Assignment 4

MRNet Dataset

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Introduction

The MRNet dataset consists of 1,370 knee MRI exams performed at Stanford University

Medical Center. The dataset contains 1,104 (80.6%) abnormal exams, with 319 (23.3%)

ACL tears and 508 (37.1%) meniscal tears; labels were obtained through manual

extraction from clinical reports.

We were asked to implement a CNN model to train the before mentioned data and see how accurately it predicted that the photo of the particular knee (given 3 different views of it) had any of the 3 labeled problems (Abnormality - ACL Tear - Meniscus Tear).

Step1: Download & Understand data:

We downloaded the dataset from the Stanford site and it contained the following:

6 CSV files , 3 for train and 3 for validation, containing the labels of the 3 different sicknesses in a single picture of a knee. 1 csv file for abnormal labels , 1 for acl tears and 1 for meniscus tears.

A train folder and a validate folder containing numpy files that contains the MRI of the knee in the form of slices , meaning that each numpy file has a particular number of slices representing the MRI of that specific knee for that specific view (Axial , Coronal , Sagittal) and it differs for each numpy file. However the pixels of each slice is the same [256,256] .

This concludes the step of downloading and understanding the dataset.

Step2: Pre-Processing:

We had to do some kind of pre-processing on the data after reading it.

We started by reading the data from google drive where we uploaded it, using panda frames we read all 3 csv label files and put them in dataframes and then we created a function that loops on the train folder directory and reading the numpy files into the shape (s,256,256) where s is the number of slices for the particular MRI.

The first pre processing thing we had to do was unite the s number for all the images and we did that using a function that finds the picture with the minimal number of slices and that the number we go with for all other pictures, we made a function that loops on all slices of each picture and choose a random combination of that same minimal number of slices previously decided.

The second pre processing step we had to was turn the 3 dimensional shape into a 4 dimensional shape because as we find out later the ResNet50 model only takes 4 dimensional shapes, so we did that by turning the 1 channel image or [grey scale] into a 3 channel image [RGB], turning it into the dimension (s,256,256,3) we did that using the CV2 resize function.

The third and last pre processing step we did was for the labels, the labels as we mentioned above were given for each picture not for each slice, so seeing that we decided to do our training on slice base information we had to enlarge the label data to be the same size and concept of the training data , so we made a function that repeated the label of each picture n times, n being the minimum number of slices in that entire MRI folder view. And that gave us our training labels.

This concludes the pre-processing part of our program.

Step3: Building The CNN Model:

We chose to use the ResNet50 architecture for our deep CNN model to perform the classification task.

We used 'imagenet' as pre-trained weights to help with the model building, the input_shape of our CNN is (256,256,3) the 3 channel (RGB) image.

Next we used GlobalAveragePooling2D() layer to help tune our model and for more efficient use of our RAM, followed by a dropout layer of 0.7 value, and a dense layer of a 'softmax' activation. We compiled using 'adam' optimization , categorical cross-entropy loss calculation and 'accuracy' metrics.

We then fit to our training data and training labels for the abnormal labels and we evaluate() on the test data and test abnormal labels we save the output of the evaluate() which is the loss and accuracy.

Followed by another model fit for the training data but with the ACL labels and evaluation on test data and ACL test labels. And ofcourse another fit with the Meniscus labels both train and test.

This is done using a function and the only thing that changes when we call it is the training and test data which each time is called using a different view (Axial,Coronal,Sagittal).

This way we end up with 9 accuracies , 3 for each view, 1 for each labeled sickness.

Results:

Step4: Combining Results:

To gather up the labels, we take the 3 Abnormal labels from all 3 models and append them in an array separately and the same goes for the 3 ACL labels and 3 Meniscus labels.

We then send each of these arrays to a function we made to combine all 3 labels into the final prediction :

If two of these abels is 0 , then the patient is considered to be healthy and doesn't have the disease.

If two of these labels is 1 , then the patient is considered to be sick.

We also provided another function that takes accuracies instead of the labels. And by the same concept calculates flags and returns average accuracy

<u>Step5: Tuning:</u>

We tried a few different but simple parameters to try and reach higher results and this is where we landed..

Epochs = 10

Batch size	Dropout ratio	Validation set
50	0.1	0.48288
50	0.7	0.5714
70	0.7	0.46433
80	0.7	0.56322
85	0.7	-
90	0.7	-

Step6: OUTPUT:

For a run with 3 epochs :

```
Epoch 1/3

10735/10735 [==============================] - 191s 18ms/step - loss: 1.2091 - acc: 
0.5046

Epoch 2/3

10735/10735 [==============================] - 180s 17ms/step - loss: 1.1135 - acc: 
0.4947

Epoch 3/3

10735/10735 [==============================] - 181s 17ms/step - loss: 1.1119 - acc: 
0.5081

1320/1320 [==============================] - 10s 7ms/step

F-Scores for Axial-Abnormal:

[0.55882353 0.42307692]

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Layer (type)                    Output Shape         Param #     Connected to

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input_4 (InputLayer)            (None, 256, 256, 3)  0

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conv1_pad (ZeroPadding2D)       (None, 262, 262, 3)  0           input_4[0][0]

__________________________________________________________________________________________________
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```
conv1 (Conv2D)                  (None, 128, 128, 64) 9472        conv1_pad[0][0]
__________________________________________________________________________________________________
bn_conv1 (BatchNormalization)   (None, 128, 128, 64) 256         conv1[0][0]
__________________________________________________________________________________________________
activation_135 (Activation)     (None, 128, 128, 64) 0           bn_conv1[0][0]
__________________________________________________________________________________________________
pool1_pad (ZeroPadding2D)       (None, 130, 130, 64) 0           activation_135[0][0]
__________________________________________________________________________________________________
max_pooling2d_4 (MaxPooling2D)  (None, 64, 64, 64)   0           pool1_pad[0][0]
__________________________________________________________________________________________________
res2a_branch2a (Conv2D)         (None, 64, 64, 64)   4160        max_pooling2d_4[0][0]
__________________________________________________________________________________________________
bn2a_branch2a (BatchNormalizati (None, 64, 64, 64)   256         res2a_branch2a[0][0]
__________________________________________________________________________________________________
activation_136 (Activation)     (None, 64, 64, 64)   0           bn2a_branch2a[0][0]
__________________________________________________________________________________________________
res2a_branch2b (Conv2D)         (None, 64, 64, 64)   36928       activation_136[0][0]
__________________________________________________________________________________________________
bn2a_branch2b (BatchNormalizati (None, 64, 64, 64)   256         res2a_branch2b[0][0]
__________________________________________________________________________________________________
activation_137 (Activation)     (None, 64, 64, 64)   0           bn2a_branch2b[0][0]
__________________________________________________________________________________________________
res2a_branch2c (Conv2D)         (None, 64, 64, 256)  16640       activation_137[0][0]
__________________________________________________________________________________________________
res2a_branch1 (Conv2D)          (None, 64, 64, 256)  16640       max_pooling2d_4[0][0]
__________________________________________________________________________________________________
bn2a_branch2c (BatchNormalizati (None, 64, 64, 256)  1024        res2a_branch2c[0][0]
__________________________________________________________________________________________________
bn2a_branch1 (BatchNormalizatio (None, 64, 64, 256)  1024        res2a_branch1[0][0]
__________________________________________________________________________________________________
add_44 (Add)                    (None, 64, 64, 256)  0           bn2a_branch2c[0][0]
                                                                 bn2a_branch1[0][0]
__________________________________________________________________________________________________
activation_138 (Activation)     (None, 64, 64, 256)  0           add_44[0][0]
__________________________________________________________________________________________________
res2b_branch2a (Conv2D)         (None, 64, 64, 64)   16448       activation_138[0][0]
__________________________________________________________________________________________________
bn2b_branch2a (BatchNormalizati (None, 64, 64, 64)   256         res2b_branch2a[0][0]
__________________________________________________________________________________________________
activation_139 (Activation)     (None, 64, 64, 64)   0           bn2b_branch2a[0][0]
__________________________________________________________________________________________________
res2b_branch2b (Conv2D)         (None, 64, 64, 64)   36928       activation_139[0][0]
__________________________________________________________________________________________________
bn2b_branch2b (BatchNormalizati (None, 64, 64, 64)   256         res2b_branch2b[0][0]
__________________________________________________________________________________________________
activation_140 (Activation)     (None, 64, 64, 64)   0           bn2b_branch2b[0][0]
__________________________________________________________________________________________________
res2b_branch2c (Conv2D)         (None, 64, 64, 256)  16640       activation_140[0][0]
__________________________________________________________________________________________________
bn2b_branch2c (BatchNormalizati (None, 64, 64, 256)  1024        res2b_branch2c[0][0]
__________________________________________________________________________________________________
add_45 (Add)                    (None, 64, 64, 256)  0           bn2b_branch2c[0][0]
                                                                 activation_138[0][0]
__________________________________________________________________________________________________
activation_141 (Activation)     (None, 64, 64, 256)  0           add_45[0][0]
__________________________________________________________________________________________________
res2c_branch2a (Conv2D)         (None, 64, 64, 64)   16448       activation_141[0][0]
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bn2c_branch2a (BatchNormalizati (None, 64, 64, 64)   256         res2c_branch2a[0][0]

__________________________________________________________________________________________________

activation_142 (Activation)     (None, 64, 64, 64)   0           bn2c_branch2a[0][0]

__________________________________________________________________________________________________

res2c_branch2b (Conv2D)         (None, 64, 64, 64)   36928       activation_142[0][0]

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bn2c_branch2b (BatchNormalizati (None, 64, 64, 64)   256         res2c_branch2b[0][0]

__________________________________________________________________________________________________

activation_143 (Activation)     (None, 64, 64, 64)   0           bn2c_branch2b[0][0]

__________________________________________________________________________________________________

res2c_branch2c (Conv2D)         (None, 64, 64, 256)  16640       activation_143[0][0]

__________________________________________________________________________________________________

bn2c_branch2c (BatchNormalizati (None, 64, 64, 256)  1024        res2c_branch2c[0][0]

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add_46 (Add)                    (None, 64, 64, 256)  0           bn2c_branch2c[0][0]

                                                                 activation_141[0][0]

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activation_144 (Activation)     (None, 64, 64, 256)  0           add_46[0][0]

__________________________________________________________________________________________________

res3a_branch2a (Conv2D)         (None, 32, 32, 128)  32896       activation_144[0][0]

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bn3a_branch2a (BatchNormalizati (None, 32, 32, 128)  512         res3a_branch2a[0][0]

__________________________________________________________________________________________________

activation_145 (Activation)     (None, 32, 32, 128)  0           bn3a_branch2a[0][0]

__________________________________________________________________________________________________

res3a_branch2b (Conv2D)         (None, 32, 32, 128)  147584      activation_145[0][0]

__________________________________________________________________________________________________

bn3a_branch2b (BatchNormalizati (None, 32, 32, 128)  512         res3a_branch2b[0][0]

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activation_146 (Activation)     (None, 32, 32, 128)  0           bn3a_branch2b[0][0]

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res3a_branch2c (Conv2D)         (None, 32, 32, 512)  66048       activation_146[0][0]

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res3a_branch1 (Conv2D)          (None, 32, 32, 512)  131584      activation_144[0][0]

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bn3a_branch2c (BatchNormalizati (None, 32, 32, 512)  2048        res3a_branch2c[0][0]

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bn3a_branch1 (BatchNormalizatio (None, 32, 32, 512)  2048        res3a_branch1[0][0]

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add_47 (Add)                    (None, 32, 32, 512)  0           bn3a_branch2c[0][0]

                                                                 bn3a_branch1[0][0]

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activation_147 (Activation)     (None, 32, 32, 512)  0           add_47[0][0]

__________________________________________________________________________________________________

res3b_branch2a (Conv2D)         (None, 32, 32, 128)  65664       activation_147[0][0]

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bn3b_branch2a (BatchNormalizati (None, 32, 32, 128)  512         res3b_branch2a[0][0]

__________________________________________________________________________________________________

activation_148 (Activation)     (None, 32, 32, 128)  0           bn3b_branch2a[0][0]

__________________________________________________________________________________________________

res3b_branch2b (Conv2D)         (None, 32, 32, 128)  147584      activation_148[0][0]

__________________________________________________________________________________________________

bn3b_branch2b (BatchNormalizati (None, 32, 32, 128)  512         res3b_branch2b[0][0]

__________________________________________________________________________________________________

activation_149 (Activation)     (None, 32, 32, 128)  0           bn3b_branch2b[0][0]

__________________________________________________________________________________________________

res3b_branch2c (Conv2D)         (None, 32, 32, 512)  66048       activation_149[0][0]

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bn3b_branch2c (BatchNormalizati (None, 32, 32, 512)  2048        res3b_branch2c[0][0]

__________________________________________________________________________________________________

add_48 (Add)                    (None, 32, 32, 512)  0           bn3b_branch2c[0][0]

                                                                 activation_147[0][0]

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activation_150 (Activation)     (None, 32, 32, 512)  0           add_48[0][0]

__________________________________________________________________________________________________

res3c_branch2a (Conv2D)         (None, 32, 32, 128)  65664       activation_150[0][0]

__________________________________________________________________________________________________

bn3c_branch2a (BatchNormalizati (None, 32, 32, 128)  512         res3c_branch2a[0][0]

__________________________________________________________________________________________________

activation_151 (Activation)     (None, 32, 32, 128)  0           bn3c_branch2a[0][0]

__________________________________________________________________________________________________

res3c_branch2b (Conv2D)         (None, 32, 32, 128)  147584      activation_151[0][0]

__________________________________________________________________________________________________

bn3c_branch2b (BatchNormalizati (None, 32, 32, 128)  512         res3c_branch2b[0][0]

__________________________________________________________________________________________________

activation_152 (Activation)     (None, 32, 32, 128)  0           bn3c_branch2b[0][0]

__________________________________________________________________________________________________

res3c_branch2c (Conv2D)         (None, 32, 32, 512)  66048       activation_152[0][0]

__________________________________________________________________________________________________

bn3c_branch2c (BatchNormalizati (None, 32, 32, 512)  2048        res3c_branch2c[0][0]

__________________________________________________________________________________________________

add_49 (Add)                    (None, 32, 32, 512)  0           bn3c_branch2c[0][0]

                                                                 activation_150[0][0]

__________________________________________________________________________________________________

activation_153 (Activation)     (None, 32, 32, 512)  0           add_49[0][0]

__________________________________________________________________________________________________

res3d_branch2a (Conv2D)         (None, 32, 32, 128)  65664       activation_153[0][0]
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__________________________________________________________________________________________________
bn3d_branch2a (BatchNormalizati (None, 32, 32, 128)  512         res3d_branch2a[0][0]
__________________________________________________________________________________________________
activation_154 (Activation)     (None, 32, 32, 128)  0           bn3d_branch2a[0][0]
__________________________________________________________________________________________________
res3d_branch2b (Conv2D)         (None, 32, 32, 128)  147584      activation_154[0][0]
__________________________________________________________________________________________________
bn3d_branch2b (BatchNormalizati (None, 32, 32, 128)  512         res3d_branch2b[0][0]
__________________________________________________________________________________________________
activation_155 (Activation)     (None, 32, 32, 128)  0           bn3d_branch2b[0][0]
__________________________________________________________________________________________________
res3d_branch2c (Conv2D)         (None, 32, 32, 512)  66048       activation_155[0][0]
__________________________________________________________________________________________________
bn3d_branch2c (BatchNormalizati (None, 32, 32, 512)  2048        res3d_branch2c[0][0]
__________________________________________________________________________________________________
add_50 (Add)                    (None, 32, 32, 512)  0           bn3d_branch2c[0][0]
                                                                 activation_153[0][0]
__________________________________________________________________________________________________
activation_156 (Activation)     (None, 32, 32, 512)  0           add_50[0][0]
__________________________________________________________________________________________________
res4a_branch2a (Conv2D)         (None, 16, 16, 256)  131328      activation_156[0][0]
__________________________________________________________________________________________________
bn4a_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4a_branch2a[0][0]
__________________________________________________________________________________________________
activation_157 (Activation)     (None, 16, 16, 256)  0           bn4a_branch2a[0][0]
__________________________________________________________________________________________________
res4a_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_157[0][0]
__________________________________________________________________________________________________
bn4a_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4a_branch2b[0][0]
__________________________________________________________________________________________________
activation_158 (Activation)     (None, 16, 16, 256)  0           bn4a_branch2b[0][0]
__________________________________________________________________________________________________
res4a_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_158[0][0]
__________________________________________________________________________________________________
res4a_branch1 (Conv2D)          (None, 16, 16, 1024) 525312      activation_156[0][0]
__________________________________________________________________________________________________
bn4a_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4a_branch2c[0][0]
__________________________________________________________________________________________________
bn4a_branch1 (BatchNormalizatio (None, 16, 16, 1024) 4096        res4a_branch1[0][0]
__________________________________________________________________________________________________
add_51 (Add)                    (None, 16, 16, 1024) 0           bn4a_branch2c[0][0]
                                                                 bn4a_branch1[0][0]
__________________________________________________________________________________________________
activation_159 (Activation)     (None, 16, 16, 1024) 0           add_51[0][0]
__________________________________________________________________________________________________
res4b_branch2a (Conv2D)         (None, 16, 16, 256)  262400      activation_159[0][0]
__________________________________________________________________________________________________
bn4b_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4b_branch2a[0][0]
__________________________________________________________________________________________________
activation_160 (Activation)     (None, 16, 16, 256)  0           bn4b_branch2a[0][0]
__________________________________________________________________________________________________
res4b_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_160[0][0]
__________________________________________________________________________________________________
bn4b_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4b_branch2b[0][0]
__________________________________________________________________________________________________
activation_161 (Activation)     (None, 16, 16, 256)  0           bn4b_branch2b[0][0]
__________________________________________________________________________________________________
res4b_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_161[0][0]
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__________________________________________________________________________________________________
bn4b_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4b_branch2c[0][0]
__________________________________________________________________________________________________
add_52 (Add)                    (None, 16, 16, 1024) 0           bn4b_branch2c[0][0]
                                                                 activation_159[0][0]
__________________________________________________________________________________________________
activation_162 (Activation)     (None, 16, 16, 1024) 0           add_52[0][0]
__________________________________________________________________________________________________
res4c_branch2a (Conv2D)         (None, 16, 16, 256)  262400      activation_162[0][0]
__________________________________________________________________________________________________
bn4c_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4c_branch2a[0][0]
__________________________________________________________________________________________________
activation_163 (Activation)     (None, 16, 16, 256)  0           bn4c_branch2a[0][0]
__________________________________________________________________________________________________
res4c_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_163[0][0]
__________________________________________________________________________________________________
bn4c_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4c_branch2b[0][0]
__________________________________________________________________________________________________
activation_164 (Activation)     (None, 16, 16, 256)  0           bn4c_branch2b[0][0]
__________________________________________________________________________________________________
res4c_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_164[0][0]
__________________________________________________________________________________________________
bn4c_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4c_branch2c[0][0]
__________________________________________________________________________________________________
add_53 (Add)                    (None, 16, 16, 1024) 0           bn4c_branch2c[0][0]
                                                                 activation_162[0][0]
__________________________________________________________________________________________________
activation_165 (Activation)     (None, 16, 16, 1024) 0           add_53[0][0]
__________________________________________________________________________________________________
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res4d_branch2a (Conv2D)         (None, 16, 16, 256)  262400      activation_165[0][0]

__________________________________________________________________________________________________

bn4d_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4d_branch2a[0][0]

__________________________________________________________________________________________________

activation_166 (Activation)     (None, 16, 16, 256)  0           bn4d_branch2a[0][0]

__________________________________________________________________________________________________

res4d_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_166[0][0]

__________________________________________________________________________________________________

bn4d_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4d_branch2b[0][0]

__________________________________________________________________________________________________

activation_167 (Activation)     (None, 16, 16, 256)  0           bn4d_branch2b[0][0]

__________________________________________________________________________________________________

res4d_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_167[0][0]

__________________________________________________________________________________________________

bn4d_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4d_branch2c[0][0]

__________________________________________________________________________________________________

add_54 (Add)                    (None, 16, 16, 1024) 0           bn4d_branch2c[0][0]

                                                                 activation_165[0][0]

__________________________________________________________________________________________________

activation_168 (Activation)     (None, 16, 16, 1024) 0           add_54[0][0]

__________________________________________________________________________________________________

res4e_branch2a (Conv2D)         (None, 16, 16, 256)  262400      activation_168[0][0]

__________________________________________________________________________________________________

bn4e_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4e_branch2a[0][0]

__________________________________________________________________________________________________

activation_169 (Activation)     (None, 16, 16, 256)  0           bn4e_branch2a[0][0]

__________________________________________________________________________________________________

res4e_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_169[0][0]

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bn4e_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4e_branch2b[0][0]

__________________________________________________________________________________________________

activation_170 (Activation)     (None, 16, 16, 256)  0           bn4e_branch2b[0][0]

__________________________________________________________________________________________________

res4e_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_170[0][0]

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bn4e_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4e_branch2c[0][0]

__________________________________________________________________________________________________

add_55 (Add)                    (None, 16, 16, 1024) 0           bn4e_branch2c[0][0]

                                                                 activation_168[0][0]

__________________________________________________________________________________________________

activation_171 (Activation)     (None, 16, 16, 1024) 0           add_55[0][0]

__________________________________________________________________________________________________

res4f_branch2a (Conv2D)         (None, 16, 16, 256)  262400      activation_171[0][0]

__________________________________________________________________________________________________

bn4f_branch2a (BatchNormalizati (None, 16, 16, 256)  1024        res4f_branch2a[0][0]

__________________________________________________________________________________________________

activation_172 (Activation)     (None, 16, 16, 256)  0           bn4f_branch2a[0][0]

__________________________________________________________________________________________________

res4f_branch2b (Conv2D)         (None, 16, 16, 256)  590080      activation_172[0][0]

__________________________________________________________________________________________________

bn4f_branch2b (BatchNormalizati (None, 16, 16, 256)  1024        res4f_branch2b[0][0]

__________________________________________________________________________________________________

activation_173 (Activation)     (None, 16, 16, 256)  0           bn4f_branch2b[0][0]

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res4f_branch2c (Conv2D)         (None, 16, 16, 1024) 263168      activation_173[0][0]

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bn4f_branch2c (BatchNormalizati (None, 16, 16, 1024) 4096        res4f_branch2c[0][0]

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add_56 (Add)                    (None, 16, 16, 1024) 0           bn4f_branch2c[0][0]

                                                                 activation_171[0][0]

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activation_174 (Activation)     (None, 16, 16, 1024) 0           add_56[0][0]

__________________________________________________________________________________________________

res5a_branch2a (Conv2D)         (None, 8, 8, 512)    524800      activation_174[0][0]

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bn5a_branch2a (BatchNormalizati (None, 8, 8, 512)    2048        res5a_branch2a[0][0]

__________________________________________________________________________________________________

activation_175 (Activation)     (None, 8, 8, 512)    0           bn5a_branch2a[0][0]

__________________________________________________________________________________________________

res5a_branch2b (Conv2D)         (None, 8, 8, 512)    2359808     activation_175[0][0]

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bn5a_branch2b (BatchNormalizati (None, 8, 8, 512)    2048        res5a_branch2b[0][0]

__________________________________________________________________________________________________

activation_176 (Activation)     (None, 8, 8, 512)    0           bn5a_branch2b[0][0]

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res5a_branch2c (Conv2D)         (None, 8, 8, 2048)   1050624     activation_176[0][0]

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res5a_branch1 (Conv2D)          (None, 8, 8, 2048)   2099200     activation_174[0][0]

__________________________________________________________________________________________________

bn5a_branch2c (BatchNormalizati (None, 8, 8, 2048)   8192        res5a_branch2c[0][0]

__________________________________________________________________________________________________

bn5a_branch1 (BatchNormalizatio (None, 8, 8, 2048)   8192        res5a_branch1[0][0]

__________________________________________________________________________________________________

add_57 (Add)                    (None, 8, 8, 2048)   0           bn5a_branch2c[0][0]

                                                                 bn5a_branch1[0][0]

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activation_177 (Activation)     (None, 8, 8, 2048)   0           add_57[0][0]
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__________________________________________________________________________________________________
res5b_branch2a (Conv2D)         (None, 8, 8, 512)    1049088     activation_177[0][0]
__________________________________________________________________________________________________
bn5b_branch2a (BatchNormalizati (None, 8, 8, 512)    2048        res5b_branch2a[0][0]
__________________________________________________________________________________________________
activation_178 (Activation)     (None, 8, 8, 512)    0           bn5b_branch2a[0][0]
__________________________________________________________________________________________________
res5b_branch2b (Conv2D)         (None, 8, 8, 512)    2359808     activation_178[0][0]
__________________________________________________________________________________________________
bn5b_branch2b (BatchNormalizati (None, 8, 8, 512)    2048        res5b_branch2b[0][0]
__________________________________________________________________________________________________
activation_179 (Activation)     (None, 8, 8, 512)    0           bn5b_branch2b[0][0]
__________________________________________________________________________________________________
res5b_branch2c (Conv2D)         (None, 8, 8, 2048)   1050624     activation_179[0][0]
__________________________________________________________________________________________________
bn5b_branch2c (BatchNormalizati (None, 8, 8, 2048)   8192        res5b_branch2c[0][0]
__________________________________________________________________________________________________
add_58 (Add)                    (None, 8, 8, 2048)   0           bn5b_branch2c[0][0]
                                                                 activation_177[0][0]
__________________________________________________________________________________________________
activation_180 (Activation)     (None, 8, 8, 2048)   0           add_58[0][0]
__________________________________________________________________________________________________
res5c_branch2a (Conv2D)         (None, 8, 8, 512)    1049088     activation_180[0][0]
__________________________________________________________________________________________________
bn5c_branch2a (BatchNormalizati (None, 8, 8, 512)    2048        res5c_branch2a[0][0]
__________________________________________________________________________________________________
activation_181 (Activation)     (None, 8, 8, 512)    0           bn5c_branch2a[0][0]
__________________________________________________________________________________________________
res5c_branch2b (Conv2D)         (None, 8, 8, 512)    2359808     activation_181[0][0]
```

```
________________________________________________________________________________________________

bn5c_branch2b (BatchNormalizati (None, 8, 8, 512)    2048        res5c_branch2b[0][0]

________________________________________________________________________________________________

activation_182 (Activation)     (None, 8, 8, 512)    0           bn5c_branch2b[0][0]

________________________________________________________________________________________________

res5c_branch2c (Conv2D)         (None, 8, 8, 2048)   1050624     activation_182[0][0]

________________________________________________________________________________________________

bn5c_branch2c (BatchNormalizati (None, 8, 8, 2048)   8192        res5c_branch2c[0][0]

________________________________________________________________________________________________

add_59 (Add)                    (None, 8, 8, 2048)   0           bn5c_branch2c[0][0]

                                                                 activation_180[0][0]

________________________________________________________________________________________________

activation_183 (Activation)     (None, 8, 8, 2048)   0           add_59[0][0]

________________________________________________________________________________________________

global_average_pooling2d_3 (Glo (None, 2048)         0           activation_183[0][0]

________________________________________________________________________________________________

dropout_3 (Dropout)             (None, 2048)         0           global_average_pooling2d_3[0][0]

________________________________________________________________________________________________

dense_3 (Dense)                 (None, 2)            4098        dropout_3[0][0]

================================================================================================

Total params: 23,591,810

Trainable params: 23,538,690

Non-trainable params: 53,120

Epoch 1/3

10735/10735 [==============================] - 181s 17ms/step - loss: 0.2773 - acc: 0.5058

Epoch 2/3

10735/10735 [==============================] - 181s 17ms/step - loss: 0.2773 - acc: 0.4873

Epoch 3/3

10735/10735 [==============================] - 181s 17ms/step - loss: 0.2773 - acc: 0.4875
```

```
1320/1320 [==============================] - 7s 5ms/step

F-Scores for Axial-ACL:

[0.60273973 0.38297872]
```

```
Epoch 1/3

10735/10735 [==============================] - 182s 17ms/step - loss: 0.5079 - acc: 0.5031

Epoch 2/3

10735/10735 [==============================] - 182s 17ms/step - loss: 0.5079 - acc: 0.5086

Epoch 3/3

10735/10735 [==============================] - 181s 17ms/step - loss: 0.5079 - acc: 0.5060

printaya le mennaya eval 2

1320/1320 [==============================] - 7s 5ms/step

F-Scores for Axial-Meniscus:

[0.52631579 0.18181818]
```

Loss = 0.8318139567519679

Test Accuracy = 0.5787878784266385

Loss = 0.3696857517415827

Test Accuracy = 0.4492424249649048

Loss = 0.1617361494989106

Test Accuracy = 0.4340909087296688

CORONAL:

```
Epoch 1/3

9605/9605 [==============================] - 185s 19ms/step - loss: 1.2095 - acc: 0.4999

Epoch 2/3

9605/9605 [==============================] - 167s 17ms/step - loss: 1.1128 - acc: 0.4913

Epoch 3/3

9605/9605 [==============================] - 167s 17ms/step - loss: 1.1118 - acc: 0.4826

printaya le mennaya eval 0

1020/1020 [==============================] - 12s 12ms/step

F-Scores for Coronal-Abnormal:

[0.27906977 0.5974026 ]




Epoch 1/3

9605/9605 [==============================] - 167s 17ms/step - loss: 0.2773 - acc:
0.4658

Epoch 2/3
```

```
9605/9605 [==============================] - 167s 17ms/step - loss: 0.2773 - acc:
0.4804

Epoch 3/3

9605/9605 [==============================] - 167s 17ms/step - loss: 0.2773 - acc:
0.4811

printaya le mennaya eval 1

1020/1020 [==============================] - 5s 5ms/step

F-Scores for Coronal-ACL:

[0.46376812 0.2745098 ]
```

```
Epoch 1/3

9605/9605 [==============================] - 167s 17ms/step - loss: 0.5079 - acc: 0.4734

Epoch 2/3

9605/9605 [==============================] - 167s 17ms/step - loss: 0.5079 - acc: 0.4918

Epoch 3/3

9605/9605 [==============================] - 167s 17ms/step - loss: 0.5079 - acc: 0.4965

printaya le mennaya eval 2

1020/1020 [==============================] - 5s 5ms/step

F-Scores for Coronal-Meniscus:

[0.63414634 0.21052632]
```

Loss = 0.8317977049771477

Test Accuracy = 0.39901960854436835

Loss = 0.3696818092290093

Test Accuracy = 0.4411764707051071

Loss = 0.1617348264245426

Test Accuracy = 0.4833333334502052

```
Epoch 1/3

9605/9605 [==============================] - 174s 18ms/step - loss: 1.2174 - acc:
0.5028

Epoch 2/3

9605/9605 [==============================] - 165s 17ms/step - loss: 1.1139 - acc:
0.4994

Epoch 3/3

9605/9605 [==============================] - 165s 17ms/step - loss: 1.1120 - acc:
0.5049

1260/1260 [==============================] - 11s 8ms/step

F-Scores for sagittal-Abnormal:

[0.51724138 0.5483871 ]

Epoch 1/3

9605/9605 [==============================] - 169s 18ms/step - loss: 0.2773 - acc:
0.5071

Epoch 2/3

9605/9605 [==============================] - 169s 18ms/step - loss: 0.2773 - acc:
0.5085

Epoch 3/3

9605/9605 [==============================] - 169s 18ms/step - loss: 0.2773 - acc:
0.5027

1260/1260 [==============================] - 6s 5ms/step

F-Scores for Sagittal-ACL:

[0.30188679 0.44776119]

Epoch 1/3

9605/9605 [==============================] - 170s 18ms/step - loss: 0.5079 - acc:
0.5044

Epoch 2/3
```

```
9605/9605 [==============================] - 170s 18ms/step - loss: 0.5079 - acc:
0.5044

Epoch 3/3

9605/9605 [==============================] - 169s 18ms/step - loss: 0.5079 - acc:
0.5095


1260/1260 [==============================] - 6s 5ms/step

F-Scores for Sagittal-Meniscus:

[0.41791045 0.26415094]


Loss = 0.8318177465408567

Test Accuracy = 0.5420634918742709

Loss = 0.36969071134688364

Test Accuracy = 0.3650793651739756

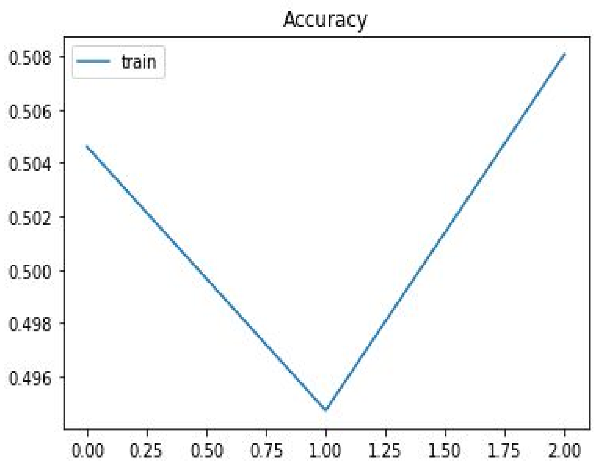
Loss = 0.161735363044436

Test Accuracy = 0.4063492062545958
```

Big Picture:

AXIAL:

Abnormal F-score & Accuracy:



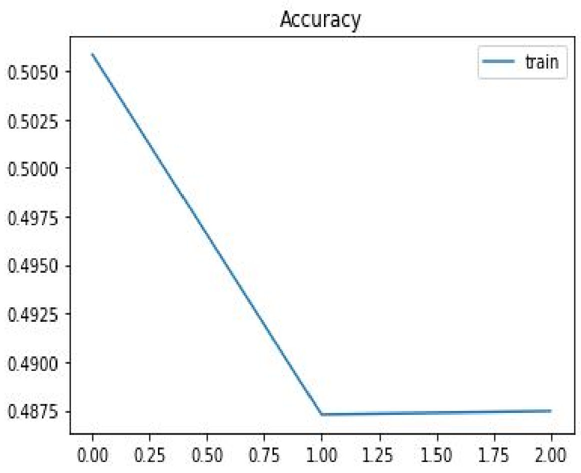
F-score:

[0.55882353 0.42307692]

Loss = 0.8318139567519679

Test Accuracy = 0.5787878784266385

ACL F-score & Accuracy:



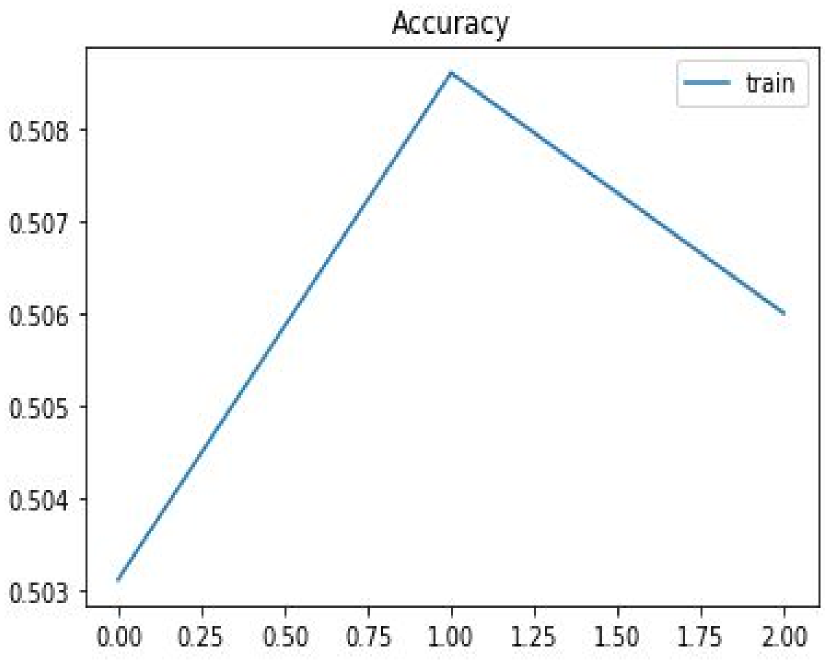
F-score:

[0.60273973 0.38297872]

Loss = 0.3696857517415827

Test Accuracy = 0.4492424249649048

Meniscus F-score & Accuracy:



F-score:

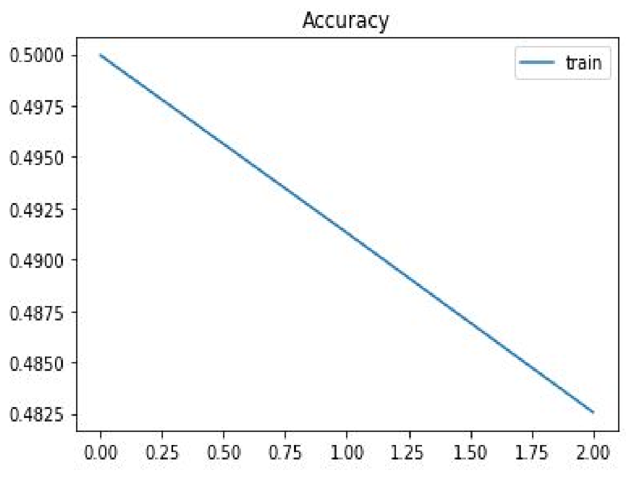
[0.52631579 0.18181818]

Loss = 0.1617361494989106

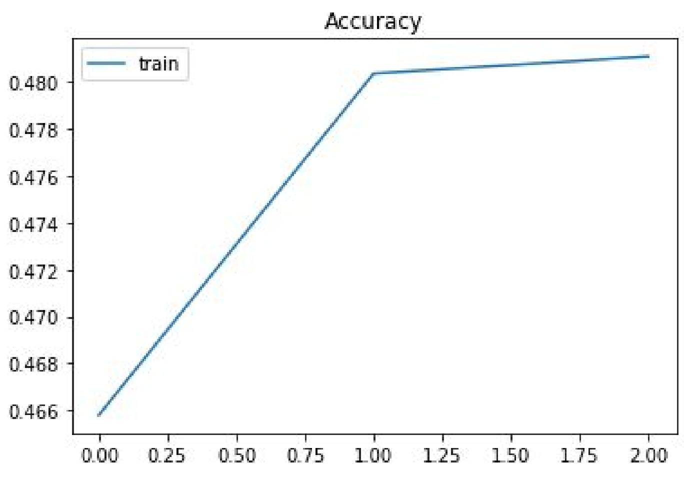
Test Accuracy = 0.4340909087296688

CORONAL:

Abnormal F-score & Accuracy:



ACL F-score & Accuracy:



F-score:

[0.27906977 0.5974026]

Loss = 0.8317977049771477

Test Accuracy = 0.39901960854436835

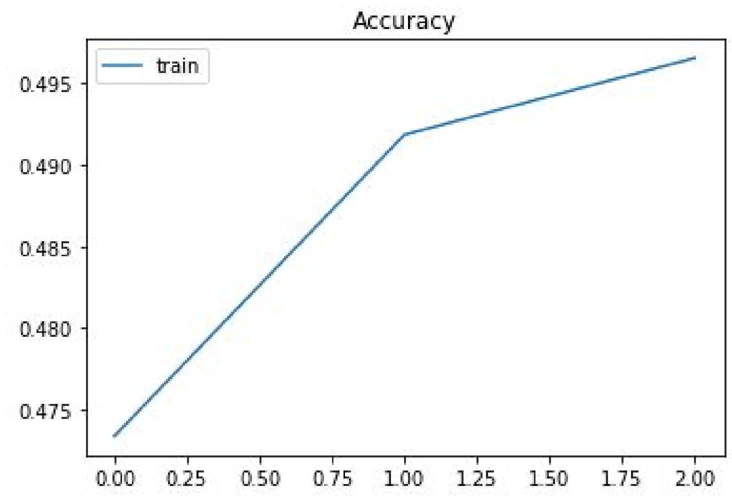
F-score:

[0.46376812 0.2745098]

Loss = 0.3696818092290093

Test Accuracy = 0.4411764707051071

Meniscus F-score & Accuracy:



F-Score:

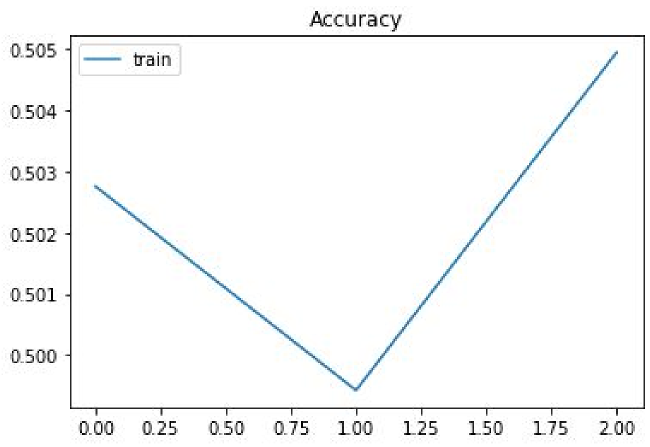
[0.63414634 0.21052632]

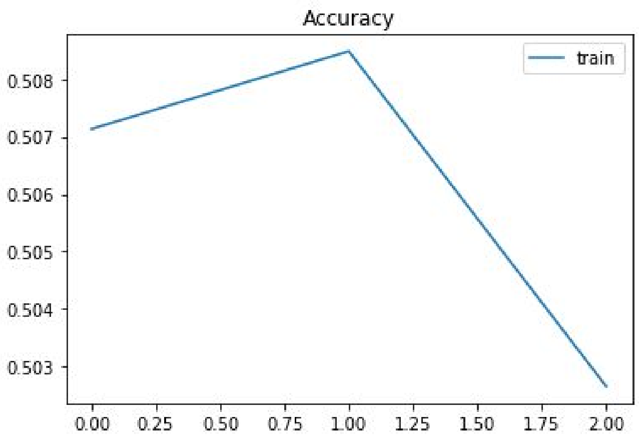
Loss = 0.1617348264245426

Test Accuracy = 0.4833333334502052

Sagittal:

Abnormal F-score & Accuracy: ACL F-score & Accuracy:





F-score:

```
[0.51724138 0.5483871 ]
```

Loss = 0.8318177465408567

Test Accuracy = 0.5420634918742709

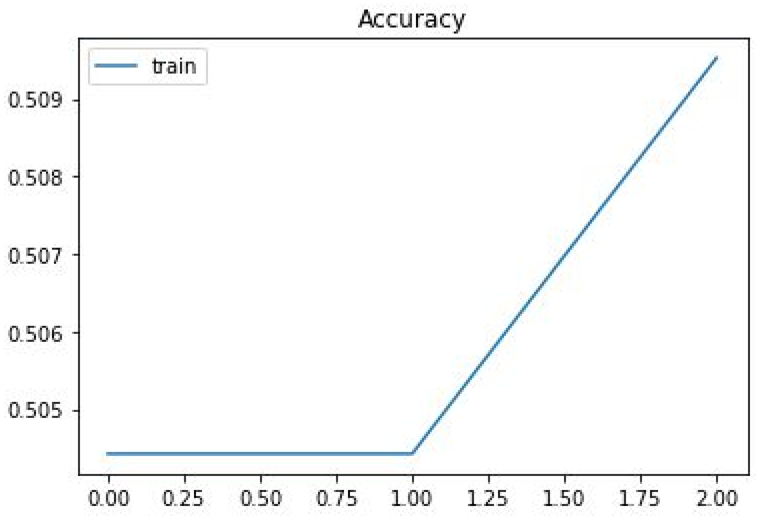
F-score:

```
[0.30188679 0.44776119]
```

Loss = 0.36969071134688364

Test Accuracy = 0.3650793651739756

Meniscus F-score & Accuracy:



F-Score:

[0.41791045 0.26415094]

Loss = 0.161735363044436

Test Accuracy = 0.4063492062545958