```python
import tensorflow as tf
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats as stats
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Flatten, Dense, Dropout,
BatchNormalization
from tensorflow.keras.layers import Conv2D, MaxPool2D
from tensorflow.keras.optimizers import Adam
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, LabelEncoder
from mlxtend.plotting import plot_confusion_matrix
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score,
accuracy_score
from sklearn.metrics import hamming_loss

file =
open('/Users/91934/Documents/NM/WISDM_ar_v1.1/WISDM_ar_v1.1_raw.txt')
lines = file.readlines()

processedList = []

for i, line in enumerate(lines):
    try:
        line = line.split(',')
        last = line[5].split(';')[0]
        last = last.strip()
        if last == '':
            break;
        temp = [line[0], line[1], line[2], line[3], line[4], last]
        processedList.append(temp)
    except:
        print('Error at line number: ', i)
```

```
Error at line number:  281873
Error at line number:  281874
Error at line number:  281875
```

```python
import os
print(os.getcwd())
```

```
C:\Users\91934\Documents\NM\WISDM_ar_v1.1
```

```python
processedList[:100]
```

```
[['33', 'Jogging', '49105962326000', '-0.6946377', '12.680544',
'0.50395286'],
 ['33', 'Jogging', '49106062271000', '5.012288', '11.264028',
```

```
 '0.95342433'],
 ['33', 'Jogging', '49106112167000', '4.903325', '10.882658', '-
0.08172209'],
 ['33', 'Jogging', '49106222305000', '-0.61291564', '18.496431',
'3.0237172'],
 ['33', 'Jogging', '49106332290000', '-1.1849703', '12.108489',
'7.205164'],
 ['33', 'Jogging', '49106442306000', '1.3756552', '-2.4925237', '-
6.510526'],
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'5.706926'],
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'7.0553403'],
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'5.134871'],
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'1.6480621'],
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'2.7240696'],
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'6.510526'],
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'13.525005'],
```

```
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```

3.336985'],
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 ['33', 'Jogging', '49114742355000', '-4.671779', '11.727119', '0.38136974'],
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 ['33', 'Jogging', '49115072311000', '-2.9147544', '19.57244', '7.5865335'],
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 ['33', 'Jogging', '49116122238000', '2.3426998', '15.894946', '3.6774938'],
 ['33', 'Jogging', '49116232315000', '4.7943625', '3.8273177', '0.9942854'],
 ['33', 'Jogging', '49116342330000', '-1.8387469', '12.830367', '-1.56634'],

```
 ['33', 'Jogging', '49116452316000', '5.366417', '14.410328',
'6.742072']]

columns = ['user', 'activity', 'time', 'x', 'y', 'z']
data = pd.DataFrame(data = processedList, columns = columns)
data.head()
```

```
   user activity             time           x          y           z
0    33  Jogging  49105962326000   -0.6946377  12.680544   0.50395286
1    33  Jogging  49106062271000     5.012288  11.264028   0.95342433
2    33  Jogging  49106112167000     4.903325  10.882658  -0.08172209
3    33  Jogging  49106222305000   -0.61291564  18.496431    3.0237172
4    33  Jogging  49106332290000   -1.1849703  12.108489     7.205164
```

```
data.shape
```

```
(343416, 6)
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 343416 entries, 0 to 343415
Data columns (total 6 columns):
 #   Column    Non-Null Count   Dtype
---  ------    --------------   -----
 0   user      343416 non-null  object
 1   activity  343416 non-null  object
 2   time      343416 non-null  object
 3   x         343416 non-null  object
 4   y         343416 non-null  object
 5   z         343416 non-null  object
dtypes: object(6)
memory usage: 15.7+ MB
```

```
data.isnull().sum()
```

```
user        0
activity    0
time        0
x           0
y           0
z           0
dtype: int64
```

```
data['x'] = data['x'].astype('float')
data['y'] = data['y'].astype('float')
data['z'] = data['z'].astype('float')

Fs = 20
activities = data['activity'].value_counts().index
activities
```

```
Index(['Walking', 'Jogging', 'Upstairs', 'Downstairs', 'Sitting',
'Standing'], dtype='object')

def plot_activity(activity, data):
    fig, (ax0, ax1, ax2) = plt.subplots(nrows=3, figsize=(9, 4),
sharex=True)
    plot_axis(ax0, data['time'], data['x'], 'X-Axis')
    plot_axis(ax1, data['time'], data['y'], 'Y-Axis')
    plot_axis(ax2, data['time'], data['z'], 'Z-Axis')
    plt.subplots_adjust(hspace=0.3)
    fig.suptitle(activity)
    plt.subplots_adjust(top=0.85)
    plt.show()

def plot_axis(ax, x, y, title):
    ax.plot(x, y, 'r')
    ax.set_title(title)
    ax.xaxis.set_visible(False)
    ax.set_ylim([min(y) - np.std(y), max(y) + np.std(y)])
    ax.set_xlim([min(x), max(x)])
    ax.grid(True)

for activity in activities:
    data_for_plot = data[(data['activity'] == activity)][:Fs*10]
    plot_activity(activity, data_for_plot)
```
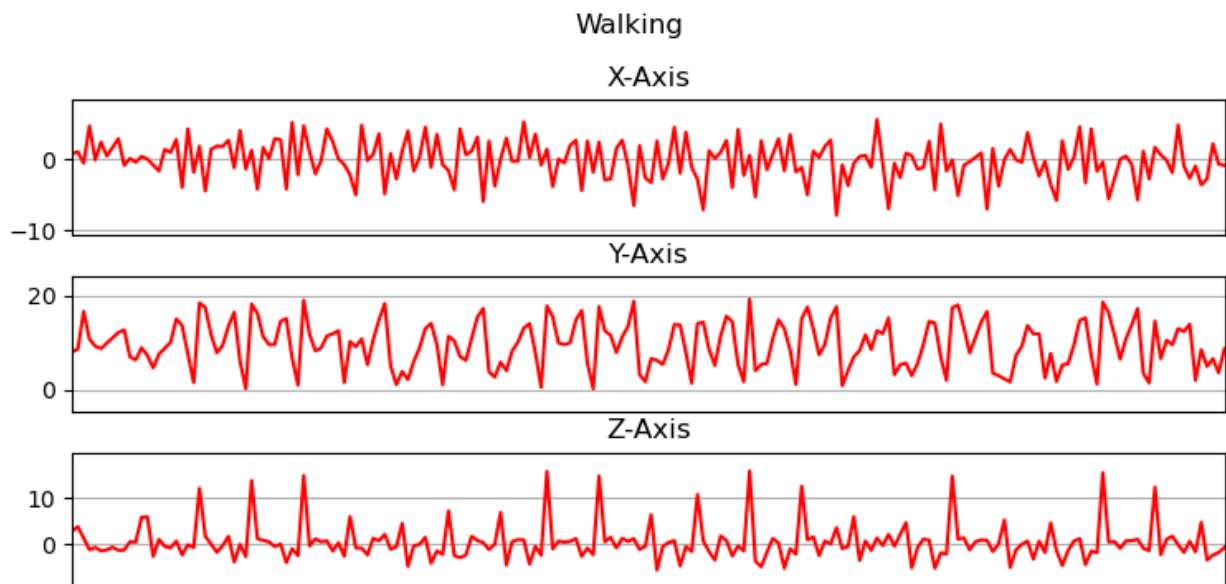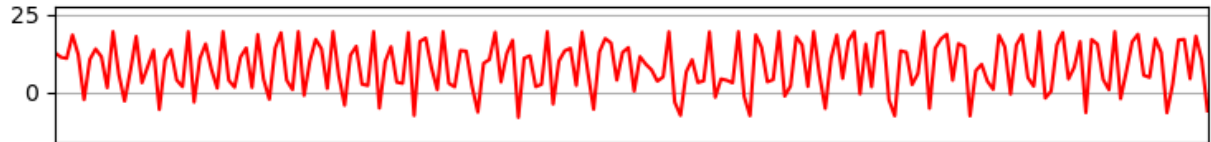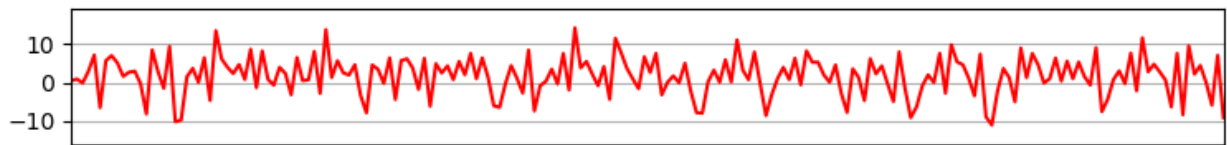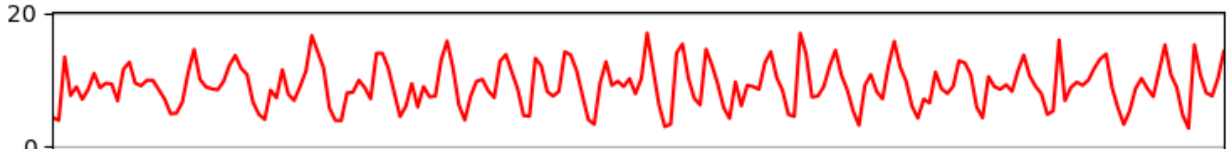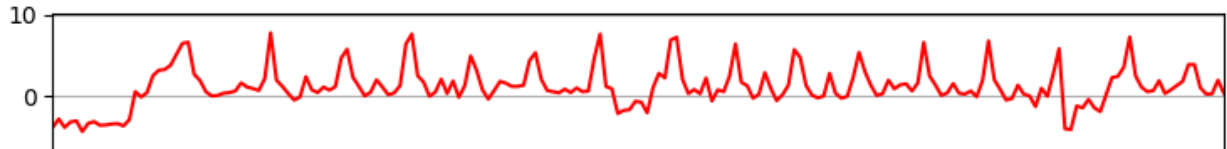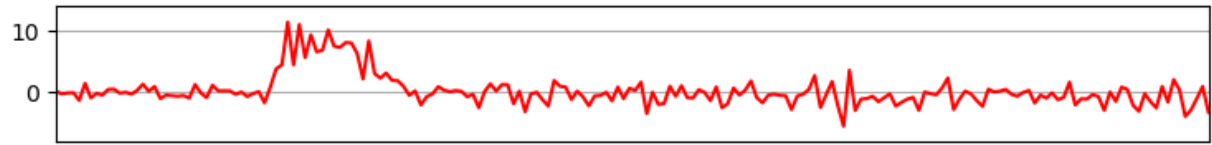
Jogging

X-Axis
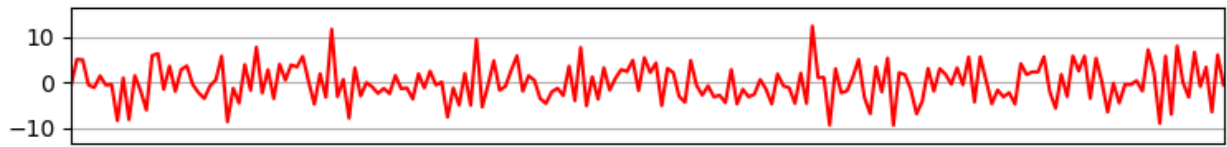
Y-Axis

Z-Axis

Upstairs

X-Axis

Y-Axis

Z-Axis
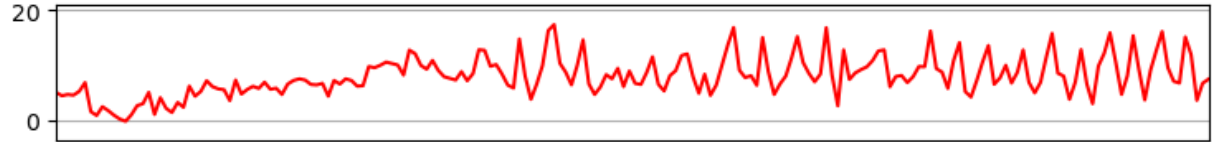
Downstairs

X-Axis

Y-Axis

Z-Axis

Sitting

X-Axis

Y-Axis

Z-Axis

Standing
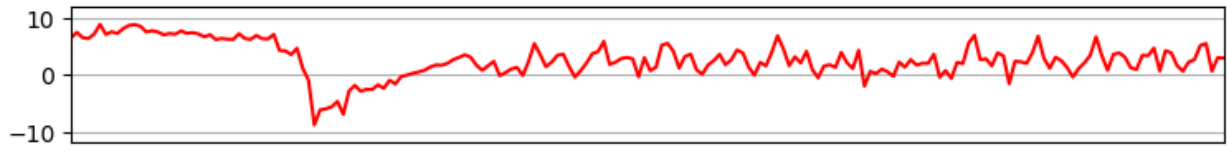
X-Axis
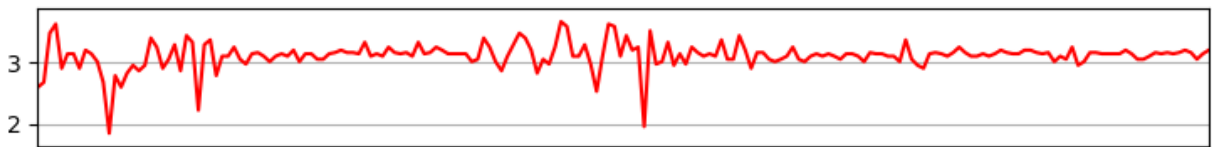
Y-Axis
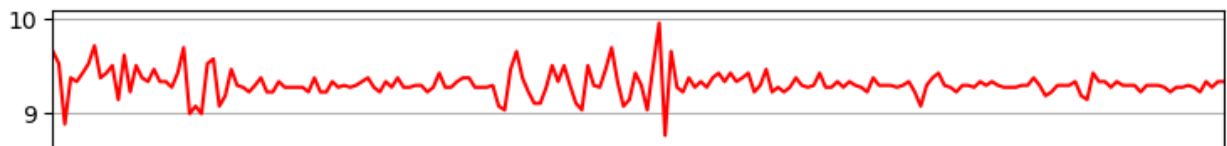
Z-Axis
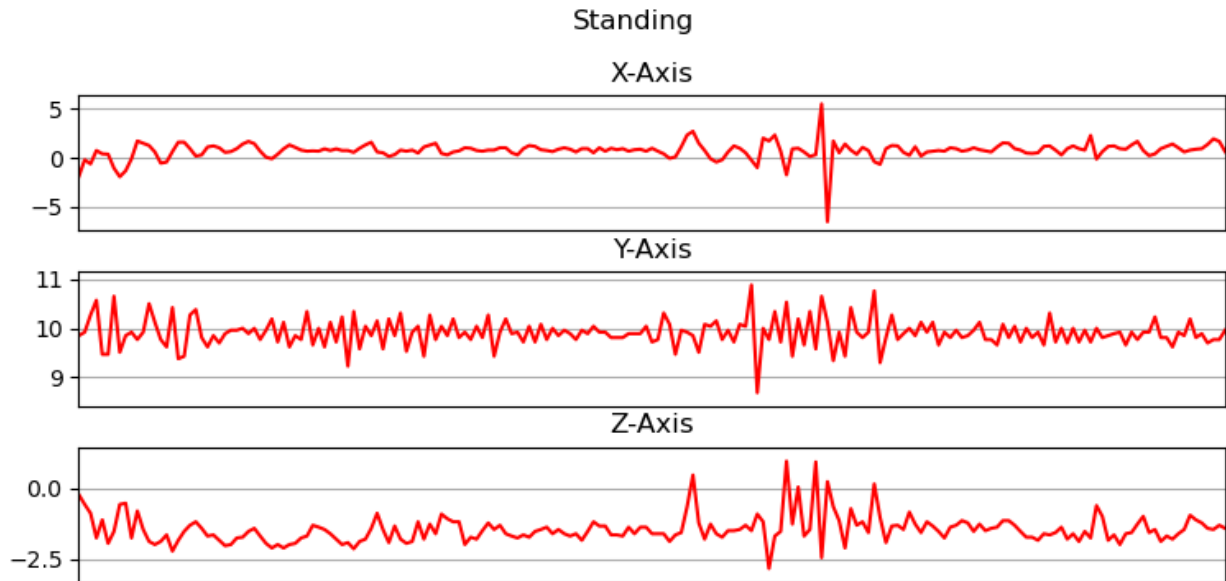

```python
df = data.drop(['user', 'time'], axis = 1).copy()
df.head()
```

```
  activity          x          y          z
0  Jogging  -0.694638  12.680544   0.503953
1  Jogging   5.012288  11.264028   0.953424
2  Jogging   4.903325  10.882658  -0.081722
3  Jogging  -0.612916  18.496431   3.023717
4  Jogging  -1.184970  12.108489   7.205164
```

```python
df['activity'].value_counts()
```

```
Walking        137375
Jogging        129392
Upstairs        35137
Downstairs      33358
Sitting          4599
Standing         3555
Name: activity, dtype: int64
```

```python
Walking = df[df['activity']=='Walking'].head(3555).copy()
Jogging = df[df['activity']=='Jogging'].head(3555).copy()
Upstairs = df[df['activity']=='Upstairs'].head(3555).copy()
Downstairs = df[df['activity']=='Downstairs'].head(3555).copy()
Sitting = df[df['activity']=='Sitting'].head(3555).copy()
Standing = df[df['activity']=='Standing'].copy()

balanced_data = pd.DataFrame()
balanced_data = balanced_data.append([Walking, Jogging, Upstairs,
Downstairs, Sitting, Standing])
balanced_data.shape
```

```
C:\Users\91934\AppData\Local\Temp\ipykernel_24852\4122297741.py:9:
FutureWarning: The frame.append method is deprecated and will be
removed from pandas in a future version. Use pandas.concat instead.
  balanced_data = balanced_data.append([Walking, Jogging, Upstairs,
Downstairs, Sitting, Standing])
```

(21330, 4)

balanced_data['activity'].value_counts()

```
Walking        3555
Jogging        3555
Upstairs       3555
Downstairs     3555
Sitting        3555
Standing       3555
Name: activity, dtype: int64
```

balanced_data.head()

```
    activity         x          y          z
597  Walking  0.844462   8.008764   2.792171
598  Walking  1.116869   8.621680   3.786457
599  Walking -0.503953  16.657684   1.307553
600  Walking  4.794363  10.760075 -1.184970
601  Walking -0.040861   9.234595 -0.694638
```

label = LabelEncoder()
balanced_data['label'] =
label.fit_transform(balanced_data['activity'])
balanced_data.head()

```
    activity         x          y          z  label
597  Walking  0.844462   8.008764   2.792171      5
598  Walking  1.116869   8.621680   3.786457      5
599  Walking -0.503953  16.657684   1.307553      5
600  Walking  4.794363  10.760075 -1.184970      5
601  Walking -0.040861   9.234595 -0.694638      5
```

label.classes_

```
array(['Downstairs', 'Jogging', 'Sitting', 'Standing', 'Upstairs',
       'Walking'], dtype=object)
```

X = balanced_data[['x', 'y', 'z']]
y = balanced_data['label']

scaler = StandardScaler()
X = scaler.fit_transform(X)

scaled_X = pd.DataFrame(data = X, columns = ['x', 'y', 'z'])
scaled_X['label'] = y.values
```

```
scaled_X.head()

          x          y          z   label
0   0.000503 -0.099190   0.337933       5
1   0.073590  0.020386   0.633446       5
2  -0.361275  1.588160  -0.103312       5
3   1.060258  0.437573  -0.844119       5
4  -0.237028  0.139962  -0.698386       5

Fs = 20
frame_size = Fs*4 # 80
hop_size = Fs*2 # 40

def get_frames(df, frame_size, hop_size):

    N_FEATURES = 3

    frames = []
    labels = []
    for i in range(0, len(df) - frame_size, hop_size):
        x = df['x'].values[i: i + frame_size]
        y = df['y'].values[i: i + frame_size]
        z = df['z'].values[i: i + frame_size]

        # Retrieve the used label
        label = stats.mode(df['label'][i: i + frame_size])[0][0]
        frames.append([x, y, z])
        labels.append(label)

    # Reshape
    frames = np.asarray(frames).reshape(-1, frame_size, N_FEATURES)
    labels = np.asarray(labels)

    return frames, labels

X, y = get_frames(scaled_X, frame_size, hop_size)

X.shape, y.shape

C:\Users\91934\AppData\Local\Temp\ipykernel_24852\2828031039.py:17:
FutureWarning: Unlike other reduction functions (e.g. `skew`,
`kurtosis`), the default behavior of `mode` typically preserves the
axis it acts along. In SciPy 1.11.0, this behavior will change: the
default value of `keepdims` will become False, the `axis` over which
the statistic is taken will be eliminated, and the value None will no
longer be accepted. Set `keepdims` to True or False to avoid this
warning.
  label = stats.mode(df['label'][i: i + frame_size])[0][0]

((532, 80, 3), (532,))
```

```python
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size =
0.2, random_state = 0, stratify = y)
X_train.shape, X_test.shape
```

((425, 80, 3), (107, 80, 3))

```python
X_train[0].shape, X_test[0].shape
```

((80, 3), (80, 3))

```python
X_train = X_train.reshape(425, 80, 3, 1)
X_test = X_test.reshape(107, 80, 3, 1)
X_train[0].shape, X_test[0].shape
```

((80, 3, 1), (80, 3, 1))

```python
model = Sequential()
model.add(Conv2D(32, (2, 2), activation = 'relu', input_shape =
X_train[0].shape))
model.add(Dropout(0.1))

model.add(Conv2D(64, (2, 2), activation='relu'))
model.add(Dropout(0.2))

model.add(Flatten())

model.add(Dense(128, activation = 'relu'))
model.add(Dropout(0.5))

model.add(Dense(6, activation='softmax'))
```

C:\Users\91934\anaconda3\Lib\site-packages\keras\src\layers\
convolutional\base_conv.py:99: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential
models, prefer using an `Input(shape)` object as the first layer in
the model instead.
  super().__init__(

```python
model.compile(optimizer=Adam(learning_rate = 0.003), loss =
'sparse_categorical_crossentropy', metrics = ['accuracy'])
history = model.fit(X_train, y_train, epochs = 250, validation_data=
(X_test, y_test), verbose=1)
```

Epoch 1/250
14/14 ──────────────────── 2s 24ms/step - accuracy: 0.2897 - loss:
1.6382 - val_accuracy: 0.8037 - val_loss: 0.7209
Epoch 2/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.7182 - loss:
0.7380 - val_accuracy: 0.8037 - val_loss: 0.3782
Epoch 3/250
14/14 ──────────────────── 0s 11ms/step - accuracy: 0.8676 - loss:
0.4004 - val_accuracy: 0.8879 - val_loss: 0.2378

```
Epoch 4/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.8935 - loss:
0.2694 - val_accuracy: 0.9159 - val_loss: 0.2322
Epoch 5/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 0.9485 - loss:
0.1557 - val_accuracy: 0.9159 - val_loss: 0.1831
Epoch 6/250
14/14 ──────────────────── 0s 16ms/step - accuracy: 0.9723 - loss:
0.0820 - val_accuracy: 0.9252 - val_loss: 0.1818
Epoch 7/250
14/14 ──────────────────── 0s 11ms/step - accuracy: 0.9660 - loss:
0.0912 - val_accuracy: 0.9159 - val_loss: 0.2041
Epoch 8/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9907 - loss:
0.0554 - val_accuracy: 0.9252 - val_loss: 0.2056
Epoch 9/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9936 - loss:
0.0306 - val_accuracy: 0.9252 - val_loss: 0.1695
Epoch 10/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9781 - loss:
0.0564 - val_accuracy: 0.9159 - val_loss: 0.2105
Epoch 11/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9901 - loss:
0.0386 - val_accuracy: 0.9252 - val_loss: 0.2033
Epoch 12/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9926 - loss:
0.0205 - val_accuracy: 0.9159 - val_loss: 0.2079
Epoch 13/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9860 - loss:
0.0369 - val_accuracy: 0.9159 - val_loss: 0.2152
Epoch 14/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9824 - loss:
0.0430 - val_accuracy: 0.9159 - val_loss: 0.2092
Epoch 15/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9848 - loss:
0.0301 - val_accuracy: 0.9159 - val_loss: 0.2348
Epoch 16/250
14/14 ──────────────────── 0s 11ms/step - accuracy: 0.9899 - loss:
0.0349 - val_accuracy: 0.9065 - val_loss: 0.2105
Epoch 17/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9866 - loss:
0.0458 - val_accuracy: 0.9065 - val_loss: 0.2075
Epoch 18/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9941 - loss:
0.0328 - val_accuracy: 0.9346 - val_loss: 0.1693
Epoch 19/250
14/14 ──────────────────── 0s 11ms/step - accuracy: 0.9965 - loss:
0.0221 - val_accuracy: 0.9346 - val_loss: 0.2046
Epoch 20/250
```

```
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9987 - loss:
0.0146 - val_accuracy: 0.9346 - val_loss: 0.2129
Epoch 21/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9985 - loss:
0.0072 - val_accuracy: 0.9439 - val_loss: 0.1689
Epoch 22/250
14/14 ──────────────── 0s 11ms/step - accuracy: 0.9971 - loss:
0.0085 - val_accuracy: 0.9346 - val_loss: 0.1985
Epoch 23/250
14/14 ──────────────── 0s 12ms/step - accuracy: 1.0000 - loss:
0.0040 - val_accuracy: 0.9346 - val_loss: 0.2247
Epoch 24/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9987 - loss:
0.0061 - val_accuracy: 0.9346 - val_loss: 0.1839
Epoch 25/250
14/14 ──────────────── 0s 12ms/step - accuracy: 0.9912 - loss:
0.0194 - val_accuracy: 0.9439 - val_loss: 0.1806
Epoch 26/250
14/14 ──────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0051 - val_accuracy: 0.9439 - val_loss: 0.1938
Epoch 27/250
14/14 ──────────────── 0s 12ms/step - accuracy: 0.9978 - loss:
0.0095 - val_accuracy: 0.9439 - val_loss: 0.2033
Epoch 28/250
14/14 ──────────────── 0s 12ms/step - accuracy: 0.9974 - loss:
0.0114 - val_accuracy: 0.9346 - val_loss: 0.2306
Epoch 29/250
14/14 ──────────────── 0s 14ms/step - accuracy: 0.9856 - loss:
0.0300 - val_accuracy: 0.9346 - val_loss: 0.2146
Epoch 30/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9902 - loss:
0.0268 - val_accuracy: 0.9346 - val_loss: 0.2479
Epoch 31/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9892 - loss:
0.0445 - val_accuracy: 0.9439 - val_loss: 0.1487
Epoch 32/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9931 - loss:
0.0088 - val_accuracy: 0.9533 - val_loss: 0.1411
Epoch 33/250
14/14 ──────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0058 - val_accuracy: 0.9346 - val_loss: 0.1899
Epoch 34/250
14/14 ──────────────── 0s 14ms/step - accuracy: 0.9992 - loss:
0.0078 - val_accuracy: 0.9439 - val_loss: 0.1966
Epoch 35/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9985 - loss:
0.0065 - val_accuracy: 0.9346 - val_loss: 0.2290
Epoch 36/250
14/14 ──────────────── 0s 13ms/step - accuracy: 0.9978 - loss:
```

```
0.0064 - val_accuracy: 0.9439 - val_loss: 0.1629
Epoch 37/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9941 - loss:
0.0296 - val_accuracy: 0.9439 - val_loss: 0.1877
Epoch 38/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0030 - val_accuracy: 0.9346 - val_loss: 0.1821
Epoch 39/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0021 - val_accuracy: 0.9346 - val_loss: 0.1833
Epoch 40/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0030 - val_accuracy: 0.9346 - val_loss: 0.2559
Epoch 41/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 0.9931 - loss:
0.0206 - val_accuracy: 0.9533 - val_loss: 0.1743
Epoch 42/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0024 - val_accuracy: 0.9533 - val_loss: 0.1664
Epoch 43/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0034 - val_accuracy: 0.9439 - val_loss: 0.1759
Epoch 44/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0036 - val_accuracy: 0.9346 - val_loss: 0.1925
Epoch 45/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0017 - val_accuracy: 0.9346 - val_loss: 0.2097
Epoch 46/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 1.0000 - loss:
0.0020 - val_accuracy: 0.9439 - val_loss: 0.2428
Epoch 47/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 1.0000 - loss:
0.0010 - val_accuracy: 0.9439 - val_loss: 0.2550
Epoch 48/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 0.9968 - loss:
0.0140 - val_accuracy: 0.9439 - val_loss: 0.2390
Epoch 49/250
14/14 ──────────────────── 0s 13ms/step - accuracy: 0.9987 - loss:
0.0026 - val_accuracy: 0.9439 - val_loss: 0.2125
Epoch 50/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 0.9978 - loss:
0.0066 - val_accuracy: 0.9626 - val_loss: 0.2262
Epoch 51/250
14/14 ──────────────────── 0s 12ms/step - accuracy: 1.0000 - loss:
0.0017 - val_accuracy: 0.9346 - val_loss: 0.2643
Epoch 52/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9956 - loss:
0.0119 - val_accuracy: 0.9439 - val_loss: 0.2245
```

```
Epoch 53/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9942 - loss:
0.0142 - val_accuracy: 0.9252 - val_loss: 0.2246
Epoch 54/250
14/14 ──────────────── 0s 10ms/step - accuracy: 0.9913 - loss:
0.0465 - val_accuracy: 0.9159 - val_loss: 0.2259
Epoch 55/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9960 - loss:
0.0151 - val_accuracy: 0.9533 - val_loss: 0.1862
Epoch 56/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9930 - loss:
0.0178 - val_accuracy: 0.9252 - val_loss: 0.1821
Epoch 57/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0028 - val_accuracy: 0.9439 - val_loss: 0.1544
Epoch 58/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0018 - val_accuracy: 0.9252 - val_loss: 0.1867
Epoch 59/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9987 - loss:
0.0040 - val_accuracy: 0.9159 - val_loss: 0.2555
Epoch 60/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9951 - loss:
0.0259 - val_accuracy: 0.9346 - val_loss: 0.2549
Epoch 61/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9994 - loss:
0.0047 - val_accuracy: 0.9346 - val_loss: 0.2696
Epoch 62/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0011 - val_accuracy: 0.9252 - val_loss: 0.2494
Epoch 63/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9962 - loss:
0.0102 - val_accuracy: 0.9252 - val_loss: 0.2348
Epoch 64/250
14/14 ──────────────── 0s 10ms/step - accuracy: 0.9987 - loss:
0.0018 - val_accuracy: 0.9346 - val_loss: 0.2028
Epoch 65/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0027 - val_accuracy: 0.9439 - val_loss: 0.1906
Epoch 66/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0022 - val_accuracy: 0.9346 - val_loss: 0.1945
Epoch 67/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9969 - loss:
0.0041 - val_accuracy: 0.9159 - val_loss: 0.3052
Epoch 68/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0041 - val_accuracy: 0.9252 - val_loss: 0.2991
Epoch 69/250
```

```
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0018 - val_accuracy: 0.9252 - val_loss: 0.2980
Epoch 70/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9992 - loss:
0.0034 - val_accuracy: 0.9159 - val_loss: 0.3003
Epoch 71/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9906 - loss:
0.0295 - val_accuracy: 0.9346 - val_loss: 0.2232
Epoch 72/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9912 - loss:
0.0493 - val_accuracy: 0.9159 - val_loss: 0.5361
Epoch 73/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9841 - loss:
0.0501 - val_accuracy: 0.9533 - val_loss: 0.1631
Epoch 74/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0064 - val_accuracy: 0.9439 - val_loss: 0.1451
Epoch 75/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0049 - val_accuracy: 0.9533 - val_loss: 0.1656
Epoch 76/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9974 - loss:
0.0169 - val_accuracy: 0.9626 - val_loss: 0.1479
Epoch 77/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0034 - val_accuracy: 0.9626 - val_loss: 0.1501
Epoch 78/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9985 - loss:
0.0077 - val_accuracy: 0.9533 - val_loss: 0.1751
Epoch 79/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0012 - val_accuracy: 0.9439 - val_loss: 0.2037
Epoch 80/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
4.0908e-04 - val_accuracy: 0.9439 - val_loss: 0.2329
Epoch 81/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9997 - loss:
0.0048 - val_accuracy: 0.9346 - val_loss: 0.2416
Epoch 82/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0015 - val_accuracy: 0.9439 - val_loss: 0.2396
Epoch 83/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0022 - val_accuracy: 0.9533 - val_loss: 0.2279
Epoch 84/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9910 - loss:
0.0232 - val_accuracy: 0.9533 - val_loss: 0.2079
Epoch 85/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9992 - loss:
```

```
0.0039 - val_accuracy: 0.9533 - val_loss: 0.2137
Epoch 86/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9990 - loss:
0.0038 - val_accuracy: 0.9533 - val_loss: 0.2128
Epoch 87/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9974 - loss:
0.0053 - val_accuracy: 0.9346 - val_loss: 0.2050
Epoch 88/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
4.6179e-04 - val_accuracy: 0.9346 - val_loss: 0.2163
Epoch 89/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0015 - val_accuracy: 0.9439 - val_loss: 0.2293
Epoch 90/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0014 - val_accuracy: 0.9439 - val_loss: 0.2313
Epoch 91/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0034 - val_accuracy: 0.9533 - val_loss: 0.1860
Epoch 92/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.9649e-04 - val_accuracy: 0.9533 - val_loss: 0.1769
Epoch 93/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9974 - loss:
0.0047 - val_accuracy: 0.9439 - val_loss: 0.2061
Epoch 94/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9970 - loss:
0.0094 - val_accuracy: 0.9439 - val_loss: 0.2106
Epoch 95/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9884 - loss:
0.0284 - val_accuracy: 0.9533 - val_loss: 0.2193
Epoch 96/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9978 - loss:
0.0084 - val_accuracy: 0.9533 - val_loss: 0.1947
Epoch 97/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9978 - loss:
0.0038 - val_accuracy: 0.9533 - val_loss: 0.1730
Epoch 98/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0026 - val_accuracy: 0.9439 - val_loss: 0.2044
Epoch 99/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9968 - loss:
0.0046 - val_accuracy: 0.9439 - val_loss: 0.2302
Epoch 100/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9931 - loss:
0.0080 - val_accuracy: 0.9533 - val_loss: 0.2373
Epoch 101/250

14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9995 - loss:
0.0018 - val_accuracy: 0.9439 - val_loss: 0.2538
```

```
Epoch 102/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
7.0938e-04 - val_accuracy: 0.9346 - val_loss: 0.2841
Epoch 103/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
0.0050 - val_accuracy: 0.9439 - val_loss: 0.2660
Epoch 104/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9920 - loss:
0.0111 - val_accuracy: 0.9533 - val_loss: 0.2165
Epoch 105/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
0.0022 - val_accuracy: 0.9533 - val_loss: 0.2062
Epoch 106/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0053 - val_accuracy: 0.9533 - val_loss: 0.2350
Epoch 107/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
7.7421e-04 - val_accuracy: 0.9533 - val_loss: 0.2495
Epoch 108/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
2.9515e-04 - val_accuracy: 0.9533 - val_loss: 0.2780
Epoch 109/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
3.9777e-04 - val_accuracy: 0.9533 - val_loss: 0.2777
Epoch 110/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.3693e-04 - val_accuracy: 0.9533 - val_loss: 0.2691
Epoch 111/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9963 - loss:
0.0046 - val_accuracy: 0.9533 - val_loss: 0.1983
Epoch 112/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0019 - val_accuracy: 0.9533 - val_loss: 0.1606
Epoch 113/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9969 - loss:
0.0035 - val_accuracy: 0.9533 - val_loss: 0.1845
Epoch 114/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0012 - val_accuracy: 0.9533 - val_loss: 0.1999
Epoch 115/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9913 - loss:
0.0135 - val_accuracy: 0.9439 - val_loss: 0.2308
Epoch 116/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9982 - loss:
0.0045 - val_accuracy: 0.9346 - val_loss: 0.2011
Epoch 117/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9981 - loss:
0.0067 - val_accuracy: 0.9533 - val_loss: 0.1660
Epoch 118/250
```

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14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9952 - loss:
0.0262 - val_accuracy: 0.9346 - val_loss: 0.3290
Epoch 119/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9946 - loss:
0.0194 - val_accuracy: 0.9439 - val_loss: 0.2747
Epoch 120/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 0.9990 - loss:
0.0031 - val_accuracy: 0.9626 - val_loss: 0.2417
Epoch 121/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
0.0026 - val_accuracy: 0.9533 - val_loss: 0.2118
Epoch 122/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9962 - loss:
0.0216 - val_accuracy: 0.9533 - val_loss: 0.2927
Epoch 123/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9958 - loss:
0.0169 - val_accuracy: 0.9346 - val_loss: 0.2856
Epoch 124/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9917 - loss:
0.0220 - val_accuracy: 0.9346 - val_loss: 0.2068
Epoch 125/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9957 - loss:
0.0098 - val_accuracy: 0.9252 - val_loss: 0.2229
Epoch 126/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9930 - loss:
0.0093 - val_accuracy: 0.9533 - val_loss: 0.1825
Epoch 127/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
7.8867e-04 - val_accuracy: 0.9626 - val_loss: 0.2165
Epoch 128/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
6.9492e-04 - val_accuracy: 0.9439 - val_loss: 0.2210
Epoch 129/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
0.0021 - val_accuracy: 0.9533 - val_loss: 0.2073
Epoch 130/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
2.5052e-04 - val_accuracy: 0.9533 - val_loss: 0.2089
Epoch 131/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9969 - loss:
0.0116 - val_accuracy: 0.9439 - val_loss: 0.1828
Epoch 132/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 0.9990 - loss:
0.0031 - val_accuracy: 0.9533 - val_loss: 0.1792
Epoch 133/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.9901e-04 - val_accuracy: 0.9533 - val_loss: 0.1813
Epoch 134/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 1.0000 - loss:
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4.7719e-04 - val_accuracy: 0.9439 - val_loss: 0.1835
Epoch 135/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 0.9994 - loss:
0.0051 - val_accuracy: 0.9533 - val_loss: 0.1875
Epoch 136/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 1.0000 - loss:
1.2741e-04 - val_accuracy: 0.9533 - val_loss: 0.1809
Epoch 137/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - accuracy: 0.9909 - loss:
0.0343 - val_accuracy: 0.9533 - val_loss: 0.2009
Epoch 138/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 0.9978 - loss:
0.0060 - val_accuracy: 0.9252 - val_loss: 0.3160
Epoch 139/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 0.9969 - loss:
0.0057 - val_accuracy: 0.8972 - val_loss: 0.4431
Epoch 140/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9898 - loss:
0.0338 - val_accuracy: 0.9346 - val_loss: 0.1768
Epoch 141/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
0.0018 - val_accuracy: 0.9533 - val_loss: 0.1757
Epoch 142/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0016 - val_accuracy: 0.9439 - val_loss: 0.1599
Epoch 143/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 0.9962 - loss:
0.0060 - val_accuracy: 0.9533 - val_loss: 0.1546
Epoch 144/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
2.5829e-04 - val_accuracy: 0.9533 - val_loss: 0.1514
Epoch 145/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0011 - val_accuracy: 0.9533 - val_loss: 0.1364
Epoch 146/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
5.5330e-05 - val_accuracy: 0.9533 - val_loss: 0.1385
Epoch 147/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
0.0021 - val_accuracy: 0.9533 - val_loss: 0.1129
Epoch 148/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
4.1970e-04 - val_accuracy: 0.9533 - val_loss: 0.1165
Epoch 149/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
9.9741e-04 - val_accuracy: 0.9533 - val_loss: 0.1497
Epoch 150/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
2.8555e-04 - val_accuracy: 0.9533 - val_loss: 0.1575
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Epoch 151/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
3.6786e-04 - val_accuracy: 0.9533 - val_loss: 0.1597
Epoch 152/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
3.5104e-04 - val_accuracy: 0.9533 - val_loss: 0.1657
Epoch 153/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
6.9088e-05 - val_accuracy: 0.9533 - val_loss: 0.1694
Epoch 154/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.3341e-05 - val_accuracy: 0.9533 - val_loss: 0.1707
Epoch 155/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.6421e-05 - val_accuracy: 0.9533 - val_loss: 0.1711
Epoch 156/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
3.2076e-04 - val_accuracy: 0.9533 - val_loss: 0.1619
Epoch 157/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
1.2241e-04 - val_accuracy: 0.9533 - val_loss: 0.1481
Epoch 158/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.7863e-04 - val_accuracy: 0.9533 - val_loss: 0.1466
Epoch 159/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9997 - loss:
0.0017 - val_accuracy: 0.9533 - val_loss: 0.1182
Epoch 160/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9969 - loss:
0.0036 - val_accuracy: 0.9626 - val_loss: 0.0956
Epoch 161/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.0129e-04 - val_accuracy: 0.9626 - val_loss: 0.0990
Epoch 162/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9994 - loss:
0.0070 - val_accuracy: 0.9626 - val_loss: 0.0765
Epoch 163/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 0.9990 - loss:
0.0046 - val_accuracy: 0.9720 - val_loss: 0.0538
Epoch 164/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 0.9951 - loss:
0.0475 - val_accuracy: 0.9533 - val_loss: 0.1347
Epoch 165/250
14/14 ──────────────────── 0s 11ms/step - accuracy: 1.0000 - loss:
0.0013 - val_accuracy: 0.9720 - val_loss: 0.1756
Epoch 166/250
14/14 ──────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0015 - val_accuracy: 0.9720 - val_loss: 0.1787
Epoch 167/250
14/14 ──────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
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5.4150e-04 - val_accuracy: 0.9626 - val_loss: 0.1566
Epoch 168/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.3416e-04 - val_accuracy: 0.9626 - val_loss: 0.1402
Epoch 169/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
9.3211e-04 - val_accuracy: 0.9626 - val_loss: 0.1398
Epoch 170/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
8.6458e-04 - val_accuracy: 0.9626 - val_loss: 0.1435
Epoch 171/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.2290e-04 - val_accuracy: 0.9626 - val_loss: 0.1480
Epoch 172/250
14/14 ──────────────── 0s 10ms/step - accuracy: 0.9982 - loss:
0.0016 - val_accuracy: 0.9533 - val_loss: 0.1186
Epoch 173/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.7762e-05 - val_accuracy: 0.9533 - val_loss: 0.1061
Epoch 174/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.3453e-04 - val_accuracy: 0.9533 - val_loss: 0.1037
Epoch 175/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0032 - val_accuracy: 0.9533 - val_loss: 0.1251
Epoch 176/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
6.2929e-04 - val_accuracy: 0.9533 - val_loss: 0.1417
Epoch 177/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.4740e-04 - val_accuracy: 0.9533 - val_loss: 0.1470
Epoch 178/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0026 - val_accuracy: 0.9626 - val_loss: 0.1537
Epoch 179/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.6736e-04 - val_accuracy: 0.9626 - val_loss: 0.1487
Epoch 180/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0018 - val_accuracy: 0.9626 - val_loss: 0.1097
Epoch 181/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
1.2274e-04 - val_accuracy: 0.9720 - val_loss: 0.1019
Epoch 182/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
2.0293e-04 - val_accuracy: 0.9626 - val_loss: 0.0992
Epoch 183/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
8.1971e-05 - val_accuracy: 0.9626 - val_loss: 0.0998
Epoch 184/250
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14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0020 - val_accuracy: 0.9720 - val_loss: 0.1090
Epoch 185/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
4.9786e-04 - val_accuracy: 0.9626 - val_loss: 0.1147
Epoch 186/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
4.3730e-04 - val_accuracy: 0.9626 - val_loss: 0.1056
Epoch 187/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
8.4608e-04 - val_accuracy: 0.9626 - val_loss: 0.1045
Epoch 188/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9997 - loss:
0.0014 - val_accuracy: 0.9626 - val_loss: 0.1112
Epoch 189/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
5.2069e-04 - val_accuracy: 0.9626 - val_loss: 0.2160
Epoch 190/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9994 - loss:
0.0021 - val_accuracy: 0.9533 - val_loss: 0.2630
Epoch 191/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
9.2422e-04 - val_accuracy: 0.9533 - val_loss: 0.2845
Epoch 192/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9981 - loss:
0.0050 - val_accuracy: 0.9346 - val_loss: 0.3109
Epoch 193/250
14/14 ──────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0011 - val_accuracy: 0.9346 - val_loss: 0.3655
Epoch 194/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9978 - loss:
0.0196 - val_accuracy: 0.9159 - val_loss: 0.3600
Epoch 195/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9821 - loss:
0.0838 - val_accuracy: 0.9626 - val_loss: 0.2227
Epoch 196/250
14/14 ──────────────── 0s 10ms/step - accuracy: 0.9914 - loss:
0.0845 - val_accuracy: 0.9720 - val_loss: 0.1308
Epoch 197/250
14/14 ──────────────── 0s 10ms/step - accuracy: 0.9989 - loss:
0.0088 - val_accuracy: 0.9626 - val_loss: 0.1747
Epoch 198/250
14/14 ──────────────── 0s 9ms/step - accuracy: 0.9946 - loss:
0.0268 - val_accuracy: 0.9439 - val_loss: 0.2576
Epoch 199/250
14/14 ──────────────── 0s 11ms/step - accuracy: 0.9985 - loss:
0.0035 - val_accuracy: 0.9533 - val_loss: 0.2117
Epoch 200/250
14/14 ──────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0038 - val_accuracy: 0.9533 - val_loss: 0.2649
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Epoch 201/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
0.0027 - val_accuracy: 0.9626 - val_loss: 0.2772
Epoch 202/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 0.9915 - loss:
0.0265 - val_accuracy: 0.9626 - val_loss: 0.1836
Epoch 203/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
5.1174e-04 - val_accuracy: 0.9626 - val_loss: 0.1599
Epoch 204/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 0.9974 - loss:
0.0042 - val_accuracy: 0.9626 - val_loss: 0.1802
Epoch 205/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.1098e-04 - val_accuracy: 0.9626 - val_loss: 0.1864
Epoch 206/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
1.7713e-04 - val_accuracy: 0.9626 - val_loss: 0.1895
Epoch 207/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
0.0013 - val_accuracy: 0.9626 - val_loss: 0.1350
Epoch 208/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 0.9968 - loss:
0.0064 - val_accuracy: 0.9626 - val_loss: 0.2142
Epoch 209/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
2.9305e-04 - val_accuracy: 0.9533 - val_loss: 0.2829
Epoch 210/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 0.9920 - loss:
0.0272 - val_accuracy: 0.9626 - val_loss: 0.2493
Epoch 211/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
6.7988e-05 - val_accuracy: 0.9720 - val_loss: 0.2433
Epoch 212/250
14/14 ─────────────────── 0s 11ms/step - accuracy: 1.0000 - loss:
0.0014 - val_accuracy: 0.9720 - val_loss: 0.2671
Epoch 213/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
6.8890e-04 - val_accuracy: 0.9720 - val_loss: 0.2897
Epoch 214/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 1.0000 - loss:
8.3413e-04 - val_accuracy: 0.9720 - val_loss: 0.2924
Epoch 215/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
2.9214e-05 - val_accuracy: 0.9720 - val_loss: 0.2899
Epoch 216/250
14/14 ─────────────────── 0s 9ms/step - accuracy: 0.9987 - loss:
0.0015 - val_accuracy: 0.9720 - val_loss: 0.2345
Epoch 217/250
14/14 ─────────────────── 0s 10ms/step - accuracy: 1.0000 - loss:
```

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1.3931e-04 - val_accuracy: 0.9533 - val_loss: 0.2037
Epoch 218/250
14/14 ———————————————— 0s 9ms/step - accuracy: 1.0000 - loss:
6.0335e-04 - val_accuracy: 0.9533 - val_loss: 0.2014
Epoch 219/250
14/14 ———————————————— 0s 11ms/step - accuracy: 1.0000 - loss:
7.8022e-05 - val_accuracy: 0.9533 - val_loss: 0.2020
Epoch 220/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
7.5841e-05 - val_accuracy: 0.9533 - val_loss: 0.2031
Epoch 221/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
8.7186e-05 - val_accuracy: 0.9533 - val_loss: 0.2032
Epoch 222/250
14/14 ———————————————— 0s 11ms/step - accuracy: 1.0000 - loss:
4.3728e-04 - val_accuracy: 0.9533 - val_loss: 0.2053
Epoch 223/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
1.4164e-04 - val_accuracy: 0.9533 - val_loss: 0.2052
Epoch 224/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
1.2496e-05 - val_accuracy: 0.9533 - val_loss: 0.2050
Epoch 225/250
14/14 ———————————————— 0s 12ms/step - accuracy: 0.9978 - loss:
0.0018 - val_accuracy: 0.9720 - val_loss: 0.2101
Epoch 226/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
4.4828e-05 - val_accuracy: 0.9720 - val_loss: 0.2238
Epoch 227/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
4.8654e-05 - val_accuracy: 0.9720 - val_loss: 0.2258
Epoch 228/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
3.9678e-05 - val_accuracy: 0.9720 - val_loss: 0.2259
Epoch 229/250
14/14 ———————————————— 0s 10ms/step - accuracy: 0.9992 - loss:
9.1243e-04 - val_accuracy: 0.9720 - val_loss: 0.2569
Epoch 230/250
14/14 ———————————————— 0s 11ms/step - accuracy: 1.0000 - loss:
1.4932e-05 - val_accuracy: 0.9720 - val_loss: 0.2992
Epoch 231/250
14/14 ———————————————— 0s 11ms/step - accuracy: 1.0000 - loss:
1.1340e-04 - val_accuracy: 0.9720 - val_loss: 0.3086
Epoch 232/250
14/14 ———————————————— 0s 11ms/step - accuracy: 1.0000 - loss:
1.4689e-04 - val_accuracy: 0.9720 - val_loss: 0.3030
Epoch 233/250
14/14 ———————————————— 0s 10ms/step - accuracy: 1.0000 - loss:
4.1654e-05 - val_accuracy: 0.9720 - val_loss: 0.2986
Epoch 234/250
```

```
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.2316e-04 - val_accuracy: 0.9720 - val_loss: 0.2960
Epoch 235/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
0.0037 - val_accuracy: 0.9626 - val_loss: 0.2729
Epoch 236/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
2.8308e-04 - val_accuracy: 0.9626 - val_loss: 0.2696
Epoch 237/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
8.3628e-05 - val_accuracy: 0.9626 - val_loss: 0.2681
Epoch 238/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 0.9951 - loss:
0.0124 - val_accuracy: 0.9720 - val_loss: 0.1639
Epoch 239/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9982 - loss:
0.0032 - val_accuracy: 0.9720 - val_loss: 0.1987
Epoch 240/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.9962 - loss:
0.0030 - val_accuracy: 0.9720 - val_loss: 0.2634
Epoch 241/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - accuracy: 1.0000 - loss:
0.0015 - val_accuracy: 0.9720 - val_loss: 0.2820
Epoch 242/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
1.3959e-05 - val_accuracy: 0.9720 - val_loss: 0.2804
Epoch 243/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
0.0017 - val_accuracy: 0.9720 - val_loss: 0.3069
Epoch 244/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
2.5736e-04 - val_accuracy: 0.9720 - val_loss: 0.3051
Epoch 245/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 0.9994 - loss:
0.0013 - val_accuracy: 0.9720 - val_loss: 0.3071
Epoch 246/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
4.2830e-04 - val_accuracy: 0.9720 - val_loss: 0.2962
Epoch 247/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - accuracy: 1.0000 - loss:
0.0010 - val_accuracy: 0.9720 - val_loss: 0.2586
Epoch 248/250
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.3643e-05 - val_accuracy: 0.9720 - val_loss: 0.2490
Epoch 249/250

14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 1.0000 - loss:
3.4099e-04 - val_accuracy: 0.9720 - val_loss: 0.2434
Epoch 250/250
```

```
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - accuracy: 1.0000 - loss:
5.4697e-05 - val_accuracy: 0.9720 - val_loss: 0.2428

def plot_learningCurve(history, epochs):
  # Plotting the accuracy graph of training & validation
  epoch_range = range(1, epochs+1)
  plt.plot(epoch_range, history.history['accuracy'])
  plt.plot(epoch_range, history.history['val_accuracy'])
  plt.title('Model accuracy')
  plt.ylabel('Accuracy')
  plt.xlabel('Number of Epochs')
  plt.legend(['Training', 'Validation'], loc='upper right')
  plt.show()

  # Plotting the loss graph of training & validation
  plt.plot(epoch_range, history.history['loss'])
  plt.plot(epoch_range, history.history['val_loss'])
  plt.title('Model loss')
  plt.ylabel('Loss')
  plt.xlabel('Number of Epochs')
  plt.legend(['Training', 'Validation'], loc='upper right')
  plt.show()

plot_learningCurve(history, 250)
```

Model loss
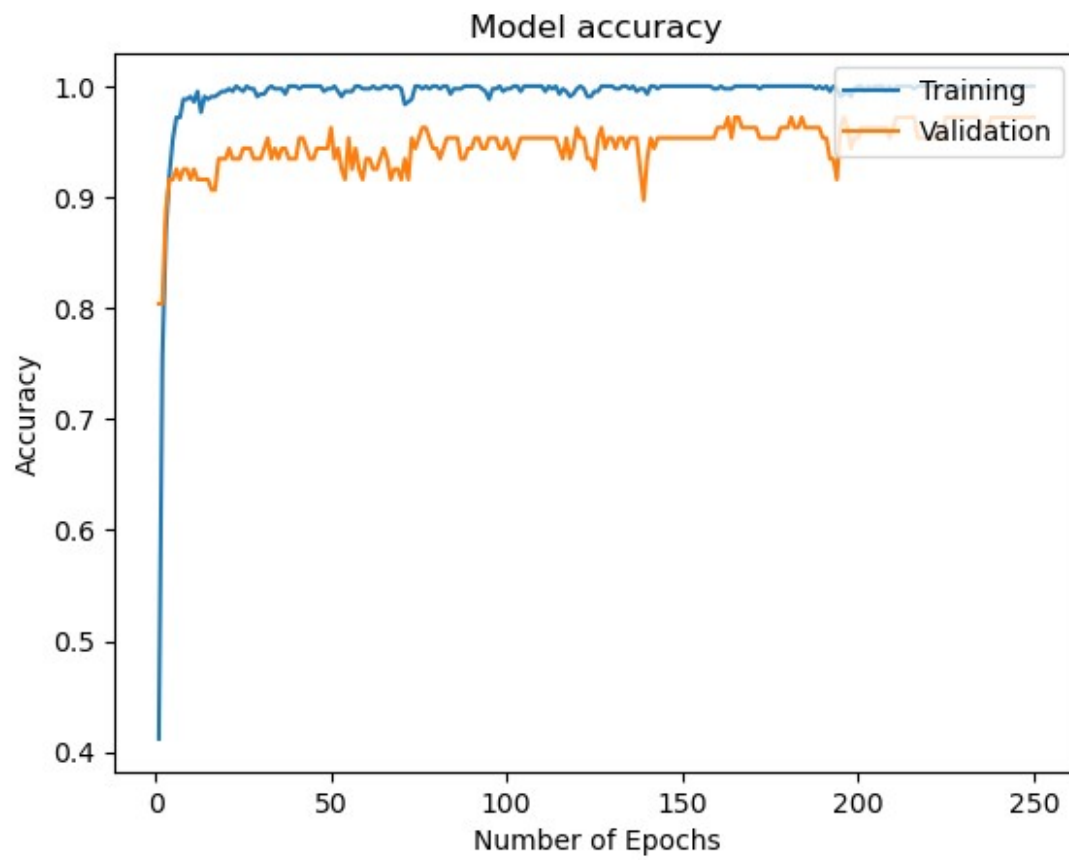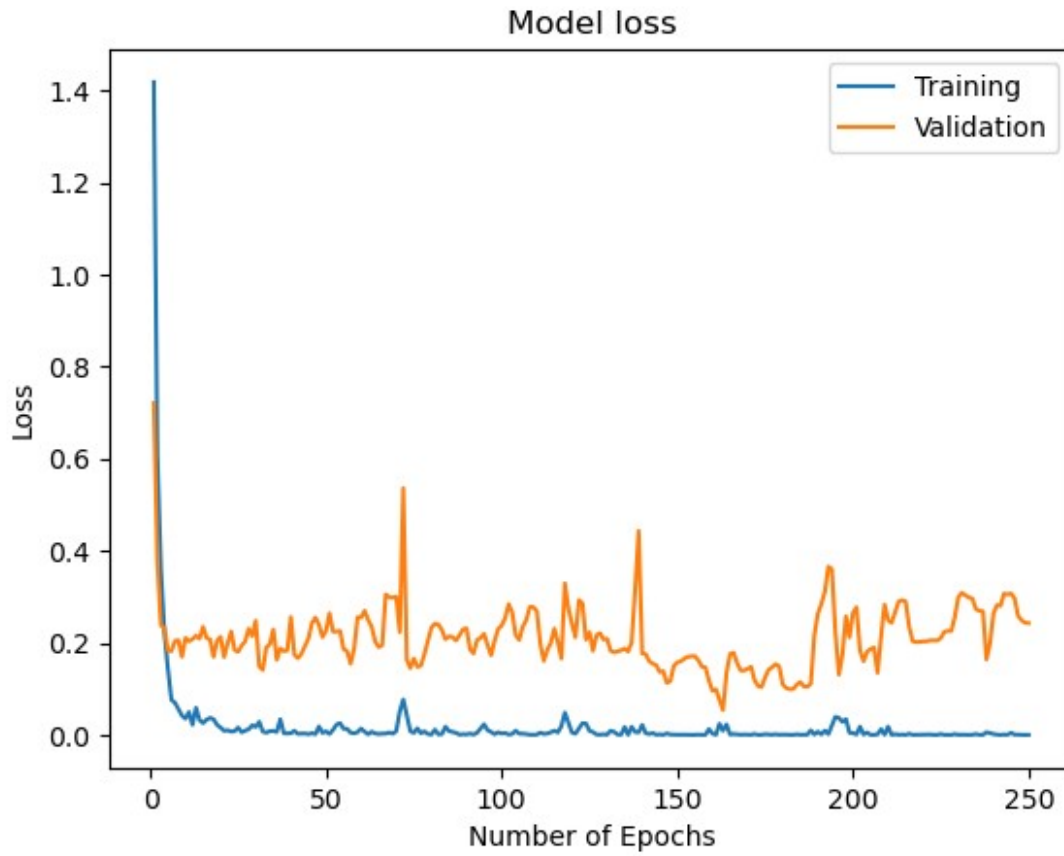
```python
plt.plot(np.array(history.history['loss']), "r--", label = "Train
loss")
plt.plot(np.array(history.history['accuracy']), "g--", label = "Train
accuracy")
plt.plot(np.array(history.history['val_loss']), "r-", label =
"Validation loss")
plt.plot(np.array(history.history['val_accuracy']), "g-", label =
"Validation accuracy")
plt.title("Training session's progress over iterations")
plt.legend(loc='upper right')
plt.ylabel('Training Progress (Loss/Accuracy)')
plt.xlabel('Training Epoch')
plt.ylim(0)
plt.show()
```

Training session's progress over iterations
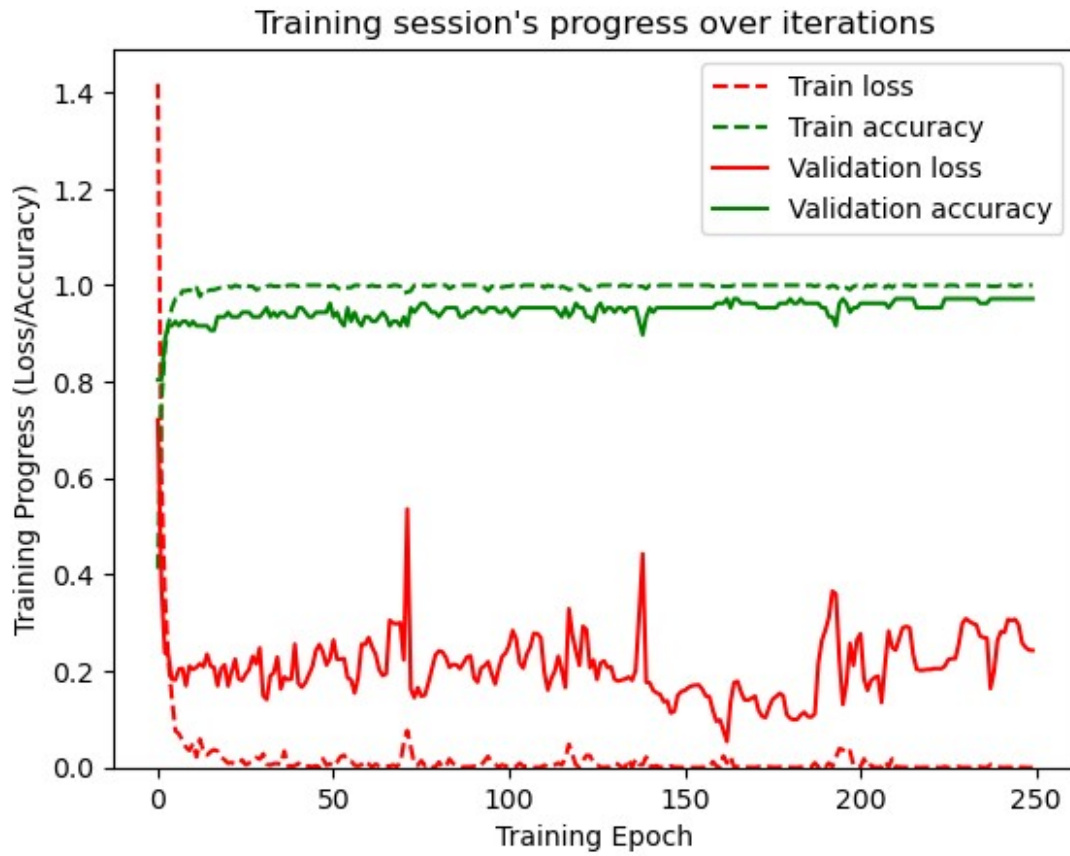
```python
def print_confusion_matrix(confusion_matrix, class_names, figsize =
(10,7), fontsize=14):
    df_cm = pd.DataFrame(confusion_matrix, index=class_names,
columns=class_names)
    fig = plt.figure(figsize=figsize)
    try:
        heatmap = sns.heatmap(df_cm, annot=True, fmt="d")
    except ValueError:
        raise ValueError("Confusion matrix values must not be
integers.")
    heatmap.yaxis.set_ticklabels(heatmap.yaxis.get_ticklabels(),
rotation=0, ha='right', fontsize=fontsize)
    heatmap.xaxis.set_ticklabels(heatmap.xaxis.get_ticklabels(),
rotation=45, ha='right', fontsize=fontsize)
    plt.ylabel('Truth')
    plt.xlabel('Prediction')

truth = ["Downstairs", "Jogging", "Sitting", "Standing", "Upstairs",
"Walking"]
prediction = ["Downstairs", "Jogging", "Sitting", "Standing",
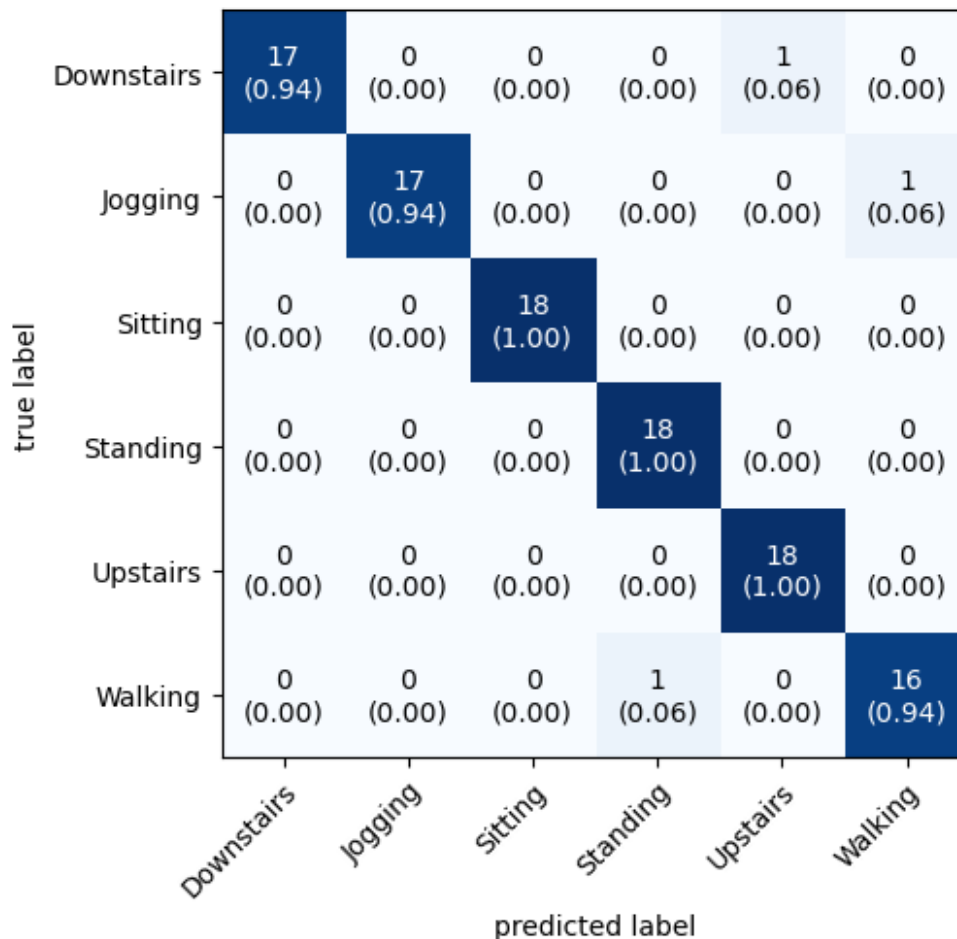"Upstairs", "Walking"]
```

```
y_pred = np.argmax(model.predict(X_test), axis=-1)
mat = confusion_matrix(y_test, y_pred)
plot_confusion_matrix(conf_mat=mat, class_names=label.classes_,
show_normed=True, figsize=(5,5))
```

4/4 ─────────────────── 0s 13ms/step

```
(<Figure size 500x500 with 1 Axes>,
 <Axes: xlabel='predicted label', ylabel='true label'>)
```



```
print("Precision Score : ",precision_score(y_test, y_pred,
average=None))
print("Recall Score : ",recall_score(y_test, y_pred, average=None))
print("Accuracy Score :", accuracy_score(y_test, y_pred,
normalize=True))
print("Loss Score :", hamming_loss(y_test, y_pred))
```

```
Precision Score :  [1.          1.          1.          0.94736842
0.94736842 0.94117647]
Recall Score :  [0.94444444 0.94444444 1.          1.          1.
```

```
0.94117647]
Accuracy Score : 0.9719626168224299
Loss Score : 0.028037383177570093
```