21BDS0340 - Abhinav Dinesh Srivatsa

In [ ]:
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
import random
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
import seaborn as sns
```

In [ ]:
```
data = np.load("ORL_faces.npz")
X_train = data["trainX"]
X_train_norm = np.array(X_train, dtype="float") / 255
X_test = data["testX"]
X_test_norm = np.array(X_test, dtype="float") / 255
y_train = data["trainY"]
y_test = data["testY"]
X_train_norm.shape, y_train.shape
```

Out[ ]:
```
((240, 10304), (240,))
```

In [ ]:
```
rows, cols = 112, 92
im_shape = (-1, rows, cols)

X_train_reshaped = np.reshape(X_train_norm, im_shape)
X_test_reshaped = np.reshape(X_test_norm, im_shape)
X_train_reshaped.shape
```

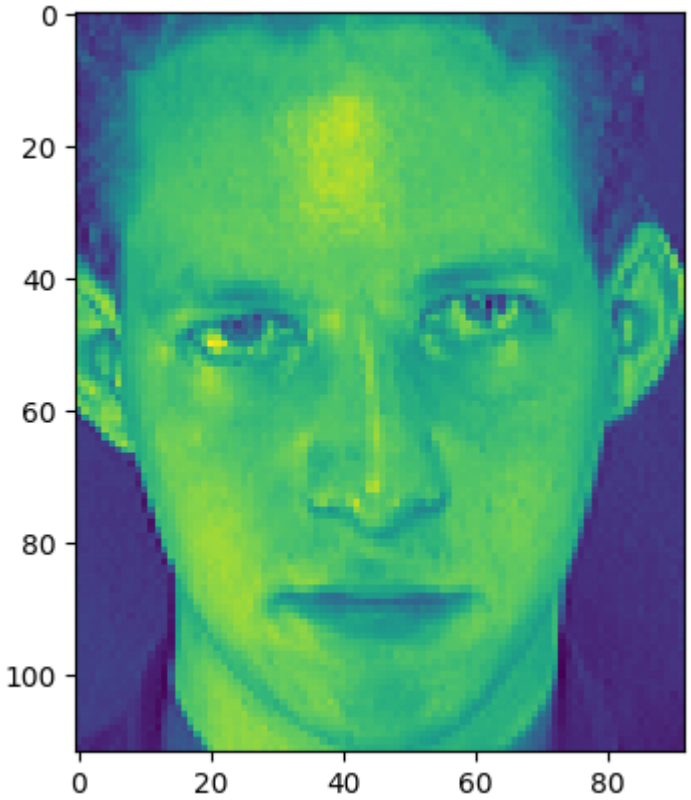
Out[ ]:
```
(240, 112, 92)
```

In [ ]:
```
X_train, X_val, y_train, y_val = train_test_split(X_train_reshaped, y_tra
X_train.shape, X_val.shape
```

Out[ ]:
```
((192, 112, 92), (48, 112, 92))
```

In [ ]:
```
def random_face(data):
    n = int(random.random() * len(data))
    plt.imshow(data[n])
```

In [ ]:
```
random_face(X_train)
```



In [ ]:
```
model1 = tf.keras.Sequential([
    tf.keras.layers.Input((rows, cols, 1)),
    tf.keras.layers.Conv2D(36, 7, activation="relu"),
    tf.keras.layers.MaxPool2D(2),
    tf.keras.layers.Conv2D(54, 5, activation="relu"),
    tf.keras.layers.MaxPool2D(2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(2048, activation="relu"),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(1024, activation="relu"),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(512, activation="relu"),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(20, activation="softmax")
])

model1.compile(
    optimizer="adam",
    loss="sparse_categorical_crossentropy",
    metrics=["accuracy"]
)

history1 = model1.fit(
    X_train, y_train,
    epochs=100, validation_data=(X_val, y_val)
)
```

```
Epoch 1/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 24s 2s/step - accuracy: 0.0458 - loss: 3.4466 - v
al_accuracy: 0.0417 - val_loss: 2.9964
Epoch 2/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 17s 2s/step - accuracy: 0.0667 - loss: 2.9951 - v
al_accuracy: 0.0625 - val_loss: 2.9951
Epoch 3/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.0689 - loss: 2.9872 - v
al_accuracy: 0.0417 - val_loss: 3.0243
Epoch 4/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.0646 - loss: 2.9982 - v
al_accuracy: 0.0625 - val_loss: 2.9967
Epoch 5/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.1097 - loss: 2.9843 - v
al_accuracy: 0.1042 - val_loss: 2.9938
Epoch 6/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 11s 2s/step - accuracy: 0.0850 - loss: 2.9790 - v
al_accuracy: 0.0208 - val_loss: 3.0041
Epoch 7/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.1057 - loss: 2.9901 - v
al_accuracy: 0.0417 - val_loss: 3.0058
Epoch 8/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 28s 3s/step - accuracy: 0.0893 - loss: 2.9833 - v
al_accuracy: 0.0417 - val_loss: 3.0322
Epoch 9/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 13s 2s/step - accuracy: 0.0936 - loss: 2.9444 - v
al_accuracy: 0.1458 - val_loss: 2.9575
Epoch 10/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.1559 - loss: 2.8848 - v
al_accuracy: 0.1875 - val_loss: 2.8893
Epoch 11/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.2330 - loss: 2.7857 - v
al_accuracy: 0.1667 - val_loss: 2.6574
Epoch 12/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.2153 - loss: 2.5889 - v
al_accuracy: 0.3125 - val_loss: 2.3189
Epoch 13/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.3759 - loss: 2.1222 - v
al_accuracy: 0.5000 - val_loss: 1.9070
Epoch 14/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.4125 - loss: 1.8827 - v
al_accuracy: 0.6250 - val_loss: 1.4847
Epoch 15/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.5778 - loss: 1.3281 - v
al_accuracy: 0.7083 - val_loss: 1.1688
Epoch 16/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.6059 - loss: 1.2618 - v
al_accuracy: 0.7083 - val_loss: 0.9985
Epoch 17/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.6760 - loss: 0.9188 - v
al_accuracy: 0.7917 - val_loss: 0.9341
Epoch 18/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.7065 - loss: 0.8871 - v
al_accuracy: 0.8125 - val_loss: 0.7149
Epoch 19/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.7281 - loss: 0.8559 - v
al_accuracy: 0.8333 - val_loss: 0.4649
Epoch 20/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.8927 - loss: 0.3756 - v
al_accuracy: 0.8958 - val_loss: 0.4468
```

```
Epoch 21/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.8911 - loss: 0.3815 - v
al_accuracy: 0.8333 - val_loss: 0.3917
Epoch 22/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.8538 - loss: 0.5548 - v
al_accuracy: 0.8958 - val_loss: 0.2854
Epoch 23/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9289 - loss: 0.2185 - v
al_accuracy: 0.8958 - val_loss: 0.2595
Epoch 24/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9275 - loss: 0.1774 - v
al_accuracy: 0.8958 - val_loss: 0.3016
Epoch 25/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 22s 2s/step - accuracy: 0.9647 - loss: 0.1512 - v
al_accuracy: 0.9375 - val_loss: 0.2089
Epoch 26/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 13s 2s/step - accuracy: 0.9795 - loss: 0.0797 - v
al_accuracy: 0.9583 - val_loss: 0.1741
Epoch 27/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9652 - loss: 0.1725 - v
al_accuracy: 0.8958 - val_loss: 0.3344
Epoch 28/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9608 - loss: 0.1135 - v
al_accuracy: 0.9375 - val_loss: 0.2157
Epoch 29/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9577 - loss: 0.0957 - v
al_accuracy: 0.9167 - val_loss: 0.2877
Epoch 30/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9891 - loss: 0.0589 - v
al_accuracy: 0.9167 - val_loss: 0.3054
Epoch 31/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9862 - loss: 0.0641 - v
al_accuracy: 0.9375 - val_loss: 0.2596
Epoch 32/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9746 - loss: 0.1114 - v
al_accuracy: 0.9583 - val_loss: 0.2686
Epoch 33/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9920 - loss: 0.0293 - v
al_accuracy: 0.9583 - val_loss: 0.2237
Epoch 34/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 11s 2s/step - accuracy: 0.9928 - loss: 0.0566 - v
al_accuracy: 0.9583 - val_loss: 0.1840
Epoch 35/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9965 - loss: 0.0205 - v
al_accuracy: 0.9583 - val_loss: 0.1724
Epoch 36/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0130 - v
al_accuracy: 0.9583 - val_loss: 0.1835
Epoch 37/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9985 - loss: 0.0105 - v
al_accuracy: 0.9583 - val_loss: 0.1737
Epoch 38/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9928 - loss: 0.0261 - v
al_accuracy: 0.9583 - val_loss: 0.1658
Epoch 39/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9885 - loss: 0.0452 - v
al_accuracy: 0.9583 - val_loss: 0.1714
Epoch 40/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 26s 3s/step - accuracy: 0.9760 - loss: 0.0386 - v
al_accuracy: 0.9375 - val_loss: 0.2329
```

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Epoch 41/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9965 - loss: 0.0450 - v
al_accuracy: 0.9375 - val_loss: 0.3381
Epoch 42/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9890 - loss: 0.0680 - v
al_accuracy: 0.9583 - val_loss: 0.1825
Epoch 43/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9550 - loss: 0.0801 - v
al_accuracy: 0.9375 - val_loss: 0.2802
Epoch 44/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9769 - loss: 0.0933 - v
al_accuracy: 0.9583 - val_loss: 0.2271
Epoch 45/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9760 - loss: 0.0793 - v
al_accuracy: 0.9583 - val_loss: 0.1735
Epoch 46/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9961 - loss: 0.0187 - v
al_accuracy: 0.9583 - val_loss: 0.2003
Epoch 47/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 1.0000 - loss: 0.0109 - v
al_accuracy: 0.9375 - val_loss: 0.3036
Epoch 48/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9928 - loss: 0.0326 - v
al_accuracy: 0.9583 - val_loss: 0.2853
Epoch 49/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9946 - loss: 0.0114 - v
al_accuracy: 0.9583 - val_loss: 0.2951
Epoch 50/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9833 - loss: 0.0484 - v
al_accuracy: 0.9583 - val_loss: 0.2710
Epoch 51/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9883 - loss: 0.0400 - v
al_accuracy: 0.9583 - val_loss: 0.2419
Epoch 52/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9883 - loss: 0.0321 - v
al_accuracy: 0.9583 - val_loss: 0.2050
Epoch 53/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 1.0000 - loss: 0.0129 - v
al_accuracy: 0.9583 - val_loss: 0.1982
Epoch 54/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9965 - loss: 0.0158 - v
al_accuracy: 0.9375 - val_loss: 0.1875
Epoch 55/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9950 - loss: 0.0140 - v
al_accuracy: 0.9167 - val_loss: 0.2611
Epoch 56/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0170 - v
al_accuracy: 0.9375 - val_loss: 0.1979
Epoch 57/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 1.0000 - loss: 0.0134 - v
al_accuracy: 0.9583 - val_loss: 0.2029
Epoch 58/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9965 - loss: 0.0108 - v
al_accuracy: 0.9583 - val_loss: 0.2102
Epoch 59/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 1.0000 - loss: 0.0068 - v
al_accuracy: 0.9583 - val_loss: 0.2105
Epoch 60/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9833 - loss: 0.0261 - v
al_accuracy: 0.9375 - val_loss: 0.2277
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Epoch 61/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9985 - loss: 0.0072 - v
al_accuracy: 0.9167 - val_loss: 0.2894
Epoch 62/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9868 - loss: 0.0238 - v
al_accuracy: 0.9583 - val_loss: 0.2485
Epoch 63/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0115 - v
al_accuracy: 0.9583 - val_loss: 0.2337
Epoch 64/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 22s 2s/step - accuracy: 0.9928 - loss: 0.0239 - v
al_accuracy: 0.9583 - val_loss: 0.2140
Epoch 65/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9950 - loss: 0.0113 - v
al_accuracy: 0.9583 - val_loss: 0.2145
Epoch 66/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 11s 2s/step - accuracy: 0.9859 - loss: 0.0279 - v
al_accuracy: 0.9583 - val_loss: 0.2225
Epoch 67/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9833 - loss: 0.0266 - v
al_accuracy: 0.9583 - val_loss: 0.2374
Epoch 68/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9913 - loss: 0.0136 - v
al_accuracy: 0.9583 - val_loss: 0.2635
Epoch 69/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 1.0000 - loss: 0.0059 - v
al_accuracy: 0.9583 - val_loss: 0.2366
Epoch 70/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9950 - loss: 0.0376 - v
al_accuracy: 0.9583 - val_loss: 0.2169
Epoch 71/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9985 - loss: 0.0144 - v
al_accuracy: 0.9375 - val_loss: 0.2309
Epoch 72/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 1.0000 - loss: 0.0070 - v
al_accuracy: 0.9583 - val_loss: 0.2476
Epoch 73/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 28s 3s/step - accuracy: 0.9985 - loss: 0.0039 - v
al_accuracy: 0.9583 - val_loss: 0.2655
Epoch 74/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 14s 2s/step - accuracy: 1.0000 - loss: 0.0044 - v
al_accuracy: 0.9375 - val_loss: 0.3651
Epoch 75/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9976 - loss: 0.0227 - v
al_accuracy: 0.9375 - val_loss: 0.3464
Epoch 76/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9976 - loss: 0.0122 - v
al_accuracy: 0.9583 - val_loss: 0.3123
Epoch 77/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9965 - loss: 0.0100 - v
al_accuracy: 0.9583 - val_loss: 0.3317
Epoch 78/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 8.2271e-04
- val_accuracy: 0.9375 - val_loss: 0.3651
Epoch 79/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0029 - v
al_accuracy: 0.9375 - val_loss: 0.2213
Epoch 80/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9883 - loss: 0.0421 - v
al_accuracy: 0.9583 - val_loss: 0.2712
```

```
Epoch 81/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 0.9965 - loss: 0.0206 - v
al_accuracy: 0.9583 - val_loss: 0.2103
Epoch 82/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 1.0000 - loss: 0.0225 - v
al_accuracy: 0.9583 - val_loss: 0.1582
Epoch 83/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 1.0000 - loss: 0.0050 - v
al_accuracy: 0.9583 - val_loss: 0.1884
Epoch 84/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 22s 2s/step - accuracy: 0.9915 - loss: 0.0075 - v
al_accuracy: 0.9583 - val_loss: 0.2948
Epoch 85/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 1.0000 - loss: 0.0076 - v
al_accuracy: 0.9583 - val_loss: 0.3382
Epoch 86/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9883 - loss: 0.0215 - v
al_accuracy: 0.9583 - val_loss: 0.2866
Epoch 87/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9935 - loss: 0.0225 - v
al_accuracy: 0.9583 - val_loss: 0.2531
Epoch 88/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 1.0000 - loss: 0.0076 - v
al_accuracy: 0.9583 - val_loss: 0.2745
Epoch 89/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 12s 2s/step - accuracy: 1.0000 - loss: 0.0011 - v
al_accuracy: 0.9583 - val_loss: 0.2697
Epoch 90/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 4.7826e-04
- val_accuracy: 0.9583 - val_loss: 0.2513
Epoch 91/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 1.0000 - loss: 0.0034 - v
al_accuracy: 0.9583 - val_loss: 0.2833
Epoch 92/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0036 - v
al_accuracy: 0.9583 - val_loss: 0.3397
Epoch 93/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 11s 2s/step - accuracy: 0.9976 - loss: 0.0052 - v
al_accuracy: 0.9583 - val_loss: 0.3481
Epoch 94/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 11s 2s/step - accuracy: 0.9883 - loss: 0.0186 - v
al_accuracy: 0.9375 - val_loss: 0.4990
Epoch 95/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9915 - loss: 0.0183 - v
al_accuracy: 0.9583 - val_loss: 0.4127
Epoch 96/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 19s 2s/step - accuracy: 0.9883 - loss: 0.0159 - v
al_accuracy: 0.9583 - val_loss: 0.3377
Epoch 97/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 22s 2s/step - accuracy: 0.9883 - loss: 0.0414 - v
al_accuracy: 0.9167 - val_loss: 0.3823
Epoch 98/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 0.9928 - loss: 0.0362 - v
al_accuracy: 0.9375 - val_loss: 0.4841
Epoch 99/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 20s 2s/step - accuracy: 1.0000 - loss: 0.0085 - v
al_accuracy: 0.8958 - val_loss: 0.5321
Epoch 100/100
6/6 ━━━━━━━━━━━━━━━━━━━━ 21s 2s/step - accuracy: 0.9802 - loss: 0.0418 - v
al_accuracy: 0.9583 - val_loss: 0.2916
```

In [ ]:
```
X_test_reshaped.shape
```

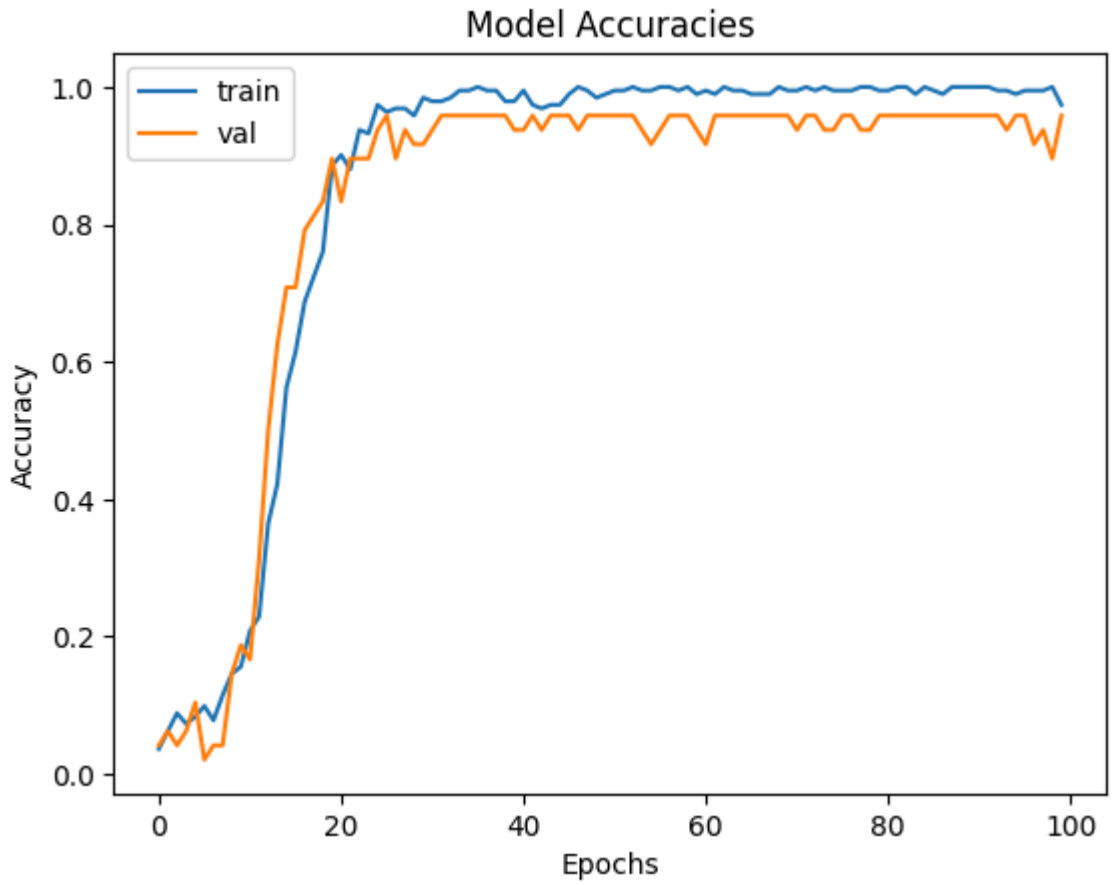
Out[ ]:
```
(160, 112, 92)
```

In [ ]:
```
model1.evaluate(X_test_reshaped, y_test, verbose=0)
```

Out[ ]:
```
[1.2689409255981445, 0.8374999761581421]
```

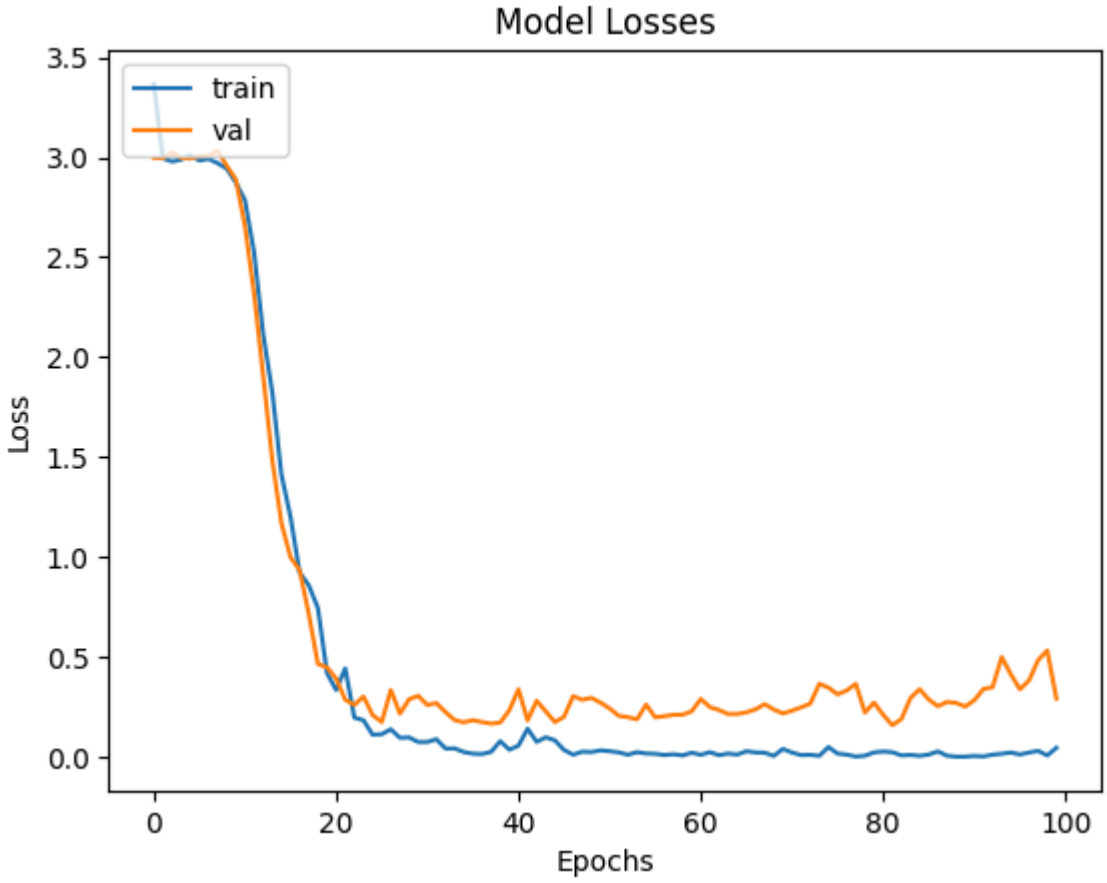
In [ ]:
```
plt.plot(history1.history["accuracy"])
plt.plot(history1.history["val_accuracy"])
plt.title("Model Accuracies")
plt.xlabel("Epochs")
plt.ylabel("Accuracy")
plt.legend(["train", "val"], loc="upper left")
```

Out[ ]:
```
<matplotlib.legend.Legend at 0x7af7b959f2b0>
```



In [ ]:
```
plt.plot(history1.history["loss"])
plt.plot(history1.history["val_loss"])
plt.title("Model Losses")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.legend(["train", "val"], loc="upper left")
```

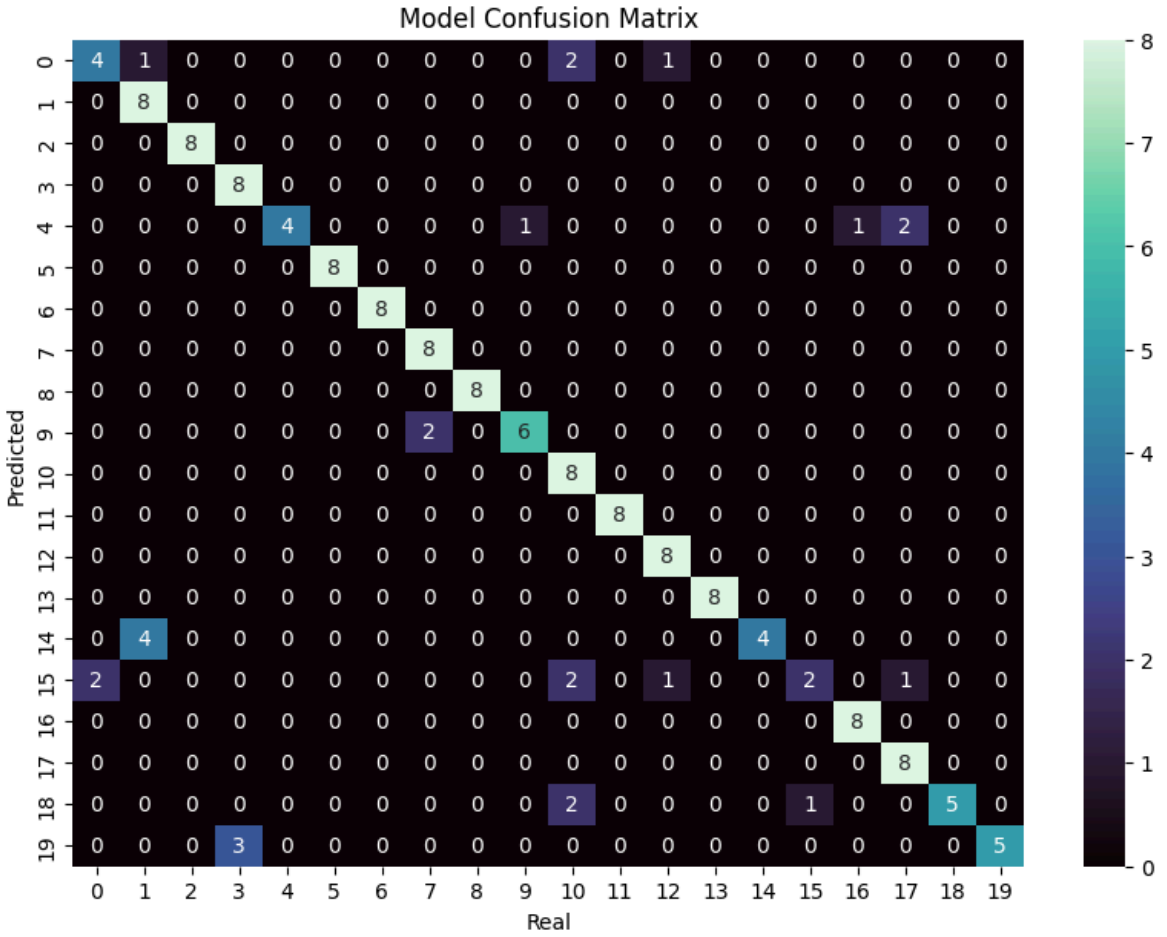
Out[ ]:
```
<matplotlib.legend.Legend at 0x7af7b82dbd00>
```



In [ ]:
```
def confusion_matrix(model, test_features, test_labels):
    y_pred = model.predict(test_features)
    y_pred = [np.argmax(row) for row in y_pred]
    matrix = np.zeros((20, 20))
    for i in range(len(y_pred)):
        real = test_labels[i]
        pred = y_pred[i]
        matrix[real][pred] += 1
    plt.figure(figsize=(10, 7))
    sns.heatmap(matrix, cmap="mako", annot=True)
    plt.title("Model Confusion Matrix")
    plt.xlabel("Real")
    plt.ylabel("Predicted")
    return y_pred
```

In [ ]:
```
y_pred = confusion_matrix(model1, X_test_reshaped, y_test)
```

```
5/5 ━━━━━━━━━━━━━━━━━━━━ 3s 533ms/step
```



In [ ]:
```
report = classification_report(y_test, y_pred)
print(report)
```

```
              precision    recall  f1-score   support

           0       0.67      0.50      0.57         8
           1       0.62      1.00      0.76         8
           2       1.00      1.00      1.00         8
           3       0.73      1.00      0.84         8
           4       1.00      0.50      0.67         8
           5       1.00      1.00      1.00         8
           6       1.00      1.00      1.00         8
           7       0.80      1.00      0.89         8
           8       1.00      1.00      1.00         8
           9       0.86      0.75      0.80         8
          10       0.57      1.00      0.73         8
          11       1.00      1.00      1.00         8
          12       0.80      1.00      0.89         8
          13       1.00      1.00      1.00         8
          14       1.00      0.50      0.67         8
          15       0.67      0.25      0.36         8
          16       0.89      1.00      0.94         8
          17       0.73      1.00      0.84         8
          18       1.00      0.62      0.77         8
          19       1.00      0.62      0.77         8

    accuracy                           0.84       160
   macro avg       0.87      0.84      0.82       160
weighted avg       0.87      0.84      0.82       160
```