

## 21113-lab7

April 3, 2024

```
[1]: pip install hmmlearn
```

Collecting hmmlearn

Obtaining dependency information for hmmlearn from [https://files.pythonhosted.org/packages/6b/62/0c7b618eac6f27220baecdfe476259e005c690bf825d02a3cb8e5470bf2c/hmmlearn-0.3.2-cp311-cp311-win\\_amd64.whl.metadata](https://files.pythonhosted.org/packages/6b/62/0c7b618eac6f27220baecdfe476259e005c690bf825d02a3cb8e5470bf2c/hmmlearn-0.3.2-cp311-cp311-win_amd64.whl.metadata)

Downloading hmmlearn-0.3.2-cp311-cp311-win\_amd64.whl.metadata (3.0 kB)

Requirement already satisfied: numpy>=1.10 in c:\users\saisu\anaconda3\lib\site-packages (from hmmlearn) (1.24.3)

Requirement already satisfied: scikit-learn!=0.22.0,>=0.16 in c:\users\saisu\anaconda3\lib\site-packages (from hmmlearn) (1.3.2)

Requirement already satisfied: scipy>=0.19 in c:\users\saisu\anaconda3\lib\site-packages (from hmmlearn) (1.10.1)

Requirement already satisfied: joblib>=1.1.1 in c:\users\saisu\anaconda3\lib\site-packages (from scikit-learn!=0.22.0,>=0.16->hmmlearn) (1.2.0)

Requirement already satisfied: threadpoolctl>=2.0.0 in c:\users\saisu\anaconda3\lib\site-packages (from scikit-learn!=0.22.0,>=0.16->hmmlearn) (2.2.0)

Downloading hmmlearn-0.3.2-cp311-cp311-win\_amd64.whl (125 kB)

```
----- 0.0/125.4 kB ? eta -:--:--
--- ----- 10.2/125.4 kB ? eta -:--:--
--- ----- 10.2/125.4 kB ? eta -:--:--
----- 30.7/125.4 kB 186.2 kB/s eta 0:00:01
----- 61.4/125.4 kB 363.1 kB/s eta 0:00:01
----- 61.4/125.4 kB 363.1 kB/s eta 0:00:01
----- 61.4/125.4 kB 363.1 kB/s eta 0:00:01
----- 61.4/125.4 kB 363.1 kB/s eta 0:00:01
----- 71.7/125.4 kB 186.7 kB/s eta 0:00:01
----- 71.7/125.4 kB 186.7 kB/s eta 0:00:01
----- 71.7/125.4 kB 186.7 kB/s eta 0:00:01
----- 125.4/125.4 kB 237.4 kB/s eta 0:00:00
```

Installing collected packages: hmmlearn

Successfully installed hmmlearn-0.3.2

Note: you may need to restart the kernel to use updated packages.

```
[1]: import numpy as np
import librosa
import librosa.display
import matplotlib.pyplot as plt
from hmmlearn import hmm
```

```
[4]: pip install numpy==1.21
```

```
Collecting numpy==1.21
  Using cached numpy-1.21.0.zip (10.3 MB)
  Installing build dependencies: started
  Installing build dependencies: finished with status 'done'
  Getting requirements to build wheel: started
  Getting requirements to build wheel: finished with status 'done'
  Preparing metadata (pyproject.toml): started
  Preparing metadata (pyproject.toml): finished with status 'done'
Building wheels for collected packages: numpy
  Building wheel for numpy (pyproject.toml): started
  Building wheel for numpy (pyproject.toml): finished with status 'error'
Failed to build numpy
Note: you may need to restart the kernel to use updated packages.

error: subprocess-exited-with-error

Building wheel for numpy (pyproject.toml) did not run successfully.
exit code: 1

[206 lines of output]
setup.py:63: RuntimeWarning: NumPy 1.21.0 may not yet support Python 3.11.
  warnings.warn(
Running from numpy source directory.
Processing numpy/random\_bounded_integers.pxd.in
Processing numpy/random\_bit_generator.pyx
Processing numpy/random\_mtrand.pyx
Processing numpy/random\_bounded_integers.pyx.in
Processing numpy/random\_common.pyx
Processing numpy/random\_generator.pyx
Processing numpy/random\_mt19937.pyx
Processing numpy/random\_pcg64.pyx
Processing numpy/random\_philox.pyx
Processing numpy/random\_sfc64.pyx
Cythonizing sources
blas_opt_info:
blas_mkl_info:
No module named 'numpy.distutils._msvccompiler' in numpy.distutils; trying
from distutils
customize MSVCCompiler
  libraries mkl_rt not found in ['C:\\\\Users\\\\SaiSu\\\\anaconda3\\\\lib', 'C:\\\\',
```

'C:\\Users\\SaiSu\\anaconda3\\libs']

NOT AVAILABLE

blis\_info:

libraries blis not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',  
'C:\\Users\\SaiSu\\anaconda3\\libs']

NOT AVAILABLE

openblas\_info:

libraries openblas not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',  
'C:\\Users\\SaiSu\\anaconda3\\libs']

get\_default\_fcompiler: matching types: '['gnu', 'intelv', 'absoft', 'compaqv',  
'intele', 'gnu95', 'g95', 'intelvem', 'intelem', 'flang']'

customize GnuFCompiler

Could not locate executable g77

Could not locate executable f77

customize IntelVisualFCompiler

Could not locate executable ifort

Could not locate executable ifl

customize AbsoftFCompiler

Could not locate executable f90

customize CompaqVisualFCompiler

Could not locate executable DF

customize IntelItaniumVisualFCompiler

Could not locate executable efl

customize Gnu95FCompiler

Could not locate executable gfortran

Could not locate executable f95

customize G95FCompiler

Could not locate executable g95

customize IntelEM64VisualFCompiler

customize IntelEM64TFCompiler

Could not locate executable efort

Could not locate executable efc

customize PGroupFlangCompiler

Could not locate executable flang

don't know how to compile Fortran code on platform 'nt'

NOT AVAILABLE

accelerate\_info:

NOT AVAILABLE

atlas\_3\_10\_blas\_threads\_info:

Setting PTATLAS=ATLAS

libraries tatlas not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',  
'C:\\Users\\SaiSu\\anaconda3\\libs']

NOT AVAILABLE

```
atlas_3_10_blas_info:
  libraries satlas not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
  NOT AVAILABLE
```

```
atlas_blas_threads_info:
Setting PTATLAS=ATLAS
  libraries ptf77blas,ptcblas,atlas not found in
['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
  NOT AVAILABLE
```

```
atlas_blas_info:
  libraries f77blas,cblas,atlas not found in
['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
  NOT AVAILABLE
```

```
C:\\Users\\SaiSu\\AppData\\Local\\Temp\\pip-install-uyd4vro6\\numpy_01caa557fc8d43888
44b0ebd991febec\\numpy\\distutils\\system_info.py:2026: UserWarning:
  Optimized (vendor) Blas libraries are not found.
  Falls back to netlib Blas library which has worse performance.
  A better performance should be easily gained by switching
  Blas library.
  if self._calc_info(blas):
blas_info:
  libraries blas not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
  NOT AVAILABLE
```

```
C:\\Users\\SaiSu\\AppData\\Local\\Temp\\pip-install-uyd4vro6\\numpy_01caa557fc8d43888
44b0ebd991febec\\numpy\\distutils\\system_info.py:2026: UserWarning:
  Blas (http://www.netlib.org/blas/) libraries not found.
  Directories to search for the libraries can be specified in the
  numpy/distutils/site.cfg file (section [blas]) or by setting
  the BLAS environment variable.
  if self._calc_info(blas):
blas_src_info:
  NOT AVAILABLE
```

```
C:\\Users\\SaiSu\\AppData\\Local\\Temp\\pip-install-uyd4vro6\\numpy_01caa557fc8d43888
44b0ebd991febec\\numpy\\distutils\\system_info.py:2026: UserWarning:
  Blas (http://www.netlib.org/blas/) sources not found.
  Directories to search for the sources can be specified in the
  numpy/distutils/site.cfg file (section [blas_src]) or by setting
  the BLAS_SRC environment variable.
  if self._calc_info(blas):
  NOT AVAILABLE
```

```

non-existing path in 'numpy\\distutils': 'site.cfg'
lapack_opt_info:
lapack_mkl_info:
    libraries mkl_rt not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
    NOT AVAILABLE

openblas_lapack_info:
    libraries openblas not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
    NOT AVAILABLE

openblas_clapack_info:
    libraries openblas,lapack not found in ['C:\\Users\\SaiSu\\anaconda3\\lib',
'C:\\', 'C:\\Users\\SaiSu\\anaconda3\\libs']
    NOT AVAILABLE

flame_info:
    libraries flame not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
    NOT AVAILABLE

atlas_3_10_threads_info:
Setting PTATLAS=ATLAS
    libraries lapack_atlas not found in C:\\Users\\SaiSu\\anaconda3\\lib
    libraries tatlas,tatlas not found in C:\\Users\\SaiSu\\anaconda3\\lib
    libraries lapack_atlas not found in C:\\
    libraries tatlas,tatlas not found in C:\\
    libraries lapack_atlas not found in C:\\Users\\SaiSu\\anaconda3\\libs
    libraries tatlas,tatlas not found in C:\\Users\\SaiSu\\anaconda3\\libs
<class 'numpy.distutils.system_info.atlas_3_10_threads_info'>
    NOT AVAILABLE

atlas_3_10_info:
    libraries lapack_atlas not found in C:\\Users\\SaiSu\\anaconda3\\lib
    libraries satlas,satlas not found in C:\\Users\\SaiSu\\anaconda3\\lib
    libraries lapack_atlas not found in C:\\
    libraries satlas,satlas not found in C:\\
    libraries lapack_atlas not found in C:\\Users\\SaiSu\\anaconda3\\libs
    libraries satlas,satlas not found in C:\\Users\\SaiSu\\anaconda3\\libs
<class 'numpy.distutils.system_info.atlas_3_10_info'>
    NOT AVAILABLE

atlas_threads_info:
Setting PTATLAS=ATLAS
    libraries lapack_atlas not found in C:\\Users\\SaiSu\\anaconda3\\lib
    libraries ptf77blas,ptcblas,atlas not found in C:\\Users\\SaiSu\\anaconda3\\lib

```

```

libraries lapack_atlas not found in C:\
libraries pt77blas,ptcblas,atlas not found in C:\
libraries lapack_atlas not found in C:\Users\SaiSu\anaconda3\libs
libraries pt77blas,ptcblas,atlas not found in C:\Users\SaiSu\anaconda3\libs
<class 'numpy.distutils.system_info.atlas_threads_info'>
NOT AVAILABLE

atlas_info:
libraries lapack_atlas not found in C:\Users\SaiSu\anaconda3\lib
libraries f77blas,cblas,atlas not found in C:\Users\SaiSu\anaconda3\lib
libraries lapack_atlas not found in C:\
libraries f77blas,cblas,atlas not found in C:\
libraries lapack_atlas not found in C:\Users\SaiSu\anaconda3\libs
libraries f77blas,cblas,atlas not found in C:\Users\SaiSu\anaconda3\libs
<class 'numpy.distutils.system_info.atlas_info'>
NOT AVAILABLE

lapack_info:
libraries lapack not found in ['C:\\Users\\SaiSu\\anaconda3\\lib', 'C:\\',
'C:\\Users\\SaiSu\\anaconda3\\libs']
NOT AVAILABLE

C:\Users\SaiSu\AppData\Local\Temp\pip-install-uyd4vro6\numpy_01caa557fc8d43888
44b0ebd991febec\numpy\distutils\system_info.py:1858: UserWarning:
Lapack (http://www.netlib.org/lapack/) libraries not found.
Directories to search for the libraries can be specified in the
numpy/distutils/site.cfg file (section [lapack]) or by setting
the LAPACK environment variable.
return getattr(self, '_calc_info_{}'.format(name))()
lapack_src_info:
NOT AVAILABLE

C:\Users\SaiSu\AppData\Local\Temp\pip-install-uyd4vro6\numpy_01caa557fc8d43888
44b0ebd991febec\numpy\distutils\system_info.py:1858: UserWarning:
Lapack (http://www.netlib.org/lapack/) sources not found.
Directories to search for the sources can be specified in the
numpy/distutils/site.cfg file (section [lapack_src]) or by setting
the LAPACK_SRC environment variable.
return getattr(self, '_calc_info_{}'.format(name))()
NOT AVAILABLE

numpy_linalg_lapack_lite:
FOUND:
language = c
define_macros = [('HAVE_BLAS_ILP64', None), ('BLAS_SYMBOL_SUFFIX', '64_')]

Warning: attempted relative import with no known parent package
C:\Users\SaiSu\AppData\Local\Temp\pip-build-env-18rwln0o\overlay\Lib\site-
```

```

packages\setuptools\_distutils\dist.py:275: UserWarning: Unknown distribution
option: 'define_macros'
    warnings.warn(msg)
    running bdist_wheel
    running build
    running config_cc
    unifying config_cc, config, build_clib, build_ext, build commands --compiler
options
    running config_fc
    unifying config_fc, config, build_clib, build_ext, build commands --fcompiler
options
    running build_src
    build_src
    building py_modules sources
    creating build
    creating build\src.win-amd64-3.11
    creating build\src.win-amd64-3.11\numpy
    creating build\src.win-amd64-3.11\numpy\distutils
    building library "npymath" sources
    error: Microsoft Visual C++ 14.0 is required. Get it with "Build Tools for
Visual Studio": https://visualstudio.microsoft.com/downloads/
    [end of output]

```

note: This error originates from a subprocess, and is likely not a problem with pip.

```

ERROR: Failed building wheel for numpy
ERROR: Could not build wheels for numpy, which is required to install
pyproject.toml-based projects

```

[3]: `pip install librosa`

```

Requirement already satisfied: librosa in c:\users\saisu\anaconda3\lib\site-
packages (0.10.1)Note: you may need to restart the kernel to use updated
packages.

```

```

Requirement already satisfied: audioread>=2.1.9 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (3.0.1)
Requirement already satisfied: numpy!=1.22.0,!1.22.1,!1.22.2,>=1.20.3 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (1.24.3)
Requirement already satisfied: scipy>=1.2.0 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (1.10.1)
Requirement already satisfied: scikit-learn>=0.20.0 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (1.3.2)
Requirement already satisfied: joblib>=0.14 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (1.2.0)
Requirement already satisfied: decorator>=4.3.0 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (5.1.1)
Requirement already satisfied: numba>=0.51.0 in

```

```

c:\users\saisu\anaconda3\lib\site-packages (from librosa) (0.57.0)
Requirement already satisfied: soundfile>=0.12.1 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (0.12.1)
Requirement already satisfied: pooch>=1.0 in c:\users\saisu\anaconda3\lib\site-
packages (from librosa) (1.4.0)
Requirement already satisfied: soxr>=0.3.2 in c:\users\saisu\anaconda3\lib\site-
packages (from librosa) (0.3.7)
Requirement already satisfied: typing-extensions>=4.1.1 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (4.7.1)
Requirement already satisfied: lazy-loader>=0.1 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (0.2)
Requirement already satisfied: msgpack>=1.0 in
c:\users\saisu\anaconda3\lib\site-packages (from librosa) (1.0.3)
Requirement already satisfied: llvmlite<0.41,>=0.40.0dev0 in
c:\users\saisu\anaconda3\lib\site-packages (from numba>=0.51.0->librosa)
(0.40.0)
Requirement already satisfied: requests in c:\users\saisu\anaconda3\lib\site-
packages (from pooch>=1.0->librosa) (2.31.0)
Requirement already satisfied: packaging in c:\users\saisu\anaconda3\lib\site-
packages (from pooch>=1.0->librosa) (23.0)
Requirement already satisfied: appdirs in c:\users\saisu\anaconda3\lib\site-
packages (from pooch>=1.0->librosa) (1.4.4)
Requirement already satisfied: threadpoolctl>=2.0.0 in
c:\users\saisu\anaconda3\lib\site-packages (from scikit-learn>=0.20.0->librosa)
(2.2.0)
Requirement already satisfied: cffi>=1.0 in c:\users\saisu\anaconda3\lib\site-
packages (from soundfile>=0.12.1->librosa) (1.15.1)
Requirement already satisfied: pycparser in c:\users\saisu\anaconda3\lib\site-
packages (from cffi>=1.0->soundfile>=0.12.1->librosa) (2.21)
Requirement already satisfied: charset-normalizer<4,>=2 in
c:\users\saisu\anaconda3\lib\site-packages (from requests->pooch>=1.0->librosa)
(2.0.4)
Requirement already satisfied: idna<4,>=2.5 in
c:\users\saisu\anaconda3\lib\site-packages (from requests->pooch>=1.0->librosa)
(3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in
c:\users\saisu\anaconda3\lib\site-packages (from requests->pooch>=1.0->librosa)
(1.26.16)
Requirement already satisfied: certifi>=2017.4.17 in
c:\users\saisu\anaconda3\lib\site-packages (from requests->pooch>=1.0->librosa)
(2023.7.22)

```

```

[28]: import numpy as np
import matplotlib.pyplot as plt
import librosa
import librosa.display
from hmmlearn import hmm

```



```

def load_audio_speech(file_path):
    signal, sample_rate = librosa.load(file_path, sr=None)
    return signal, sample_rate

def calculate_stft(signal, sample_rate):
    stft_matrix = np.abs(librosa.stft(signal))
    return stft_matrix

def train_hidden_markov_model(features, num_components=3, num_iterations=100):
    model = hmm.GaussianHMM(n_components=num_components,
    ↪covariance_type="diag", n_iter=num_iterations)
    model.fit(features)
    return model

def visualize_stft(stft_matrix, sample_rate):
    plt.figure(figsize=(12, 6))
    librosa.display.specshow(librosa.amplitude_to_db(stft_matrix, ref=np.max),
    ↪sr=sample_rate, x_axis='time', y_axis='log', cmap='inferno') # Change the
    ↪colormap here
    plt.colorbar(format='%+2.0f dB')
    plt.title('STFT Visualization')
    plt.show()

def classify_audio_signal(model, features):
    # Predict using the trained HMM model
    labels = model.predict(features.T) # Transpose features to fit HMM's
    ↪requirement
    return labels

```

```

[29]: def main():
    audio_file_path = r"C:\Users\SaiSu\Downloads\Subbu.wav"

    # Load audio
    signal, sample_rate = load_audio_speech(audio_file_path)

    # Extract STFT features
    stft = calculate_stft(signal, sample_rate)

    # Plot STFT
    visualize_stft(stft, sample_rate)

    # Train HMM
    model = train_hidden_markov_model(stft.T) # Transpose stft to fit HMM's
    ↪requirement

    # Classify signal using trained HMM

```

```

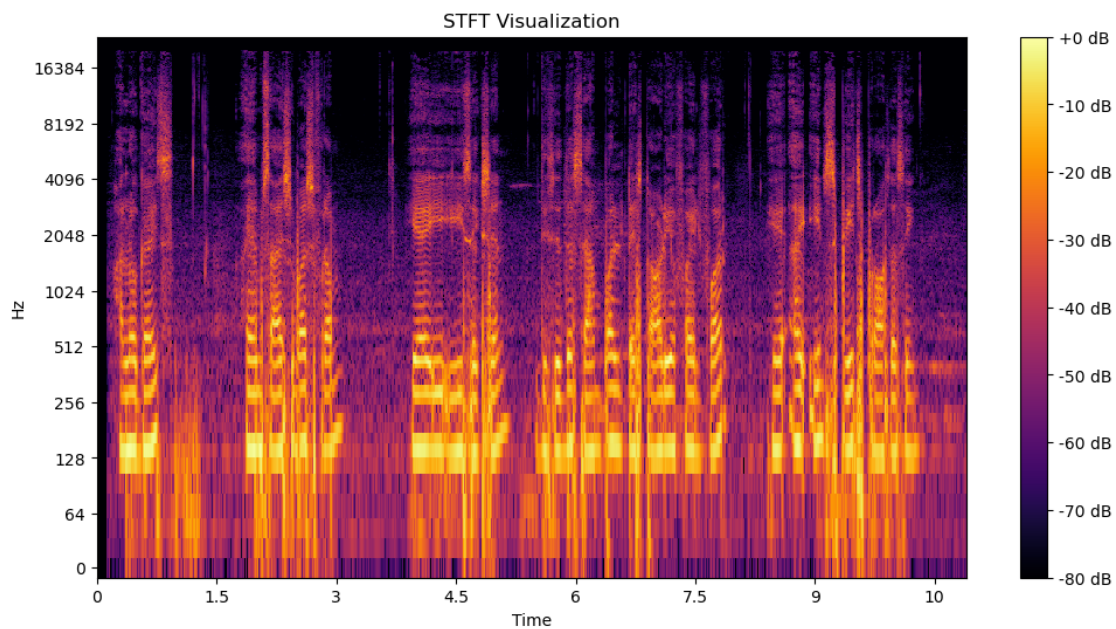
labels = classify_audio_signal(model, stft)

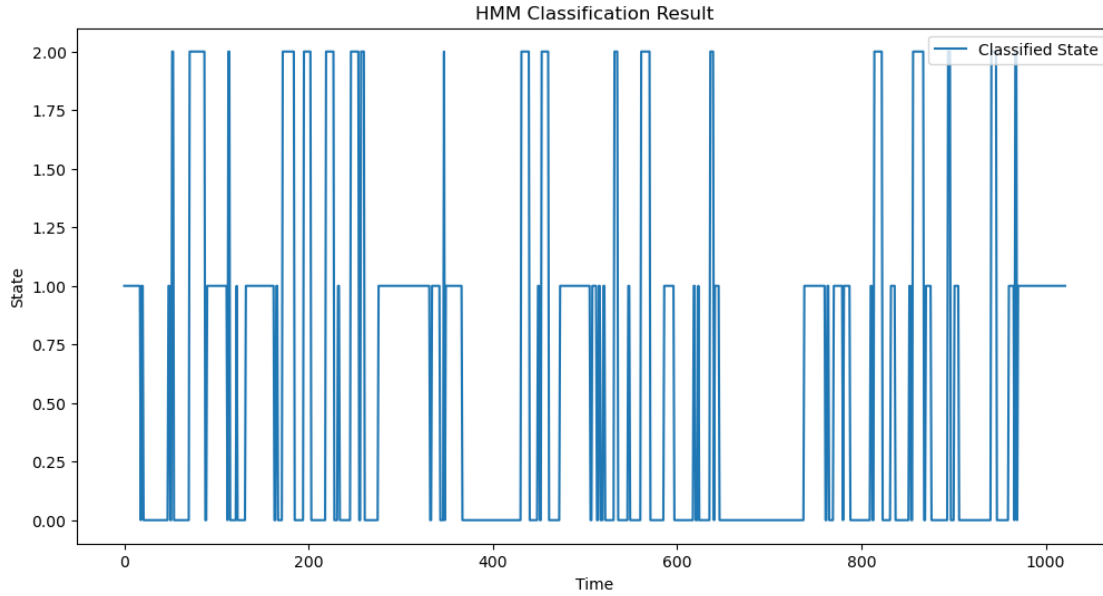
# Plot the classification result
plt.figure(figsize=(12, 6))
plt.plot(np.arange(len(labels)), labels, label='Classified State')
plt.xlabel('Time')
plt.ylabel('State')
plt.title('HMM Classification Result')
plt.legend()
plt.show()

# Print trained model parameters
print("HMM Model Parameters:")
print("Transition Matrix:")
print(model.transmat_)
print("Means:")
print(model.means_)
print("Covariances:")
print(model.covars_)

if __name__ == "__main__":
    main()

```





HMM Model Parameters:

Transition Matrix:

```
[[0.90774907 0.05719558 0.03505535]
 [0.08933718 0.91066282 0.         ]
 [0.14393936 0.         0.85606064]]
```

Means:

```
[[2.07331955e+00 4.45629206e+00 6.41783809e+00 ... 2.14487007e-04
 2.22562133e-04 2.04081317e-04]
 [6.59365509e-01 1.65377678e+00 2.44594161e+00 ... 1.51797758e-04
 1.48800899e-04 1.41913785e-04]
 [4.20283182e+00 9.33383931e+00 1.32579015e+01 ... 2.64779746e-04
 2.56684923e-04 2.25716177e-04]]
```

Covariances:

```
[[[1.09696442e+01 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
 0.00000000e+00 0.00000000e+00]
 [0.00000000e+00 3.57201787e+01 0.00000000e+00 ... 0.00000000e+00
 0.00000000e+00 0.00000000e+00]
 [0.00000000e+00 0.00000000e+00 7.52539801e+01 ... 0.00000000e+00
 0.00000000e+00 0.00000000e+00]
 ...
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 1.85684551e-05
 0.00000000e+00 0.00000000e+00]
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
 1.86548645e-05 0.00000000e+00]
 [0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
 0.00000000e+00 1.86510159e-05]]
```

```
[[3.89732649e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
```

```

0.00000000e+00 0.00000000e+00]
[0.00000000e+00 1.06371377e+01 0.00000000e+00 ... 0.00000000e+00
0.00000000e+00 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 2.36109888e+01 ... 0.00000000e+00
0.00000000e+00 0.00000000e+00]
...
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 2.87447454e-05
0.00000000e+00 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
2.87453167e-05 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
0.00000000e+00 2.87516025e-05]]

[[1.92454876e+01 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
0.00000000e+00 0.00000000e+00]
[0.00000000e+00 7.87499039e+01 0.00000000e+00 ... 0.00000000e+00
0.00000000e+00 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 1.66671251e+02 ... 0.00000000e+00
0.00000000e+00 0.00000000e+00]
...
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 7.59622769e-05
0.00000000e+00 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
7.59733407e-05 0.00000000e+00]
[0.00000000e+00 0.00000000e+00 0.00000000e+00 ... 0.00000000e+00
0.00000000e+00 7.59565733e-05]]]

```

[ ]: