

گزارش پروژه سوم درس یادگیری عمیق

دکتر سید ابوالقاسم میرروشندل

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لينك پروژه

- بررسی دیتاست (تعداد تصاویر، توزیع داده‌های هر کلاس و سایر تحلیل‌ها)

```
Number of samples in each class: {'Cloudy': 300, 'Rain': 215, 'Shine': 253, 'Sunrise': 357}  
Sum of samples: 1125
```

پس از تقسیم دیتاست به نسبت ۸۰ به ۲۰ برای آموزش و تست، تعداد داده‌های هر کدام به ترتیب به این صورت خواهد بود:

```
Found 899 images belonging to 4 classes.  
Found 226 images belonging to 4 classes.
```

از آنجایی که ارتفاع و عرض عکس‌ها یکی نبودند، برای آنها ارتفاع و عرض را به صورت پیش‌فرض ۱۲۸ در نظر گرفتیم. این انتخاب به دلیل آن بود که اگر سایز عکس‌ها بزرگ‌تر در نظر گرفته می‌شد، آموزش مدل‌ها و ذخیره آن‌ها کند و بعضاً با خطأ مواجه می‌شد، و اگر سایز کوچک‌تر از این عدد باشد، عکس‌ها برای انسان غیرقابل شناسایی می‌شوند و معیار ما که تشخیص انسان است از بین می‌رود.

• یک شبکه عصبی عمیق که از جنس CNN نباشد؛ به عبارتی فقط از لایه‌های

استفاده کنید.

○ نتایج مدل و معیارهای ارزیابی

Simple models:

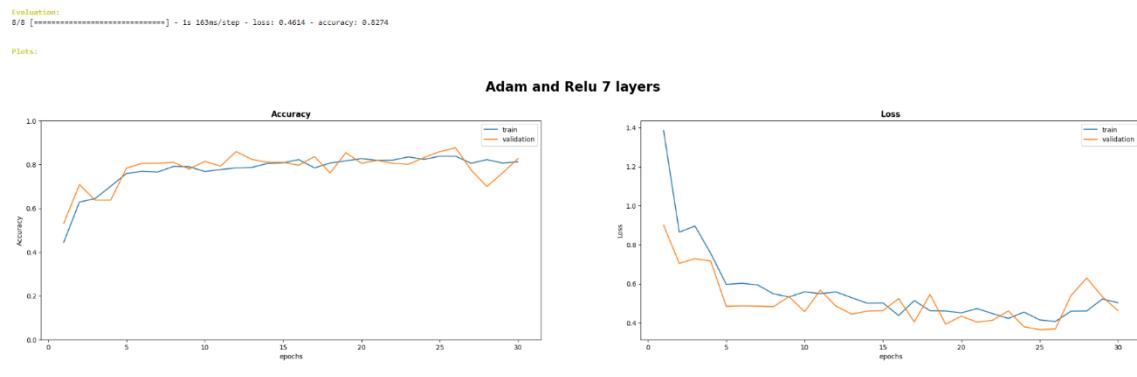
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Adam and relu 7 layers lr=0.0010142202510360857	(epoch index:25) Accuracy: 0.8375973105430603 Loss: 0.4062443971633911	(epoch index:24) Accuracy: 0.8584070801734924 Loss: 0.3640003502368927	(epoch index:24) Accuracy: 0.8375973105430603 Loss: 0.41423556208610535	(epoch index:25) Accuracy: 0.8761062026023865 Loss: 0.36784228682518005
Adam and sigmoid 7 layers lr=0.0010142202510360857	(epoch index:9) Accuracy: 0.6229143738746643 Loss: 0.8540354371070862	(epoch index:9) Accuracy: 0.6725663542747498 Loss: 0.8073405623435974	(epoch index:14) Accuracy: 0.6229143738746643 Loss: 0.8540354371070862	(epoch index:14) Accuracy: 0.6814159154891968 Loss: 0.8269771337509155
Adam and tanh 10 layers lr=0.0011538907663386716	(epoch index:5) Accuracy: 0.507230281829834 Loss: 0.9678592546463013	(epoch index:7) Accuracy: 0.5221238732337952 Loss: 0.8856440782546997	(epoch index:10) Accuracy: 0.5494994521141052 Loss: 1.0296366214752197	(epoch index:3) Accuracy: 0.6106194853782654 Loss: 0.9612170457839966
SGD and relu 10 layers lr=0.0011538907663386716	(epoch index:29) Accuracy: 0.7141268253326416 Loss: 0.8318623168945312	(epoch index:29) Accuracy: 0.7566371560096741 Loss: 0.758199155330658	(epoch index:29) Accuracy: 0.7141268253326416 Loss: 0.8310623168945312	(epoch index:28) Accuracy: 0.7743362784385681 Loss: 0.8097295761108398
SGD and sigmoid 7 layers lr=0.0010142202510360857	(epoch index:13) Accuracy: 0.31701889634132385 Loss: 1.369069218635559	(epoch index:12) Accuracy: 0.3185840845108032 Loss: 1.3682152032852173	(epoch index:0) Accuracy: 0.31701889634132385 Loss: 1.3893215656280518	(epoch index:0) Accuracy: 0.3185840845108032 Loss: 1.3828403949737549
SGD and tanh 7 layers lr=0.0010142202510360857	(epoch index:26) Accuracy: 0.836484968662262 Loss: 0.46706804633140564	(epoch index:29) Accuracy: 0.8451327681541443 Loss: 0.42318111658096313	(epoch index:21) Accuracy: 0.836484968662262 Loss: 0.49771037697792053	(epoch index:11) Accuracy: 0.8451327681541443 Loss: 0.513651251792077
RMSprop and relu 10 layers lr=0.0011538907663386716	(epoch index:28) Accuracy: 0.7808676362037659 Loss: 0.539221465587616	(epoch index:23) Accuracy: 0.8230088353157043 Loss: 0.4378228187561035	(epoch index:26) Accuracy: 0.8042269349098206 Loss: 0.5568275451660156	(epoch index:19) Accuracy: 0.8230088353157043 Loss: 0.46846941113471985
RMSprop and sigmoid 10 layers lr=0.0011538907663386716	(epoch index:19) Accuracy: 0.6117908954620361 Loss: 0.8782548308372498	(epoch index:17) Accuracy: 0.7035398483276367 Loss: 0.758625328540802	(epoch index:19) Accuracy: 0.6117908954620361 Loss: 0.8782548308372498	(epoch index:20) Accuracy: 0.7168141603469849 Loss: 0.7947893142700195
RMSprop and tanh 7 layers lr=0.0010142202510360857	(epoch index:6) Accuracy: 0.5328142642974854 Loss: 0.9602072238922119	(epoch index:5) Accuracy: 0.6283186078071594 Loss: 0.8794980049133301	(epoch index:10) Accuracy: 0.5595105886459351 Loss: 1.0247809886932373	(epoch index:5) Accuracy: 0.6283186078071594 Loss: 0.8794980049133301

همانطور که مشخص است مدل 0.0010142202510360857 lr= Adam Relu با بهترین مدل بدست آمده از فضای سرج بوده است. معماری:

[96, 224, 96, 192, 256, 128, 128]

Best Val Accuracy= 87% and Loss=0.36

○ نمودار تغییر Accuracy و Loss مجموعه آموزش و ارزیابی بهترین مدل



○ بررسی بیش برازش

برای جلوگیری از Overfitting در قسمت Stop Early فیت مدل‌ها از Call Backs استفاده شد.

○ Accuracy برای بهترین مدل (بر اساس پیشترین Confusion Matrix)

	Cloudy	Rain	Shine	Sunrise
Cloudy	34	14	11	1
Rain	6	36	1	0
Shine	2	0	48	1
Sunrise	0	1	2	69

	precision	recall	f1-score	support
0	0.8095	0.5667	0.6667	60
1	0.7059	0.8372	0.7660	43
2	0.7742	0.9412	0.8496	51
3	0.9718	0.9583	0.9650	72
accuracy			0.8274	226
macro avg	0.8154	0.8258	0.8118	226
weighted avg	0.8335	0.8274	0.8219	226

Adam and Relu 7 layers:

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
Adam and Relu 7 layers	(epoch index:25) Accuracy: 0.8375973105430683 Loss: 0.4662443971633911	(epoch index:24) Accuracy: 0.8584078801734924 Loss: 0.364008302368927	(epoch index:24) Accuracy: 0.8375973105430683 Loss: 0.41423556208610535	(epoch index:25) Accuracy: 0.8761062026023865 Loss: 0.36784228682518005

۰ نتایج استفاده از تکنیک‌های داده‌افزایی (نمود مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار Data Augmentation روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

```
# Generate Train and Val
def generate_sets():
    # fixing the seed
    set_random_seed()

    # paths of shuffled and splitted data
    train_path = "/content/splitted_output/train"
    val_path = "/content/splitted_output/val"

    # Train
    train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=True,
        class_mode='categorical')

    # Validation
    validation_generator = val_datagen.flow_from_directory(
        val_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=False,
        class_mode='categorical')

return train_generator, validation_generator
```

توضیحات تکمیلی ○

۹ حالت بالا که ترکیبی از سه اپتیمایزر Adam,Sgd,Rmsprop و توابع فعال‌سازی Relu, Sigmoid, Tanh است توسط فضای سرج Keras_Tuner با متغیرهای لرنینگ ریت و تعداد لایه به دست آمده‌اند که برای هر کدام از این ۹ حالت از بهترین مدل فضای سرج خود بودند و بعد از به دست آمدن هایپرپارامترهای مدل از فضای سرج این مدل‌ها برای epoch‌های بیشتر آموزش داده شده‌اند و در نتیجه بهترین مدل learning rate = Adam relu با ۰.۰۰۱۰۱۴۲۲۰۲۵۱۰۳۶۰۸۵۷ ترکیب برای استفاده در شبکه‌های عمیق convolution هستند هم به علت سادگی تابع relu و هم توانایی بالای استفاده adam، است.

• استفاده از لایه‌های Convolution

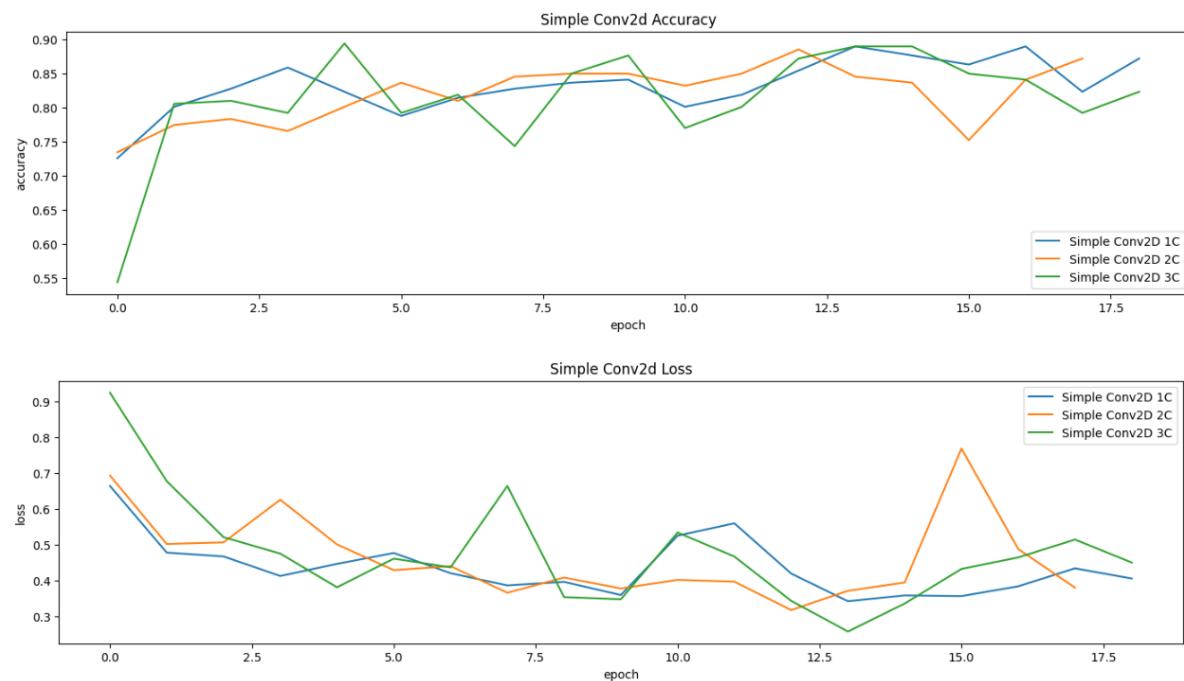
- نتایج مدل و معیارهای ارزیابی
- مدل ساده Convolution با تعداد لایه‌های مختلف:

Simple Conv2D models:

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
Simple Conv2D 1C	(epoch index:15) Accuracy: 0.9032257795333862 Loss: 0.23542065918445587	(epoch index:13) Accuracy: 0.8893805146217346 Loss: 0.3415098190307617	(epoch index:18) Accuracy: 0.9087875485428227 Loss: 0.28337135910987854	(epoch index:13) Accuracy: 0.8893805146217346 Loss: 0.3415098190307617
Simple Conv2D 2C	(epoch index:14) Accuracy: 0.8832035660743713 Loss: 0.32008013129234314	(epoch index:12) Accuracy: 0.8849557638168335 Loss: 0.31688839197158813	(epoch index:14) Accuracy: 0.8832035660743713 Loss: 0.32008013129234314	(epoch index:12) Accuracy: 0.8849557638168335 Loss: 0.31688839197158813
Simple Conv2D 3C	(epoch index:14) Accuracy: 0.8998887538909912 Loss: 0.2622014880180359	(epoch index:13) Accuracy: 0.8893805146217346 Loss: 0.25700515508651733	(epoch index:14) Accuracy: 0.8998887538909912 Loss: 0.2622014880180359	(epoch index:4) Accuracy: 0.8938053250312805 Loss: 0.38050535321235657

نتایج ارزیابی Validation مدل‌ها با تعداد لایه مختلف Convolution

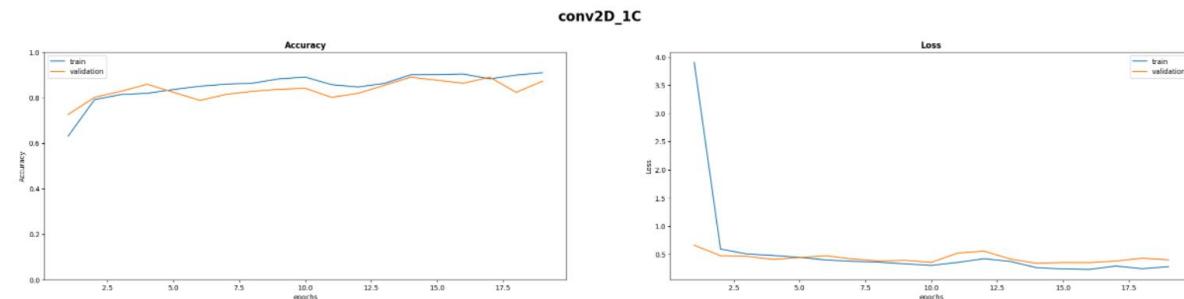
Simple Conv2d:



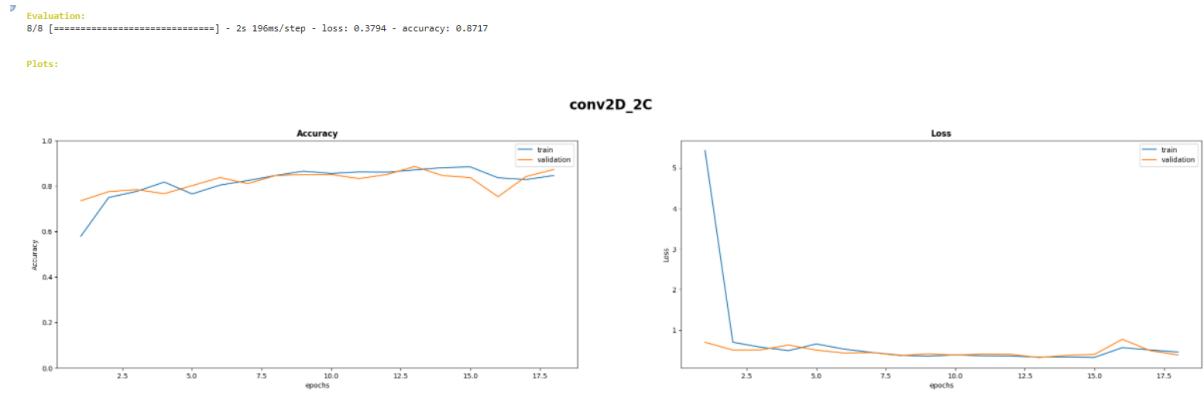
یک لایه Convolution با ۵ Kernel

```
Evaluation:
8/8 [=====] - 1s 184ms/step - loss: 0.4050 - accuracy: 0.8717
```

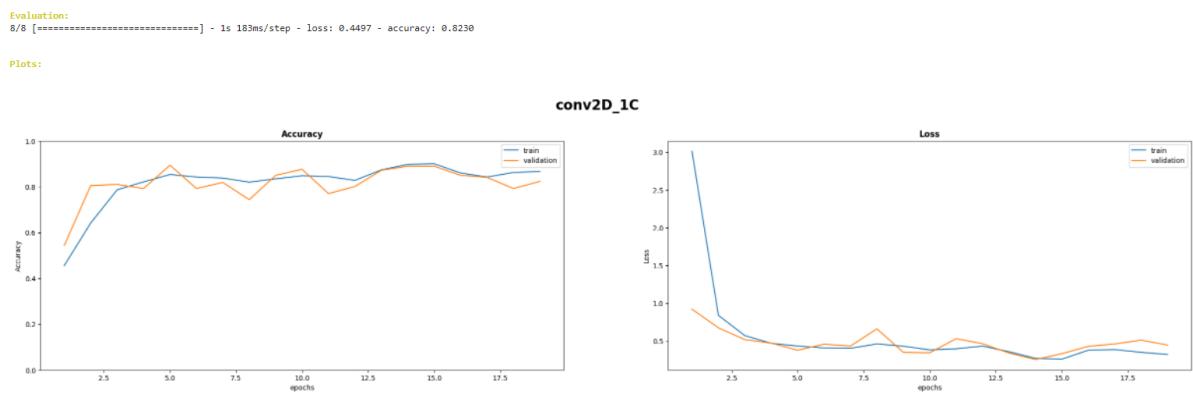
Plots:



دو لایه Kernel یا Convolution



سه لایه Kernel یا Convolution



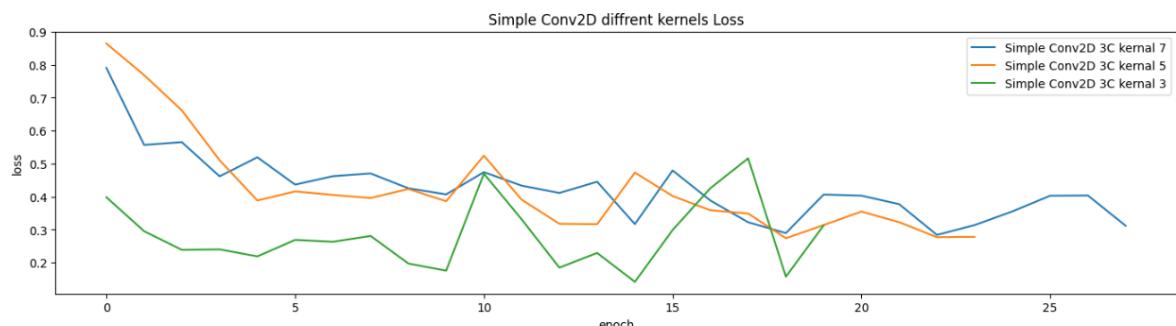
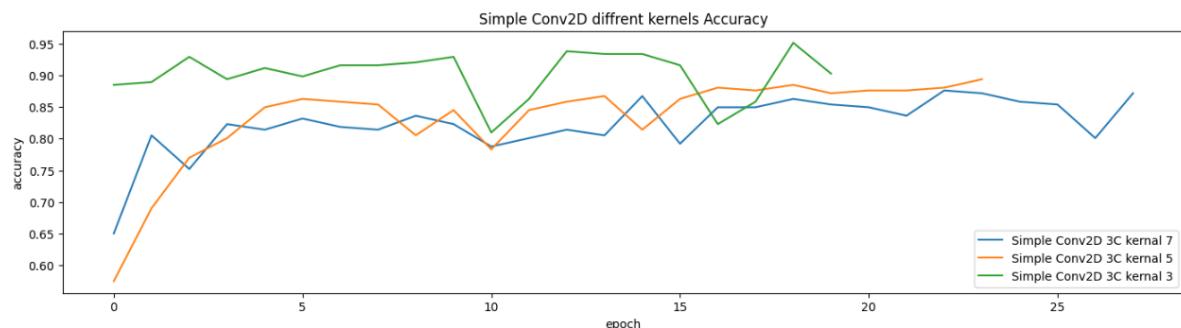
نتایج سه لایه Kernel با Convolution های ۳ و ۵ و ۷:

Simple Conv2D diffrent kernels models:

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
Simple Conv2D 3C kernel 7	(epoch index:25) Accuracy: 0.9354838728904724 Loss: 0.1698877364397049	(epoch index:22) Accuracy: 0.8761062026023865 Loss: 0.2842307984828949	(epoch index:25) Accuracy: 0.9354838728904724 Loss: 0.1698877364397049	(epoch index:22) Accuracy: 0.8761062026023865 Loss: 0.2842307984828949
Simple Conv2D 3C kernel 5	(epoch index:23) Accuracy: 0.9254727363586426 Loss: 0.20833468437194824	(epoch index:18) Accuracy: 0.8849557638168335 Loss: 0.2742147445678711	(epoch index:23) Accuracy: 0.9254727363586426 Loss: 0.20833468437194824	(epoch index:23) Accuracy: 0.8938053250312805 Loss: 0.2784665822982788
Simple Conv2D 3C kernel 3	(epoch index:15) Accuracy: 0.9621801972389221 Loss: 0.09590914100408554	(epoch index:14) Accuracy: 0.936283206939697 Loss: 0.1419530212879181	(epoch index:15) Accuracy: 0.9621801972389221 Loss: 0.09590914100408554	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.1576225757598877

نمودار سه لایه Kernel Validation با Convolution های مختلف:

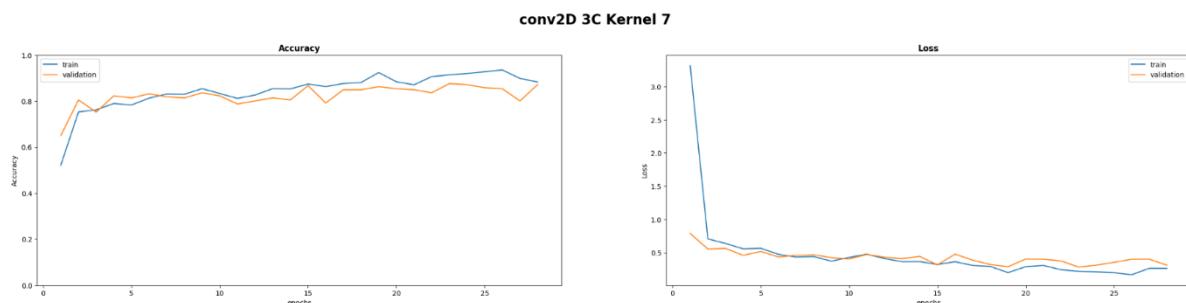
Simple Conv2D diffrent kernels:



سه لایه Kernel با Convolution :

Evaluation:
8/8 [=====] - 2s 193ms/step - loss: 0.3118 - accuracy: 0.8717

Plots:

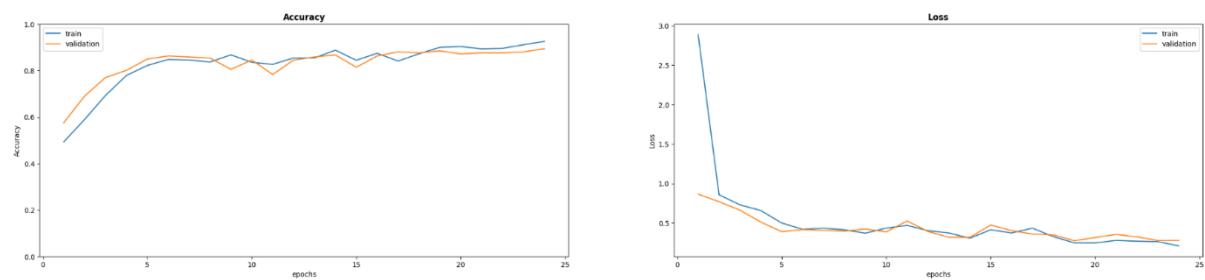


سەلادىپ Kernel بى Convolution

Evaluation: 8/8 [=====] - 2s 187ms/step - loss: 0.2785 - accuracy: 0.8938

Plots:

conv2D 3C Kernel 5

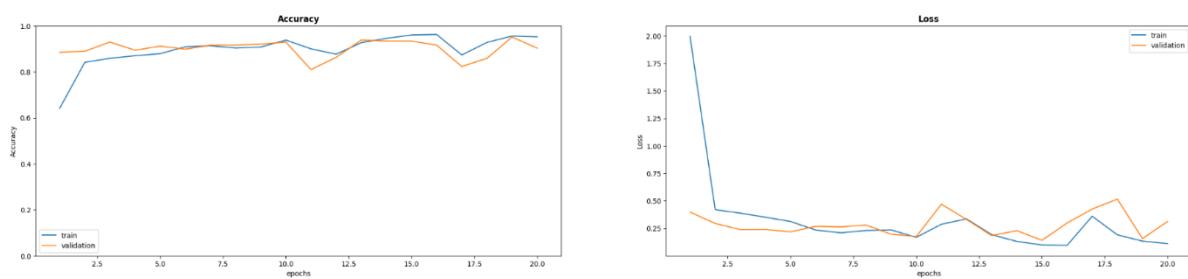


سەلادىپ Kernel بى Convolution

Evaluation: 8/8 [=====] - 2s 221ms/step - loss: 0.3131 - accuracy: 0.9027

Plots:

conv2D 3C Kernel 3



نتایج ارزیابی مدل با Stride های مختلف

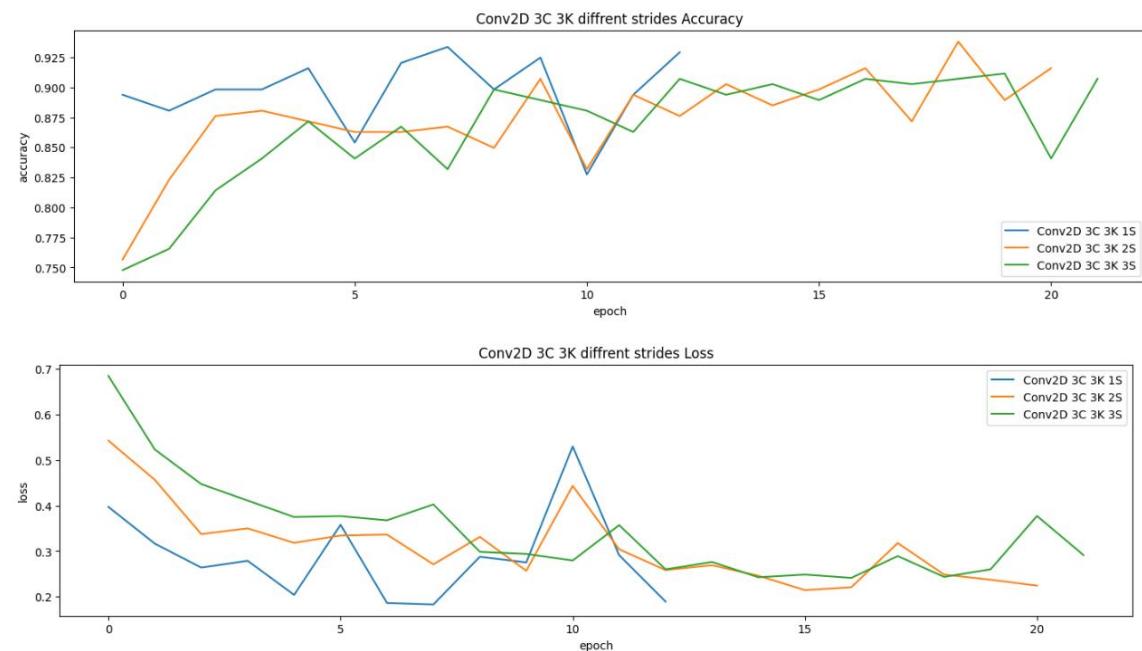
مدل سه لایه Convolution Kernel 3 Stride 1, 2, 3

Conv2D 3C 3K different strides models:

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
Conv2D 3C 3K 1S	(epoch index:9) Accuracy: 0.9466073513031006 Loss: 0.13960447907447815	(epoch index:7) Accuracy: 0.9336283206939697 Loss: 0.18307159841060638	(epoch index:9) Accuracy: 0.9466073513031006 Loss: 0.13960447907447815	(epoch index:7) Accuracy: 0.9336283206939697 Loss: 0.18307159841060638
Conv2D 3C 3K 2S	(epoch index:17) Accuracy: 0.9410455822944641 Loss: 0.17448733747005463	(epoch index:15) Accuracy: 0.8982300758361816 Loss: 0.21459722518920898	(epoch index:17) Accuracy: 0.9410455822944641 Loss: 0.17448733747005463	(epoch index:18) Accuracy: 0.9380530714988708 Loss: 0.24859705567359924
Conv2D 3C 3K 3S	(epoch index:19) Accuracy: 0.9076752066612244 Loss: 0.24662739038467407	(epoch index:16) Accuracy: 0.9076752066612244 Loss: 0.2413809448480606	(epoch index:19) Accuracy: 0.9076752066612244 Loss: 0.24662739038467407	(epoch index:19) Accuracy: 0.9115044474601746 Loss: 0.26013514399528503

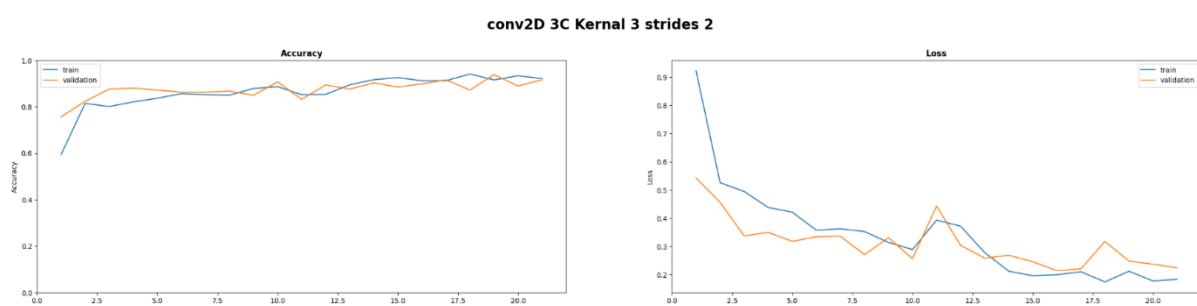
نتایج Validation با Stride های مختلف:

Conv2D 3C 3K different strides:



Evaluation: 8/8 [=====] - 1s 180ms/step - loss: 0.2244 - accuracy: 0.9159

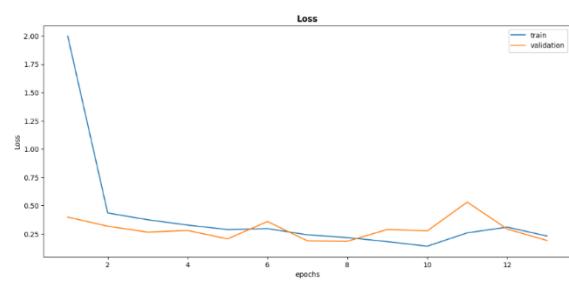
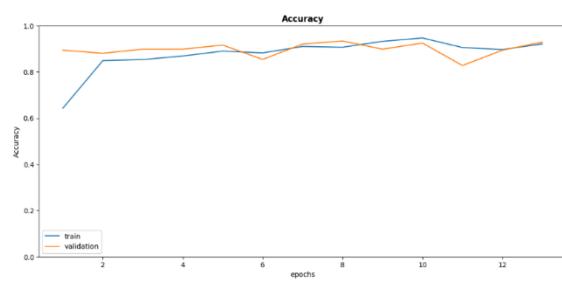
Plots:



Evaluation:
8/8 [=====] - 2s 200ms/step - loss: 0.1895 - accuracy: 0.9292

Plots:

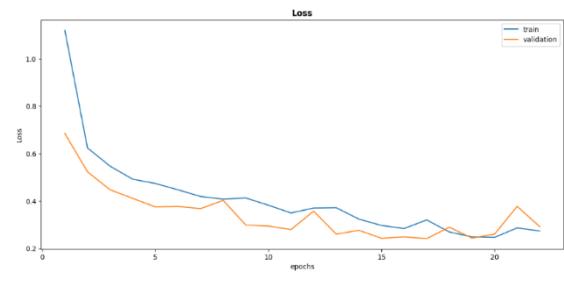
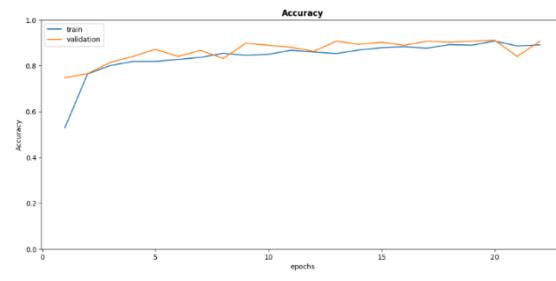
conv2D 3C Kernel 3 strides 1



Evaluation:
8/8 [=====] - 1s 183ms/step - loss: 0.2915 - accuracy: 0.9071

Plots:

conv2D 3C Kernel 3 strides 3



نتایج ارزیابی مدل با Dilations مختلف ۱، ۲، ۳

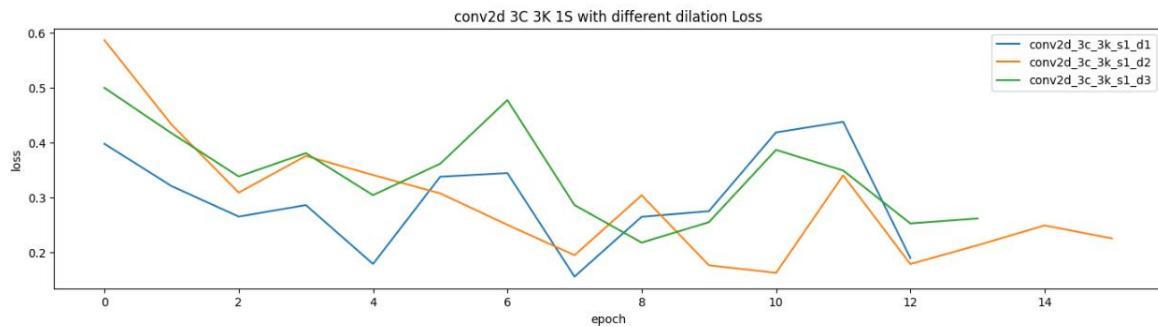
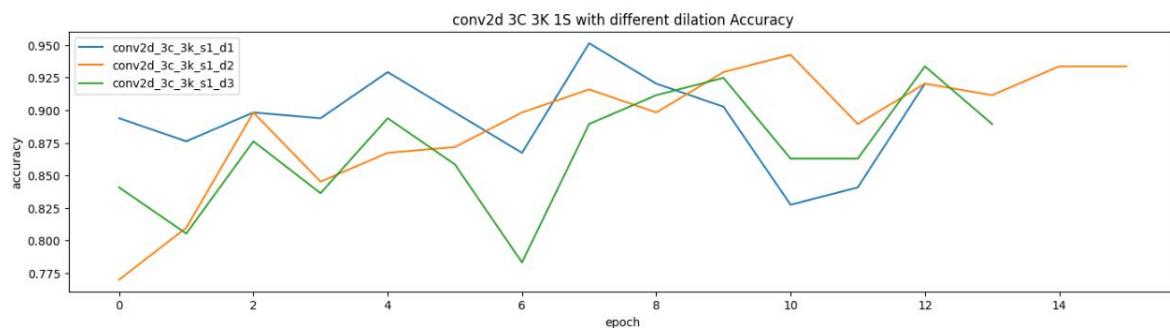
: ۱ Stride، ۳ Kernel .Convolution سه لایه

conv2d 3C 3K 1S with different dilation models:

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
conv2d_3c_3k_s1_d1	(epoch index:9) Accuracy: 0.9443826675415039 Loss: 0.147769875831604	(epoch index:7) Accuracy: 0.9513274431228638 Loss: 0.1552351713180542	(epoch index:9) Accuracy: 0.9443826675415039 Loss: 0.147769875831604	(epoch index:7) Accuracy: 0.9513274431228638 Loss: 0.1552351713180542
conv2d_3c_3k_s1_d2	(epoch index:15) Accuracy: 0.9744160175323486 Loss: 0.06688597053289413	(epoch index:10) Accuracy: 0.9424778819084167 Loss: 0.16195295751094818	(epoch index:14) Accuracy: 0.9766407012939453 Loss: 0.07696759700775146	(epoch index:10) Accuracy: 0.9424778819084167 Loss: 0.16195295751094818
conv2d_3c_3k_s1_d3	(epoch index:13) Accuracy: 0.9555061459541321 Loss: 0.12274615466594696	(epoch index:8) Accuracy: 0.9115044474601746 Loss: 0.21708624064922333	(epoch index:13) Accuracy: 0.9555061459541321 Loss: 0.12274615466594696	(epoch index:12) Accuracy: 0.9336283206939697 Loss: 0.251986026763916

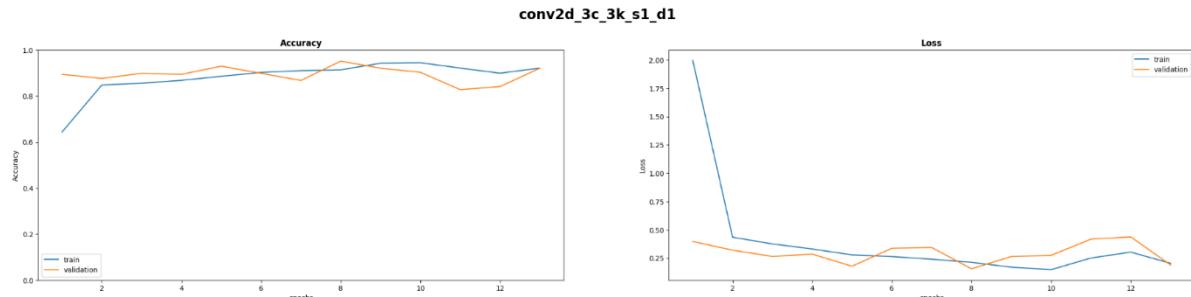
نتایج Validation با Dilations مختلف:

conv2d 3C 3K 1S with different dilation:



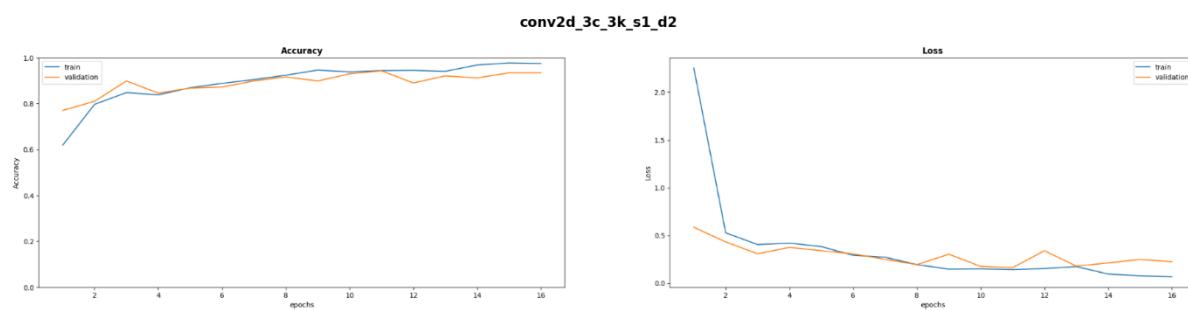
Validation:
5/5 [=====] - 2s 195ms/step - loss: 0.1890 - accuracy: 0.9204

Plots:



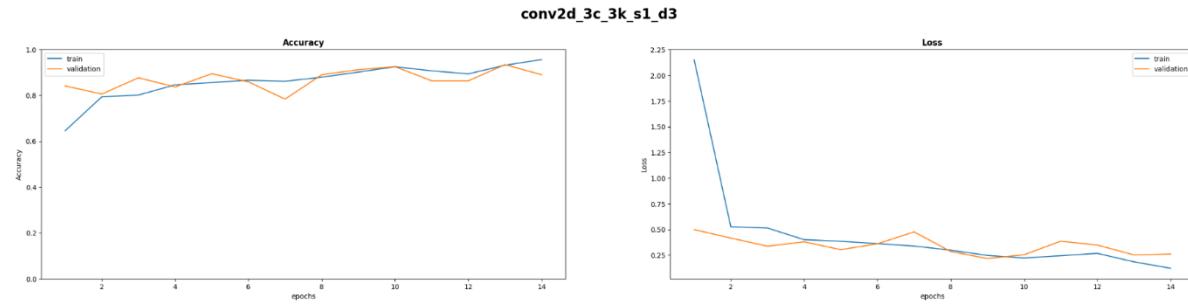
Evaluation:
8/8 [=====] - 2s 196ms/step - loss: 0.2247 - accuracy: 0.9336

Plots:



Evaluation:
8/8 [=====] - 2s 204ms/step - loss: 0.2610 - accuracy: 0.8894

Plots:



نتایج ارزیابی با Padding و Dilations مختلف

Convolution ۳ لایه

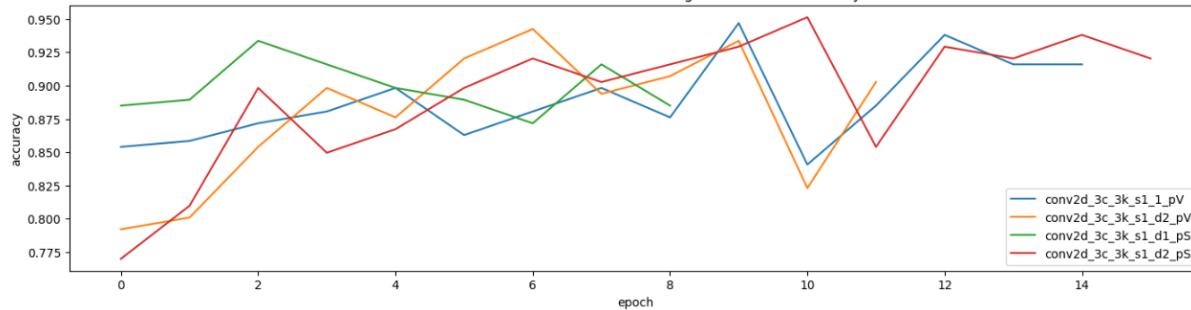
Dilation=1,2 ، Padding=Valid ، Padding= Same ، ۱ Stride ، ۳ Kernel

conv2d 3C 3K 1S with different Paddings and Dilations:

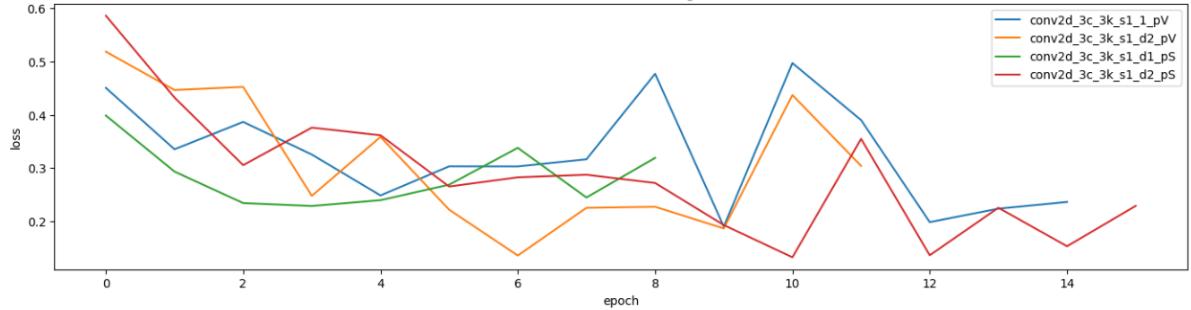
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
conv2d_3c_3k_s1_d1_pV	(epoch index:14) Accuracy: 0.951056718826294 Loss: 0.1203068345785141	(epoch index:9) Accuracy: 0.9469026327133179 Loss: 0.19009755551815033	(epoch index:13) Accuracy: 0.9566184878349304 Loss: 0.12445293366909027	(epoch index:9) Accuracy: 0.9469026327133179 Loss: 0.19009755551815033
conv2d_3c_3k_s1_d2_pV	(epoch index:9) Accuracy: 0.9532814025878906 Loss: 0.1421961486339569	(epoch index:6) Accuracy: 0.9424778819084167 Loss: 0.13578149676322937	(epoch index:9) Accuracy: 0.9532814025878906 Loss: 0.1421961486339569	(epoch index:6) Accuracy: 0.9424778819084167 Loss: 0.13578149676322937
conv2d_3c_3k_s1_d1_ps	(epoch index:8) Accuracy: 0.9354838728904724 Loss: 0.18179920315742493	(epoch index:3) Accuracy: 0.9159291982650757 Loss: 0.22880014777183533	(epoch index:8) Accuracy: 0.9354838728904724 Loss: 0.18179920315742493	(epoch index:2) Accuracy: 0.9336283206939697 Loss: 0.2341990470886205
conv2d_3c_3k_s1_d2_ps	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652

conv2d 3C 3K 1S with different Paddings and Dilations:

conv2d 3C 3K 1S with different Paddings and Dilation Accuracy



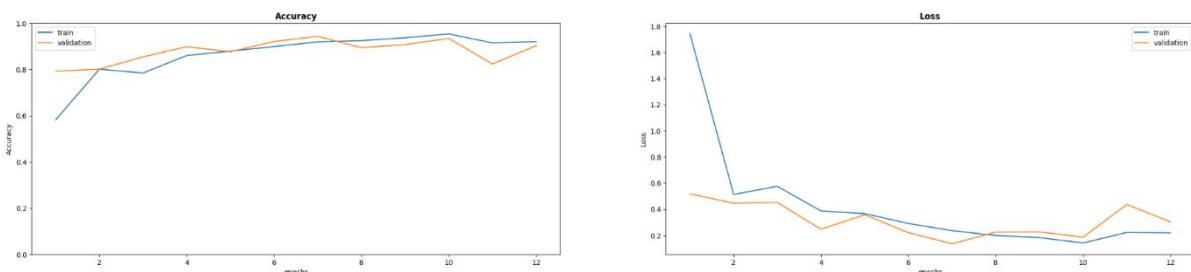
conv2d 3C 3K 1S with different Paddings and Dilation Loss



Evaluation: 8/8 [=====] - 2s 204ms/step - loss: 0.3840 - accuracy: 0.9027

Plots:

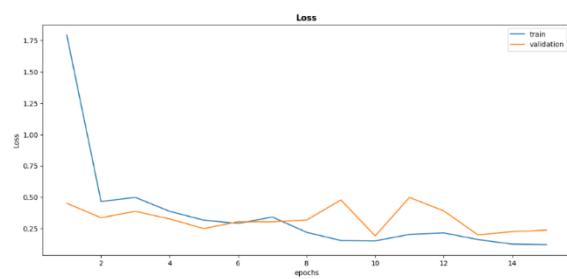
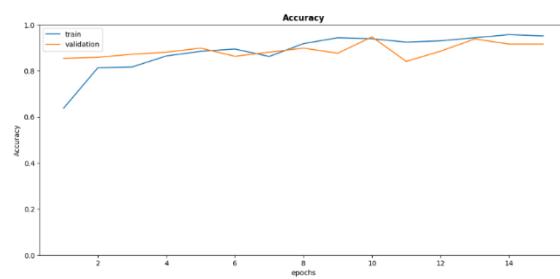
conv2d_3c_3k_s1_d2_pV



Evaluation: 8/8 [=====] - 2s 196ms/step - loss: 0.2363 - accuracy: 0.9159

Plots:

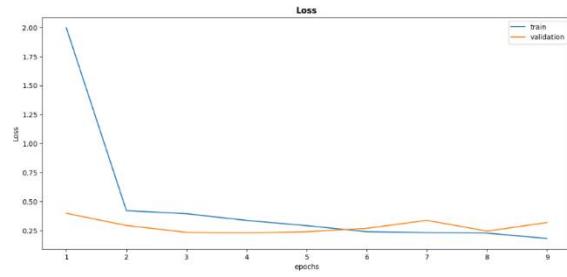
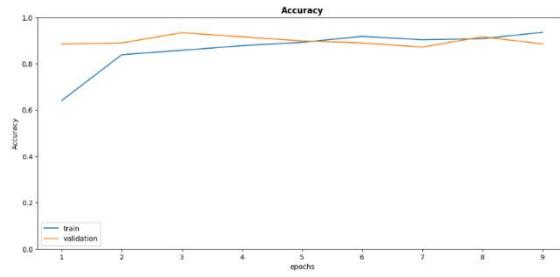
conv2d_3c_3k_s1_d1_pV



Evaluation: 8/8 [=====] - 2s 190ms/step - loss: 0.3190 - accuracy: 0.8850

Plots:

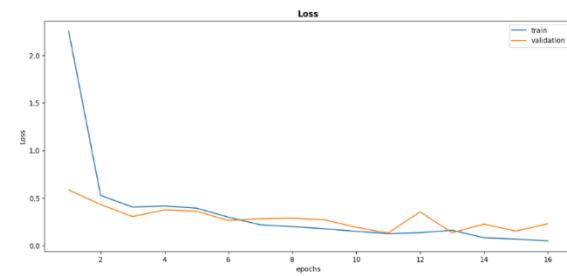
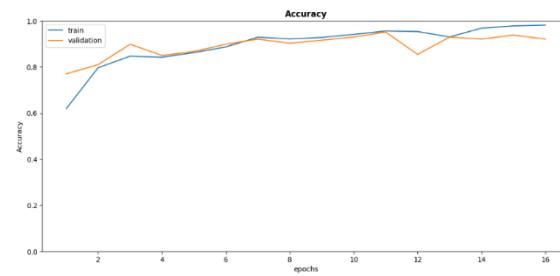
conv2d_3c_3k_s1_d1_pS



Evaluation: 8/8 [=====] - 2s 197ms/step - loss: 0.2289 - accuracy: 0.9204

Plots:

conv2d_3c_3k_s1_d2_pS



بررسی بیش برازش Stop Early در قسمت Overfitting فیت مدل‌ها از استفاده شد.

بهترین مدل Convolution

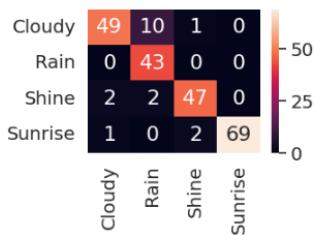
Accuracy برای بهترین مدل (بر اساس بیشترین Confusion Matrix) ○

مودل سه لایه Convolution

Same Padding , Dilation 2 , Stride 1 ,Kernel 3

Max Val Accuracy Epoch 10: 95% Loss 0.13

Confusion_matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.9423	0.8167	0.8750	60
1	0.7818	1.0000	0.8776	43
2	0.9400	0.9216	0.9307	51
3	1.0000	0.9583	0.9787	72
accuracy			0.9204	226
macro avg	0.9160	0.9241	0.9155	226
weighted avg	0.9296	0.9204	0.9211	226

conv2d_3c_3k_s1_d2_p5:

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
conv2d_3c_3k_s1_d2_p5	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652

نتایج استفاده از تکنیک‌های داده‌افزایی (نموده مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

```
# Generate Train and Val
def generate_sets():
    # fixing the seed
    set_random_seed()

    # paths of shuffled and splitted data
    train_path = "/content/splitted_output/train"
    val_path = "/content/splitted_output/val"

    # Train
    train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=True,
        class_mode='categorical')

    # Validation
    validation_generator = val_datagen.flow_from_directory(
        val_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=False,
        class_mode='categorical')

    return train_generator, validation_generator
```

• استفاده از لایه‌های Pooling در مدل

◦ نتایج مدل و معیارهای ارزیابی

◦ لایه Pooling

◦ مدل سه لایه

Pooling Max & Pooling Average Same Padding ,Kernel 3

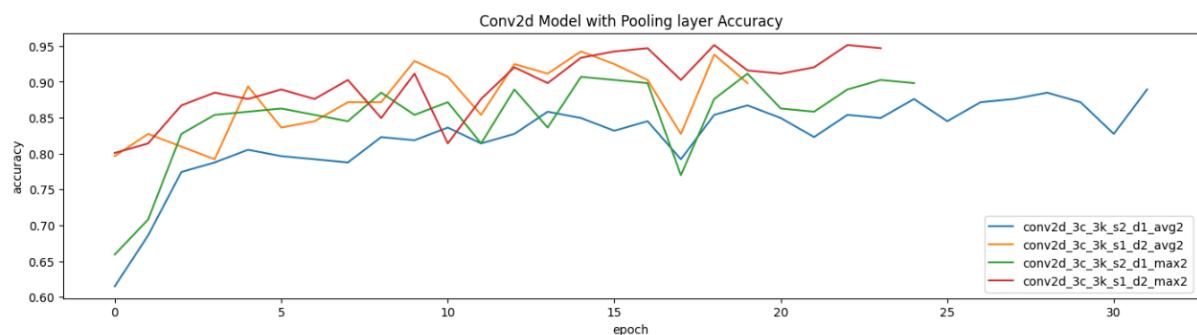
:۱ Stride و ۲ Dilation ، ۲ Stride و ۱ Dilation

Conv2d Model with Pooling layer modules:

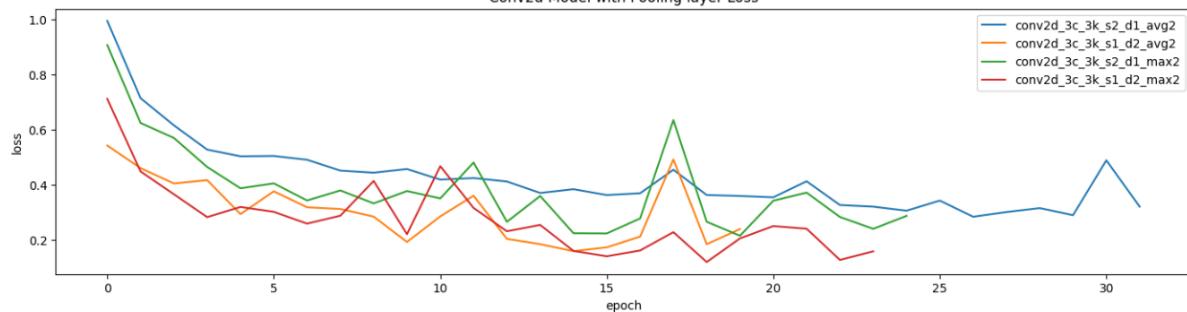
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
conv2d_3c_3k_s2_d1_avg2	(epoch index:30) Accuracy: 0.8676307201385498 Loss: 0.3340955972671509	(epoch index:26) Accuracy: 0.8716813921928406 Loss: 0.2850017249584198	(epoch index:30) Accuracy: 0.8676307201385498 Loss: 0.3340955972671509	(epoch index:31) Accuracy: 0.8893805146217346 Loss: 0.32182577252388
conv2d_3c_3k_s1_d2_avg2	(epoch index:17) Accuracy: 0.9499443769454956 Loss: 0.14421993494033813	(epoch index:14) Accuracy: 0.9424778819084167 Loss: 0.15997539460659027	(epoch index:17) Accuracy: 0.9499443769454956 Loss: 0.14421993494033813	(epoch index:14) Accuracy: 0.9424778819084167 Loss: 0.15997539460659027
conv2d_3c_3k_s2_d1_max2	(epoch index:24) Accuracy: 0.9154615998268127 Loss: 0.22666031122207642	(epoch index:19) Accuracy: 0.9115044474601746 Loss: 0.2160709798336029	(epoch index:24) Accuracy: 0.9154615998268127 Loss: 0.22666031122207642	(epoch index:19) Accuracy: 0.9115044474601746 Loss: 0.2160709798336029
conv2d_3c_3k_s1_d2_max2	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909

◦ شکل خروجی کد مجموعه ارزیابی

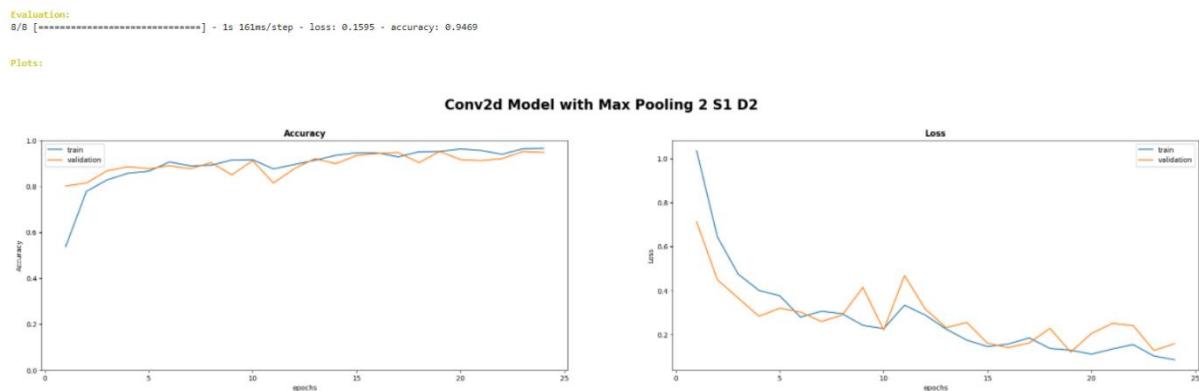
Conv2d Model with Pooling layer modules:



Conv2d Model with Pooling layer Loss



نمودار تغییر Accuracy ، Loss مجموعه آموزش و ارزیابی



بررسی بیش برآذش

برای جلوگیری از Overfitting در قسمت Call Backs فیت مدل‌ها از Stop Early استفاده شد.

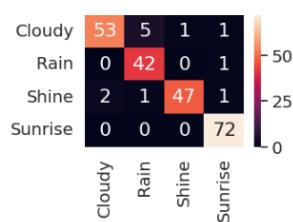
Accuracy برای بهترین مدل (بر اساس بیشترین Confusion Matrix)

سایر معیارهای ارزیابی:

بهترین نتیجه Accuracy

Dilation 2 Stride 1 ، Max Pooling 2 ، Same Padding ، Kernel 3 ، Layer Conv ۳

Confusion_matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.9636	0.8833	0.9217	60
1	0.8750	0.9767	0.9231	43
2	0.9792	0.9216	0.9495	51
3	0.9600	1.0000	0.9796	72
accuracy			0.9469	226
macro avg	0.9445	0.9454	0.9435	226
weighted avg	0.9491	0.9469	0.9467	226

Conv2d Model with Max Pooling 2 S1 D2:

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
Conv2d Model with Max Pooling 2 S1 D2	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909

◦ نتایج استفاده از تکنیک‌های داده‌افزایی (نموده مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

```
# Generate Train and Val
def generate_sets():
    # fixing the seed
    set_random_seed()

    # paths of shuffled and splitted data
    train_path = "/content/splitted_output/train"
    val_path = "/content/splitted_output/val"

    # Train
    train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=True,
        class_mode='categorical')

    # Validation
    validation_generator = val_datagen.flow_from_directory(
        val_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=False,
        class_mode='categorical')

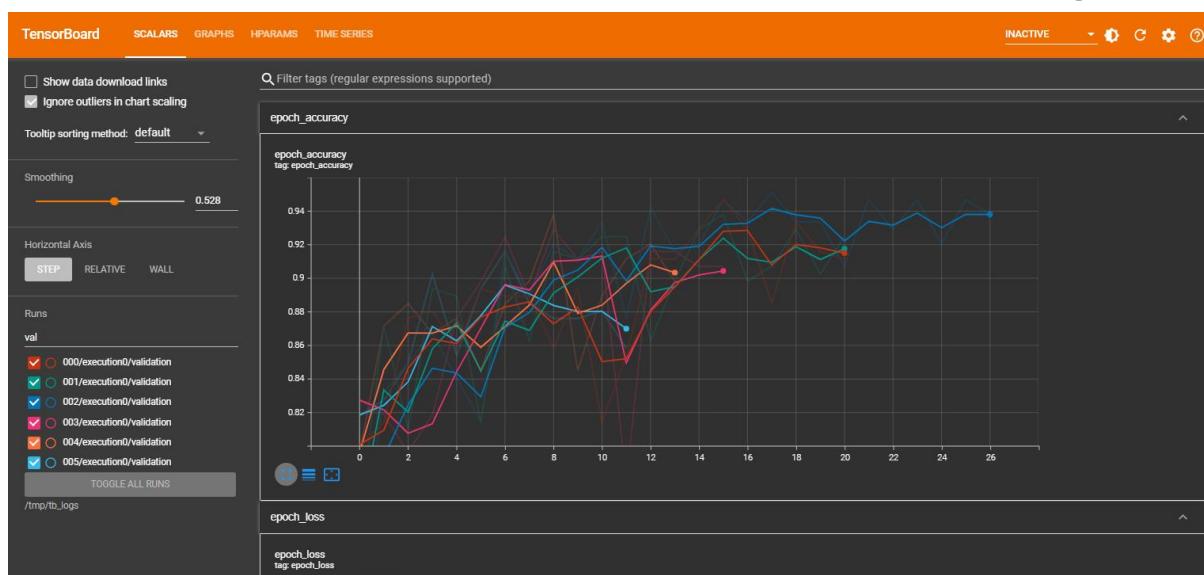
    return train_generator, validation_generator
```

◦ درنظر گرفتن Dropout در مدل Max , Same Padding , Kernel 3 , Layer Conv ۳ در Dropout ۲

Dilation 2 Stride 1 , Pooling 2

◦ نتایج مدل و معیارهای ارزیابی

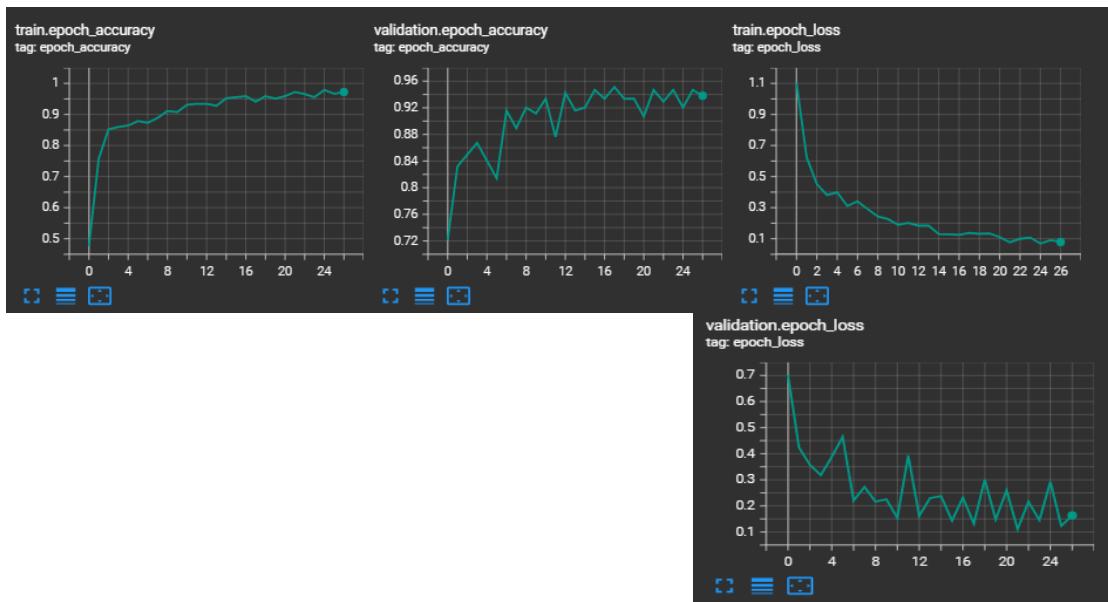
نرخ‌های مختلف Dropout



رفرنس:

Trial ID	Show Metrics	dropout	train.epoch_accuracy	validation.epoch_accuracy	train.epoch_loss	validation.epoch_loss	validation.evaluation_accuracy_vs_iterations
000	<input type="checkbox"/>	0.0000	0.94883	0.91150	0.13693	0.26361	0.91150
001	<input type="checkbox"/>	0.20000	0.88098	0.92478	0.32623	0.26050	0.92478
002	<input type="checkbox"/>	0.10000	0.97219	0.93805	0.078644	0.16345	0.93805
003	<input type="checkbox"/>	0.40000	0.94661	0.90708	0.14334	0.28724	0.90708
004	<input type="checkbox"/>	0.50000	0.91657	0.89823	0.20645	0.29298	0.89823
005	<input type="checkbox"/>	0.30000	0.91657	0.85841	0.21263	0.41805	0.85841

نمودار بهترین مدل Dropout = 0.1



:Batch normalization

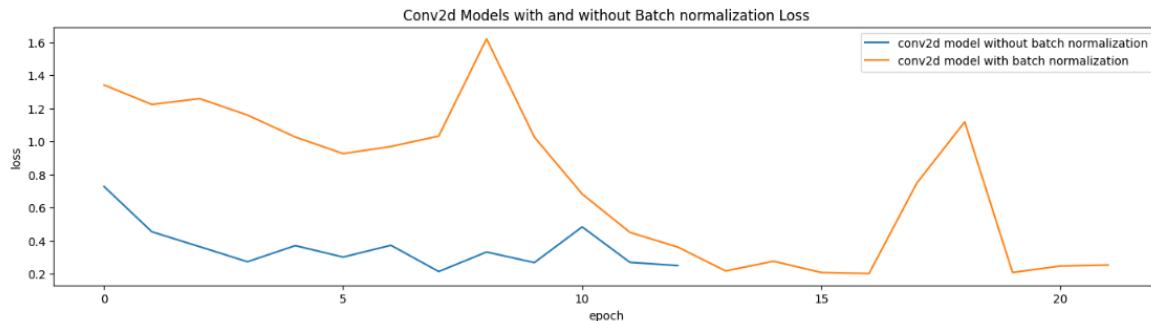
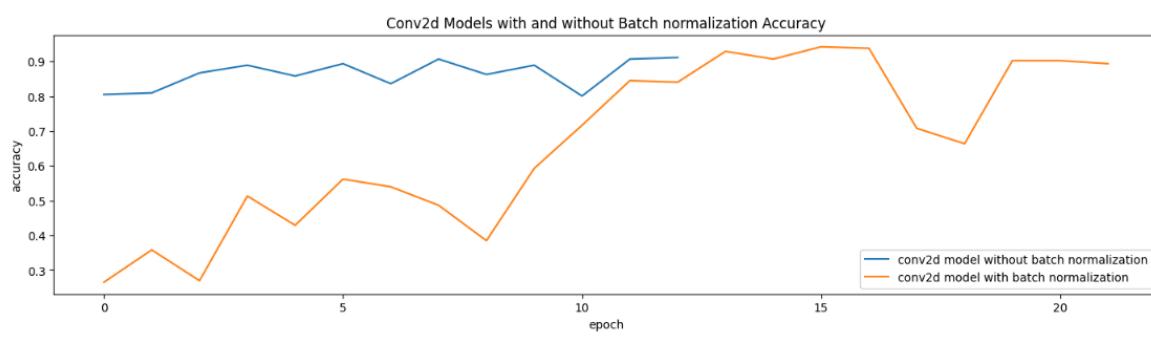
Dilation 2 Stride 1 , Max Pooling 2 , Same Padding , Kernel 3 , Layer Conv ۳

Conv2d Models with and without Batch normalization:

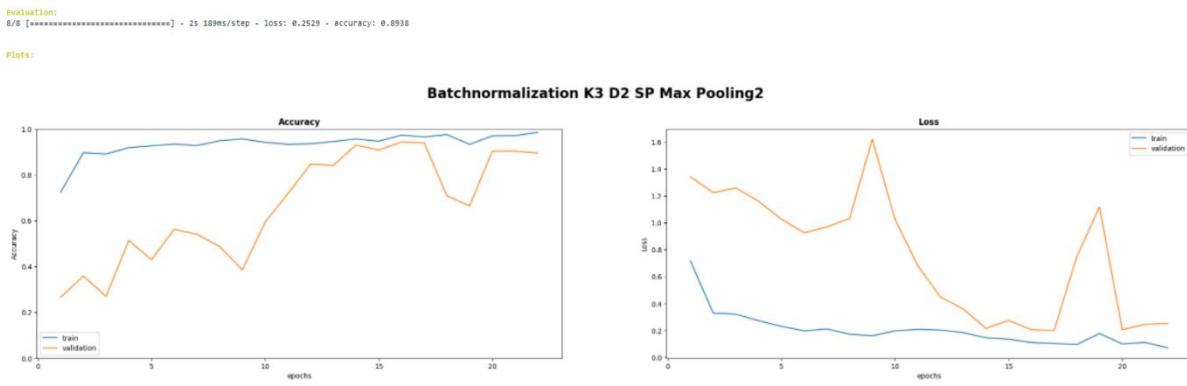
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
conv2d model without batch normalization	(epoch index:9) Accuracy: 0.9154615998268127 Loss: 0.22136729955673218	(epoch index:7) Accuracy: 0.9070796370506287 Loss: 0.21321208775043488	(epoch index:8) Accuracy: 0.9199110269546509 Loss: 0.23921668529518498	(epoch index:12) Accuracy: 0.9115044474601746 Loss: 0.249333456158638
conv2d model with batch normalization	(epoch index:21) Accuracy: 0.9844271540641785 Loss: 0.07246901839971542	(epoch index:16) Accuracy: 0.9380530714988708 Loss: 0.20128889381885529	(epoch index:21) Accuracy: 0.9844271540641785 Loss: 0.07246901839971542	(epoch index:15) Accuracy: 0.9424778819884167 Loss: 0.2073790580034256

شكل خروجی کد مجموعه ارزیابی ○

Conv2d Models with and without Batch normalization:



نمودار تغییر Accuracy و Loss مجموعه آموزش و ارزیابی



بررسی بیش برازش

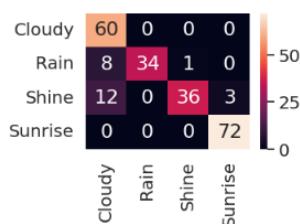
برای جلوگیری از Overfitting در قسمت Stop Early فیت مدل‌ها از Call Backs استفاده شد.

Accuracy برای بهترین مدل (بر اساس بیشترین Confusion Matrix)

سایر معیارهای ارزیابی:

Dilation 2 Stride 1 ، Max Pooling 2 ، Same Padding ، Kernel 3 ، Layer Conv ۳

Confusion matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.7500	1.0000	0.8571	60
1	1.0000	0.7907	0.8831	43
2	0.9730	0.7059	0.8182	51
3	0.9600	1.0000	0.9796	72

	accuracy	macro avg	weighted avg
	0.8938	0.8938	0.8938
accuracy	0.8938	0.8938	0.8938
macro avg	0.9207	0.8741	0.8845
weighted avg	0.9148	0.8938	0.8923

Batchnormalization K3 D2 SP Max Pooling2:

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
Batchnormalization K3 D2 SP Max Pooling2 (epoch index:21)	(epoch index:16) Accuracy: 0.9844271540641785 Loss: 0.07246901839971542	(epoch index:21) Accuracy: 0.93880530714988708 Loss: 0.2612889381885529	(epoch index:21) Accuracy: 0.9844271540641785 Loss: 0.07246901839971542	(epoch index:15) Accuracy: 0.9424778819084167 Loss: 0.2073798580034256

نتایج استفاده از تکنیک‌های داده‌افزایی (نمره مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار Data Augmentation روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

• ایده از مدل Resnet

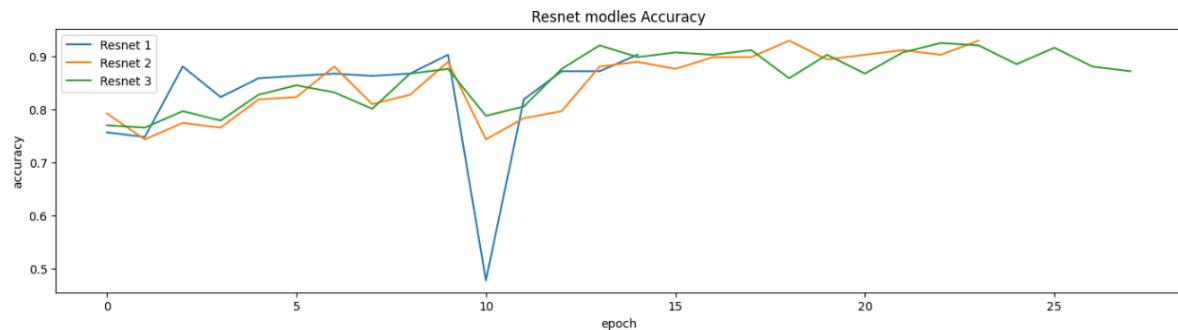
- در نمونه های مختلف این مدل از توابع و ترکیبات مختلفی استفاده شد که در نوت بوک قابل مشاهده هستند و به علت گستردگی ساختار در قالب نوشته نمیگنجد.
- نتایج مدل و معیارهای ارزیابی

Resnet modles:

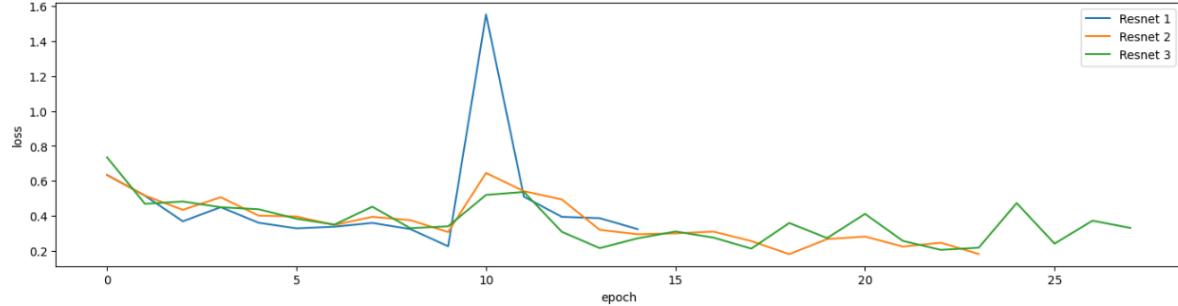
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Resnet 1	(epoch index:14) Accuracy: 0.9154615998268127 Loss: 0.24443945288658142	(epoch index:9) Accuracy: 0.9026548862457275 Loss: 0.22614695131778717	(epoch index:14) Accuracy: 0.9154615998268127 Loss: 0.24443945288658142	(epoch index:9) Accuracy: 0.9026548862457275 Loss: 0.22614695131778717
Resnet 2	(epoch index:23) Accuracy: 0.9410455822944641 Loss: 0.13715574145317078	(epoch index:18) Accuracy: 0.9292035102844238 Loss: 0.18109610676765442	(epoch index:22) Accuracy: 0.9488320350646973 Loss: 0.14798793196678162	(epoch index:18) Accuracy: 0.9292035102844238 Loss: 0.18109610676765442
Resnet 3	(epoch index:24) Accuracy: 0.9365962147712708 Loss: 0.14001886546611786	(epoch index:22) Accuracy: 0.9432703256607056 Loss: 0.20563514530658722	(epoch index:19) Accuracy: 0.9432703256607056 Loss: 0.16487659513950348	(epoch index:22) Accuracy: 0.9247787594795227 Loss: 0.20563514530658722

○ نمودار تغییر مجموعه آموزش و ارزیابی Accuracy ، Loss

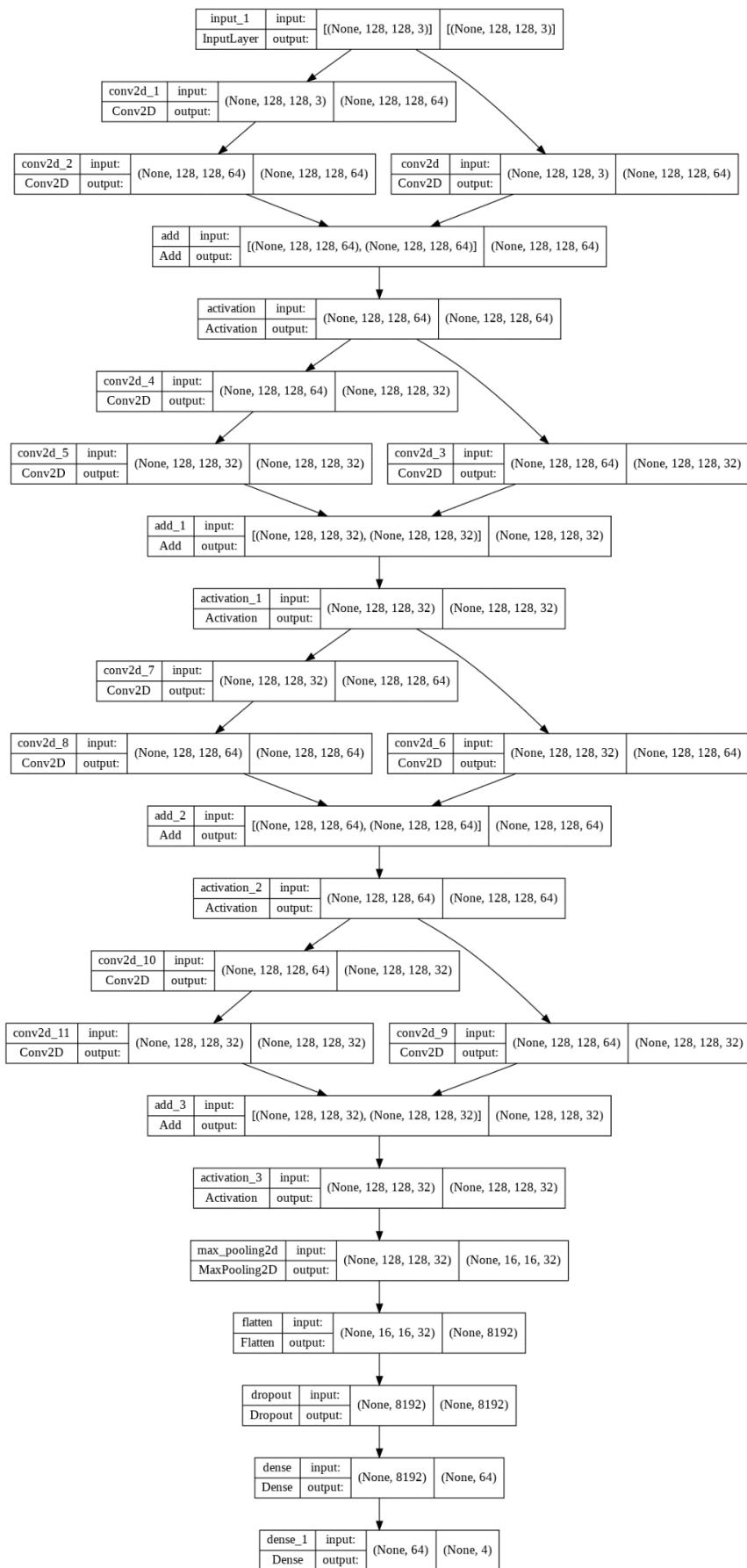
Resnet modles:



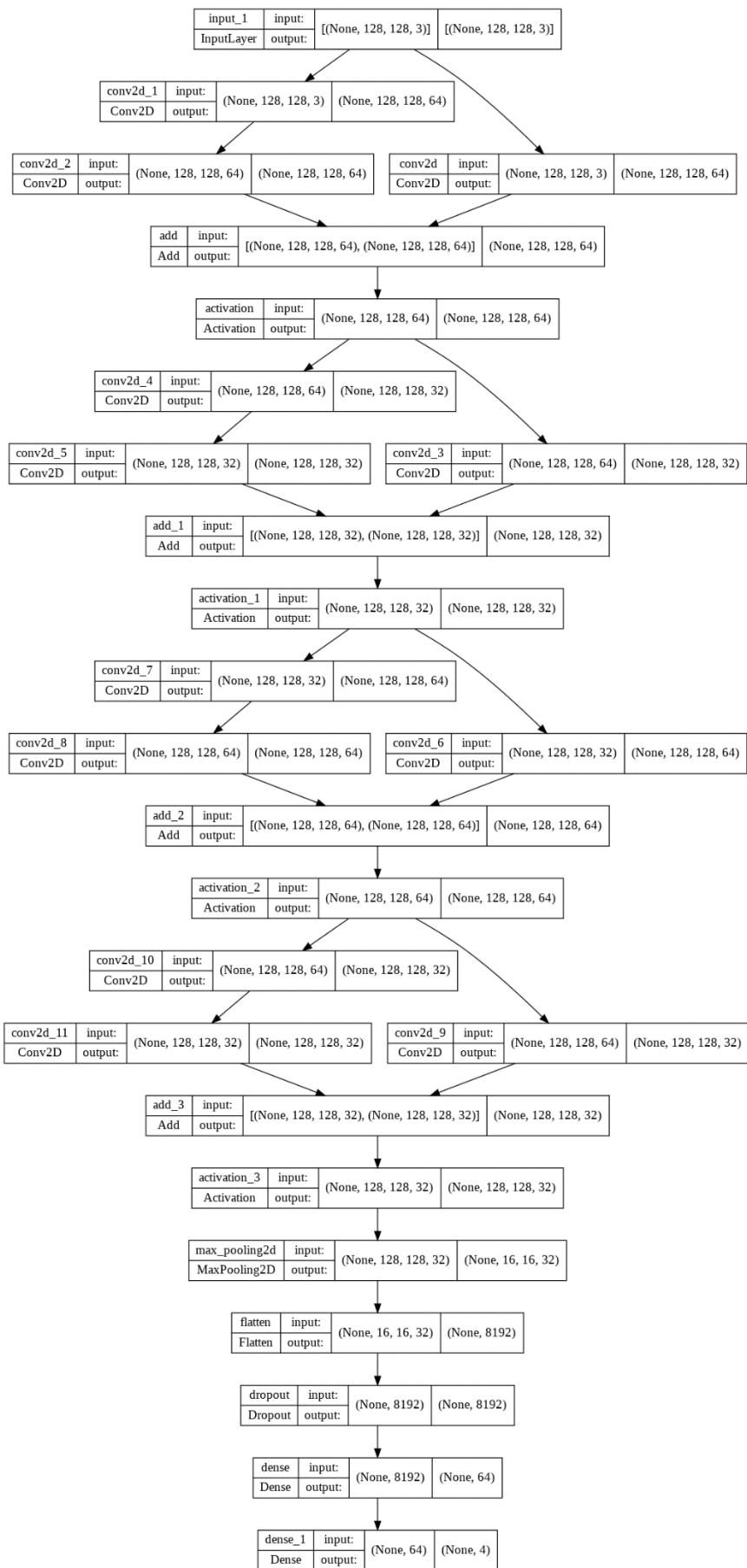
Resnet modles Loss



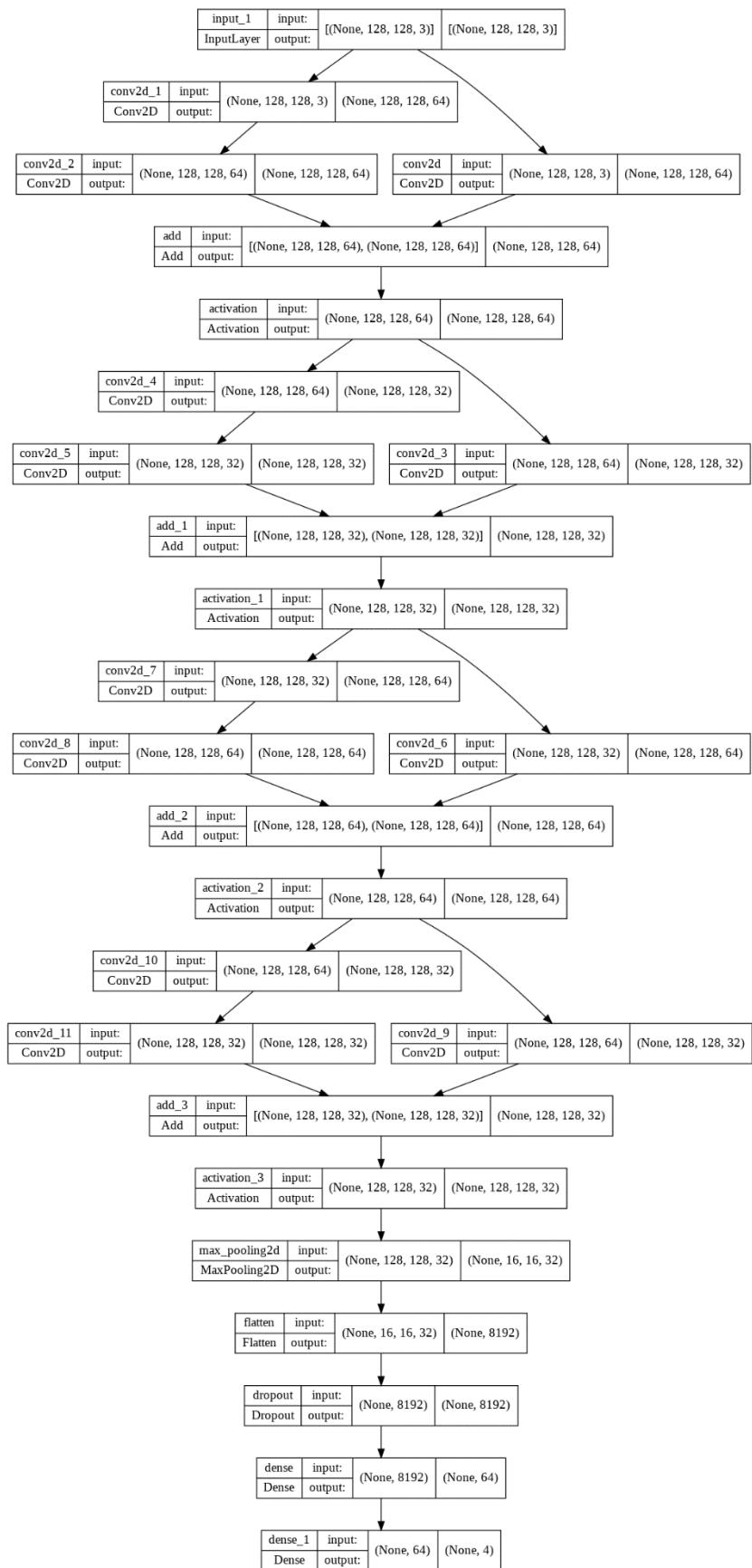
Resnet 1 مدل



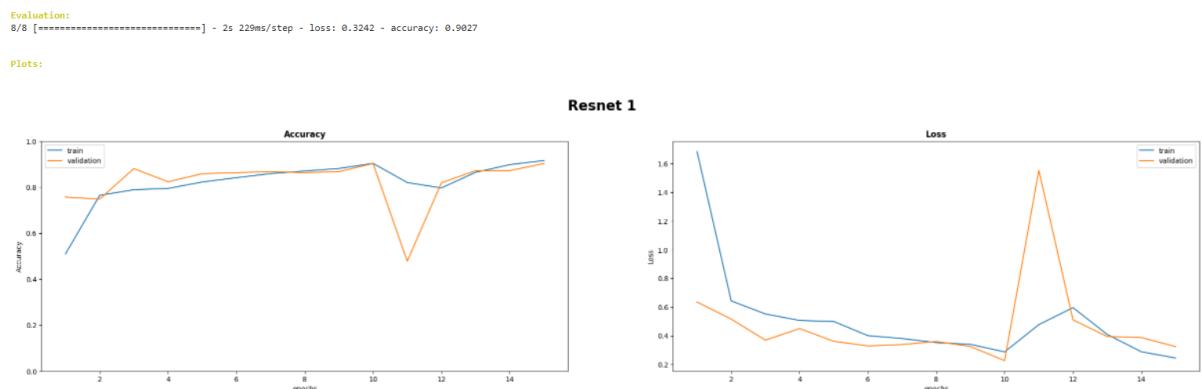
Resnet 2 مدل



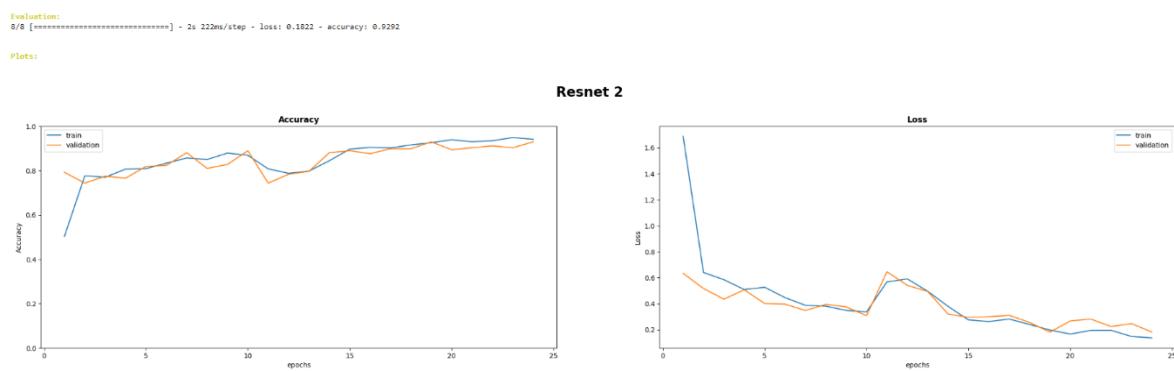
Resnet 3 مدل



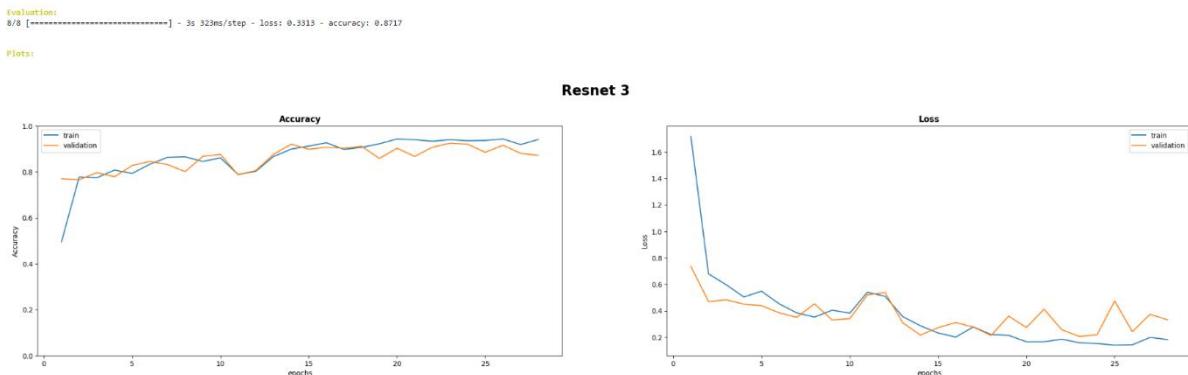
نمودار Accuracy و Loss مدل Resnet 1



نمودار Accuracy و Loss مدل Resnet 2



نمودار Accuracy و Loss مدل Resnet 3



بررسی بیش برازش

برای جلوگیری از Overfitting در قسمت Call Backs فیت مدل‌ها از Stop Early استفاده شد.

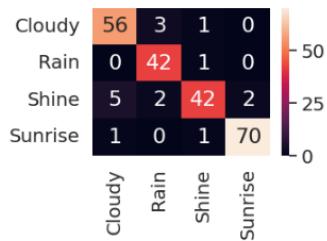
Confusion Matrix برای بهترین مدل (بر اساس بیشترین Accuracy)

سایر معیارهای ارزیابی:

نتایج بهترین مدل

Epoch 18 در Validation Loss = ۰.۱۸ Validation Accuracy = ۹۳ %

Confusion matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.9032	0.9333	0.9180	60
1	0.8936	0.9767	0.9333	43
2	0.9333	0.8235	0.8750	51
3	0.9722	0.9722	0.9722	72
accuracy			0.9292	226
macro avg	0.9256	0.9265	0.9246	226
weighted avg	0.9302	0.9292	0.9285	226

Resnet 2:

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
Resnet 2	(epoch index:23) Accuracy: 0.9410455822944641 Loss: 0.13715574145317078	(epoch index:18) Accuracy: 0.929205102844238 Loss: 0.18109610676765442	(epoch index:22) Accuracy: 0.9488320350646973 Loss: 0.14798793196678162	(epoch index:18) Accuracy: 0.929205102844238 Loss: 0.18109610676765442

نتایج استفاده از تکنیک‌های داده‌افزایی (نمره مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

```
# Generate Train and Val
def generate_sets():
    # Fixing the seed
    np.random.seed()

    # paths of shuffled and splitted data
    train_path = "/content/splitted_output/train"
    val_path = "/content/splitted_output/val"

    # Train
    train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=True,
        class_mode='categorical')

    # Validation
    validation_generator = val_datagen.flow_from_directory(
        val_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=False,
        class_mode='categorical')

    return train_generator, validation_generator
```

• ایده از Inception Network

- در نمونه های مختلف این مدل از توابع و ترکیبات مختلفی استفاده شد که در نوت بوک قابل مشاهده هستند و به علت گستردگی ساختار در قالب نوشته نمیگنجد.

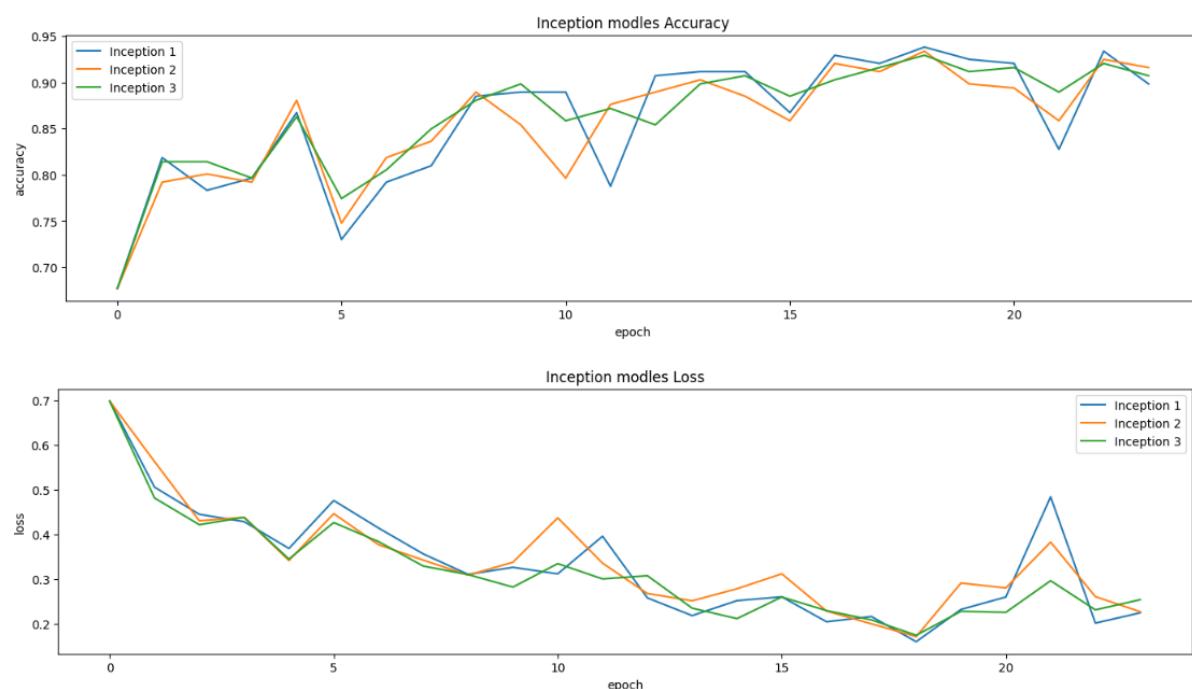
◦ نتایج مدل و معیارهای ارزیابی

Inception modles:

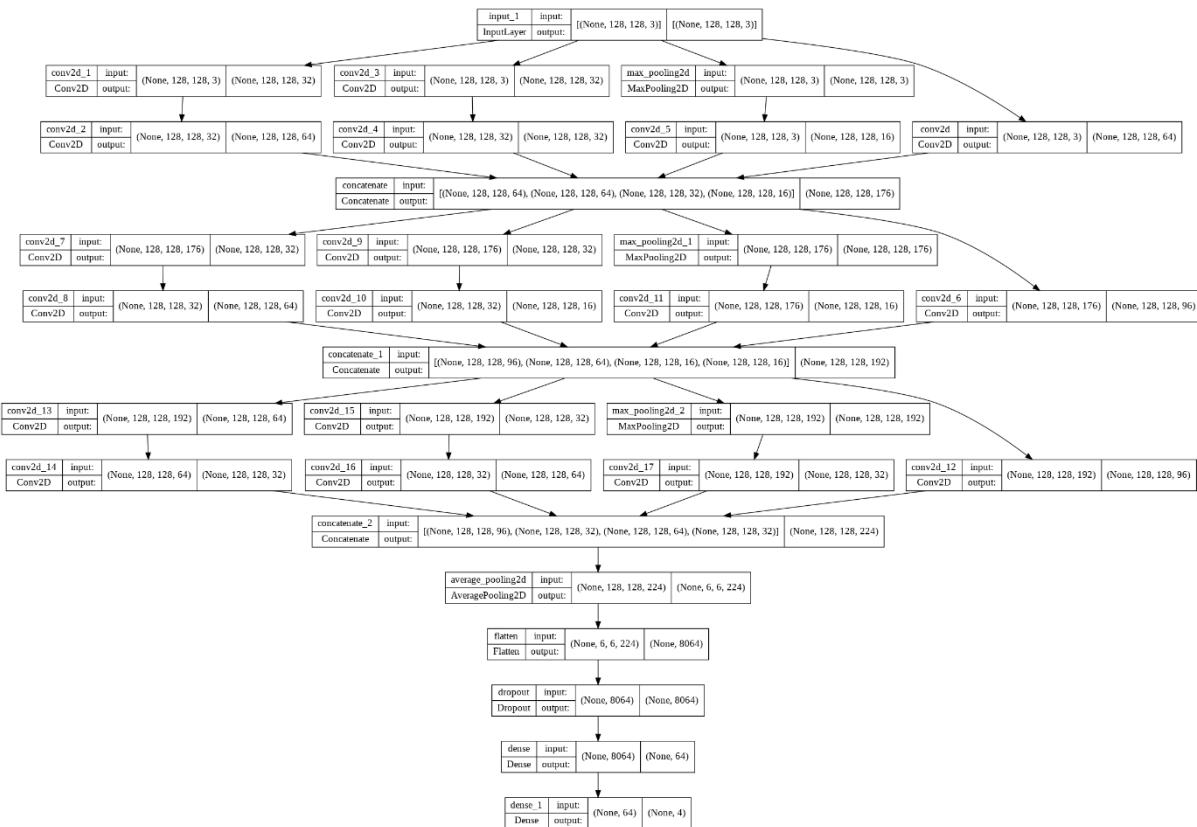
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Inception 1	(epoch index:23) Accuracy: 0.9299221634864807 Loss: 0.15949057042598724	(epoch index:18) Accuracy: 0.9380530714988708 Loss: 0.16025719046592712	(epoch index:23) Accuracy: 0.9299221634864807 Loss: 0.15949057042598724	(epoch index:18) Accuracy: 0.9380530714988708 Loss: 0.16025719046592712
Inception 2	(epoch index:23) Accuracy: 0.9454950094223022 Loss: 0.14247435331344604	(epoch index:18) Accuracy: 0.9336283206939697 Loss: 0.1715587079524994	(epoch index:23) Accuracy: 0.9454950094223022 Loss: 0.14247435331344604	(epoch index:18) Accuracy: 0.9336283206939697 Loss: 0.1715587079524994
Inception 3	(epoch index:23) Accuracy: 0.9454950094223022 Loss: 0.1536284238100052	(epoch index:18) Accuracy: 0.9292035102844238 Loss: 0.1747056096792221	(epoch index:23) Accuracy: 0.9454950094223022 Loss: 0.1536284238100052	(epoch index:18) Accuracy: 0.9292035102844238 Loss: 0.1747056096792221

◦ نمودار تغییر Accuracy و Loss مجموعه آموزش و ارزیابی

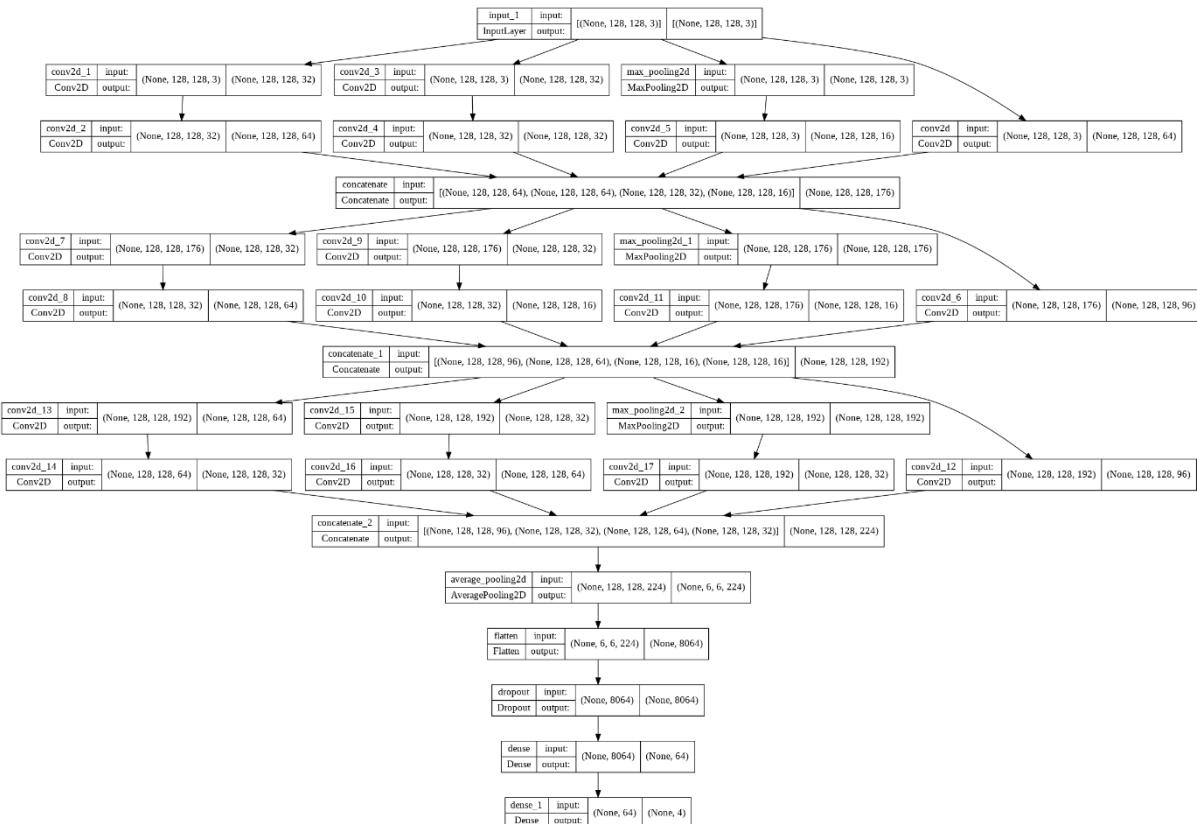
Inception modles:



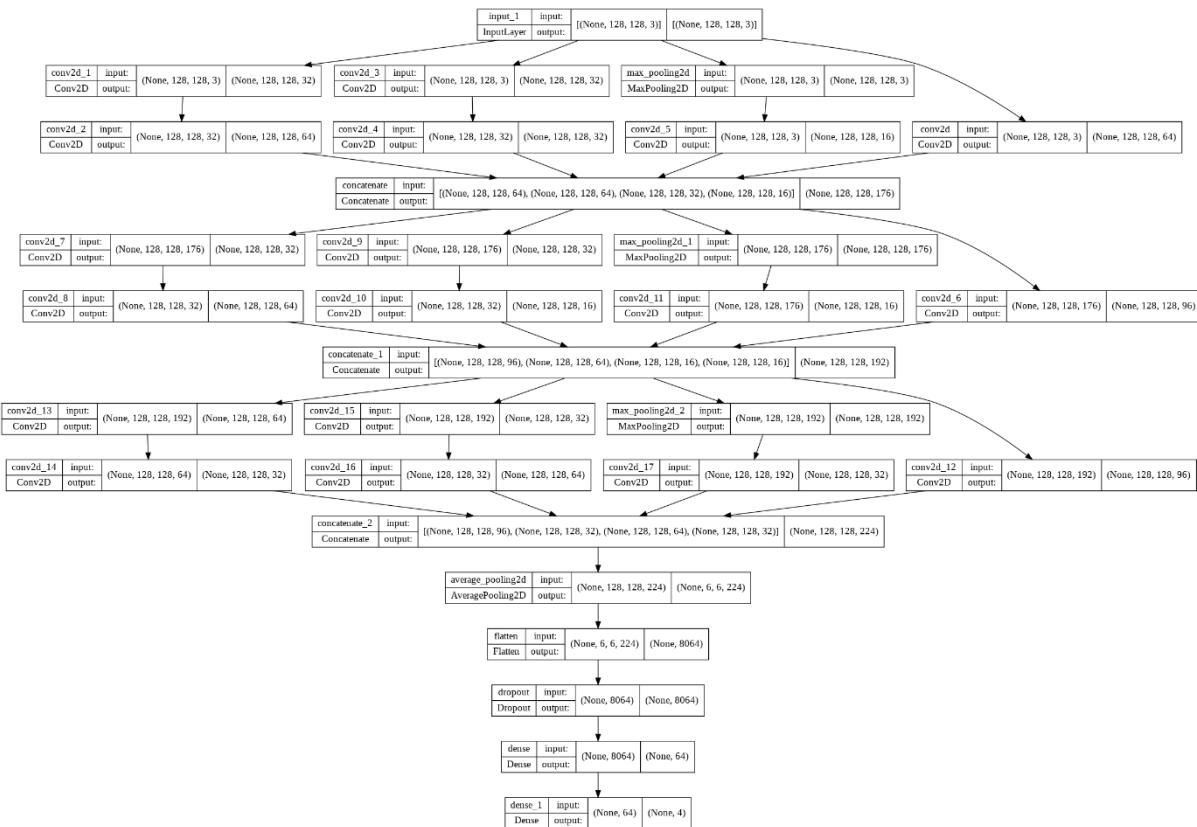
مودل Inception 1



مودل Inception 2



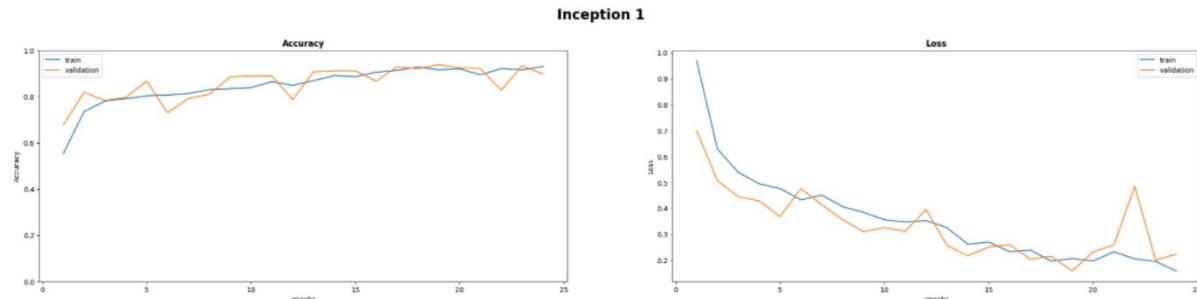
Model 3 Inception



Model 1 Accuracy و Loss

Evaluation:
8/8 [=====] - 3s 284ms/step - loss: 0.2259 - accuracy: 0.8982

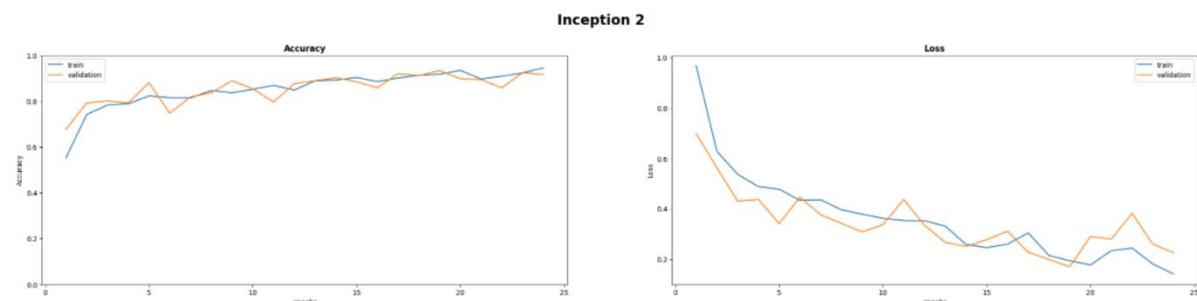
Plots:



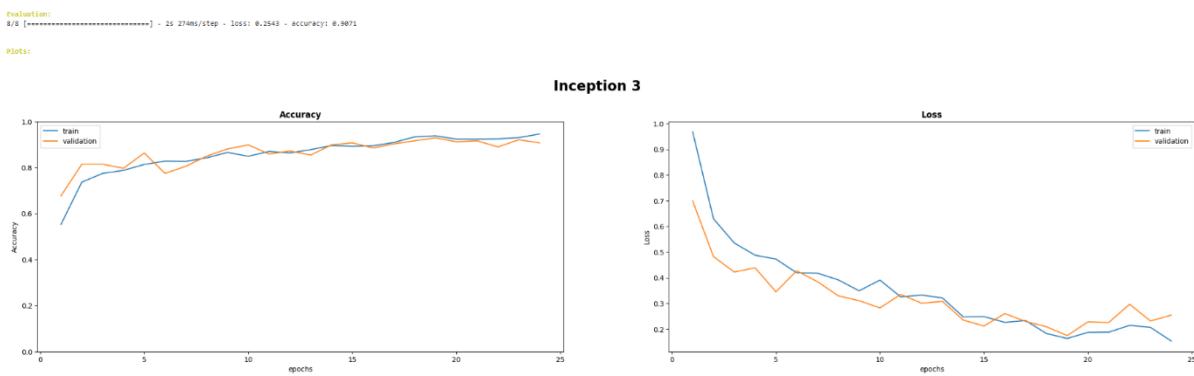
Model 2 Accuracy و Loss

Evaluation:
8/8 [=====] - 3s 280ms/step - loss: 0.2274 - accuracy: 0.9159

Plots:



نمودار Accuracy و Loss : Inception 3 مدل



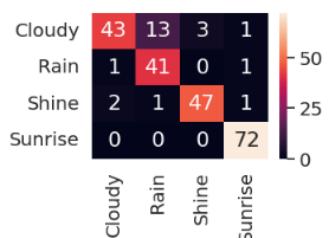
بررسی بیش برازش

برای جلوگیری از Overfitting در قسمت Call Backs فیت مدل‌ها از Stop Early استفاده شد.

Accuracy برای بهترین مدل (بر اساس بیشترین Confusion Matrix)

سایر معیارهای ارزیابی:

Confusion matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.9348	0.7167	0.8113	60
1	0.7455	0.9535	0.8367	43
2	0.9400	0.9216	0.9307	51
3	0.9600	1.0000	0.9796	72
accuracy			0.8982	226
macro avg	0.8951	0.8979	0.8896	226
weighted avg	0.9080	0.8982	0.8967	226

Inception 1:

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
Inception 1	(epoch index:23) Accuracy: 0.9299221634864807 Loss: 0.15949057042598724	(epoch index:18) Accuracy: 0.9380530714988708 Loss: 0.16025719046592712	(epoch index:23) Accuracy: 0.9299221634864807 Loss: 0.15949057042598724	(epoch index:18) Accuracy: 0.9380530714988708 Loss: 0.16025719046592712

◦ نتایج استفاده از تکنیک‌های داده‌افزایی (نموده مثبت)

از آنجایی که تعداد تصاویر این دیتاست برای آموزش یک شبکه عصبی عمیق Convolutional کم بود از ابتدای کار روی داده‌ها استفاده شد و نتایج داده‌ها بهبود چشم‌گیری داشتند.

```
# Generate Train and Val
def generate_sets():
    # fixing the seed
    set_random_seed()

    # paths of shuffled and splitted data
    train_path = "/content/splitted_output/train"
    val_path = "/content/splitted_output/val"

    # Train
    train_generator = train_datagen.flow_from_directory(
        train_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=True,
        class_mode='categorical')

    # Validation
    validation_generator = val_datagen.flow_from_directory(
        val_path,
        target_size=(avg_height, avg_width), # 334, 506
        batch_size=32,
        seed=seed,
        shuffle=False,
        class_mode='categorical')

    return train_generator, validation_generator
```

• اعلام سه مدل از بین مدل‌هایی که بیشترین دقت را داشته‌اند

۱- مدل Convolutional با سه لایه Kernel=3 و Stride=1 و Dilatation=2

و Maxpooling=2

```
Model: "sequential"
-----  

Layer (type)      Output Shape       Param #  

=====  

conv2d (Conv2D)   (None, 128, 128, 16)    448  

max_pooling2d (MaxPooling2D (None, 64, 64, 16)    0  

)  

conv2d_1 (Conv2D)   (None, 64, 64, 32)    4640  

max_pooling2d_1 (MaxPooling2D (None, 32, 32, 32)    0  

2D)  

conv2d_2 (Conv2D)   (None, 32, 32, 48)    13872  

max_pooling2d_2 (MaxPooling2D (None, 16, 16, 48)    0  

2D)  

flatten (Flatten)  (None, 12288)        0  

dense (Dense)     (None, 64)          786496  

dense_1 (Dense)   (None, 4)           260  

-----  

Total params: 805,716  

Trainable params: 805,716  

Non-trainable params: 0  

-----  

Found 899 images belonging to 4 classes.  

Found 226 images belonging to 4 classes.
```

Conv2d Model with Max Pooling 2 S1 D2:

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
Conv2d Model with Max Pooling 2 S1 D2	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909	(epoch index:23) Accuracy: 0.9644048810005188 Loss: 0.08637470006942749	(epoch index:18) Accuracy: 0.9513274431228638 Loss: 0.12058199197053909

۲- مدل Convolutional با سه لایه Kernel=3 و Stride=1 و Dilatation=2

و Padding Same

```
Model: "sequential"
-----  

Layer (type)      Output Shape       Param #  

=====  

conv2d (Conv2D)   (None, 128, 128, 16)    448  

conv2d_1 (Conv2D)   (None, 128, 128, 32)    4640  

conv2d_2 (Conv2D)   (None, 128, 128, 48)    13872  

flatten (Flatten)  (None, 786432)        0  

dense (Dense)     (None, 64)          50331712  

dense_1 (Dense)   (None, 4)           260  

-----  

Total params: 50,350,932  

Trainable params: 50,350,932  

Non-trainable params: 0  

-----  

Found 899 images belonging to 4 classes.  

Found 226 images belonging to 4 classes.
```

conv2d_3c_3k_s1_d2_pS:

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
conv2d_3c_3k_s1_d2_pS	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652	(epoch index:15) Accuracy: 0.9810901284217834 Loss: 0.04928159341216087	(epoch index:10) Accuracy: 0.9513274431228638 Loss: 0.13246247172355652

Batchnormalization مدل -۲

```
=====
conv2d (Conv2D)           (None, 128, 128, 16)    448
batch_normalization (BatchN ormalization)          (None, 128, 128, 16)    64
activation (Activation)      (None, 128, 128, 16)    0
max_pooling2d (MaxPooling2D (None, 64, 64, 16)    0
)
conv2d_1 (Conv2D)           (None, 64, 64, 32)     4640
batch_normalization_1 (BatchN ormalization)          (None, 64, 64, 32)     128
activation_1 (Activation)      (None, 64, 64, 32)     0
max_pooling2d_1 (MaxPooling2D (None, 32, 32, 32)    0
)
conv2d_2 (Conv2D)           (None, 32, 32, 48)     13872
batch_normalization_2 (BatchN ormalization)          (None, 32, 32, 48)     192
activation_2 (Activation)      (None, 32, 32, 48)     0
max_pooling2d_2 (MaxPooling2D (None, 16, 16, 48)    0
)
flatten (Flatten)           (None, 12288)        0
batch_normalization_3 (BatchN ormalization)          (None, 12288)        49152
dense (Dense)                (None, 64)          786496
batch_normalization_4 (BatchN ormalization)          (None, 64)          256
activation_3 (Activation)      (None, 64)          0
dense_1 (Dense)                (None, 4)          260
=====
Total params: 855,508
Trainable params: 830,612
Non-trainable params: 24,896
```

```
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.
```

Batchnormalization K3 D2 SP Max Pooling2:

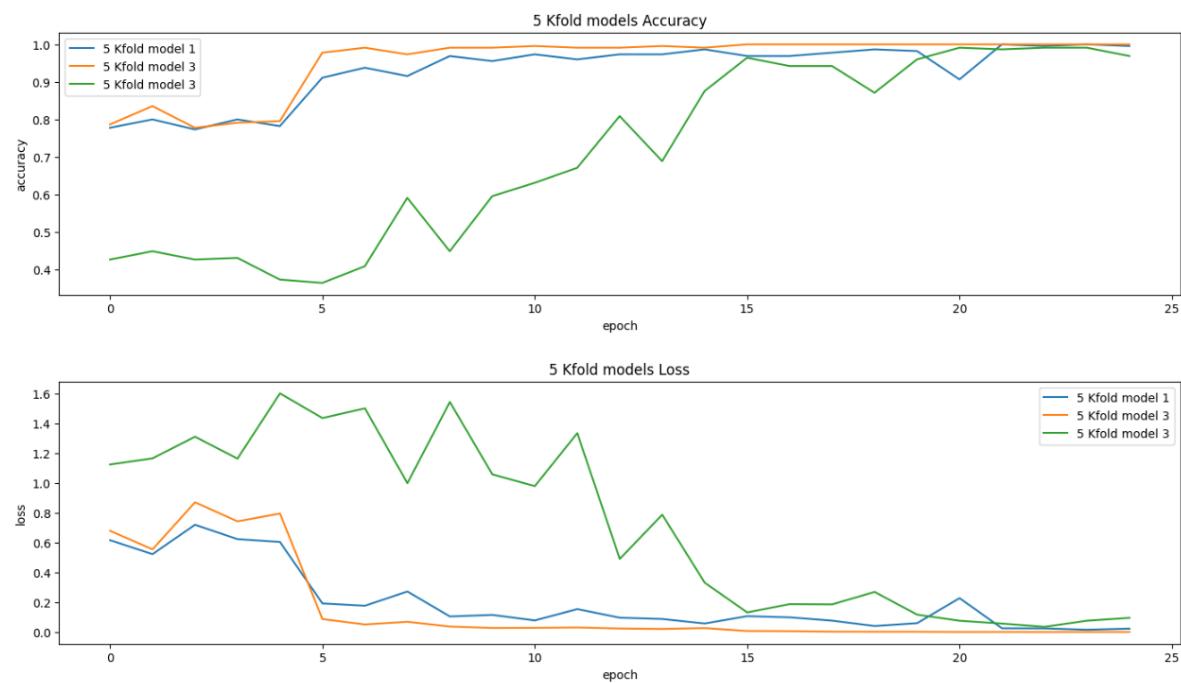
Number of Layers	Accuracy and Loss of train set according to Min train Loss	Accuracy and Loss of val set according to Min val Loss	Accuracy and Loss of train set according to Max train Accuracy	Accuracy and Loss of val set according to Max val Accuracy
Batchnormalization K3 D2 SP Max Pooling2	(epoch index:21) Accuracy: 0.9799777269363403 Loss: 0.06464717537164688	(epoch index:18) Accuracy: 0.9557521939277649 Loss: 0.16253776848316193	(epoch index:19) Accuracy: 0.9799777269363403 Loss: 0.07423228770494461	(epoch index:18) Accuracy: 0.9557521939277649 Loss: 0.16253776848316193

نتایج اجرای K=5 روی این سه مدل

5 Kfold models:

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
5 Kfold model 1	(epoch index:24) Accuracy: 0.997777600288391 Loss: 0.011578247882425785	(epoch index:23) Accuracy: 1.0 Loss: 0.014637871645390987	(epoch index:24) Accuracy: 0.997777600288391 Loss: 0.011578247882425785	(epoch index:21) Accuracy: 1.0 Loss: 0.02445078268647194
5 Kfold model 3	(epoch index:24) Accuracy: 1.0 Loss: 0.00013939336349721998	(epoch index:24) Accuracy: 1.0 Loss: 0.00012389157200232148	(epoch index:17) Accuracy: 1.0 Loss: 0.00197632797062397	(epoch index:15) Accuracy: 1.0 Loss: 0.006631745956838131
5 Kfold model 3	(epoch index:22) Accuracy: 0.9911110997200012 Loss: 0.03438982740044594	(epoch index:22) Accuracy: 0.9911110997200012 Loss: 0.03438982740044594	(epoch index:23) Accuracy: 0.997777600288391 Loss: 0.019164590165019035	(epoch index:20) Accuracy: 0.9911110997200012 Loss: 0.07533378899097443

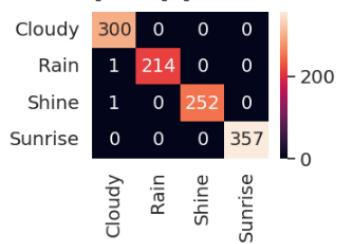
5 Kfold models:



مدل اول:

```
-----  
Training for fold 1 ...  
100% [██████████] 5/5 [00:14<0:00, 1.57s/epoch, loss=0.231, accuracy=0.918, val_loss=0.604, val_accuracy=0.782]  
Score for fold 1: loss of 0.6040328741073608; accuracy of 78.22222113609314%  
-----  
Training for fold 2 ...  
100% [██████████] 5/5 [00:02<0:00, 1.80epoch/s, loss=0.142, accuracy=0.948, val_loss=0.114, val_accuracy=0.956]  
Score for fold 2: loss of 0.11439688503742218; accuracy of 95.55555582046509%  
-----  
Training for fold 3 ...  
100% [██████████] 5/5 [00:02<0:00, 1.74epoch/s, loss=0.0921, accuracy=0.969, val_loss=0.0568, val_accuracy=0.987]  
Score for fold 3: loss of 0.05679718405008316; accuracy of 98.66666793823242%  
-----  
Training for fold 4 ...  
100% [██████████] 5/5 [00:02<0:00, 1.66epoch/s, loss=0.0212, accuracy=0.994, val_loss=0.0588, val_accuracy=0.982]  
Score for fold 4: loss of 0.05884858965873718; accuracy of 98.22221994400024%  
-----  
Training for fold 5 ...  
100% [██████████] 5/5 [00:03<0:00, 1.68epoch/s, loss=0.0116, accuracy=0.998, val_loss=0.022, val_accuracy=0.996]  
Score for fold 5: loss of 0.021996621042490005; accuracy of 99.5555579662323%
```

Confusion matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	0.9934	1.0000	0.9967	300
1	1.0000	0.9953	0.9977	215
2	1.0000	0.9960	0.9980	253
3	1.0000	1.0000	1.0000	357
accuracy			0.9982	1125
macro avg	0.9983	0.9978	0.9981	1125
weighted avg	0.9982	0.9982	0.9982	1125

5 Kfold model 1:

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
5 Kfold model 1	(epoch index:24) Accuracy: 0.997777600288391 Loss: 0.01578247882425785	(epoch index:23) Accuracy: 1.0 Loss: 0.014637871645390987	(epoch index:24) Accuracy: 0.997777600288391 Loss: 0.01578247882425785	(epoch index:21) Accuracy: 1.0 Loss: 0.02445078268647194

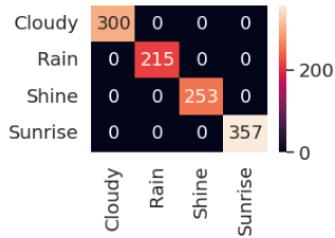
مدل دوم:

```
Training for fold 1 ...
-----[REDACTED]----- 5/5 [00:12<0:00, 2.36s/epoch, loss=0.157, accuracy=0.946, val_loss=0.795, val_accuracy=0.796]
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0270s vs `on_train_batch_end` time: 0.0380s). Check your callbacks.
Score for fold 1: loss of 0.7949630618095398; accuracy of 79.55555319786072%
-----[REDACTED]-----
Training for fold 2 ...
100% [REDACTED] 5/5 [00:11<0:00, 2.24s/epoch, loss=0.0344, accuracy=0.992, val_loss=0.0266, val_accuracy=0.991]
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0261s vs `on_train_batch_end` time: 0.0444s). Check your callbacks.
Score for fold 2: loss of 0.026560600847005844; accuracy of 99.1110997200012%
-----[REDACTED]-----
Training for fold 3 ...
100% [REDACTED] 5/5 [00:11<0:00, 2.20s/epoch, loss=0.00664, accuracy=0.998, val_loss=0.0257, val_accuracy=0.991]
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0264s vs `on_train_batch_end` time: 0.0451s). Check your callbacks.
Score for fold 3: loss of 0.025740098269104958; accuracy of 99.1110997200012%
-----[REDACTED]-----
Training for fold 4 ...
100% [REDACTED] 5/5 [00:10<0:00, 2.18s/epoch, loss=0.000224, accuracy=1, val_loss=0.00159, val_accuracy=1]
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0266s vs `on_train_batch_end` time: 0.0447s). Check your callbacks.
Score for fold 4: loss of 0.0015944538172334433; accuracy of 100.0%
-----[REDACTED]-----
Training for fold 5 ...
100% [REDACTED] 5/5 [00:11<0:00, 2.24s/epoch, loss=0.000139, accuracy=1, val_loss=0.000124, val_accuracy=1]
WARNING:tensorflow:Callback method `on_train_batch_end` is slow compared to the batch time (batch time: 0.0257s vs `on_train_batch_end` time: 0.0443s). Check your callbacks.
Score for fold 5: loss of 0.00012389157200232148; accuracy of 100.0%
```

Confusion matrix:

Found 899 images belonging to 4 classes.

Found 226 images belonging to 4 classes.



	precision	recall	f1-score	support
0	1.0000	1.0000	1.0000	300
1	1.0000	1.0000	1.0000	215
2	1.0000	1.0000	1.0000	253
3	1.0000	1.0000	1.0000	357
accuracy			1.0000	1125
macro avg	1.0000	1.0000	1.0000	1125
weighted avg	1.0000	1.0000	1.0000	1125

5 Kfold model 2:

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
5 Kfold model 2	(epoch index:24) Accuracy: 1.0 Loss: 0.00013939336349721998	(epoch index:24) Accuracy: 1.0 Loss: 0.00012389157200232148	(epoch index:17) Accuracy: 1.0 Loss: 0.00197632797062397	(epoch index:15) Accuracy: 1.0 Loss: 0.006631745956838131

مدل سوم

```
Training for fold 1 ...
100% [██████████] 5/5 [00:05<00:00, 1.22epoch/s, loss=0.0732, accuracy=0.987, val_loss=1.6, val_accuracy=0.373]
Score for fold 1: loss of 1.601885437965393; accuracy of 37.33333349227905%
-----
Training for fold 2 ...
100% [██████████] 5/5 [00:03<00:00, 1.50epoch/s, loss=0.0727, accuracy=0.982, val_loss=1.06, val_accuracy=0.596]
Score for fold 2: loss of 1.0581183433532715; accuracy of 59.55555438995361%
-----
Training for fold 3 ...
100% [██████████] 5/5 [00:03<00:00, 1.41epoch/s, loss=0.154, accuracy=0.954, val_loss=0.331, val_accuracy=0.876]
Score for fold 3: loss of 0.3308008909225464; accuracy of 87.55555748939514%
-----
Training for fold 4 ...
100% [██████████] 5/5 [00:03<00:00, 1.53epoch/s, loss=0.0511, accuracy=0.989, val_loss=0.116, val_accuracy=0.96]
Score for fold 4: loss of 0.11642072349786758; accuracy of 95.99999785423279%
-----
Training for fold 5 ...
100% [██████████] 5/5 [00:03<00:00, 1.50epoch/s, loss=0.028, accuracy=0.993, val_loss=0.0946, val_accuracy=0.969]
Score for fold 5: loss of 0.09457637369632721; accuracy of 96.88888788223267%
```

Confusion matrix:
Found 899 images belonging to 4 classes.
Found 226 images belonging to 4 classes.

	Cloudy	Rain	Shine	Sunrise
Cloudy	300	0	0	0
Rain	28	183	4	0
Shine	0	0	253	0
Sunrise	0	0	0	357

precision recall f1-score support

	0	1	2	3
0	0.9146	1.0000	0.9554	300
1	1.0000	0.8512	0.9196	215
2	0.9844	1.0000	0.9922	253
3	1.0000	1.0000	1.0000	357
accuracy			0.9716	1125
macro avg	0.9748	0.9628	0.9668	1125
weighted avg	0.9737	0.9716	0.9710	1125

5 Kfold model 3:

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
5 Kfold model 3	(epoch index:23) Accuracy: 0.997777600288391 Loss: 0.019164590165019035	(epoch index:22) Accuracy: 0.9911110997200012 Loss: 0.03438982740044594	(epoch index:23) Accuracy: 0.997777600288391 Loss: 0.019164590165019035	(epoch index:20) Accuracy: 0.9911110997200012 Loss: 0.07533378899097443

• مقایسه بین مدل‌های مختلف و اعلام بهترین مدل

با توجه به اعداد به دست آمده، مدل دوم بهترین نتیجه را دارا بود.

۱ - مدل Convolutional با سه لایه Convolution و با Kernel=3 و Stride=1 و Dilatation=2

Padding Same و

این مدل علاوه بر اینکه زودتر به مقدار خوبی از Accuracy می‌رسد، بسیار سبک بوده و درصد K Fold Accuracy قبل از آن علی‌رغم ساختار سبکش ۹۵ درصد با ۰.۱۳ Loss داشته است که با بعد از ۱۵ epoch یا ۳ فولد، به درصد ۱۰۰ Loss ۰.۰۰۶ رسید. با