Adam-sigmoid	(epoch index:38) Accuracy: 0.8645833134651184 Loss: 0.4304123818874359	(epoch index:26) Accuracy: 0.84375 Loss: 0.41376063227653503	(epoch index:38) Accuracy: 0.8645833134651184 Loss: 0.4304123818874359	(epoch index:24) Accuracy: 0.8645833134651184 Loss: 0.4184329509735107 4
RMSprop-tanh	(epoch index:14) Accuracy: 0.875 Loss: 0.3553644120693207	(epoch index:16) Accuracy: 0.84375 Loss: 0.34553971886634827	(epoch index:14) Accuracy: 0.875 Loss: 0.3553644120693207	(epoch index:13) Accuracy: 0.8541666865348816 Loss: 0.41531261801719666
RMSprop-relu	(epoch index:8) Accuracy: 0.8229166865348816 Loss: 0.41106748580932617	(epoch index:4) Accuracy: 0.78125 Loss: 0.43104514479637146	(epoch index:8) Accuracy: 0.8229166865348816 Loss: 0.41106748580932617	(epoch index:3) Accuracy: 0.875 Loss: 0.4551360607147217
RMSprop-sigmoid	(epoch index:39) Accuracy: 0.7890625 Loss: 0.5067046880722046	(epoch index:32) Accuracy: 0.8541666865348816 Loss: 0.3992272913455963	(epoch index:32) Accuracy: 0.7942708134651184 Loss: 0.5239887833595276	(epoch index:28) Accuracy: 0.8541666865348816 Loss: 0.40878984332084656
SGD-tanh	(epoch index:184) Accuracy: 0.859375 Loss: 0.4015038013458252	(epoch index:181) Accuracy: 0.84375 Loss: 0.40019115805625916	(epoch index:184) Accuracy: 0.859375 Loss: 0.4015038013458252	(epoch index:184) Accuracy: 0.8541666865348816 Loss: 0.4008321762084961
SGD-relu	(epoch index:89) Accuracy: 0.7890625 Loss: 0.46242478489875793	(epoch index:84) Accuracy: 0.78125 Loss: 0.45406821370124817	(epoch index:83) Accuracy: 0.7916666865348816 Loss: 0.4771382510662079	(epoch index:59) Accuracy: 0.8333333134651184 Loss: 0.47839829325675964
SGD-sigmoid	(epoch index:9) Accuracy: 0.4348958432674408 Loss: 1.0763846635818481	(epoch index:6) Accuracy: 0.4583333432674408 Loss: 1.0647714138031006	(epoch index:3) Accuracy: 0.4348958432674408 Loss: 1.1097699403762817	(epoch index:2) Accuracy: 0.4583333432674408 Loss: 1.082880973815918

- **شکل خروجی کد مجموعه آموزش**

- **شکل خروجی کد مجموعه ارزیابی**

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 20/20 [00:01<00:00, 16.54epoch/s, loss=0.223, accuracy=0.914, val_loss=0.417, val_accuracy=0.844]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 10/10 [00:01<00:00, 11.69epoch/s, loss=0.314, accuracy=0.878, val_loss=0.521, val_accuracy=0.781]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 39/39 [00:03<00:00, 16.45epoch/s, loss=0.43, accuracy=0.865, val_loss=0.461, val_accuracy=0.812]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 17/17 [00:02<00:00, 14.12epoch/s, loss=0.369, accuracy=0.854, val_loss=0.346, val_accuracy=0.844]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 9/9 [00:01<00:00, 9.61epoch/s, loss=0.411, accuracy=0.823, val_loss=0.512, val_accuracy=0.792]

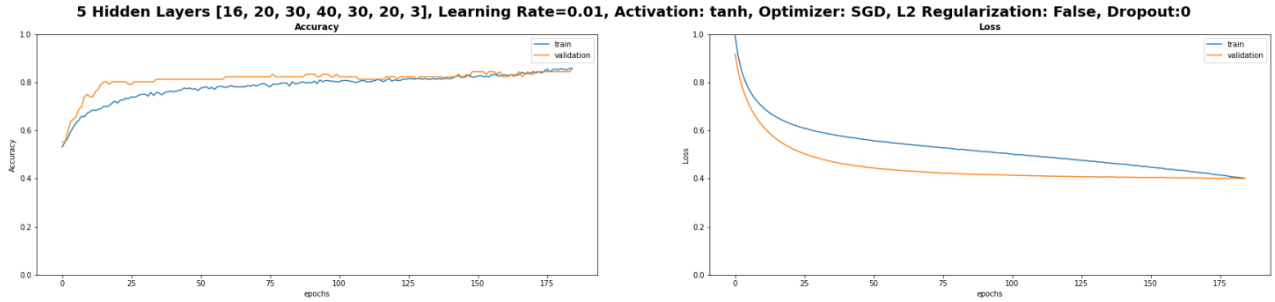
5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: RMSprop, L2 Regularization: False, Dropout:0
100% 40/40 [00:03<00:00, 17.50epoch/s, loss=0.507, accuracy=0.789, val_loss=0.458, val_accuracy=0.792]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 185/185 [00:09<00:00, 19.93epoch/s, loss=0.402, accuracy=0.859, val_loss=0.401, val_accuracy=0.854]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: relu, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 90/90 [00:05<00:00, 19.33epoch/s, loss=0.462, accuracy=0.789, val_loss=0.458, val_accuracy=0.802]

5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.01, Activation: sigmoid, Optimizer: SGD, L2 Regularization: False, Dropout:0
100% 10/10 [00:01<00:00, 12.29epoch/s, loss=1.08, accuracy=0.435, val_loss=1.07, val_accuracy=0.458]

- نمودار تغییر Loss مجموعه آموزش
- نمودار تغییر Loss مجموعه ارزیابی
- نمودار تغییر Accuracy مجموعه آموزش
- نمودار تغییر Accuracy مجموعه ارزیابی



	precision	recall	f1-score	support
0	0.875	0.875	0.875	24
1	0.833	0.893	0.862	28
2	0.857	0.818	0.837	44
accuracy			0.854	96
macro avg	0.855	0.862	0.858	96
weighted avg	0.855	0.854	0.854	96

- **بررسی بیش برازش**

مسلماً در طول آموزش مدل‌ها این اتفاق رخ داد که با استفاده از Early stopping و دادن مقادیر متفاوت به ایپاک مدل‌ها اثر این اتفاق کم شد.

- **Confusion Matrix برای بهترین مدل (بر اساس بیشترین Accuracy)**

بیشترین accuracy برای مدل سه لایه میانی با تابع تانژانت هایپربولیک و Adam optimizer بود.

```
[[19  0  5]
 [ 0 24  4]
 [ 2  2 40]]
```

	precision	recall	f1-score	support
0	0.905	0.792	0.844	24
1	0.923	0.857	0.889	28
2	0.816	0.909	0.860	44
accuracy			0.865	96
macro avg	0.881	0.853	0.865	96
weighted avg	0.870	0.865	0.865	96

- **نتایج بهبود مدل و استفاده از تکنیک‌های مهندسی ویژگی (نمره مثبت)**

- **توضیحات تکمیلی**

- **در نظر گرفتن Dropout در مدل**
  - **نتایج مدل و معیارهای ارزیابی**

Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Three layers: alpha 0.0169, dropout 0.1	(epoch index:13) Accuracy: 0.8333333134651184 Loss: 0.420125812292099	(epoch index:13) Accuracy: 0.8333333134651184 Loss: 0.3816981613636017	(epoch index:13) Accuracy: 0.8333333134651184 Loss: 0.420125812292099	(epoch index:11) Accuracy: 0.8541666865348816 Loss: 0.4544197618961334
Four layers: alpha 0.0169, dropout 0.1	(epoch index:17) Accuracy: 0.7682291865348816 Loss: 0.5570536255836487	(epoch index:21) Accuracy: 0.84375 Loss: 0.41827836632728577	(epoch index:21) Accuracy: 0.7734375 Loss: 0.5742616057395935	(epoch index:10) Accuracy: 0.8541666865348816 Loss: 0.4485086500644684
Five layers: alpha 0.0169, dropout 0.1	(epoch index:252) Accuracy: 0.8255208134651184 Loss: 0.4380817413330078	(epoch index:247) Accuracy: 0.8854166865348816 Loss: 0.3578874170780182	(epoch index:235) Accuracy: 0.8463541865348816 Loss: 0.45545831322669983	(epoch index:266) Accuracy: 0.90625 Loss: 0.3594994246959686 3
Three layers: alpha 0.0169, dropout 0.2	(epoch index:12) Accuracy: 0.765625 Loss: 0.5334399342536926	(epoch index:12) Accuracy: 0.84375 Loss: 0.40910783410072327	(epoch index:12) Accuracy: 0.765625 Loss: 0.5334399342536926	(epoch index:12) Accuracy: 0.84375 Loss: 0.40910783410072327
Four layers: alpha 0.0169, dropout 0.2	(epoch index:31) Accuracy: 0.8020833134651184 Loss: 0.5141585469245911	(epoch index:32) Accuracy: 0.8229166865348816 Loss: 0.4041384756565094	(epoch index:31) Accuracy: 0.8020833134651184 Loss: 0.5141585469245911	(epoch index:17) Accuracy: 0.8541666865348816 Loss: 0.4354982078075409
Five layers: alpha 0.0169, dropout 0.2	(epoch index:94) Accuracy: 0.7213541865348816 Loss: 0.583505392074585	(epoch index:99) Accuracy: 0.8125 Loss: 0.4220016300678253	(epoch index:83) Accuracy: 0.7395833134651184 Loss: 0.6178932189941406	(epoch index:60) Accuracy: 0.8229166865348816 Loss: 0.445264607667923
Three layers: alpha 0.0169, dropout 0.3	(epoch index:20) Accuracy: 0.7682291865348816 Loss: 0.5028338432312012	(epoch index:33) Accuracy: 0.8958333134651184 Loss: 0.3777802884578705	(epoch index:22) Accuracy: 0.8046875 Loss: 0.5036677718162537	(epoch index:33) Accuracy: 0.8958333134651184 Loss: 0.3777802884578705
Four layers: alpha 0.0169, dropout 0.3	(epoch index:31) Accuracy: 0.7682291865348816 Loss: 0.5643802285194397	(epoch index:34) Accuracy: 0.8125 Loss: 0.4190608561038971	(epoch index:32) Accuracy: 0.7916666865348816 Loss: 0.5711579918861389	(epoch index:35) Accuracy: 0.875 Loss: 0.4399462938308716
Five layers: alpha 0.0169, dropout 0.3	(epoch index:183) Accuracy: 0.7213541865348816 Loss: 0.5798746943473816	(epoch index:201) Accuracy: 0.8229166865348816 Loss: 0.42554140090942383	(epoch index:191) Accuracy: 0.7421875 Loss: 0.5861461162567139	(epoch index:203) Accuracy: 0.8333333134651184 Loss: 0.4270721971988678
Three layers: alpha 0.0169, dropout 0.5	(epoch index:17) Accuracy: 0.7161458134651184 Loss: 0.6259340643882751	(epoch index:22) Accuracy: 0.8333333134651184 Loss: 0.44838014245033264	(epoch index:22) Accuracy: 0.7239583134651184 Loss: 0.6482087969779968	(epoch index:23) Accuracy: 0.84375 Loss: 0.45006147027015686
Four layers: alpha 0.0169, dropout 0.5	(epoch index:78) Accuracy: 0.7526041865348816 Loss: 0.5661548972129822	(epoch index:79) Accuracy: 0.84375 Loss: 0.4241904020309448	(epoch index:73) Accuracy: 0.7760416865348816 Loss: 0.6106815338134766	(epoch index:80) Accuracy: 0.875 Loss: 0.44575539231300354
Five layers: alpha 0.0169, dropout 0.5	(epoch index:25) Accuracy: 0.5703125 Loss: 0.8283517360687256	(epoch index:29) Accuracy: 0.6770833134651184 Loss: 0.6268720626831055	(epoch index:25) Accuracy: 0.5703125 Loss: 0.8283517360687256	(epoch index:30) Accuracy: 0.6875 Loss: 0.6283847093582153
Three layers: alpha 0.0103, dropout 0.1	(epoch index:21) Accuracy: 0.8255208134651184 Loss: 0.41781875491142273	(epoch index:21) Accuracy: 0.8229166865348816 Loss: 0.3847269117832184	(epoch index:20) Accuracy: 0.8333333134651184 Loss: 0.421610563993454	(epoch index:6) Accuracy: 0.8645833134651184 Loss: 0.41347649693489075
Four layers: alpha 0.0103, dropout 0.1	(epoch index:31) Accuracy: 0.8020833134651184 Loss: 0.5247654318809509	(epoch index:32) Accuracy: 0.8541666865348816 Loss: 0.4074768126010895	(epoch index:31) Accuracy: 0.8020833134651184 Loss: 0.5247654318809509	(epoch index:32) Accuracy: 0.8541666865348816 Loss: 0.4074768126010895
Five layers: alpha 0.0103, dropout 0.1	(epoch index:348) Accuracy: 0.8177083134651184 Loss: 0.4310339391231537	(epoch index:373) Accuracy: 0.875 Loss: 0.36084166169166565	(epoch index:332) Accuracy: 0.8255208134651184 Loss: 0.44219768047332764	(epoch index:333) Accuracy: 0.8958333134651184 Loss: 0.3699204623699188
Three layers: alpha 0.0103, dropout 0.2	(epoch index:6) Accuracy: 0.71875 Loss: 0.6116942167282104	(epoch index:6) Accuracy: 0.84375 Loss: 0.40946444869041443	(epoch index:6) Accuracy: 0.71875 Loss: 0.6116942167282104	(epoch index:6) Accuracy: 0.84375 Loss: 0.40946444869041443
Four layers: alpha 0.0103, dropout 0.2	(epoch index:31) Accuracy: 0.765625 Loss: 0.5328630208969116	(epoch index:32) Accuracy: 0.84375 Loss: 0.4140157699584961	(epoch index:40) Accuracy: 0.7916666865348816 Loss: 0.5558726787567139	(epoch index:40) Accuracy: 0.8645833134651184 Loss: 0.42493733763694763
Five layers: alpha 0.0103, dropout 0.2	(epoch index:365) Accuracy: 0.7890625 Loss: 0.4965827167034149	(epoch index:380) Accuracy: 0.84375 Loss: 0.38939762115478516	(epoch index:337) Accuracy: 0.796875 Loss: 0.5476391315460205	(epoch index:240) Accuracy: 0.8541666865348816 Loss: 0.4087900221347809
Three layers: alpha 0.0103, dropout 0.3	(epoch index:56) Accuracy: 0.8125 Loss: 0.44069981575012207	(epoch index:55) Accuracy: 0.8541666865348816 Loss: 0.4018454849720001	(epoch index:55) Accuracy: 0.8255208134651184 Loss: 0.4500463008880615	(epoch index:56) Accuracy: 0.8645833134651184 Loss: 0.4140358865261078
Four layers: alpha 0.0103, dropout 0.3	(epoch index:45) Accuracy: 0.7578125 Loss: 0.5734787583351135	(epoch index:32) Accuracy: 0.8541666865348816 Loss: 0.4099823236465454	(epoch index:32) Accuracy: 0.7838541865348816 Loss: 0.5900497436523438	(epoch index:45) Accuracy: 0.875 Loss: 0.41735371947288513
Five layers: alpha 0.0103, dropout 0.3	(epoch index:365) Accuracy: 0.7369791865348816 Loss: 0.5521326661109924	(epoch index:379) Accuracy: 0.8229166865348816 Loss: 0.4210129678249359	(epoch index:368) Accuracy: 0.7552083134651184 Loss: 0.5851386189460754	(epoch index:352) Accuracy: 0.8333333134651184 Loss: 0.42800453305244446
Three layers: alpha 0.0103, dropout 0.5	(epoch index:13) Accuracy: 0.6979166865348816 Loss: 0.6379187703132629	(epoch index:20) Accuracy: 0.8333333134651184 Loss: 0.4629718363250647	(epoch index:11) Accuracy: 0.7057291865348816 Loss: 0.6396759152412415	(epoch index:20) Accuracy: 0.8333333134651184 Loss: 0.4629718363250647
Four layers: alpha 0.0103, dropout 0.5	(epoch index:78) Accuracy: 0.734375 Loss: 0.5919035077095032	(epoch index:75) Accuracy: 0.84375 Loss: 0.42436257004737854	(epoch index:83) Accuracy: 0.7604166865348816 Loss: 0.6019454598426819	(epoch index:86) Accuracy: 0.875 Loss: 0.4249441921710968
Five layers: alpha 0.0103, dropout 0.5	(epoch index:80) Accuracy: 0.5807291865348816 Loss: 0.7848655581474304	(epoch index:80) Accuracy: 0.6666666865348816 Loss: 0.6170304417610168	(epoch index:67) Accuracy: 0.5989583134651184 Loss: 0.814075767993927	(epoch index:37) Accuracy: 0.6770833134651184 Loss: 0.6320752501487732

Three layers: alpha 0.0018, dropout 0.1	(epoch index:43) Accuracy: 0.8020833134651184 Loss: 0.47139692306518555	(epoch index:43) Accuracy: 0.8645833134651184 Loss: 0.3626522123813629	(epoch index:41) Accuracy: 0.8072916865348816 Loss: 0.4863779544830322	(epoch index:44) Accuracy: 0.8854166865348816 Loss: 0.3670882284641266
Four layers: alpha 0.0018, dropout 0.1	(epoch index:152) Accuracy: 0.7942708134651184 Loss: 0.51975017786026	(epoch index:159) Accuracy: 0.84375 Loss: 0.4069208800792694	(epoch index:152) Accuracy: 0.7942708134651184 Loss: 0.51975017786026	(epoch index:132) Accuracy: 0.8541666865348816 Loss: 0.4073883593082428
Five layers: alpha 0.0018, dropout 0.1	(epoch index:498) Accuracy: 0.7578125 Loss: 0.559631884098053	(epoch index:498) Accuracy: 0.8125 Loss: 0.4268569052219391	(epoch index:264) Accuracy: 0.78125 Loss: 0.598053514957428	(epoch index:377) Accuracy: 0.8229166865348816 Loss: 0.439731627702713
Three layers: alpha 0.0018, dropout 0.2	(epoch index:37) Accuracy: 0.75 Loss: 0.5547534823417664	(epoch index:37) Accuracy: 0.8645833134651184 Loss: 0.385385662317276	(epoch index:32) Accuracy: 0.7630208134651184 Loss: 0.5618888735771179	(epoch index:37) Accuracy: 0.8645833134651184 Loss: 0.385385662317276
Four layers: alpha 0.0018, dropout 0.2	(epoch index:172) Accuracy: 0.7890625 Loss: 0.5229970812797546	(epoch index:181) Accuracy: 0.8541666865348816 Loss: 0.4133542478084564	(epoch index:172) Accuracy: 0.7890625 Loss: 0.5229970812797546	(epoch index:181) Accuracy: 0.8541666865348816 Loss: 0.4133542478084564
Five layers: alpha 0.0018, dropout 0.2	(epoch index:704) Accuracy: 0.7317708134651184 Loss: 0.5821962356567383	(epoch index:793) Accuracy: 0.8020833134651184 Loss: 0.4301133155822754	(epoch index:734) Accuracy: 0.7682291865348816 Loss: 0.5835935473442078	(epoch index:446) Accuracy: 0.8125 Loss: 0.4585812985897064
Three layers: alpha 0.0018, dropout 0.3	(epoch index:91) Accuracy: 0.7734375 Loss: 0.5099763870239258	(epoch index:96) Accuracy: 0.8333333134651184 Loss: 0.38319745659828186	(epoch index:90) Accuracy: 0.7864583134651184 Loss: 0.5389977693557739	(epoch index:38) Accuracy: 0.8541666865348816 Loss: 0.4097571074962616
Four layers: alpha 0.0018, dropout 0.3	(epoch index:142) Accuracy: 0.75 Loss: 0.5906849503517151	(epoch index:147) Accuracy: 0.8541666865348816 Loss: 0.4344615936279297	(epoch index:142) Accuracy: 0.75 Loss: 0.5906849503517151	(epoch index:147) Accuracy: 0.8541666865348816 Loss: 0.4344615936279297
Five layers: alpha 0.0018, dropout 0.3	(epoch index:556) Accuracy: 0.6901041865348816 Loss: 0.6474456787109375	(epoch index:597) Accuracy: 0.78125 Loss: 0.49209436774253845	(epoch index:366) Accuracy: 0.71875 Loss: 0.6858020424842834	(epoch index:159) Accuracy: 0.8125 Loss: 0.5547900199890137
Three layers: alpha 0.0018, dropout 0.5	(epoch index:82) Accuracy: 0.7161458134651184 Loss: 0.6111571192741394	(epoch index:92) Accuracy: 0.8541666865348816 Loss: 0.4348630905151367	(epoch index:88) Accuracy: 0.7317708134651184 Loss: 0.6134292483329773	(epoch index:92) Accuracy: 0.8541666865348816 Loss: 0.4348630905151367
Four layers: alpha 0.0018, dropout 0.5	(epoch index:369) Accuracy: 0.734375 Loss: 0.5677343010902405	(epoch index:383) Accuracy: 0.8541666865348816 Loss: 0.42604413628578186	(epoch index:383) Accuracy: 0.7760416865348816 Loss: 0.5791347622871399	(epoch index:259) Accuracy: 0.8541666865348816 Loss: 0.47786733508110046
Five layers: alpha 0.0018, dropout 0.5	(epoch index:234) Accuracy: 0.5677083134651184 Loss: 0.845349133014679	(epoch index:220) Accuracy: 0.65625 Loss: 0.627691924571991	(epoch index:215) Accuracy: 0.5963541865348816 Loss: 0.8831007480621338	(epoch index:237) Accuracy: 0.6875 Loss: 0.6281628012657166

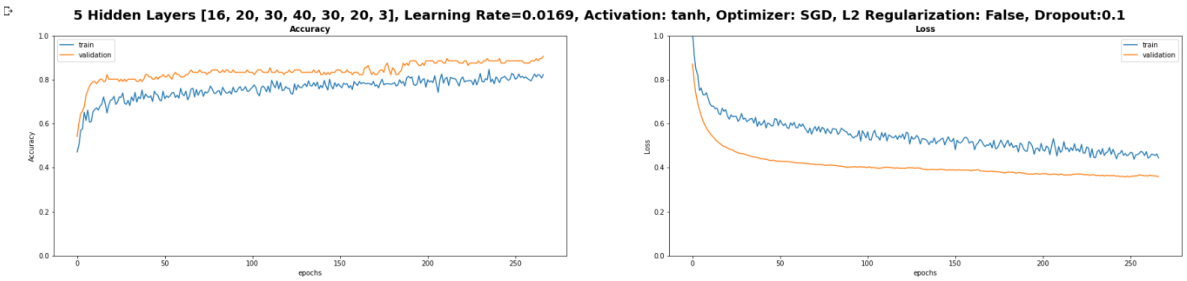
- **سایر معیارهای ارزیابی:**

در این مدل با در نظر گرفتن و ترکیب موارد زیر خروجی‌های زیر حاصل شد:

- مدل سه لایه، چهار لایه و پنج لایه‌ی برتر از قسمت قبل
- `learning rates = [0.0169 0.0103 0.0018]`
- `drop out rates = [0.1, 0.2, 0.3, 0.5]`
- **شکل خروجی کد مجموعه آموزش**
- **شکل خروجی کد مجموعه ارزیابی**

```
5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.0169, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0.1
100% 267/267 [00:18<00:00, 19.58epoch/s, loss=0.444, accuracy=0.823, val_loss=0.359, val_accuracy=0.906]
```

- **نمودار تغییر Loss مجموعه آموزش**
- **نمودار تغییر Loss مجموعه ارزیابی**
- **نمودار تغییر Accuracy مجموعه آموزش**
- **نمودار تغییر Accuracy مجموعه ارزیابی**



	precision	recall	f1-score	support
0	0.913	0.875	0.894	24
1	0.962	0.893	0.926	28
2	0.872	0.932	0.901	44
accuracy			0.906	96
macro avg	0.916	0.900	0.907	96
weighted avg	0.909	0.906	0.906	96

- **بررسی بیش برازش**

- مسلماً در طول آموزش مدل‌ها این اتفاق رخ داد که با استفاده از Early stopping و دادن مقادیر متفاوت به ایپاک مدل‌ها اثر این اتفاق کم شد.

- **Confusion Matrix برای بهترین مدل (بر اساس بیشترین Accuracy)**
- مدل ۵ لایه با SGD optimizer و lr=0.0169 و dropout=0.1 در ۲۶۷ امین epoch

```
[[21  0  3]
 [ 0 25  3]
 [ 2  1 41]]
```

	precision	recall	f1-score	support
0	0.913	0.875	0.894	24
1	0.962	0.893	0.926	28
2	0.872	0.932	0.901	44
accuracy			0.906	96
macro avg	0.916	0.900	0.907	96
weighted avg	0.909	0.906	0.906	96

- **نتایج بهبود مدل و استفاده از تکنیک‌های مهندسی ویژگی (نمره مثبت)**

- **توضیحات تکمیلی**

- **در نظر گرفتن Batch Normalization در مدل**
  - **نتایج مدل و معیارهای ارزیابی**

Five layers, SGD, tanh, learningrate: 0.0169, dropout 0.1,:

alpha = 0.01

Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Three layers Adam	(epoch index:14) Accuracy: 0.8932291865348816 Loss: 0.2499765157699585	(epoch index:15) Accuracy: 0.8854166865348816 Loss: 0.3072158992290497	(epoch index:12) Accuracy: 0.9010416865348816 Loss: 0.2512845993041992	(epoch index:15) Accuracy: 0.8854166865348816 Loss: 0.3072158992290497
Four layers RMSprop	(epoch index:38) Accuracy: 0.9270833134651184 Loss: 0.1975012868642807	(epoch index:41) Accuracy: 0.8229166865348816 Loss: 0.38207435607910156	(epoch index:38) Accuracy: 0.9270833134651184 Loss: 0.1975012868642807	(epoch index:33) Accuracy: 0.8229166865348816 Loss: 0.40843260288238525
Five layers SGD	(epoch index:54) Accuracy: 0.8802083134651184 Loss: 0.32962295413017273	(epoch index:54) Accuracy: 0.8229166865348816 Loss: 0.46209916472435	(epoch index:50) Accuracy: 0.8984375 Loss: 0.3313029110431671	(epoch index:47) Accuracy: 0.84375 Loss: 0.47550585865974426

  - **سایر معیارهای ارزیابی:**

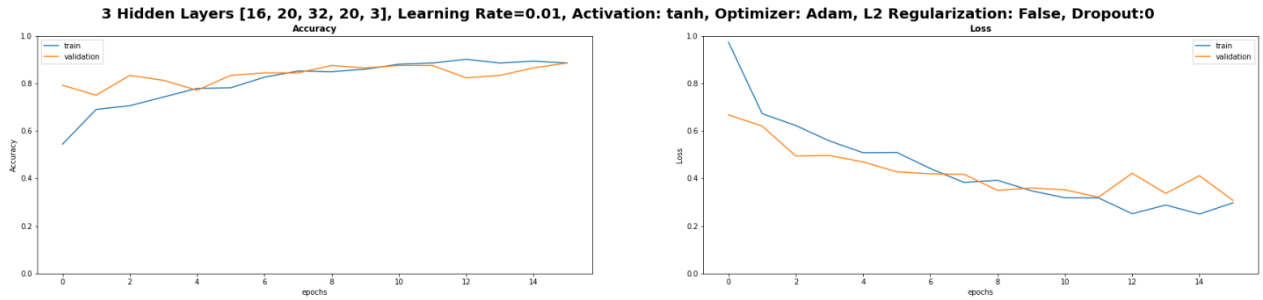
    ترکیب مدل‌های برتر بدست آمده از قسمت اول

  - **شکل خروجی کد مجموعه آموزش**

  - **شکل خروجی کد مجموعه ارزیابی**

```
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 16/16 [00:03<00:00, 12.05epoch/s, loss=0.297, accuracy=0.885, val_loss=0.307, val_accuracy=0.885]
```

- نمودار تغییر Loss مجموعه آموزش
- نمودار تغییر Loss مجموعه ارزیابی
- نمودار تغییر Accuracy مجموعه آموزش
- نمودار تغییر Accuracy مجموعه ارزیابی



	precision	recall	f1-score	support
0	0.840	0.875	0.857	24
1	0.900	0.964	0.931	28
2	0.902	0.841	0.871	44
accuracy			0.885	96
macro avg	0.881	0.893	0.886	96
weighted avg	0.886	0.885	0.885	96

- بررسی بیش برازش

- مسلماً در طول آموزش مدل‌ها این اتفاق رخ داد که با استفاده از Early stopping و دادن مقادیر متفاوت به اپیاک مدل‌ها اثر این اتفاق کم شد.

- Confusion Matrix برای بهترین مدل (بر اساس بیشترین Accuracy)

```
[[21  0  3]
 [ 0 27  1]
 [ 4  3 37]]
```

	precision	recall	f1-score	support
0	0.840	0.875	0.857	24
1	0.900	0.964	0.931	28
2	0.902	0.841	0.871	44
accuracy			0.885	96
macro avg	0.881	0.893	0.886	96
weighted avg	0.886	0.885	0.885	96

- نتایج بهبود مدل و استفاده از تکنیک‌های مهندسی ویژگی (نمره مثبت)

- توضیحات تکمیلی

- **اعلام سه مدل از بین مدل‌هایی که بیشترین دقت را داشته اند.**

مدل سه لایه با Batch Normalization و مشخصات زیر:

```
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 16/16 [00:03<00:00, 12.05epoch/s, loss=0.297, accuracy=0.885, val_loss=0.307, val_accuracy=0.885]
```

مدل ۵ لایه با Dropout و مشخصات زیر:

```
5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.0169, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0.1
100% 267/267 [00:18<00:00, 19.58epoch/s, loss=0.444, accuracy=0.823, val_loss=0.359, val_accuracy=0.906]
```

مدل سه لایه با مشخصات زیر:

```
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 8/8 [00:01<00:00, 7.54epoch/s, loss=0.432, accuracy=0.823, val_loss=0.393, val_accuracy=0.865]
```

- **نتایج اجرای k fold cross validation با k=5 روی این سه مدل**

مدل سه لایه با Batch Normalization و مشخصات زیر:

```
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 16/16 [00:03<00:00, 12.05epoch/s, loss=0.297, accuracy=0.885, val_loss=0.307, val_accuracy=0.885]
```

K-Fold:

```
First Model

------------------------------------------------------------------------
Training for fold 1 ...
100% 16/16 [00:02<00:00, 13.88epoch/s, loss=0.224, accuracy=0.914, val_loss=0.664, val_accuracy=0.708]
Score for fold 1: loss of 0.6640923619270325; accuracy of 70.83333134651184%
------------------------------------------------------------------------
Training for fold 2 ...
100% 16/16 [00:01<00:00, 16.65epoch/s, loss=0.159, accuracy=0.94, val_loss=0.308, val_accuracy=0.896]
Score for fold 2: loss of 0.30767011642456055; accuracy of 89.58333134651184%
------------------------------------------------------------------------
Training for fold 3 ...
100% 16/16 [00:00<00:00, 18.62epoch/s, loss=0.096, accuracy=0.966, val_loss=0.407, val_accuracy=0.854]
Score for fold 3: loss of 0.4068678319454193; accuracy of 85.41666865348816%
------------------------------------------------------------------------
Training for fold 4 ...
100% 16/16 [00:01<00:00, 16.12epoch/s, loss=0.0448, accuracy=0.987, val_loss=0.287, val_accuracy=0.927]
Score for fold 4: loss of 0.2867339253425598; accuracy of 92.70833134651184%
------------------------------------------------------------------------
Training for fold 5 ...
100% 16/16 [00:01<00:00, 15.14epoch/s, loss=0.128, accuracy=0.953, val_loss=0.315, val_accuracy=0.906]
Score for fold 5: loss of 0.3154960572719574; accuracy of 90.625%
```

- **Confusion Matrix**

```
[[23  0  1]
 [ 0 27  1]
 [ 0  0 44]]
```

	precision	recall	f1-score	support
0	1.000	0.958	0.979	24
1	1.000	0.964	0.982	28
2	0.957	1.000	0.978	44
accuracy			0.979	96
macro avg	0.986	0.974	0.979	96
weighted avg	0.980	0.979	0.979	96

مدل ۵ لایه با Dropout و مشخصات زیر:

```
5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.0169, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0.1
100% 267/267 [00:18<00:00, 19.58epoch/s, loss=0.444, accuracy=0.823, val_loss=0.359, val_accuracy=0.906]
```

K-Fold:

```
Second Model

------------------------------------------------------------------------
Training for fold 1 ...
100% 267/267 [00:14<00:00, 18.91epoch/s, loss=0.17, accuracy=0.956, val_loss=0.67, val_accuracy=0.781]
Score for fold 1: loss of 0.6701204180717468; accuracy of 78.125%
------------------------------------------------------------------------
Training for fold 2 ...
100% 267/267 [00:14<00:00, 18.96epoch/s, loss=0.0479, accuracy=0.979, val_loss=0.48, val_accuracy=0.823]
Score for fold 2: loss of 0.4798267185688019; accuracy of 82.29166865348816%
------------------------------------------------------------------------
Training for fold 3 ...
100% 267/267 [00:25<00:00, 10.37epoch/s, loss=0.0184, accuracy=0.995, val_loss=0.224, val_accuracy=0.917]
Score for fold 3: loss of 0.22383259236812592; accuracy of 91.66666865348816%
------------------------------------------------------------------------
Training for fold 4 ...
100% 267/267 [00:19<00:00, 19.13epoch/s, loss=0.0364, accuracy=0.992, val_loss=0.0703, val_accuracy=0.958]
Score for fold 4: loss of 0.07026200741529465; accuracy of 95.83333134651184%
------------------------------------------------------------------------
Training for fold 5 ...
100% 267/267 [00:13<00:00, 20.22epoch/s, loss=0.00659, accuracy=0.997, val_loss=0.175, val_accuracy=0.948]
Score for fold 5: loss of 0.174820676445961; accuracy of 94.79166865348816%
```

- **Confusion Matrix**

```
[[23  0  1]
 [ 0 28  0]
 [ 0  0 44]]
```

	precision	recall	f1-score	support
0	1.000	0.958	0.979	24
1	1.000	1.000	1.000	28
2	0.978	1.000	0.989	44
accuracy			0.990	96
macro avg	0.993	0.986	0.989	96
weighted avg	0.990	0.990	0.990	96

مدل سه لایه با مشخصات زیر:

```
3 Hidden Layers [16, 20, 32, 20, 3], Learning Rate=0.01, Activation: tanh, Optimizer: Adam, L2 Regularization: False, Dropout:0
100% 8/8 [00:01<00:00, 7.54epoch/s, loss=0.432, accuracy=0.823, val_loss=0.393, val_accuracy=0.865]
```

K-Fold:

```
Third Model

------------------------------------------------------------------------
Training for fold 1 ...
100% 8/8 [00:01<00:00, 10.06epoch/s, loss=0.383, accuracy=0.849, val_loss=0.619, val_accuracy=0.75]
Score for fold 1: loss of 0.6187989115715027; accuracy of 75.0%
------------------------------------------------------------------------
Training for fold 2 ...
100% 8/8 [00:00<00:00, 18.44epoch/s, loss=0.231, accuracy=0.917, val_loss=0.325, val_accuracy=0.865]
Score for fold 2: loss of 0.3250311315059662; accuracy of 86.45833134651184%
------------------------------------------------------------------------
Training for fold 3 ...
100% 8/8 [00:00<00:00, 17.94epoch/s, loss=0.106, accuracy=0.966, val_loss=0.323, val_accuracy=0.875]
Score for fold 3: loss of 0.3226816952228546; accuracy of 87.5%
------------------------------------------------------------------------
Training for fold 4 ...
100% 8/8 [00:00<00:00, 15.88epoch/s, loss=0.0421, accuracy=0.997, val_loss=0.185, val_accuracy=0.896]
Score for fold 4: loss of 0.18530046939849854; accuracy of 89.58333134651184%
------------------------------------------------------------------------
Training for fold 5 ...
100% 8/8 [00:00<00:00, 18.00epoch/s, loss=0.087, accuracy=0.969, val_loss=0.144, val_accuracy=0.948]
Score for fold 5: loss of 0.14407230913639069; accuracy of 94.79166865348816%
```

- **Confusion Matrix**

```
[[24  0  0]
 [ 0 27  1]
 [ 0  0 44]]

              precision    recall  f1-score   support

           0      1.000     1.000     1.000        24
           1      1.000     0.964     0.982        28
           2      0.978     1.000     0.989        44

    accuracy                          0.990        96
   macro avg      0.993     0.988     0.990        96
weighted avg      0.990     0.990     0.990        96
```

- **معیارهای ارزیابی**

Accuracy , loss, macro avg، در ارزیابی این مدل ها استفاده شدند.

- **مقایسه بین مدل‌های مختلف و اعلام بهترین مدل**

بهترین مدل:

```
5 Hidden Layers [16, 20, 30, 40, 30, 20, 3], Learning Rate=0.0169, Activation: tanh, Optimizer: SGD, L2 Regularization: False, Dropout:0.1
100% 267/267 [00:18<00:00, 19.58epoch/s, loss=0.444, accuracy=0.823, val_loss=0.359, val_accuracy=0.906]
```

- مدل ۵ لایه با SGD optimizer و lr=0.0169 و dropout=0.1 در ۲۶۷ امین epoch

```
[[21  0  3]
 [ 0 25  3]
 [ 2  1 41]]

              precision    recall  f1-score   support

           0      0.913     0.875     0.894        24
           1      0.962     0.893     0.926        28
           2      0.872     0.932     0.901        44

    accuracy                          0.906        96
   macro avg      0.916     0.900     0.907        96
weighted avg      0.909     0.906     0.906        96
```

- **توضیحات تکمیلی**
- **نتایج بهبود بهترین مدل (نمره مثبت)**