This is for the competition in kaggle:
https://www.kaggle.com/t/067f885fce1c49019c3a92f6ccea148c

Start Here

Upload the data files and split

Noah Choate Lab 8

```
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils import to_categorical
import numpy as np

from google.colab import drive
drive.mount('/content/drive')

X = np.load("/content/drive/My Drive/ColabNotebooks/DSC4310/Data/x_train.npy")
y = np.load("/content/drive/My Drive/ColabNotebooks/DSC4310/Data/y_train.npy")
x_test = np.load("/content/drive/My Drive/ColabNotebooks/DSC4310/Data/x_test.npy")

# Loaded in for Jupyter Notebook (Not a fan of Google Colab)
#X = np.load(r"C:\Users\noahc\DSC4310-MachineLearning\Data\x_train.npy")
#y = np.load(r"C:\Users\noahc\DSC4310-MachineLearning\Data\y_train.npy")
#x_test = np.load(r"C:\Users\noahc\DSC4310-MachineLearning\Data\x_test.npy")

x_train, x_val, y_train, y_val = train_test_split(X, y,
                                                  test_size=0.2,
                                                  random_state=42)
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mour
```

```
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
x_val = x_val.astype('float32')
x_train = x_train.reshape((len(x_train), np.prod(x_train.shape[1:])))
x_test = x_test.reshape((len(x_test), np.prod(x_test.shape[1:])))
x_val = x_val.reshape((len(x_val), np.prod(x_val.shape[1:])))
y_train = to_categorical(y_train, len(set(y_train)))
y_val = to_categorical(y_val, len(set(y_val)))
print('x_train shape:', x_train.shape)
print('x_test shape:', x_test.shape)
print('x_val shape:', x_val.shape)
```

```
x_train shape: (980, 3009)
x_test shape: (1226, 3009)
x_val shape: (245, 3009)
```

```
from tensorflow.keras.layers import Input, Dense, Dropout
from tensorflow.keras.models import Model
from tensorflow.keras.optimizers import RMSprop

# dimensionality of input and latent encoded representations
inpt_dim = 59*51
ltnt_dim = 100

# --- define an autoencoder model here
inpt_vec = Input(shape=(inpt_dim,))
           # <-- add more layers here if you want
l0 = Dense(512, activation='relu')(inpt_vec)
l1 = Dropout(0.2)(inpt_vec)
encoder = Dense(ltnt_dim, activation='sigmoid') (l1)   # <-- do not change this

# model that takes input and encodes it into the latent space
latent_ncdr = Model(inpt_vec, encoder)   # <-- do not change this, you will need
                                    #     to access the layers of the encoder
           # <-- add more layers here if you want
l2 = Dense(512, activation='relu')(encoder)
l3 = Dropout(0.2)(encoder)
decoder = Dense(inpt_dim, activation='sigmoid') (l2)

# model that takes input, encodes it, and decodes it
autoencoder = Model(inpt_vec, decoder)

opt = RMSprop(learning_rate=0.01)

autoencoder.compile(loss='mean_absolute_error', optimizer=opt)
# --- end of model definitions
```

```
from tensorflow.keras.callbacks import ReduceLROnPlateau, EarlyStopping
```

```
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.9, patience=10,
                              min_delta=1e-4, mode='min')

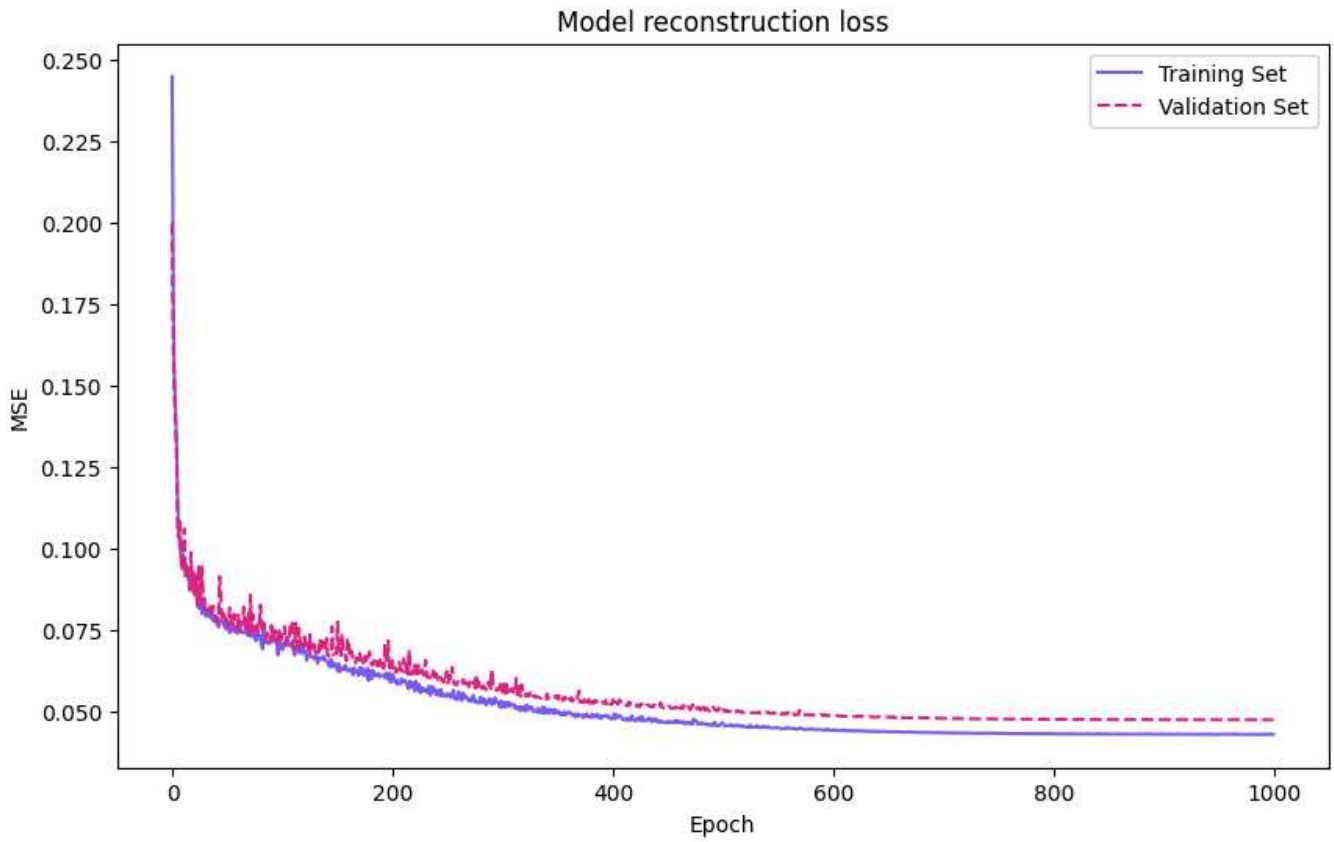
stop_alg = EarlyStopping(monitor='val_loss', patience=100, restore_best_weights=True)

hist = autoencoder.fit(x_train, x_train, batch_size=100, epochs=1000,
                   verbose=0, callbacks=[stop_alg, reduce_lr], shuffle=True,
                   validation_data=(x_val, x_val))

autoencoder.save_weights("autoencoder.weights.h5")
```

```
 import matplotlib.pyplot as plt

fig = plt.figure(figsize=(10,6))
plt.plot(hist.history['loss'], color='#785ef0')
plt.plot(hist.history['val_loss'], '--', color='#dc267f')
# plt.yscale('log')
plt.title('Model reconstruction loss')
plt.ylabel('MSE')
plt.xlabel('Epoch')
plt.legend(['Training Set', 'Validation Set'], loc='upper right')
plt.show()
```




```
plt.figure(figsize=(10, 9.5))
for i, comp in enumerate(latent_ncdr.get_weights()[0].T):
    plt.subplot(10, 10, i + 1)
    plt.imshow(comp.reshape((59, 51)), cmap=plt.cm.gray_r,
               interpolation='nearest')
    plt.xticks(())
    plt.yticks(())
plt.subplots_adjust(0.08, 0.02, 0.92, 0.85, 0.08, 0.23)
```

```
import matplotlib.pyplot as plt
import umap

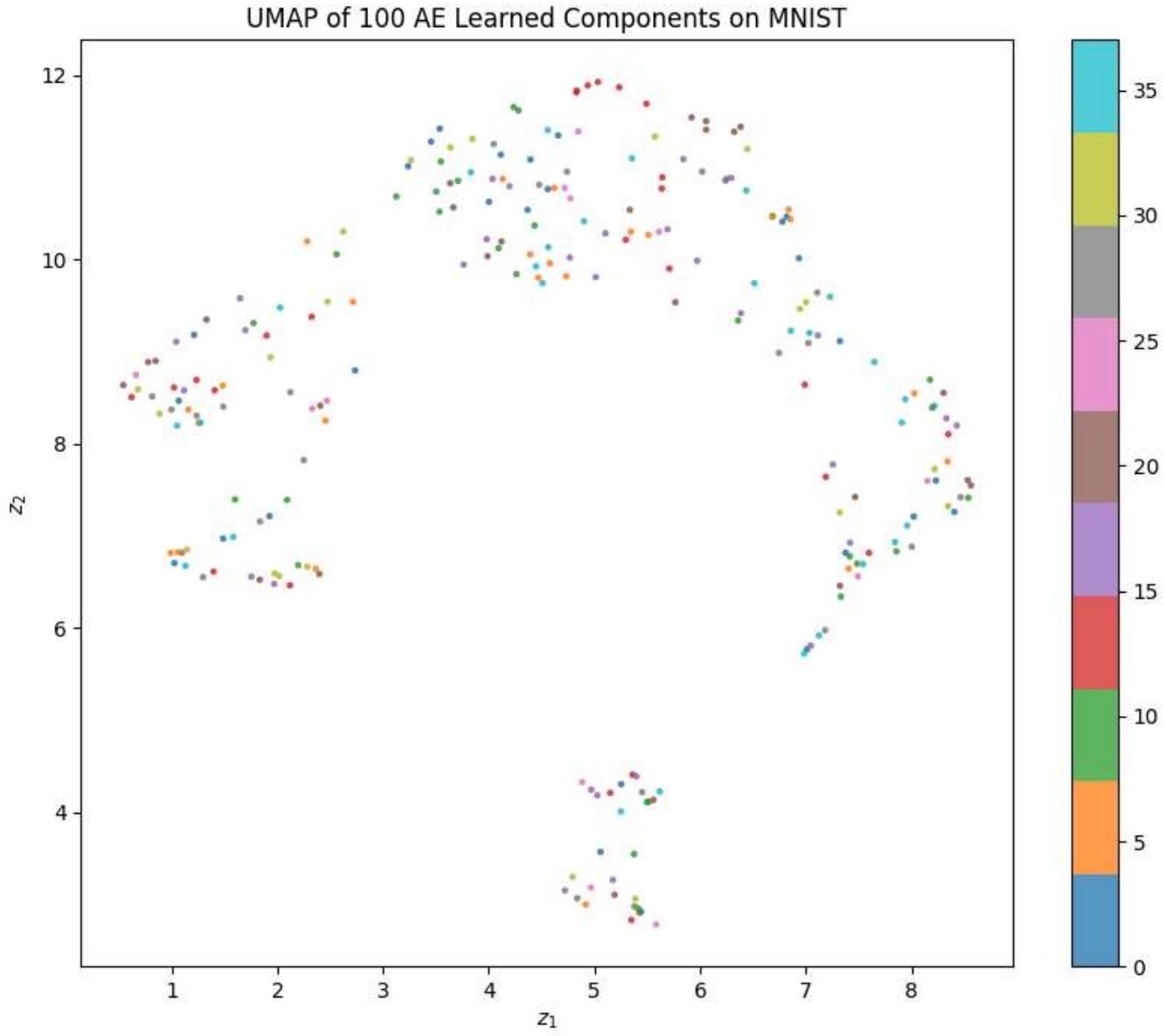
y_ = list(map(int, np.argmax(y_val, axis=1, out=None)))
X_ = latent_ncdr.predict(x_val)

print(X_.shape)
```

```
X_ = umap.UMAP().fit_transform(X_)
print(X_.shape)

plt.figure(figsize=(10,8))
plt.title('UMAP of 100 AE Learned Components on MNIST')
plt.scatter(X_[:,0], X_[:,1], s=5.0, c=y_, alpha=0.75, cmap='tab10')
plt.xlabel('$z_1$')
plt.ylabel('$z_2$')
plt.colorbar()
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 24ms/step
(245, 100)
/usr/local/lib/python3.11/dist-packages/sklearn/utils/deprecation.py:151: FutureWarning:
  warnings.warn(
(245, 2)
<matplotlib.colorbar.Colorbar at 0x7c9f6209da10>
```




```
plt.figure(figsize=(10, 2))
for i in range(10):
  plt.subplot(2, 10, i+1)
  plt.imshow(x_val[i].reshape((59, 51)), cmap='gray')
  plt.xticks(())
  plt.yticks(())
```

```
X_ = autoencoder.predict(x_val[:10])
for i in range(10):
  plt.subplot(2, 10, i+11)
  plt.imshow(X_[i].reshape((59, 51)), cmap='gray')
  plt.xticks(())
  plt.yticks(())

plt.subplots_adjust(0.08, 0.02, 0.92, 0.85, 0.08, 0.23)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 400ms/step
```

Fine-tune autoencoder for classification

```
from tensorflow.keras.layers import Input, Dense, Dropout
from tensorflow.keras.models import Model, Sequential
from tensorflow.keras.optimizers import RMSprop

# dimensionality of input and latent encoded representations
inpt_dim = 59*51
ltnt_dim = 100
n_classes = 38

# --- define a dense model here (deep or wide); do not change anything here ...
model = Sequential()                          # except for the two things below
for layer in latent_ncdr.layers:
    print(layer.name)
    model.add(layer)
model.add(Dropout(0.5))  # < -- the dropout rate is the only thing you are ...
model.add(Dense(n_classes, activation='sigmoid'))       # allowed to change here

model.summary()    # v -- you are also allowed to change the optimizer
model.compile(loss='binary_crossentropy', optimizer='rmsprop')
# --- end of model definition
```

```
input_layer_1
dropout_3
dense_6
```

Model: "sequential_1"

Layer (type)	Output Shape	Param #
dropout_3 (Dropout)	(None, 3009)	0
dense_6 (Dense)	(None, 100)	301,000
dropout_5 (Dropout)	(None, 100)	0
dense_9 (Dense)	(None, 38)	3,838

Total params: 304,838 (1.16 MB)
Trainable params: 304,838 (1.16 MB)
Non-trainable params: 0 (0.00 B)

```
from tensorflow.keras.callbacks import ReduceLROnPlateau, EarlyStopping

reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.9, patience=10,
                              min_delta=1e-4, mode='min')

stop_alg = EarlyStopping(monitor='val_loss', patience=100, restore_best_weights=True)

hist = model.fit(x_train, y_train, batch_size=100, epochs=1000,
                  verbose=0, callbacks=[stop_alg, reduce_lr], shuffle=True,
                  validation_data=(x_val, y_val))

model.save_weights("tunedautoencoder.weights.h5")


#=== this will prepare a submission using the fine-tuned autoencoder
y_test = model.predict(x_test)
with open('aesubmission.csv', 'w', newline='') as file:
  file.write('Id,Category\n')
  for k in range(y_test.shape[0]):
    line = str(k) + ',' + str(np.argmax(y_test[k]))
    print(line)
    file.write(line)
    file.write('\n')
#=== submit your file and indicate this was with an autoencoder
from google.colab import files
files.download(file_name)
```

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39/39 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
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---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-29-e99db9452246> in <cell line: 0>()
     10 #=== submit your file and indicate this was with an autoencoder
     11 from google.colab import files
---> 12 files.download(file_name)

NameError: name 'file_name' is not defined
```

```
#=== this will prepare a submission using the fine-tuned autoencoder
y_test = model.predict(x_test)
file_name = 'aesubmission.csv'  # Define file_name here
with open(file_name, 'w', newline='') as file:
  file.write('Id,Category\n')
  for k in range(y_test.shape[0]):
    line = str(k) + ',' + str(np.argmax(y_test[k]))
    print(line)
    file.write(line)
    file.write('\n')
#=== submit your file and indicate this was with an autoencoder
from google.colab import files
files.download(file_name)
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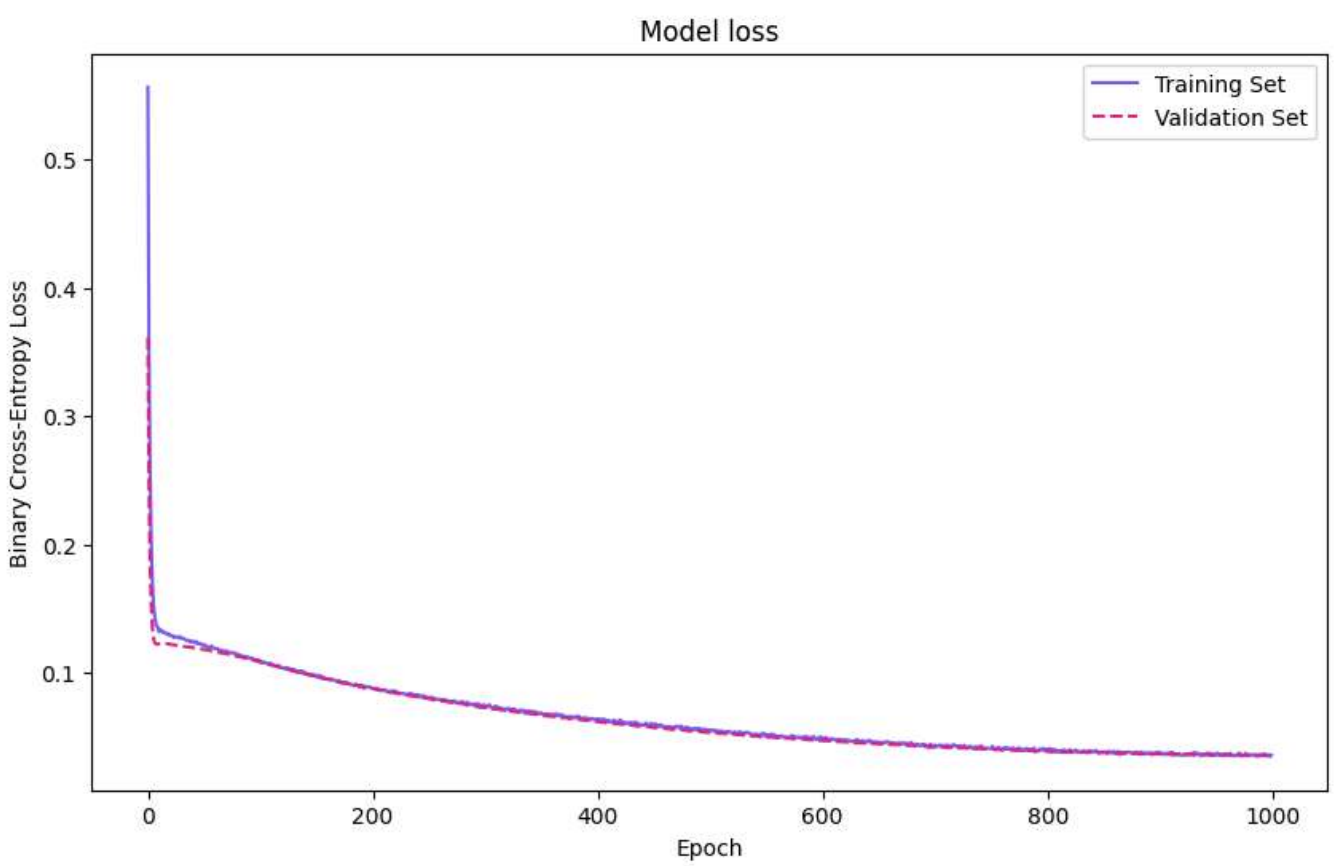
1138,18
1139,29
1140,10
1141,12
1142,30
1143,21
1144,32
1145,10
1146,22
1147,14
1148,4
1149,30
1150,21
1151,26
1152,23
1153,2
1154,11
1155,33
1156,0
1157,21
1158,22
1159,15
1160,16
1161,29
1162,18
1163,36
1164,0
1165,34
1166,25
1167,20
1168,18
1169,9
1170,17
1171,29
1172,20
1173,19
1174,23
1175,7
1176,3
1177,22
1178,8
1179,24
1180,17
1181,11
1182,33
1183,33
1184,0
```

```
1185,9
1186,18
1187,24
1188,9
1189,33
1190,24
1191,35
1192,14
1193,32
1194,36
1195,22
1196,20
1197,27
1198,28
1199,10
1200,15
1201,11
1202,26
1203,20
1204,7
1205,1
1206,33
1207,23
1208,34
1209,26
1210,2
1211,11
1212,23
1213,0
1214,14
1215,31
1216,30
1217,14
1218,7
1219,2
1220,2
1221,3
1222,7
1223,36
1224,17
1225,25
```

```
import matplotlib.pyplot as plt

fig = plt.figure(figsize=(10,6))
plt.plot(hist.history['loss'], color='#785ef0')
plt.plot(hist.history['val_loss'], '--', color='#dc267f')
# plt.yscale('log')
plt.title('Model loss')
plt.ylabel('Binary Cross-Entropy Loss')
plt.xlabel('Epoch')
plt.legend(['Training Set', 'Validation Set'], loc='upper right')
plt.show()
```




```
plt.figure(figsize=(10, 9.5))
for i, comp in enumerate(model.get_weights()[0].T):
    plt.subplot(10, 10, i + 1)
    plt.imshow(comp.reshape((59, 51)), cmap=plt.cm.gray_r,
               interpolation='nearest')
    plt.xticks(())
    plt.yticks(())
```

```
plt.subplots_adjust(0.08, 0.02, 0.92, 0.85, 0.08, 0.23)
```

```
import random
import numpy as np
import matplotlib.pyplot as plt
```

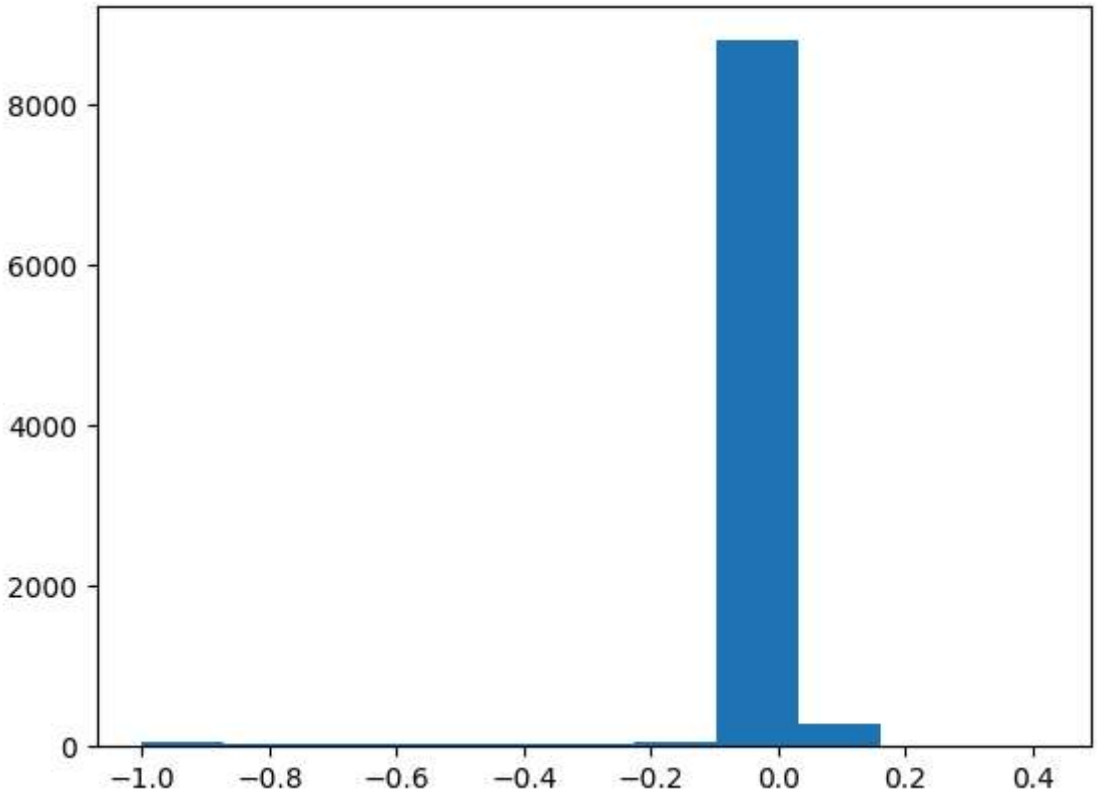
```
y_hat = model.predict(x_val)
diff = y_hat - y_val
plt.hist(diff.flatten(), bins=11)
plt.show()  #error histogram

inc_idx = []
for idx in range(y_hat.shape[0]):
  if np.argmax(y_hat[idx]) != np.argmax(y_val[idx]):
    inc_idx.append(idx)

sorted_idx = list(np.argsort(np.sum(np.abs(y_hat[inc_idx] - y_val[inc_idx]), axis=1)))

inc_idx = [inc_idx[i] for i in sorted_idx]
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step
```




```
import matplotlib.pyplot as plt
import numpy as np

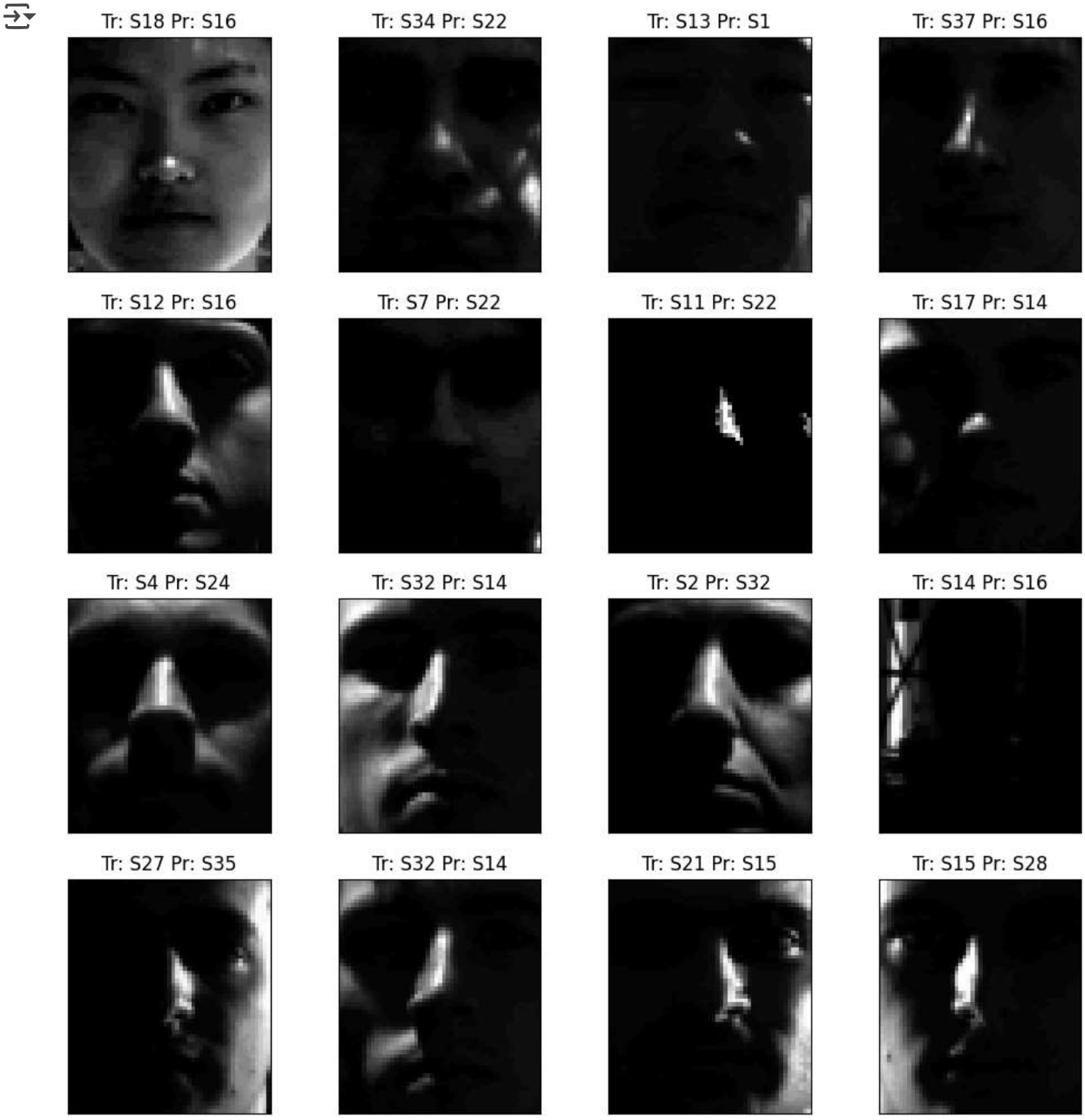
labels = np.argmax(y_val, axis=1, out=None)

clsmap = {}
for k in range(len(set(labels))):
  clsmap[k] = 'S' + str(k)


plt.figure(figsize=(12,6))
for i, (img, y) in enumerate(zip(x_val[inc_idx[0:8]].reshape(8, 59, 51), labels[inc_idx[0:8]
```

```
    plt.subplot(241 + i)
    plt.imshow(img, cmap='gray')
    plt.xticks([])
    plt.yticks([])
    plt.title('Tr: '+clsmap[y]+' Pr: '+clsmap[np.argmax(y_hat[inc_idx[i]])])
plt.savefig('best.errors.png', bbox_inches='tight', dpi=350)
plt.show()

plt.figure(figsize=(12,6))
for i, (img, y) in enumerate(zip(x_val[inc_idx[-8:]].reshape(8, 59, 51), labels[inc_idx[-8:]
    plt.subplot(241 + i)
    plt.imshow(img, cmap='gray')
    plt.xticks([])
    plt.yticks([])
    plt.title('Tr: '+clsmap[y]+' Pr: '+clsmap[np.argmax(y_hat[inc_idx[-8+i]])])
plt.savefig('worst.errors.png', bbox_inches='tight', dpi=350)
plt.show()
```


Tr: S18 Pr: S16
Tr: S34 Pr: S22
Tr: S13 Pr: S1
Tr: S37 Pr: S16
Tr: S12 Pr: S16
Tr: S7 Pr: S22
Tr: S11 Pr: S22
Tr: S17 Pr: S14
Tr: S4 Pr: S24
Tr: S32 Pr: S14
Tr: S2 Pr: S32
Tr: S14 Pr: S16
Tr: S27 Pr: S35
Tr: S32 Pr: S14
Tr: S21 Pr: S15
Tr: S15 Pr: S28

```
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import balanced_accuracy_score
import matplotlib.pyplot as plt
import numpy as np
import umap
import seaborn as sns

labels = np.argmax(y_val, axis=1, out=None)

y_ = labels
y_hat = model.predict(x_val)
y_pred = np.argmax(y_hat, axis=1)

print(y_hat.shape)
print(y_pred.shape)

print(y_hat[0] - y_val[0])
print(classification_report(np.argmax(y_val, axis=1), np.argmax(y_hat, axis=1), labels=list(
cm = confusion_matrix(np.argmax(y_val, axis=1), np.argmax(y_hat, axis=1), labels=list(set(la
print(cm)
ber = 1- balanced_accuracy_score(np.argmax(y_val, axis=1), np.argmax(y_hat, axis=1))
print('BER', ber)

fig, ax = plt.subplots(figsize=(14,12))
im = ax.imshow(cm, interpolation='nearest', cmap=plt.cm.Greens)
ax.figure.colorbar(im, ax=ax)

# Show ticks
ax.set(xticks=np.arange(cm.shape[1]),
       yticks=np.arange(cm.shape[0]),
       # add class labels
       xticklabels=set(labels),
       yticklabels=set(labels),
       title='Confusion Matrix  (BER = {0:0.3f})'.format(ber),
       ylabel='True Class',
       xlabel='Predicted Class')

# Rotate the tick labels and set their alignment.
# plt.setp(ax.get_xticklabels(), rotation=45, ha="right",
#          rotation_mode="anchor")

# Loop over data dimensions and create text annotations.
thresh = cm.max() / 2.
for i in range(cm.shape[0]):
    for j in range(cm.shape[1]):
        ax.text(j, i, format(cm[i, j], 'd'),
                ha="center", va="center",
                color="white" if cm[i, j] > thresh else "black")
fig.tight_layout()
np.set_printoptions(precision=2)
```

```
    plt.axis('tight')
    plt.show()
```

```
    X_ = umap.UMAP().fit_transform(y_hat)
    print(X_.shape)
```

```
    plt.figure(figsize=(10,8))
    plt.title('MLP Model')
    plt.scatter(X_[:,0], X_[:,1], s=5.0, c=y_, alpha=0.75, cmap='tab10')
    plt.xlabel('First UMAP dimension')
    plt.ylabel('Second UMAP dimension')
    plt.colorbar()
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
(245, 38)
(245,)
[ 2.50224546e-02  2.64551919e-02  1.05842378e-03  3.81335244e-02
  3.53887081e-02  4.92968364e-04  7.36522581e-03  4.33879392e-03
  8.81808228e-04  1.17752679e-04  6.93155394e-04  2.70228105e-04
  4.70103550e-04  2.77041877e-03  1.74948722e-02  2.35831190e-04
  1.61786797e-03  2.44183233e-03  3.41564454e-02  1.46230974e-03
  1.87493803e-04  1.16121024e-03  1.21114249e-06  8.52978677e-02
  1.91274151e-01  7.13271947e-05  5.59029868e-03  1.03480920e-01
  7.75130000e-03  2.85991147e-04  7.89475860e-04  4.90800850e-03
  5.13022496e-05  2.41050002e-05  6.43085630e-04 -6.22603238e-01
  7.37877330e-04  1.62676035e-03]
              precision    recall  f1-score   support

           0       0.60      1.00      0.75         6
           1       0.71      1.00      0.83         5
           2       0.86      0.75      0.80         8
           3       1.00      0.88      0.93         8
           4       1.00      0.80      0.89         5
           5       1.00      0.50      0.67         8
           6       0.83      1.00      0.91         5
           7       1.00      0.88      0.93         8
           8       1.00      1.00      1.00         2
           9       1.00      0.80      0.89        10
          10       1.00      0.88      0.93         8
          11       1.00      0.86      0.92         7
          12       1.00      0.71      0.83         7
          13       1.00      0.91      0.95        11
          14       0.62      0.71      0.67         7
          15       0.88      0.78      0.82         9
          16       0.56      1.00      0.71         5
          17       1.00      0.75      0.86         8
          18       1.00      0.75      0.86         8
          19       0.90      1.00      0.95         9
          20       1.00      1.00      1.00         7
          21       1.00      0.80      0.89         5
          22       0.57      1.00      0.73         4
          23       0.75      0.75      0.75         4
          24       0.80      1.00      0.89         4
          25       1.00      1.00      1.00         4
          26       1.00      1.00      1.00         6
          27       1.00      0.60      0.75         5
          28       0.88      1.00      0.93         7
          29       0.83      1.00      0.91         5
          30       0.50      1.00      0.67         3
          31       1.00      1.00      1.00         4
          32       0.75      0.82      0.78        11
          33       1.00      1.00      1.00         3
          34       0.67      0.86      0.75         7
          35       0.90      0.75      0.82        12
          36       0.67      1.00      0.80         2
          37       1.00      0.88      0.93         8

    accuracy                           0.86       245
   macro avg       0.88      0.88      0.86       245
```

```
weighted avg       0.89      0.86      0.86       245

[[6 0 0 ... 0 0 0]
 [0 5 0 ... 0 0 0]
 [0 0 6 ... 0 0 0]
 ...
 [2 1 0 ... 9 0 0]
 [0 0 0 ... 0 2 0]
 [0 0 0 ... 0 0 7]]
BER 0.12110769347611461
```