

Arrhythmia Detection EDA

August 6, 2023

1 MIT-BIH Arrhythmia Data Analysis

1.1 Overview

- Set of over 4000 long-term Holter Recordings
- Obtained by the Beth Israel Hospital Arrhythmia Laboratory
- Obtained between 1975 and 1979
- **60% of the recordings were obtained from inpatients**
- **23 records in total chosen from id 100-124 inclusive (Group A)**
- **25 records chosen from ids 200-234 inclusive (Group B)**
- **Total there are 48 records**
- **Each record is 30 minutes long**
- **2 signals recorded**
- Group B records were chosen to include complex ventricular, junctional and supraventricular arrhythmias and conduction abnormalities
- Subjects were 25 men aged 32 to 89 years, 22 women aged 23 to 89 years.
- Records 201 and 202 came from the same male subject

1.2 ECG Lead Configuration

- Most records the first signal seen is the modified limb lead II (MLII) obtained by placing the electrodes on the chest
- The lower signal is a modified lead V1
- QRS Complexes are seen in the MLII signal only
- Normal beats are difficult to discern in the lower signal

1.3 Exceptions

- Record 114 the signals are reversed .i.e MLII is the second signal.
- Records 102 and 104 do not have MLII signal because of surgical dressing, modified lead V5 used for the upper signal.
- 4 records (102,104,107,217) include paced beats

1.4 Digitisation process

The digitization process happened at **360Hz** The ADCs were unipolar, with 11 bit resolution ranging from +5mv to -5mV Sample values range from 0 to 2047 inclusive with a value of 1024 corresponding to 0

A number of frequency-domain artifacts have been identified and related to specific mechanical components of the recorders and the playback unit:

Frequency(Hz)	Source
0.042	Recorder pressure wheel
0.083	Playback unit capstan
0.090	Recorder capstan
0.167	Playback unit capstan
0.10-0.18	Takeup reel
0.20-0.36	Supply reel

- **Bit Depth(n):** 11
- **Levels(2n):**2048
- **Voltage Range(r):** 10mV
- **Step Size(delta):** 4.88x10-3mV
- **Maximum Voltage:** 5mV
- **Minimum Voltage:** -5mV

Calculations:

```
Index = Round((Xalpha - Xmin)/delta) # Calculate the corresponding discrete value for a voltage
```

```
Xalpha = Xmin + (Index*delta) # Calculate the corresponding voltage for a discrete value.
```

1.5 Exploration

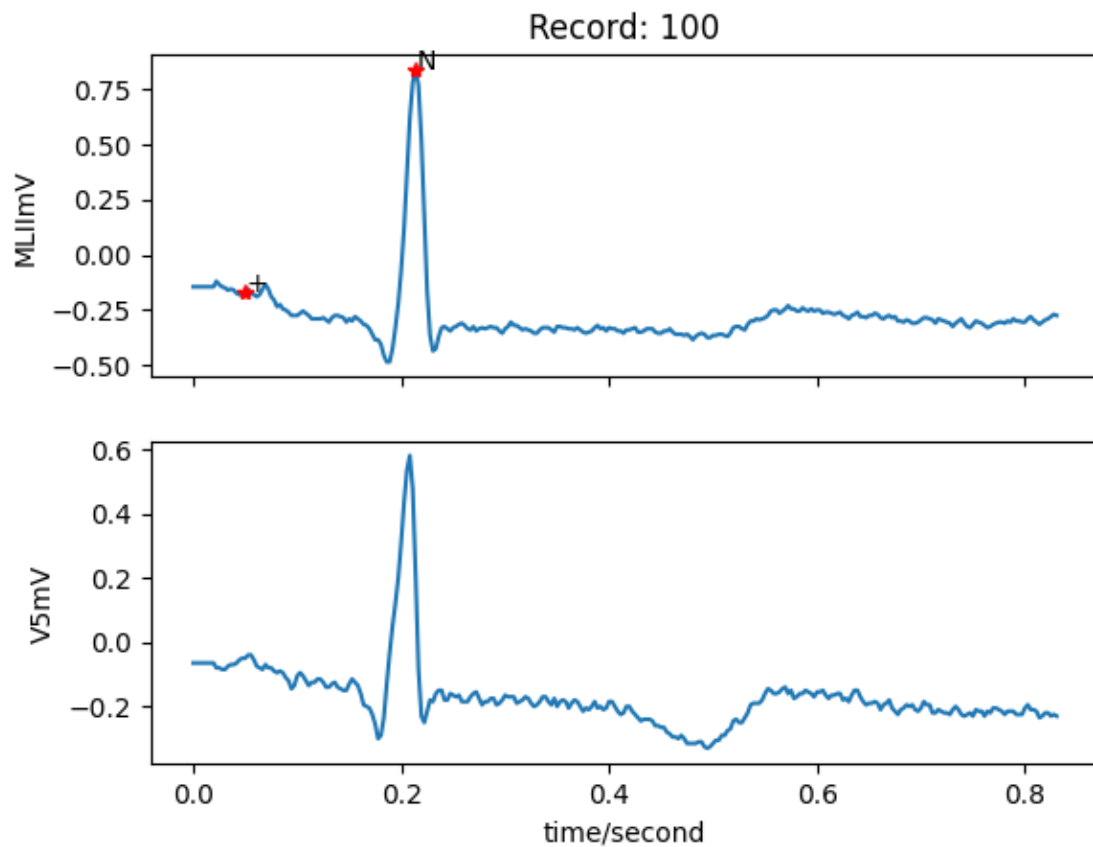
```
[1]: from data_set_utils.data_reader import DataReader
```

```
[2]: %matplotlib inline
```

```
[3]: path = "/mnt/d/git/Arrhythmia-Detection/raw_data/mit-bih-arrhythmia-database-1.
      ↪0.0"
      dr = DataReader(path, 11, 5, -5)
      columns = ["N", "/", "R", "L", "V", "gender", "age", "leads"]
      symbols_of_interest = ["N", "/", "R", "L", "V"]
```

1.5.1 Example Record

```
[4]: dr.plot_record("100", 300)
```



```
[5]: from utils.common_utils import load_patient_ids
```

```
[6]: patient_ids = load_patient_ids(path)
```

```
[7]: patient_ids.remove("102-0")
```

```
[8]: patient_ids
```

```
[8]: ['100',  
      '101',  
      '102',  
      '103',  
      '104',  
      '105',  
      '106',  
      '107',  
      '108',  
      '109',  
      '111',  
      '112',
```

```
'113',  
'114',  
'115',  
'116',  
'117',  
'118',  
'119',  
'121',  
'122',  
'123',  
'124',  
'200',  
'201',  
'202',  
'203',  
'205',  
'207',  
'208',  
'209',  
'210',  
'212',  
'213',  
'214',  
'215',  
'217',  
'219',  
'220',  
'221',  
'222',  
'223',  
'228',  
'230',  
'231',  
'232',  
'233',  
'234']
```

```
[9]: len(patient_ids)
```

```
[9]: 48
```

1.5.2 Loading all patient records

```
[10]: records = dr.load_records(record_ids=patient_ids)
```

Counting annotations in all records

```
[11]: from data_set_utils.data_reader import count_annotations
```

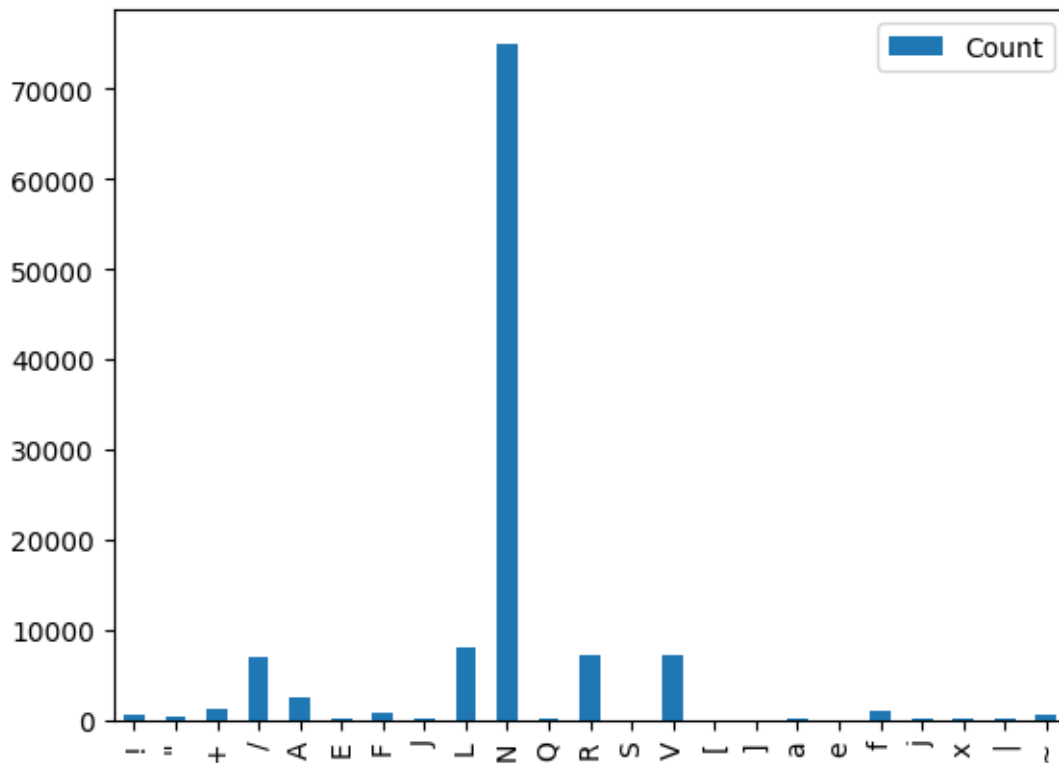
```
[12]: count_tuple = count_annotations(records)
```

```
[13]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
[14]: df = pd.DataFrame(data={"Count": count_tuple[1]}, index=count_tuple[0])
```

```
[15]: df.plot(kind="bar")
```

```
[15]: <Axes: >
```



```
[16]: patient_data = dict()
patient_data["id"] = patient_ids
```

```
[17]: for i in count_tuple[0]:
    patient_data[i] = [0] * len(patient_ids)
```

```
[18]: patient_data_frame = pd.DataFrame(data=patient_data)
```

```
[19]: patient_data_frame.set_index("id", inplace=True)
```

```
[20]: ages = []
gender = []
leads = []
for record_id in patient_data["id"]:
    ecg_record = dr.load_record(record_id)
    ages.append(ecg_record.patient_age())
    gender.append(ecg_record.patient_gender())
    leads.append(ecg_record.leads())
    record_annotation_count_tuple = count_annotations([ecg_record])
    for symbol, count in zip(
        record_annotation_count_tuple[0], record_annotation_count_tuple[1]
    ):
        patient_data_frame.loc[record_id][symbol] = count
```

```
[21]: patient_data_frame["age"] = np.array(ages)
```

```
[22]: patient_data_frame["gender"] = np.array(gender)
```

```
[23]: lead_matrix = np.array(leads)
patient_data_frame["First lead"] = lead_matrix[:, 0]
patient_data_frame["Second Lead"] = lead_matrix[:, 1]
```

```
[24]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
g.map(sns.distplot, "age")
```

/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
<https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

```
func(*plot_args, **plot_kwargs)
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:  
UserWarning:
```

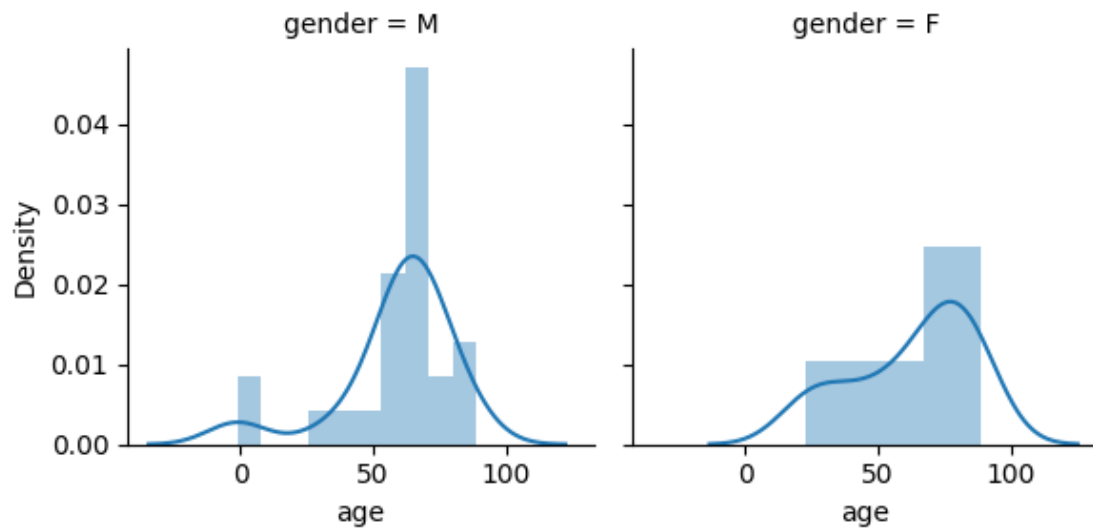
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

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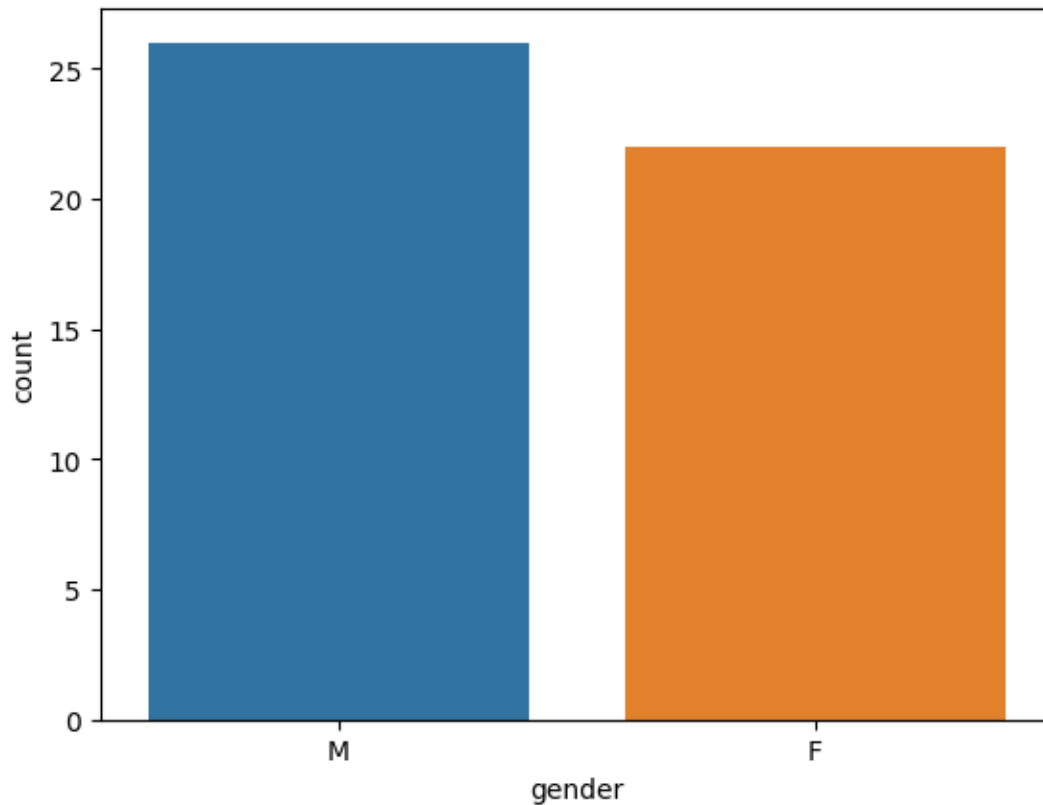
```
func(*plot_args, **plot_kwargs)
```

```
[24]: <seaborn.axisgrid.FacetGrid at 0x7efe8267f700>
```



```
[25]: sns.countplot(data=patient_data_frame, x="gender")
```

```
[25]: <Axes: xlabel='gender', ylabel='count'>
```



```
[26]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
      g.map(sns.distplot, "N")
```

```
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

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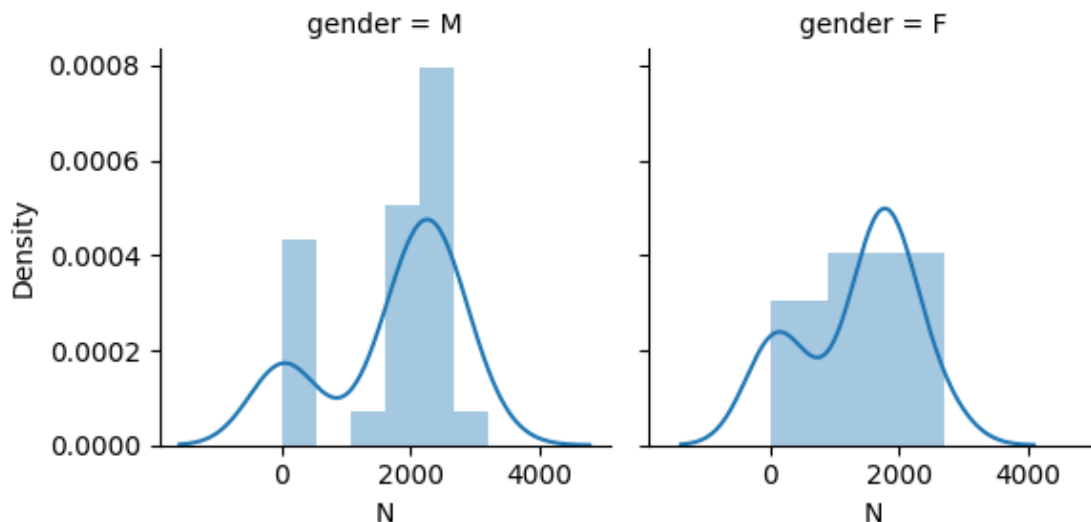
Please adapt your code to use either ``displot`` (a figure-level function with

similar flexibility) or `histplot` (an axes-level function for histograms).

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```
func(*plot_args, **plot_kwargs)
```

[26]: <seaborn.axisgrid.FacetGrid at 0x7efe82f58d00>



```
[27]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
      g.map(sns.distplot, "/")
```

/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:

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```
func(*plot_args, **plot_kwargs)
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

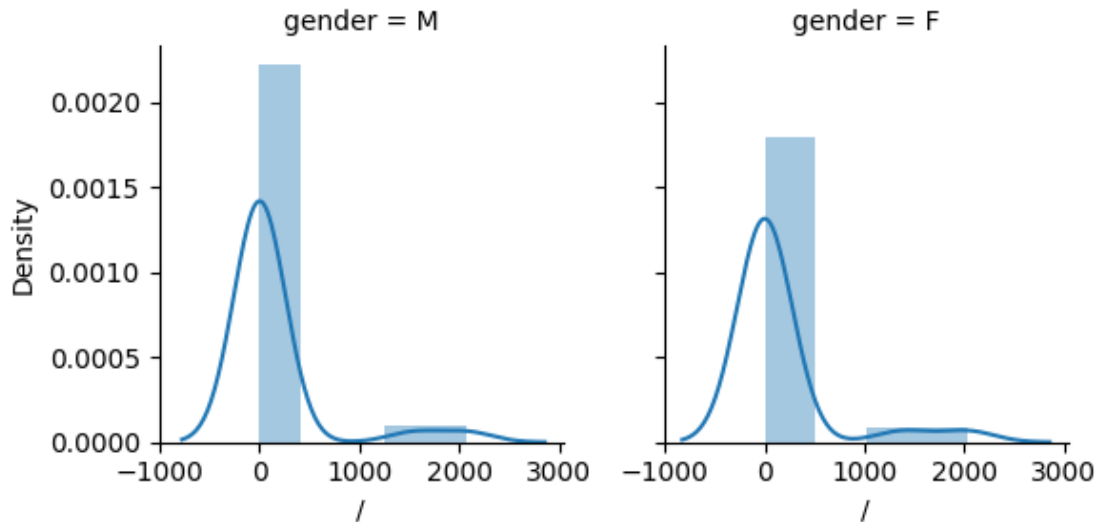
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either ``displot`` (a figure-level function with similar flexibility) or ``histplot`` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

```
func(*plot_args, **plot_kwargs)
```

```
[27]: <seaborn.axisgrid.FacetGrid at 0x7efe82ea76a0>
```



```
[28]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
      g.map(sns.distplot, "R")
```

```
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

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```
func(*plot_args, **plot_kwargs)
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

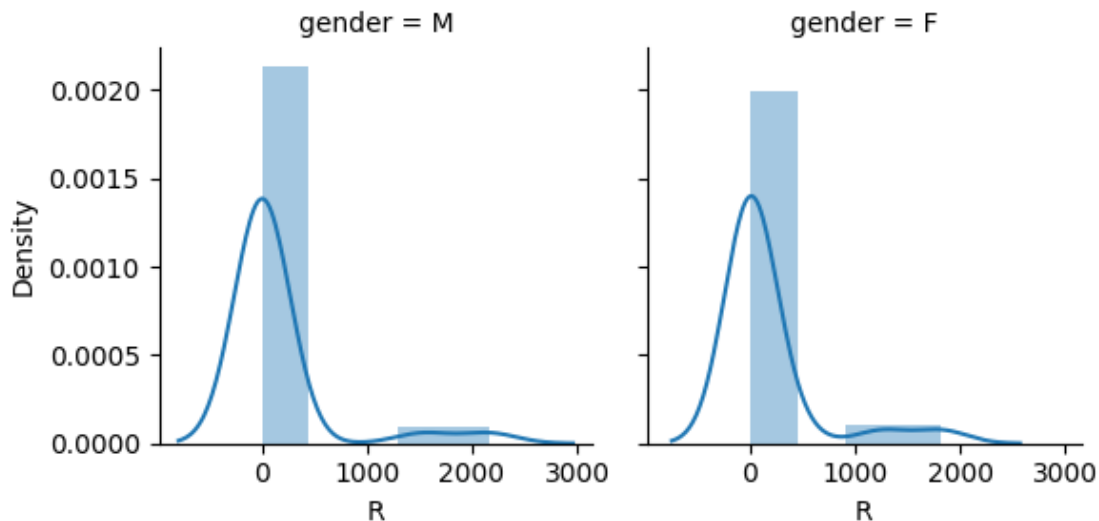
``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

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For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

```
func(*plot_args, **plot_kwargs)
```

```
[28]: <seaborn.axisgrid.FacetGrid at 0x7efea48fbb0>
```



```
[29]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
      g.map(sns.distplot, "L")
```

```
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

```
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.
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```
func(*plot_args, **plot_kwargs)
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

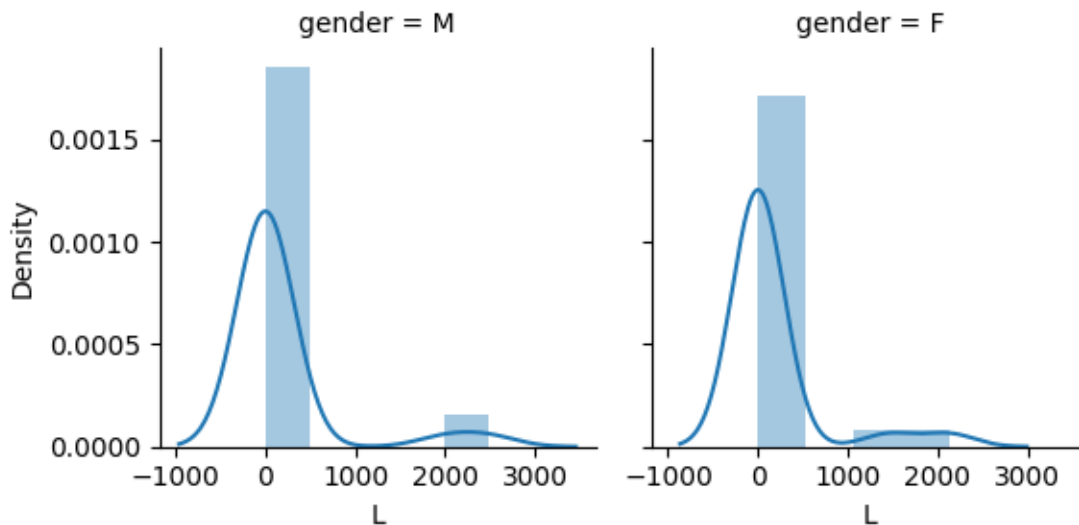
``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either ``displot`` (a figure-level function with similar flexibility) or ``histplot`` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

```
func(*plot_args, **plot_kwargs)
```

[29]: <seaborn.axisgrid.FacetGrid at 0x7efe82d67550>



```
[30]: g = sns.FacetGrid(data=patient_data_frame, col="gender")
      g.map(sns.distplot, "V")
```

/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:

``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either ``displot`` (a figure-level function with similar flexibility) or ``histplot`` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

```
func(*plot_args, **plot_kwargs)
/home/alton/.local/lib/python3.9/site-packages/seaborn/axisgrid.py:848:
UserWarning:
```

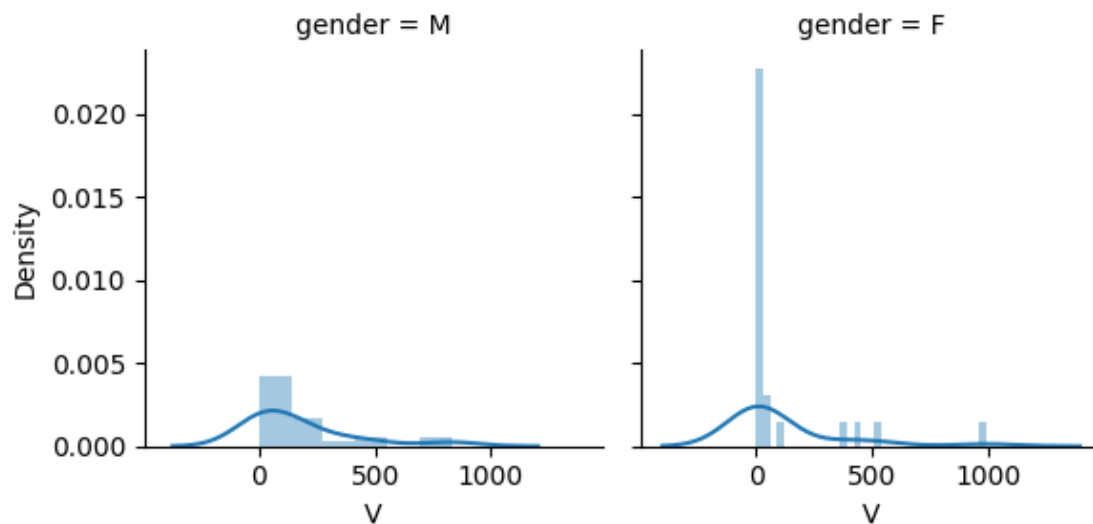
``distplot`` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either ``displot`` (a figure-level function with similar flexibility) or ``histplot`` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

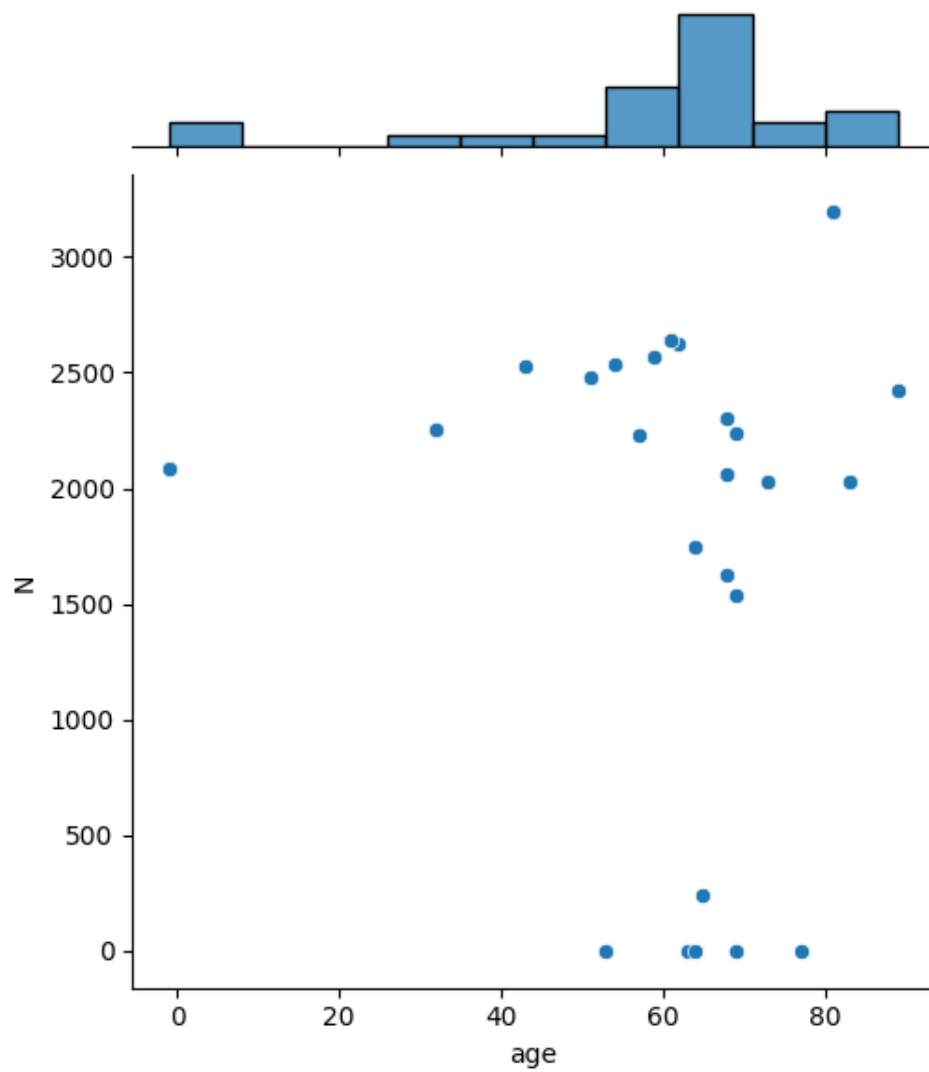
```
func(*plot_args, **plot_kwargs)
```

```
[30]: <seaborn.axisgrid.FacetGrid at 0x7efe82b6b130>
```



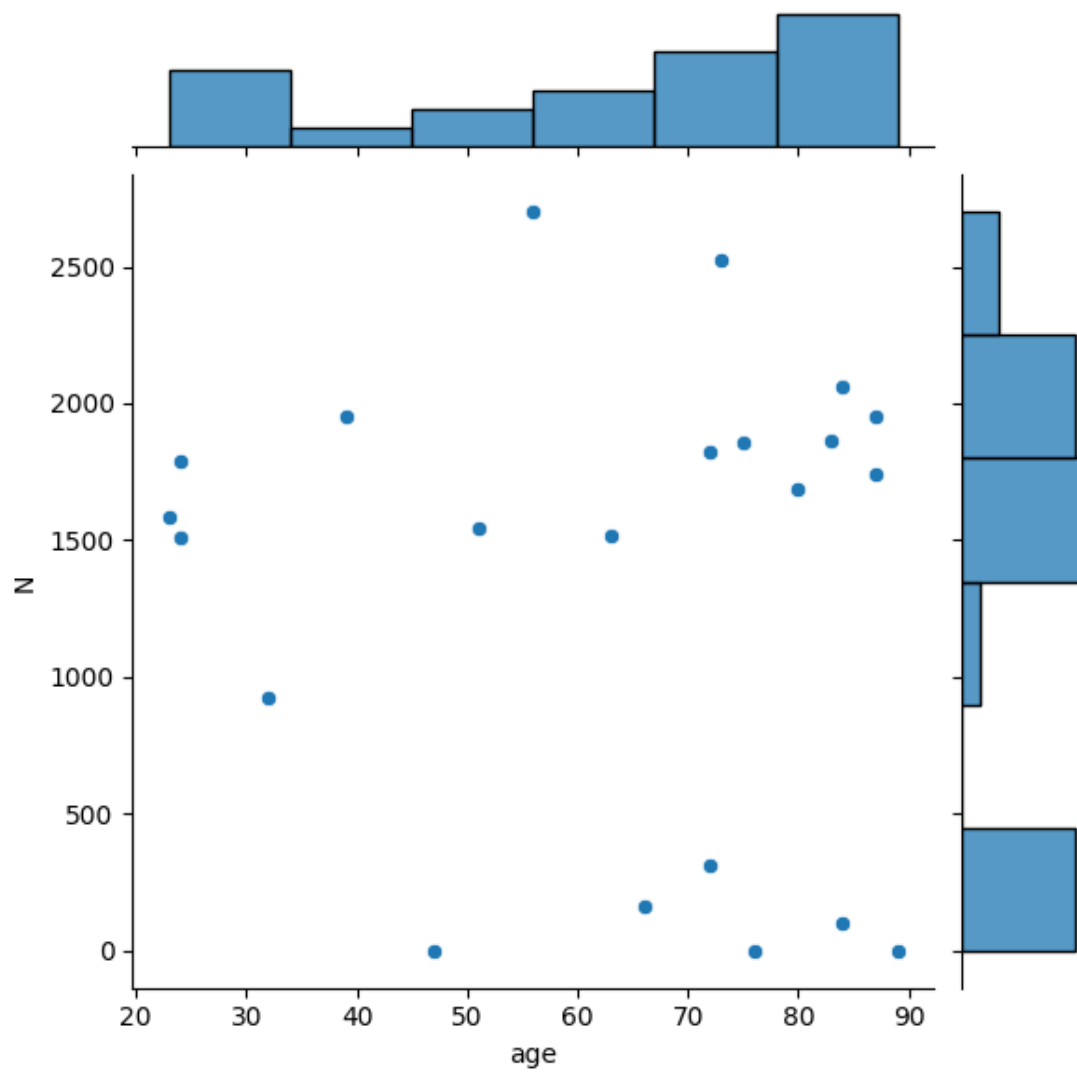
```
[31]: sns.jointplot(  
    data=patient_data_frame[patient_data_frame["gender"] == "M"], x="age", y="N"  
)
```

```
[31]: <seaborn.axisgrid.JointGrid at 0x7efe82b71e80>
```



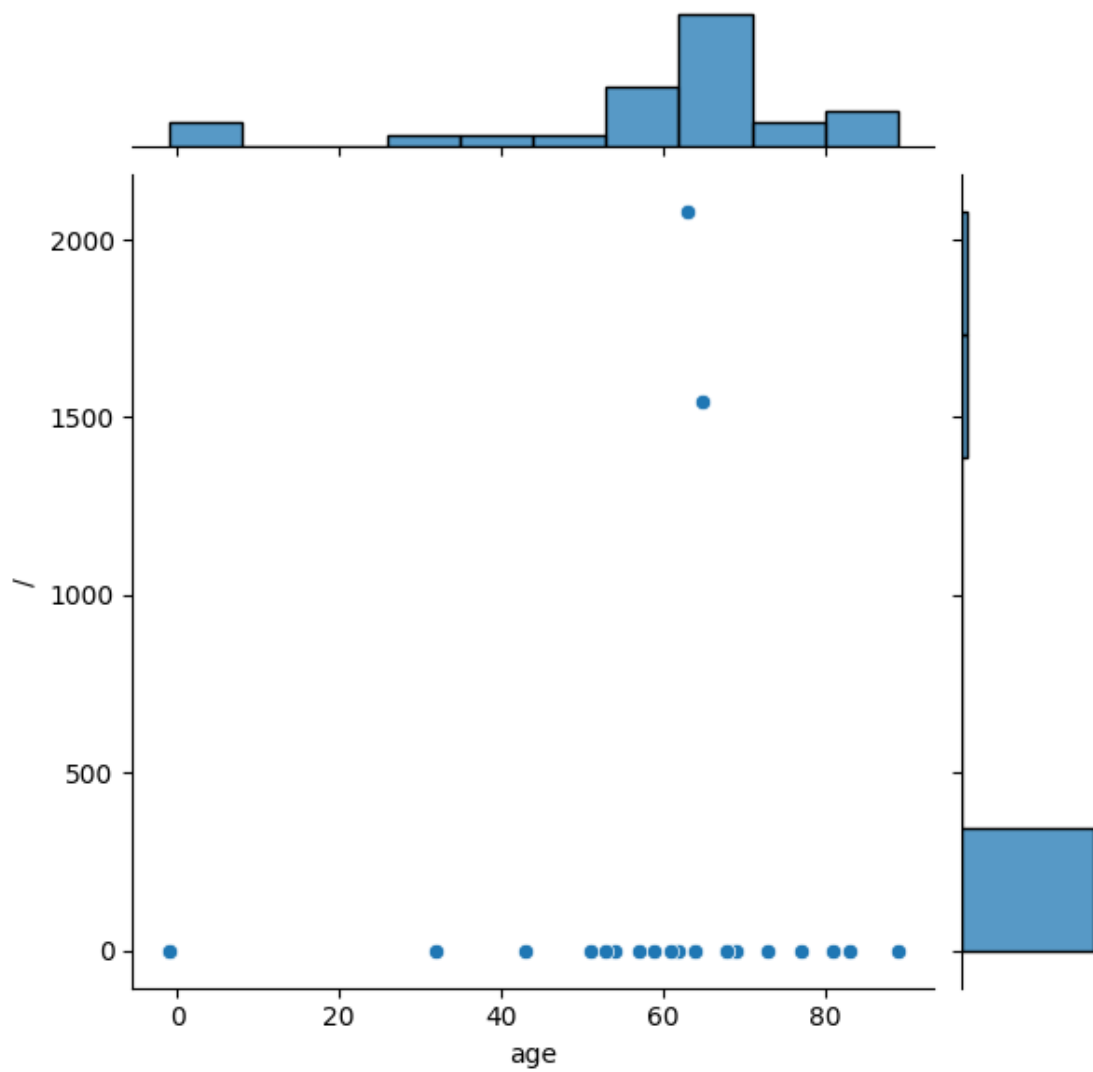
```
[32]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "F"], x="age", y="N"
    )
```

```
[32]: <seaborn.axisgrid.JointGrid at 0x7efe82999790>
```



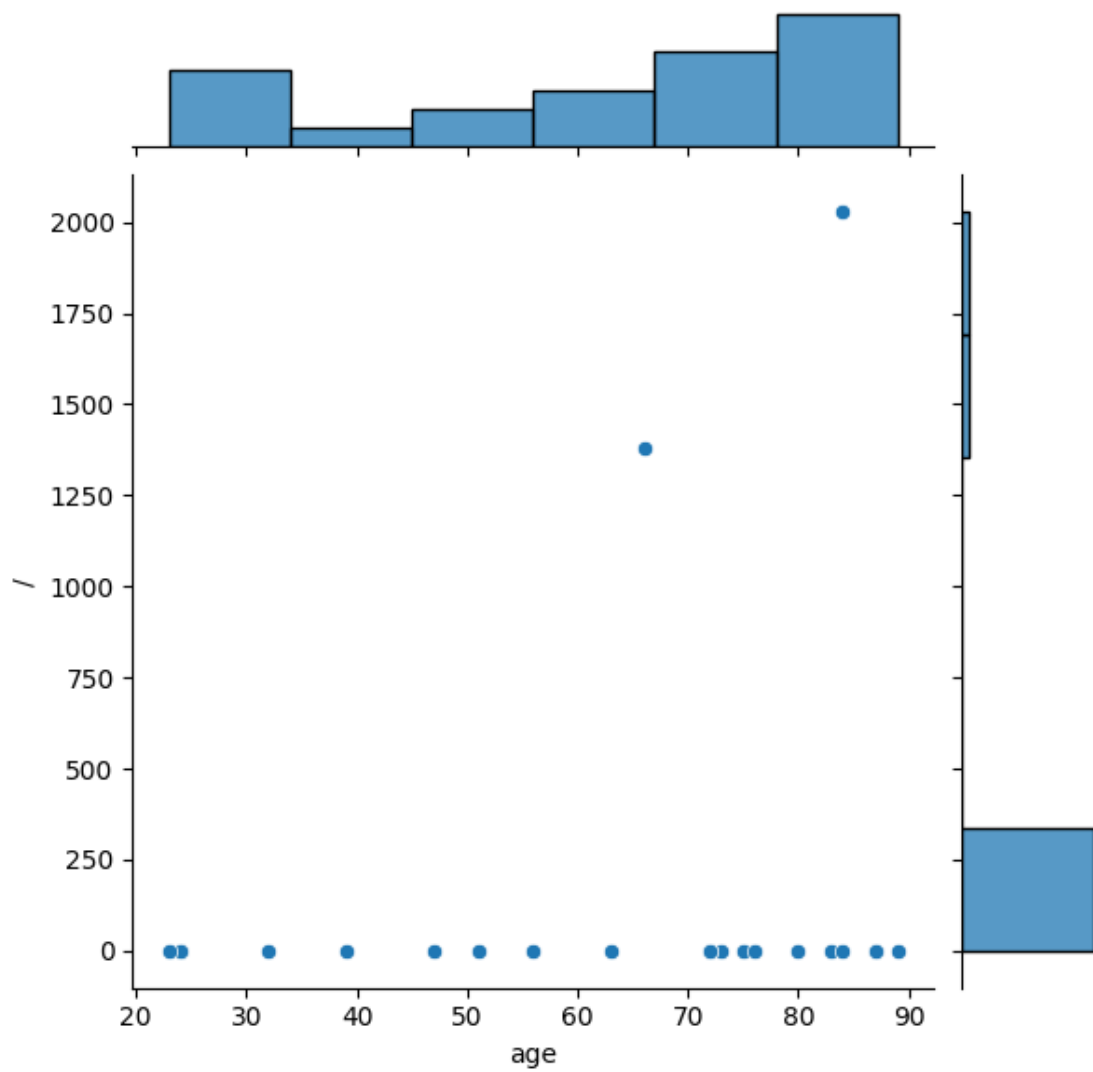
```
[33]: sns.jointplot(  
      data=patient_data_frame[patient_data_frame["gender"] == "M"], x="age", y="/"   
      )
```

```
[33]: <seaborn.axisgrid.JointGrid at 0x7efe82813f40>
```



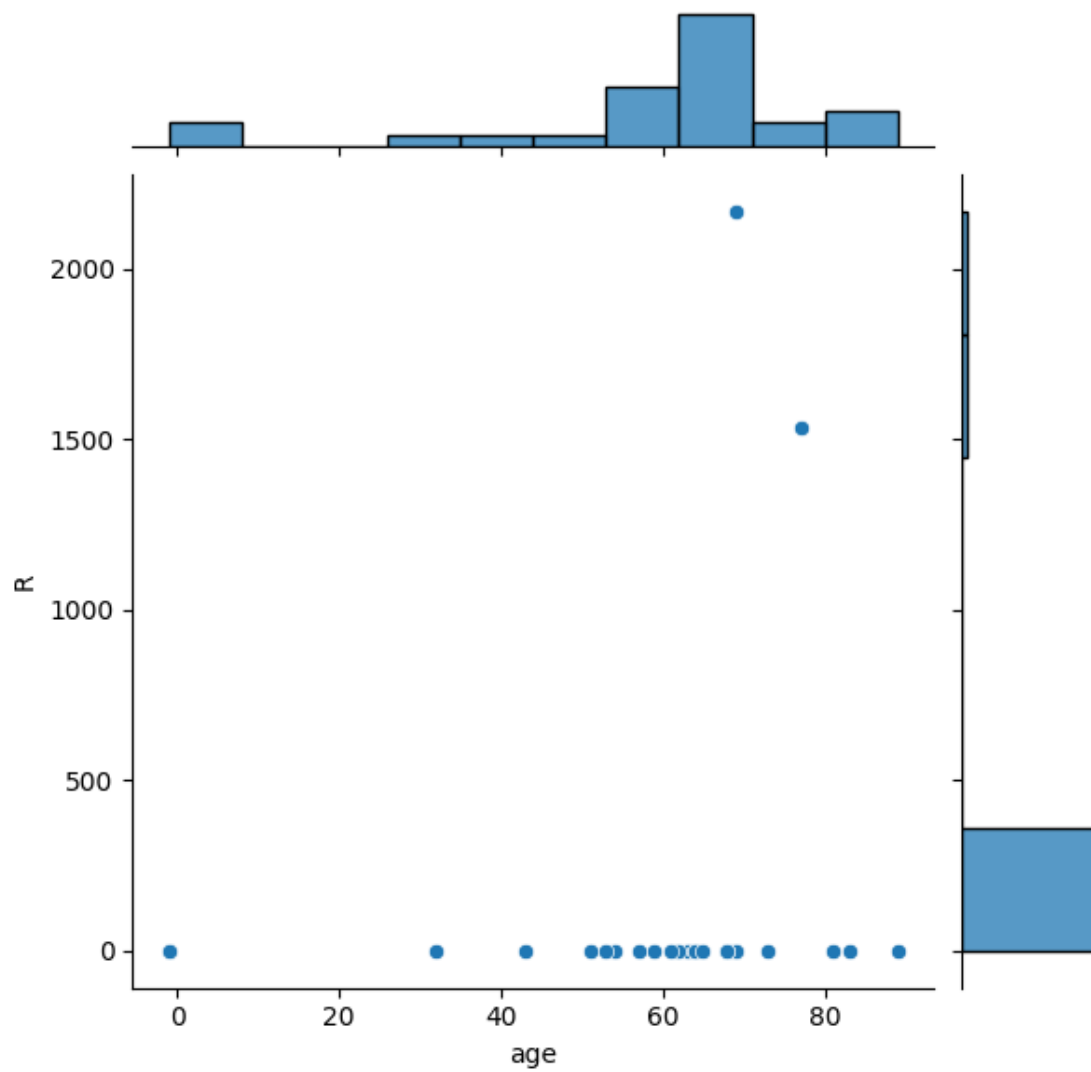
```
[34]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "F"], x="age", y="/"
    )
```

```
[34]: <seaborn.axisgrid.JointGrid at 0x7efe8066b970>
```

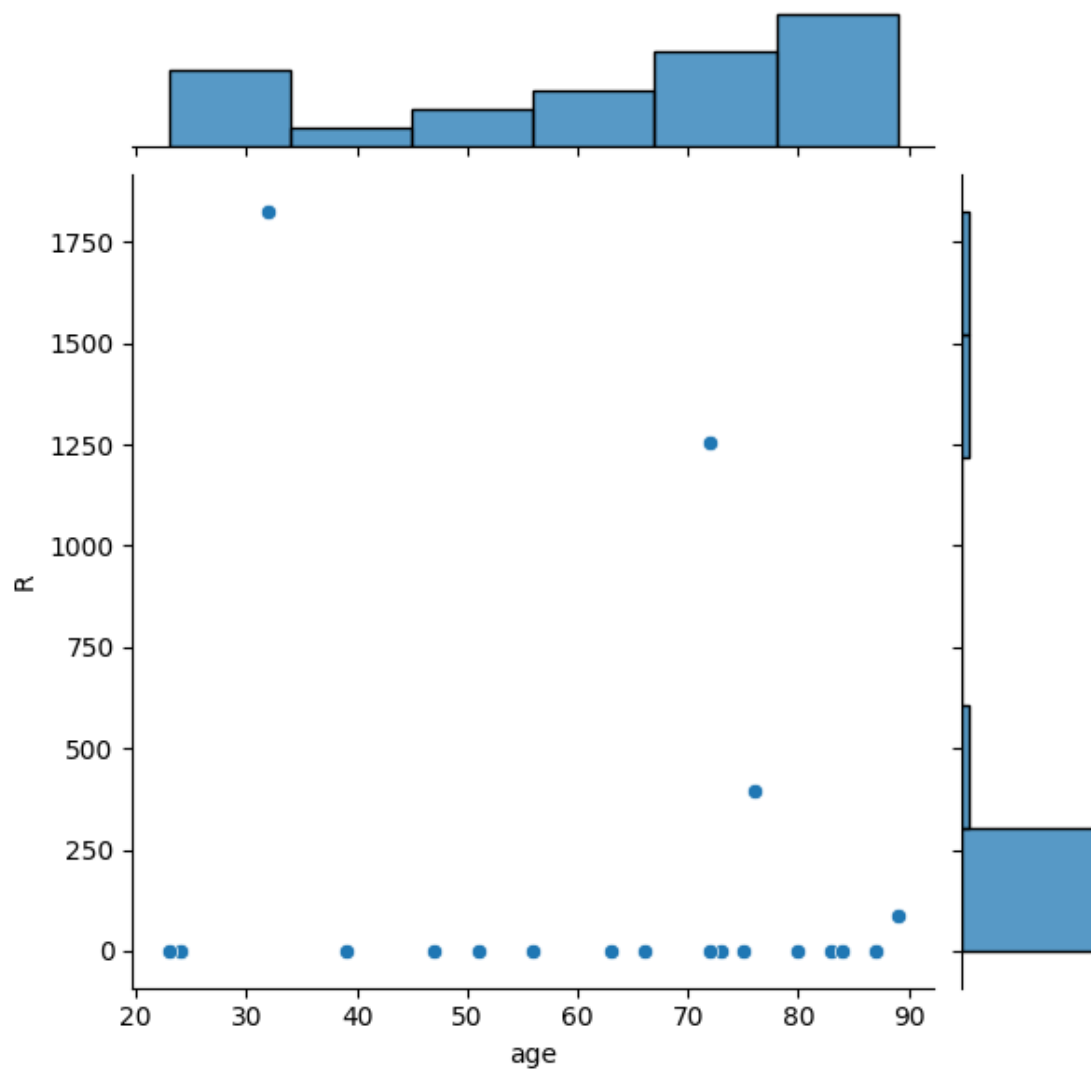
```
[35]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "M"], x="age", y="R"
    )
```

```
[35]: <seaborn.axisgrid.JointGrid at 0x7efe827263d0>
```



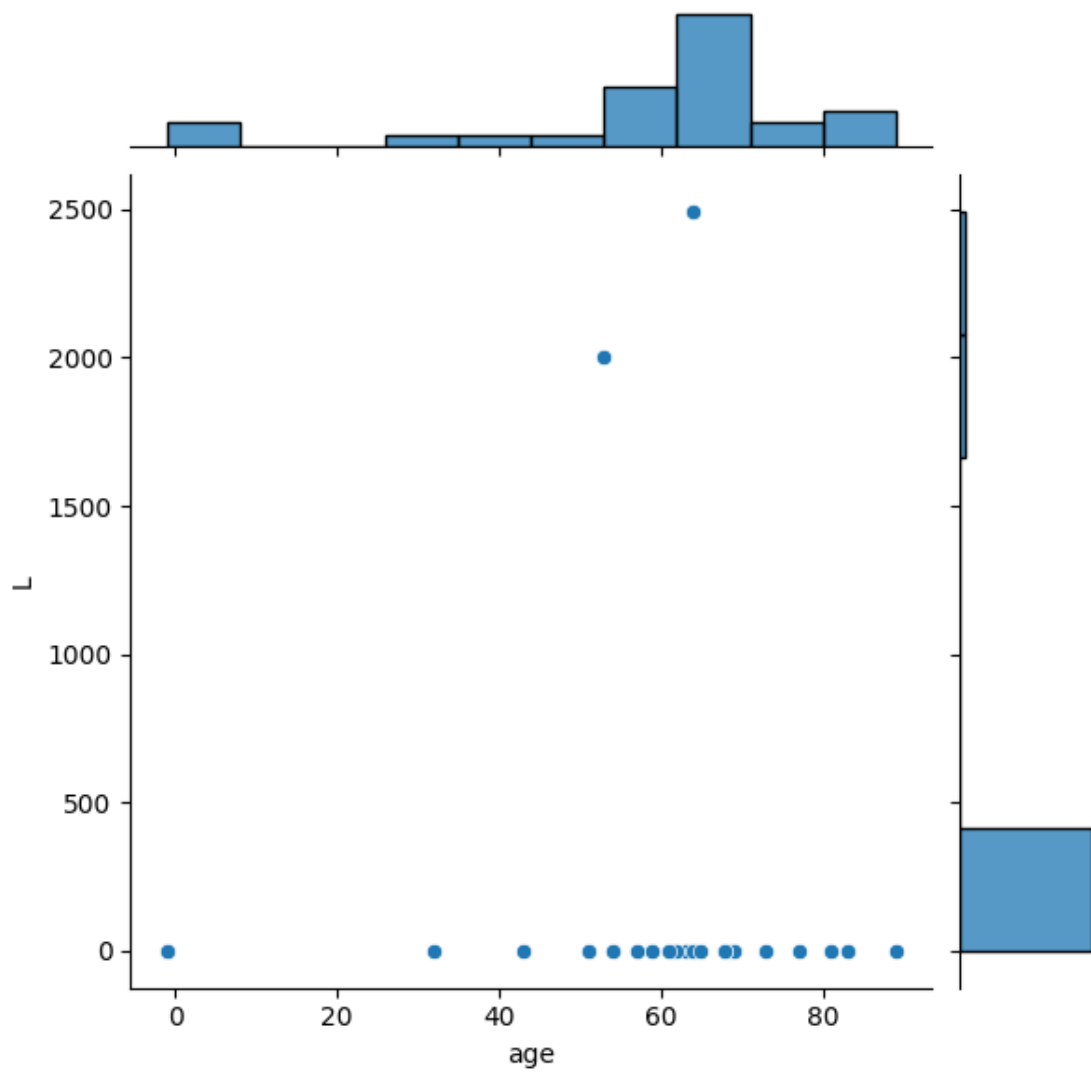
```
[36]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "F"], x="age", y="R"
    )
```

```
[36]: <seaborn.axisgrid.JointGrid at 0x7efe8039f670>
```



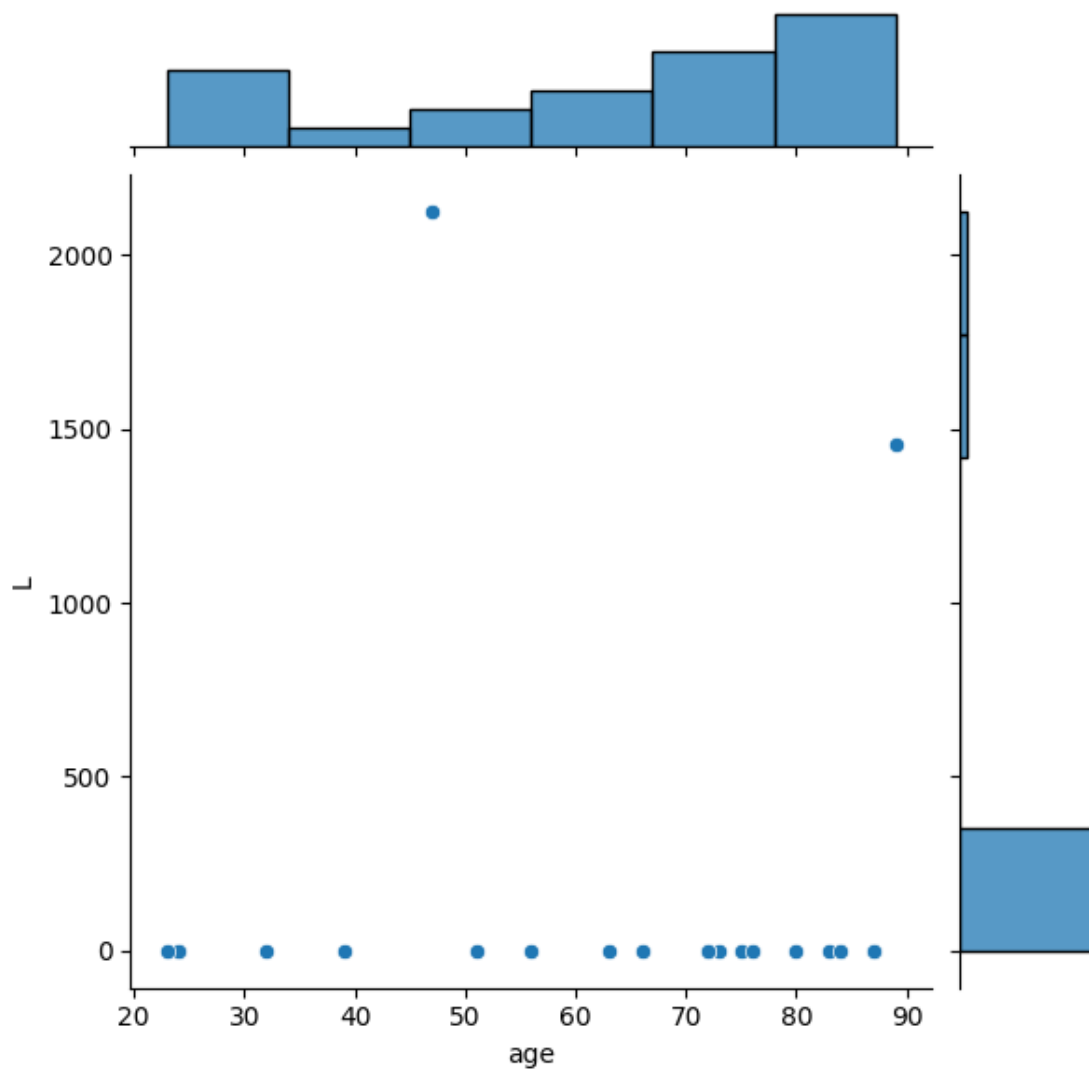
```
[37]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "M"], x="age", y="L"
    )
```

[37]: <seaborn.axisgrid.JointGrid at 0x7efe8020f370>



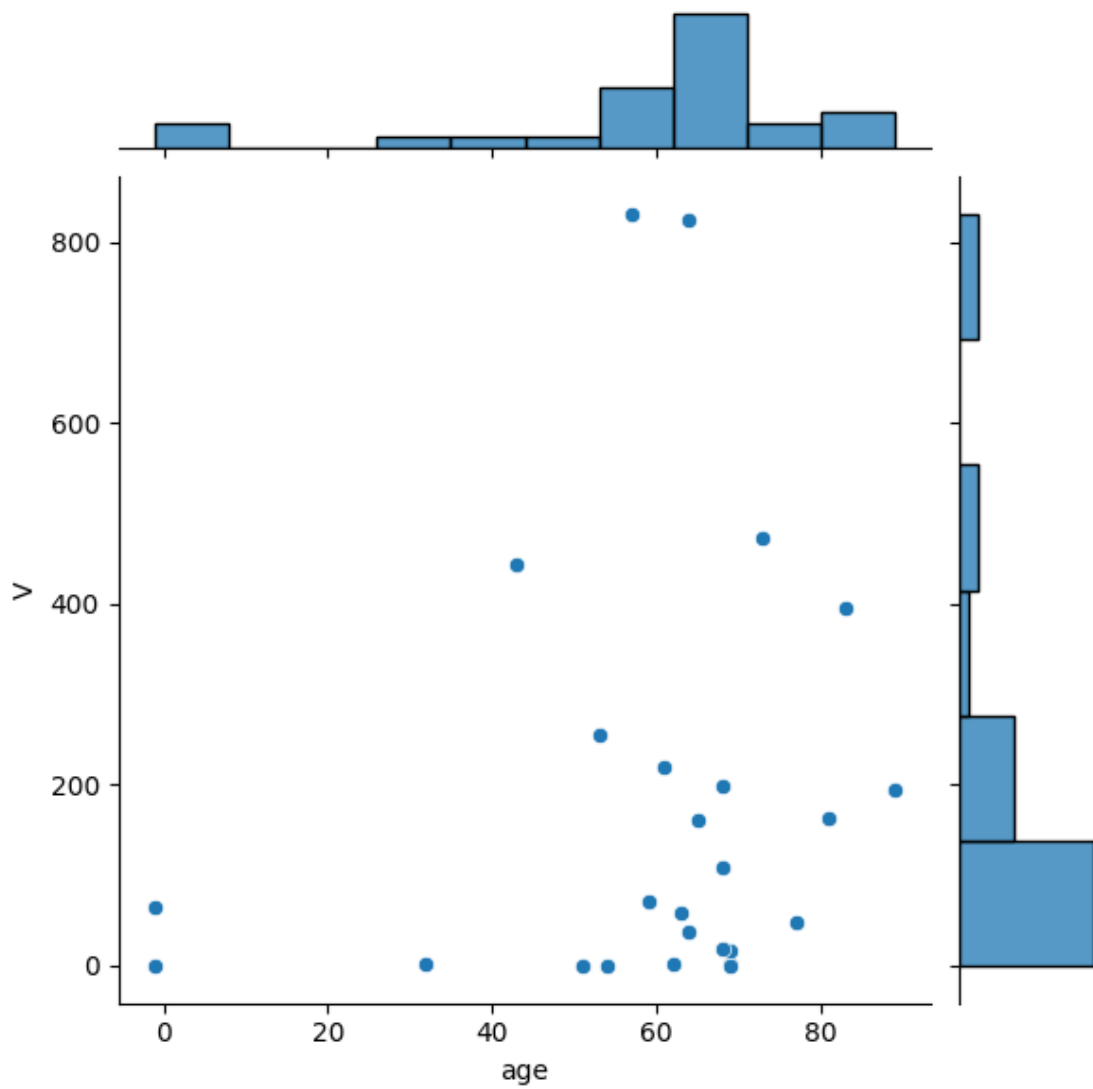
```
[38]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "F"], x="age", y="L"
    )
```

```
[38]: <seaborn.axisgrid.JointGrid at 0x7efe801ff2e0>
```



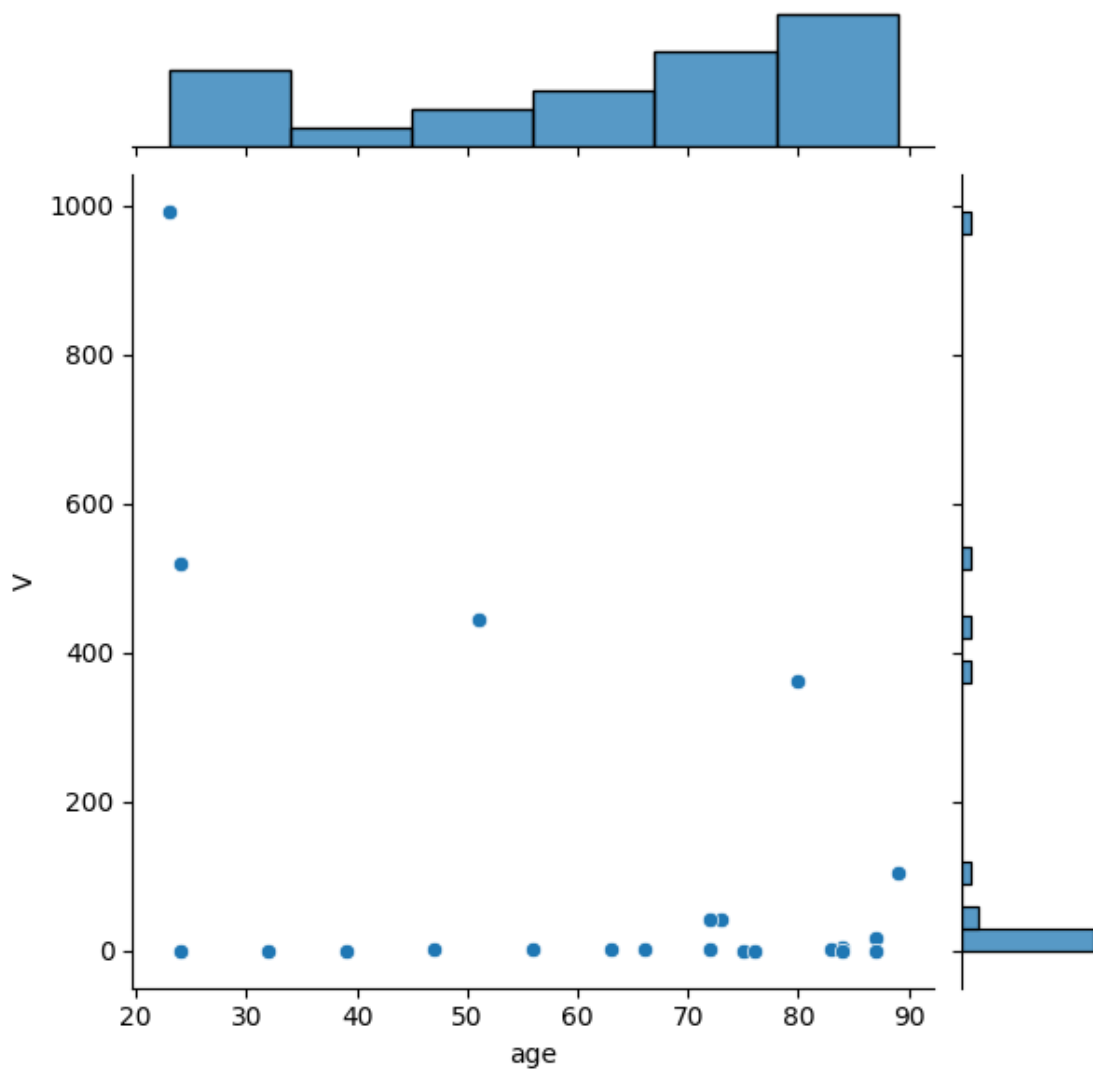
```
[39]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "M"], x="age", y="V"
    )
```

```
[39]: <seaborn.axisgrid.JointGrid at 0x7efe7ffec160>
```



```
[40]: sns.jointplot(
      data=patient_data_frame[patient_data_frame["gender"] == "F"], x="age", y="V"
    )
```

```
[40]: <seaborn.axisgrid.JointGrid at 0x7efe82726df0>
```



```
[41]: def categorize_age(age):
    if age > 0 and age <= 20:
        return "0-20"
    elif age > 20 and age <= 40:
        return "20-40"
    elif age > 40 and age <= 60:
        return "40-60"
    elif age > 60 and age <= 80:
        return "60-80"
    elif age > 80 and age <= 100:
        return "80-100"
    else:
        return "Invalid"
```

```
patient_data_frame["age_category"] = patient_data_frame["age"].
    ↪apply(categorize_age)
```

```
[42]: patient_data_frame.head()
```

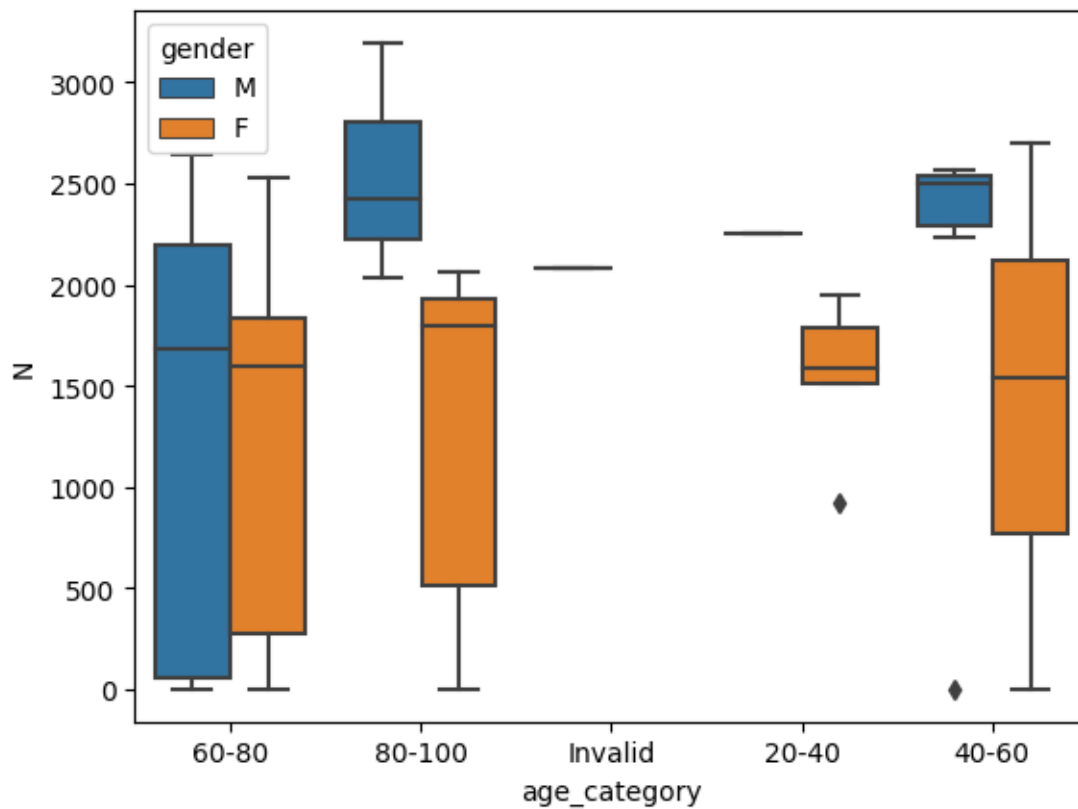
```
[42]:      !  "  +    /  A  E  F  J  L    N  ...  f  j  x  |  ~  age  gender  \
id
100  0  0  1    0  33  0  0  0  0  2239  ...  0  0  0  0  0  69      M
101  0  0  1    0  3  0  0  0  0  1860  ...  0  0  0  4  4  75      F
102  0  0  5  2028  0  0  0  0  0   99  ...  56  0  0  0  0  84      F
103  0  0  1    0  2  0  0  0  0  2082  ...  0  0  0  0  6  -1      M
104  0  0  45  1380  0  0  0  0  0   163  ...  666  0  0  0  37  66      F
```

```
      First lead  Second Lead  age_category
id
100      MLII      V5      60-80
101      MLII      V1      60-80
102      V5      V2      80-100
103      MLII      V2      Invalid
104      V5      V2      60-80
```

```
[5 rows x 28 columns]
```

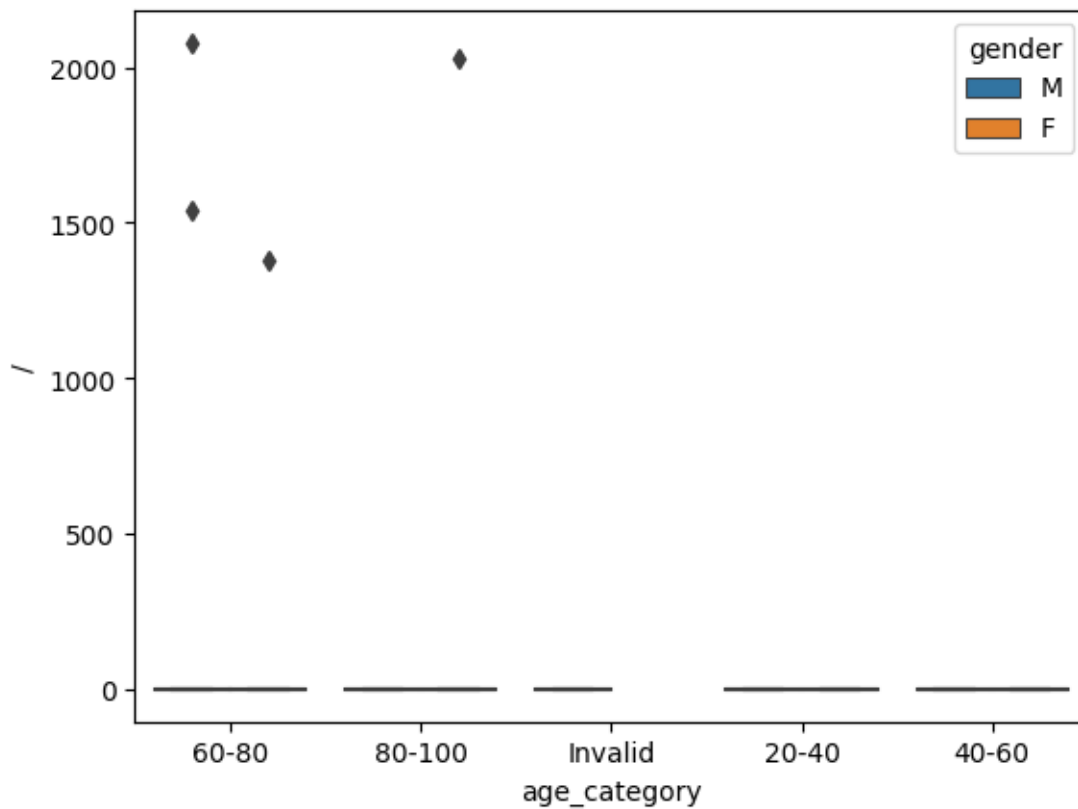
```
[43]: sns.boxplot(data=patient_data_frame, x="age_category", y="N", hue="gender")
```

```
[43]: <Axes: xlabel='age_category', ylabel='N'>
```

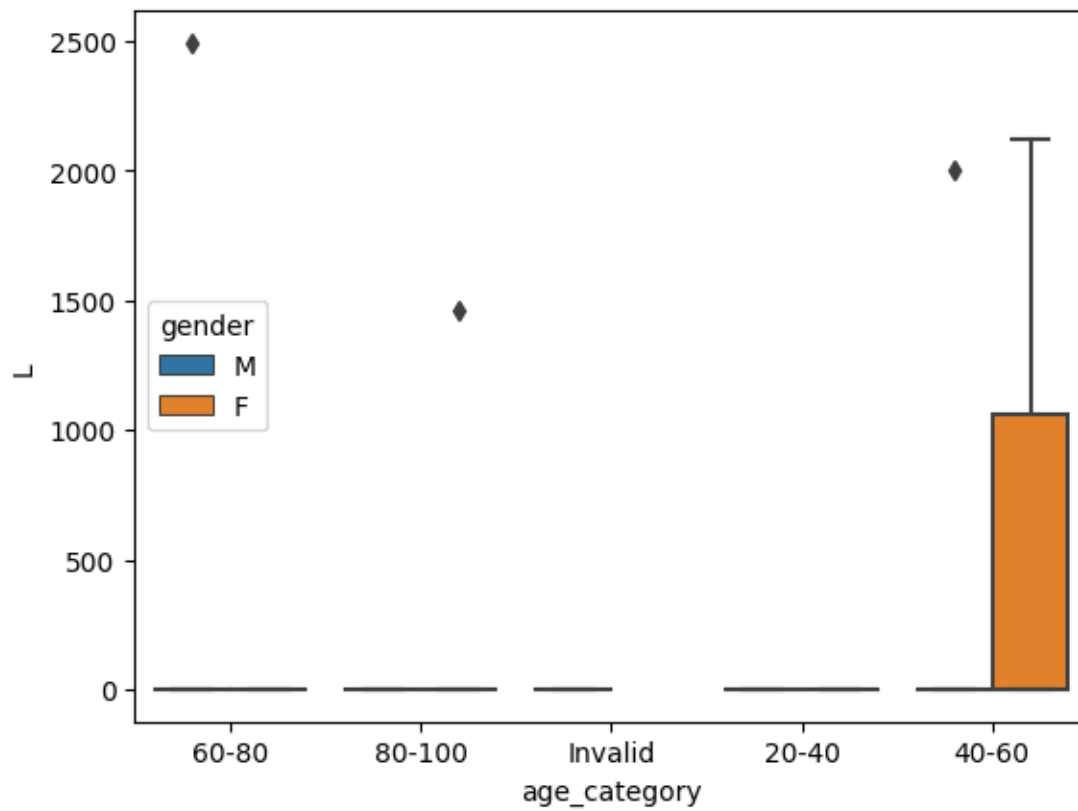
```
[44]: sns.boxplot(data=patient_data_frame, x="age_category", y="/", hue="gender")
```

```
[44]: <Axes: xlabel='age_category', ylabel='/'>
```



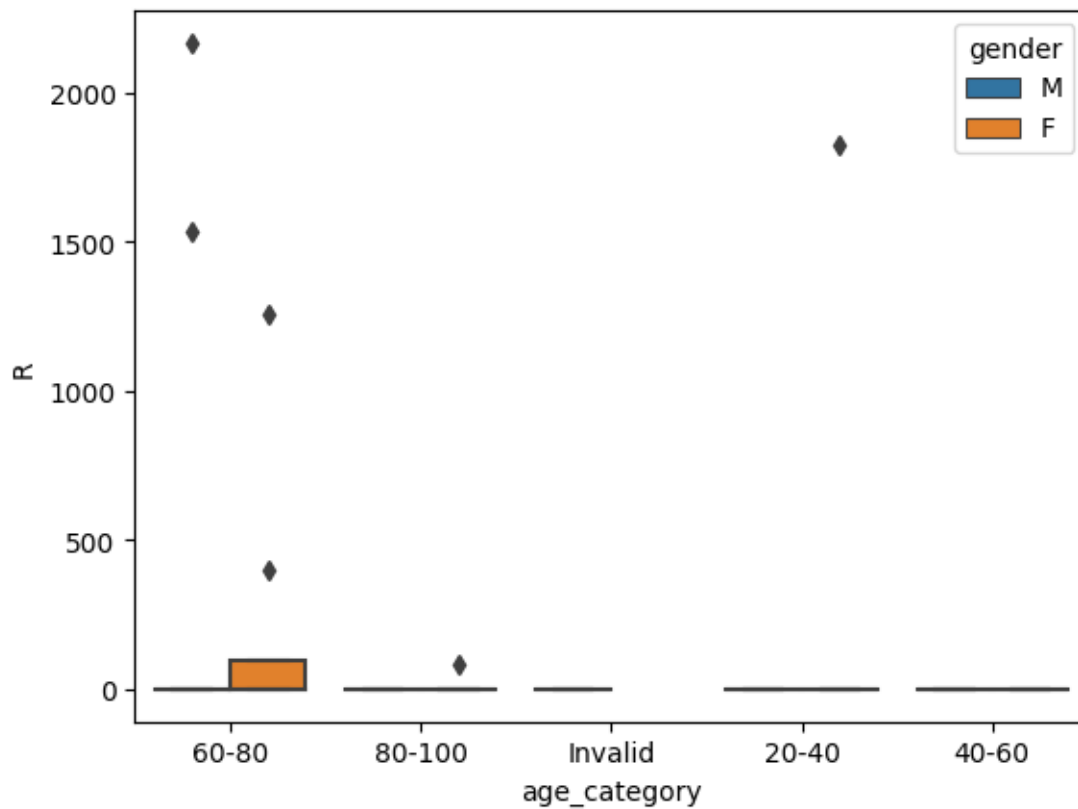
```
[45]: sns.boxplot(data=patient_data_frame, x="age_category", y="L", hue="gender")
```

```
[45]: <Axes: xlabel='age_category', ylabel='L'>
```



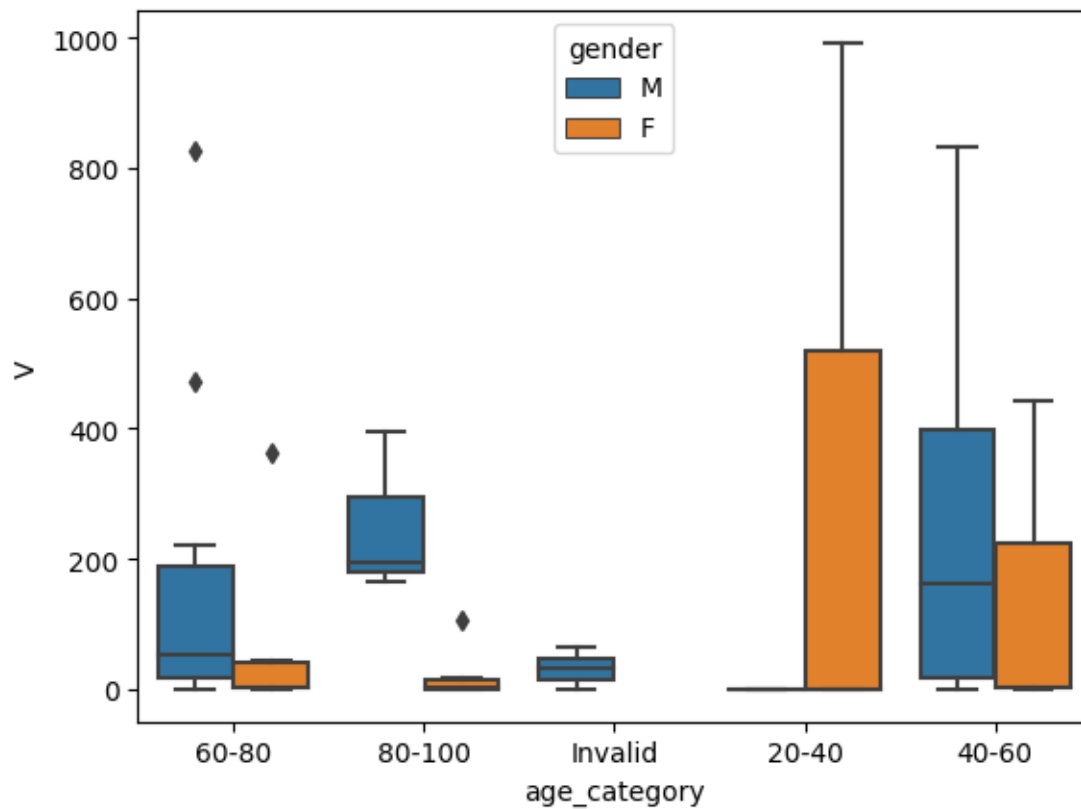
```
[46]: sns.boxplot(data=patient_data_frame, x="age_category", y="R", hue="gender")
```

```
[46]: <Axes: xlabel='age_category', ylabel='R'>
```



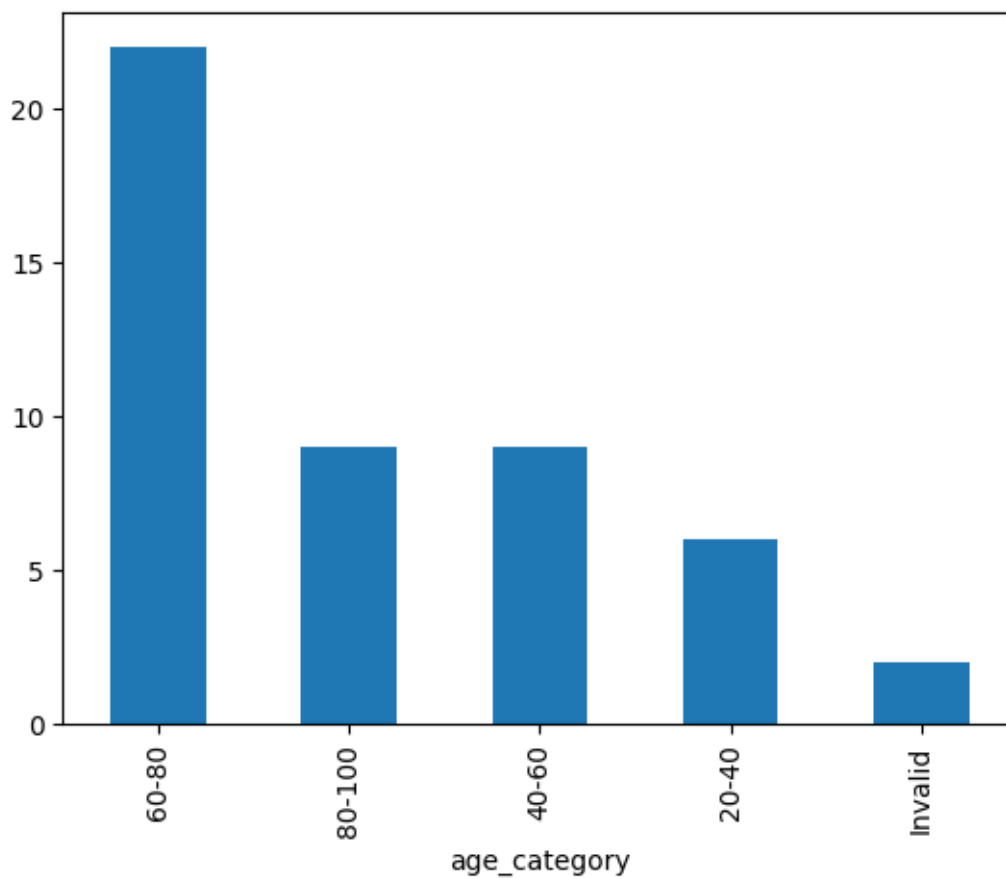
```
[47]: sns.boxplot(data=patient_data_frame, x="age_category", y="V", hue="gender")
```

```
[47]: <Axes: xlabel='age_category', ylabel='V'>
```



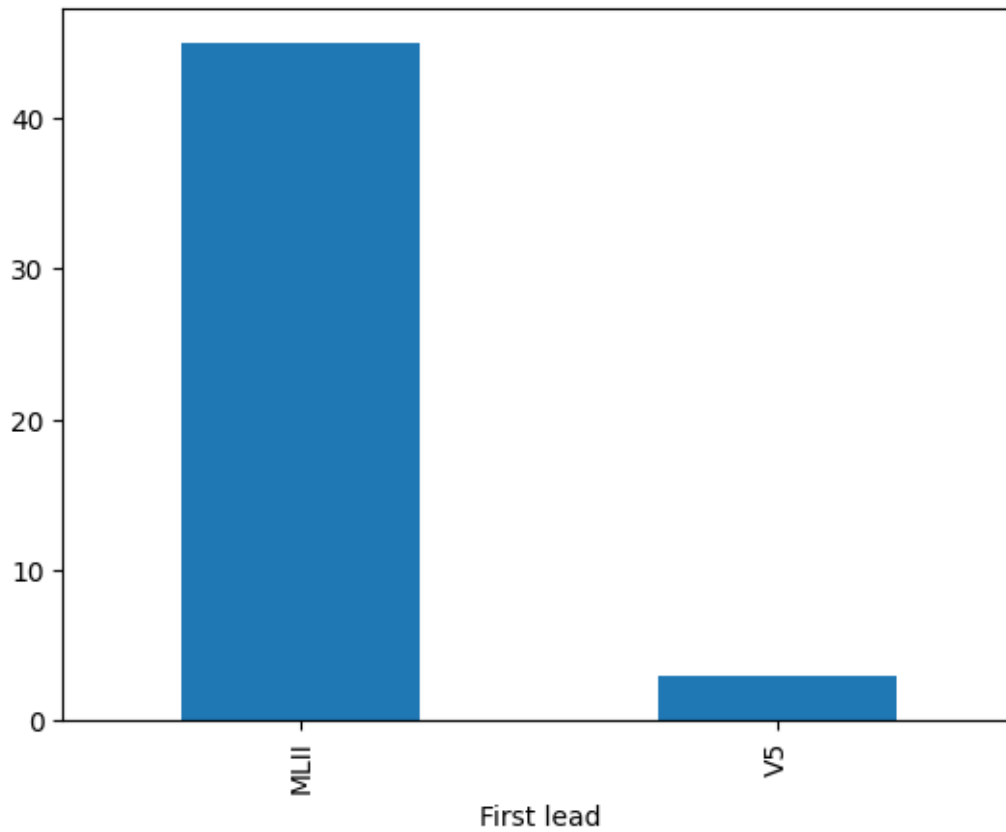
```
[48]: patient_data_frame["age_category"].value_counts().plot(kind="bar")
```

```
[48]: <Axes: xlabel='age_category'>
```



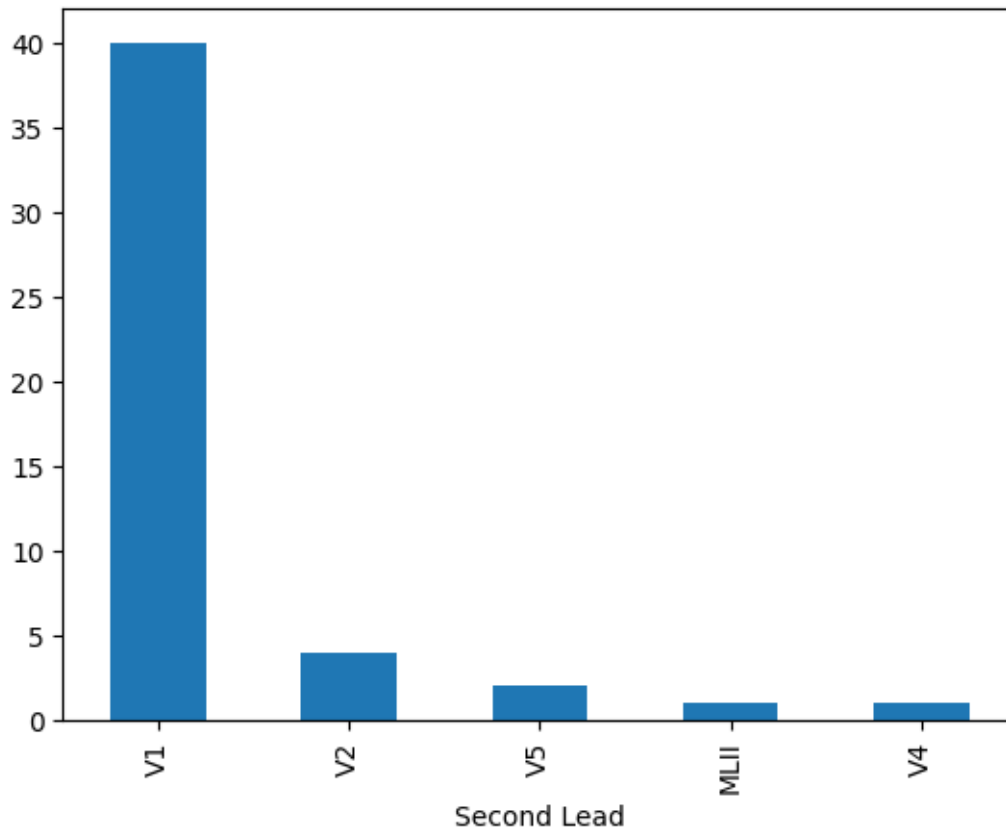
```
[49]: patient_data_frame["First lead"].value_counts().plot(kind="bar")
```

```
[49]: <Axes: xlabel='First lead'>
```



```
[50]: patient_data_frame["Second Lead"].value_counts().plot(kind="bar")
```

```
[50]: <Axes: xlabel='Second Lead'>
```



1.6 Data Preprocessing

```
[51]: record100_raw = records[0].ecg_signal()
```

```
[52]: record100_raw
```

```
[52]: array([[ -0.145, -0.065],
          [ -0.145, -0.065],
          [ -0.145, -0.065],
          ...,
          [ -0.675, -0.365],
          [ -0.765, -0.335],
          [ -1.28 ,  0.   ]])
```

1.6.1 Frequencies Present in the Signal

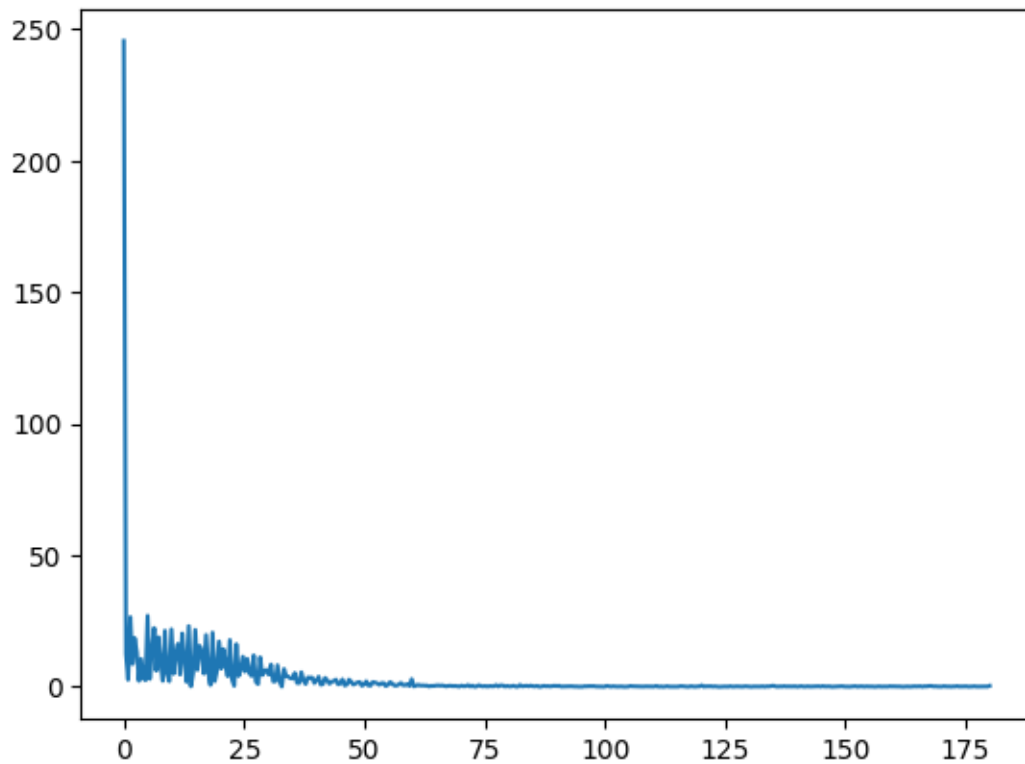
```
[53]: from scipy.fft import rfft, rfftfreq
```

```
[54]: yf = rfft(record100_raw[:800, 0])
      xf = rfftfreq(len(record100_raw[:800, 0]), 1 / 360)
```



```
[55]: plt.plot(xf, np.abs(yf))
```

```
[55]: [<matplotlib.lines.Line2D at 0x7efe7f598700>]
```



The human ECG spectrum covers the frequency range 0.05 Hz - 100 Hz, with the main part of the QRS complex being in the range 0.5 Hz - 45 Hz. Most of the time the ECG signal is overlaid by the mains frequency of 50 Hz/60 Hz.

1.6.2 Removing Baseline Wandering

```
[56]: lead_II_signal = record100_raw[:, 0]
```

```
[57]: lead_II_signal
```

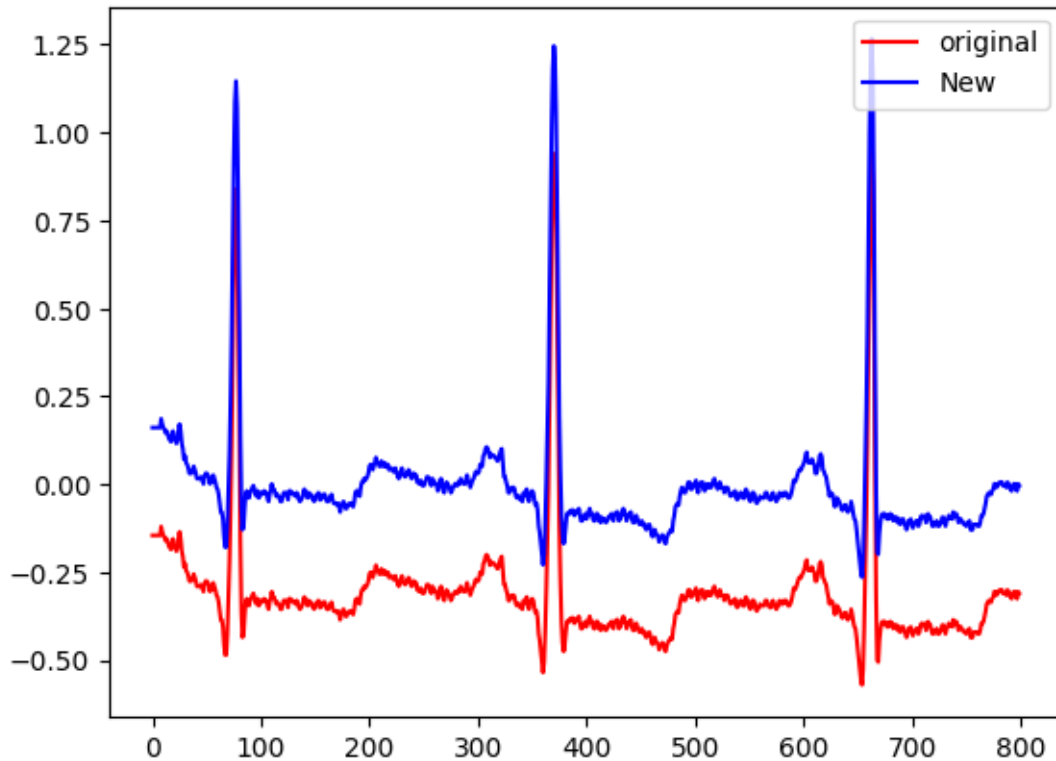
```
[57]: array([-0.145, -0.145, -0.145, ..., -0.675, -0.765, -1.28 ])
```

```
[58]: from utils.common_utils import remove_baseline_wander
```

```
new_signal_after_removal_of_baseline_wandering =  
    ↪ remove_baseline_wander(lead_II_signal)
```

```
[59]: plt.plot(lead_II_signal[:800], color="red")
plt.plot(new_signal_after_removal_of_baseline_wandering[:800], color="blue")
plt.legend(("original", "New"))
```

[59]: <matplotlib.legend.Legend at 0x7efe7f56fee0>



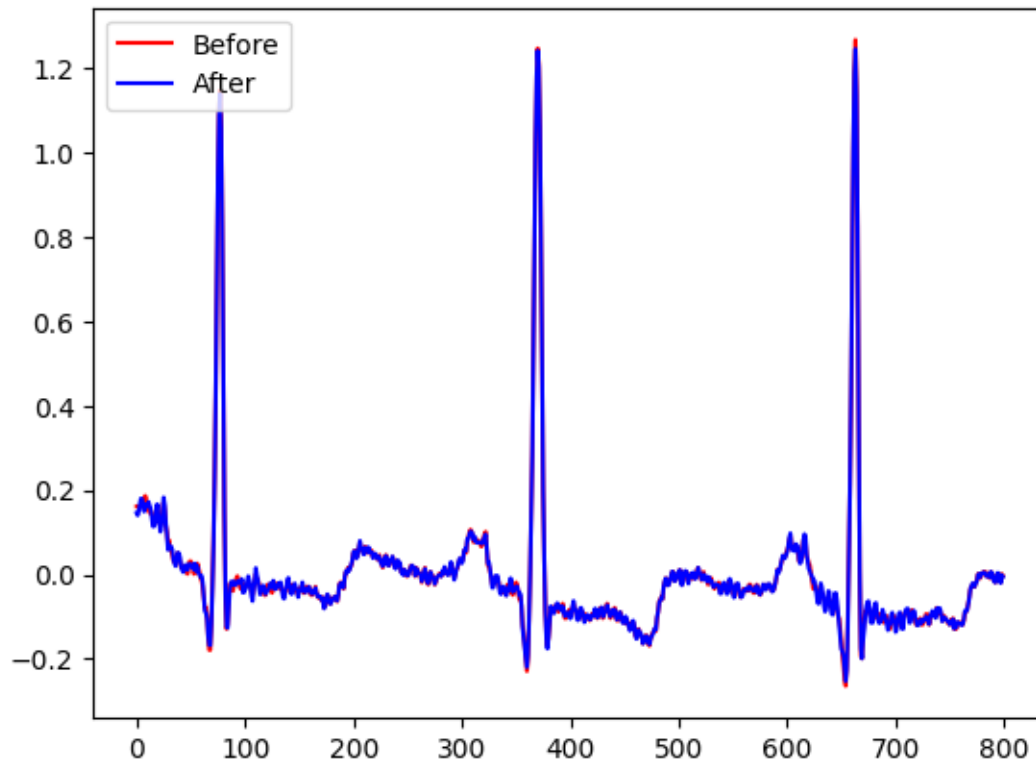
1.6.3 Removing Power Line Interference

```
[60]: from utils.common_utils import remove_powerline_interference

new_signal_after_removal_p_intr = remove_powerline_interference(
    50, new_signal_after_removal_of_baseline_wandering, 360, 2
)
```

```
[61]: plt.plot(new_signal_after_removal_of_baseline_wandering[:800], color="red")
plt.plot(new_signal_after_removal_p_intr[:800], color="blue")
plt.legend(("Before", "After"))
```

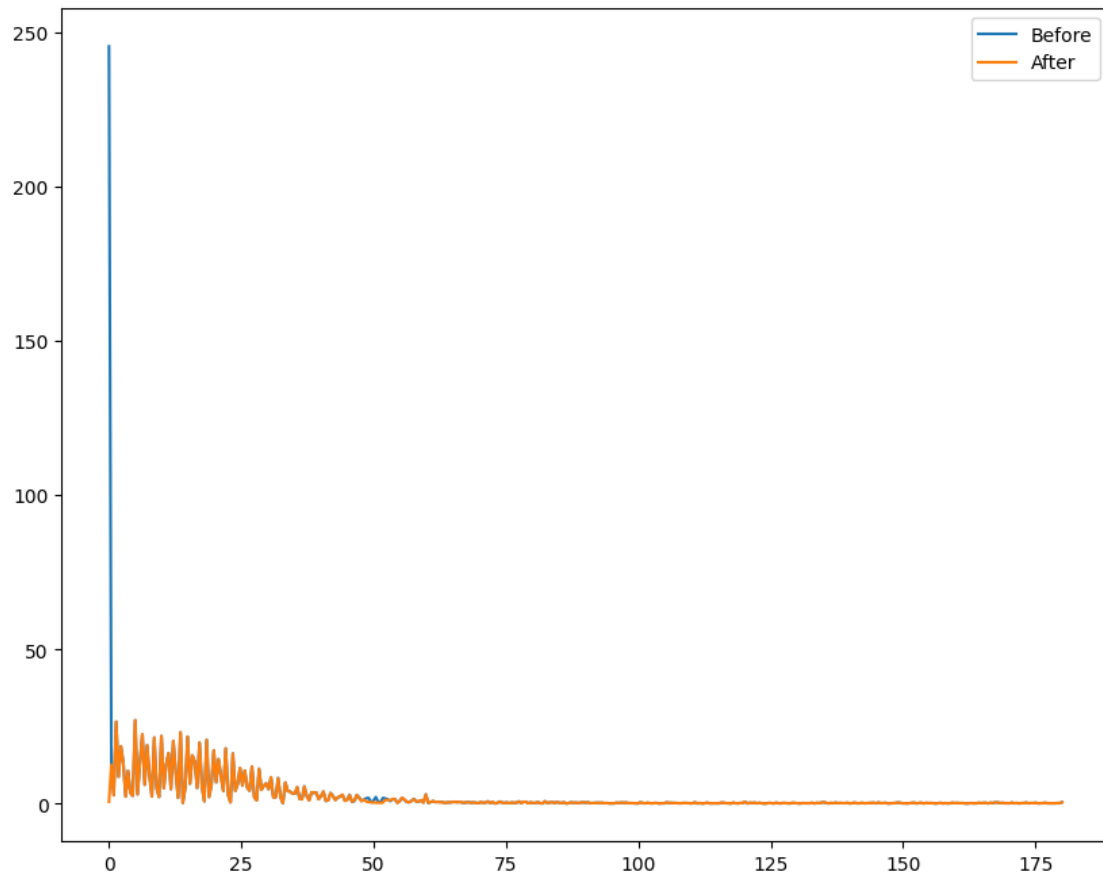
[61]: <matplotlib.legend.Legend at 0x7efe7fdffb50>



```
[62]: yf_after = rfft(new_signal_after_removal_p_intr[:800])
      xf_after = rfftfreq(len(new_signal_after_removal_p_intr[:800]), 1 / 360)
```

```
[63]: plt.figure(figsize=(10, 8))
      plt.plot(xf, np.abs(yf))
      plt.plot(xf_after, np.abs(yf_after))
      plt.legend(("Before", "After"))
```

```
[63]: <matplotlib.legend.Legend at 0x7efe7f6cbb50>
```



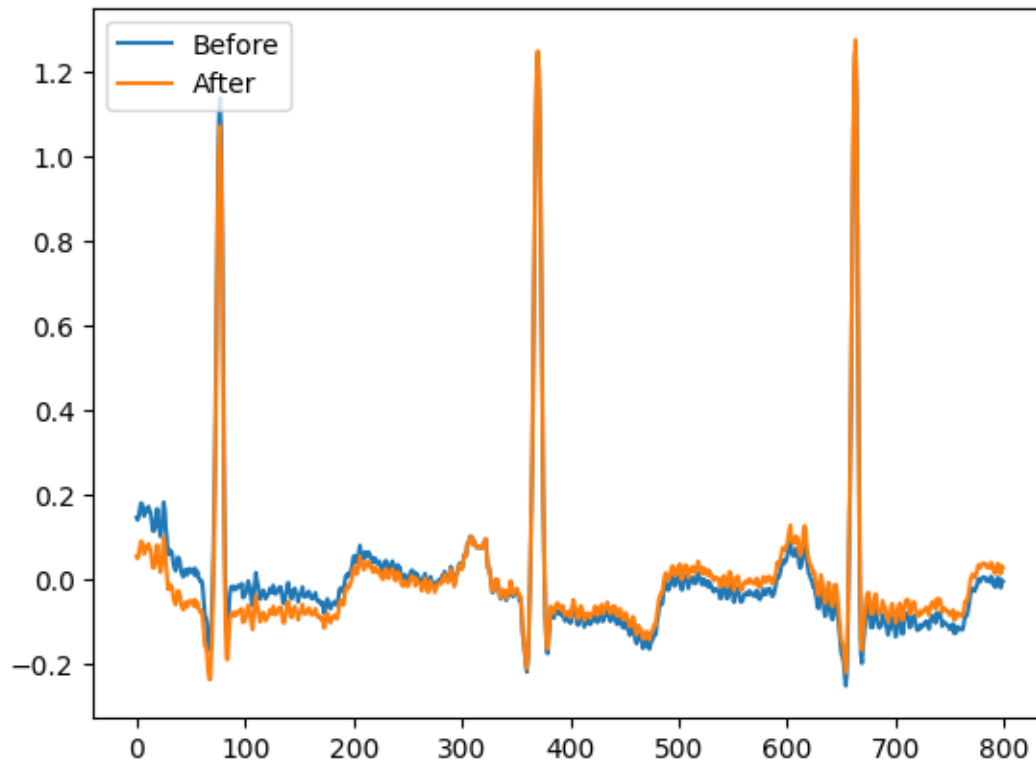
1.6.4 High Pass Filter at 0.5Hz

```
[64]: from utils.common_utils import high_pass_filter
```

```
[65]: filteredHighPass = high_pass_filter(new_signal_after_removal_p_intr, 0.5)
```

```
[66]: plt.plot(new_signal_after_removal_p_intr[:800])
plt.plot(filteredHighPass[:800])
plt.legend(("Before", "After"))
```

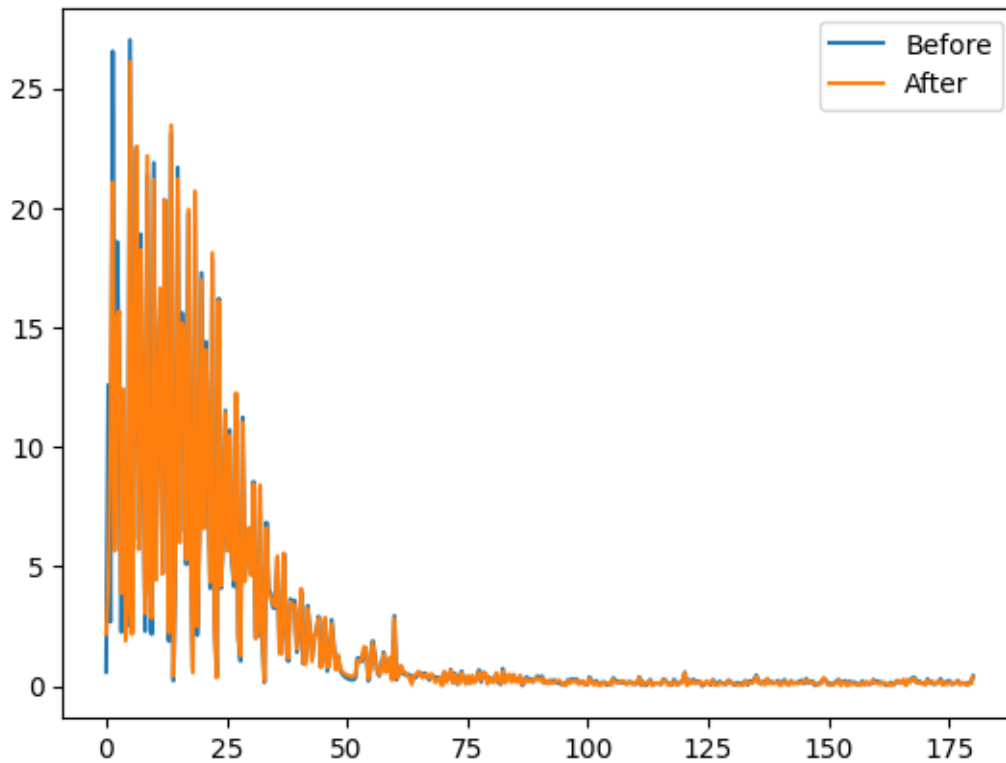
```
[66]: <matplotlib.legend.Legend at 0x7efe7f389c40>
```



```
[67]: yf_before = rfft(new_signal_after_removal_p_intr[:800])
      xf_before = rfftfreq(len(new_signal_after_removal_p_intr[:800]), 1 / 360)
      yf_after = rfft(filteredHighPass[:800])
      xf_after = rfftfreq(len(filteredHighPass[:800]), 1 / 360)
```

```
[68]: plt.plot(xf_before, np.abs(yf_before))
      plt.plot(xf_after, np.abs(yf_after))
      plt.legend(("Before", "After"))
```

```
[68]: <matplotlib.legend.Legend at 0x7efe7f325d30>
```



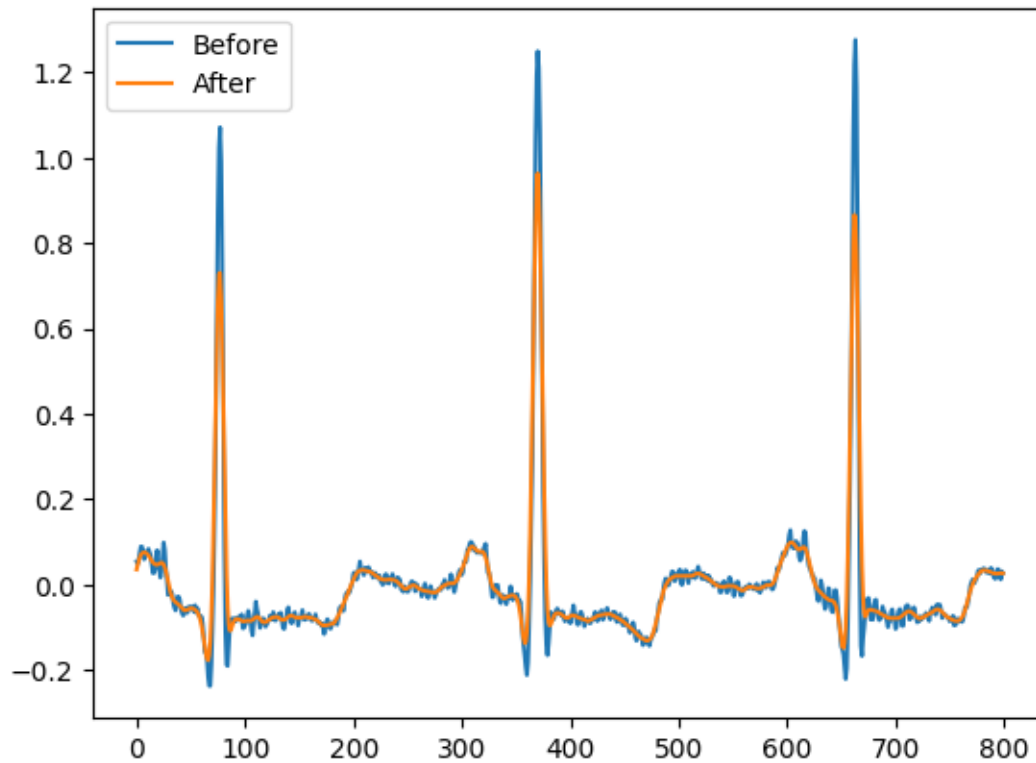
1.6.5 Low Pass Filter with Convolution

```
[69]: from utils.common_utils import hanning_filter
```

```
[70]: filteredLowPass = hanning_filter(filteredHighPass, 15)
```

```
[71]: plt.plot(filteredHighPass[:800])
plt.plot(filteredLowPass[:800])
plt.legend(("Before", "After"))
```

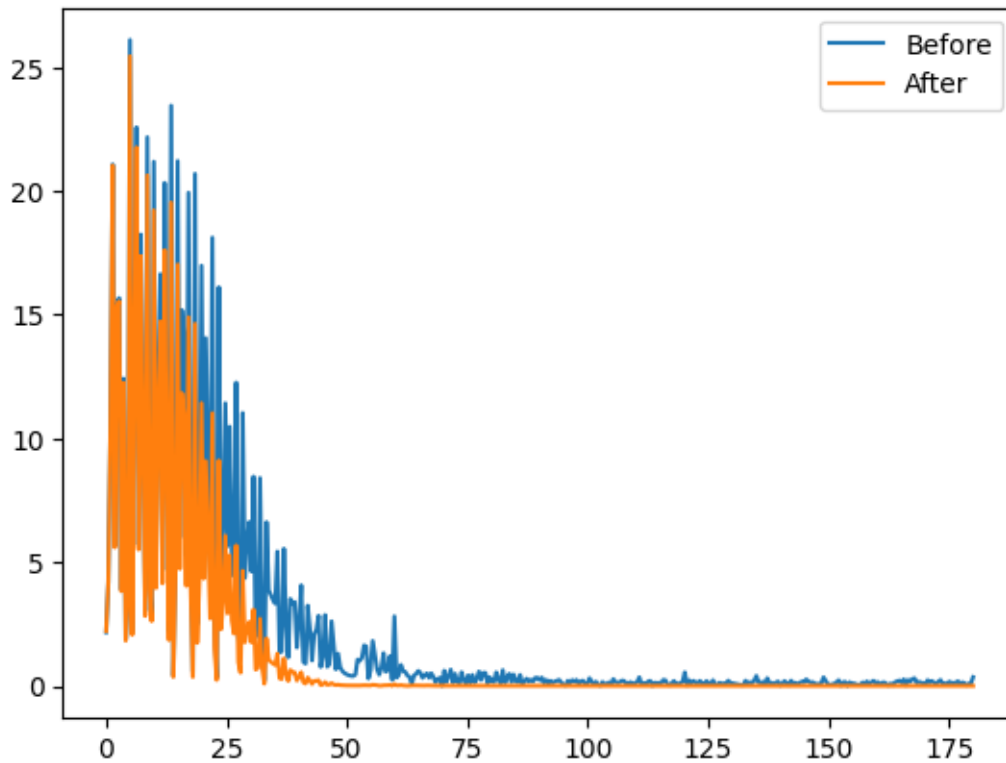
```
[71]: <matplotlib.legend.Legend at 0x7efe7f2b40d0>
```



```
[72]: yf_before = rfft(filteredHighPass[:800])
      xf_before = rfftfreq(len(filteredHighPass[:800]), 1 / 360)
      yf_after = rfft(filteredLowPass[:800])
      xf_after = rfftfreq(len(filteredLowPass[:800]), 1 / 360)
```

```
[73]: plt.plot(xf_before, np.abs(yf_before))
      plt.plot(xf_after, np.abs(yf_after))
      plt.legend(("Before", "After"))
```

```
[73]: <matplotlib.legend.Legend at 0x7efe7f1d6370>
```



1.6.6 Segmentation

```
[74]: from data_set_utils.data_generator import DataMaker
```

```
[75]: dm = DataMaker(records, 50, 360, "MLII", 15, 0.5, 2, 100, 100)
```

```
[76]: ecg_segments = dm.perform_segmentation(symbols_of_interest)
```

No MLII for 102

No MLII for 104

1.6.7 Data Frame Preparation

```
[77]: readings = list()
      record_ids = list()
      segment_starts = list()
      segment_ends = list()
      annotation_class = list()
```

```
[78]: for segment in ecg_segments:
      if len(segment.get_readings()) == 200 and any(
```



```

        [ann.get_symbol() in symbols_of_interest for ann in segment.
↪get_annotations()]
    ):
        readings.append(segment.get_readings())
        record_ids.append(segment.get_record_id())
        start, stop = segment.get_segment_positions()
        segment_starts.append(start)
        segment_ends.append(stop)
        for i, ann in enumerate(segment.get_annotations()):
            if ann.get_symbol() in symbols_of_interest:
                annotation_class.append(ann.get_symbol())
                break
        else:
            print(f"Skipping {segment.get_record_id()}")
            print(f"Size:{len(segment.get_readings())}")
            print(f"Segment:{segment.get_segment_positions()}")
            print(f" Annotations:[{ann.get_symbol() for ann in segment.
↪get_annotations()}]")
            print("+++++")

```

```

Skipping 100
Size:200
Segment:(1959, 2159)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(66706, 66906)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(74923, 75123)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(99518, 99718)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(128023, 128223)
Annotations:['A']
+++++
Skipping 100
Size:200

```

```

Segment:(170654, 170854)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(279490, 279690)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(305609, 305809)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(307683, 307883)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(312726, 312926)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(317721, 317921)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(319137, 319337)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(346719, 346919)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(351396, 351596)
  Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(376996, 377196)
  Annotations:['A']
+++++

```

```
Skipping 100
Size:200
Segment:(397250, 397450)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(421931, 422131)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(422719, 422919)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(433780, 433980)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(436063, 436263)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(442560, 442760)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(444642, 444842)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(454589, 454789)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(458083, 458283)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(496613, 496813)
```

```

Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(520897, 521097)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(562750, 562950)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(566160, 566360)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(567318, 567518)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(574330, 574530)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(579363, 579563)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(592982, 593182)
Annotations:['A']
+++++
Skipping 100
Size:200
Segment:(629112, 629312)
Annotations:['A']
+++++
Skipping 101
Size:200
Segment:(63033, 63233)
Annotations:[]
+++++
Skipping 101

```

```

Size:200
Segment:(63343, 63543)
Annotations:['|']
+++++
Skipping 101
Size:200
Segment:(114622, 114822)
Annotations:['|', 'Q']
+++++
Skipping 101
Size:200
Segment:(115099, 115299)
Annotations:[]
+++++
Skipping 101
Size:200
Segment:(115210, 115410)
Annotations:[]
+++++
Skipping 101
Size:200
Segment:(135217, 135417)
Annotations:['A']
+++++
Skipping 101
Size:200
Segment:(215507, 215707)
Annotations:['A']
+++++
Skipping 101
Size:200
Segment:(308177, 308377)
Annotations:['Q']
+++++
Skipping 101
Size:200
Segment:(531954, 532154)
Annotations:['A']
+++++
Skipping 103
Size:200
Segment:(9, 209)
Annotations:['+']
+++++
Skipping 103
Size:200
Segment:(418190, 418390)
Annotations:['A']

```

```

+++++
Skipping 103
Size:200
Segment:(489577, 489777)
  Annotations:['A']
+++++
Skipping 103
Size:186
Segment:(649814, 650000)
  Annotations:['N']
+++++
Skipping 105
Size:200
Segment:(74215, 74415)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(227362, 227562)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(238002, 238202)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(370724, 370924)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(432970, 433170)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(433547, 433747)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(434875, 435075)
  Annotations:[]
+++++
Skipping 105
Size:200

```

```

Segment:(436878, 437078)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(437833, 438033)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(439410, 439610)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(440919, 441119)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(441497, 441697)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(441985, 442185)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(442461, 442661)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(444009, 444209)
  Annotations:['Q']
+++++
Skipping 105
Size:200
Segment:(444120, 444320)
  Annotations:[]
+++++
Skipping 105
Size:200
Segment:(445273, 445473)
  Annotations:['Q']
+++++

```

```
Skipping 105
Size:200
Segment:(447843, 448043)
Annotations:['Q']
+++++
Skipping 105
Size:200
Segment:(447993, 448193)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(463428, 463628)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(468653, 468853)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(469708, 469908)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(471660, 471860)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(472463, 472663)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(472580, 472780)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(475617, 475817)
Annotations:[]
+++++
Skipping 105
Size:200
Segment:(476810, 477010)
```



```

Annotations: []
+++++
Skipping 105
Size:200
Segment:(477343, 477543)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(478520, 478720)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(478631, 478831)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(478743, 478943)
Annotations:['~']
+++++
Skipping 105
Size:200
Segment:(482217, 482417)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(594515, 594715)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(595059, 595259)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(595171, 595371)
Annotations: []
+++++
Skipping 105
Size:200
Segment:(595428, 595628)
Annotations:['~', 'Q']
+++++
Skipping 105

```

```

Size:200
Segment:(610817, 611017)
Annotations:[]
+++++
Skipping 106
Size:200
Segment:(11, 211)
Annotations:['~']
+++++
Skipping 108
Size:200
Segment:(743, 943)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(1446, 1646)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(3191, 3391)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(3546, 3746)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(3878, 4078)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(4138, 4338)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(4575, 4775)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(5302, 5502)
Annotations:[]

```

```

+++++
Skipping 108
Size:200
Segment:(6433, 6633)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(8758, 8958)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(10002, 10202)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(10279, 10479)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(10932, 11132)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(29054, 29254)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(32216, 32416)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(33075, 33275)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(33843, 34043)
Annotations:[]
+++++
Skipping 108
Size:200

```

```

Segment:(36069, 36269)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(36427, 36627)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(37250, 37450)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(37735, 37935)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(40869, 41069)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(42046, 42246)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(43176, 43376)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(43962, 44162)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(44345, 44545)
  Annotations:[]
+++++
Skipping 108
Size:200
Segment:(44731, 44931)
  Annotations:[]
+++++

```

Skipping 108
Size:200
Segment:(45102, 45302)
Annotations: []
++++
Skipping 108
Size:200
Segment:(45449, 45649)
Annotations: []
++++
Skipping 108
Size:200
Segment:(45861, 46061)
Annotations: []
++++
Skipping 108
Size:200
Segment:(46240, 46440)
Annotations: []
++++
Skipping 108
Size:200
Segment:(46616, 46816)
Annotations: []
++++
Skipping 108
Size:200
Segment:(46934, 47134)
Annotations: []
++++
Skipping 108
Size:200
Segment:(47308, 47508)
Annotations: []
++++
Skipping 108
Size:200
Segment:(47683, 47883)
Annotations: []
++++
Skipping 108
Size:200
Segment:(47916, 48116)
Annotations: []
++++
Skipping 108
Size:200
Segment:(48150, 48350)

```

Annotations: []
+++++
Skipping 108
Size:200
Segment:(48594, 48794)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(48943, 49143)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(49348, 49548)
Annotations: ['~']
+++++
Skipping 108
Size:200
Segment:(49737, 49937)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(50133, 50333)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(50517, 50717)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(50869, 51069)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(51222, 51422)
Annotations: []
+++++
Skipping 108
Size:200
Segment:(51558, 51758)
Annotations: []
+++++
Skipping 108

```

Size:200
Segment:(51945, 52145)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(52352, 52552)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(52730, 52930)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(53103, 53303)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(53471, 53671)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(53818, 54018)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(54215, 54415)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(54639, 54839)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(54994, 55194)
Annotations:[]
++++
Skipping 108
Size:200
Segment:(55367, 55567)
Annotations:[]

```

+++++
Skipping 108
Size:200
Segment:(55737, 55937)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(56128, 56328)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(56521, 56721)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(56923, 57123)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(79308, 79508)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(93219, 93419)
Annotations:[]
+++++
Skipping 108
Size:200
Segment:(180511, 180711)
Annotations:['F']
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Skipping 108
Size:200
Segment:(263107, 263307)
Annotations:['A']
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Skipping 108
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Segment:(376696, 376896)
Annotations:[]
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Skipping 108
Size:200

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Segment:(377404, 377604)
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Size:200
Segment:(378450, 378650)
Annotations:[]
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Skipping 108
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Segment:(378798, 378998)
Annotations:[]
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Skipping 108
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Segment:(379481, 379681)
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Skipping 108
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Segment:(379813, 380013)
Annotations:[]
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Skipping 108
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Segment:(380158, 380358)
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Skipping 108
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Segment:(380852, 381052)
Annotations:[]
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Skipping 108
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Segment:(382866, 383066)
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Skipping 108
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Annotations:[]
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Skipping 108
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Segment:(388223, 388423)
Annotations:[]
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Skipping 108
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Segment:(389839, 390039)
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Skipping 108
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Segment:(392747, 392947)
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Skipping 108
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Segment:(435591, 435791)
Annotations:['j']
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Segment:(438092, 438292)
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Segment:(449443, 449643)
Annotations:[]
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Skipping 108
Size:200
Segment:(528179, 528379)
Annotations:['A']
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Segment:(528895, 529095)
Annotations:['A']
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Skipping 108
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Segment:(601439, 601639)
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Skipping 108
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Segment:(602863, 603063)
Annotations:[]
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Skipping 108
Size:200
Segment:(603230, 603430)

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Segment:(606377, 606577)
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Segment:(607408, 607608)
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Segment:(611278, 611478)
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Segment:(611924, 612124)
Annotations: []
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Skipping 108
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Segment:(612545, 612745)
Annotations: []
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Skipping 108

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Segment:(613455, 613655)
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Segment:(615914, 616114)
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Segment:(616234, 616434)
Annotations:[]
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Skipping 108
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Segment:(616534, 616734)
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Segment:(616864, 617064)
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Segment:(617178, 617378)
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Segment:(617486, 617686)
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Skipping 108
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Segment:(617796, 617996)
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Skipping 108
Size:200
Segment:(618124, 618324)
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Segment:(618789, 618989)
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Segment:(619573, 619773)
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Segment:(619860, 620060)
Annotations:[]
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Segment:(620154, 620354)
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Segment:(620491, 620691)
Annotations:[]
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Skipping 108
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Segment:(620784, 620984)
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Skipping 108
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Segment:(621068, 621268)
Annotations:[]
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Skipping 108
Size:200

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Segment:(621364, 621564)
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Skipping 108
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Segment:(621615, 621815)
  Annotations: []
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Skipping 108
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Segment:(622211, 622411)
  Annotations: []
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Skipping 108
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Segment:(622493, 622693)
  Annotations: []
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Segment:(622813, 623013)
  Annotations: []
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Segment:(623680, 623880)
  Annotations: []
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Segment:(623968, 624168)
  Annotations: []
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Skipping 108
Size:200
Segment:(624254, 624454)
  Annotations: []
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Skipping 108
Size:200
Segment:(624588, 624788)
  Annotations: []
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Skipping 108
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Segment:(624888, 625088)
  Annotations: []
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Skipping 108
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Segment:(625489, 625689)
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Segment:(625769, 625969)
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Segment:(626060, 626260)
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Segment:(626350, 626550)
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Segment:(626661, 626861)
Annotations: []
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Segment:(626976, 627176)
Annotations: []
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Segment:(627255, 627455)
Annotations: []
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Skipping 108
Size:200
Segment:(627578, 627778)
Annotations: []
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Skipping 108
Size:200
Segment:(627869, 628069)

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Annotations: []
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Segment:(628751, 628951)
Annotations: []
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Segment:(629047, 629247)
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Segment:(629370, 629570)
Annotations: []
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Segment:(629667, 629867)
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Segment:(629954, 630154)
Annotations: []
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Segment:(630245, 630445)
Annotations: []
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Skipping 108
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Segment:(630560, 630760)
Annotations: []
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Skipping 108
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Segment:(630865, 631065)
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Segment:(631283, 631483)
Annotations:['A']
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Segment:(631796, 631996)
Annotations:[]
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Skipping 108
Size:200
Segment:(632079, 632279)
Annotations:[]
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Size:200
Segment:(632383, 632583)
Annotations:[]
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Skipping 108
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Segment:(632989, 633189)
Annotations:[]
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Segment:(633281, 633481)
Annotations:[]
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Skipping 108
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Segment:(636352, 636552)
Annotations:[]
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Skipping 108
Size:200
Segment:(636951, 637151)
Annotations:[]
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Skipping 108
Size:200
Segment:(637907, 638107)
Annotations:[]

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Segment:(642051, 642251)
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Size:200
Segment:(642405, 642605)
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Segment:(644990, 645190)
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Skipping 108
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Segment:(645284, 645484)
Annotations:[]
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Skipping 108
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Segment:(647196, 647396)
Annotations:[]
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Skipping 108
Size:200
Segment:(647504, 647704)
Annotations:[]
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Skipping 108
Size:200
Segment:(648154, 648354)
Annotations:[]
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Skipping 108
Size:200

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Segment:(648465, 648665)
  Annotations:[]
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Skipping 108
Size:200
Segment:(649126, 649326)
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Skipping 108
Size:200
Segment:(649427, 649627)
  Annotations:[]
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Skipping 108
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Segment:(649725, 649925)
  Annotations:[]
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Skipping 109
Size:200
Segment:(6198, 6398)
  Annotations:['F']
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Skipping 109
Size:200
Segment:(11249, 11449)
  Annotations:['F']
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Skipping 109
Size:130
Segment:(649870, 650000)
  Annotations:['L']
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Skipping 111
Size:200
Segment:(129, 329)
  Annotations:[]
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Skipping 112
Size:200
Segment:(253512, 253712)
  Annotations:['A']
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Skipping 112
Size:200
Segment:(278422, 278622)
  Annotations:['A']
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Skipping 112
Size:185
Segment:(649815, 650000)
Annotations:['N']
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Skipping 113
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Segment:(8559, 8759)
Annotations:['a']
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Skipping 113
Size:200
Segment:(141967, 142167)
Annotations:['a']
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Skipping 113
Size:200
Segment:(146628, 146828)
Annotations:['a']
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Size:200
Segment:(182936, 183136)
Annotations:['a']
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Size:200
Segment:(456991, 457191)
Annotations:['a']
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Skipping 113
Size:200
Segment:(481133, 481333)
Annotations:['a']
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Skipping 114
Size:200
Segment:(24, 224)
Annotations:[]
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Skipping 114
Size:200
Segment:(248, 448)
Annotations:[]
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Skipping 114
Size:200
Segment:(89262, 89462)

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Annotations:['J']
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Skipping 114
Size:200
Segment:(132895, 133095)
Annotations:['F']
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Skipping 114
Size:200
Segment:(168852, 169052)
Annotations:['F']
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Skipping 114
Size:200
Segment:(200100, 200300)
Annotations:['F']
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Skipping 114
Size:200
Segment:(251890, 252090)
Annotations:['+', 'A']
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Skipping 114
Size:200
Segment:(252091, 252291)
Annotations:['A']
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Skipping 114
Size:200
Segment:(252274, 252474)
Annotations:['A']
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Skipping 114
Size:200
Segment:(252423, 252623)
Annotations:['A']
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Skipping 114
Size:200
Segment:(252728, 252928)
Annotations:['A']
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Skipping 114
Size:200
Segment:(253223, 253423)
Annotations:['J']
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Skipping 114

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Size:200
Segment:(265528, 265728)
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Segment:(354959, 355159)
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Segment:(575464, 575664)
Annotations:['A']
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Size:200
Segment:(577663, 577863)
Annotations:['A']
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Skipping 114
Size:200
Segment:(580310, 580510)
Annotations:['A']
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Skipping 115
Size:109
Segment:(649891, 650000)
Annotations:['N']
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Skipping 116
Size:200
Segment:(19, 219)
Annotations:['+']
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Skipping 116
Size:200
Segment:(298855, 299055)
Annotations:['A']
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Skipping 116
Size:200
Segment:(360601, 360801)
Annotations:[]
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Skipping 116
Size:130
Segment:(649870, 650000)
Annotations:['N']

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Skipping 117
Size:200
Segment:(261467, 261667)
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Skipping 117
Size:162
Segment:(649838, 650000)
  Annotations:['N']
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Skipping 118
Size:200
Segment:(33592, 33792)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(35329, 35529)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(37877, 38077)
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Size:200
Segment:(40463, 40663)
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Segment:(60862, 61062)
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Size:200
Segment:(71708, 71908)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(72297, 72497)
  Annotations:['A']
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Skipping 118
Size:200

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Segment:(98973, 99173)
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Skipping 118
Size:200
Segment:(100694, 100894)
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Segment:(102436, 102636)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(109751, 109951)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(111440, 111640)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(125641, 125841)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(127091, 127291)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(127649, 127849)
  Annotations:['A']
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Size:200
Segment:(128219, 128419)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(128789, 128989)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(129936, 130136)
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Skipping 118
Size:200
Segment:(141588, 141788)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(158108, 158308)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(161623, 161823)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(166150, 166350)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(179697, 179897)
  Annotations:['A']
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Segment:(184087, 184287)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(186386, 186586)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(190891, 191091)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(199726, 199926)

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Annotations:['A']
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Segment:(200521, 200721)
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Skipping 118
Size:200
Segment:(217128, 217328)
Annotations:['A']
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Skipping 118
Size:200
Segment:(226399, 226599)
Annotations:['A']
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Skipping 118
Size:200
Segment:(234865, 235065)
Annotations:['A']
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Skipping 118
Size:200
Segment:(239339, 239539)
Annotations:['A']
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Segment:(240478, 240678)
Annotations:['A']
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Skipping 118
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Segment:(253285, 253485)
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Skipping 118
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Segment:(261068, 261268)
Annotations:['A']
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Skipping 118
Size:200
Segment:(262508, 262708)
Annotations:['A']
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Skipping 118

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Size:200
Segment:(263875, 264075)
Annotations:['A']
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Segment:(269132, 269332)
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Size:200
Segment:(272349, 272549)
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Segment:(273883, 274083)
Annotations:['A']
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Skipping 118
Size:200
Segment:(275462, 275662)
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Segment:(277619, 277819)
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Skipping 118
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Segment:(279184, 279384)
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Size:200
Segment:(286472, 286672)
Annotations:['A']
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Size:200
Segment:(291985, 292185)
Annotations:['A']

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Segment:(305520, 305720)
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Segment:(307036, 307236)
  Annotations:['A']
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Segment:(309482, 309682)
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Segment:(314104, 314304)
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Segment:(319487, 319687)
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Skipping 118
Size:200
Segment:(330042, 330242)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(339321, 339521)
  Annotations:['A']
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Size:200
Segment:(342674, 342874)
  Annotations:['A']
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Skipping 118
Size:200
Segment:(344982, 345182)
  Annotations:['A']
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Skipping 118
Size:200

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Segment:(350872, 351072)
Annotations:['A']
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Segment:(354223, 354423)
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Segment:(361809, 362009)
Annotations:['A']
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Size:200
Segment:(376893, 377093)
Annotations:['A']
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Skipping 118
Size:200
Segment:(399280, 399480)
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Size:200
Segment:(406686, 406886)
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Segment:(422449, 422649)
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Segment:(424120, 424320)
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Skipping 118
Size:200
Segment:(430587, 430787)
Annotations:['A']
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Skipping 118
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Segment:(447681, 447881)
Annotations:['A']
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Skipping 118
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Segment:(482624, 482824)
Annotations:['A']
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Annotations:['A']
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Segment:(491592, 491792)
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Skipping 118
Size:200
Segment:(496941, 497141)
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Skipping 118
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Segment:(499148, 499348)
Annotations:['A']
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Segment:(503274, 503474)
Annotations:['A']
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Segment:(507036, 507236)
Annotations:['A']
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Skipping 118
Size:200
Segment:(508551, 508751)
Annotations:['A']
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Skipping 118
Size:200
Segment:(510036, 510236)
Annotations:['A']
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Skipping 118
Size:200
Segment:(512435, 512635)

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Annotations:['A']
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Segment:(513625, 513825)
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Skipping 118
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Segment:(514825, 515025)
Annotations:['A']
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Size:200
Segment:(549877, 550077)
Annotations:['A']
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Skipping 118
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Segment:(557022, 557222)
Annotations:['A']
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Skipping 118
Size:200
Segment:(563965, 564165)
Annotations:['A']
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Skipping 118
Size:200
Segment:(582225, 582425)
Annotations:['A']
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Segment:(583952, 584152)
Annotations:['A']
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Skipping 118
Size:200
Segment:(599357, 599557)
Annotations:['A']
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Skipping 118
Size:200
Segment:(612143, 612343)
Annotations:['A']
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Skipping 118

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Size:200
Segment:(615060, 615260)
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Segment:(616291, 616491)
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Segment:(624068, 624268)
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Segment:(627349, 627549)
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Segment:(627526, 627726)
Annotations:['A']
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Segment:(637415, 637615)
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Segment:(639308, 639508)
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Segment:(640569, 640769)
Annotations:['A']
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Segment:(646186, 646386)
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Skipping 118
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Segment:(647432, 647632)
Annotations:['A']


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Size:200
Segment:(649365, 649565)
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Segment:(16, 216)
Annotations:['+']
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Skipping 119
Size:116
Segment:(649884, 650000)
Annotations:[]
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Skipping 121
Size:200
Segment:(364177, 364377)
Annotations:['A']
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Skipping 121
Size:185
Segment:(649815, 650000)
Annotations:['N']
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Skipping 122
Size:178
Segment:(649822, 650000)
Annotations:['N']
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Skipping 124
Size:200
Segment:(16, 216)
Annotations:['+']
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Skipping 124
Size:200
Segment:(103353, 103553)
Annotations:['J']
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Skipping 124
Size:200

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Segment:(103682, 103882)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(104042, 104242)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(104415, 104615)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(104767, 104967)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(105105, 105305)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(105441, 105641)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(105777, 105977)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(106114, 106314)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(106448, 106648)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(106768, 106968)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(107122, 107322)
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Skipping 124
Size:200
Segment:(107469, 107669)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(107815, 108015)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(108511, 108711)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(108872, 109072)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(109196, 109396)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(109823, 110023)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(110186, 110386)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(110533, 110733)
  Annotations:['J']
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Skipping 124
Size:200
Segment:(110894, 111094)

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Annotations:['J']
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Skipping 124
Size:200
Segment:(111254, 111454)
Annotations:['J']
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Skipping 124
Size:200
Segment:(111623, 111823)
Annotations:['J']
+++++
Skipping 124
Size:200
Segment:(112007, 112207)
Annotations:['F']
+++++
Skipping 124
Size:200
Segment:(119252, 119452)
Annotations:['F']
+++++
Skipping 124
Size:200
Segment:(119645, 119845)
Annotations:['J']
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Skipping 124
Size:200
Segment:(120032, 120232)
Annotations:['J']
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Skipping 124
Size:200
Segment:(120380, 120580)
Annotations:['J']
+++++
Skipping 124
Size:200
Segment:(120795, 120995)
Annotations:['J']
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Skipping 124
Size:200
Segment:(121172, 121372)
Annotations:['J']
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Skipping 124

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Size:200
Segment:(121558, 121758)
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Skipping 124
Size:200
Segment:(160287, 160487)
  Annotations:['A']
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Skipping 124
Size:200
Segment:(220417, 220617)
  Annotations:['j']
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Skipping 124
Size:200
Segment:(221940, 222140)
  Annotations:['j']
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Skipping 124
Size:200
Segment:(226663, 226863)
  Annotations:['F']
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Skipping 124
Size:200
Segment:(227074, 227274)
  Annotations:['F']
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Skipping 124
Size:200
Segment:(229486, 229686)
  Annotations:['F']
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Skipping 124
Size:200
Segment:(438941, 439141)
  Annotations:['A']
+++++
Skipping 124
Size:200
Segment:(599589, 599789)
  Annotations:['j']
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Skipping 124
Size:200
Segment:(599960, 600160)
  Annotations:['j']

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Skipping 124
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Segment:(649816, 650000)
Annotations:['R']
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Skipping 200
Size:200
Segment:(11, 211)
Annotations:['+']
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Skipping 200
Size:200
Segment:(75431, 75631)
Annotations:['A']
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Skipping 200
Size:200
Segment:(85896, 86096)
Annotations:['A']
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Skipping 200
Size:200
Segment:(153276, 153476)
Annotations:['A']
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Skipping 200
Size:200
Segment:(160659, 160859)
Annotations:['A']
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Skipping 200
Size:200
Segment:(186898, 187098)
Annotations:['A']
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Skipping 200
Size:200
Segment:(218814, 219014)
Annotations:['F']
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Skipping 200
Size:200

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Segment:(225833, 226033)
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Size:200
Segment:(254814, 255014)
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Skipping 200
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Segment:(260540, 260740)
  Annotations:['A']
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Skipping 200
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Segment:(268312, 268512)
  Annotations:['A']
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Size:200
Segment:(277031, 277231)
  Annotations:['A']
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Skipping 200
Size:200
Segment:(283079, 283279)
  Annotations:['A']
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Skipping 200
Size:200
Segment:(347529, 347729)
  Annotations:['A']
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Skipping 200
Size:200
Segment:(350396, 350596)
  Annotations:['A']
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Skipping 200
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Segment:(373206, 373406)
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Skipping 200
Size:200
Segment:(375821, 376021)
  Annotations:['A']
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Skipping 200
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Segment:(476656, 476856)
Annotations:['A']
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Skipping 200
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Segment:(488517, 488717)
Annotations:['A']
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Skipping 200
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Segment:(536998, 537198)
Annotations:['A']
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Skipping 200
Size:200
Segment:(543734, 543934)
Annotations:['A']
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Skipping 200
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Segment:(548234, 548434)
Annotations:['A']
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Size:200
Segment:(548470, 548670)
Annotations:['A']
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Segment:(565432, 565632)
Annotations:['A']
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Skipping 200
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Segment:(577143, 577343)
Annotations:['A']
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Segment:(582673, 582873)
Annotations:['A']
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Skipping 200
Size:200
Segment:(590861, 591061)


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Annotations:['A']
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Segment:(596472, 596672)
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Skipping 200
Size:200
Segment:(602365, 602565)
Annotations:['A']
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Skipping 200
Size:200
Segment:(609082, 609282)
Annotations:['A']
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Skipping 200
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Segment:(621135, 621335)
Annotations:['A']
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Skipping 200
Size:200
Segment:(627771, 627971)
Annotations:['A']
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Skipping 200
Size:200
Segment:(634309, 634509)
Annotations:['A']
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Skipping 200
Size:133
Segment:(649867, 650000)
Annotations:['N']
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Skipping 201
Size:200
Segment:(17483, 17683)
Annotations:['a']
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Skipping 201
Size:200
Segment:(42616, 42816)
Annotations:[]
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Skipping 201

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Segment:(95187, 95387)
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Segment:(106122, 106322)
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Skipping 201
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Segment:(109551, 109751)
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Segment:(137367, 137567)
Annotations:['j']
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Skipping 201
Size:200
Segment:(138106, 138306)
Annotations:['j']
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Skipping 201
Size:200
Segment:(139232, 139432)
Annotations:['j']
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Segment:(158012, 158212)
Annotations:['a']
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Skipping 201
Size:200
Segment:(181527, 181727)
Annotations:['a']
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Segment:(185977, 186177)
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Skipping 201
Size:200
Segment:(187040, 187240)
  Annotations:['j']
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Skipping 201
Size:200
Segment:(187262, 187462)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(187923, 188123)
  Annotations:['j']
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Skipping 201
Size:200
Segment:(188123, 188323)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(189537, 189737)
  Annotations:['J']
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Skipping 201
Size:200
Segment:(208450, 208650)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(229300, 229500)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(268241, 268441)
  Annotations:['a']
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Skipping 201
Size:200

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Segment:(283830, 284030)
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Skipping 201
Size:200
Segment:(352598, 352798)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(362075, 362275)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(392117, 392317)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(396755, 396955)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(397736, 397936)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(398832, 399032)
  Annotations:['j']
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Skipping 201
Size:200
Segment:(400531, 400731)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(400671, 400871)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(406092, 406292)
  Annotations:['j']
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Skipping 201
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Segment:(406321, 406521)
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Segment:(412636, 412836)
Annotations:['A']
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Skipping 201
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Segment:(412769, 412969)
Annotations:['A']
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Segment:(414165, 414365)
Annotations:['A']
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Segment:(417371, 417571)
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Skipping 201
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Segment:(417530, 417730)
Annotations:['A']
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Segment:(419326, 419526)
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Segment:(424591, 424791)
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Segment:(424723, 424923)
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Skipping 201
Size:200
Segment:(427439, 427639)

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Annotations:['a']
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Segment:(439372, 439572)
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Segment:(439539, 439739)
Annotations:['A']
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Segment:(442253, 442453)
Annotations:['a']
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Skipping 201
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Segment:(444989, 445189)
Annotations:['A']
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Skipping 201
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Segment:(446923, 447123)
Annotations:['A']
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Segment:(522339, 522539)
Annotations:['a']
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Segment:(522480, 522680)
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Segment:(523485, 523685)
Annotations:['a']
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Skipping 201
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Segment:(524586, 524786)
Annotations:['a', 'a']
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Skipping 201

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Size:200
Segment:(525901, 526101)
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Size:200
Segment:(526502, 526702)
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Size:200
Segment:(527254, 527454)
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Skipping 201
Size:200
Segment:(528656, 528856)
Annotations:['a']
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Skipping 201
Size:200
Segment:(529404, 529604)
Annotations:['a']
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Skipping 201
Size:200
Segment:(530793, 530993)
Annotations:['a']
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Skipping 201
Size:200
Segment:(532249, 532449)
Annotations:['a']
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Skipping 201
Size:200
Segment:(533647, 533847)
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Skipping 201
Size:200
Segment:(534381, 534581)
Annotations:['a']
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Skipping 201
Size:200
Segment:(535112, 535312)
Annotations:['a']

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+++++
Skipping 201
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Segment:(535231, 535431)
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Skipping 201
Size:200
Segment:(535810, 536010)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(537230, 537430)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(537969, 538169)
  Annotations:['a', 'a']
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Skipping 201
Size:200
Segment:(538672, 538872)
  Annotations:['a']
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Segment:(540091, 540291)
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Skipping 201
Size:200
Segment:(540832, 541032)
  Annotations:['a']
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Skipping 201
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Segment:(541565, 541765)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(542311, 542511)
  Annotations:['A']
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Skipping 201
Size:200

```



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Segment:(543088, 543288)
  Annotations:['a']
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Skipping 201
Size:200
Segment:(544513, 544713)
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Skipping 201
Size:200
Segment:(545238, 545438)
  Annotations:['A']
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Segment:(546043, 546243)
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Segment:(547423, 547623)
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Skipping 201
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Segment:(547556, 547756)
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Segment:(548159, 548359)
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Skipping 201
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Segment:(549635, 549835)
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Skipping 201
Size:200
Segment:(551057, 551257)
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Skipping 201
Size:200
Segment:(552535, 552735)
  Annotations:['a']
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Skipping 201
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Segment:(555969, 556169)
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Segment:(557393, 557593)
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Skipping 201
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Segment:(557517, 557717)
  Annotations:['A']
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Skipping 201
Size:200
Segment:(558767, 558967)
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Skipping 201
Size:200
Segment:(558885, 559085)
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Skipping 201
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Segment:(559413, 559613)
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Segment:(559544, 559744)
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Size:200
Segment:(560089, 560289)
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Skipping 201
Size:200
Segment:(561526, 561726)
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Skipping 201
Size:200
Segment:(561652, 561852)

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Annotations:['a']
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Segment:(563503, 563703)
Annotations:['a']
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Segment:(564179, 564379)
Annotations:['a']
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Skipping 201
Size:200
Segment:(565483, 565683)
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Segment:(565650, 565850)
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Skipping 201
Size:200
Segment:(567083, 567283)
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Skipping 201
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Segment:(569228, 569428)
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Skipping 201
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Segment:(570594, 570794)
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Segment:(570732, 570932)
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Skipping 201

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Segment:(573926, 574126)
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Segment:(607498, 607698)
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Segment:(615174, 615374)
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Segment:(644534, 644734)
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Segment:(645742, 645942)
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Segment:(144984, 145184)
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Segment:(264932, 265132)
Annotations:['A']
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Skipping 202
Size:200
Segment:(265075, 265275)
Annotations:['A']

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Size:200
Segment:(267825, 268025)
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Skipping 202
Size:200
Segment:(268782, 268982)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(269793, 269993)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(273038, 273238)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(274055, 274255)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(278322, 278522)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(280550, 280750)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(281986, 282186)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(283031, 283231)
  Annotations:['A']
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Skipping 202
Size:200

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Segment:(288738, 288938)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(290170, 290370)
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Skipping 202
Size:200
Segment:(302487, 302687)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(404329, 404529)
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Size:200
Segment:(405076, 405276)
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Skipping 202
Size:200
Segment:(405202, 405402)
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Skipping 202
Size:200
Segment:(405763, 405963)
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Skipping 202
Size:200
Segment:(406458, 406658)
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Skipping 202
Size:200
Segment:(407158, 407358)
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Skipping 202
Size:200
Segment:(407842, 408042)
  Annotations:['a']
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Skipping 202
Size:200
Segment:(407984, 408184)
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Segment:(408542, 408742)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(409230, 409430)
  Annotations:['a']
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Skipping 202
Size:200
Segment:(409353, 409553)
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Skipping 202
Size:200
Segment:(409926, 410126)
  Annotations:['A']
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Skipping 202
Size:200
Segment:(410098, 410298)
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Segment:(410637, 410837)
  Annotations:['A']
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Size:200
Segment:(411330, 411530)
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Skipping 202
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Segment:(411461, 411661)
  Annotations:['a']
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Skipping 202
Size:200
Segment:(417680, 417880)

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Annotations:['A']
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Segment:(417841, 418041)
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Skipping 202
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Segment:(418455, 418655)
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Segment:(418611, 418811)
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Skipping 202
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Segment:(419170, 419370)
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Skipping 202
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Segment:(419340, 419540)
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Skipping 202
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Segment:(419890, 420090)
Annotations:['A']
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Skipping 202
Size:200
Segment:(420060, 420260)
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Skipping 202
Size:200
Segment:(420636, 420836)
Annotations:['A']
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Skipping 202
Size:200
Segment:(421356, 421556)
Annotations:['a']
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Skipping 202

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Size:200
Segment:(422041, 422241)
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Skipping 202
Size:200
Segment:(422194, 422394)
Annotations:['A']
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Size:200
Segment:(422765, 422965)
Annotations:['a']
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Skipping 202
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Segment:(422904, 423104)
Annotations:['A']
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Size:200
Segment:(466418, 466618)
Annotations:['A']
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Skipping 202
Size:200
Segment:(466981, 467181)
Annotations:['F']
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Skipping 202
Size:200
Segment:(467175, 467375)
Annotations:['A']
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Skipping 202
Size:200
Segment:(467358, 467558)
Annotations:['A']
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Skipping 202
Size:200
Segment:(467983, 468183)
Annotations:['A']
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Size:200
Segment:(481822, 482022)
Annotations:[]

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+++++
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Segment:(483456, 483656)
Annotations:[]
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Skipping 202
Size:200
Segment:(596788, 596988)
Annotations:[]
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Skipping 202
Size:200
Segment:(632534, 632734)
Annotations:[]
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Skipping 202
Size:200
Segment:(636882, 637082)
Annotations:[]
+++++
Skipping 202
Size:184
Segment:(649816, 650000)
Annotations:['N']
+++++
Skipping 203
Size:200
Segment:(2280, 2480)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(7820, 8020)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(16897, 17097)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(19331, 19531)
Annotations:[]
+++++
Skipping 203
Size:200

```

```

Segment:(20649, 20849)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(20951, 21151)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(22800, 23000)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(23337, 23537)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(23710, 23910)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(24278, 24478)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(24943, 25143)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(34372, 34572)
  Annotations:['a']
+++++
Skipping 203
Size:200
Segment:(35577, 35777)
  Annotations:['a']
+++++
Skipping 203
Size:200
Segment:(35847, 36047)
  Annotations:[]
+++++

```

```

Skipping 203
Size:200
Segment:(38062, 38262)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(38923, 39123)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(40781, 40981)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(43616, 43816)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(49130, 49330)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(49617, 49817)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(54388, 54588)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(67267, 67467)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(77206, 77406)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(85368, 85568)

```

```

Annotations: []
+++++
Skipping 203
Size:200
Segment:(89868, 90068)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(90242, 90442)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(95876, 96076)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(99030, 99230)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(100368, 100568)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(103165, 103365)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(107889, 108089)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(109566, 109766)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(110105, 110305)
Annotations: []
+++++
Skipping 203

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Size:200
Segment:(121761, 121961)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(123810, 124010)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(129015, 129215)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(129518, 129718)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(135810, 136010)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(137270, 137470)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(141721, 141921)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(145711, 145911)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(146227, 146427)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(148509, 148709)
Annotations:[]

```

+++++
Skipping 203
Size:200
Segment:(153533, 153733)
  Annotations:['~']
+++++
Skipping 203
Size:200
Segment:(163386, 163586)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(169494, 169694)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(170834, 171034)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(172737, 172937)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(172998, 173198)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(178466, 178666)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(179721, 179921)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(181096, 181296)
  Annotations:[]
+++++
Skipping 203
Size:200

```

```

Segment:(182280, 182480)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(184773, 184973)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(192601, 192801)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(193517, 193717)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(196598, 196798)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(199050, 199250)
  Annotations:['Q', '~']
+++++
Skipping 203
Size:200
Segment:(204501, 204701)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(211272, 211472)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(212809, 213009)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(213803, 214003)
  Annotations:[]
+++++

```



```

Skipping 203
Size:200
Segment:(217042, 217242)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(222956, 223156)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(226410, 226610)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(236147, 236347)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(240245, 240445)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(240807, 241007)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(251734, 251934)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(254033, 254233)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(255827, 256027)
Annotations: ['+']
+++++
Skipping 203
Size:200
Segment:(258050, 258250)

```

```

Annotations: []
+++++
Skipping 203
Size:200
Segment:(258941, 259141)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(261420, 261620)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(262237, 262437)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(267075, 267275)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(267672, 267872)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(270852, 271052)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(271552, 271752)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(276226, 276426)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(279488, 279688)
Annotations: []
+++++
Skipping 203

```

Size:200
Segment:(281542, 281742)
Annotations: []
++++
Skipping 203
Size:200
Segment:(285541, 285741)
Annotations: []
++++
Skipping 203
Size:200
Segment:(288007, 288207)
Annotations: []
++++
Skipping 203
Size:200
Segment:(288997, 289197)
Annotations: []
++++
Skipping 203
Size:200
Segment:(291101, 291301)
Annotations: []
++++
Skipping 203
Size:200
Segment:(292796, 292996)
Annotations: []
++++
Skipping 203
Size:200
Segment:(293330, 293530)
Annotations: []
++++
Skipping 203
Size:200
Segment:(293660, 293860)
Annotations: []
++++
Skipping 203
Size:200
Segment:(293998, 294198)
Annotations: []
++++
Skipping 203
Size:200
Segment:(297175, 297375)
Annotations: []

```

+++++
Skipping 203
Size:200
Segment:(298739, 298939)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(301415, 301615)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(307369, 307569)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(308007, 308207)
Annotations:['|']
+++++
Skipping 203
Size:200
Segment:(313058, 313258)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(314584, 314784)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(316179, 316379)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(316546, 316746)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(317790, 317990)
Annotations:['~']
+++++
Skipping 203
Size:200

```

```

Segment:(322083, 322283)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(323928, 324128)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(324752, 324952)
  Annotations:['~']
+++++
Skipping 203
Size:200
Segment:(329503, 329703)
  Annotations:['|', '|', '|']
+++++
Skipping 203
Size:200
Segment:(329621, 329821)
  Annotations:['|', '~']
+++++
Skipping 203
Size:200
Segment:(331841, 332041)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(340325, 340525)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(344163, 344363)
  Annotations:[]
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Skipping 203
Size:200
Segment:(347577, 347777)
  Annotations:[]
+++++
Skipping 203
Size:200
Segment:(348368, 348568)
  Annotations:[]
+++++

```

Skipping 203
Size:200
Segment:(350582, 350782)
Annotations: []
++++
Skipping 203
Size:200
Segment:(355749, 355949)
Annotations: []
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Skipping 203
Size:200
Segment:(356360, 356560)
Annotations: []
++++
Skipping 203
Size:200
Segment:(363064, 363264)
Annotations: []
++++
Skipping 203
Size:200
Segment:(367379, 367579)
Annotations: []
++++
Skipping 203
Size:200
Segment:(368905, 369105)
Annotations: []
++++
Skipping 203
Size:200
Segment:(372449, 372649)
Annotations: []
++++
Skipping 203
Size:200
Segment:(374773, 374973)
Annotations: []
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Skipping 203
Size:200
Segment:(375331, 375531)
Annotations: []
++++
Skipping 203
Size:200
Segment:(377280, 377480)

```

Annotations: []
+++++
Skipping 203
Size:200
Segment:(379516, 379716)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(383534, 383734)
Annotations: []
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Skipping 203
Size:200
Segment:(387760, 387960)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(390210, 390410)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(392436, 392636)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(397018, 397218)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(400954, 401154)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(409194, 409394)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(409445, 409645)
Annotations: []
+++++
Skipping 203

```

Size:200
Segment:(414077, 414277)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(414999, 415199)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(415894, 416094)
Annotations:[]
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Skipping 203
Size:200
Segment:(416386, 416586)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(416942, 417142)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(421249, 421449)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(426059, 426259)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(428595, 428795)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(431514, 431714)
Annotations:[]
++++
Skipping 203
Size:200
Segment:(433080, 433280)
Annotations:[]


```

+++++
Skipping 203
Size:200
Segment:(436813, 437013)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(437512, 437712)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(437966, 438166)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(439289, 439489)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(439781, 439981)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(451296, 451496)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(457055, 457255)
Annotations:['~', '|']
+++++
Skipping 203
Size:200
Segment:(457383, 457583)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(458643, 458843)
Annotations:[]
+++++
Skipping 203
Size:200

```

```

Segment:(462216, 462416)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(463106, 463306)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(477732, 477932)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(484412, 484612)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(484922, 485122)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(501512, 501712)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(509300, 509500)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(509747, 509947)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(510781, 510981)
  Annotations: []
+++++
Skipping 203
Size:200
Segment:(512422, 512622)
  Annotations: []
+++++

```

```

Skipping 203
Size:200
Segment:(513862, 514062)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(518500, 518700)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(526501, 526701)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(531093, 531293)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(535528, 535728)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(537374, 537574)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(539085, 539285)
Annotations:['|']
+++++
Skipping 203
Size:200
Segment:(540038, 540238)
Annotations:['~']
+++++
Skipping 203
Size:200
Segment:(549739, 549939)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(553781, 553981)

```

```

Annotations: []
+++++
Skipping 203
Size:200
Segment:(559655, 559855)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(560748, 560948)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(573413, 573613)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(573504, 573704)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(578516, 578716)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(579300, 579500)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(580404, 580604)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(599436, 599636)
Annotations: []
+++++
Skipping 203
Size:200
Segment:(599827, 600027)
Annotations: []
+++++
Skipping 203

```

```
Size:200
Segment:(603716, 603916)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(606689, 606889)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(607799, 607999)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(610937, 611137)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(612074, 612274)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(622638, 622838)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(630223, 630423)
Annotations:[]
+++++
Skipping 203
Size:200
Segment:(636146, 636346)
Annotations:[]
+++++
Skipping 205
Size:200
Segment:(19, 219)
Annotations:[]
+++++
Skipping 205
Size:200
Segment:(107420, 107620)
Annotations:['A', '+']
```

```

+++++
Skipping 205
Size:200
Segment:(107897, 108097)
Annotations:[]
+++++
Skipping 205
Size:200
Segment:(108257, 108457)
Annotations:[]
+++++
Skipping 205
Size:200
Segment:(110052, 110252)
Annotations:[]
+++++
Skipping 205
Size:200
Segment:(294600, 294800)
Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(301702, 301902)
Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(329326, 329526)
Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(338636, 338836)
Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(340103, 340303)
Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(341298, 341498)
Annotations:['F']
+++++
Skipping 205
Size:200

```

```

Segment:(346816, 347016)
  Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(350884, 351084)
  Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(352324, 352524)
  Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(353738, 353938)
  Annotations:['F']
+++++
Skipping 205
Size:200
Segment:(432590, 432790)
  Annotations:['A']
+++++
Skipping 205
Size:200
Segment:(527273, 527473)
  Annotations:['+']
+++++
Skipping 205
Size:200
Segment:(530543, 530743)
  Annotations:[]
+++++
Skipping 205
Size:200
Segment:(531003, 531203)
  Annotations:['A']
+++++
Skipping 205
Size:200
Segment:(531855, 532055)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(14687, 14887)
  Annotations:['+']
+++++

```

```

Skipping 207
Size:200
Segment:(14827, 15027)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(14941, 15141)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(15060, 15260)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(15178, 15378)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(15319, 15519)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(15564, 15764)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(15728, 15928)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(15868, 16068)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(15998, 16198)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16116, 16316)

```



```

    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16316, 16516)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(16420, 16620)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16534, 16734)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16644, 16844)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16758, 16958)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16872, 17072)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(16992, 17192)
    Annotations:[]
+++++
Skipping 207
Size:200
Segment:(17174, 17374)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(17313, 17513)
    Annotations:['!']
+++++
Skipping 207

```

```

Size:200
Segment:(17434, 17634)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(17590, 17790)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(17740, 17940)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(17864, 18064)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(18007, 18207)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(18182, 18382)
Annotations:['!', '']
+++++
Skipping 207
Size:200
Segment:(19753, 19953)
Annotations:['+', '!']
+++++
Skipping 207
Size:200
Segment:(19885, 20085)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(20001, 20201)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(20316, 20516)
Annotations:['!']

```

```

+++++
Skipping 207
Size:200
Segment:(20440, 20640)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(20556, 20756)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(20666, 20866)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(20963, 21163)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(21102, 21302)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(21233, 21433)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(21353, 21553)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(21530, 21730)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(87202, 87402)
  Annotations:['+', '!']
+++++
Skipping 207
Size:200

```

```

Segment:(87449, 87649)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(87573, 87773)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(87697, 87897)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(87807, 88007)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(88140, 88340)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(88412, 88612)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(88580, 88780)
  Annotations:['!', ']']
+++++
Skipping 207
Size:200
Segment:(90544, 90744)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(90674, 90874)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(90806, 91006)
  Annotations:['!']
+++++

```

```

Skipping 207
Size:200
Segment:(91609, 91809)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(91828, 92028)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(91941, 92141)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(92050, 92250)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(92161, 92361)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(92271, 92471)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(92567, 92767)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(92784, 92984)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(92893, 93093)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(93020, 93220)

```

```

Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(93344, 93544)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(93599, 93799)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(93725, 93925)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(93841, 94041)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(97056, 97256)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(97196, 97396)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(97414, 97614)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(97635, 97835)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(97746, 97946)
Annotations:['!']
+++++
Skipping 207

```

```

Size:200
Segment:(97972, 98172)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(98084, 98284)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(98203, 98403)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(98304, 98504)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(99615, 99815)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(99748, 99948)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(99928, 100128)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(100056, 100256)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(100244, 100444)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(100378, 100578)
  Annotations:['!']

```

```

+++++
Skipping 207
Size:200
Segment:(100501, 100701)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(100613, 100813)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(100738, 100938)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(100888, 101088)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(150833, 151033)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(554751, 554951)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(554890, 555090)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(555015, 555215)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(555139, 555339)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200

```



```

Segment:(555258, 555458)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(555375, 555575)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(555493, 555693)
  Annotations:[]
+++++
Skipping 207
Size:200
Segment:(556176, 556376)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(556286, 556486)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(556405, 556605)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(557122, 557322)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(557504, 557704)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(557915, 558115)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(559396, 559596)
  Annotations:['!', '!']
+++++

```

Skipping 207
Size:200
Segment:(559623, 559823)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(559734, 559934)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(559844, 560044)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(559959, 560159)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(560172, 560372)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(560298, 560498)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(564669, 564869)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(564766, 564966)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(567335, 567535)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(567525, 567725)

```

Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(567625, 567825)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(569387, 569587)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(569569, 569769)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(569764, 569964)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(570751, 570951)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(571002, 571202)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(571126, 571326)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(571317, 571517)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(571419, 571619)
Annotations:['!']
+++++
Skipping 207

```

Size:200
Segment:(572286, 572486)
Annotations:['!', '!', '!']
++++
Skipping 207
Size:200
Segment:(572395, 572595)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(572582, 572782)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(572777, 572977)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(572976, 573176)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(573085, 573285)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(573180, 573380)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(573815, 574015)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(573922, 574122)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(574474, 574674)
Annotations:['!', '!', '!']

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+++++
Skipping 207
Size:200
Segment:(574610, 574810)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(574819, 575019)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(574918, 575118)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(576052, 576252)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(576562, 576762)
Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(576960, 577160)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(577333, 577533)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(577722, 577922)
Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(577842, 578042)
Annotations:['!']
+++++
Skipping 207
Size:200

```

```

Segment:(578103, 578303)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(578203, 578403)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(578803, 579003)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(579104, 579304)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(579265, 579465)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(579398, 579598)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(579595, 579795)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(579972, 580172)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(580184, 580384)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(580290, 580490)
  Annotations:['!']
+++++

```

```

Skipping 207
Size:200
Segment:(581091, 581291)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(581280, 581480)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(581602, 581802)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(581723, 581923)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(581889, 582089)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(581998, 582198)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(582116, 582316)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(582308, 582508)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(582454, 582654)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(582577, 582777)

```

```

    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(582685, 582885)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(582852, 583052)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(582949, 583149)
    Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(583456, 583656)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(583737, 583937)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(583930, 584130)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(584246, 584446)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(584438, 584638)
    Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(584813, 585013)
    Annotations:['!', '!']
+++++
Skipping 207

```


Size:200
Segment:(584933, 585133)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(585218, 585418)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(585422, 585622)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(585620, 585820)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(585737, 585937)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(585996, 586196)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(586152, 586352)
Annotations:['!', '!']
++++
Skipping 207
Size:200
Segment:(586290, 586490)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(586388, 586588)
Annotations:['!']
++++
Skipping 207
Size:200
Segment:(586600, 586800)
Annotations:['!', '!']

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+++++
Skipping 207
Size:200
Segment:(586710, 586910)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(586821, 587021)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(586923, 587123)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(587414, 587614)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(587545, 587745)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(587737, 587937)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(587867, 588067)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(588039, 588239)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(588246, 588446)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200

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Segment:(588371, 588571)
  Annotations:['!']
+++++
Skipping 207
Size:200
Segment:(588538, 588738)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(588710, 588910)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(588839, 589039)
  Annotations:[]
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Skipping 207
Size:200
Segment:(588974, 589174)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(589088, 589288)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(589207, 589407)
  Annotations:[]
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Skipping 207
Size:200
Segment:(589330, 589530)
  Annotations:['!']
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Skipping 207
Size:200
Segment:(589488, 589688)
  Annotations:['!', '!']
+++++
Skipping 207
Size:200
Segment:(589620, 589820)
  Annotations:[]
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Skipping 207
Size:200
Segment:(590541, 590741)
Annotations:['E']
++++
Skipping 207
Size:200
Segment:(591361, 591561)
Annotations:['E']
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Skipping 207
Size:200
Segment:(592224, 592424)
Annotations:['E']
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Skipping 207
Size:200
Segment:(592735, 592935)
Annotations:['E']
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Skipping 207
Size:200
Segment:(593216, 593416)
Annotations:['E']
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Skipping 207
Size:200
Segment:(593632, 593832)
Annotations:['E']
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Skipping 207
Size:200
Segment:(594054, 594254)
Annotations:['E']
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Skipping 207
Size:200
Segment:(594485, 594685)
Annotations:['E']
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Skipping 207
Size:200
Segment:(594894, 595094)
Annotations:['E']
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Skipping 207
Size:200
Segment:(595292, 595492)

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Annotations:['E']
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Skipping 207
Size:200
Segment:(595699, 595899)
Annotations:['E']
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Skipping 207
Size:200
Segment:(596129, 596329)
Annotations:['E']
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Skipping 207
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Segment:(596534, 596734)
Annotations:['E']
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Skipping 207
Size:200
Segment:(596940, 597140)
Annotations:['E']
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Skipping 207
Size:200
Segment:(597334, 597534)
Annotations:['E']
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Skipping 207
Size:200
Segment:(597730, 597930)
Annotations:['E']
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Skipping 207
Size:200
Segment:(598129, 598329)
Annotations:['E']
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Skipping 207
Size:200
Segment:(598556, 598756)
Annotations:['E']
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Skipping 207
Size:200
Segment:(598981, 599181)
Annotations:['E']
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Skipping 207

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Size:200
Segment:(599381, 599581)
Annotations:['E']
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Skipping 207
Size:200
Segment:(599764, 599964)
Annotations:['E']
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Skipping 207
Size:200
Segment:(600173, 600373)
Annotations:['E']
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Skipping 207
Size:200
Segment:(600593, 600793)
Annotations:['E']
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Skipping 207
Size:200
Segment:(600992, 601192)
Annotations:['E']
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Skipping 207
Size:200
Segment:(601382, 601582)
Annotations:['E']
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Skipping 207
Size:200
Segment:(601763, 601963)
Annotations:['E']
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Skipping 207
Size:200
Segment:(602120, 602320)
Annotations:['E']
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Skipping 207
Size:200
Segment:(602509, 602709)
Annotations:['E']
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Skipping 207
Size:200
Segment:(602906, 603106)
Annotations:['E']

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+++++
Skipping 207
Size:200
Segment:(603282, 603482)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(603625, 603825)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(603976, 604176)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(604329, 604529)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(604677, 604877)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(605038, 605238)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(605384, 605584)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(605719, 605919)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(606055, 606255)
  Annotations:['E']
+++++
Skipping 207
Size:200

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Segment:(606377, 606577)
  Annotations:['E']
+++++
Skipping 207
Size:200
Segment:(606706, 606906)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(607054, 607254)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(607383, 607583)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(607715, 607915)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(608025, 608225)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(608330, 608530)
  Annotations:['E']
+++++
Skipping 207
Size:200
Segment:(608634, 608834)
  Annotations:['E']
+++++
Skipping 207
Size:200
Segment:(608965, 609165)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(609299, 609499)
  Annotations:['E']
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Skipping 207
Size:200
Segment:(609600, 609800)
Annotations:['E']
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Skipping 207
Size:200
Segment:(609926, 610126)
Annotations:['E']
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Skipping 207
Size:200
Segment:(610236, 610436)
Annotations:['E']
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Skipping 207
Size:200
Segment:(610534, 610734)
Annotations:['E']
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Skipping 207
Size:200
Segment:(610826, 611026)
Annotations:['E']
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Skipping 207
Size:200
Segment:(611149, 611349)
Annotations:['E']
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Skipping 207
Size:200
Segment:(611479, 611679)
Annotations:['E']
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Skipping 207
Size:200
Segment:(611795, 611995)
Annotations:['E']
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Skipping 207
Size:200
Segment:(612101, 612301)
Annotations:['E']
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Skipping 207
Size:200
Segment:(612397, 612597)

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Annotations:['E']
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Skipping 207
Size:200
Segment:(612959, 613159)
Annotations:['E']
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Skipping 207
Size:200
Segment:(613354, 613554)
Annotations:['E']
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Skipping 207
Size:200
Segment:(613667, 613867)
Annotations:['E']
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Skipping 207
Size:200
Segment:(614232, 614432)
Annotations:['E']
+++++
Skipping 207
Size:200
Segment:(614631, 614831)
Annotations:['E']
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Skipping 207
Size:200
Segment:(614959, 615159)
Annotations:['E']
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Skipping 207
Size:200
Segment:(615286, 615486)
Annotations:['E']
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Skipping 207
Size:200
Segment:(615645, 615845)
Annotations:['E']
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Skipping 207
Size:200
Segment:(615989, 616189)
Annotations:['E']
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Skipping 207

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Size:200
Segment:(616338, 616538)
Annotations:['E']
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Skipping 207
Size:200
Segment:(616671, 616871)
Annotations:['E']
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Skipping 207
Size:200
Segment:(616998, 617198)
Annotations:['E']
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Skipping 207
Size:200
Segment:(617345, 617545)
Annotations:['E']
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Skipping 207
Size:200
Segment:(617699, 617899)
Annotations:['E']
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Skipping 207
Size:200
Segment:(618047, 618247)
Annotations:['E']
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Skipping 207
Size:200
Segment:(618386, 618586)
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Segment:(137839, 138039)
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Segment:(152371, 152571)
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Segment:(153039, 153239)
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Segment:(153565, 153765)
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Segment:(153710, 153910)

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Segment:(155897, 156097)
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Segment:(173923, 174123)
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Segment:(176194, 176394)
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Segment:(187777, 187977)
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Segment:(199993, 200193)
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Segment:(200123, 200323)
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Segment:(200281, 200481)
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Segment:(200617, 200817)
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Segment:(201495, 201695)
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Segment:(201628, 201828)
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Segment:(201790, 201990)
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Size:200

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Segment:(203012, 203212)
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Segment:(203286, 203486)
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Size:200
Segment:(203717, 203917)
  Annotations:['A', 'A']
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Segment:(204233, 204433)
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Segment:(204365, 204565)
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Segment:(204496, 204696)
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Segment:(204624, 204824)

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Segment:(205177, 205377)
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Segment:(205456, 205656)
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Segment:(205594, 205794)
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Segment:(205734, 205934)
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Skipping 209
Size:200
Segment:(205849, 206049)
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Segment:(207888, 208088)
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Segment:(208135, 208335)
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Segment:(209226, 209426)
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Segment:(209361, 209561)
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Segment:(209474, 209674)
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Segment:(209648, 209848)
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Segment:(216321, 216521)
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Segment:(216571, 216771)

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Segment:(217697, 217897)
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Segment:(219182, 219382)
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Segment:(220100, 220300)
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Segment:(220236, 220436)
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Segment:(220375, 220575)
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Segment:(220520, 220720)
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Segment:(220657, 220857)
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Segment:(220818, 221018)
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Segment:(221223, 221423)
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Segment:(221481, 221681)
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Segment:(221593, 221793)
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Segment:(221748, 221948)
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Segment:(222014, 222214)
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Segment:(222126, 222326)
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Segment:(222648, 222848)
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Segment:(222814, 223014)
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Segment:(254599, 254799)
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Skipping 209

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Segment:(264612, 264812)
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Segment:(264989, 265189)
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Segment:(265151, 265351)
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Segment:(266125, 266325)
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Segment:(266241, 266441)
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Segment:(267594, 267794)
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Segment:(267753, 267953)
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Segment:(268980, 269180)
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Segment:(269110, 269310)

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Annotations:['A']
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Segment:(287231, 287431)
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Segment:(287658, 287858)
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Segment:(287806, 288006)
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Segment:(287947, 288147)
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Segment:(288108, 288308)
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Segment:(310710, 310910)
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Segment:(311791, 311991)
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Segment:(311954, 312154)
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Segment:(312066, 312266)

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Segment:(402866, 403066)
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Segment:(503321, 503521)
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Size:200
Segment:(506289, 506489)
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Skipping 209
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Segment:(507435, 507635)
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Segment:(550475, 550675)
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Segment:(550893, 551093)
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Segment:(551042, 551242)
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Size:200
Segment:(551164, 551364)

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Segment:(557089, 557289)
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Segment:(560092, 560292)
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Segment:(566092, 566292)
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Skipping 209

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Segment:(598612, 598812)
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Segment:(601348, 601548)
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Segment:(611602, 611802)
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Segment:(614424, 614624)
Annotations:['A']

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Skipping 209
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Segment:(618564, 618764)
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Skipping 209
Size:200
Segment:(618774, 618974)
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Skipping 209
Size:200

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Segment:(618969, 619169)
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Segment:(619979, 620179)
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Segment:(620102, 620302)
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Size:200
Segment:(622097, 622297)
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Segment:(628876, 629076)
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Segment:(631720, 631920)
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Skipping 209
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Segment:(631920, 632120)
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Segment:(632095, 632295)
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Segment:(632205, 632405)
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Segment:(632347, 632547)
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Size:200
Segment:(632490, 632690)
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Size:200
Segment:(632633, 632833)

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Annotations:['A']
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Segment:(645268, 645468)
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Segment:(647378, 647578)
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Segment:(19043, 19243)
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Segment:(75601, 75801)
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Segment:(80527, 80727)
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Segment:(93326, 93526)
Annotations:[]
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Skipping 210
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Segment:(96721, 96921)
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Segment:(152683, 152883)
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Segment:(170546, 170746)
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Segment:(197767, 197967)
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Segment:(200982, 201182)
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Segment:(202101, 202301)
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Skipping 210
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Segment:(219474, 219674)
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Skipping 210
Size:200
Segment:(262217, 262417)
Annotations:[]

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Segment:(326685, 326885)
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Segment:(346070, 346270)
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Segment:(346180, 346380)
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Skipping 210
Size:200
Segment:(349321, 349521)
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Segment:(366141, 366341)
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Skipping 210
Size:200
Segment:(378200, 378400)
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Skipping 210
Size:200

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Segment:(379959, 380159)
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Skipping 210
Size:200
Segment:(380867, 381067)
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Skipping 210
Size:200
Segment:(388614, 388814)
  Annotations:['F']
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Skipping 210
Size:200
Segment:(390547, 390747)
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Skipping 210
Size:200
Segment:(396407, 396607)
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Skipping 210
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Segment:(399208, 399408)
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Skipping 210
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Segment:(409252, 409452)
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Segment:(411394, 411594)
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Segment:(416988, 417188)
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Skipping 210
Size:200
Segment:(428179, 428379)
  Annotations:['a']
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Segment:(446241, 446441)
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Segment:(460179, 460379)
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Segment:(461836, 462036)
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Segment:(512255, 512455)
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Segment:(515506, 515706)
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Annotations: []
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Segment:(304284, 304484)
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Segment:(305466, 305666)
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Segment:(307885, 308085)
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Segment:(311094, 311294)
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Segment:(318223, 318423)
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Segment:(319470, 319670)
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Skipping 213

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Skipping 213
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Skipping 213
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Segment:(322636, 322836)
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Segment:(324235, 324435)
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Segment:(326830, 327030)
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Segment:(329833, 330033)
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Segment:(330228, 330428)
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Skipping 213
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Segment:(331820, 332020)
  Annotations:['A']
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Skipping 213
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Segment:(332782, 332982)
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Segment:(375002, 375202)
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Segment:(375401, 375601)
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Segment:(378232, 378432)
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Segment:(378622, 378822)
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Skipping 213
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Segment:(379036, 379236)
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Skipping 213
Size:200

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Segment:(380233, 380433)
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Segment:(383039, 383239)
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Segment:(383432, 383632)
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Segment:(384243, 384443)
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Segment:(385051, 385251)
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Segment:(388251, 388451)
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Segment:(388790, 388990)
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Segment:(396886, 397086)
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Segment:(397288, 397488)
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Segment:(397684, 397884)
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Segment:(399284, 399484)
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Segment:(399693, 399893)
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Segment:(403310, 403510)

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Segment:(407333, 407533)
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Segment:(407739, 407939)
Annotations:['F']
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Segment:(408133, 408333)
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Segment:(408541, 408741)
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Segment:(409337, 409537)
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Segment:(411767, 411967)
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Segment:(418210, 418410)
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Segment:(420230, 420430)
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Segment:(421826, 422026)
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Segment:(425051, 425251)
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Segment:(478287, 478487)
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Segment:(478691, 478891)
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Segment:(479105, 479305)
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Size:200

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Segment:(479518, 479718)
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Segment:(479920, 480120)
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Segment:(480324, 480524)
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Segment:(481553, 481753)
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Segment:(481951, 482151)
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Segment:(482762, 482962)
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Segment:(483577, 483777)
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Segment:(484803, 485003)
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Segment:(485211, 485411)
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Segment:(488052, 488252)
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Segment:(488454, 488654)
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Segment:(488856, 489056)
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Segment:(489253, 489453)
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Segment:(490066, 490266)
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Segment:(491690, 491890)

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Segment:(504891, 505091)
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Segment:(505081, 505281)
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Segment:(505489, 505689)
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Segment:(505903, 506103)
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Segment:(511984, 512184)
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Segment:(514422, 514622)
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Segment:(517253, 517453)
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Segment:(517670, 517870)
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Segment:(518205, 518405)
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Segment:(520089, 520289)
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Segment:(524163, 524363)
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Segment:(524561, 524761)
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Segment:(524916, 525116)
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Skipping 213
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Segment:(525781, 525981)
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Segment:(529045, 529245)
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Segment:(531901, 532101)
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Segment:(532722, 532922)
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Segment:(535170, 535370)
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Segment:(535923, 536123)
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Segment:(563116, 563316)
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Segment:(563236, 563436)
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Segment:(572078, 572278)
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Segment:(579667, 579867)
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Segment:(580478, 580678)
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Segment:(581697, 581897)
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Segment:(582128, 582328)
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Segment:(583340, 583540)
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Segment:(594347, 594547)

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Segment:(597191, 597391)
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Segment:(597602, 597802)
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Segment:(597997, 598197)
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Segment:(598768, 598968)
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Segment:(599217, 599417)
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Segment:(603705, 603905)
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Skipping 213
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Segment:(608620, 608820)
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Skipping 213
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Segment:(612296, 612496)
Annotations:['F']
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Skipping 213

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Segment:(615962, 616162)
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Segment:(617199, 617399)
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Segment:(619245, 619445)
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Segment:(619651, 619851)
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Segment:(622509, 622709)
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Segment:(623335, 623535)
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Segment:(626596, 626796)
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Segment:(627005, 627205)
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Skipping 213
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Segment:(630255, 630455)
Annotations:['A']

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Segment:(642971, 643171)
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Skipping 213
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Segment:(643797, 643997)
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Segment:(647462, 647662)
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Segment:(648458, 648658)
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Segment:(112987, 113187)
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Skipping 214
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Segment:(113505, 113705)
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Size:200

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Segment:(134065, 134265)
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Segment:(172735, 172935)
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Segment:(203185, 203385)
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Segment:(226581, 226781)
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Segment:(283523, 283723)
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Segment:(295809, 296009)
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Segment:(319756, 319956)
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Skipping 214
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Segment:(395259, 395459)
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Skipping 214
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Segment:(583082, 583282)
Annotations:[]
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Skipping 214
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Segment:(603585, 603785)
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Segment:(641503, 641703)
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Skipping 214
Size:171
Segment:(649829, 650000)
  Annotations:['L']
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Skipping 215
Size:200
Segment:(9154, 9354)
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Skipping 215
Size:200
Segment:(14955, 15155)
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Skipping 215
Size:200
Segment:(19491, 19691)
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Segment:(27703, 27903)
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Skipping 215
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Segment:(34783, 34983)
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Skipping 215
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Segment:(64728, 64928)
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Skipping 215
Size:200
Segment:(65207, 65407)

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Segment:(131390, 131590)
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Segment:(137156, 137356)
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Segment:(173268, 173468)
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Segment:(179654, 179854)
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Segment:(189573, 189773)
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Segment:(192061, 192261)
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Segment:(206193, 206393)
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Segment:(212982, 213182)
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Segment:(346567, 346767)
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Skipping 215
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Segment:(469712, 469912)
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Segment:(510255, 510455)
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Segment:(526192, 526392)
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Skipping 215
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Segment:(530617, 530817)
Annotations:[]

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Segment:(649807, 650000)
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Skipping 217
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Segment:(144, 344)
Annotations:[]
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Skipping 217
Size:200
Segment:(1656, 1856)
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Skipping 217
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Segment:(28705, 28905)
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Segment:(29242, 29442)
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Segment:(30966, 31166)
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Size:200
Segment:(31520, 31720)
Annotations:['f']
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Skipping 217
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Segment:(32072, 32272)
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Segment:(32608, 32808)
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Segment:(40947, 41147)
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Segment:(57600, 57800)
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Segment:(58116, 58316)
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Segment:(58678, 58878)
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Segment:(64737, 64937)
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Size:200
Segment:(67038, 67238)
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Segment:(73177, 73377)
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Segment:(74024, 74224)
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Segment:(75158, 75358)
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Segment:(75447, 75647)
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Segment:(78083, 78283)
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Segment:(85037, 85237)
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Segment:(85575, 85775)
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Segment:(92792, 92992)

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Segment:(343611, 343811)
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Segment:(427676, 427876)
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Segment:(429257, 429457)
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Segment:(429406, 429606)
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Size:200

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Segment:(431519, 431719)
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Segment:(432060, 432260)
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Segment:(435180, 435380)

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Segment:(450865, 451065)
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Segment:(451469, 451669)
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Segment:(456278, 456478)
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Segment:(456695, 456895)
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Segment:(457055, 457255)
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Segment:(458296, 458496)
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Segment:(461523, 461723)
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Segment:(461814, 462014)
  Annotations:['j', '~']
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Segment:(462157, 462357)

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Segment:(463088, 463288)
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Segment:(463676, 463876)
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Segment:(464620, 464820)
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Segment:(466189, 466389)
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Segment:(466319, 466519)
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Segment:(467617, 467817)
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Segment:(467940, 468140)
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Segment:(472478, 472678)
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Size:200

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Segment:(476656, 476856)
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Segment:(480604, 480804)
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Segment:(491960, 492160)
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Segment:(495601, 495801)
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Segment:(495975, 496175)
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Segment:(496339, 496539)
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Segment:(502701, 502901)
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Segment:(503635, 503835)
Annotations:['A']

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Segment:(510184, 510384)
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Segment:(510516, 510716)
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Segment:(513996, 514196)
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Segment:(514274, 514474)
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Segment:(515001, 515201)
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Skipping 222
Size:200
Segment:(515608, 515808)
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Segment:(516302, 516502)
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Segment:(516815, 517015)
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Segment:(517644, 517844)
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Segment:(518760, 518960)
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Segment:(518936, 519136)
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Segment:(519213, 519413)
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Skipping 222
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Segment:(520087, 520287)
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Segment:(525359, 525559)
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Size:200
Segment:(525688, 525888)

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Segment:(526663, 526863)
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Segment:(529238, 529438)
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Segment:(531536, 531736)
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Skipping 222
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Skipping 222

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Segment:(543979, 544179)
Annotations:['j']

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Segment:(557417, 557617)
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Size:200

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Skipping 223
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Segment:(53311, 53511)

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Segment:(56469, 56669)
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Segment:(62125, 62325)
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Segment:(62900, 63100)
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Segment:(66897, 67097)
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Segment:(81272, 81472)
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Annotations:['A']
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Segment:(296677, 296877)
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Segment:(299512, 299712)

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Skipping 223
Size:200

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Skipping 223
Size:200
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Segment:(632845, 633045)

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Skipping 228
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Skipping 231
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Segment:(52533, 52733)
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Skipping 231

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Size:193
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Skipping 232
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  Annotations:['+']
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Skipping 232
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Skipping 232
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Segment:(282, 482)
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Skipping 232
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Size:200

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Segment:(10454, 10654)
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Segment:(10709, 10909)
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Segment:(11617, 11817)
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Segment:(12150, 12350)
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Segment:(12405, 12605)
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Skipping 232
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Segment:(12660, 12860)
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Skipping 232
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Segment:(12949, 13149)
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Segment:(13971, 14171)
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Segment:(17627, 17827)

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Segment:(19847, 20047)
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Segment:(20112, 20312)
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Segment:(21718, 21918)
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Segment:(21979, 22179)
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Segment:(23170, 23370)
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Segment:(30459, 30659)
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Segment:(31449, 31649)
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Segment:(31734, 31934)
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Segment:(33451, 33651)
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Segment:(33715, 33915)
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Segment:(34501, 34701)
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Skipping 232
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Segment:(34765, 34965)
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Segment:(35695, 35895)
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Segment:(42519, 42719)

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Segment:(66740, 66940)


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Segment:(78002, 78202)
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Segment:(83993, 84193)
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Segment:(88938, 89138)

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Segment:(101964, 102164)
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Segment:(114036, 114236)

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Segment:(130556, 130756)
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Skipping 232
Size:200
Segment:(130821, 131021)
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Segment:(135623, 135823)
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Segment:(136150, 136350)

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Segment:(601292, 601492)


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Skipping 232

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Segment:(621353, 621553)
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Annotations:['A']

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Size:200
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  Annotations:['A']
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Skipping 232
Size:200

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Segment:(640456, 640656)
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Skipping 232
Size:200
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Skipping 233

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Skipping 233
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Segment:(80675, 80875)
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Skipping 233
Size:200
Segment:(81311, 81511)
Annotations:['F']
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Skipping 233
Size:200
Segment:(92399, 92599)
Annotations:['F']
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Skipping 233
Size:200
Segment:(101969, 102169)
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Skipping 233
Size:200
Segment:(153696, 153896)
Annotations:[]
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Skipping 233
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Segment:(161509, 161709)
Annotations:['F']
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```

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Size:200
Segment:(229330, 229530)
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Segment:(309543, 309743)
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Size:200
Segment:(340969, 341169)
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Skipping 233
Size:200

```

```

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Skipping 233
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Skipping 233
Size:200
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Skipping 234
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Segment:(304979, 305179)
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Segment:(305342, 305542)
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Segment:(305749, 305949)
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Size:200
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Annotations:['J']
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Segment:(307489, 307689)
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Segment:(308600, 308800)
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Skipping 234
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Segment:(308827, 309027)
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Skipping 234
Size:200
Segment:(309018, 309218)
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Skipping 234

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Size:200
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Segment:(310625, 310825)
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Segment:(310794, 310994)
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Skipping 234
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Segment:(311105, 311305)
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Segment:(311270, 311470)
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Segment:(311460, 311660)
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Segment:(311749, 311949)
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Segment:(312087, 312287)
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Segment:(312244, 312444)
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Skipping 234
Size:200

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Segment:(312398, 312598)
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Segment:(312702, 312902)
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Segment:(312844, 313044)
Annotations:['J']
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Segment:(312993, 313193)
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Segment:(313143, 313343)
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Size:200
Segment:(313285, 313485)
Annotations:['J']
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Skipping 234
Size:200
Segment:(313433, 313633)
Annotations:['J']
+++++

```

```
[79]: readings = np.array(readings)
```

```
[80]: readings.shape
```

```
[80]: (99174, 200)
```

```
[81]: ecg_data = pd.DataFrame(readings, columns=range(0, 200))
```

```
[82]: ecg_data["Record ID"] = np.array(record_ids)
      ecg_data["Segment Start"] = np.array(segment_starts)
      ecg_data["Segment End"] = np.array(segment_ends)
      ecg_data["Annotation Class"] = np.array(annotation_class)
```

```
[83]: ecg_data.head()
```

```
[83]:
```

	0	1	2	3	4	5	6 \
0	0.059449	0.055308	0.052035	0.049666	0.047961	0.046922	0.046801
1	0.084239	0.087566	0.088956	0.088621	0.086919	0.084459	0.081823
2	-0.006937	-0.005690	-0.005184	-0.005172	-0.005405	-0.005802	-0.006385
3	0.072086	0.073128	0.073026	0.071802	0.069731	0.067336	0.065156
4	0.084762	0.083995	0.082327	0.080127	0.077701	0.075216	0.072963

	7	8	9 ...	194	195	196	197 \
0	0.047770	0.049465	0.051072 ...	0.033981	0.034276	0.034166	0.033702
1	0.079506	0.077958	0.077429 ...	0.020272	0.020719	0.020971	0.020866
2	-0.007163	-0.008008	-0.008625 ...	-0.084841	-0.084325	-0.082953	-0.080644
3	0.063624	0.062977	0.063282 ...	0.040177	0.039328	0.038051	0.036671
4	0.071264	0.070261	0.069845 ...	0.027249	0.029211	0.031715	0.034364

	198	199	Record ID	Segment Start	Segment End	Annotation Class
0	0.033134	0.032648	100	13	213	N
1	0.020622	0.020434	100	307	507	N
2	-0.077424	-0.073181	100	563	763	N
3	0.035565	0.034817	100	883	1083	N
4	0.036462	0.037443	100	1168	1368	N

[5 rows x 204 columns]

```
[84]: for i, column_to_move in enumerate(["Record ID", "Segment Start", "Segment_
      ↪End"]):
      column = ecg_data.pop(column_to_move)
      ecg_data.insert(i, column_to_move, column)
```

```
[85]: ecg_data.head()
```

```
[85]:
```

	Record ID	Segment Start	Segment End	0	1	2 \
0	100	13	213	0.059449	0.055308	0.052035
1	100	307	507	0.084239	0.087566	0.088956
2	100	563	763	-0.006937	-0.005690	-0.005184
3	100	883	1083	0.072086	0.073128	0.073026
4	100	1168	1368	0.084762	0.083995	0.082327

	3	4	5	6 ...	191	192	193 \
0	0.049666	0.047961	0.046922	0.046801 ...	0.029812	0.031902	0.033233
1	0.088621	0.086919	0.084459	0.081823 ...	0.020380	0.020170	0.020049

```

2 -0.005172 -0.005405 -0.005802 -0.006385 ... -0.083923 -0.084476 -0.084798
3  0.071802  0.069731  0.067336  0.065156 ...  0.040917  0.040820  0.040605
4  0.080127  0.077701  0.075216  0.072963 ...  0.024691  0.025225  0.025977

```

```

          194          195          196          197          198          199  \
0  0.033981  0.034276  0.034166  0.033702  0.033134  0.032648
1  0.020272  0.020719  0.020971  0.020866  0.020622  0.020434
2 -0.084841 -0.084325 -0.082953 -0.080644 -0.077424 -0.073181
3  0.040177  0.039328  0.038051  0.036671  0.035565  0.034817
4  0.027249  0.029211  0.031715  0.034364  0.036462  0.037443

```

```

Annotation Class
0                N
1                N
2                N
3                N
4                N

```

[5 rows x 204 columns]

```
[86]: ecg_data["Annotation Class"].value_counts()
```

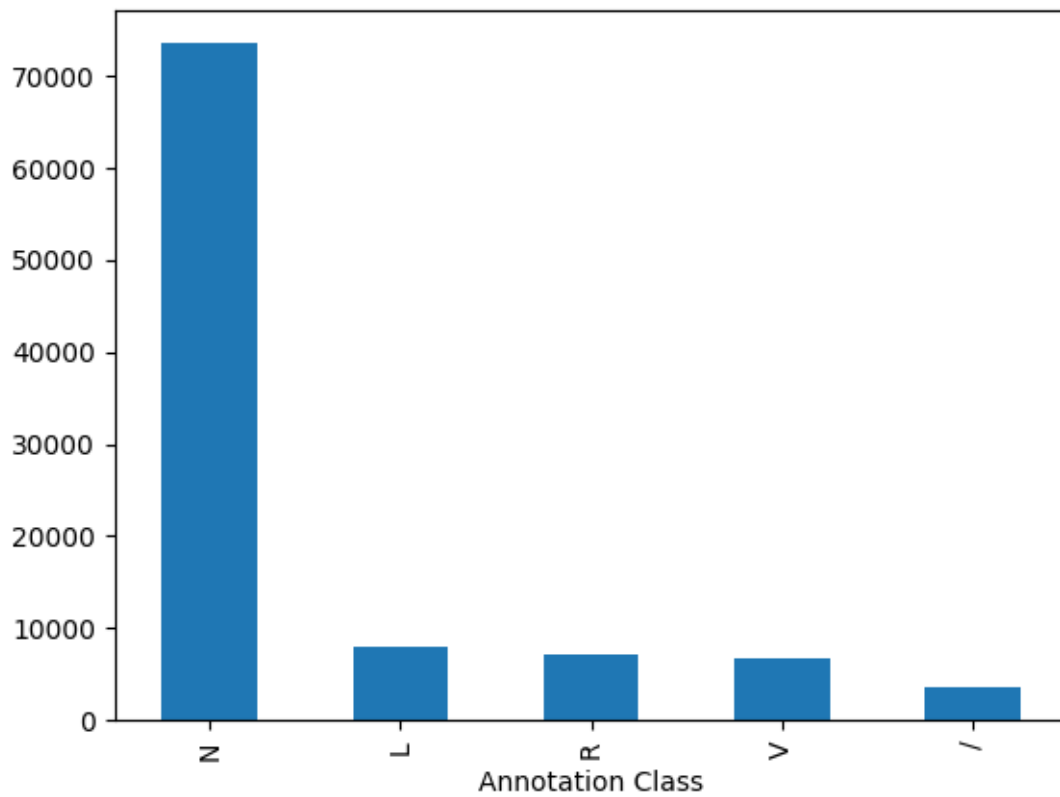
```

[86]: Annotation Class
N      73439
L       8068
R       7255
V       6793
/       3619
Name: count, dtype: int64

```

```
[87]: ecg_data["Annotation Class"].value_counts().plot(kind="bar")
```

```
[87]: <Axes: xlabel='Annotation Class'>
```



```
[88]: ecg_data.to_csv("processed_data/ecg_processed_data.csv")
```

```
[89]: df.to_csv("processed_data/annotation_count.csv")
```

```
[90]: patient_data_frame.to_csv("processed_data/patient_summary_info.csv")
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

Machine Learning

August 6, 2023

1 Machine Learning

```
[1]: import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
```

```
[2]: %matplotlib inline
```

1.1 Loading Data

```
[3]: ecg_data = pd.read_csv("./processed_data/ecg_processed_data.csv", index_col=0)
```

```
[4]: ecg_data.head()
```

```
[4]:
```

	Record ID	Segment Start	Segment End	0	1	2	\
0	100	13	213	0.059449	0.055308	0.052035	
1	100	307	507	0.084239	0.087566	0.088956	
2	100	563	763	-0.006937	-0.005690	-0.005184	
3	100	883	1083	0.072086	0.073128	0.073026	
4	100	1168	1368	0.084762	0.083995	0.082327	

	3	4	5	6	...	191	192	193	\
0	0.049666	0.047961	0.046922	0.046801	...	0.029812	0.031902	0.033233	
1	0.088621	0.086919	0.084459	0.081823	...	0.020380	0.020170	0.020049	
2	-0.005172	-0.005405	-0.005802	-0.006385	...	-0.083923	-0.084476	-0.084798	
3	0.071802	0.069731	0.067336	0.065156	...	0.040917	0.040820	0.040605	
4	0.080127	0.077701	0.075216	0.072963	...	0.024691	0.025225	0.025977	

	194	195	196	197	198	199	\
0	0.033981	0.034276	0.034166	0.033702	0.033134	0.032648	
1	0.020272	0.020719	0.020971	0.020866	0.020622	0.020434	
2	-0.084841	-0.084325	-0.082953	-0.080644	-0.077424	-0.073181	
3	0.040177	0.039328	0.038051	0.036671	0.035565	0.034817	
4	0.027249	0.029211	0.031715	0.034364	0.036462	0.037443	

Annotation Class

```

0          N
1          N
2          N
3          N
4          N

```

```
[5 rows x 204 columns]
```

```
[5]: ecg_data["Annotation Class"].unique()
```

```
[5]: array(['N', 'V', '/', 'L', 'R'], dtype=object)
```

```
[6]: ecg_data["Annotation Class"].nunique()
```

```
[6]: 5
```

```
[7]: ecg_data["Annotation Class"].value_counts()
```

```

[7]: Annotation Class
N      73439
L      8068
R      7255
V      6793
/      3619
Name: count, dtype: int64

```

1.2 Preprocessing

1.2.1 Converting Non Numeric Column to Numeric discontinuous Columns

```

[8]: annotation_dict = dict()
for i, symbol in enumerate(ecg_data["Annotation Class"].unique()):
    annotation_dict[symbol] = i + 1
ecg_data["Annotation Class Numeric"] = ecg_data["Annotation Class"].apply(
    lambda x: annotation_dict[x]
)

```

```
[9]: ecg_data.head()
```

```

[9]:   Record ID  Segment Start  Segment End      0      1      2 \
0         100           13        213  0.059449  0.055308  0.052035
1         100          307        507  0.084239  0.087566  0.088956
2         100          563        763 -0.006937 -0.005690 -0.005184
3         100          883       1083  0.072086  0.073128  0.073026
4         100         1168       1368  0.084762  0.083995  0.082327

      3      4      5      6 ...      192      193      194 \

```



```

0  0.049666  0.047961  0.046922  0.046801  ...  0.031902  0.033233  0.033981
1  0.088621  0.086919  0.084459  0.081823  ...  0.020170  0.020049  0.020272
2 -0.005172 -0.005405 -0.005802 -0.006385  ... -0.084476 -0.084798 -0.084841
3  0.071802  0.069731  0.067336  0.065156  ...  0.040820  0.040605  0.040177
4  0.080127  0.077701  0.075216  0.072963  ...  0.025225  0.025977  0.027249

```

```

          195          196          197          198          199  Annotation Class \
0  0.034276  0.034166  0.033702  0.033134  0.032648                      N
1  0.020719  0.020971  0.020866  0.020622  0.020434                      N
2 -0.084325 -0.082953 -0.080644 -0.077424 -0.073181                      N
3  0.039328  0.038051  0.036671  0.035565  0.034817                      N
4  0.029211  0.031715  0.034364  0.036462  0.037443                      N

```

```

Annotation Class Numeric
0                      1
1                      1
2                      1
3                      1
4                      1

```

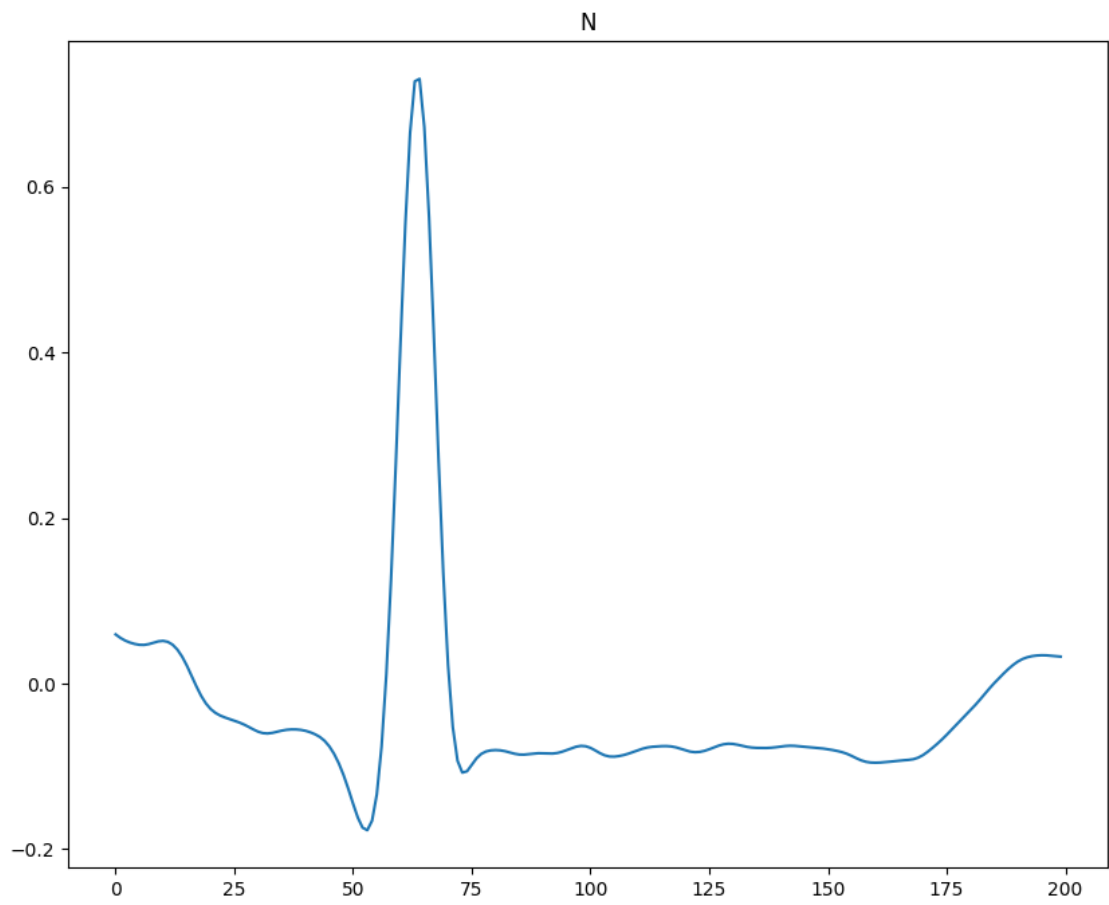
[5 rows x 205 columns]

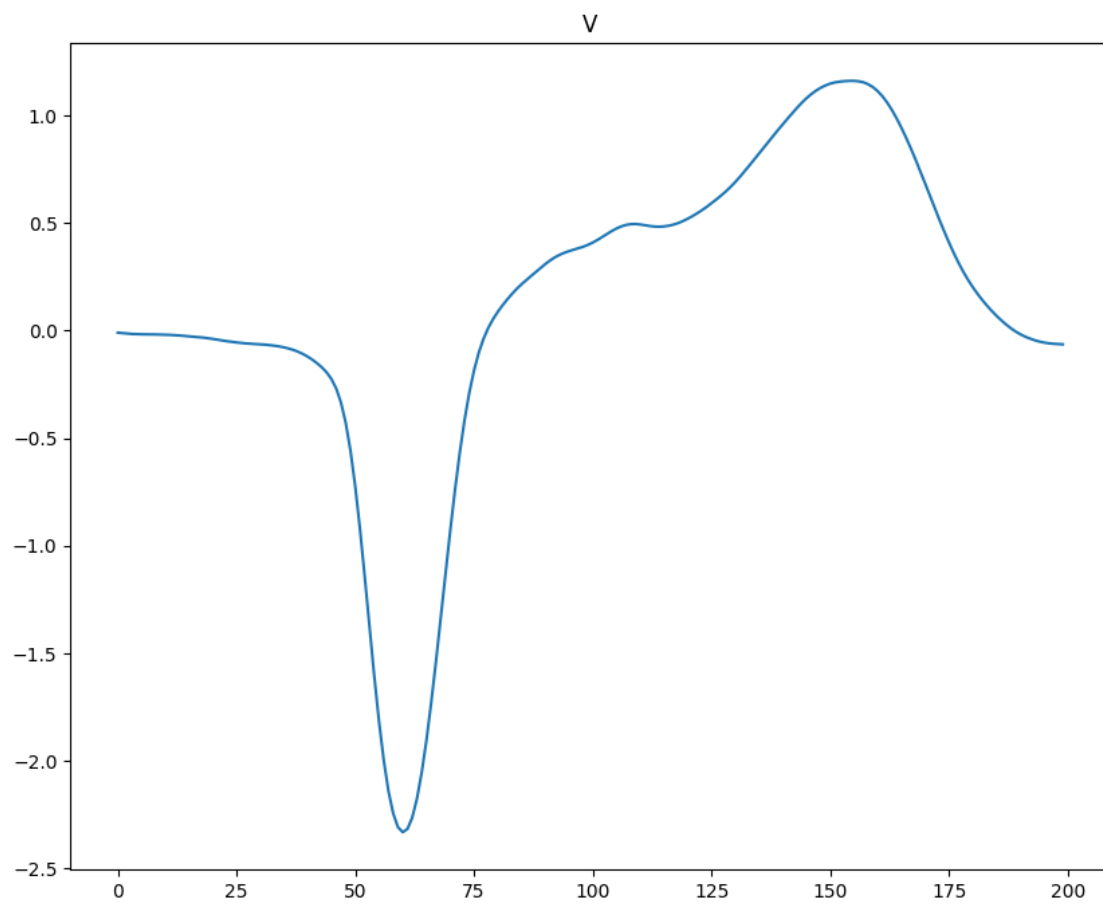
```
[10]: x_columns = [str(i) for i in range(0, 200)]
```

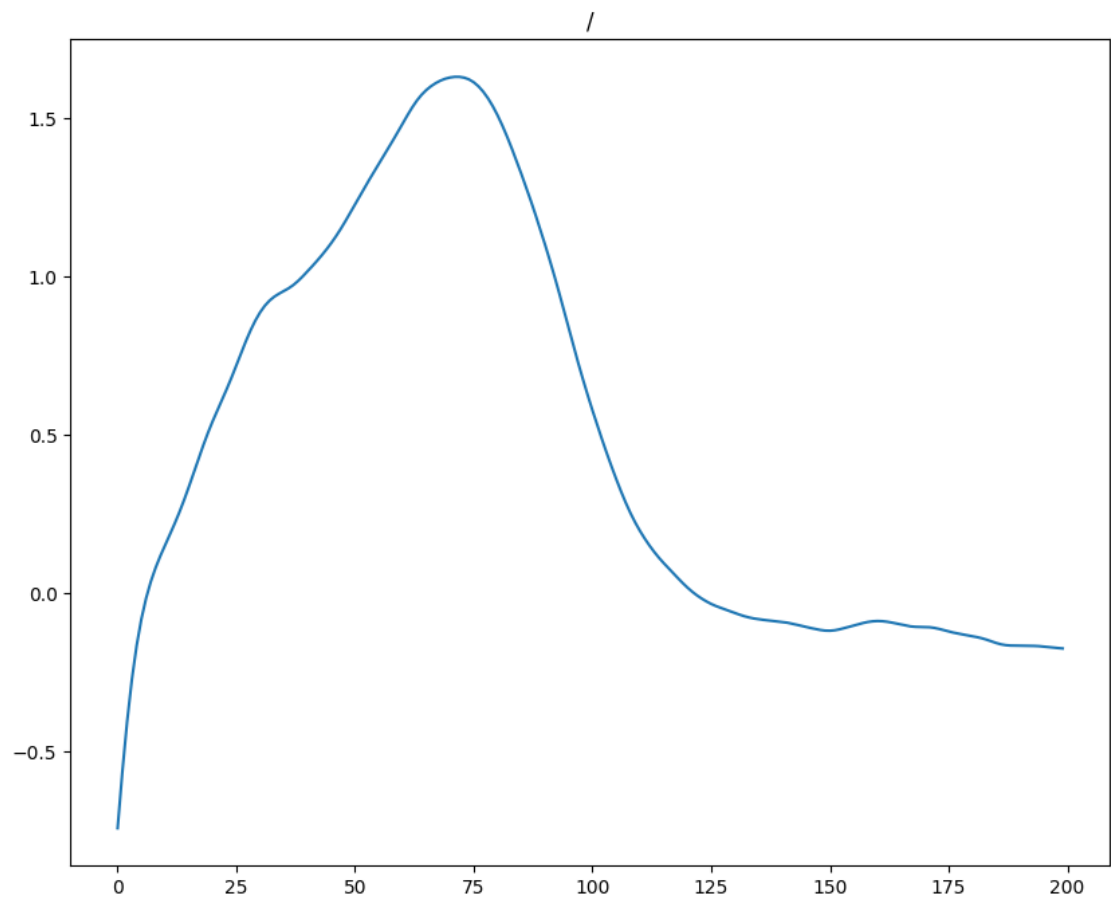
1.3 What each Annotation looks like?

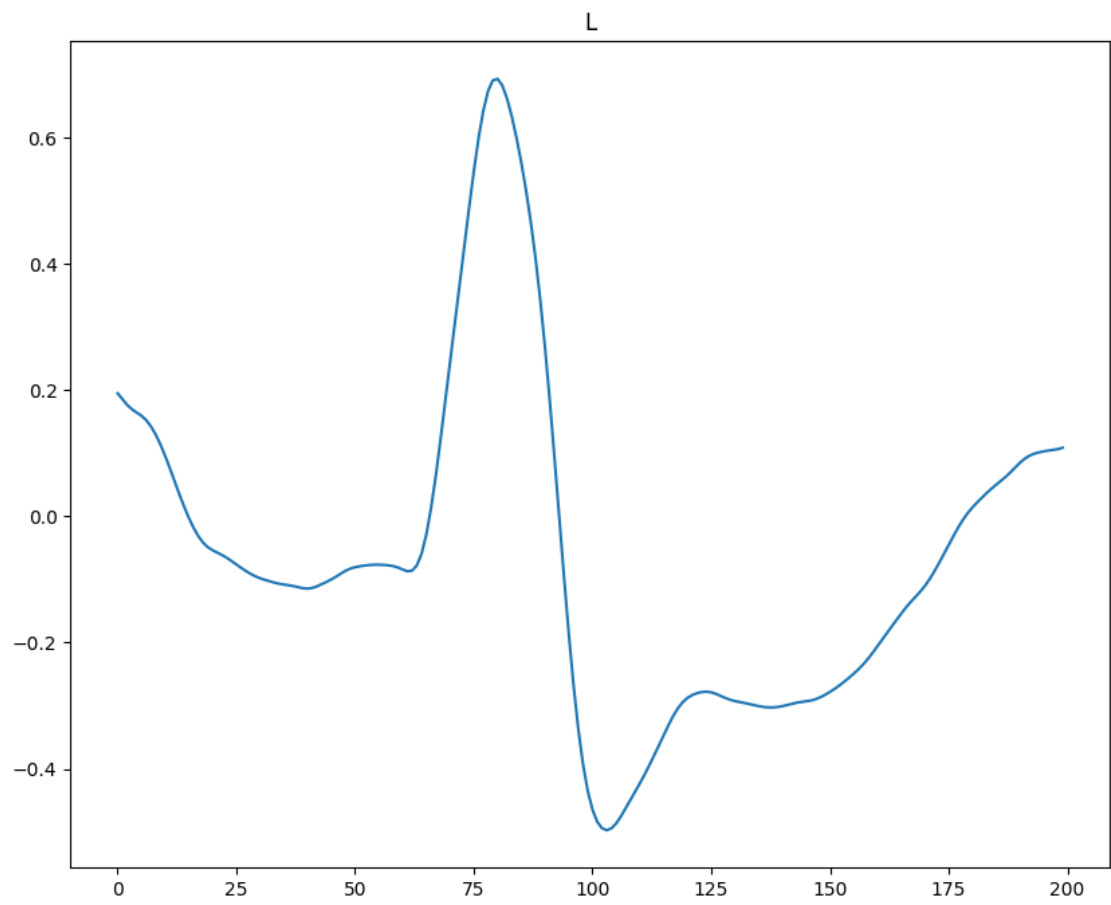
```
[11]: for symbol in ecg_data["Annotation Class"].unique():
        readings = (
            ecg_data[ecg_data["Annotation Class"] == symbol].head(1)[x_columns].
            ↪values[0]
        )
        plt.figure(figsize=(10, 8))
        plt.title(label=symbol)
        plt.plot(readings)
        plt.show()

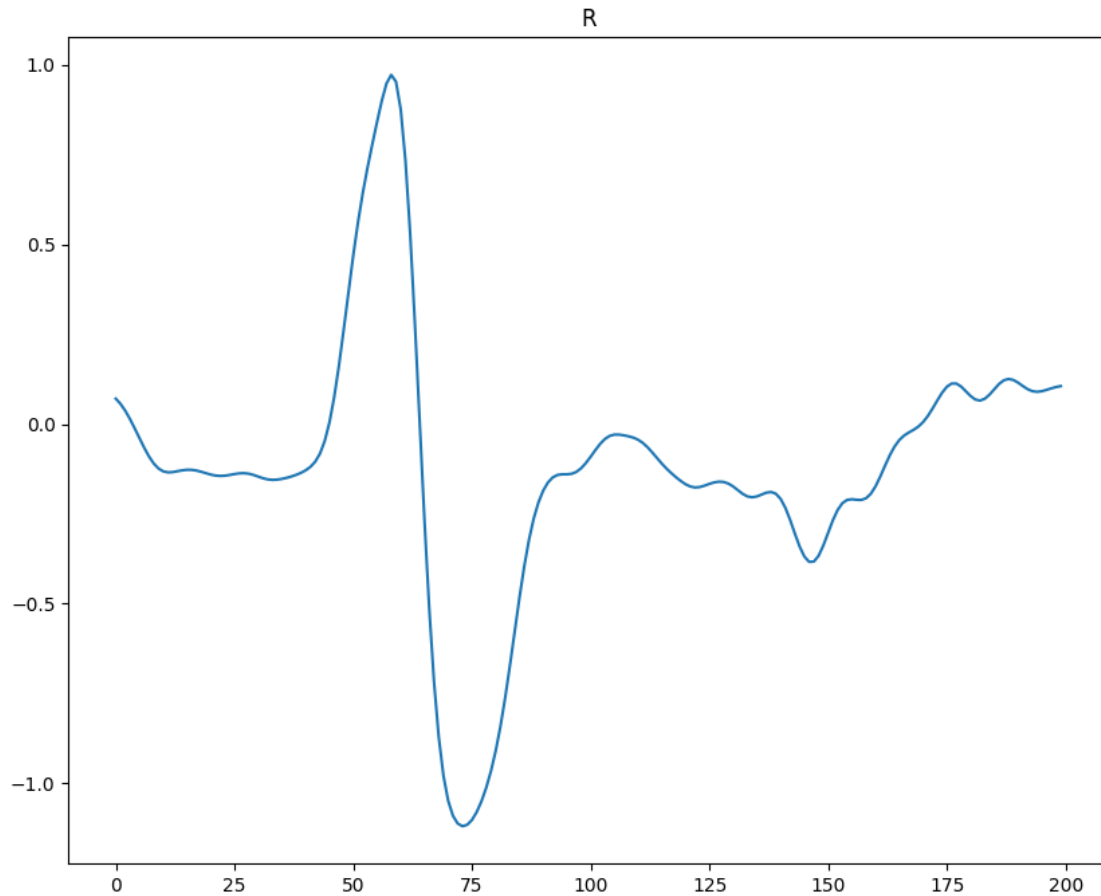
```











1.4 Splitting into Test and Train Data

```
[12]: from sklearn.preprocessing import MinMaxScaler
```

```
[13]: from sklearn.pipeline import Pipeline
```

```
[14]: from sklearn.model_selection import train_test_split
```

```
[15]: X = ecg_data[x_columns].values
```

```
[16]: y = ecg_data["Annotation Class Numeric"].values
```

```
[17]: X_train, X_test, y_train, y_test = train_test_split(
        X, y, test_size=0.2, random_state=101, stratify=y, shuffle=True
    )
    X_train_1, X_val, y_train_1, y_val = train_test_split(
        X_train, y_train, test_size=0.2, stratify=y_train, shuffle=True,
        random_state=101
```

```
)
```

```
[18]: X_train.shape
```

```
[18]: (79339, 200)
```

```
[19]: y_train.shape
```

```
[19]: (79339,)
```

```
[20]: X_test.shape
```

```
[20]: (19835, 200)
```

```
[21]: y_test.shape
```

```
[21]: (19835,)
```

1.5 Logistic Regression

```
[22]: from sklearn.linear_model import LogisticRegression  
      from sklearn.model_selection import GridSearchCV
```

```
[23]: from skopt import BayesSearchCV
```

```
[24]: lr_params = {"multi_class": ["ovr", "multinomial", "auto"]}
```

```
[25]: pipeline = Pipeline(  
    [  
        ("minmax", MinMaxScaler()),  
        ("lr", GridSearchCV(LogisticRegression(), lr_params, verbose=3)),  
    ]  
)
```

```
[26]: pipeline.fit(X_train, y_train)
```

Fitting 5 folds for each of 3 candidates, totalling 15 fits

```
/home/alton/.local/lib/python3.9/site-  
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed  
to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-

```
regression
  n_iter_i = _check_optimize_result(
[CV 1/5] END ..multi_class=ovr;, score=0.839 total time= 11.4s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 2/5] END ..multi_class=ovr;, score=0.843 total time= 13.2s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 3/5] END ..multi_class=ovr;, score=0.843 total time= 10.8s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 4/5] END ..multi_class=ovr;, score=0.845 total time= 11.3s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```


Increase the number of iterations (max_iter) or scale the data as shown in:
<https://scikit-learn.org/stable/modules/preprocessing.html>
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
n_iter_i = _check_optimize_result(
[CV 5/5] END ..multi_class=ovr;; score=0.839 total time= 12.8s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
<https://scikit-learn.org/stable/modules/preprocessing.html>
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
n_iter_i = _check_optimize_result(
[CV 1/5] END ..multi_class=multinomial;; score=0.840 total time= 16.8s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
<https://scikit-learn.org/stable/modules/preprocessing.html>
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
n_iter_i = _check_optimize_result(
[CV 2/5] END ..multi_class=multinomial;; score=0.842 total time= 9.1s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
<https://scikit-learn.org/stable/modules/preprocessing.html>
Please also refer to the documentation for alternative solver options:
https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
n_iter_i = _check_optimize_result(
[CV 3/5] END ..multi_class=multinomial;; score=0.840 total time= 11.6s

```
/home/alton/.local/lib/python3.9/site-  
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed  
to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression

```
n_iter_i = _check_optimize_result(
```

```
[CV 4/5] END ..multi_class=multinomial;; score=0.838 total time= 10.5s
```

```
/home/alton/.local/lib/python3.9/site-  
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed  
to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression

```
n_iter_i = _check_optimize_result(
```

```
[CV 5/5] END ..multi_class=multinomial;; score=0.832 total time= 11.0s
```

```
/home/alton/.local/lib/python3.9/site-  
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed  
to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression

```
n_iter_i = _check_optimize_result(
```

```
[CV 1/5] END ..multi_class=auto;; score=0.840 total time= 16.4s
```

```
/home/alton/.local/lib/python3.9/site-  
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed  
to converge (status=1):  
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression

```
regression
  n_iter_i = _check_optimize_result(
[CV 2/5] END ..multi_class=auto;; score=0.842 total time= 14.3s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 3/5] END ..multi_class=auto;; score=0.840 total time= 11.4s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 4/5] END ..multi_class=auto;; score=0.838 total time= 12.4s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

[https://scikit-learn.org/stable/modules/linear_model.html#logistic-](https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression)

regression

```
  n_iter_i = _check_optimize_result(
[CV 5/5] END ..multi_class=auto;; score=0.832 total time= 12.7s
/home/alton/.local/lib/python3.9/site-
packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

Increase the number of iterations (max_iter) or scale the data as shown in:

<https://scikit-learn.org/stable/modules/preprocessing.html>

Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression

```
n_iter_i = _check_optimize_result(
```

```
[26]: Pipeline(steps=[('minmax', MinMaxScaler()),  
                      ('lr',  
                       GridSearchCV(estimator=LogisticRegression(),  
                                     param_grid={'multi_class': ['ovr', 'multinomial',  
                                                                 'auto']},  
                                     verbose=3))])
```

```
[27]: pred = pipeline.predict(X_test)
```

```
[28]: from sklearn.metrics import classification_report, confusion_matrix,  
      ↪ accuracy_score
```

```
[29]: print(confusion_matrix(y_test, pred))
```

```
[[14562   27    1   66   32]  
 [  647  476   22  112  101]  
 [    6    3  703   12    0]  
 [ 1051   26    1  534    2]  
 [  981   14    0   23  433]]
```

```
[30]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	0.84	0.99	0.91	14688
2	0.87	0.35	0.50	1358
3	0.97	0.97	0.97	724
4	0.71	0.33	0.45	1614
5	0.76	0.30	0.43	1451
accuracy			0.84	19835
macro avg	0.83	0.59	0.65	19835
weighted avg	0.83	0.84	0.81	19835

1.6 KNN

```
[31]: from sklearn.neighbors import KNeighborsClassifier
```

```
[32]: error_rate = []  
      for i in range(1, 5000, 500):
```

```

knn = Pipeline(
    [("minmax", MinMaxScaler()), ("knn",
↪KNeighborsClassifier(n_neighbors=i))]
)
knn.fit(X_train_1, y_train_1)
pred_i = knn.predict(X_val)
print(f"Neighbours {i}")
print(f"Loss: {np.mean(pred_i != y_val)}")
# Take the mean where prediction is not equal to actual
error_rate.append(np.mean(pred_i != y_val))

```

```

Neighbours 1
Loss: 0.004726493571968742
Neighbours 501
Loss: 0.053062767834635746
Neighbours 1001
Loss: 0.08343836652382153
Neighbours 1501
Loss: 0.11828837912780439
Neighbours 2001
Loss: 0.14866397781699017
Neighbours 2501
Loss: 0.1872321653642551
Neighbours 3001
Loss: 0.2096672548525334
Neighbours 3501
Loss: 0.21785984371061257
Neighbours 4001
Loss: 0.22384673556843962
Neighbours 4501
Loss: 0.22920342828333753

```

```

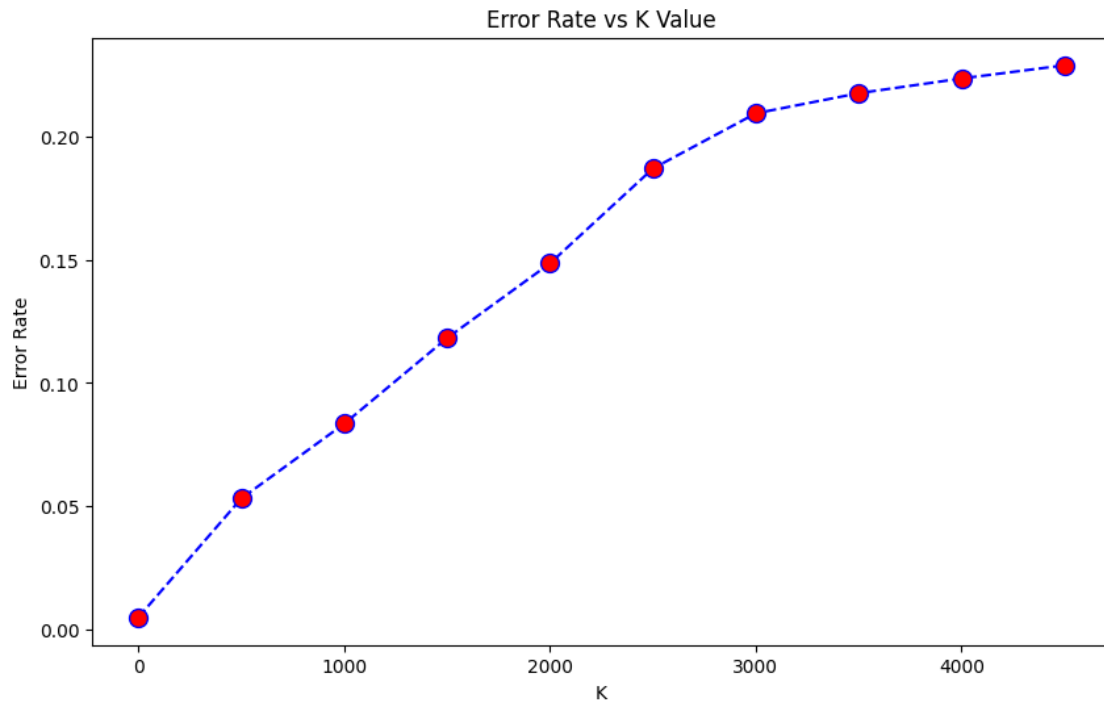
[33]: plt.figure(figsize=(10, 6))
plt.plot(
    range(1, 5000, 500),
    error_rate,
    color="blue",
    linestyle="dashed",
    marker="o",
    markerfacecolor="red",
    markersize=10,
)
plt.title("Error Rate vs K Value")
plt.xlabel("K")
plt.ylabel("Error Rate")

```

```

[33]: Text(0, 0.5, 'Error Rate')

```



```
[34]: knn = Pipeline(
      [("minmax", MinMaxScaler()), ("knn", KNeighborsClassifier(n_neighbors=5))]
    )
    knn.fit(X_train_1, y_train_1)
```

```
[34]: Pipeline(steps=[('minmax', MinMaxScaler()), ('knn', KNeighborsClassifier())])
```

```
[35]: pred = knn.predict(X_test)
```

```
[36]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	1.00	1.00	1.00	14688
2	0.98	0.95	0.96	1358
3	1.00	1.00	1.00	724
4	0.99	0.99	0.99	1614
5	0.99	1.00	0.99	1451
accuracy			0.99	19835
macro avg	0.99	0.99	0.99	19835
weighted avg	0.99	0.99	0.99	19835

```
[37]: print(confusion_matrix(y_test, pred))
```

```
[[14659    20     2     3     4]
 [   47  1288     1    18     4]
 [    0     0   723     1     0]
 [    7     4     0  1603     0]
 [    6     0     0     1  1444]]
```

```
[38]: print(accuracy_score(y_test, pred))
```

```
0.9940509200907487
```

1.7 Decision Tree

```
[39]: from sklearn.tree import DecisionTreeClassifier
```

```
[40]: dt_params = {
        "criterion": ["gini", "entropy", "log_loss"],
        "splitter": ["best", "random"],
    }
    dt = Pipeline(
        [
            ("minmax", MinMaxScaler()),
            ("Bayes", GridSearchCV(DecisionTreeClassifier(), dt_params, verbose=3)),
        ]
    )
```

```
[41]: dt.fit(X_train_1, y_train_1)
```

Fitting 5 folds for each of 6 candidates, totalling 30 fits

```
[CV 1/5] END ...criterion=gini, splitter=best;; score=0.979 total time= 45.1s
[CV 2/5] END ...criterion=gini, splitter=best;; score=0.978 total time= 42.1s
[CV 3/5] END ...criterion=gini, splitter=best;; score=0.979 total time= 39.7s
[CV 4/5] END ...criterion=gini, splitter=best;; score=0.978 total time= 43.6s
[CV 5/5] END ...criterion=gini, splitter=best;; score=0.979 total time= 40.9s
[CV 1/5] END ...criterion=gini, splitter=random;; score=0.982 total time= 3.7s
[CV 2/5] END ...criterion=gini, splitter=random;; score=0.980 total time= 4.4s
[CV 3/5] END ...criterion=gini, splitter=random;; score=0.981 total time= 2.9s
[CV 4/5] END ...criterion=gini, splitter=random;; score=0.983 total time= 3.5s
[CV 5/5] END ...criterion=gini, splitter=random;; score=0.984 total time= 3.1s
[CV 1/5] END ..criterion=entropy, splitter=best;; score=0.984 total time= 34.7s
[CV 2/5] END ..criterion=entropy, splitter=best;; score=0.981 total time= 34.1s
[CV 3/5] END ..criterion=entropy, splitter=best;; score=0.983 total time= 33.4s
[CV 4/5] END ..criterion=entropy, splitter=best;; score=0.983 total time= 33.9s
[CV 5/5] END ..criterion=entropy, splitter=best;; score=0.981 total time= 33.3s
[CV 1/5] END criterion=entropy, splitter=random;; score=0.984 total time= 2.0s
[CV 2/5] END criterion=entropy, splitter=random;; score=0.983 total time= 2.3s
[CV 3/5] END criterion=entropy, splitter=random;; score=0.984 total time= 2.3s
```

```

[CV 4/5] END criterion=entropy, splitter=random;; score=0.983 total time= 1.9s
[CV 5/5] END criterion=entropy, splitter=random;; score=0.983 total time= 2.1s
[CV 1/5] END .criterion=log_loss, splitter=best;; score=0.983 total time= 34.7s
[CV 2/5] END .criterion=log_loss, splitter=best;; score=0.982 total time= 33.6s
[CV 3/5] END .criterion=log_loss, splitter=best;; score=0.984 total time= 33.3s
[CV 4/5] END .criterion=log_loss, splitter=best;; score=0.983 total time= 35.3s
[CV 5/5] END .criterion=log_loss, splitter=best;; score=0.981 total time= 38.4s
[CV 1/5] END criterion=log_loss, splitter=random;; score=0.984 total time=
2.4s
[CV 2/5] END criterion=log_loss, splitter=random;; score=0.982 total time=
2.6s
[CV 3/5] END criterion=log_loss, splitter=random;; score=0.984 total time=
2.5s
[CV 4/5] END criterion=log_loss, splitter=random;; score=0.983 total time=
2.1s
[CV 5/5] END criterion=log_loss, splitter=random;; score=0.983 total time=
1.9s

```

```

[41]: Pipeline(steps=[('minmax', MinMaxScaler()),
                        ('Bayes',
                         GridSearchCV(estimator=DecisionTreeClassifier(),
                                       param_grid={'criterion': ['gini', 'entropy',
                                                                'log_loss'],
                                                  'splitter': ['best', 'random']},
                                       verbose=3))])

```

```

[42]: pred_val = dt.predict(X_val)

```

```

[43]: print(confusion_matrix(y_val, pred_val))

```

```

[[11663    40     1    24    22]
 [   52  1008     7    13     7]
 [    2     6   569     2     0]
 [   25    15     0  1250     1]
 [   20    10     0     2  1129]]

```

```

[44]: print(classification_report(y_val, pred_val))

```

	precision	recall	f1-score	support
1	0.99	0.99	0.99	11750
2	0.93	0.93	0.93	1087
3	0.99	0.98	0.98	579
4	0.97	0.97	0.97	1291
5	0.97	0.97	0.97	1161
accuracy			0.98	15868
macro avg	0.97	0.97	0.97	15868

weighted avg	0.98	0.98	0.98	15868
--------------	------	------	------	-------

```
[45]: pred = dt.predict(X_test)
```

```
[46]: print(confusion_matrix(y_test, pred))
```

```
[[14585    60     2    21    20]
 [   66  1255     5    16    16]
 [    4     4   715     1     0]
 [   22    17     0  1570     5]
 [   27     3     0     2  1419]]
```

```
[47]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	0.99	0.99	0.99	14688
2	0.94	0.92	0.93	1358
3	0.99	0.99	0.99	724
4	0.98	0.97	0.97	1614
5	0.97	0.98	0.97	1451
accuracy			0.99	19835
macro avg	0.97	0.97	0.97	19835
weighted avg	0.99	0.99	0.99	19835

1.8 Random Forest

```
[48]: from sklearn.ensemble import RandomForestClassifier
```

```
[49]: rand = Pipeline(
    [ ("minmax", MinMaxScaler()), ("rand",
    ↪ RandomForestClassifier(criterion="gini")) ]
)
```

```
[50]: rand.fit(X_train_1, y_train_1)
```

```
[50]: Pipeline(steps=[('minmax', MinMaxScaler()), ('rand', RandomForestClassifier())])
```

```
[51]: pred_val = rand.predict(X_val)
```

```
[52]: print(classification_report(y_val, pred_val))
```

	precision	recall	f1-score	support
1	0.99	1.00	1.00	11750

2	0.97	0.96	0.96	1087
3	1.00	0.99	0.99	579
4	0.99	0.97	0.98	1291
5	1.00	0.98	0.99	1161
accuracy			0.99	15868
macro avg	0.99	0.98	0.99	15868
weighted avg	0.99	0.99	0.99	15868

```
[53]: print(confusion_matrix(y_val, pred_val))
```

```
[[11731  18    0    1    0]
 [   38 1041    2    5    1]
 [    2    2  574    1    0]
 [   23   10    0 1258    0]
 [   24    1    0    0 1136]]
```

```
[54]: pred = rand.predict(X_test)
```

```
[55]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	0.99	1.00	1.00	14688
2	0.98	0.95	0.96	1358
3	1.00	1.00	1.00	724
4	0.99	0.98	0.99	1614
5	1.00	0.99	0.99	1451
accuracy			0.99	19835
macro avg	0.99	0.98	0.99	19835
weighted avg	0.99	0.99	0.99	19835

```
[56]: print(confusion_matrix(y_test, pred))
```

```
[[14667  15    1    3    2]
 [   59 1289    2    5    3]
 [    2    1  721    0    0]
 [   19   14    0 1581    0]
 [   16    1    0    2 1432]]
```

1.9 SVM

```
[57]: from sklearn.svm import SVC
```

```
[58]: svm_param_grid = {"C": [0.1, 1, 10, 100, 1000], "gamma": [1, 0.1, 0.01, 0.001, 0.0001]}
```

```
[59]: svm = Pipeline([("minmax", MinMaxScaler()), ("SVM", SVC(C=0.1, gamma=1))])
```

```
[ ]:
```

```
[60]: svm.fit(X_train_1, y_train_1)
```

```
[60]: Pipeline(steps=[('minmax', MinMaxScaler()), ('SVM', SVC(C=0.1, gamma=1))])
```

```
[61]: pred_val = svm.predict(X_val)
```

```
[62]: print(classification_report(y_val, pred_val))
```

	precision	recall	f1-score	support
1	0.98	0.99	0.99	11750
2	0.95	0.92	0.94	1087
3	0.99	0.99	0.99	579
4	0.97	0.93	0.95	1291
5	0.99	0.91	0.95	1161
accuracy			0.98	15868
macro avg	0.98	0.95	0.96	15868
weighted avg	0.98	0.98	0.98	15868

```
[63]: print(confusion_matrix(y_val, pred_val))
```

```
[[11687   34    0   21    8]
 [   73  996    5   11    2]
 [    1    3  574    1    0]
 [   83    9    0 1199    0]
 [   98    1    0    0 1062]]
```

```
[64]: pred = svm.predict(X_test)
```

```
[65]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	0.98	0.99	0.99	14688
2	0.95	0.90	0.93	1358
3	1.00	1.00	1.00	724
4	0.97	0.93	0.95	1614
5	0.98	0.92	0.95	1451

accuracy			0.98	19835
macro avg	0.98	0.95	0.96	19835
weighted avg	0.98	0.98	0.98	19835

```
[66]: print(confusion_matrix(y_test, pred))
```

```
[[14608   39    0   32    9]
 [  102 1228    2   14   12]
 [    1    1  722    0    0]
 [   95   17    0 1502    0]
 [   118    2    0    1 1330]]
```

1.10 Gaussian Naive Bayes

```
[67]: from sklearn.naive_bayes import GaussianNB
```

```
[68]: gnb = Pipeline([("minmax", MinMaxScaler()), ("GNB", GaussianNB())])
```

```
[69]: gnb.fit(X_train_1, y_train_1)
```

```
[69]: Pipeline(steps=[('minmax', MinMaxScaler()), ('GNB', GaussianNB())])
```

```
[70]: pred_val = gnb.predict(X_val)
```

```
[71]: print(classification_report(y_val, pred_val))
```

	precision	recall	f1-score	support
1	0.94	0.69	0.79	11750
2	0.44	0.56	0.50	1087
3	0.63	0.93	0.75	579
4	0.29	0.79	0.42	1291
5	0.54	0.72	0.62	1161
accuracy			0.70	15868
macro avg	0.57	0.74	0.62	15868
weighted avg	0.82	0.70	0.73	15868

```
[72]: print(confusion_matrix(y_val, pred_val))
```

```
[[8065  649  143 2232  661]
 [  23  612  173  236   43]
 [   0   39  540    0    0]
 [ 188   71    5 1021    6]
 [ 265    8    0   56  832]]
```

```
[73]: pred = gnb.predict(X_test)
```

```
[74]: print(classification_report(y_test, pred))
```

	precision	recall	f1-score	support
1	0.95	0.70	0.81	14688
2	0.44	0.55	0.49	1358
3	0.67	0.94	0.78	724
4	0.30	0.80	0.43	1614
5	0.56	0.72	0.63	1451
accuracy			0.71	19835
macro avg	0.58	0.74	0.63	19835
weighted avg	0.82	0.71	0.74	19835

```
[75]: print(confusion_matrix(y_test, pred))
```

```
[[10325  807  149 2660  747]
 [   38  748  174  324   74]
 [    1   44  678    1    0]
 [  217   91    6 1291    9]
 [  341   13    0   53 1044]]
```

2 ANN

```
[76]: from tensorflow.keras.models import Sequential
```

```
2023-07-05 10:24:47.054506: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-07-05 10:24:47.210747: I tensorflow/tsl/cuda/cudart_stub.cc:28] Could not
find cuda drivers on your machine, GPU will not be used.
2023-07-05 10:24:47.212063: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild
TensorFlow with the appropriate compiler flags.
2023-07-05 10:24:49.061011: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT
```

```
[77]: from tensorflow.keras.layers import Dense, Dropout
```

```
[78]: from tensorflow.keras.callbacks import EarlyStopping
```

```
[79]: from keras.utils import to_categorical
```

```
[80]: early_stop = EarlyStopping(monitor="val_loss", mode="min", verbose=1,  
    ↪patience=25)
```

```
[81]: model = Sequential()
```

```
[82]: model.add(Dense(300, activation="relu"))
```

```
[83]: model.add(Dropout(0.5))
```

```
[84]: model.add(Dense(150, activation="relu"))
```

```
[85]: model.add(Dropout(0.5))
```

```
[86]: model.add(Dense(75, activation="relu"))
```

```
[87]: model.add(Dropout(0.5))
```

```
[88]: model.add(Dense(35, activation="relu"))
```

```
[89]: model.add(Dropout(0.5))
```

```
[90]: model.add(Dense(15, activation="relu"))
```

```
[91]: model.add(Dropout(0.5))
```

```
[92]: model.add(Dense(5, activation="softmax"))
```

```
[93]: model.compile(loss="categorical_crossentropy", optimizer="adam")
```

```
[94]: model.fit(  
    x=X_train_1,  
    y=to_categorical(y_train_1)[:, 1:],  
    epochs=600,  
    validation_data=(X_val, to_categorical(y_val)[:, 1:]),  
    batch_size=32,  
    callbacks=[early_stop],  
)
```

Epoch 1/600

1984/1984 [=====] - 11s 5ms/step - loss: 0.6362 -
val_loss: 0.3861

Epoch 2/600

1984/1984 [=====] - 10s 5ms/step - loss: 0.4144 -
val_loss: 0.2850

Epoch 3/600

1984/1984 [=====] - 10s 5ms/step - loss: 0.3508 -
val_loss: 0.2124

Epoch 4/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.3092 -
val_loss: 0.1773

Epoch 5/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.2719 -
val_loss: 0.1573

Epoch 6/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.2562 -
val_loss: 0.1316

Epoch 7/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.2406 -
val_loss: 0.1300

Epoch 8/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.2297 -
val_loss: 0.1213

Epoch 9/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.2280 -
val_loss: 0.1042

Epoch 10/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.2090 -
val_loss: 0.1170

Epoch 11/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.2083 -
val_loss: 0.1070

Epoch 12/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.2004 -
val_loss: 0.0979

Epoch 13/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1961 -
val_loss: 0.1079

Epoch 14/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1876 -
val_loss: 0.0866

Epoch 15/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1791 -
val_loss: 0.0859

Epoch 16/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1778 -
val_loss: 0.0813

Epoch 17/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1747 -
val_loss: 0.0818

Epoch 18/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1743 -
val_loss: 0.0816

Epoch 19/600
1984/1984 [=====] - 12s 6ms/step - loss: 0.1716 -
val_loss: 0.0844

Epoch 20/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1668 -
val_loss: 0.0889

Epoch 21/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1635 -
val_loss: 0.0842

Epoch 22/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1624 -
val_loss: 0.0920

Epoch 23/600
1984/1984 [=====] - 12s 6ms/step - loss: 0.1621 -
val_loss: 0.0810

Epoch 24/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1637 -
val_loss: 0.0872

Epoch 25/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1607 -
val_loss: 0.0878

Epoch 26/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1612 -
val_loss: 0.0821

Epoch 27/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1553 -
val_loss: 0.0785

Epoch 28/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1531 -
val_loss: 0.0749

Epoch 29/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1549 -
val_loss: 0.0856

Epoch 30/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1564 -
val_loss: 0.0721

Epoch 31/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1503 -
val_loss: 0.0797

Epoch 32/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1552 -
val_loss: 0.0732

Epoch 33/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1500 -
val_loss: 0.0739

Epoch 34/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1444 -
val_loss: 0.0682

Epoch 35/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1547 -
val_loss: 0.0729

Epoch 36/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1491 -
val_loss: 0.0668
Epoch 37/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1497 -
val_loss: 0.0641
Epoch 38/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1439 -
val_loss: 0.0710
Epoch 39/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1506 -
val_loss: 0.0684
Epoch 40/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1373 -
val_loss: 0.0713
Epoch 41/600
1984/1984 [=====] - 11s 6ms/step - loss: 0.1434 -
val_loss: 0.0677
Epoch 42/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1417 -
val_loss: 0.0767
Epoch 43/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1415 -
val_loss: 0.0708
Epoch 44/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1507 -
val_loss: 0.0650
Epoch 45/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1439 -
val_loss: 0.0724
Epoch 46/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1487 -
val_loss: 0.0691
Epoch 47/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1398 -
val_loss: 0.0787
Epoch 48/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1477 -
val_loss: 0.0849
Epoch 49/600
1984/1984 [=====] - 10s 5ms/step - loss: 0.1405 -
val_loss: 0.0660
Epoch 50/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1400 -
val_loss: 0.0718
Epoch 51/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1519 -
val_loss: 0.0691

```

Epoch 52/600
1984/1984 [=====] - 11s 5ms/step - loss: 0.1337 -
val_loss: 0.0689
Epoch 53/600
1984/1984 [=====] - 384s 194ms/step - loss: 0.1342 -
val_loss: 0.0746
Epoch 54/600
1984/1984 [=====] - 9s 4ms/step - loss: 0.1354 -
val_loss: 0.0782
Epoch 55/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1369 -
val_loss: 0.0796
Epoch 56/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1476 -
val_loss: 0.0704
Epoch 57/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1456 -
val_loss: 0.0695
Epoch 58/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1412 -
val_loss: 0.0807
Epoch 59/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1359 -
val_loss: 0.0677
Epoch 60/600
1984/1984 [=====] - 8s 4ms/step - loss: 0.1393 -
val_loss: 0.0711
Epoch 61/600
1984/1984 [=====] - 9s 4ms/step - loss: 0.1427 -
val_loss: 0.0687
Epoch 62/600
1984/1984 [=====] - 9s 5ms/step - loss: 0.1326 -
val_loss: 0.0694
Epoch 62: early stopping

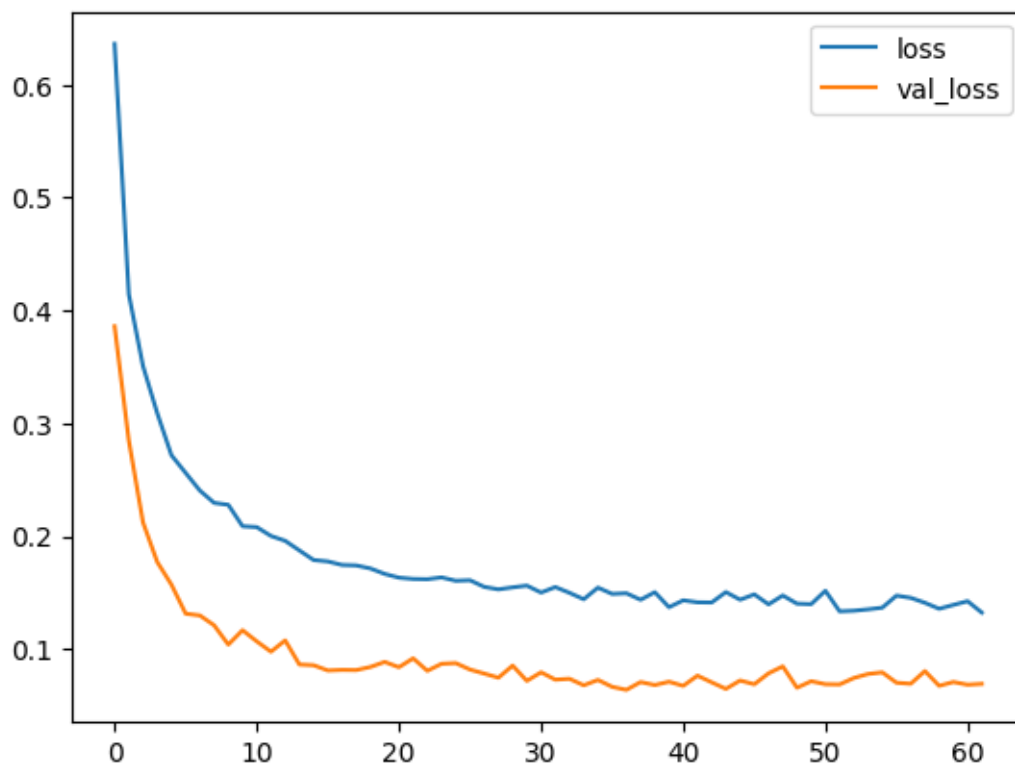
```

```
[94]: <keras.callbacks.History at 0x7fce885ebe20>
```

```
[95]: losses = pd.DataFrame(model.history.history)
```

```
[96]: losses.plot()
```

```
[96]: <Axes: >
```



```
[97]: probs = model.predict(X_test)
```

```
620/620 [=====] - 1s 2ms/step
```

```
[98]: preds = np.argmax(probs, axis=1)
```

```
[99]: preds = preds + 1
```

```
[100]: y_test
```

```
[100]: array([3, 1, 1, ..., 1, 2, 1])
```

```
[101]: print(classification_report(y_test, preds))
```

	precision	recall	f1-score	support
1	0.99	1.00	0.99	14688
2	0.98	0.93	0.95	1358
3	1.00	1.00	1.00	724
4	0.98	0.99	0.98	1614
5	0.99	0.99	0.99	1451
accuracy			0.99	19835

macro avg	0.99	0.98	0.98	19835
weighted avg	0.99	0.99	0.99	19835

```
[102]: print(confusion_matrix(y_test, preds))
```

```
[[14638    21     1    18    10]
 [   84  1257     1    11     5]
 [    1     0   722     1     0]
 [   10     9     0  1592     3]
 [   10     0     0     1  1440]]
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

Deep Learning

August 7, 2023

1 Deep Learning

```
[1]: import torch
import torch.nn as nn
import torch.nn.functional as F

import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
```

```
[2]: %matplotlib inline
```

1.1 Loading data

```
[3]: df = pd.read_csv("./processed_data/processed_data/ecg_processed_data.csv",
    ↪index_col=0)
```

```
[4]: df.head()
```

```
[4]:
```

	Record ID	Segment	Start	Segment	End	0	1	2	\
0	100		13		213	0.059449	0.055308	0.052035	
1	100		307		507	0.084239	0.087566	0.088956	
2	100		563		763	-0.006937	-0.005690	-0.005184	
3	100		883		1083	0.072086	0.073128	0.073026	
4	100		1168		1368	0.084762	0.083995	0.082327	
		3	4	5	6	...	191	192	193 \
0	0.049666	0.047961	0.046922	0.046801	...	0.029812	0.031902	0.033233	
1	0.088621	0.086919	0.084459	0.081823	...	0.020380	0.020170	0.020049	
2	-0.005172	-0.005405	-0.005802	-0.006385	...	-0.083923	-0.084476	-0.084798	
3	0.071802	0.069731	0.067336	0.065156	...	0.040917	0.040820	0.040605	
4	0.080127	0.077701	0.075216	0.072963	...	0.024691	0.025225	0.025977	
		194	195	196	197	198	199	\	
0	0.033981	0.034276	0.034166	0.033702	0.033134	0.032648			
1	0.020272	0.020719	0.020971	0.020866	0.020622	0.020434			

```

2 -0.084841 -0.084325 -0.082953 -0.080644 -0.077424 -0.073181
3  0.040177  0.039328  0.038051  0.036671  0.035565  0.034817
4  0.027249  0.029211  0.031715  0.034364  0.036462  0.037443

```

```

      Annotation Class
0                    N
1                    N
2                    N
3                    N
4                    N

```

[5 rows x 204 columns]

```
[5]: df.describe().transpose()
```

```

[5]:
      count      mean      std      min \
Record ID  99174.0  170.801752  51.985347  100.000000
Segment Start  99174.0  325045.609051  188363.760147  9.000000
Segment End  99174.0  325245.609051  188363.760147  209.000000
0  99174.0  -0.042127  0.119547  -1.900955
1  99174.0  -0.042054  0.118728  -1.887876
...      ...      ...      ...      ...
195  99174.0  0.068449  0.243398  -2.685320
196  99174.0  0.065637  0.240538  -2.715343
197  99174.0  0.062668  0.237743  -2.734072
198  99174.0  0.059560  0.234978  -2.743276
199  99174.0  0.056335  0.232210  -2.742996

      25%      50%      75%      max
Record ID  114.000000  203.000000  215.000000  234.000000
Segment Start  160745.000000  326069.500000  488528.500000  649793.000000
Segment End  160945.000000  326269.500000  488728.500000  649993.000000
0  -0.097349  -0.045074  0.006416  2.195452
1  -0.097490  -0.044461  0.006934  2.207827
...      ...      ...      ...      ...
195  -0.058351  -0.001114  0.128255  2.462435
196  -0.058428  -0.001539  0.122874  2.480217
197  -0.058666  -0.002161  0.117917  2.494743
198  -0.059124  -0.003069  0.112630  2.506468
199  -0.059530  -0.004525  0.107668  2.515870

```

[203 rows x 8 columns]

```
[6]: df.info()
```

```

<class 'pandas.core.frame.DataFrame'>
Index: 99174 entries, 0 to 99173

```

```
Columns: 204 entries, Record ID to Annotation Class
dtypes: float64(200), int64(3), object(1)
memory usage: 155.1+ MB
```

1.2 Preprocessing

```
[7]: X = df[[str(i) for i in range(0, 200)]].values
```

```
[8]: X
```

```
[8]: array([[ 0.05944944,  0.05530813,  0.05203533, ...,  0.03370211,
            0.03313351,  0.03264835],
          [ 0.08423915,  0.08756617,  0.08895633, ...,  0.02086591,
            0.02062246,  0.02043396],
          [-0.00693746, -0.00568975, -0.00518379, ..., -0.08064385,
            -0.07742402, -0.07318052],
          ...,
          [-0.0464351 , -0.04455849, -0.04386177, ..., -0.08220224,
            -0.08951841, -0.09635549],
          [-0.09173968, -0.09411179, -0.09693917, ...,  0.01425364,
            0.01084743,  0.0081831 ],
          [ 0.07593816,  0.07788971,  0.07865438, ...,  0.05425404,
            0.04719546,  0.0410799 ]])
```

```
[9]: X.shape
```

```
[9]: (99174, 200)
```

```
[10]: y = df["Annotation Class"].astype("category")
```

```
[11]: y.describe()
```

```
[11]: count      99174
      unique         5
      top           N
      freq       73439
      Name: Annotation Class, dtype: object
```

```
[12]: y.info()
```

```
<class 'pandas.core.series.Series'>
Index: 99174 entries, 0 to 99173
Series name: Annotation Class
Non-Null Count  Dtype
-----
99174 non-null  category
dtypes: category(1)
memory usage: 871.9 KB
```

```
[13]: y.cat.codes
```

```
[13]: 0      2
      1      2
      2      2
      3      2
      4      2
      ..
     99169    2
     99170    2
     99171    2
     99172    2
     99173    2
     Length: 99174, dtype: int8
```

```
[14]: y.cat.categories
```

```
[14]: Index(['/', 'L', 'N', 'R', 'V'], dtype='object')
```

```
[15]: y_code = y.cat.codes.values
```

```
[16]: y_code
```

```
[16]: array([2, 2, 2, ..., 2, 2, 2], dtype=int8)
```

```
[17]: y_code.shape
```

```
[17]: (99174,)
```

```
[18]: y_code
```

```
[18]: array([2, 2, 2, ..., 2, 2, 2], dtype=int8)
```

```
[19]: from sklearn.model_selection import train_test_split
```

```
[20]: X_train, X_test, y_train, y_test = train_test_split(
      X, y_code, test_size=0.2, random_state=101, stratify=y, shuffle=True
    )
```

```
[21]: X_train, X_val, y_train, y_val = train_test_split(
      X_train, y_train, test_size=0.2, random_state=101, stratify=y_train,
      ↪shuffle=True
    )
```

```
[22]: X_train_tensor = torch.FloatTensor(X_train)
      X_val_tensor = torch.FloatTensor(X_val)
      X_test_tensor = torch.FloatTensor(X_test)
```



```
y_train_tensor = torch.LongTensor(y_train)
y_val_tensor = torch.LongTensor(y_val)
y_test_tensor = torch.LongTensor(y_test)
```

```
[23]: X_train_tensor.shape
```

```
[23]: torch.Size([63471, 200])
```

```
[24]: X_val_tensor.shape
```

```
[24]: torch.Size([15868, 200])
```

1.3 ANN

```
[25]: from ecg_deep_learning_models.models import ECGANNModel, ECGCNNModel, \
      ↪ ECGLSTMMModel
      from ecg_deep_learning_models.utils import (
          count_parameters,
          train_model,
          eval_model,
          show_metrics, profile
      )
```

```
[26]: ecg_ann_model = ECGANNModel(layers=[100, 50])
      ecg_ann_model_1 = ECGANNModel(layers=[100, 50, 25])
```

```
[27]: count_parameters(ecg_ann_model)
```

```
20000
  100
 5000
   50
   250
    5
-----
25405
```

```
[28]: count_parameters(ecg_ann_model_1)
```

```
20000
  100
 5000
   50
 1250
   25
  125
    5
```

26555

```
[29]: ecg_ann_model
```

```
[29]: ECGANNModel(  
  (layers): Sequential(  
    (0): Linear(in_features=200, out_features=100, bias=True)  
    (1): ReLU(inplace=True)  
    (2): Dropout(p=0.5, inplace=False)  
    (3): Linear(in_features=100, out_features=50, bias=True)  
    (4): ReLU(inplace=True)  
    (5): Dropout(p=0.5, inplace=False)  
    (6): Linear(in_features=50, out_features=5, bias=True)  
  )  
)
```

```
[30]: ecg_ann_model_1
```

```
[30]: ECGANNModel(  
  (layers): Sequential(  
    (0): Linear(in_features=200, out_features=100, bias=True)  
    (1): ReLU(inplace=True)  
    (2): Dropout(p=0.5, inplace=False)  
    (3): Linear(in_features=100, out_features=50, bias=True)  
    (4): ReLU(inplace=True)  
    (5): Dropout(p=0.5, inplace=False)  
    (6): Linear(in_features=50, out_features=25, bias=True)  
    (7): ReLU(inplace=True)  
    (8): Dropout(p=0.5, inplace=False)  
    (9): Linear(in_features=25, out_features=5, bias=True)  
  )  
)
```

```
[31]: X_train_tensor.shape
```

```
[31]: torch.Size([63471, 200])
```

```
[32]: ecg_ann_model.parameters()
```

```
[32]: <generator object Module.parameters at 0x7f2b4abd34a0>
```

```
[33]: ecg_ann_model_1.parameters()
```

```
[33]: <generator object Module.parameters at 0x7f2b4abd3820>
```

```
[34]: ecg_ann_model.parameters
```

```
[34]: <bound method Module.parameters of ECGANNModel(
(layers): Sequential(
  (0): Linear(in_features=200, out_features=100, bias=True)
  (1): ReLU(inplace=True)
  (2): Dropout(p=0.5, inplace=False)
  (3): Linear(in_features=100, out_features=50, bias=True)
  (4): ReLU(inplace=True)
  (5): Dropout(p=0.5, inplace=False)
  (6): Linear(in_features=50, out_features=5, bias=True)
)
)>
```

```
[35]: ecg_ann_model_1.parameters
```

```
[35]: <bound method Module.parameters of ECGANNModel(
(layers): Sequential(
  (0): Linear(in_features=200, out_features=100, bias=True)
  (1): ReLU(inplace=True)
  (2): Dropout(p=0.5, inplace=False)
  (3): Linear(in_features=100, out_features=50, bias=True)
  (4): ReLU(inplace=True)
  (5): Dropout(p=0.5, inplace=False)
  (6): Linear(in_features=50, out_features=25, bias=True)
  (7): ReLU(inplace=True)
  (8): Dropout(p=0.5, inplace=False)
  (9): Linear(in_features=25, out_features=5, bias=True)
)
)>
```

```
[36]: train_accuracies, test_accuracies, train_mean_losses, test_mean_losses = _
      ↪ train_model(
        model=ecg_ann_model,
        X_train=X_train_tensor,
        y_train=y_train_tensor,
        X_test=X_val_tensor,
        y_test=y_val_tensor,
        learning_rate=0.001,
        batch_size=100,
        val_batch_size=100,
        epochs=100,
      )
```

epoch:1 Train Loss:	0.45	Train Accuracy:	86.30	Test Loss:
0.18 Test Accuracy:	94.93	Tolerance Count:	0	
epoch:2 Train Loss:	0.23	Train Accuracy:	93.15	Test Loss:
0.12 Test Accuracy:	96.43	Tolerance Count:	0	
epoch:3 Train Loss:	0.19	Train Accuracy:	94.37	Test Loss:

0.10	Test Accuracy:	97.42	Tolerance Count:0	
epoch:4	Train Loss:	0.17	Train Accuracy:	95.12 Test Loss:
0.09	Test Accuracy:	97.59	Tolerance Count:0	
epoch:5	Train Loss:	0.15	Train Accuracy:	95.65 Test Loss:
0.08	Test Accuracy:	97.72	Tolerance Count:0	
epoch:6	Train Loss:	0.15	Train Accuracy:	95.82 Test Loss:
0.07	Test Accuracy:	98.02	Tolerance Count:0	
epoch:7	Train Loss:	0.14	Train Accuracy:	96.08 Test Loss:
0.07	Test Accuracy:	98.13	Tolerance Count:0	
epoch:8	Train Loss:	0.13	Train Accuracy:	96.30 Test Loss:
0.07	Test Accuracy:	98.24	Tolerance Count:0	
epoch:9	Train Loss:	0.13	Train Accuracy:	96.29 Test Loss:
0.06	Test Accuracy:	98.34	Tolerance Count:0	
epoch:10	Train Loss:	0.12	Train Accuracy:	96.55 Test
Loss:	0.06	Test Accuracy:	98.33	Tolerance Count:0
epoch:11	Train Loss:	0.12	Train Accuracy:	96.62 Test
Loss:	0.06	Test Accuracy:	98.49	Tolerance Count:0
epoch:12	Train Loss:	0.11	Train Accuracy:	96.83 Test
Loss:	0.06	Test Accuracy:	98.51	Tolerance Count:0
epoch:13	Train Loss:	0.11	Train Accuracy:	96.85 Test
Loss:	0.05	Test Accuracy:	98.48	Tolerance Count:0
epoch:14	Train Loss:	0.11	Train Accuracy:	96.83 Test
Loss:	0.06	Test Accuracy:	98.54	Tolerance Count:0
epoch:15	Train Loss:	0.10	Train Accuracy:	97.01 Test
Loss:	0.06	Test Accuracy:	98.66	Tolerance Count:0
epoch:16	Train Loss:	0.11	Train Accuracy:	96.96 Test
Loss:	0.05	Test Accuracy:	98.56	Tolerance Count:0
epoch:17	Train Loss:	0.10	Train Accuracy:	97.13 Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:0
epoch:18	Train Loss:	0.10	Train Accuracy:	97.09 Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:0
epoch:19	Train Loss:	0.10	Train Accuracy:	97.13 Test
Loss:	0.05	Test Accuracy:	98.61	Tolerance Count:0
epoch:20	Train Loss:	0.10	Train Accuracy:	97.01 Test
Loss:	0.05	Test Accuracy:	98.71	Tolerance Count:0
epoch:21	Train Loss:	0.10	Train Accuracy:	97.15 Test
Loss:	0.05	Test Accuracy:	98.68	Tolerance Count:0
epoch:22	Train Loss:	0.10	Train Accuracy:	97.17 Test
Loss:	0.05	Test Accuracy:	98.70	Tolerance Count:0
epoch:23	Train Loss:	0.10	Train Accuracy:	97.21 Test
Loss:	0.05	Test Accuracy:	98.65	Tolerance Count:0
epoch:24	Train Loss:	0.10	Train Accuracy:	97.22 Test
Loss:	0.05	Test Accuracy:	98.78	Tolerance Count:0
epoch:25	Train Loss:	0.09	Train Accuracy:	97.39 Test
Loss:	0.05	Test Accuracy:	98.78	Tolerance Count:0
epoch:26	Train Loss:	0.10	Train Accuracy:	97.18 Test
Loss:	0.05	Test Accuracy:	98.76	Tolerance Count:0
epoch:27	Train Loss:	0.10	Train Accuracy:	97.31 Test

Loss:	0.05	Test Accuracy:	98.78	Tolerance Count:0	
epoch:28		Train Loss:	0.09	Train Accuracy:	97.32 Test
Loss:	0.05	Test Accuracy:	98.73	Tolerance Count:0	
epoch:29		Train Loss:	0.09	Train Accuracy:	97.28 Test
Loss:	0.05	Test Accuracy:	98.76	Tolerance Count:0	
epoch:30		Train Loss:	0.09	Train Accuracy:	97.34 Test
Loss:	0.05	Test Accuracy:	98.78	Tolerance Count:0	
epoch:31		Train Loss:	0.09	Train Accuracy:	97.40 Test
Loss:	0.05	Test Accuracy:	98.71	Tolerance Count:0	
epoch:32		Train Loss:	0.09	Train Accuracy:	97.36 Test
Loss:	0.05	Test Accuracy:	98.70	Tolerance Count:0	
epoch:33		Train Loss:	0.09	Train Accuracy:	97.33 Test
Loss:	0.05	Test Accuracy:	98.80	Tolerance Count:0	
epoch:34		Train Loss:	0.09	Train Accuracy:	97.42 Test
Loss:	0.05	Test Accuracy:	98.71	Tolerance Count:0	
epoch:35		Train Loss:	0.09	Train Accuracy:	97.40 Test
Loss:	0.05	Test Accuracy:	98.74	Tolerance Count:0	
epoch:36		Train Loss:	0.09	Train Accuracy:	97.39 Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	
epoch:37		Train Loss:	0.09	Train Accuracy:	97.46 Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:38		Train Loss:	0.09	Train Accuracy:	97.47 Test
Loss:	0.04	Test Accuracy:	98.79	Tolerance Count:0	
epoch:39		Train Loss:	0.09	Train Accuracy:	97.52 Test
Loss:	0.04	Test Accuracy:	98.75	Tolerance Count:0	
epoch:40		Train Loss:	0.09	Train Accuracy:	97.45 Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:41		Train Loss:	0.09	Train Accuracy:	97.56 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:42		Train Loss:	0.09	Train Accuracy:	97.52 Test
Loss:	0.04	Test Accuracy:	98.78	Tolerance Count:0	
epoch:43		Train Loss:	0.09	Train Accuracy:	97.52 Test
Loss:	0.04	Test Accuracy:	98.81	Tolerance Count:0	
epoch:44		Train Loss:	0.08	Train Accuracy:	97.52 Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:45		Train Loss:	0.09	Train Accuracy:	97.56 Test
Loss:	0.04	Test Accuracy:	98.90	Tolerance Count:0	
epoch:46		Train Loss:	0.08	Train Accuracy:	97.59 Test
Loss:	0.04	Test Accuracy:	98.83	Tolerance Count:0	
epoch:47		Train Loss:	0.08	Train Accuracy:	97.60 Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	
epoch:48		Train Loss:	0.08	Train Accuracy:	97.54 Test
Loss:	0.05	Test Accuracy:	98.77	Tolerance Count:0	
epoch:49		Train Loss:	0.08	Train Accuracy:	97.49 Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:50		Train Loss:	0.08	Train Accuracy:	97.60 Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:51		Train Loss:	0.08	Train Accuracy:	97.53 Test

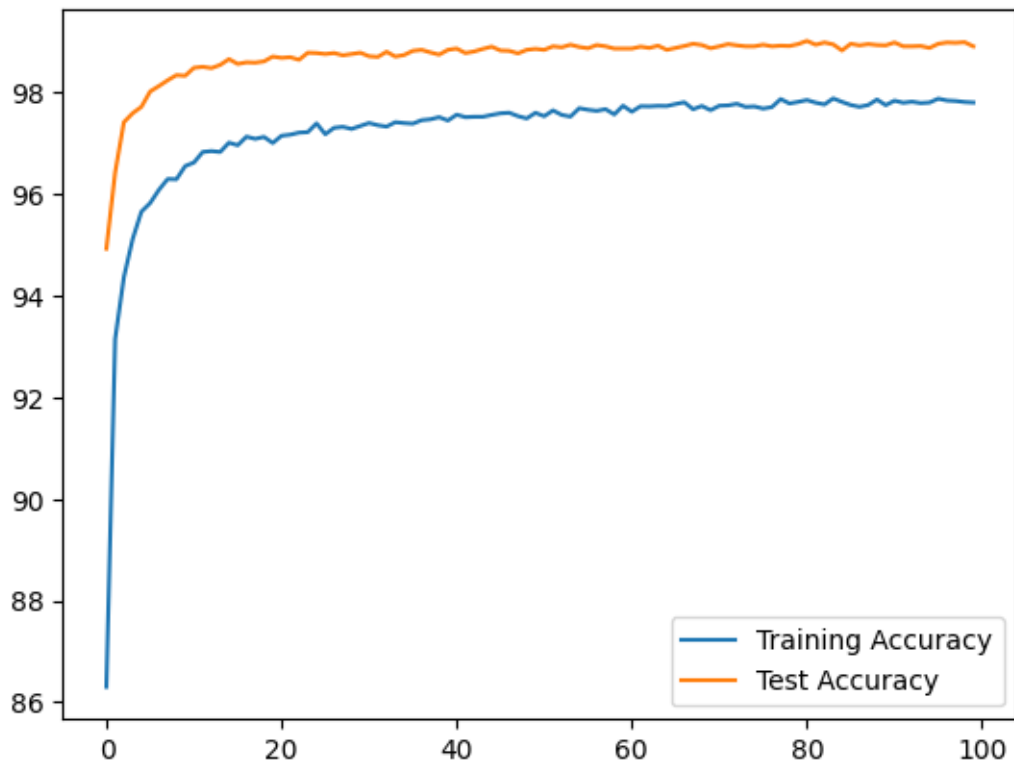
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:52		Train Loss:	0.08	Train Accuracy:	97.65 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:53		Train Loss:	0.09	Train Accuracy:	97.56 Test
Loss:	0.04	Test Accuracy:	98.89	Tolerance Count:0	
epoch:54		Train Loss:	0.09	Train Accuracy:	97.53 Test
Loss:	0.04	Test Accuracy:	98.94	Tolerance Count:0	
epoch:55		Train Loss:	0.08	Train Accuracy:	97.69 Test
Loss:	0.04	Test Accuracy:	98.90	Tolerance Count:0	
epoch:56		Train Loss:	0.08	Train Accuracy:	97.66 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:57		Train Loss:	0.08	Train Accuracy:	97.64 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:58		Train Loss:	0.08	Train Accuracy:	97.67 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:59		Train Loss:	0.08	Train Accuracy:	97.57 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:60		Train Loss:	0.08	Train Accuracy:	97.74 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:61		Train Loss:	0.08	Train Accuracy:	97.62 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:62		Train Loss:	0.08	Train Accuracy:	97.73 Test
Loss:	0.04	Test Accuracy:	98.90	Tolerance Count:0	
epoch:63		Train Loss:	0.08	Train Accuracy:	97.73 Test
Loss:	0.04	Test Accuracy:	98.88	Tolerance Count:0	
epoch:64		Train Loss:	0.08	Train Accuracy:	97.74 Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:65		Train Loss:	0.08	Train Accuracy:	97.73 Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:66		Train Loss:	0.08	Train Accuracy:	97.77 Test
Loss:	0.04	Test Accuracy:	98.88	Tolerance Count:0	
epoch:67		Train Loss:	0.08	Train Accuracy:	97.81 Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:68		Train Loss:	0.08	Train Accuracy:	97.67 Test
Loss:	0.04	Test Accuracy:	98.96	Tolerance Count:0	
epoch:69		Train Loss:	0.08	Train Accuracy:	97.74 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:70		Train Loss:	0.08	Train Accuracy:	97.65 Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:71		Train Loss:	0.08	Train Accuracy:	97.74 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:72		Train Loss:	0.08	Train Accuracy:	97.75 Test
Loss:	0.04	Test Accuracy:	98.95	Tolerance Count:0	
epoch:73		Train Loss:	0.08	Train Accuracy:	97.78 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:74		Train Loss:	0.08	Train Accuracy:	97.72 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:75		Train Loss:	0.08	Train Accuracy:	97.73 Test

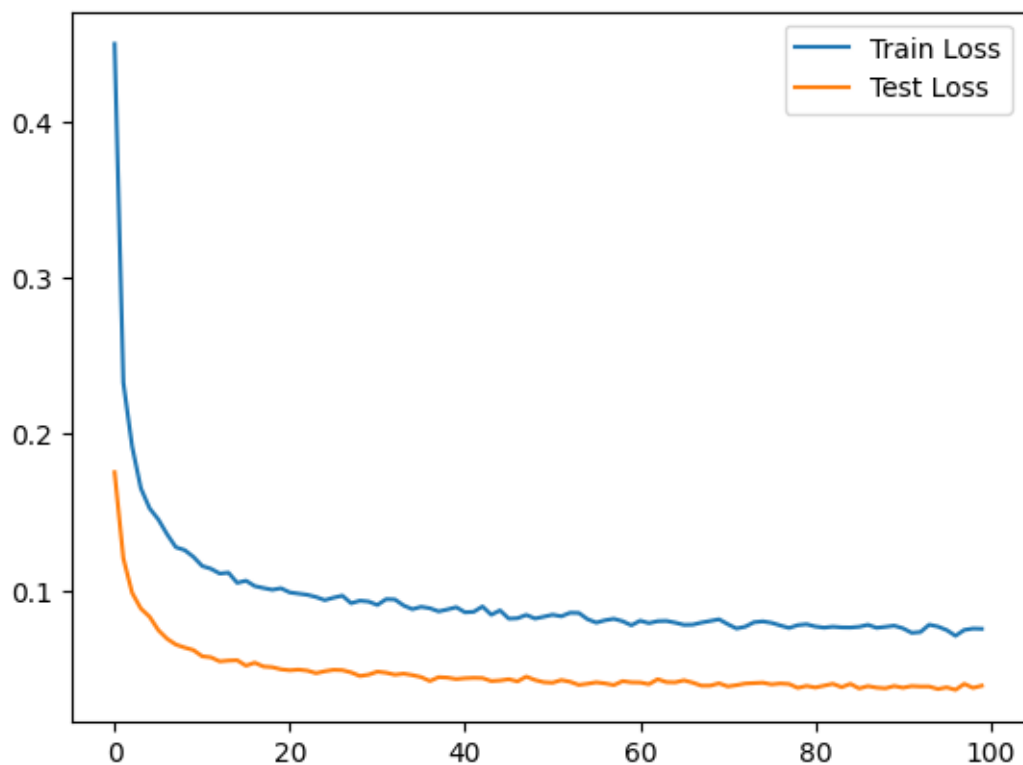
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:76		Train Loss:	0.08	Train Accuracy:	97.68 Test
Loss:	0.04	Test Accuracy:	98.94	Tolerance Count:0	
epoch:77		Train Loss:	0.08	Train Accuracy:	97.71 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:78		Train Loss:	0.08	Train Accuracy:	97.87 Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:79		Train Loss:	0.08	Train Accuracy:	97.78 Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:80		Train Loss:	0.08	Train Accuracy:	97.82 Test
Loss:	0.04	Test Accuracy:	98.95	Tolerance Count:0	
epoch:81		Train Loss:	0.08	Train Accuracy:	97.85 Test
Loss:	0.04	Test Accuracy:	99.02	Tolerance Count:0	
epoch:82		Train Loss:	0.08	Train Accuracy:	97.80 Test
Loss:	0.04	Test Accuracy:	98.94	Tolerance Count:0	
epoch:83		Train Loss:	0.08	Train Accuracy:	97.77 Test
Loss:	0.04	Test Accuracy:	98.99	Tolerance Count:0	
epoch:84		Train Loss:	0.08	Train Accuracy:	97.88 Test
Loss:	0.04	Test Accuracy:	98.95	Tolerance Count:0	
epoch:85		Train Loss:	0.08	Train Accuracy:	97.82 Test
Loss:	0.04	Test Accuracy:	98.83	Tolerance Count:0	
epoch:86		Train Loss:	0.08	Train Accuracy:	97.75 Test
Loss:	0.04	Test Accuracy:	98.96	Tolerance Count:0	
epoch:87		Train Loss:	0.08	Train Accuracy:	97.72 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:88		Train Loss:	0.08	Train Accuracy:	97.75 Test
Loss:	0.04	Test Accuracy:	98.95	Tolerance Count:0	
epoch:89		Train Loss:	0.08	Train Accuracy:	97.86 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:90		Train Loss:	0.08	Train Accuracy:	97.75 Test
Loss:	0.04	Test Accuracy:	98.93	Tolerance Count:0	
epoch:91		Train Loss:	0.08	Train Accuracy:	97.84 Test
Loss:	0.04	Test Accuracy:	98.99	Tolerance Count:0	
epoch:92		Train Loss:	0.07	Train Accuracy:	97.80 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:93		Train Loss:	0.07	Train Accuracy:	97.82 Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:94		Train Loss:	0.08	Train Accuracy:	97.79 Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:95		Train Loss:	0.08	Train Accuracy:	97.80 Test
Loss:	0.04	Test Accuracy:	98.88	Tolerance Count:0	
epoch:96		Train Loss:	0.07	Train Accuracy:	97.88 Test
Loss:	0.04	Test Accuracy:	98.96	Tolerance Count:0	
epoch:97		Train Loss:	0.07	Train Accuracy:	97.84 Test
Loss:	0.04	Test Accuracy:	98.99	Tolerance Count:0	
epoch:98		Train Loss:	0.07	Train Accuracy:	97.83 Test
Loss:	0.04	Test Accuracy:	98.98	Tolerance Count:0	
epoch:99		Train Loss:	0.08	Train Accuracy:	97.81 Test

Loss: 0.04 Test Accuracy: 98.99 Tolerance Count:0
epoch:100 Train Loss: 0.08 Train Accuracy: 97.80 Test
Loss: 0.04 Test Accuracy: 98.91 Tolerance Count:0

Duration: 761 seconds

```
[38]: show_metrics(train_accuracies, test_accuracies, train_mean_losses, test_mean_losses)
eval_model(ecg_ann_model, X_test_tensor, y_test_tensor)
profile(ecg_ann_model, tuple([200]))
```





	precision	recall	f1-score	support
0	1.00	1.00	1.00	724
1	0.98	0.99	0.98	1594
2	1.00	0.99	0.99	14734
3	0.99	1.00	0.99	1442
4	0.95	0.96	0.96	1341
accuracy			0.99	19835
macro avg	0.98	0.99	0.98	19835
weighted avg	0.99	0.99	0.99	19835


```

[[ 723    0    0    0    1]
 [   0 1575   12    0    7]
 [   0   23 14637   14   60]
 [   0    0    5 1436    1]
 [   1   16   34    1 1289]]

```

Duration: 1 seconds

Warning: module Dropout is treated as a zero-op.

Warning: module ECGANNModel is treated as a zero-op.

ECGANNModel(

```

25.41 k, 100.000% Params, 25.55 KMac, 100.000% MACs,
(layers): Sequential(
  25.41 k, 100.000% Params, 25.55 KMac, 100.000% MACs,
  (0): Linear(20.1 k, 79.118% Params, 20.1 KMac, 78.654% MACs,
in_features=200, out_features=100, bias=True)
  (1): ReLU(0, 0.000% Params, 100.0 Mac, 0.391% MACs, inplace=True)
  (2): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
  (3): Linear(5.05 k, 19.878% Params, 5.05 KMac, 19.761% MACs,
in_features=100, out_features=50, bias=True)
  (4): ReLU(0, 0.000% Params, 50.0 Mac, 0.196% MACs, inplace=True)
  (5): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
  (6): Linear(255, 1.004% Params, 255.0 Mac, 0.998% MACs, in_features=50,
out_features=5, bias=True)
)
)
Computational complexity: 25.55 KMac
Computational complexity: 51.1 KFlops
Number of parameters: 25.41 k

```

```

[39]: train_accuracies, test_accuracies, train_mean_losses, test_mean_losses =
      ↪train_model(
        model=ecg_ann_model_1,
        X_train=X_train_tensor,
        y_train=y_train_tensor,
        X_test=X_val_tensor,
        y_test=y_val_tensor,
        learning_rate=0.001,
        batch_size=100,
        val_batch_size=100,
        epochs=100,
      )

```

epoch:1 Train Loss:	0.58	Train Accuracy:	80.00	Test Loss:
0.24 Test Accuracy:	93.06	Tolerance Count:	0	
epoch:2 Train Loss:	0.32	Train Accuracy:	89.26	Test Loss:
0.16 Test Accuracy:	95.75	Tolerance Count:	0	
epoch:3 Train Loss:	0.27	Train Accuracy:	91.75	Test Loss:
0.13 Test Accuracy:	96.30	Tolerance Count:	0	
epoch:4 Train Loss:	0.24	Train Accuracy:	92.80	Test Loss:
0.11 Test Accuracy:	96.80	Tolerance Count:	0	
epoch:5 Train Loss:	0.22	Train Accuracy:	93.53	Test Loss:
0.10 Test Accuracy:	97.18	Tolerance Count:	0	
epoch:6 Train Loss:	0.21	Train Accuracy:	93.87	Test Loss:
0.09 Test Accuracy:	97.32	Tolerance Count:	0	
epoch:7 Train Loss:	0.20	Train Accuracy:	94.32	Test Loss:
0.09 Test Accuracy:	97.52	Tolerance Count:	0	
epoch:8 Train Loss:	0.18	Train Accuracy:	94.61	Test Loss:
0.08 Test Accuracy:	97.83	Tolerance Count:	0	

epoch:9	Train Loss:	0.18	Train Accuracy:	94.79	Test Loss:
0.08	Test Accuracy:	97.85	Tolerance Count:	0	
epoch:10	Train Loss:	0.17	Train Accuracy:	95.02	Test
Loss:	0.07	Test Accuracy:	97.92	Tolerance Count:	0
epoch:11	Train Loss:	0.16	Train Accuracy:	95.28	Test
Loss:	0.08	Test Accuracy:	97.93	Tolerance Count:	0
epoch:12	Train Loss:	0.16	Train Accuracy:	95.38	Test
Loss:	0.07	Test Accuracy:	97.91	Tolerance Count:	0
epoch:13	Train Loss:	0.16	Train Accuracy:	95.44	Test
Loss:	0.07	Test Accuracy:	98.12	Tolerance Count:	0
epoch:14	Train Loss:	0.15	Train Accuracy:	95.69	Test
Loss:	0.06	Test Accuracy:	98.22	Tolerance Count:	0
epoch:15	Train Loss:	0.15	Train Accuracy:	95.74	Test
Loss:	0.06	Test Accuracy:	98.18	Tolerance Count:	0
epoch:16	Train Loss:	0.15	Train Accuracy:	95.82	Test
Loss:	0.06	Test Accuracy:	98.34	Tolerance Count:	0
epoch:17	Train Loss:	0.14	Train Accuracy:	95.98	Test
Loss:	0.06	Test Accuracy:	98.34	Tolerance Count:	0
epoch:18	Train Loss:	0.14	Train Accuracy:	95.90	Test
Loss:	0.06	Test Accuracy:	98.31	Tolerance Count:	0
epoch:19	Train Loss:	0.14	Train Accuracy:	96.06	Test
Loss:	0.06	Test Accuracy:	98.35	Tolerance Count:	0
epoch:20	Train Loss:	0.14	Train Accuracy:	96.08	Test
Loss:	0.06	Test Accuracy:	98.42	Tolerance Count:	0
epoch:21	Train Loss:	0.13	Train Accuracy:	96.25	Test
Loss:	0.05	Test Accuracy:	98.53	Tolerance Count:	0
epoch:22	Train Loss:	0.14	Train Accuracy:	96.16	Test
Loss:	0.05	Test Accuracy:	98.48	Tolerance Count:	0
epoch:23	Train Loss:	0.14	Train Accuracy:	96.13	Test
Loss:	0.05	Test Accuracy:	98.55	Tolerance Count:	0
epoch:24	Train Loss:	0.13	Train Accuracy:	96.23	Test
Loss:	0.06	Test Accuracy:	98.44	Tolerance Count:	0
epoch:25	Train Loss:	0.13	Train Accuracy:	96.21	Test
Loss:	0.06	Test Accuracy:	98.20	Tolerance Count:	0
epoch:26	Train Loss:	0.13	Train Accuracy:	96.36	Test
Loss:	0.05	Test Accuracy:	98.41	Tolerance Count:	0
epoch:27	Train Loss:	0.13	Train Accuracy:	96.51	Test
Loss:	0.05	Test Accuracy:	98.53	Tolerance Count:	0
epoch:28	Train Loss:	0.13	Train Accuracy:	96.53	Test
Loss:	0.05	Test Accuracy:	98.60	Tolerance Count:	0
epoch:29	Train Loss:	0.13	Train Accuracy:	96.45	Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:	0
epoch:30	Train Loss:	0.13	Train Accuracy:	96.44	Test
Loss:	0.05	Test Accuracy:	98.51	Tolerance Count:	0
epoch:31	Train Loss:	0.12	Train Accuracy:	96.58	Test
Loss:	0.05	Test Accuracy:	98.55	Tolerance Count:	0
epoch:32	Train Loss:	0.13	Train Accuracy:	96.50	Test
Loss:	0.05	Test Accuracy:	98.60	Tolerance Count:	0

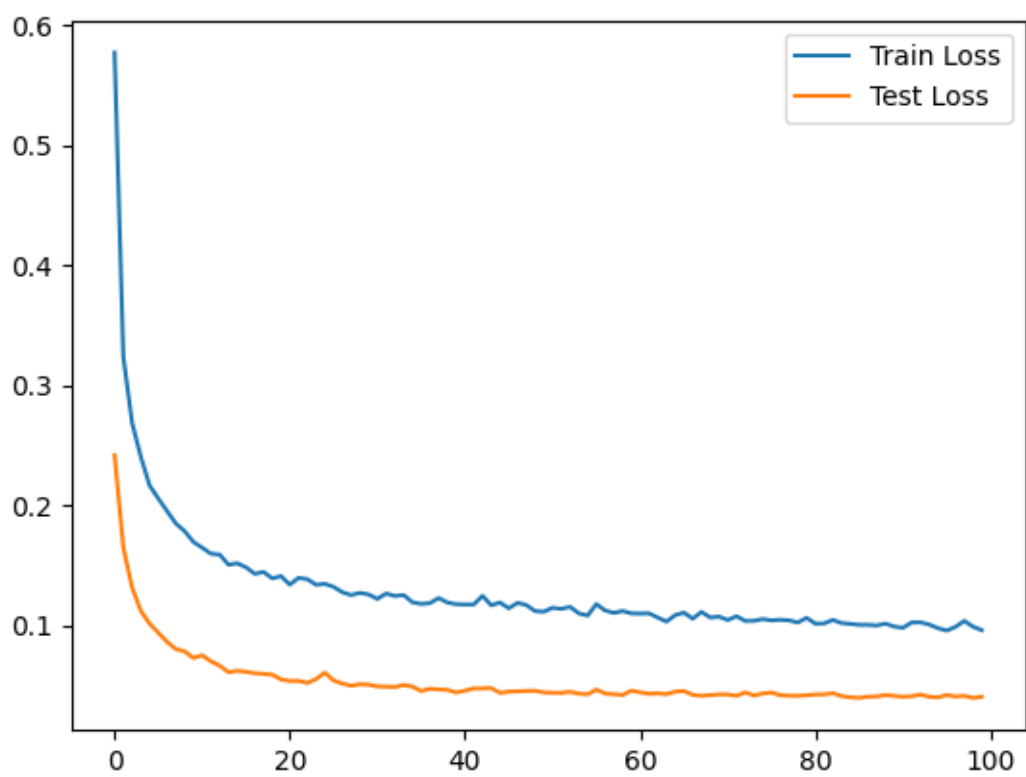
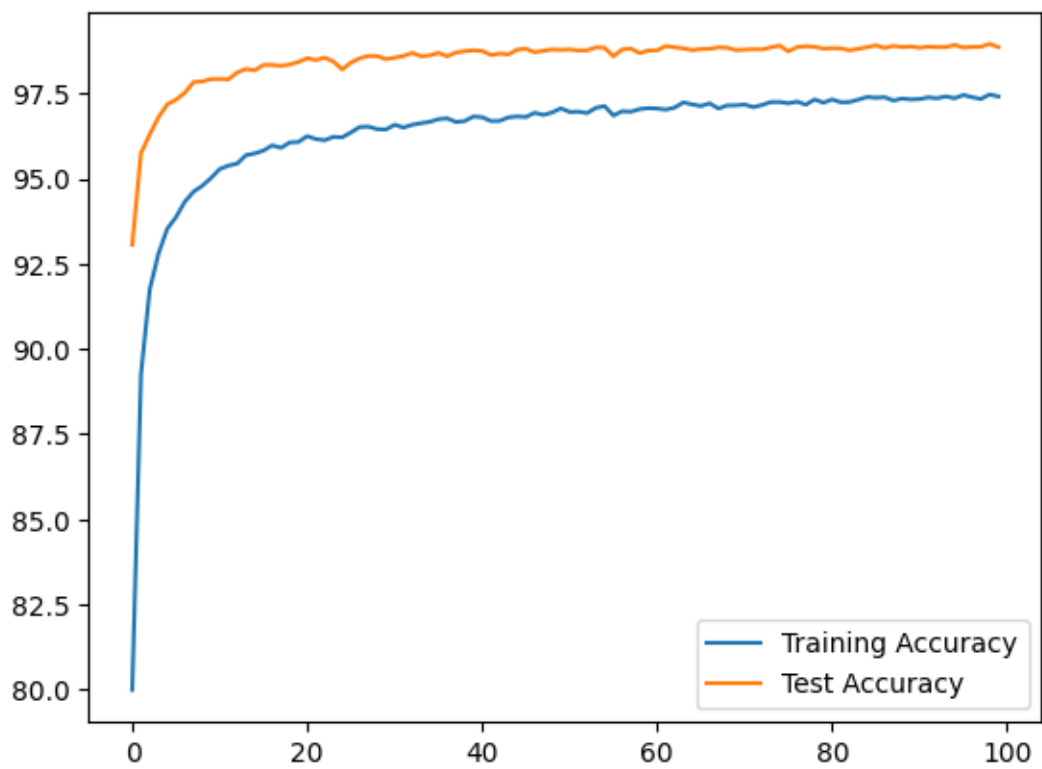
epoch:33	Train Loss:	0.12	Train Accuracy:	96.58	Test
Loss:	0.05	Test Accuracy:	98.69	Tolerance Count:0	
epoch:34	Train Loss:	0.13	Train Accuracy:	96.63	Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:0	
epoch:35	Train Loss:	0.12	Train Accuracy:	96.67	Test
Loss:	0.05	Test Accuracy:	98.61	Tolerance Count:0	
epoch:36	Train Loss:	0.12	Train Accuracy:	96.74	Test
Loss:	0.05	Test Accuracy:	98.69	Tolerance Count:0	
epoch:37	Train Loss:	0.12	Train Accuracy:	96.77	Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:0	
epoch:38	Train Loss:	0.12	Train Accuracy:	96.66	Test
Loss:	0.05	Test Accuracy:	98.70	Tolerance Count:0	
epoch:39	Train Loss:	0.12	Train Accuracy:	96.69	Test
Loss:	0.05	Test Accuracy:	98.74	Tolerance Count:0	
epoch:40	Train Loss:	0.12	Train Accuracy:	96.82	Test
Loss:	0.04	Test Accuracy:	98.76	Tolerance Count:0	
epoch:41	Train Loss:	0.12	Train Accuracy:	96.80	Test
Loss:	0.05	Test Accuracy:	98.75	Tolerance Count:0	
epoch:42	Train Loss:	0.12	Train Accuracy:	96.69	Test
Loss:	0.05	Test Accuracy:	98.63	Tolerance Count:0	
epoch:43	Train Loss:	0.12	Train Accuracy:	96.69	Test
Loss:	0.05	Test Accuracy:	98.67	Tolerance Count:0	
epoch:44	Train Loss:	0.12	Train Accuracy:	96.80	Test
Loss:	0.05	Test Accuracy:	98.65	Tolerance Count:0	
epoch:45	Train Loss:	0.12	Train Accuracy:	96.82	Test
Loss:	0.04	Test Accuracy:	98.78	Tolerance Count:0	
epoch:46	Train Loss:	0.11	Train Accuracy:	96.81	Test
Loss:	0.04	Test Accuracy:	98.81	Tolerance Count:0	
epoch:47	Train Loss:	0.12	Train Accuracy:	96.93	Test
Loss:	0.05	Test Accuracy:	98.71	Tolerance Count:0	
epoch:48	Train Loss:	0.12	Train Accuracy:	96.87	Test
Loss:	0.05	Test Accuracy:	98.75	Tolerance Count:0	
epoch:49	Train Loss:	0.11	Train Accuracy:	96.94	Test
Loss:	0.05	Test Accuracy:	98.79	Tolerance Count:0	
epoch:50	Train Loss:	0.11	Train Accuracy:	97.06	Test
Loss:	0.04	Test Accuracy:	98.78	Tolerance Count:0	
epoch:51	Train Loss:	0.11	Train Accuracy:	96.95	Test
Loss:	0.04	Test Accuracy:	98.79	Tolerance Count:0	
epoch:52	Train Loss:	0.11	Train Accuracy:	96.97	Test
Loss:	0.04	Test Accuracy:	98.76	Tolerance Count:0	
epoch:53	Train Loss:	0.12	Train Accuracy:	96.92	Test
Loss:	0.04	Test Accuracy:	98.76	Tolerance Count:0	
epoch:54	Train Loss:	0.11	Train Accuracy:	97.08	Test
Loss:	0.04	Test Accuracy:	98.85	Tolerance Count:0	
epoch:55	Train Loss:	0.11	Train Accuracy:	97.13	Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:56	Train Loss:	0.12	Train Accuracy:	96.85	Test
Loss:	0.05	Test Accuracy:	98.59	Tolerance Count:0	

epoch:57	Train Loss:	0.11	Train Accuracy:	96.98	Test
Loss:	0.04	Test Accuracy:	98.79	Tolerance Count:0	
epoch:58	Train Loss:	0.11	Train Accuracy:	96.96	Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	
epoch:59	Train Loss:	0.11	Train Accuracy:	97.04	Test
Loss:	0.04	Test Accuracy:	98.68	Tolerance Count:0	
epoch:60	Train Loss:	0.11	Train Accuracy:	97.07	Test
Loss:	0.05	Test Accuracy:	98.76	Tolerance Count:0	
epoch:61	Train Loss:	0.11	Train Accuracy:	97.06	Test
Loss:	0.04	Test Accuracy:	98.76	Tolerance Count:0	
epoch:62	Train Loss:	0.11	Train Accuracy:	97.03	Test
Loss:	0.04	Test Accuracy:	98.89	Tolerance Count:0	
epoch:63	Train Loss:	0.11	Train Accuracy:	97.09	Test
Loss:	0.04	Test Accuracy:	98.85	Tolerance Count:0	
epoch:64	Train Loss:	0.10	Train Accuracy:	97.24	Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	
epoch:65	Train Loss:	0.11	Train Accuracy:	97.18	Test
Loss:	0.04	Test Accuracy:	98.77	Tolerance Count:0	
epoch:66	Train Loss:	0.11	Train Accuracy:	97.13	Test
Loss:	0.05	Test Accuracy:	98.80	Tolerance Count:0	
epoch:67	Train Loss:	0.11	Train Accuracy:	97.21	Test
Loss:	0.04	Test Accuracy:	98.81	Tolerance Count:0	
epoch:68	Train Loss:	0.11	Train Accuracy:	97.06	Test
Loss:	0.04	Test Accuracy:	98.85	Tolerance Count:0	
epoch:69	Train Loss:	0.11	Train Accuracy:	97.15	Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:70	Train Loss:	0.11	Train Accuracy:	97.15	Test
Loss:	0.04	Test Accuracy:	98.77	Tolerance Count:0	
epoch:71	Train Loss:	0.10	Train Accuracy:	97.17	Test
Loss:	0.04	Test Accuracy:	98.78	Tolerance Count:0	
epoch:72	Train Loss:	0.11	Train Accuracy:	97.10	Test
Loss:	0.04	Test Accuracy:	98.80	Tolerance Count:0	
epoch:73	Train Loss:	0.10	Train Accuracy:	97.16	Test
Loss:	0.04	Test Accuracy:	98.79	Tolerance Count:0	
epoch:74	Train Loss:	0.10	Train Accuracy:	97.25	Test
Loss:	0.04	Test Accuracy:	98.85	Tolerance Count:0	
epoch:75	Train Loss:	0.11	Train Accuracy:	97.25	Test
Loss:	0.04	Test Accuracy:	98.90	Tolerance Count:0	
epoch:76	Train Loss:	0.10	Train Accuracy:	97.21	Test
Loss:	0.04	Test Accuracy:	98.73	Tolerance Count:0	
epoch:77	Train Loss:	0.10	Train Accuracy:	97.26	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:78	Train Loss:	0.10	Train Accuracy:	97.17	Test
Loss:	0.04	Test Accuracy:	98.88	Tolerance Count:0	
epoch:79	Train Loss:	0.10	Train Accuracy:	97.32	Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:80	Train Loss:	0.11	Train Accuracy:	97.23	Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	

epoch:81	Train Loss:	0.10	Train Accuracy:	97.32	Test
Loss:	0.04	Test Accuracy:	98.83	Tolerance Count:0	
epoch:82	Train Loss:	0.10	Train Accuracy:	97.24	Test
Loss:	0.04	Test Accuracy:	98.82	Tolerance Count:0	
epoch:83	Train Loss:	0.10	Train Accuracy:	97.25	Test
Loss:	0.04	Test Accuracy:	98.76	Tolerance Count:0	
epoch:84	Train Loss:	0.10	Train Accuracy:	97.32	Test
Loss:	0.04	Test Accuracy:	98.81	Tolerance Count:0	
epoch:85	Train Loss:	0.10	Train Accuracy:	97.40	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:86	Train Loss:	0.10	Train Accuracy:	97.37	Test
Loss:	0.04	Test Accuracy:	98.91	Tolerance Count:0	
epoch:87	Train Loss:	0.10	Train Accuracy:	97.39	Test
Loss:	0.04	Test Accuracy:	98.83	Tolerance Count:0	
epoch:88	Train Loss:	0.10	Train Accuracy:	97.29	Test
Loss:	0.04	Test Accuracy:	98.90	Tolerance Count:0	
epoch:89	Train Loss:	0.10	Train Accuracy:	97.35	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:90	Train Loss:	0.10	Train Accuracy:	97.32	Test
Loss:	0.04	Test Accuracy:	98.88	Tolerance Count:0	
epoch:91	Train Loss:	0.10	Train Accuracy:	97.34	Test
Loss:	0.04	Test Accuracy:	98.84	Tolerance Count:0	
epoch:92	Train Loss:	0.10	Train Accuracy:	97.38	Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:93	Train Loss:	0.10	Train Accuracy:	97.36	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:94	Train Loss:	0.10	Train Accuracy:	97.41	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	
epoch:95	Train Loss:	0.10	Train Accuracy:	97.36	Test
Loss:	0.04	Test Accuracy:	98.92	Tolerance Count:0	
epoch:96	Train Loss:	0.10	Train Accuracy:	97.45	Test
Loss:	0.04	Test Accuracy:	98.85	Tolerance Count:0	
epoch:97	Train Loss:	0.10	Train Accuracy:	97.39	Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:98	Train Loss:	0.10	Train Accuracy:	97.34	Test
Loss:	0.04	Test Accuracy:	98.87	Tolerance Count:0	
epoch:99	Train Loss:	0.10	Train Accuracy:	97.47	Test
Loss:	0.04	Test Accuracy:	98.95	Tolerance Count:0	
epoch:100	Train Loss:	0.10	Train Accuracy:	97.41	Test
Loss:	0.04	Test Accuracy:	98.86	Tolerance Count:0	

Duration: 828 seconds

```
[40]: show_metrics(train_accuracies, test_accuracies, train_mean_losses,
↳test_mean_losses)
eval_model(ecg_ann_model_1, X_test_tensor, y_test_tensor)
profile(ecg_ann_model_1,tuple([200]))
```



	precision	recall	f1-score	support
0	0.99	1.00	0.99	717
1	0.97	0.99	0.98	1582
2	0.99	0.99	0.99	14689
3	0.99	1.00	0.99	1436
4	0.96	0.93	0.94	1411
accuracy			0.99	19835
macro avg	0.98	0.98	0.98	19835
weighted avg	0.99	0.99	0.99	19835

```
[[ 716    0    1    0    0]
 [   0 1567   12    0    3]
 [   1   19 14610   12   47]
 [   0    0    4 1430    2]
 [   7   28   61    9 1306]]
```

Duration: 1 seconds

Warning: module Dropout is treated as a zero-op.

Warning: module ECGANNModel is treated as a zero-op.

```
ECGANNModel(
  26.55 k, 100.000% Params, 26.73 KMac, 100.000% MACs,
  (layers): Sequential(
    26.55 k, 100.000% Params, 26.73 KMac, 100.000% MACs,
    (0): Linear(20.1 k, 75.692% Params, 20.1 KMac, 75.196% MACs,
in_features=200, out_features=100, bias=True)
    (1): ReLU(0, 0.000% Params, 100.0 Mac, 0.374% MACs, inplace=True)
    (2): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
    (3): Linear(5.05 k, 19.017% Params, 5.05 KMac, 18.893% MACs,
in_features=100, out_features=50, bias=True)
    (4): ReLU(0, 0.000% Params, 50.0 Mac, 0.187% MACs, inplace=True)
    (5): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
    (6): Linear(1.27 k, 4.801% Params, 1.27 KMac, 4.770% MACs, in_features=50,
out_features=25, bias=True)
    (7): ReLU(0, 0.000% Params, 25.0 Mac, 0.094% MACs, inplace=True)
    (8): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
    (9): Linear(130, 0.490% Params, 130.0 Mac, 0.486% MACs, in_features=25,
out_features=5, bias=True)
  )
)
```

Computational complexity: 26.73 KMac

Computational complexity: 53.46 KFlops

Number of parameters: 26.55 k

1.4 CNN

```
[41]: ecg_cnn_model = ECGCNNModel()
```

```
[42]: count_parameters(ecg_cnn_model)
```

```
48
16
1536
32
32
32
6144
64
24576
128
128
128
2432000
100
5000
50
250
5
-----
2470269
```

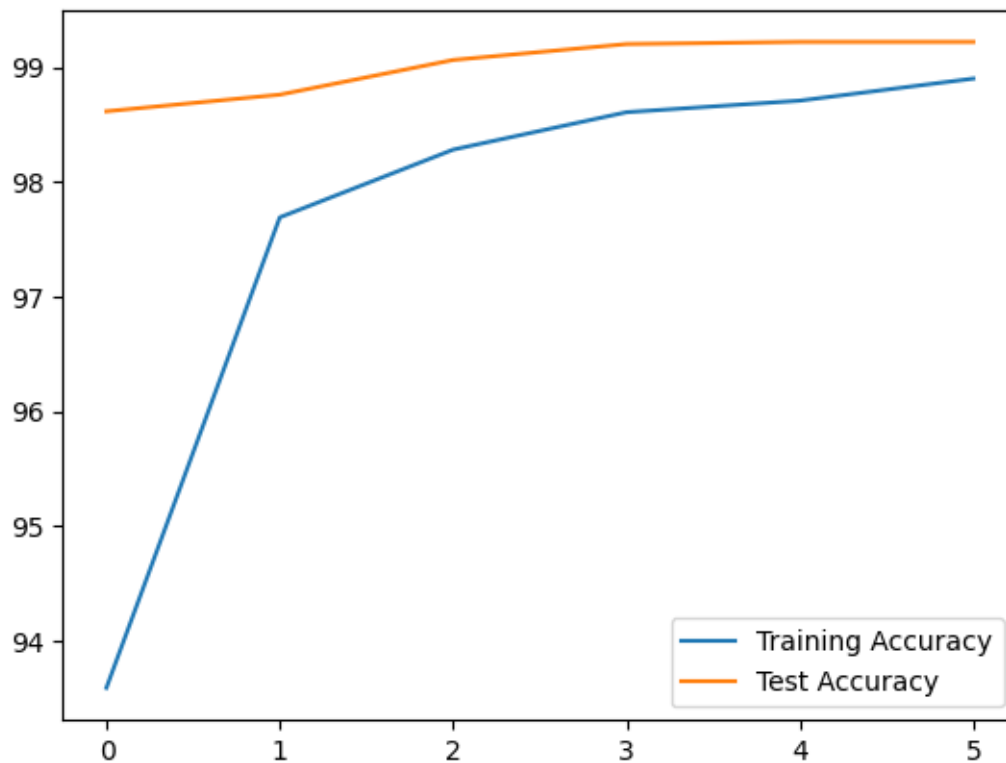
```
[43]: train_accuracies, test_accuracies, train_mean_losses, test_mean_losses = ↳train_model(
    model=ecg_cnn_model,
    X_train=X_train_tensor.reshape(-1, 1, 200),
    y_train=y_train_tensor,
    X_test=X_val_tensor.reshape(-1, 1, 200),
    y_test=y_val_tensor,
    learning_rate=0.001,
    batch_size=100,
    val_batch_size=100,
    epochs=6,
)
```

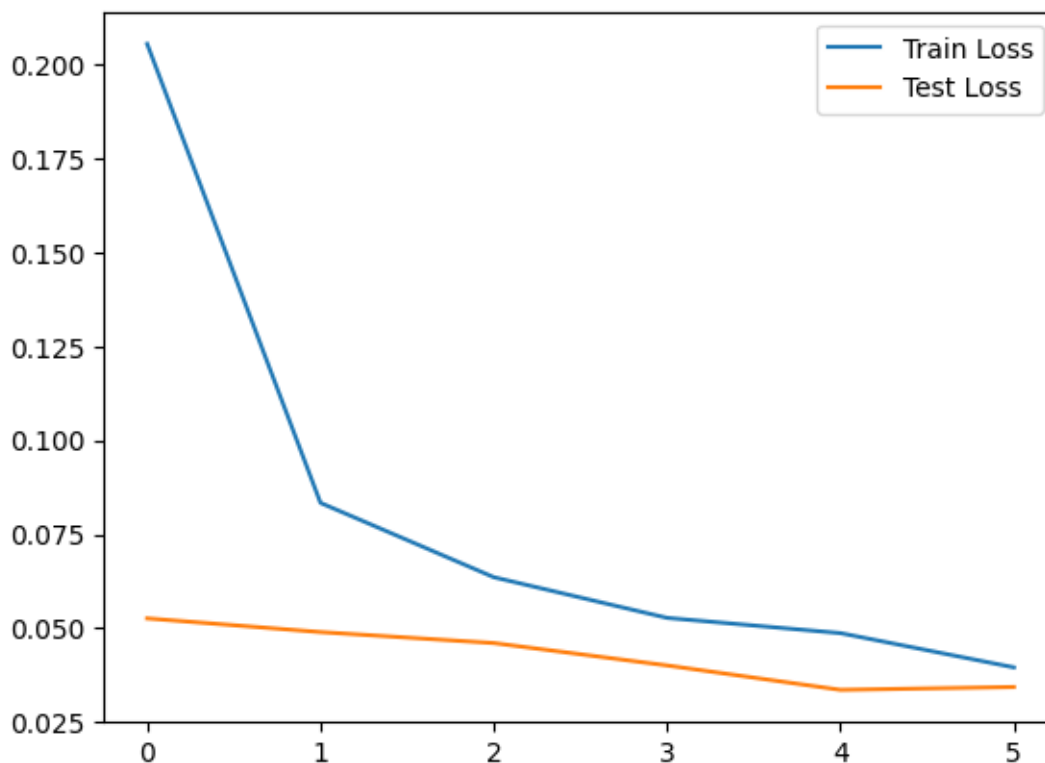
epoch:1 Train Loss:	0.21	Train Accuracy:	93.59	Test Loss:
0.05 Test Accuracy:	98.61	Tolerance Count:	0	
epoch:2 Train Loss:	0.08	Train Accuracy:	97.69	Test Loss:
0.05 Test Accuracy:	98.76	Tolerance Count:	0	
epoch:3 Train Loss:	0.06	Train Accuracy:	98.28	Test Loss:
0.05 Test Accuracy:	99.06	Tolerance Count:	0	
epoch:4 Train Loss:	0.05	Train Accuracy:	98.61	Test Loss:
0.04 Test Accuracy:	99.20	Tolerance Count:	0	

```
epoch:5 Train Loss:      0.05 Train Accuracy:      98.71      Test Loss:
0.03 Test Accuracy:      99.22      Tolerance Count:0
epoch:6 Train Loss:      0.04 Train Accuracy:      98.90      Test Loss:
0.03 Test Accuracy:      99.22      Tolerance Count:0
```

Duration: 840 seconds

```
[46]: show_metrics(train_accuracies, test_accuracies, train_mean_losses,
↳test_mean_losses)
eval_model(ecg_cnn_model, X_test_tensor.reshape(-1, 1, 200), y_test_tensor)
profile(ecg_cnn_model, tuple([1,200]))
```





	precision	recall	f1-score	support
0	1.00	1.00	1.00	725
1	0.99	0.99	0.99	1616
2	1.00	0.99	1.00	14746
3	1.00	1.00	1.00	1450
4	0.94	0.98	0.96	1298
accuracy			0.99	19835
macro avg	0.98	0.99	0.99	19835
weighted avg	0.99	0.99	0.99	19835

```

[[ 723    0    2    0    0]
 [   0 1594    5    0   17]
 [   0   10 14659    7   70]
 [   0    0    5 1444    1]
 [   1   10   17    0 1270]]

```

Duration: 12 seconds

Warning: variables `__flops__` or `__params__` are already defined for the moduleConv1d ptflops can affect your code!

Warning: variables `__flops__` or `__params__` are already defined for the

```

moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleConv1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleMaxPool1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleBatchNorm1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleConv1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleConv1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleMaxPool1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleBatchNorm1d ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleLinear ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleLinear ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleReLU ptflops can affect your code!
Warning: variables __flops__ or __params__ are already defined for the
moduleLinear ptflops can affect your code!
Warning: module Flatten is treated as a zero-op.
Warning: module Dropout is treated as a zero-op.
Warning: module ECGCNNModel is treated as a zero-op.
ECGCNNModel(
  2.47 M, 100.000% Params, 8.81 MMac, 100.000% MACs,
  (conv_layer): Sequential(
    32.86 k, 1.330% Params, 6.37 MMac, 72.339% MACs,
    (0): Conv1d(64, 0.003% Params, 12.67 KMac, 0.144% MACs, 1, 16,
kernel_size=(3,), stride=(1,))
    (1): ReLU(0, 0.000% Params, 3.17 KMac, 0.036% MACs, inplace=True)
    (2): Conv1d(1.57 k, 0.063% Params, 307.33 KMac, 3.488% MACs, 16, 32,
kernel_size=(3,), stride=(1,))
    (3): ReLU(0, 0.000% Params, 6.27 KMac, 0.071% MACs, inplace=True)
    (4): MaxPool1d(0, 0.000% Params, 6.27 KMac, 0.071% MACs, kernel_size=2,
stride=1, padding=0, dilation=1, ceil_mode=False)
    (5): BatchNorm1d(64, 0.003% Params, 12.48 KMac, 0.142% MACs, 32, eps=1e-05,
momentum=0.1, affine=True, track_running_stats=True)

```

```

(6): Conv1d(6.21 k, 0.251% Params, 1.2 MMac, 13.596% MACs, 32, 64,
kernel_size=(3,), stride=(1,))
(7): ReLU(0, 0.000% Params, 12.35 KMac, 0.140% MACs, inplace=True)
(8): Conv1d(24.7 k, 1.000% Params, 4.72 MMac, 53.544% MACs, 64, 128,
kernel_size=(3,), stride=(1,))
(9): ReLU(0, 0.000% Params, 24.45 KMac, 0.277% MACs, inplace=True)
(10): MaxPool1d(0, 0.000% Params, 24.45 KMac, 0.277% MACs, kernel_size=2,
stride=1, padding=0, dilation=1, ceil_mode=False)
(11): BatchNorm1d(256, 0.010% Params, 48.64 KMac, 0.552% MACs, 128,
eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
(12): Flatten(0, 0.000% Params, 0.0 Mac, 0.000% MACs, start_dim=1,
end_dim=-1)
)
(fc_layers): Sequential(
  2.44 M, 98.670% Params, 2.44 MMac, 27.661% MACs,
  (0): Linear(2.43 M, 98.455% Params, 2.43 MMac, 27.599% MACs,
in_features=24320, out_features=100, bias=True)
  (1): ReLU(0, 0.000% Params, 100.0 Mac, 0.001% MACs, inplace=True)
  (2): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
  (3): Linear(5.05 k, 0.204% Params, 5.05 KMac, 0.057% MACs, in_features=100,
out_features=50, bias=True)
  (4): ReLU(0, 0.000% Params, 50.0 Mac, 0.001% MACs, inplace=True)
  (5): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
  (6): Linear(255, 0.010% Params, 255.0 Mac, 0.003% MACs, in_features=50,
out_features=5, bias=True)
)
)
Computational complexity: 8.81 MMac
Computational complexity: 17.62 MFlops
Number of parameters: 2.47 M

```

1.5 LSTM

```
[47]: ecg_lstm_model = ECGLSTMModel()
```

```
[48]: ecg_lstm_model.parameters()
```

```
[48]: <generator object Module.parameters at 0x7f2b2e99b890>
```

```
[49]: ecg_lstm_model.parameters
```

```

[49]: <bound method Module.parameters of ECGLSTMModel(
  (lstm): LSTM(200, 50, num_layers=2, batch_first=True)
  (fc): Sequential(
    (0): Flatten(start_dim=1, end_dim=-1)
    (1): Linear(in_features=50, out_features=25, bias=True)
    (2): ReLU(inplace=True)

```

```

        (3): Dropout(p=0.5, inplace=False)
        (4): Linear(in_features=25, out_features=5, bias=True)
    )
)>

```

```
[50]: count_parameters(ecg_lstm_model)
```

```

40000
10000
 200
 200
10000
10000
 200
 200
1250
 25
125
 5

```

```

-----
72205

```

```
[51]: train_accuracies, test_accuracies, train_mean_losses, test_mean_losses = \
    ↪train_model(
        model=ecg_lstm_model,
        X_train=X_train_tensor.reshape(-1,1,200),
        y_train=y_train_tensor,
        X_test=X_val_tensor.reshape(-1,1,200),
        y_test=y_val_tensor,
        learning_rate=0.001,
        batch_size=100,
        val_batch_size=100,
        epochs=10, lstm=True
    )

```

epoch:1 Train Loss:	0.48	Train Accuracy:	81.91	Test Loss:
0.15 Test Accuracy:	95.36	Tolerance Count:	0	
epoch:2 Train Loss:	0.15	Train Accuracy:	95.65	Test Loss:
0.08 Test Accuracy:	97.91	Tolerance Count:	0	
epoch:3 Train Loss:	0.10	Train Accuracy:	97.48	Test Loss:
0.06 Test Accuracy:	98.51	Tolerance Count:	0	
epoch:4 Train Loss:	0.08	Train Accuracy:	98.01	Test Loss:
0.05 Test Accuracy:	98.68	Tolerance Count:	0	
epoch:5 Train Loss:	0.07	Train Accuracy:	98.34	Test Loss:
0.05 Test Accuracy:	98.83	Tolerance Count:	0	
epoch:6 Train Loss:	0.06	Train Accuracy:	98.52	Test Loss:
0.05 Test Accuracy:	98.93	Tolerance Count:	0	

```

epoch:7 Train Loss:      0.05 Train Accuracy:      98.66      Test Loss:
0.04 Test Accuracy:      98.95      Tolerance Count:0
epoch:8 Train Loss:      0.05 Train Accuracy:      98.74      Test Loss:
0.04 Test Accuracy:      99.00      Tolerance Count:0
epoch:9 Train Loss:      0.05 Train Accuracy:      98.87      Test Loss:
0.04 Test Accuracy:      99.02      Tolerance Count:0
epoch:10      Train Loss:      0.04 Train Accuracy:      98.92      Test
Loss:      0.04 Test Accuracy:      99.12      Tolerance Count:0

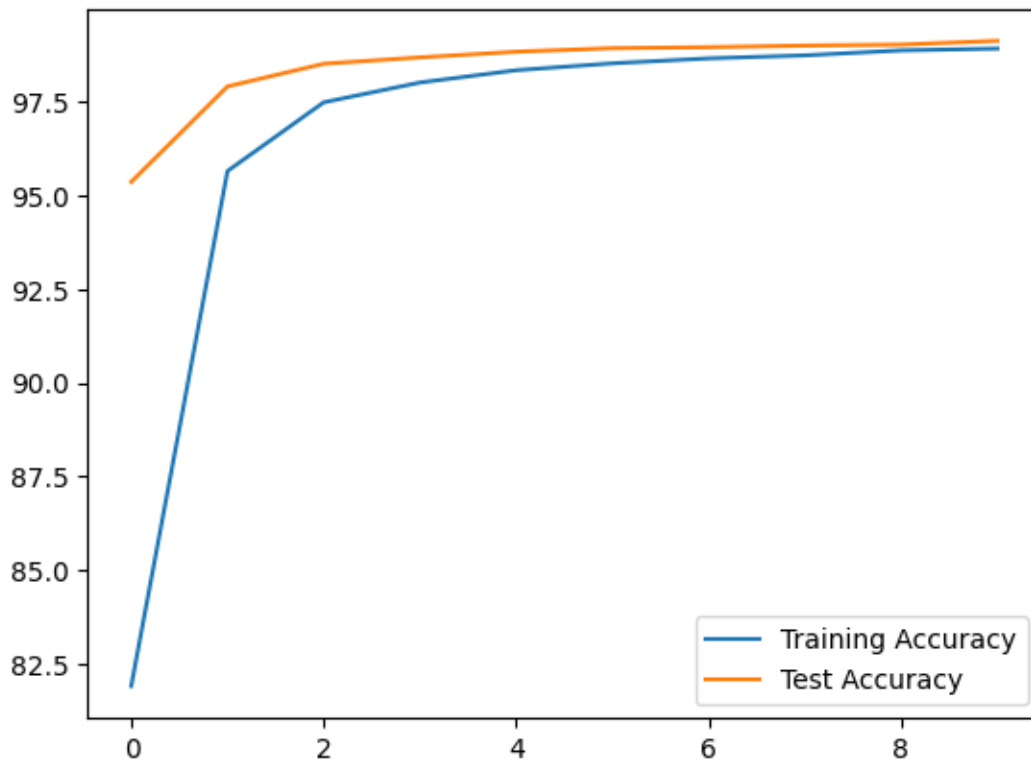
```

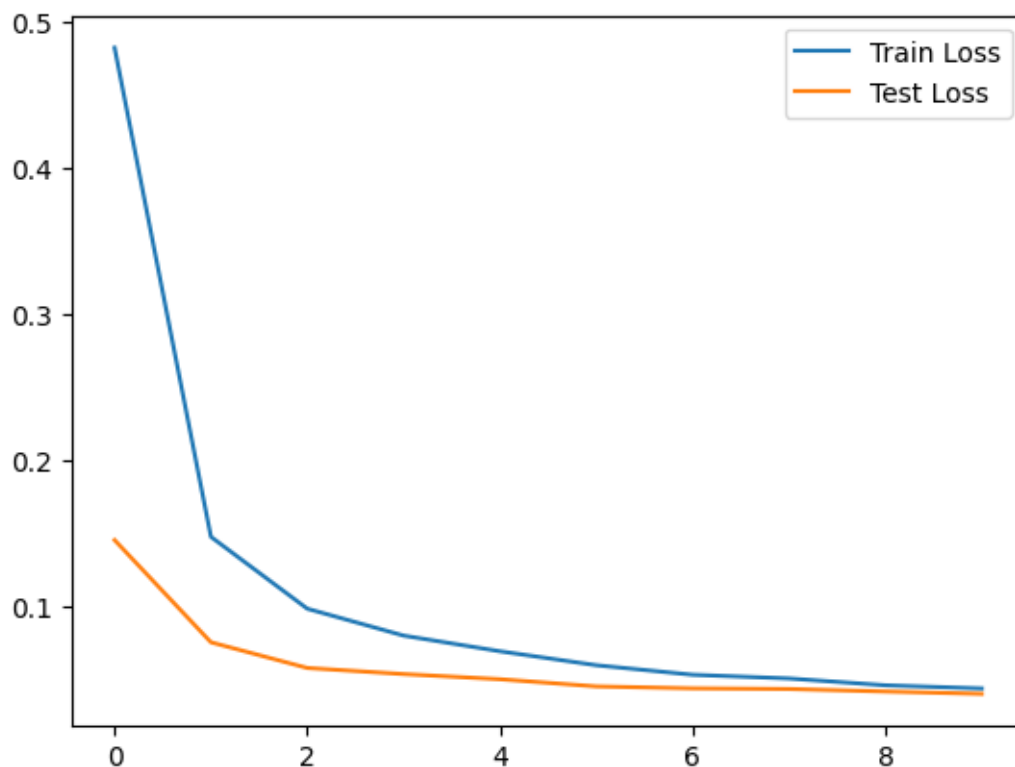
Duration: 110 seconds

```

[52]: show_metrics(train_accuracies, test_accuracies, train_mean_losses,
↳test_mean_losses)
eval_model(ecg_lstm_model, X_test_tensor.reshape(-1, 1, 200), y_test_tensor)
profile(ecg_lstm_model,tuple([ 1, 200]))

```





	precision	recall	f1-score	support
0	1.00	1.00	1.00	724
1	0.98	0.98	0.98	1627
2	1.00	0.99	1.00	14714
3	0.99	0.99	0.99	1454
4	0.94	0.97	0.96	1316
accuracy			0.99	19835
macro avg	0.98	0.99	0.98	19835
weighted avg	0.99	0.99	0.99	19835


```

[[ 723    0    1    0    0]
 [   0 1587   19    0   21]
 [   0   12 14637    9   56]
 [   0    0   13 1438    3]
 [   1   15   18    4 1278]]

```

Duration: 1 seconds

Warning: module Flatten is treated as a zero-op.

Warning: module Dropout is treated as a zero-op.

Warning: module ECGLSTMModel is treated as a zero-op.


```

ECGLSTMModel(
  72.2 k, 100.000% Params, 73.23 KMac, 100.000% MACs,
  (lstm): LSTM(70.8 k, 98.054% Params, 71.8 KMac, 98.047% MACs, 200, 50,
num_layers=2, batch_first=True)
  (fc): Sequential(
    1.41 k, 1.946% Params, 1.43 KMac, 1.953% MACs,
    (0): Flatten(0, 0.000% Params, 0.0 Mac, 0.000% MACs, start_dim=1,
end_dim=-1)
    (1): Linear(1.27 k, 1.766% Params, 1.27 KMac, 1.741% MACs, in_features=50,
out_features=25, bias=True)
    (2): ReLU(0, 0.000% Params, 25.0 Mac, 0.034% MACs, inplace=True)
    (3): Dropout(0, 0.000% Params, 0.0 Mac, 0.000% MACs, p=0.5, inplace=False)
    (4): Linear(130, 0.180% Params, 130.0 Mac, 0.178% MACs, in_features=25,
out_features=5, bias=True)
  )
)
Computational complexity: 73.23 KMac
Computational complexity: 146.46 KFlops
Number of parameters: 72.2 k

```

[]:

[]:

[]:

[]: