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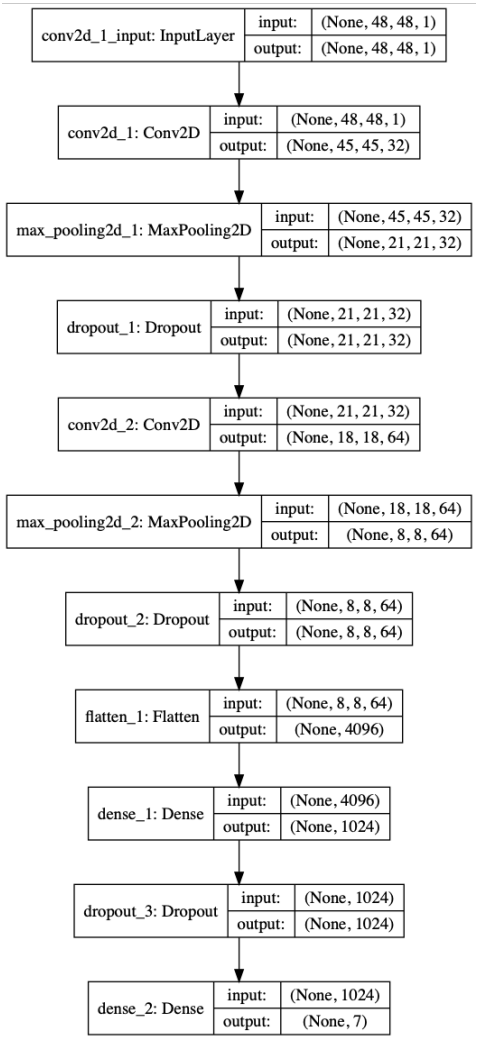
4. model_2, Convolutional Neural Network: After modifications, my model reaches an accuracy around 55% (the original model_1 was around 45%), achieves an increase of 10% in accuracy. The test loss and accuracy for model_2 in detail is as following:

```
Testing loss: 1.2016050369170224, acc: 0.5547506269238792
```

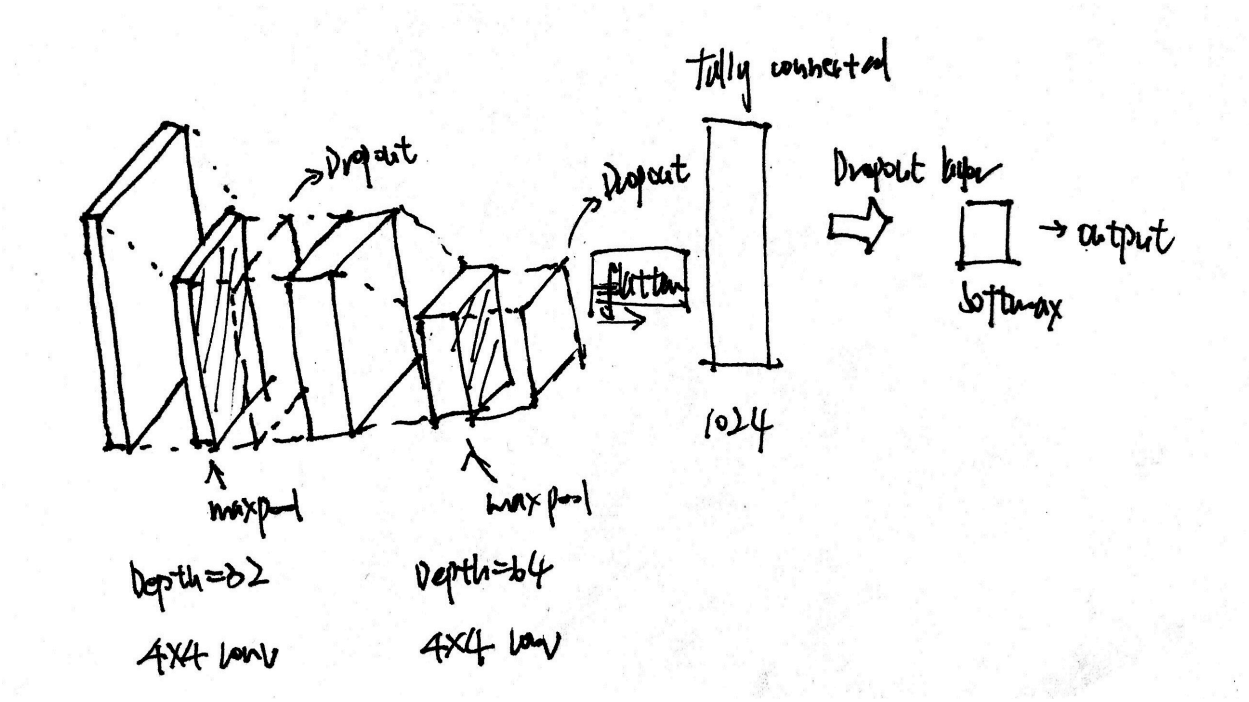
I tried a bunch of different modifications (such as adding BatchNormalization layers), and the following modifications are made to model_1 to reach the highest accuracy:

1) batch_size is changed from 256 to 128. Batch_size is the amount of data used for each train in SGD. lower the batch_size may help to prevent traps in local minimum.
2) Epochs increase from 5 to 6.
3) Model changed to a 2 layer 2D convolution network, with 1st layer 32 filters and 2nd layer 64 filters. Kernel size is changed to kernel_size=(4, 4), pool size is changed to pool_size=(4, 4).
4) Dropout layers are added, and the parameter for dropout layer is set to 0.1 after MaxPooling, set to 0.5 after the 1st dense layer.

Following is the model structure plotted by Keras using plot_model function:



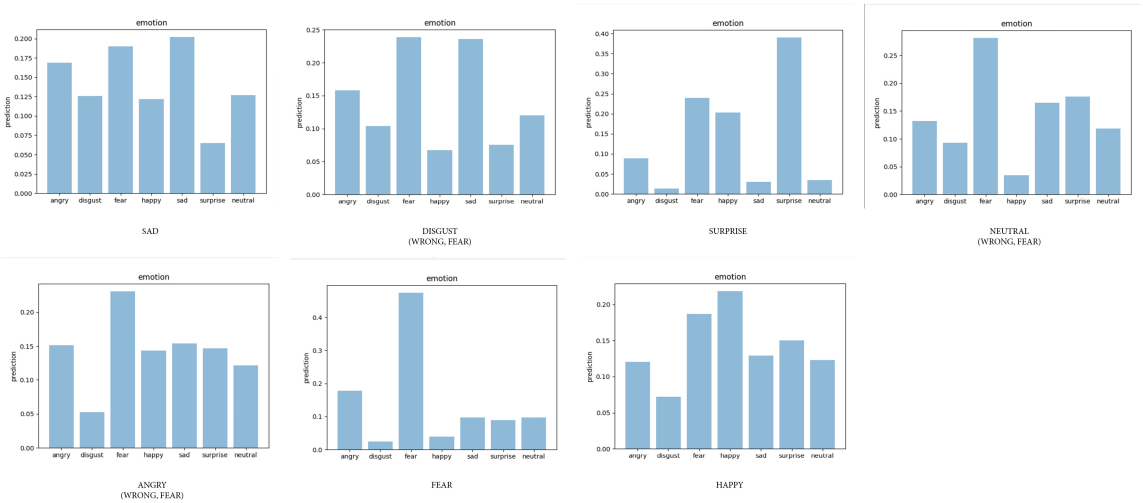
I also draw a diagram to show the structure:
Structure: 2D Conv (32, 4*4, relu) -> MaxPooling (4*4) -> Dropout (0.1) -> 2D Conv (64, 4*4, relu) -> MaxPooling (4*4) -> Dropout (0.1) -> Flatten -> Dense (1024, relu) -> Dropout (0.5) -> Dense (7, softmax) -> Output



5. Model 3, Transfer Learning: the loss and accuracy for the model is as following:

```
Testing loss: 1.382993459701538, acc: 0.5714285969734192
```

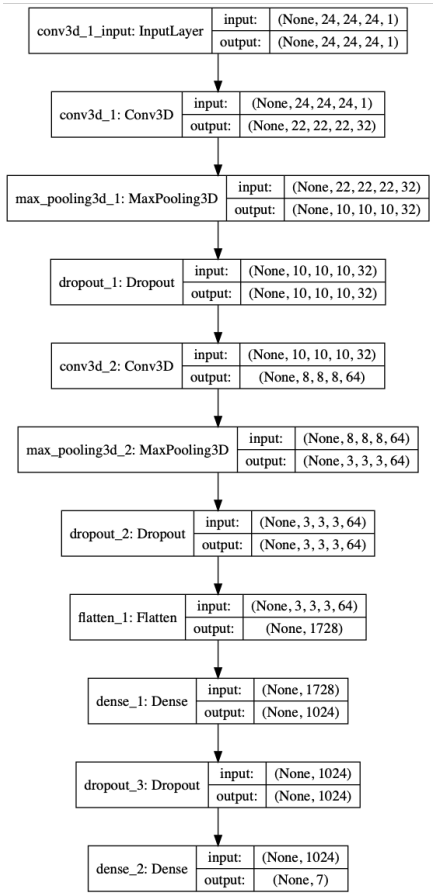
This accuracy implies it classifies 4 out of 7 images right. Following are the plot out diagrams for each emotion:



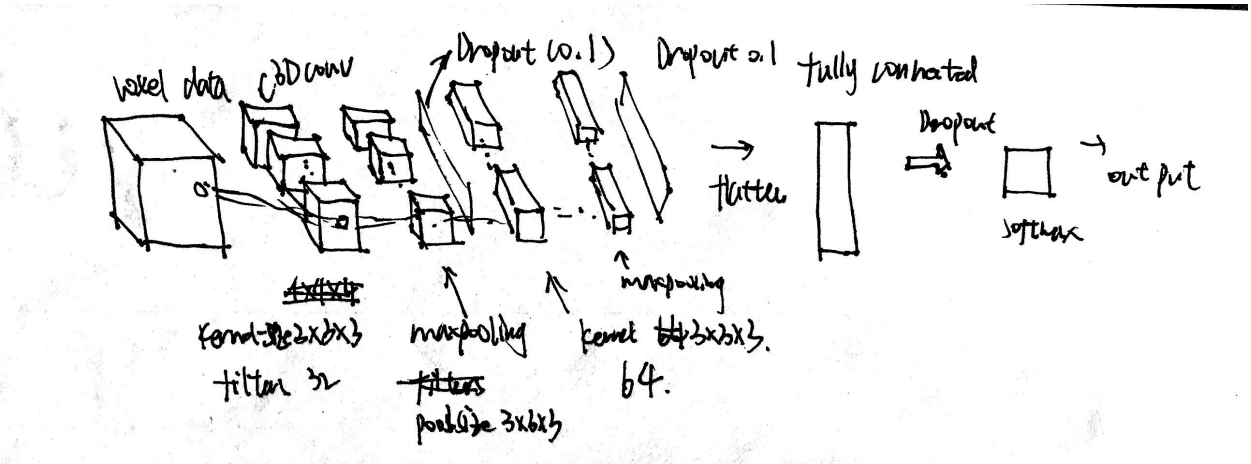
Disgust, Neutral and Angry are identified wrong, and are all identified as Fear. I think some expressions are recognized better due the the more dis-similarity between it with other expressions. As a human-being, I can recognized my smile expression quite easy, but hard to figure out the difference between my Neutral expression and Disgust expression. Therefore, I think some expressions are by nature harder to distinguish.

9. cnnX: Point Cloud Expression Data: FACS identifies emotion by AUs (action units), classifies each emotion by determining which AU it used. As I observed through the 3D face data, I think “Happy” and “Surprise” expressions are the most unique, while “Disgust”, “Sad” and “Neutral” expressions are quite similar. The point cloud gives us not only a 2-Dimensional representation of how much muscles moved, but a 3-Dimensional representation, which contains more information. It also gives us a 3-D structure of the face comparing with the RGB data in a 2-D image.

12: 3D Conv Model: Above is the accuracy and loss for my 3D conv model: (Print out by plot_model)



I try to draw a visualized diagram for 3D convolutional neural network:



Test/Train Ratio = 0.3
Batch_size = 12
Epochs = 6
Structure: 3D Conv (32, 3*3*3, relu) -> 3DMaxPooling (3*3*3) -> Dropout (0.1) -> 3D Conv (64, 3*3*3, relu) -> 3DMaxPooling (3*3*3) -> Dropout (0.1) -> Flatten -> Dense (1024, relu) -> Dropout (0.5) -> Dense (7, softmax) -> Output
Loss and Accuracy:

```
MiniProject4 — -bash — 80×24
2019-03-24 02:22:46.111702: I tensorflow/core/platform/cpu_feature_guard.cc:140]
 Your CPU supports instructions that this TensorFlow binary was not compiled to
use: AVX2 FMA
270/270 [==============================] - 40s 149ms/step - loss: 2.0583 - acc:
0.2333
Epoch 2/6
270/270 [==============================] - 40s 148ms/step - loss: 1.3502 - acc:
0.4852
Epoch 3/6
270/270 [==============================] - 39s 146ms/step - loss: 1.1964 - acc:
0.5407
Epoch 4/6
270/270 [==============================] - 39s 145ms/step - loss: 0.9286 - acc:
0.6519
Epoch 5/6
270/270 [==============================] - 39s 145ms/step - loss: 0.8628 - acc:
0.7000
Epoch 6/6
270/270 [==============================] - 39s 145ms/step - loss: 0.7891 - acc:
0.7222

Testing loss: 0.6722130179405212, acc: 0.75
```

Testing loss 0.67, Accuracy 75%

Also meet the requirement for Extra Credit 1.