CIS4930 Assignment 3

May 1, 2023

[116]:
```
import os
import librosa
import random
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import ConfusionMatrixDisplay, confusion_matrix,␣
↪roc_curve, auc, classification_report
from sklearn.naive_bayes import GaussianNB
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.neural_network import MLPClassifier # multi-layer perceptron model
```

0.0.1 Step 1: Split the dataset into training and test sets

[80]:
```
pathHappy = "data_folder/happy/"
pathFear = "data_folder/fear/"
pathAngry = "data_folder/angry/"
pathSad = "data_folder/sad/"

filesHappy = librosa.util.find_files(pathHappy)
filesFear = librosa.util.find_files(pathFear)
filesAngry = librosa.util.find_files(pathAngry)
filesSad = librosa.util.find_files(pathSad)
```

[81]:
```
filesHappy = np.asarray(filesHappy)
filesFear = np.asarray(filesFear)
filesAngry = np.asarray(filesAngry)
filesSad = np.asarray(filesSad)
```

[82]:
```
targets_h = np.full(100, 1) # array of 1s for happy target
```

```
train_h, test_h, target_h,  t_h= train_test_split(filesHappy, targets_h,␣
 ↪test_size = 0.3, shuffle=True, random_state=42)

targets_f = np.full(100, 2) # array of 2s for fear target

train_f, test_f, target_f, t_f = train_test_split(filesFear, targets_f,␣
 ↪test_size = 0.3, shuffle=True, random_state=42)

targets_a = np.full(100, 3) # array of 3s for angry target

train_a, test_a, target_a, t_a = train_test_split(filesAngry, targets_a,␣
 ↪test_size = 0.3, shuffle=True, random_state=42)

targets_s = np.full(100, 4) # array of 4s for sad target

train_s, test_s, target_s, t_s = train_test_split(filesSad, targets_s,␣
 ↪test_size = 0.3, shuffle=True, random_state=42)

np.info(train_s)
```

```
class:  ndarray
shape:  (70,)
strides:  (372,)
itemsize:  372
aligned:  True
contiguous:  True
fortran:  True
data pointer: 0x1cdf9030400
byteorder:  little
byteswap:  False
type: <U93
```

[83]:
```
train = np.append(train_h, train_f)
train = np.append(train, train_a)
train = np.append(train, train_s)

np.info(train)
```

```
class:  ndarray
shape:  (280,)
strides:  (388,)
itemsize:  388
aligned:  True
contiguous:  True
fortran:  True
data pointer: 0x1cdf02fac10
byteorder:  little
byteswap:  False
```

```
type: <U97
```

[84]:
```
target = np.append(target_h, target_f)
target = np.append(target, target_a)
target = np.append(target, target_s)

np.info(target)
```

```
class:  ndarray
shape:  (280,)
strides:  (4,)
itemsize:  4
aligned:  True
contiguous:  True
fortran:  True
data pointer: 0x1cdf224bd70
byteorder:  little
byteswap:  False
type: int32
```

[85]:
```
test = np.append(test_h, test_f)
test = np.append(test, test_a)
test = np.append(test, test_s)

np.info(test)
```

```
class:  ndarray
shape:  (120,)
strides:  (388,)
itemsize:  388
aligned:  True
contiguous:  True
fortran:  True
data pointer: 0x1cde7e3d190
byteorder:  little
byteswap:  False
type: <U97
```

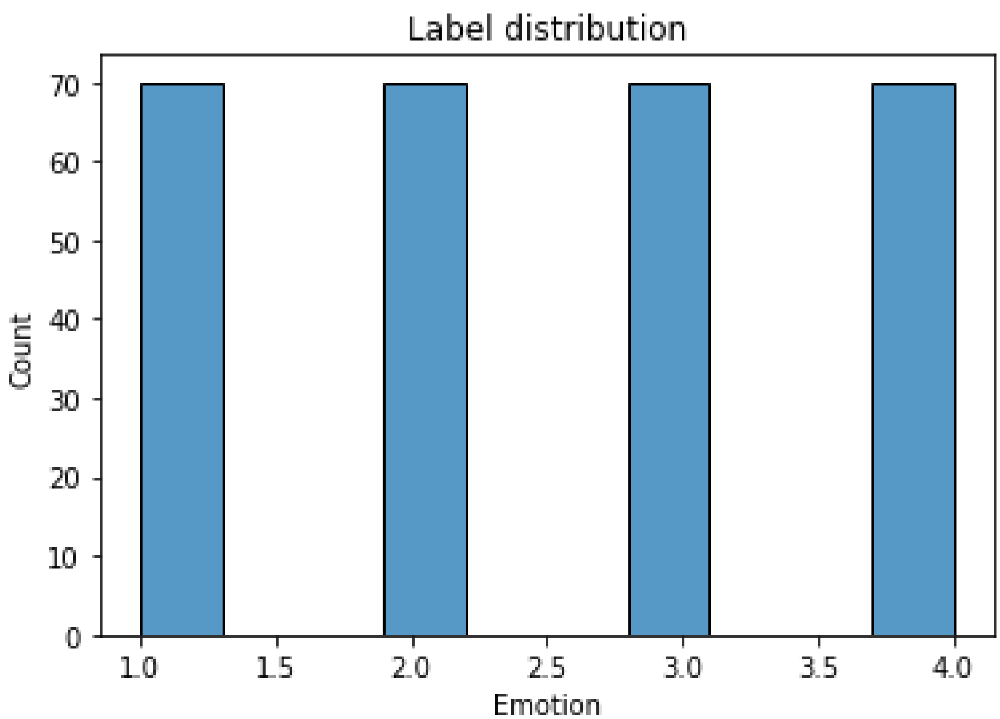
[86]:
```
t = np.append(t_h, t_f)
t = np.append(t, t_a)
t = np.append(t, t_s)

np.info(t)
```

```
class:  ndarray
shape:  (120,)
strides:  (4,)
itemsize:  4
aligned:  True
```

```
contiguous:  True
fortran:  True
data pointer: 0x1cde295e880
byteorder:  little
byteswap:  False
type: int32
```

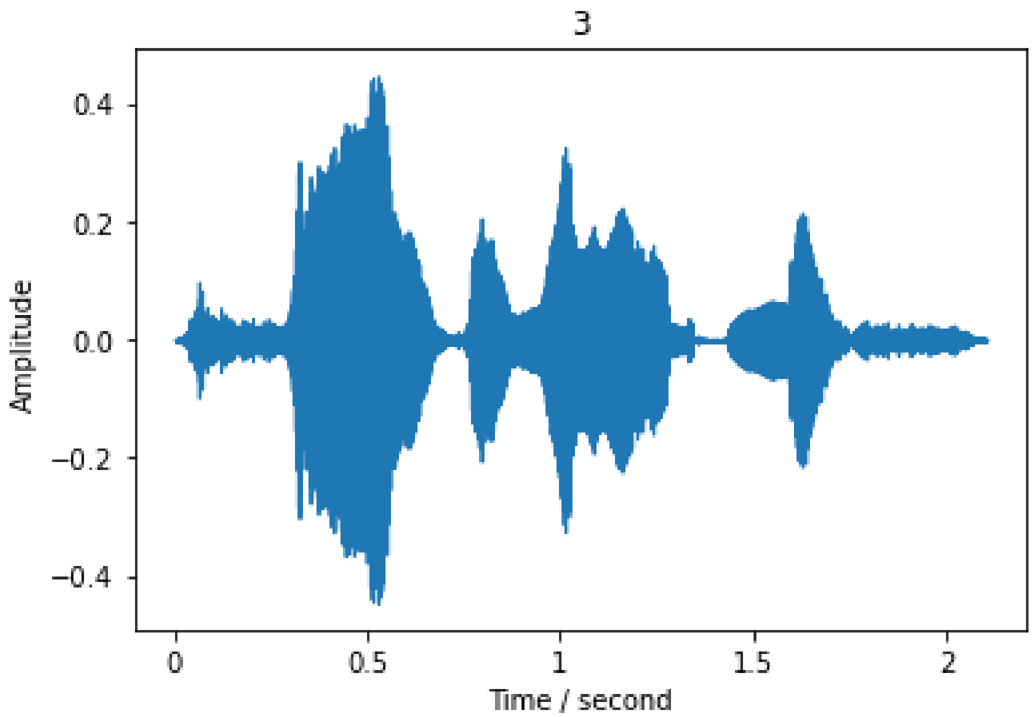
0.0.2 Step 2. Exploratory Data Analysis

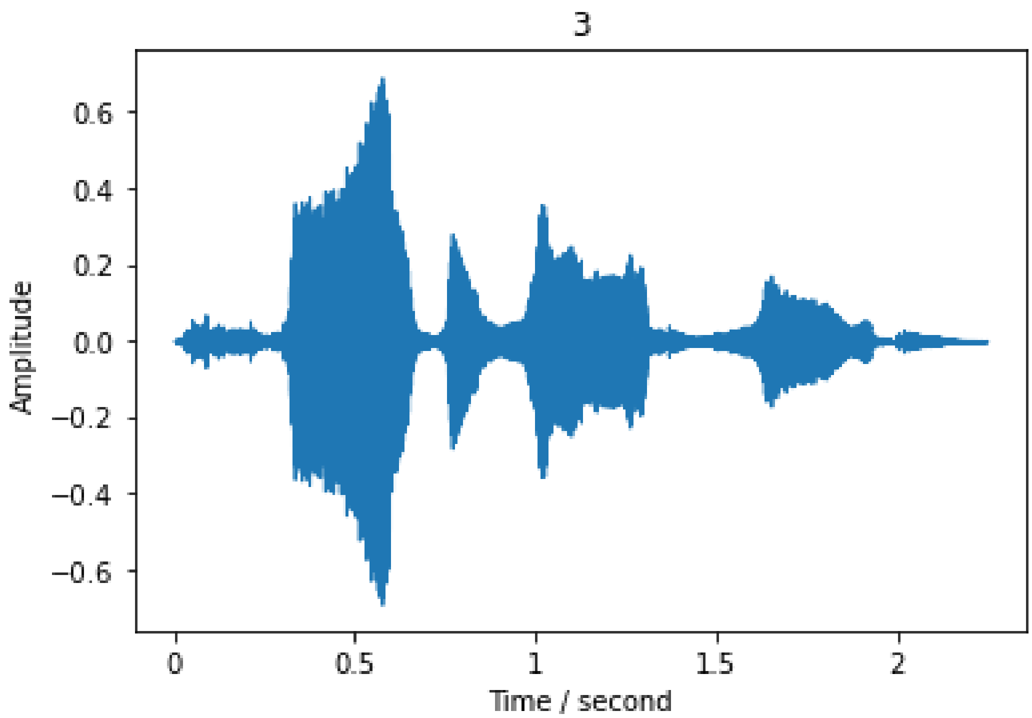
[93]:
```
sns.histplot(data=target, palette='bright')
plt.title("Label distribution")
plt.xlabel("Emotion")
plt.show()
```

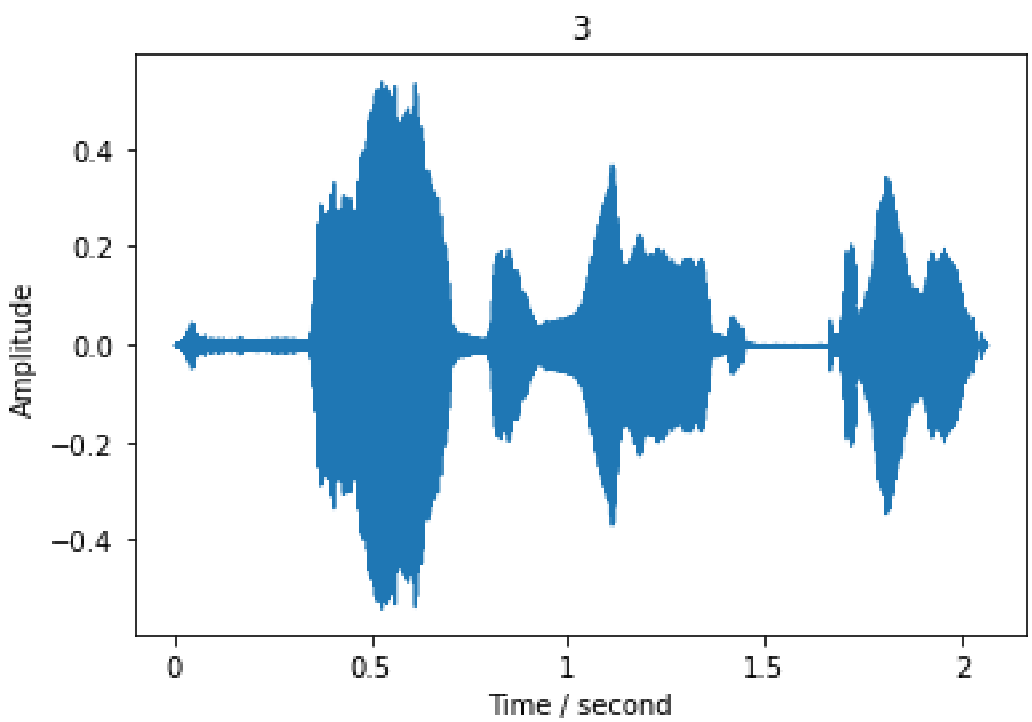


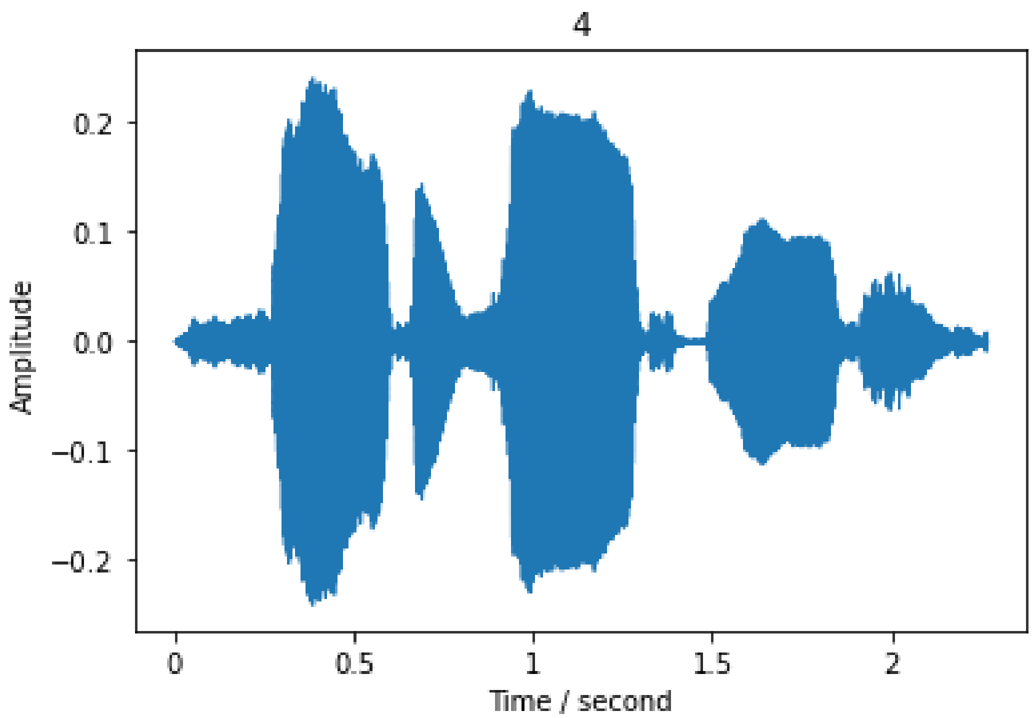
[88]:
```
# sample of 10 files in time domain
rand_nums = random.sample(range(280), 10)
train_rand = np.array([train[i] for i in rand_nums])
t_rand = np.array([target[i] for i in rand_nums])

for i in range(len(train_rand)):
    signal, sample_rate = librosa.load(train_rand[i], sr = 16000,mono = True)
    librosa.display.waveshow(y=signal, sr=sample_rate)
    plt.xlabel('Time / second')
```

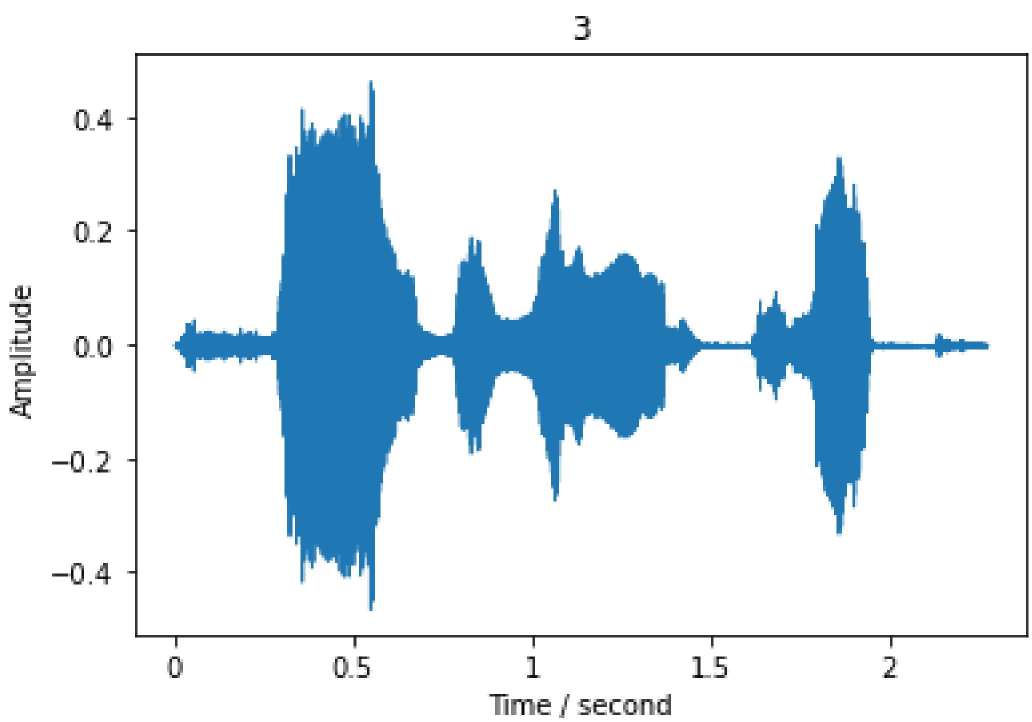
```
    plt.ylabel('Amplitude')
    plt.title(t_rand[i])
    plt.show()
```

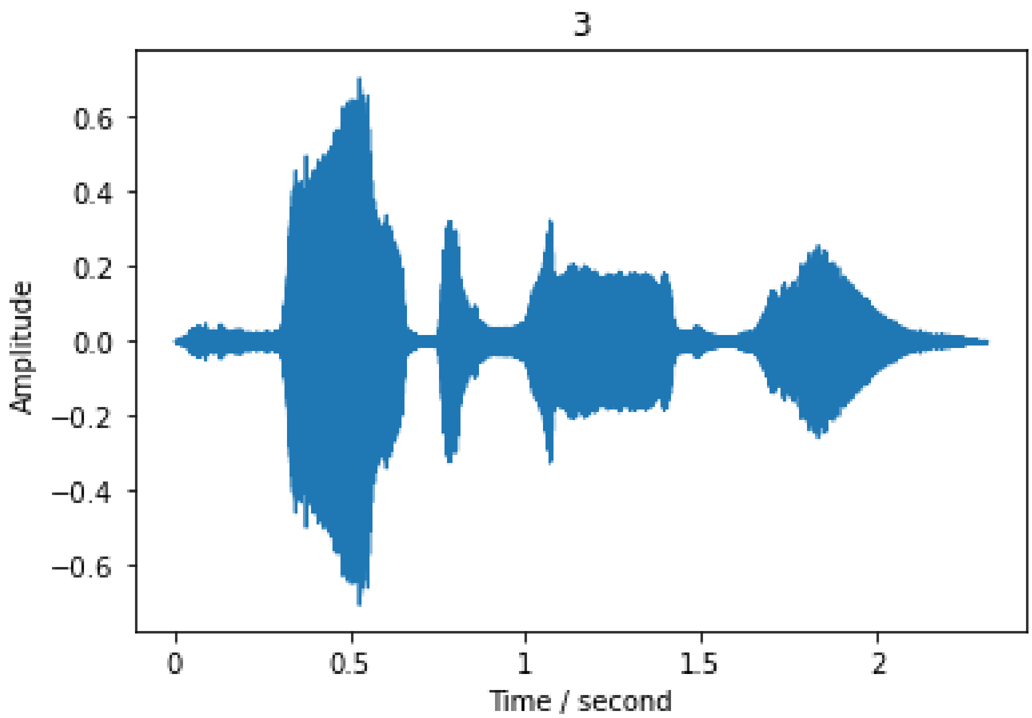


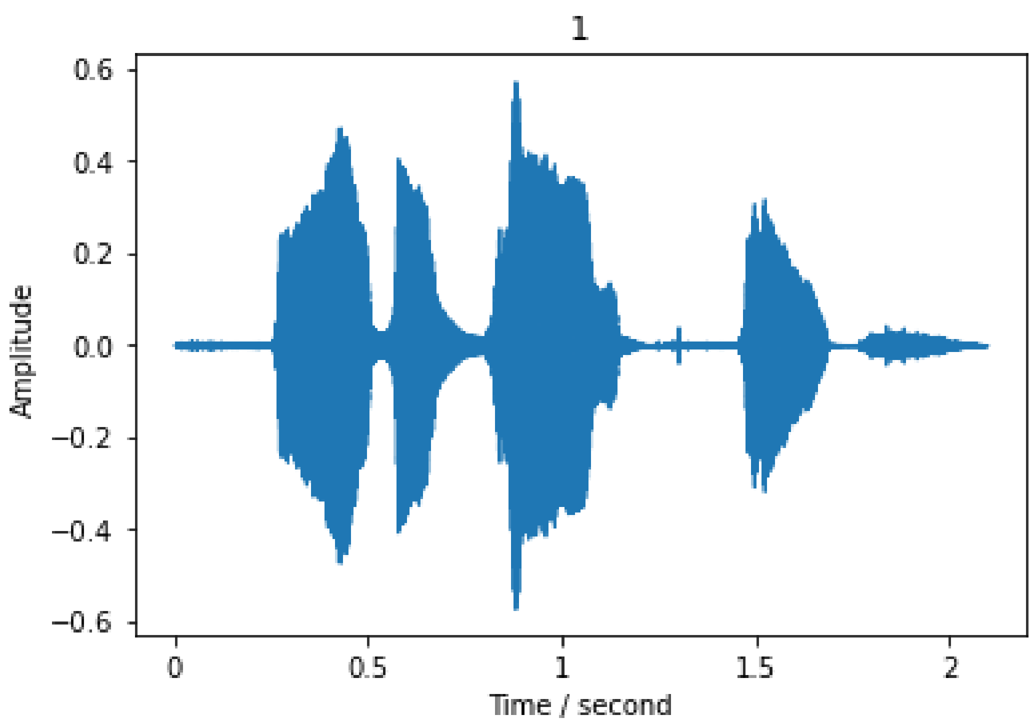

3
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Amplitude
0
0.5
1
1.5
2
Time / second

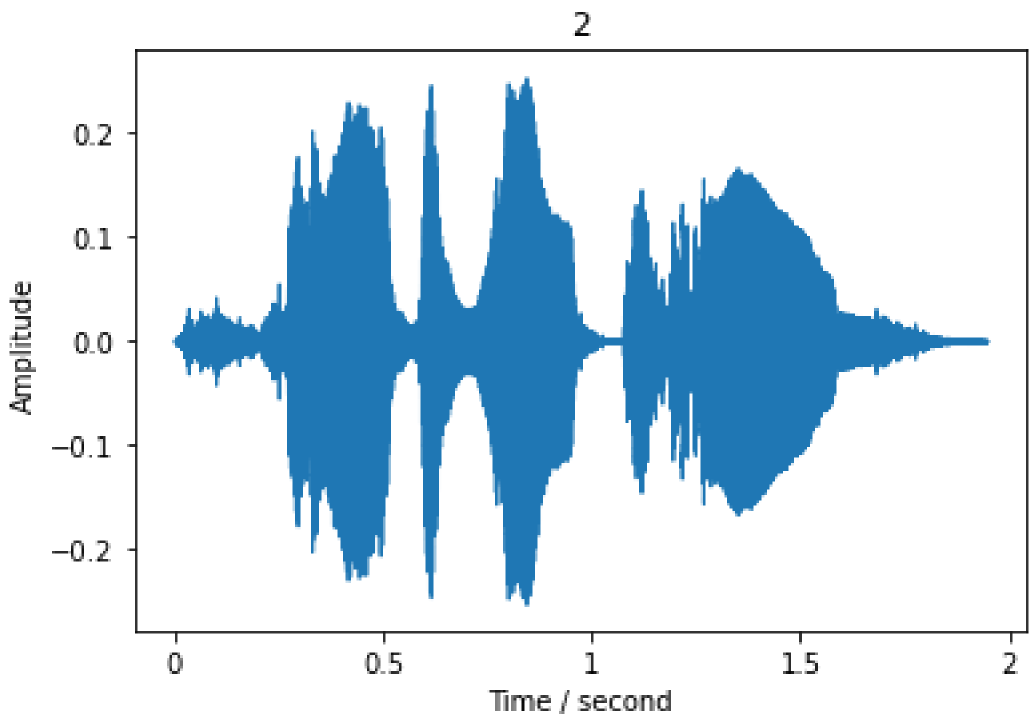

3
0.4
0.2
0.0
−0.2
−0.4
Amplitude
0
0.5
1
1.5
2
Time / second

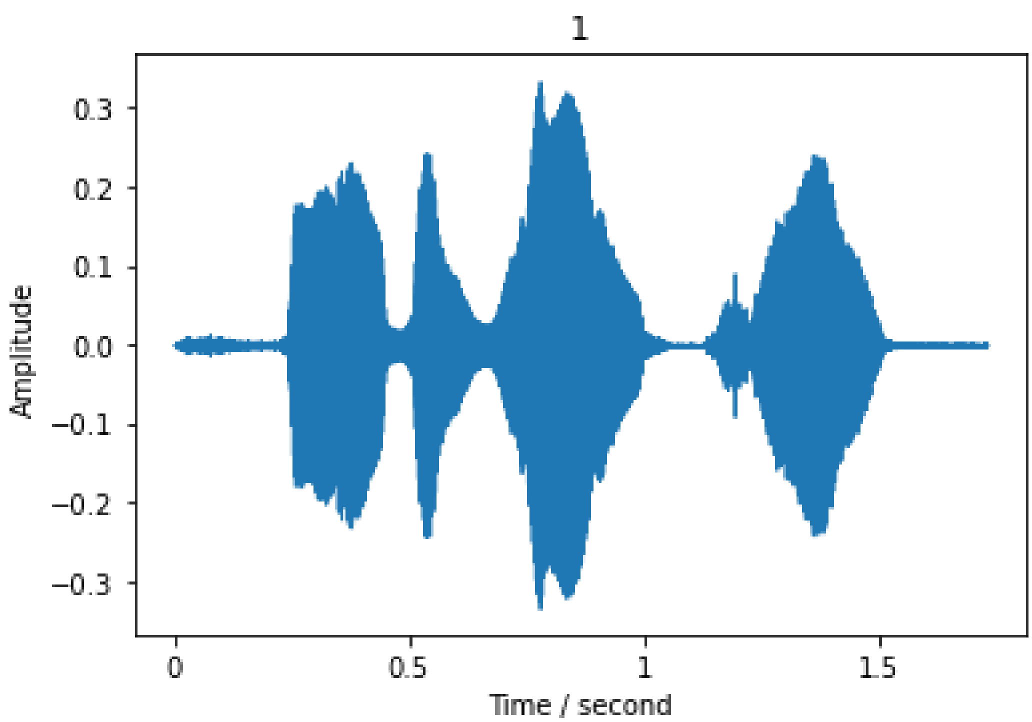

4
0.2
0.1
0.0
−0.1
−0.2
Amplitude
0
0.5
1
1.5
2
Time / second

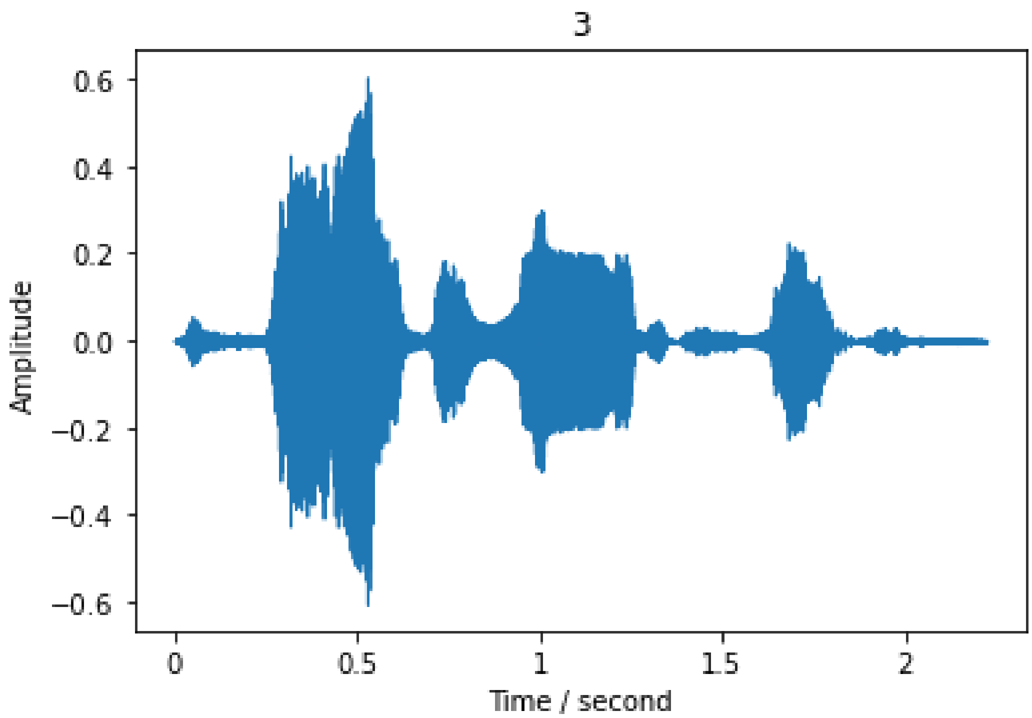

3
0.4
0.2
0.0
−0.2
−0.4
Amplitude
0
0.5
1
1.5
2
Time / second


3
Amplitude
Time / second
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
0
0.5
1
1.5
2

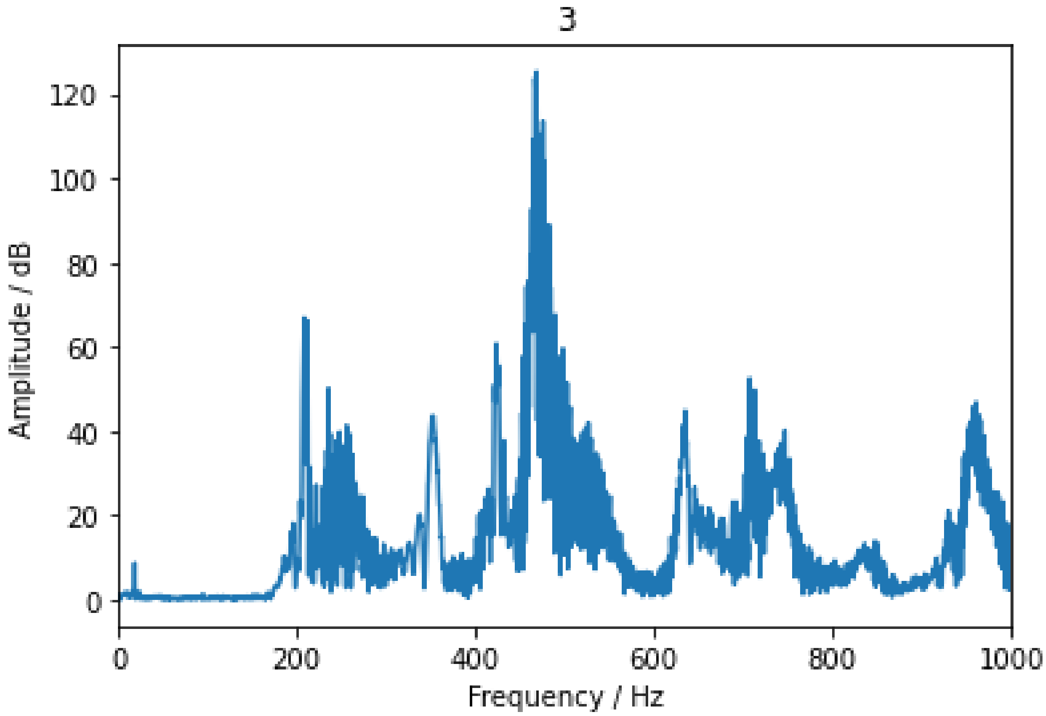

1
Amplitude
Time / second
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
0
0.5
1
1.5
2

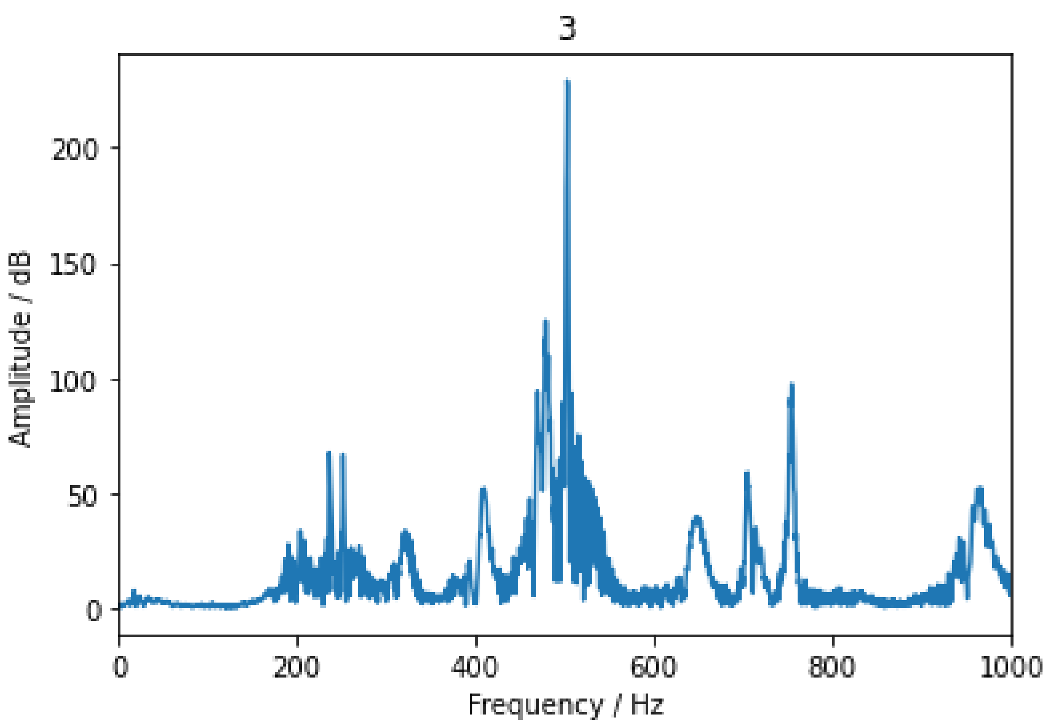

2
Amplitude
0.2
0.1
0.0
−0.1
−0.2
0
0.5
1
1.5
2
Time / second

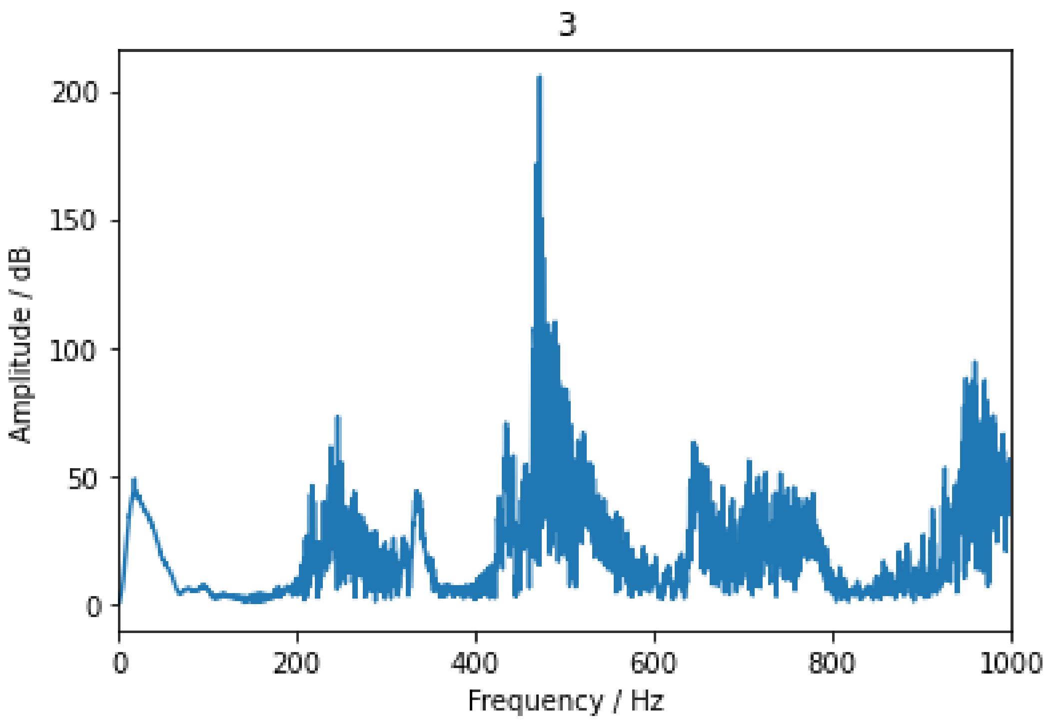

1
Amplitude
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
0
0.5
1
1.5
Time / second

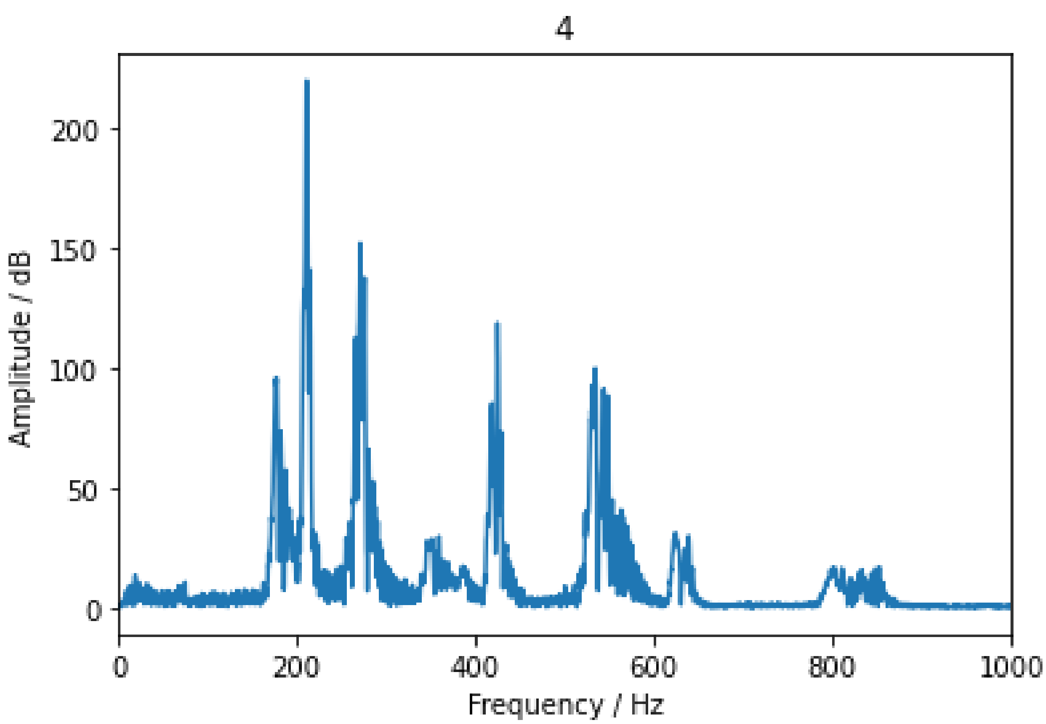


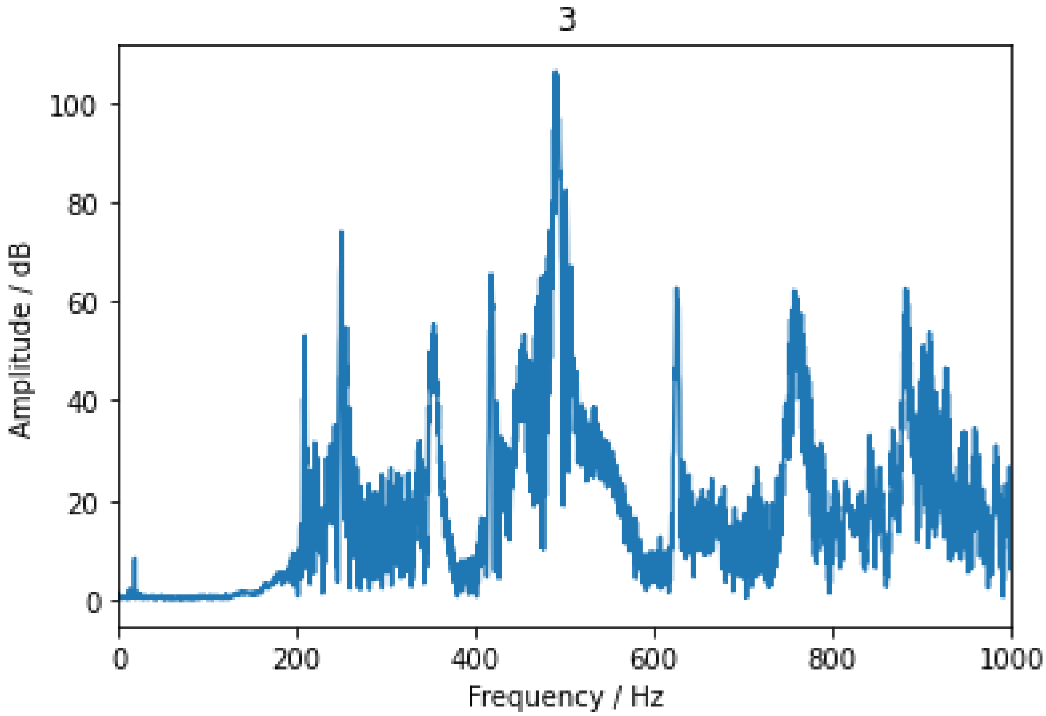
[89]:
```
# sample of 10 files in the frequency domain (some code copied from Coding␣
↪Materials)
for i in range(len(train_rand)):
    signal, sample_rate = librosa.load(train_rand[i], sr = 16000,mono = True)
    k = np.arange(len(signal))
    T = len(signal)/sample_rate
    freq = k/T

    DATA_0 = np.fft.fft(signal)
    abs_DATA_0 = abs(DATA_0)
    plt.figure(2)
    plt.plot(freq, abs_DATA_0)
    plt.title(t_rand[i])
    plt.xlabel("Frequency / Hz")
    plt.ylabel("Amplitude / dB")
    plt.xlim([0, 1000])
    plt.show()
```

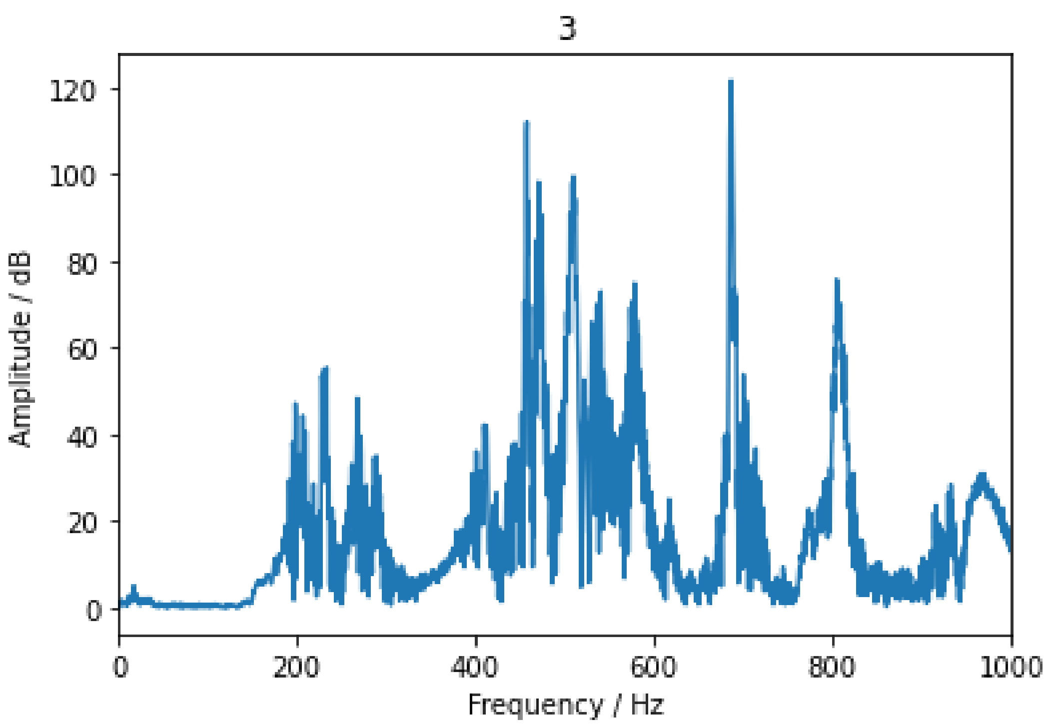

3
Amplitude / dB
Frequency / Hz
0
20
40
60
80
100
120
0
200
400
600
800
1000

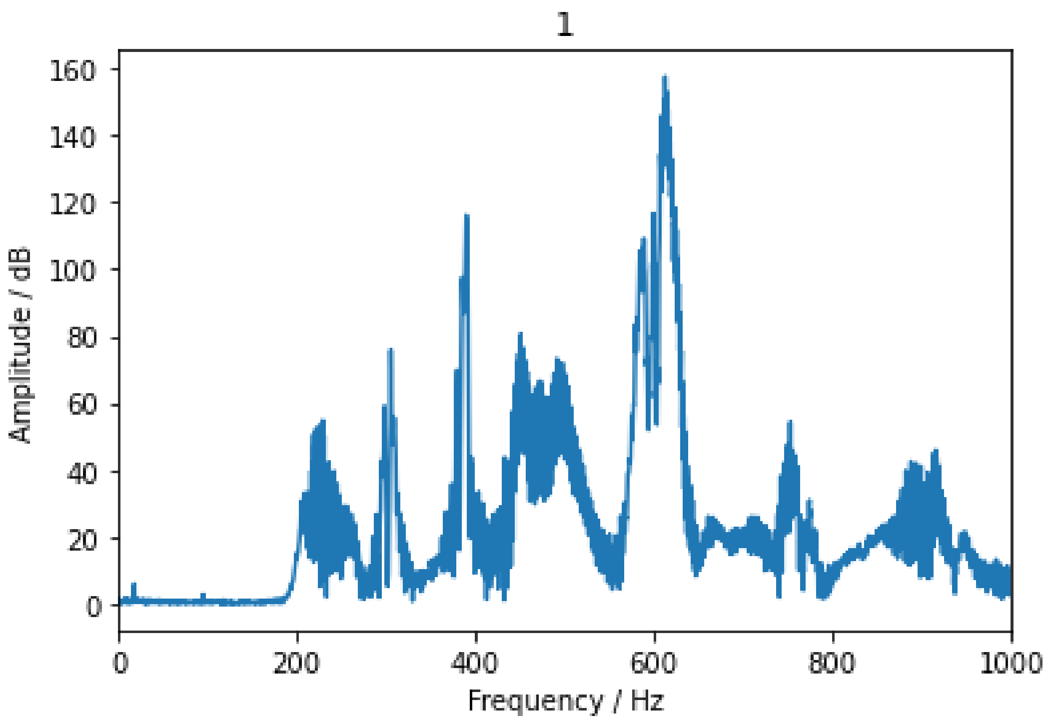

3
Amplitude / dB
Frequency / Hz
0
50
100
150
200
0
200
400
600
800
1000

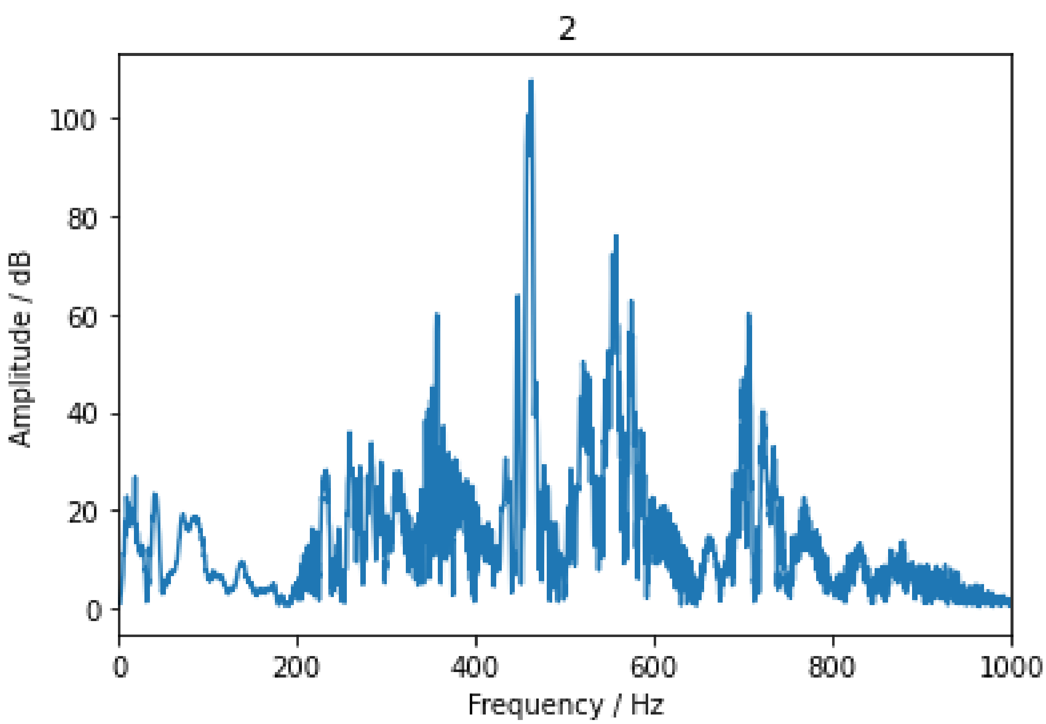

3
Amplitude / dB
Frequency / Hz
0
50
100
150
200
0
200
400
600
800
1000

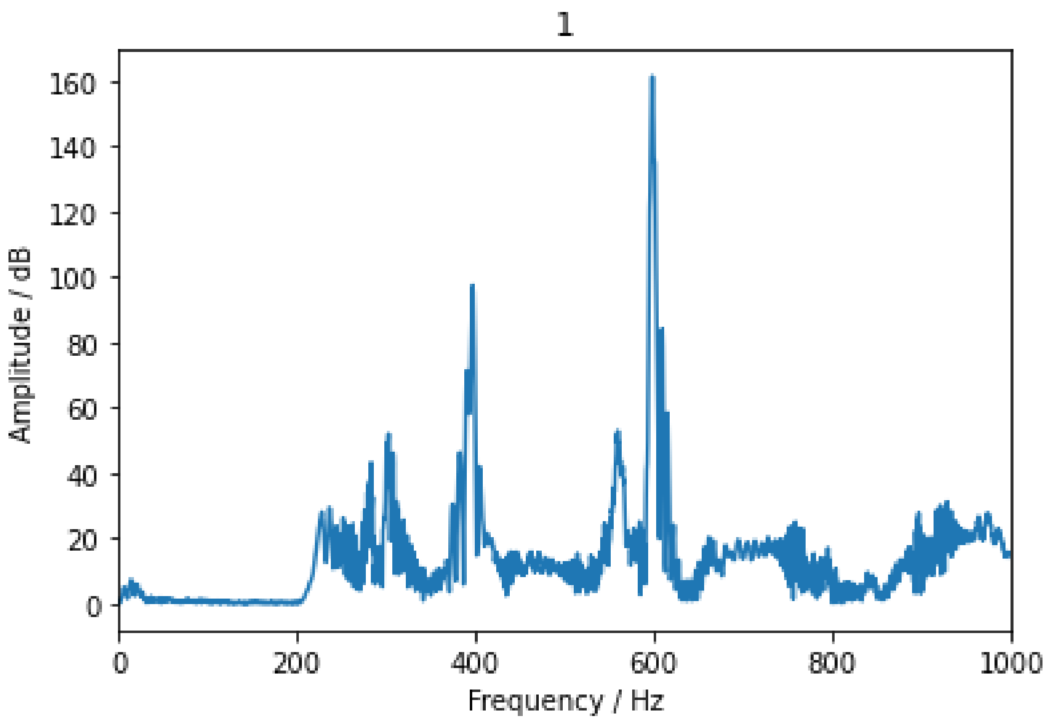

4
Amplitude / dB
Frequency / Hz
0
50
100
150
200
0
200
400
600
800
1000

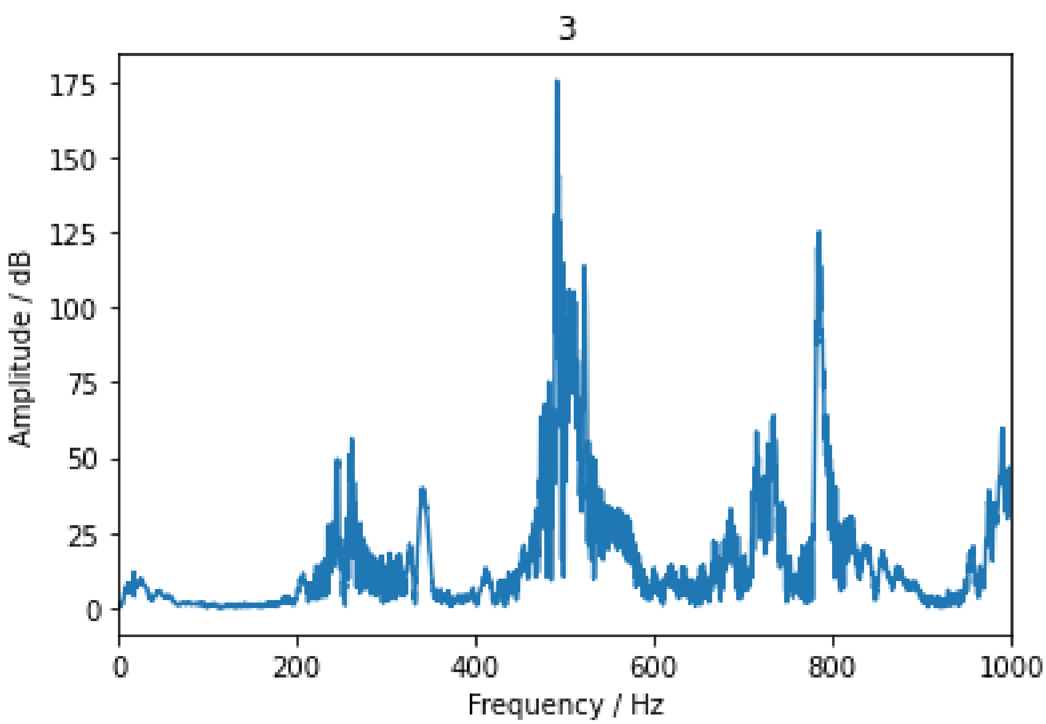

3
Amplitude / dB
Frequency / Hz
0
20
40
60
80
100
0
200
400
600
800
1000


3
Amplitude / dB
Frequency / Hz
0
20
40
60
80
100
120
0
200
400
600
800
1000


1
Amplitude / dB
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
Frequency / Hz

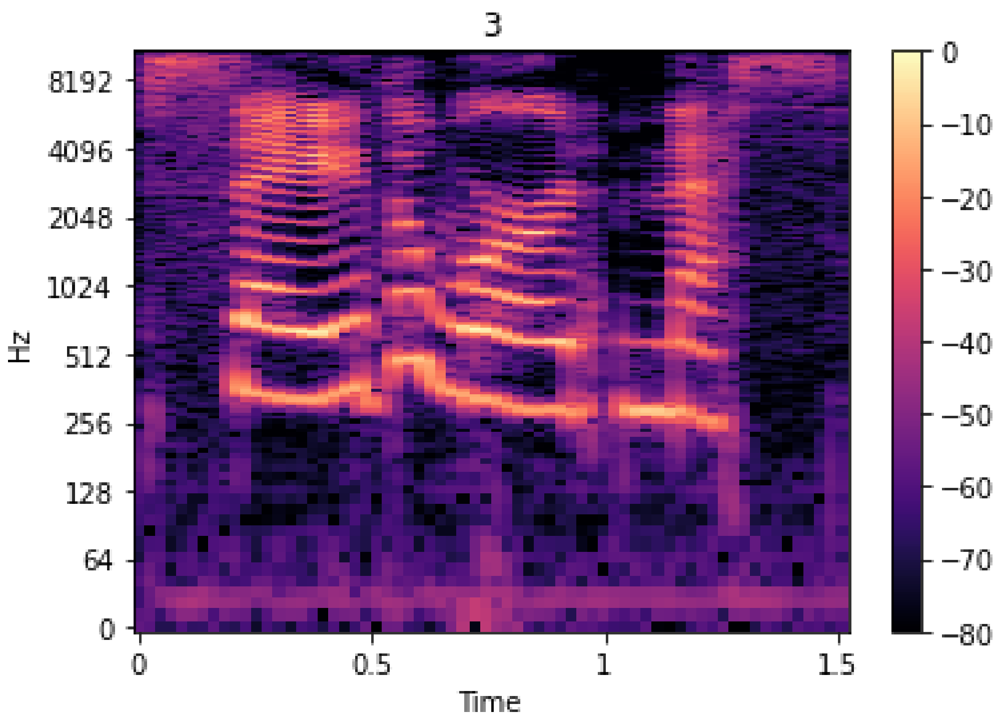

2
Amplitude / dB
100
80
60
40
20
0
0
200
400
600
800
1000
Frequency / Hz

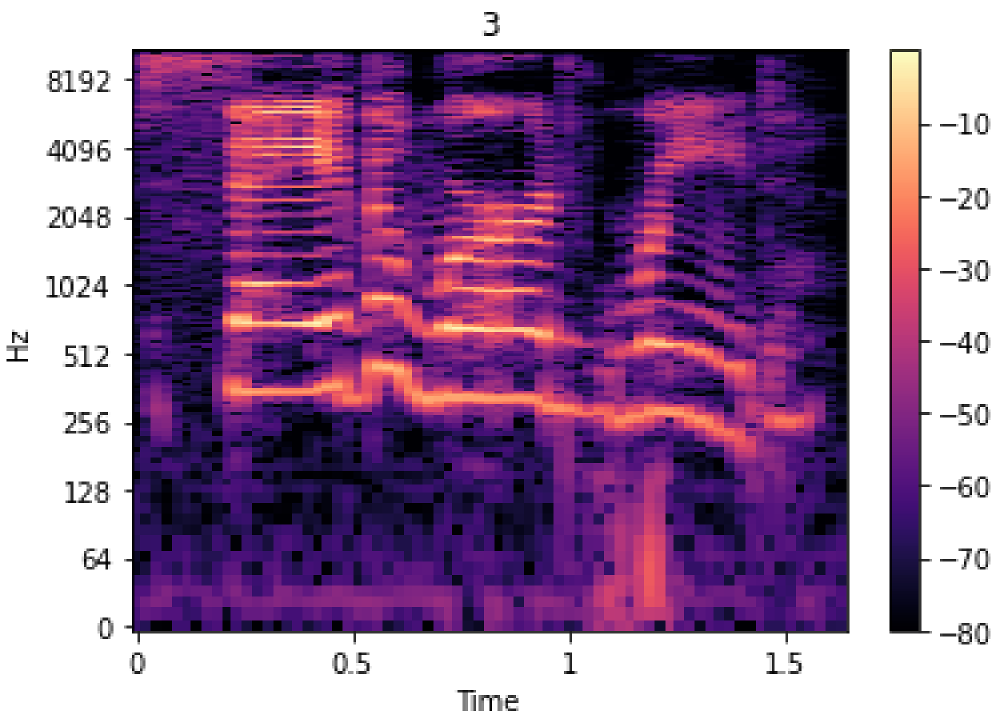

1
Amplitude / dB
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
Frequency / Hz

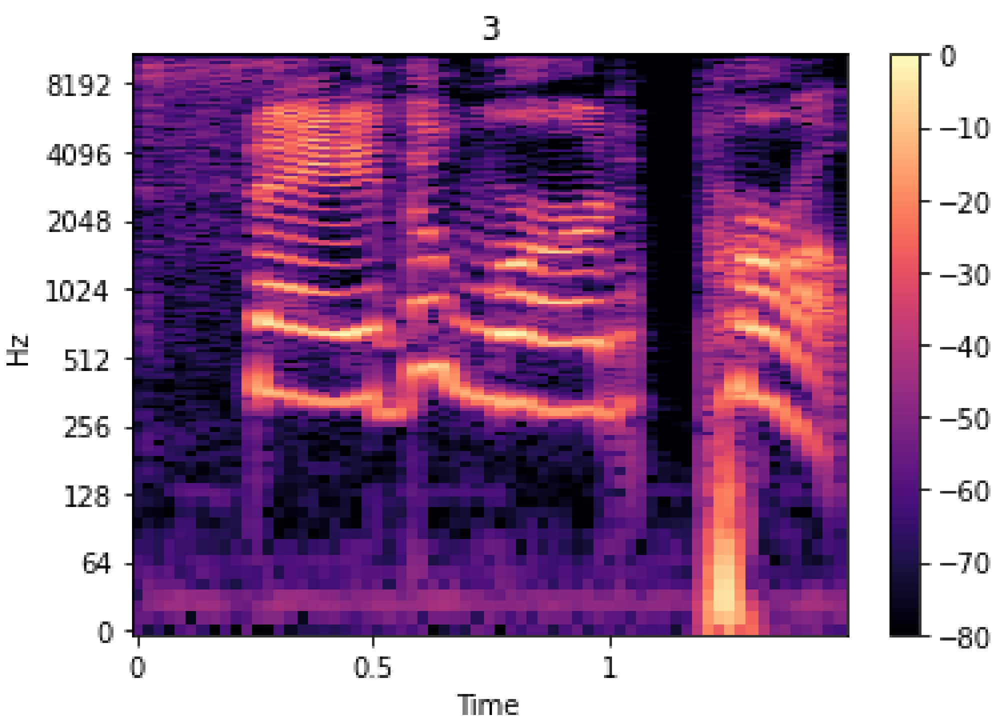

3
Amplitude / dB
0
25
50
75
100
125
150
175
0
200
400
600
800
1000
Frequency / Hz

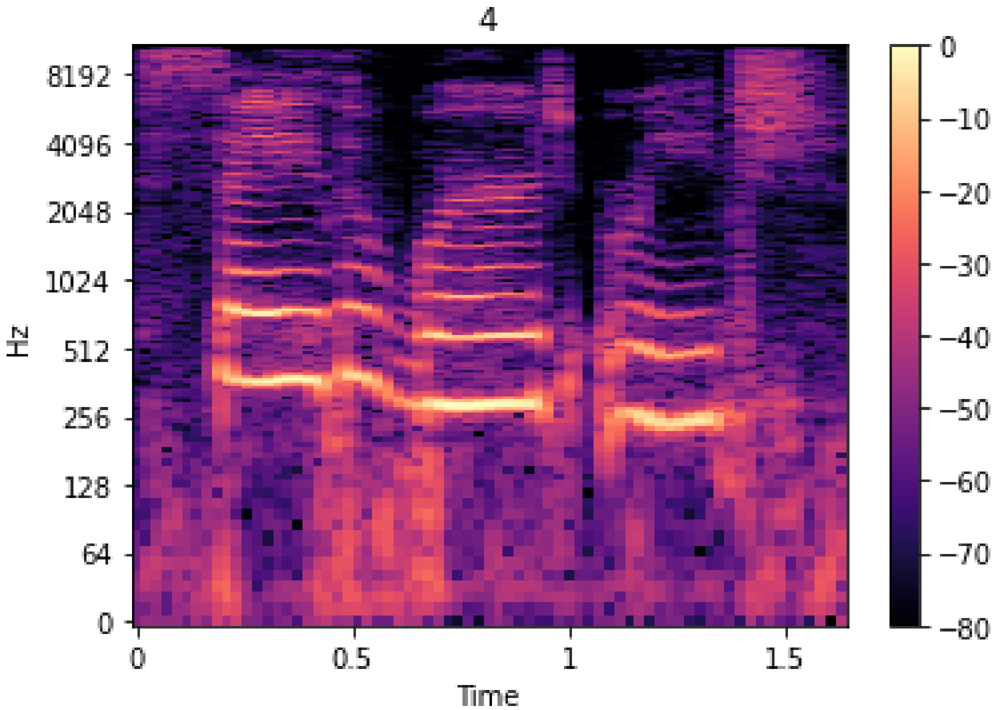
[90]:

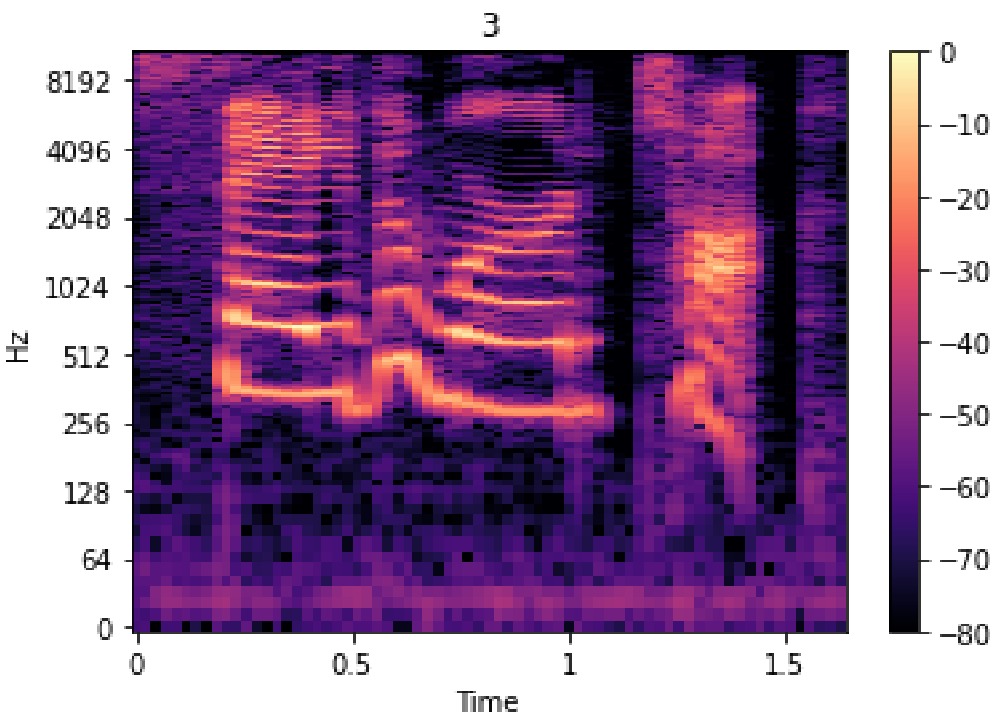
```python
# sample of 10 files in the time-frequency domain (some code copied from Coding␣
↪Materials)
for i in range(len(train_rand)):
    signal, sample_rate = librosa.load(train_rand[i], sr = 16000,mono = True)
    D = librosa.stft(signal)  # STFT of y
    S_db = librosa.amplitude_to_db(np.abs(D), ref=np.max)
    plt.figure(3)
    librosa.display.specshow(S_db, x_axis='time', y_axis='log')
    plt.title(t_rand[i])
    plt.colorbar()
    plt.show()
```

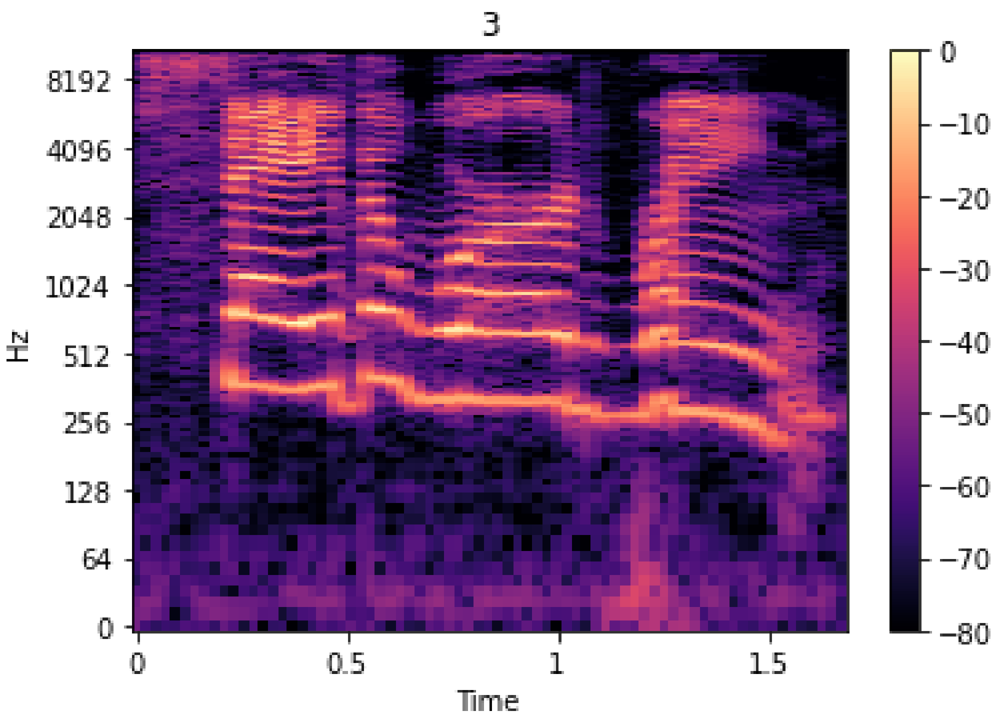


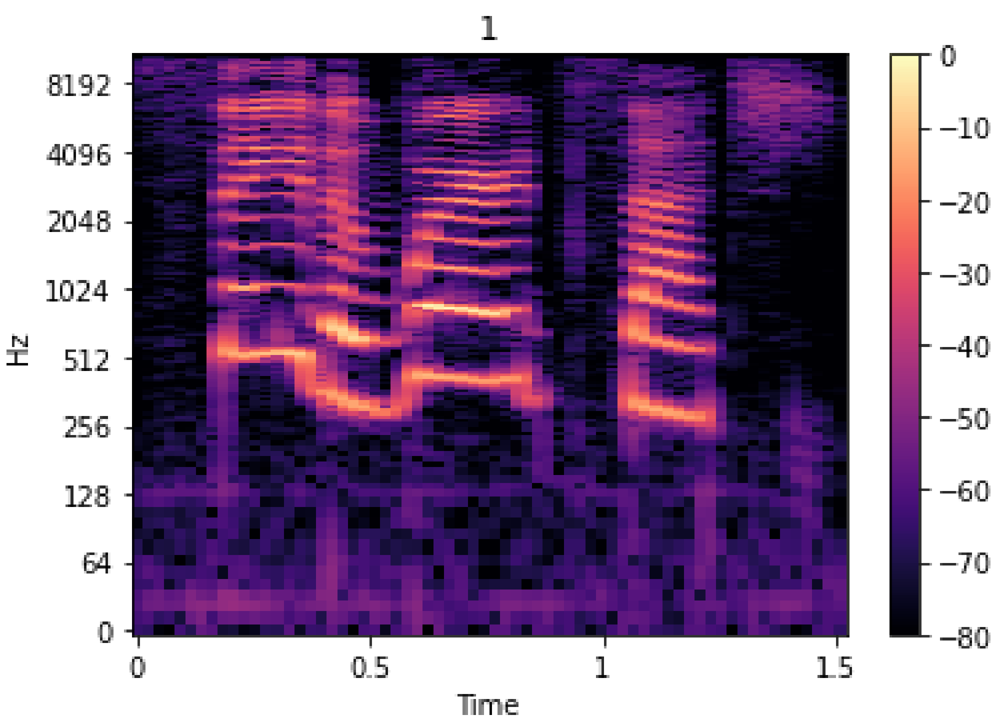

3
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
1.5
Time
−10
−20
−30
−40
−50
−60
−70
−80

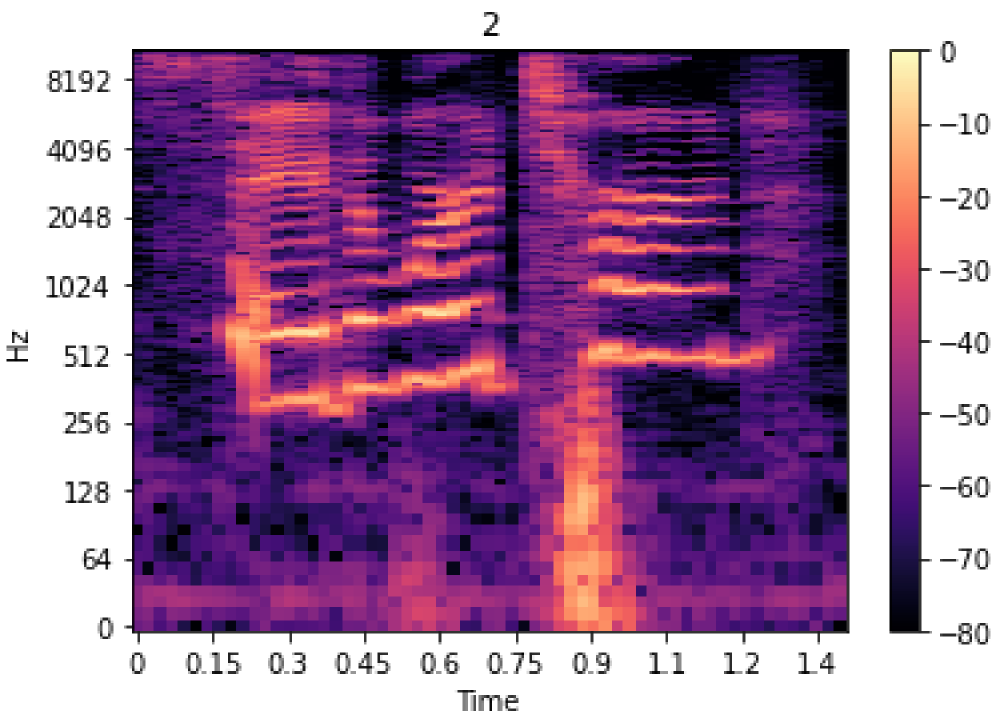

3
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
Time
0
−10
−20
−30
−40
−50
−60
−70
−80

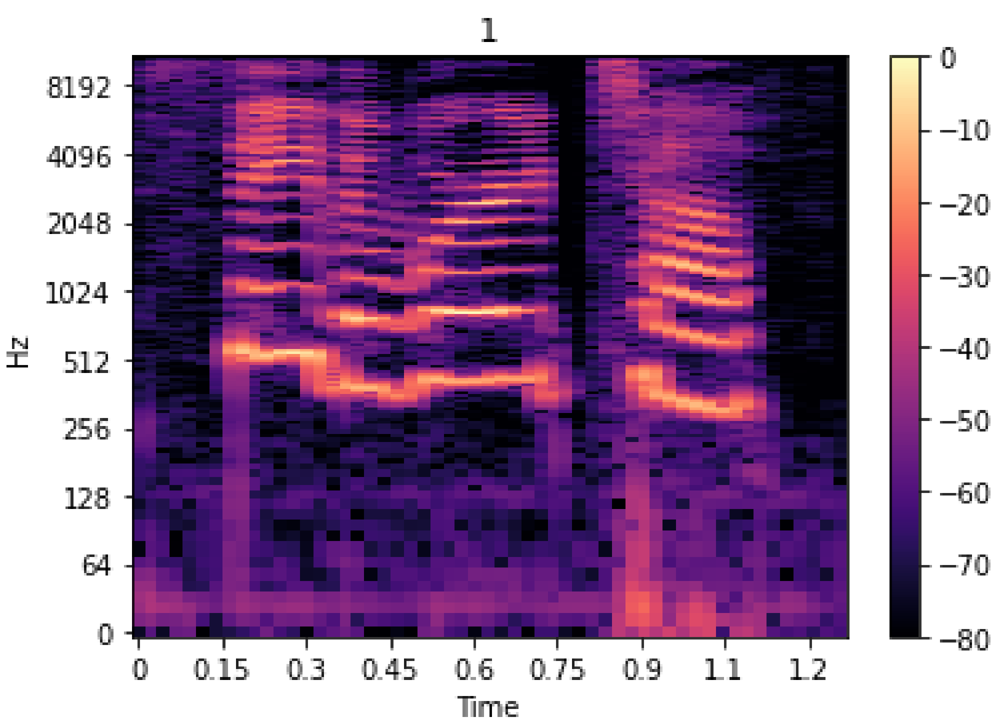

4
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
1.5
Time
0
−10
−20
−30
−40
−50
−60
−70
−80

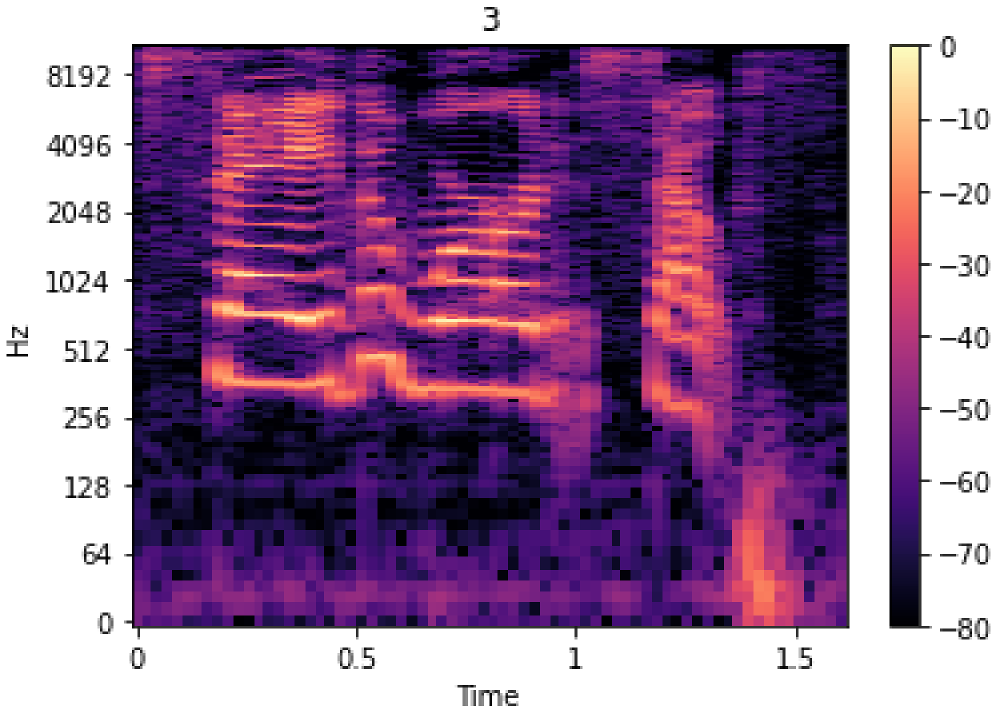

3
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
1.5
Time
0
−10
−20
−30
−40
−50
−60
−70
−80


3
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
1.5
Time
0
−10
−20
−30
−40
−50
−60
−70
−80


1
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.5
1
1.5
Time
0
−10
−20
−30
−40
−50
−60
−70
−80


2
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.15
0.3
0.45
0.6
0.75
0.9
1.1
1.2
1.4
Time
0
−10
−20
−30
−40
−50
−60
−70
−80


1
8192
4096
2048
1024
512
256
128
64
0
Hz
0
0.15
0.3
0.45
0.6
0.75
0.9
1.1
1.2
Time
0
−10
−20
−30
−40
−50
−60
−70
−80



0.0.3 Step 3 + 4. Acoustic Feature Extraction and Feature Post-Processing

[125]:
```python
train_final = []
# going to use mel, chroma, mfcc, and zero-crossing rate
for X in train:
    result = np.array([])
    signal, sample_rate = librosa.load(X, sr = 16000,mono = True)

    mel = np.mean(librosa.feature.melspectrogram(y=signal, sr=sample_rate,
 ↪n_mels=12).T, axis=0)
    result = np.hstack((result, mel))

    stft = np.abs(librosa.stft(signal))
    chroma = np.mean(librosa.feature.chroma_stft(S=stft, sr=sample_rate).
 ↪T,axis=0)
    result = np.hstack((result, chroma))

    mfcc = np.mean(librosa.feature.mfcc(y=signal, sr=sample_rate, n_mfcc=40).T,
 ↪axis=0)
    result = np.hstack((result, mfcc))

    zcr = np.mean(librosa.feature.zero_crossing_rate(y=signal).T, axis=0)
    result = np.hstack((result, zcr))
```

```
    train_final.append(result)

train_final = np.array(train_final)
```

[126]:
```
#Same for test set
test_final = []
# going to use mel, chroma, mfcc, and zero-crossing rate
for X in test:
    result = np.array([])
    signal, sample_rate = librosa.load(X, sr = 16000,mono = True)

    mel = np.mean(librosa.feature.melspectrogram(y=signal, sr=sample_rate,␣
 ↪n_mels=12).T, axis=0)
    result = np.hstack((result, mel))

    stft = np.abs(librosa.stft(signal))
    chroma = np.mean(librosa.feature.chroma_stft(S=stft, sr=sample_rate).
 ↪T,axis=0)
    result = np.hstack((result, chroma))

    mfcc = np.mean(librosa.feature.mfcc(y=signal, sr=sample_rate, n_mfcc=40).T,␣
 ↪axis=0)
    result = np.hstack((result, mfcc))

    zcr = np.mean(librosa.feature.zero_crossing_rate(y=signal).T, axis=0)
    result = np.hstack((result, zcr))

    test_final.append(result)

test_final = np.array(test_final)
test_final[:5]
```

[126]:
```
array([[ 2.78944135e+00,  1.08825836e+01,  7.50644064e+00,
         4.32202637e-01,  4.96461809e-01,  7.82982945e-01,
         1.01789522e+00,  7.35965133e-01,  2.70323604e-01,
         1.84393838e-01,  2.24445969e-01,  3.10021476e-03,
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```

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  3.62640762e+00, -3.17840672e+00, -4.17687833e-01,
```

```
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-5.08901787e+00,  2.21525065e-01]])
```

0.0.4 Step 5: Audio emotion Recognition Model

[129]:
```
nbc = GaussianNB()
rfc = RandomForestClassifier()
svm = SVC(probability=True)
knn = KNeighborsClassifier(n_neighbors = 7)

model_params = {
    'alpha': 0.01,
    'batch_size': 256,
    'epsilon': 1e-08,
    'hidden_layer_sizes': (300,),
    'learning_rate': 'adaptive',
    'max_iter': 500,
}

mlp = MLPClassifier(**model_params)
```

[130]:
```
nbc.fit(train_final, target)
rfc.fit(train_final, target)
svm.fit(train_final, target)
knn.fit(train_final, target)
mlp.fit(train_final, target)
```

[130]:
```
MLPClassifier(alpha=0.01, batch_size=256, hidden_layer_sizes=(300,),
              learning_rate='adaptive', max_iter=500)
```

[131]:
```
y_nbc_predicted = nbc.predict(test_final)
y_nbc_pred_proba = nbc.predict_proba(test_final)

y_rfc_predicted = rfc.predict(test_final)
y_rfc_pred_proba = rfc.predict_proba(test_final)

y_svc_predicted = svm.predict(test_final)
y_svc_pred_proba = svm.predict_proba(test_final)

y_knn_predicted = knn.predict(test_final)
y_knn_pred_proba = knn.predict_proba(test_final)

y_mlp_predicted = mlp.predict(test_final)
y_mlp_pred_proba = mlp.predict_proba(test_final)
```

[135]:
```
#Copied from class coding materials with a few adjustments
```

```
print(classification_report(t, y_nbc_predicted))
print(classification_report(t, y_rfc_predicted))
print(classification_report(t, y_svc_predicted))
print(classification_report(t, y_knn_predicted))
print(classification_report(t, y_mlp_predicted))

models = ['Naive Bayes Classifier', 'Random Forest Classifier', 'Support Vector␣
↪Machine', 'K-Nearest Neighbors',
         'Multi-Layer Perceptron']
predictions = [y_nbc_predicted, y_rfc_predicted, y_svc_predicted,␣
↪y_knn_predicted, y_mlp_predicted]
pred_probabilities = [y_nbc_pred_proba, y_rfc_pred_proba, y_svc_pred_proba,␣
↪y_knn_pred_proba, y_mlp_predicted]

plot = 1

for model, prediction, pred_proba in zip(models, predictions,␣
↪pred_probabilities):
    disp = ConfusionMatrixDisplay(confusion_matrix(t.ravel(), prediction))
    disp.plot(
        include_values=True,
        cmap='gray',
        colorbar=False
    )
    disp.ax_.set_title(f"{model} Confusion Matrix")

plt.show()
```

```
              precision    recall  f1-score   support

           1       1.00      1.00      1.00        30
           2       1.00      1.00      1.00        30
           3       1.00      1.00      1.00        30
           4       1.00      1.00      1.00        30

    accuracy                           1.00       120
   macro avg       1.00      1.00      1.00       120
weighted avg       1.00      1.00      1.00       120

              precision    recall  f1-score   support

           1       1.00      1.00      1.00        30
           2       1.00      1.00      1.00        30
           3       1.00      1.00      1.00        30
           4       1.00      1.00      1.00        30

    accuracy                           1.00       120
```

```
   macro avg       1.00      1.00      1.00       120
weighted avg       1.00      1.00      1.00       120

              precision    recall  f1-score   support

           1       0.94      0.97      0.95        30
           2       1.00      1.00      1.00        30
           3       0.97      0.93      0.95        30
           4       1.00      1.00      1.00        30

    accuracy                           0.97       120
   macro avg       0.98      0.98      0.97       120
weighted avg       0.98      0.97      0.97       120

              precision    recall  f1-score   support

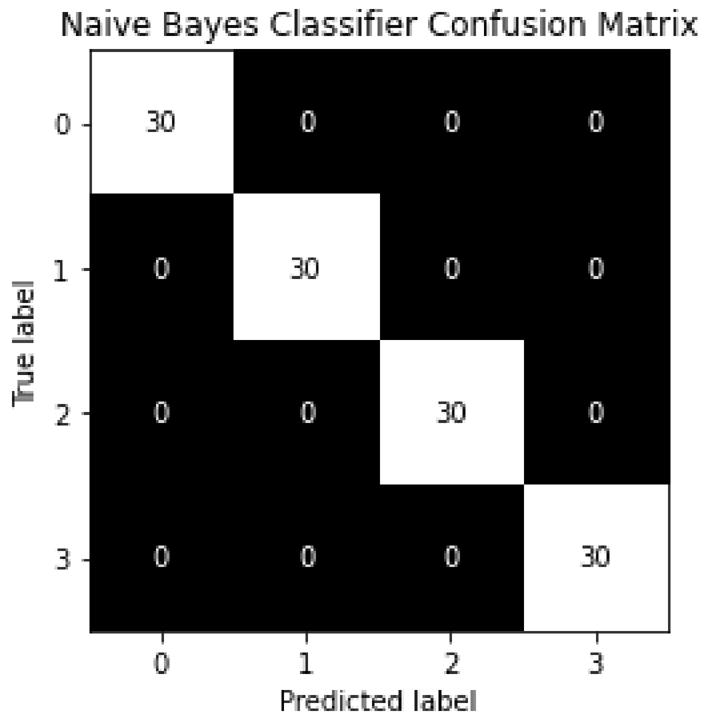
           1       0.97      1.00      0.98        30
           2       1.00      1.00      1.00        30
           3       1.00      0.97      0.98        30
           4       1.00      1.00      1.00        30

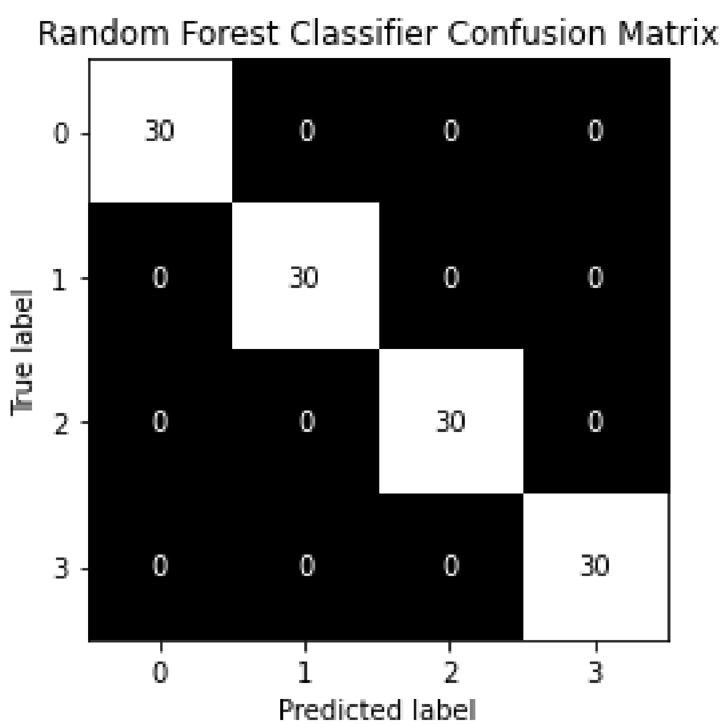
    accuracy                           0.99       120
   macro avg       0.99      0.99      0.99       120
weighted avg       0.99      0.99      0.99       120

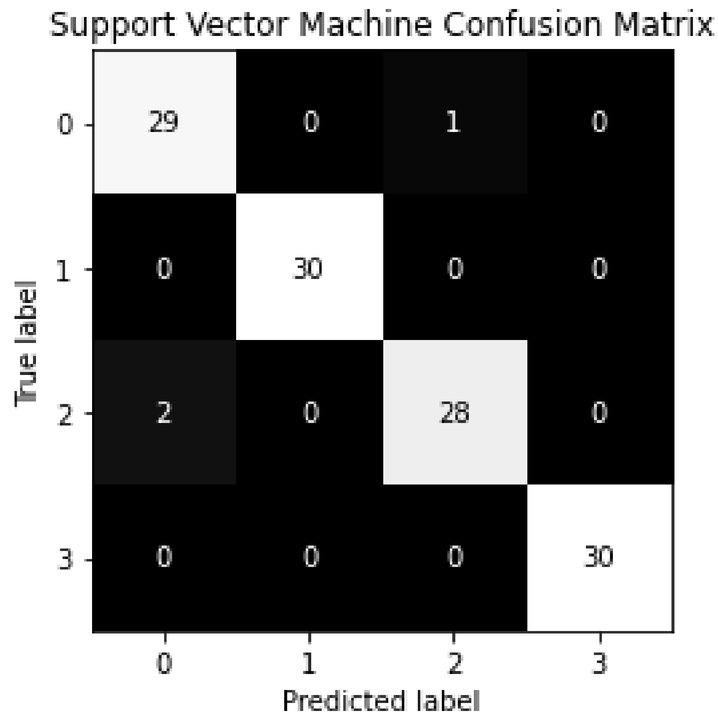
              precision    recall  f1-score   support

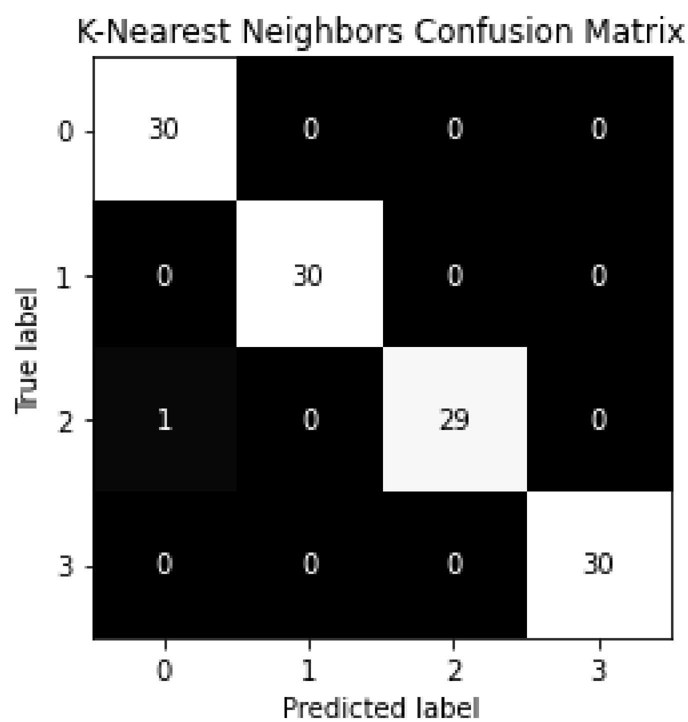
           1       1.00      1.00      1.00        30
           2       1.00      1.00      1.00        30
           3       1.00      1.00      1.00        30
           4       1.00      1.00      1.00        30

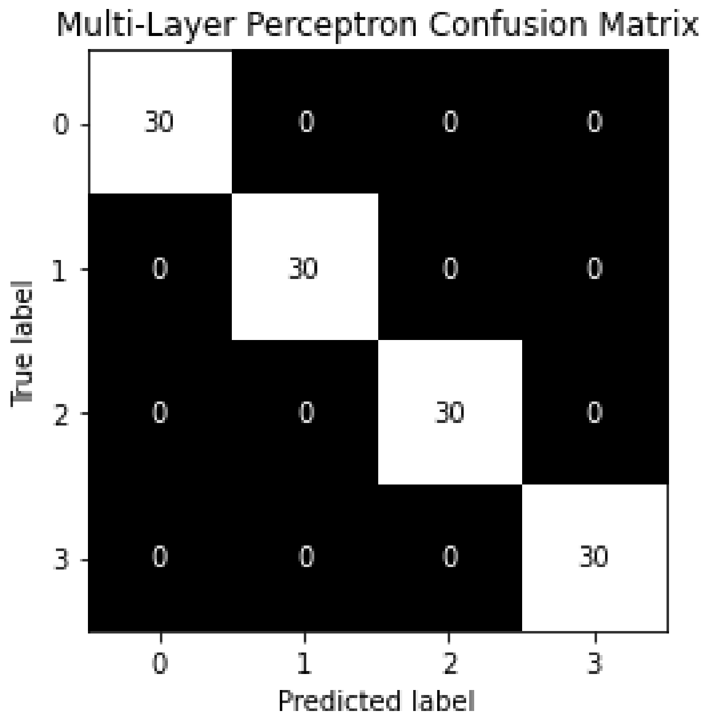
    accuracy                           1.00       120
   macro avg       1.00      1.00      1.00       120
weighted avg       1.00      1.00      1.00       120
```


Naive Bayes Classifier Confusion Matrix
True label
Predicted label
0
1
2
3
30
0
30


Random Forest Classifier Confusion Matrix
True label
Predicted label
0
1
2
3
30
0
30


Support Vector Machine Confusion Matrix
29
0
1
0
0
30
0
0
2
0
28
0
0
0
0
30
True label
0
1
2
3
Predicted label


K-Nearest Neighbors Confusion Matrix
30
0
0
0
0
30
0
0
1
0
29
0
0
0
0
30
True label
0
1
2
3
Predicted label


Multi-Layer Perceptron Confusion Matrix
True label
Predicted label
0
1
2
3
30
0

[ ]: