Capstone 1: Data Analysis of speech-to-text accuracy

March 19, 2025

0.0.1 Part 1: Data Analysis and Visualization

Task 1: Dataset Selection & Exploration Step 1: Import Datasets

[1]:
```
import os

#Navigate. to the audio clip directory
audio_dir = '/content/drive/MyDrive/Colab_Notebooks/M2M Tech/Mozilla Common␣
 ↪Voice/clips'

#List the audio file extensions
audio_extensions = [file.split('.')[-1] for file in os.listdir(audio_dir)]

#Print the unique audio file extensions
print(set(audio_extensions))
```

```
{'mp3'}
```

Step 2: Inspect Transcription Text Files

The transcription text files are in TSV(Tab Seperated Values) format. Lets load one of the files.

[2]:
```
import pandas as pd
import numpy as np

#Load the validation.tsv file
validated_df = pd.read_csv('/content/drive/MyDrive/Colab_Notebooks/M2M Tech/
 ↪Mozilla Common Voice/validated.tsv', sep='\t')

copy_df = validated_df.copy()

#Display the first few rows of the dataframe
validated_df.head()
```

[2]:

	client_id	\
0	031903093b6fa1aeb0a243843eb9ed57baf6e99d1f8f92…	
1	058fe5b1170aa09ef3f1092b179384639bc46ac53c1675…	
2	08190396a5c298331813531d1a832b56d8ffe44aaedcb7…	
3	14698ee63cabe08b43f0faa93304202d1e6ffeaa2cdf86…	
4	28d8f8a88afad9eb9e5b36ee84bd4c5ba84137310da15f…	

```
                          path  \
0  common_voice_en_41383256.mp3
1  common_voice_en_41823983.mp3
2  common_voice_en_41881685.mp3
3  common_voice_en_41799514.mp3
4  common_voice_en_41552032.mp3

                                          sentence_id  \
0  f19a785911b1a3b1338e3eb5cc785e58b8381d21ec7c33…
1  f50360e1be367d8155b3c8340f0b3d38d1e6701df79dc5…
2  f4f3a5714cc36a9abbabf78a33feb4a9c368005f1f4bf5…
3  f4d04f6e48777c3ad180c629858a19fdfa4cb875d2bb22…
4  f262ed293fa5fe0986d1e7a80b5bbae11205f8089a1857…

                                            sentence  sentence_domain  \
0  The outer rim has undergone some erosion due t…              NaN
1  For purposes of this definition, the intent ma…              NaN
2  Bennett was educated at Lawnswood High School,…              NaN
3  These rules became known as Admiral-Lord Mount…              NaN
4  The grouping traditionally called apes is brac…              NaN

   up_votes  down_votes       age           gender  \
0         2           0       NaN              NaN
1         3           0   fifties  female_feminine
2         2           0  fourties  female_feminine
3         2           0  twenties              NaN
4         2           0       NaN              NaN

                                accents  variant locale  segment
0                                   NaN      NaN     en      NaN
1  United States English,Washington State      NaN     en      NaN
2    United States English,southern draw      NaN     en      NaN
3                         Japan English      NaN     en      NaN
4     Canadian English,English Hungarian      NaN     en      NaN
```

[3]:
```
validated_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 250 entries, 0 to 249
Data columns (total 13 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   client_id        250 non-null    object
 1   path             250 non-null    object
 2   sentence_id      250 non-null    object
 3   sentence         250 non-null    object
```

```
 4   sentence_domain  0 non-null      float64
 5   up_votes         250 non-null    int64
 6   down_votes       250 non-null    int64
 7   age              230 non-null    object
 8   gender           122 non-null    object
 9   accents          240 non-null    object
 10  variant          0 non-null      float64
 11  locale           250 non-null    object
 12  segment          0 non-null      float64
dtypes: float64(3), int64(2), object(8)
memory usage: 25.5+ KB
```

0.0.2 Task 2: Data Cleaning

Step 1: Check for na's

[4]:
```
# Check for missing values
print(validated_df.isnull().sum())

# Drop rows with missing values
validated_df = validated_df.fillna('Unknown')
print('\n')
# Check the updated DataFrame
print(validated_df.head())
```

```
client_id            0
path                 0
sentence_id          0
sentence             0
sentence_domain    250
up_votes             0
down_votes           0
age                 20
gender             128
accents             10
variant            250
locale               0
segment            250
dtype: int64


                                           client_id  \
0  031903093b6fa1aeb0a243843eb9ed57baf6e99d1f8f92…
1  058fe5b1170aa09ef3f1092b179384639bc46ac53c1675…
2  08190396a5c298331813531d1a832b56d8ffe44aaedcb7…
3  14698ee63cabe08b43f0faa93304202d1e6ffeaa2cdf86…
4  28d8f8a88afad9eb9e5b36ee84bd4c5ba84137310da15f…
```

```
                          path  \
0  common_voice_en_41383256.mp3
1  common_voice_en_41823983.mp3
2  common_voice_en_41881685.mp3
3  common_voice_en_41799514.mp3
4  common_voice_en_41552032.mp3

                                        sentence_id  \
0  f19a785911b1a3b1338e3eb5cc785e58b8381d21ec7c33…
1  f50360e1be367d8155b3c8340f0b3d38d1e6701df79dc5…
2  f4f3a5714cc36a9abbabf78a33feb4a9c368005f1f4bf5…
3  f4d04f6e48777c3ad180c629858a19fdfa4cb875d2bb22…
4  f262ed293fa5fe0986d1e7a80b5bbae11205f8089a1857…

                                          sentence sentence_domain  \
0  The outer rim has undergone some erosion due t…         Unknown
1  For purposes of this definition, the intent ma…         Unknown
2  Bennett was educated at Lawnswood High School,…         Unknown
3  These rules became known as Admiral-Lord Mount…         Unknown
4  The grouping traditionally called apes is brac…         Unknown

   up_votes  down_votes       age           gender  \
0         2           0   Unknown          Unknown
1         3           0   fifties  female_feminine
2         2           0  fourties  female_feminine
3         2           0  twenties          Unknown
4         2           0   Unknown          Unknown

                               accents  variant locale  segment
0                              Unknown  Unknown     en  Unknown
1  United States English,Washington State  Unknown     en  Unknown
2    United States English,southern draw  Unknown     en  Unknown
3                         Japan English  Unknown     en  Unknown
4     Canadian English,English Hungarian  Unknown     en  Unknown
```

[5]:
```
print(validated_df.columns)
```

```
Index(['client_id', 'path', 'sentence_id', 'sentence', 'sentence_domain',
       'up_votes', 'down_votes', 'age', 'gender', 'accents', 'variant',
       'locale', 'segment'],
      dtype='object')
```

Task 2: Clean up age column and change datatype

[6]:
```
#Get unique values from the age column
unique_ages = validated_df['age'].unique()

#Print the unique ages
```

```
print(unique_ages)
```

```
['Unknown' 'fifties' 'fourties' 'twenties' 'sixties' 'thirties'
 'seventies' 'teens']
```

[7]:
```
# Define the age mapping
age_mapping = {'Unknown':np.nan, 'teens':15, 'twenties':25, 'thirties':35,␣
 ↪'fourties':45, 'fifties':55, 'sixties':65, 'seventies':75}

#Replace string values with numeric ages
validated_df['age'] = validated_df['age'].replace(age_mapping).astype('float64')

print(validated_df['age'])
print('\n')
print(validated_df['age'].describe())
```

```
0       NaN
1      55.0
2      45.0
3      25.0
4       NaN
       …
245    65.0
246    65.0
247    65.0
248    65.0
249    65.0
Name: age, Length: 250, dtype: float64


count    230.00000
mean      42.00000
std       18.81071
min       15.00000
25%       25.00000
50%       35.00000
75%       65.00000
max       75.00000
Name: age, dtype: float64

<ipython-input-7-91966202e9d2>:5: FutureWarning: Downcasting behavior in
`replace` is deprecated and will be removed in a future version. To retain the
old behavior, explicitly call `result.infer_objects(copy=False)`. To opt-in to
the future behavior, set `pd.set_option('future.no_silent_downcasting', True)`
  validated_df['age'] =
validated_df['age'].replace(age_mapping).astype('float64')
```

Task 3: Clean up gender and accents column and change datatype

[8]:
```
# Get unique values for gender
gender_uniques = validated_df['gender'].unique()
print("Unique values for gender:")
print(gender_uniques)
print('\n')

# Get unique values for accent
accent_uniques = validated_df['accents'].unique()
print("\nUnique values for accents:")
print(accent_uniques)
```

```
Unique values for gender:
['Unknown' 'female_feminine' 'male_masculine' 'non-binary' 'transgender']



Unique values for accents:
['Unknown' 'United States English,Washington State'
 'United States English,southern draw' 'Japan English'
 'Canadian English,English Hungarian' 'United States English'
 'England English,Kent' 'England English'
 'India and South Asia (India, Pakistan, Sri Lanka),South India,Kannadiga'
 'chicago italian' 'United States English,Chicago/Midwestern'
 'Southern African (South Africa, Zimbabwe, Namibia)'
 'India and South Asia (India, Pakistan, Sri Lanka)' 'Filipino'
 'French speaking english' 'Korean' 'Israeli English' 'Canadian English'
 'British with slightly Brazilian accent,British and slightly Brazilian '
 'Californian Accent' 'United States English,German,Russian'
 'United States English,learnt from Spanish' 'geordie ,England Northern'
 'United States English,Malaysian English' 'Japanese English'
 'Scottish English']
```

[9]:
```
gender_mapping = {
    'Unknown': 'Unknown',
    'female_feminine': 'Female',
    'male_masculine': 'Male',
    'non-binary': 'Non-binary',
    'transgender': 'Transgender'
}

accent_mapping = {
    'Unknown': 'Unknown',
    'United States English,Washington State': 'US English',
    'United States English,southern draw': 'US English (Southern)',
    'United States English,Chicago/Midwestern': 'US English (Midwestern)',
    'United States English,German,Russian': 'US English (European influence)',
```

```
    'United States English,learnt from Spanish': 'US English (Latin American␣
↪influence)',
    'United States English,Malaysian English': 'US English (Asian influence)',
    'Canadian English': 'Canadian English',
    'Canadian English,English Hungarian': 'Canadian English (Eastern European␣
↪influence)',
    'England English': 'UK English',
    'England English,Kent': 'UK English (Southern)',
    'British with slightly Brazilian accent,British and slightly Brazilian ':␣
↪'UK English (Latin American influence)',
    'Scottish English': 'UK English (Scottish)',
    'geordie ,England Northern': 'UK English (Northern)',
    'India and South Asia (India, Pakistan, Sri Lanka)': 'South Asian English',
    'India and South Asia (India, Pakistan, Sri Lanka),South India,Kannadiga':␣
↪'South Asian English (Indian influence)',
    'Japan English': 'Japanese English',
    'Japanese English': 'Japanese English',
    'Korean': 'Korean English',
    'Israeli English': 'Middle Eastern English',
    'Filipino': 'Southeast Asian English',
    'French speaking english': 'European English (French influence)',
    'Southern African (South Africa, Zimbabwe, Namibia)': 'African English',
    'chicago italian': 'US English (Italian influence)',
    'Californian Accent': 'US English (West Coast)'
}
```

[10]:
```
validated_df['gender'] = validated_df['gender'].replace(gender_mapping)
validated_df['accents'] = validated_df['accents'].replace(accent_mapping)
```

[11]:
```
validated_df.head()
```

[11]:

	client_id	path	sentence_id
0	031903093b6fa1aeb0a243843eb9ed57baf6e99d1f8f92…	common_voice_en_41383256.mp3	f19a785911b1a3b1338e3eb5cc785e58b8381d21ec7c33…
1	058fe5b1170aa09ef3f1092b179384639bc46ac53c1675…	common_voice_en_41823983.mp3	
2	08190396a5c298331813531d1a832b56d8ffe44aaedcb7…	common_voice_en_41881685.mp3	
3	14698ee63cabe08b43f0faa93304202d1e6ffeaa2cdf86…	common_voice_en_41799514.mp3	
4	28d8f8a88afad9eb9e5b36ee84bd4c5ba84137310da15f…	common_voice_en_41552032.mp3	

```
1  f50360e1be367d8155b3c8340f0b3d38d1e6701df79dc5…
2  f4f3a5714cc36a9abbabf78a33feb4a9c368005f1f4bf5…
3  f4d04f6e48777c3ad180c629858a19fdfa4cb875d2bb22…
4  f262ed293fa5fe0986d1e7a80b5bbae11205f8089a1857…

                                            sentence sentence_domain  \
0  The outer rim has undergone some erosion due t…         Unknown
1  For purposes of this definition, the intent ma…         Unknown
2  Bennett was educated at Lawnswood High School,…         Unknown
3  These rules became known as Admiral-Lord Mount…         Unknown
4  The grouping traditionally called apes is brac…         Unknown

   up_votes  down_votes   age   gender  \
0         2           0   NaN  Unknown
1         3           0  55.0   Female
2         2           0  45.0   Female
3         2           0  25.0  Unknown
4         2           0   NaN  Unknown

                                       accents  variant locale  segment
0                                      Unknown  Unknown     en  Unknown
1                                   US English  Unknown     en  Unknown
2                         US English (Southern)  Unknown     en  Unknown
3                              Japanese English  Unknown     en  Unknown
4  Canadian English (Eastern European influence)  Unknown     en  Unknown
```

0.0.3 Task 3: Generate Basic Statistics

[12]:
```
# Calculate word frequency
word_freq = validated_df['sentence'].apply(lambda x:len(x.split()))
print("word frequency:")
print(word_freq.describe())

print('\n')
# Calculate sentence length
sentence_length = validated_df['sentence'].apply(lambda x:len(x))
print("sentence length:")
print( sentence_length.describe())
print('\n')

#calculate punctuation use
punctuation_use = validated_df['sentence'].apply(lambda x: sum(not c.isalnum()␣
 ↪for c in x))
print("Punctuation Use:")
print(punctuation_use.describe())
```

```
word frequency:
```

```
count    250.000000
mean       9.964000
std        2.816101
min        3.000000
25%        8.000000
50%       10.000000
75%       12.000000
max       14.000000
Name: sentence, dtype: float64


sentence length:
count    250.000000
mean      61.100000
std       19.364657
min       10.000000
25%       48.000000
50%       61.000000
75%       74.750000
max      102.000000
Name: sentence, dtype: float64


Punctuation Use:
count    250.000000
mean      10.668000
std        3.113285
min        3.000000
25%        8.000000
50%       11.000000
75%       13.000000
max       17.000000
Name: sentence, dtype: float64
```

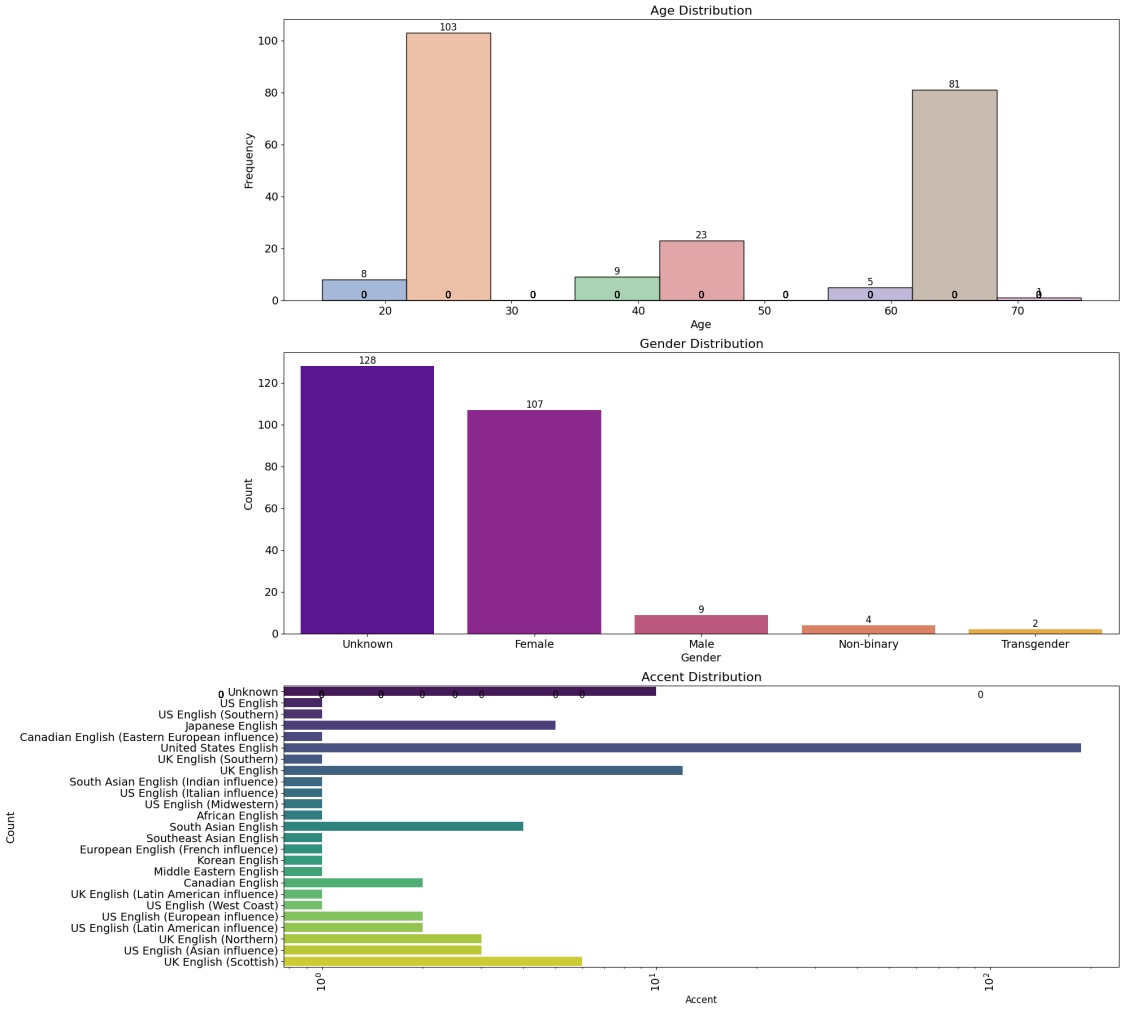
0.0.4 Task 4: Visualizations

[13]:
```
import plotly.express as px
from plotly.subplots import make_subplots

# Create a figure with three subplots
fig = make_subplots(rows=3, cols=1, subplot_titles=['Age Distribution', 'Gender␣
 ↪Distribution', 'Accent Distribution'], vertical_spacing=0.1)

# Add the plots to the subplots
fig.add_trace(px.histogram(validated_df, x='age',␣
 ↪color_discrete_sequence=['rgba(0, 0, 255, 0.5)']).data[0], row=1, col=1)
```

```
fig.add_trace(px.bar(validated_df, x='gender', color_discrete_sequence=px.
 ↪colors.qualitative.Pastel1).data[0], row=2, col=1)
fig.add_trace(px.bar(validated_df, x='accents', color_discrete_sequence=px.
 ↪colors.qualitative.Pastel).data[0], row=3, col=1)

# Update the layout to make the plots larger
fig.update_layout(height=1000, margin=dict(l=50, r=50, t=100, b=50))

# Apply log scale to the y-axis of the Accent Distribution chart (yaxis3)
fig.update_yaxes(type='log', row=3, col=1)

# Show the plot
fig.show()
```

[14]:
```
import matplotlib.pyplot as plt
import seaborn as sns

# Define plot settings
figsize = (20, 18)
bins = 20
rotation = 90

# Create a figure with three subplots
fig, axs = plt.subplots(3, 1, figsize=figsize)

# Define plot functions
def plot_age_distribution(ax):
    sns.histplot(x='age', data=validated_df, hue='age', palette='deep',␣
 ↪legend=False, ax=ax)
    ax.set_title('Age Distribution', fontsize=16)
    ax.set_xlabel('Age', fontsize=14)
    ax.set_ylabel('Frequency', fontsize=14)
    ax.tick_params(axis='both', labelsize=14)
    for patch in ax.patches:
        ax.text(patch.get_x() + patch.get_width()/2, patch.get_height(),␣
 ↪str(int(patch.get_height())), fontsize=12, ha='center', va='bottom',␣
 ↪color='black')

def plot_gender_distribution(ax):
    sns.countplot(x='gender', data=validated_df, hue='gender',␣
 ↪palette='plasma', legend=False, ax=ax)
    ax.set_title('Gender Distribution', fontsize=16)
    ax.set_xlabel('Gender', fontsize=14)
    ax.set_ylabel('Count', fontsize=14)
    ax.tick_params(axis='both', labelsize=14)
    for patch in ax.patches:
```

```
        ax.text(patch.get_x() + patch.get_width()/2, patch.get_height(),␣
 ↪str(int(patch.get_height())), fontsize=12, ha='center', va='bottom',␣
 ↪color='black')

def plot_accent_distribution(ax):
    sns.countplot(y='accents', data=validated_df, hue='accents',␣
 ↪palette='viridis', legend=False, ax=ax)
    ax.set_title('Accent Distribution', fontsize=16)
    ax.tick_params(axis='x', rotation=rotation)
    ax.tick_params(axis='both', labelsize=14)
    ax.set_xlabel('Accent', fontsize=12)
    ax.set_ylabel('Count', fontsize=14)
    ax.set_xscale('log')
    for patch in ax.patches:
        ax.text(patch.get_x() + patch.get_width()/2, patch.get_height(),␣
 ↪str(int(patch.get_height())), fontsize=12, ha='center', va='bottom',␣
 ↪color='black')


# Plot the distributions
plot_age_distribution(axs[0])
plot_gender_distribution(axs[1])
plot_accent_distribution(axs[2])

# Show the plot
plt.tight_layout()
plt.show()
```



0.0.5 Summary

The analysis reveals imbalances in age, gender, and accent distributions. The dataset is dominated by users in their 20s and 60s, with underrepresentation in the 30s and 50s.

There's a bias towards female speakers, and while the dataset includes non-binary and transgender speakers, their numbers are small.

Accent distribution is also skewed, with "Unknown" accents dominating and underrepresentation of regional variants. These imbalances may impact speech model performance and robustness.

0.0.6 Part 2: AI vs Human Transcription Accuracy

Step 1: Transcribe Audio with Whisper AI

[15]:
```
!pip install -U openai-whisper jiwer
import whisper
```

```
Collecting openai-whisper
  Downloading openai-whisper-20240930.tar.gz (800 kB)
                           0.0/800.5
kB ? eta -:--:--

512.0/800.5 kB 15.4 MB/s eta 0:00:01
                     800.5/800.5 kB
15.1 MB/s eta 0:00:00
  Installing build dependencies … done
  Getting requirements to build wheel … done
  Preparing metadata (pyproject.toml) … done
Collecting jiwer
  Downloading jiwer-3.1.0-py3-none-any.whl.metadata (2.6 kB)
Requirement already satisfied: numba in /usr/local/lib/python3.11/dist-packages
(from openai-whisper) (0.60.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packages
(from openai-whisper) (2.0.2)
Requirement already satisfied: torch in /usr/local/lib/python3.11/dist-packages
(from openai-whisper) (2.6.0+cu124)
Requirement already satisfied: tqdm in /usr/local/lib/python3.11/dist-packages
(from openai-whisper) (4.67.1)
Requirement already satisfied: more-itertools in /usr/local/lib/python3.11/dist-
packages (from openai-whisper) (10.6.0)
Collecting tiktoken (from openai-whisper)
  Downloading tiktoken-0.9.0-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (6.7 kB)
Requirement already satisfied: triton>=2.0.0 in /usr/local/lib/python3.11/dist-
packages (from openai-whisper) (3.2.0)
Requirement already satisfied: click>=8.1.8 in /usr/local/lib/python3.11/dist-
packages (from jiwer) (8.1.8)
Collecting rapidfuzz>=3.9.7 (from jiwer)
  Downloading rapidfuzz-3.12.2-cp311-cp311-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (12 kB)
Requirement already satisfied: llvmlite<0.44,>=0.43.0dev0 in
/usr/local/lib/python3.11/dist-packages (from numba->openai-whisper) (0.43.0)
Requirement already satisfied: regex>=2022.1.18 in
/usr/local/lib/python3.11/dist-packages (from tiktoken->openai-whisper)
(2024.11.6)
Requirement already satisfied: requests>=2.26.0 in
/usr/local/lib/python3.11/dist-packages (from tiktoken->openai-whisper) (2.32.3)
Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-
packages (from torch->openai-whisper) (3.17.0)
Requirement already satisfied: typing-extensions>=4.10.0 in
/usr/local/lib/python3.11/dist-packages (from torch->openai-whisper) (4.12.2)
Requirement already satisfied: networkx in /usr/local/lib/python3.11/dist-
packages (from torch->openai-whisper) (3.4.2)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.11/dist-packages
```

```
(from torch->openai-whisper) (3.1.6)
Requirement already satisfied: fsspec in /usr/local/lib/python3.11/dist-packages
(from torch->openai-whisper) (2024.10.0)
Collecting nvidia-cuda-nvrtc-cu12==12.4.127 (from torch->openai-whisper)
  Downloading nvidia_cuda_nvrtc_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-cuda-runtime-cu12==12.4.127 (from torch->openai-whisper)
  Downloading nvidia_cuda_runtime_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-cuda-cupti-cu12==12.4.127 (from torch->openai-whisper)
  Downloading nvidia_cuda_cupti_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl.metadata (1.6 kB)
Collecting nvidia-cudnn-cu12==9.1.0.70 (from torch->openai-whisper)
  Downloading nvidia_cudnn_cu12-9.1.0.70-py3-none-
manylinux2014_x86_64.whl.metadata (1.6 kB)
Collecting nvidia-cublas-cu12==12.4.5.8 (from torch->openai-whisper)
  Downloading nvidia_cublas_cu12-12.4.5.8-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-cufft-cu12==11.2.1.3 (from torch->openai-whisper)
  Downloading nvidia_cufft_cu12-11.2.1.3-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-curand-cu12==10.3.5.147 (from torch->openai-whisper)
  Downloading nvidia_curand_cu12-10.3.5.147-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Collecting nvidia-cusolver-cu12==11.6.1.9 (from torch->openai-whisper)
  Downloading nvidia_cusolver_cu12-11.6.1.9-py3-none-
manylinux2014_x86_64.whl.metadata (1.6 kB)
Collecting nvidia-cusparse-cu12==12.3.1.170 (from torch->openai-whisper)
  Downloading nvidia_cusparse_cu12-12.3.1.170-py3-none-
manylinux2014_x86_64.whl.metadata (1.6 kB)
Requirement already satisfied: nvidia-cusparselt-cu12==0.6.2 in
/usr/local/lib/python3.11/dist-packages (from torch->openai-whisper) (0.6.2)
Requirement already satisfied: nvidia-nccl-cu12==2.21.5 in
/usr/local/lib/python3.11/dist-packages (from torch->openai-whisper) (2.21.5)
Requirement already satisfied: nvidia-nvtx-cu12==12.4.127 in
/usr/local/lib/python3.11/dist-packages (from torch->openai-whisper) (12.4.127)
Collecting nvidia-nvjitlink-cu12==12.4.127 (from torch->openai-whisper)
  Downloading nvidia_nvjitlink_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl.metadata (1.5 kB)
Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.11/dist-
packages (from torch->openai-whisper) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/usr/local/lib/python3.11/dist-packages (from sympy==1.13.1->torch->openai-
whisper) (1.3.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
/usr/local/lib/python3.11/dist-packages (from
requests>=2.26.0->tiktoken->openai-whisper) (3.4.1)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dist-
```

```
packages (from requests>=2.26.0->tiktoken->openai-whisper) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/usr/local/lib/python3.11/dist-packages (from
requests>=2.26.0->tiktoken->openai-whisper) (2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.11/dist-packages (from
requests>=2.26.0->tiktoken->openai-whisper) (2025.1.31)
Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.11/dist-packages (from jinja2->torch->openai-whisper)
(3.0.2)
Downloading jiwer-3.1.0-py3-none-any.whl (22 kB)
Downloading
rapidfuzz-3.12.2-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (3.1
MB)
                         3.1/3.1 MB
62.2 MB/s eta 0:00:00
Downloading
tiktoken-0.9.0-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.2
MB)
                         1.2/1.2 MB
42.6 MB/s eta 0:00:00
Downloading nvidia_cublas_cu12-12.4.5.8-py3-none-manylinux2014_x86_64.whl
(363.4 MB)
                         363.4/363.4 MB
4.5 MB/s eta 0:00:00
Downloading nvidia_cuda_cupti_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl (13.8 MB)
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94.8 MB/s eta 0:00:00
Downloading nvidia_cuda_nvrtc_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl (24.6 MB)
                         24.6/24.6 MB
72.9 MB/s eta 0:00:00
Downloading nvidia_cuda_runtime_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl (883 kB)
                         883.7/883.7 kB
46.5 MB/s eta 0:00:00
Downloading nvidia_cudnn_cu12-9.1.0.70-py3-none-manylinux2014_x86_64.whl
(664.8 MB)
                         664.8/664.8 MB
2.7 MB/s eta 0:00:00
Downloading nvidia_cufft_cu12-11.2.1.3-py3-none-manylinux2014_x86_64.whl
(211.5 MB)
                         211.5/211.5 MB
4.9 MB/s eta 0:00:00
Downloading nvidia_curand_cu12-10.3.5.147-py3-none-
manylinux2014_x86_64.whl (56.3 MB)
                         56.3/56.3 MB
```

```
16.5 MB/s eta 0:00:00
Downloading nvidia_cusolver_cu12-11.6.1.9-py3-none-
manylinux2014_x86_64.whl (127.9 MB)
                         127.9/127.9 MB
7.6 MB/s eta 0:00:00
Downloading nvidia_cusparse_cu12-12.3.1.170-py3-none-
manylinux2014_x86_64.whl (207.5 MB)
                         207.5/207.5 MB
5.7 MB/s eta 0:00:00
Downloading nvidia_nvjitlink_cu12-12.4.127-py3-none-
manylinux2014_x86_64.whl (21.1 MB)
                         21.1/21.1 MB
78.0 MB/s eta 0:00:00
Building wheels for collected packages: openai-whisper
  Building wheel for openai-whisper (pyproject.toml) … done
  Created wheel for openai-whisper: filename=openai_whisper-20240930-py3-none-
any.whl size=803375
sha256=5ddfb61ae458d6180f3f0b584b6e67d455cbadfff1716b7ba4926305e0aab34c
  Stored in directory: /root/.cache/pip/wheels/2f/f2/ce/6eb23db4091d026238ce7670
3bd66da60b969d70bcc81d5d3a
Successfully built openai-whisper
Installing collected packages: rapidfuzz, nvidia-nvjitlink-cu12, nvidia-curand-
cu12, nvidia-cufft-cu12, nvidia-cuda-runtime-cu12, nvidia-cuda-nvrtc-cu12,
nvidia-cuda-cupti-cu12, nvidia-cublas-cu12, tiktoken, nvidia-cusparse-cu12,
nvidia-cudnn-cu12, jiwer, nvidia-cusolver-cu12, openai-whisper
  Attempting uninstall: nvidia-nvjitlink-cu12
    Found existing installation: nvidia-nvjitlink-cu12 12.5.82
    Uninstalling nvidia-nvjitlink-cu12-12.5.82:
      Successfully uninstalled nvidia-nvjitlink-cu12-12.5.82
  Attempting uninstall: nvidia-curand-cu12
    Found existing installation: nvidia-curand-cu12 10.3.6.82
    Uninstalling nvidia-curand-cu12-10.3.6.82:
      Successfully uninstalled nvidia-curand-cu12-10.3.6.82
  Attempting uninstall: nvidia-cufft-cu12
    Found existing installation: nvidia-cufft-cu12 11.2.3.61
    Uninstalling nvidia-cufft-cu12-11.2.3.61:
      Successfully uninstalled nvidia-cufft-cu12-11.2.3.61
  Attempting uninstall: nvidia-cuda-runtime-cu12
    Found existing installation: nvidia-cuda-runtime-cu12 12.5.82
    Uninstalling nvidia-cuda-runtime-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-runtime-cu12-12.5.82
  Attempting uninstall: nvidia-cuda-nvrtc-cu12
    Found existing installation: nvidia-cuda-nvrtc-cu12 12.5.82
    Uninstalling nvidia-cuda-nvrtc-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-nvrtc-cu12-12.5.82
  Attempting uninstall: nvidia-cuda-cupti-cu12
    Found existing installation: nvidia-cuda-cupti-cu12 12.5.82
    Uninstalling nvidia-cuda-cupti-cu12-12.5.82:
```

```
    Successfully uninstalled nvidia-cuda-cupti-cu12-12.5.82
  Attempting uninstall: nvidia-cublas-cu12
    Found existing installation: nvidia-cublas-cu12 12.5.3.2
    Uninstalling nvidia-cublas-cu12-12.5.3.2:
      Successfully uninstalled nvidia-cublas-cu12-12.5.3.2
  Attempting uninstall: nvidia-cusparse-cu12
    Found existing installation: nvidia-cusparse-cu12 12.5.1.3
    Uninstalling nvidia-cusparse-cu12-12.5.1.3:
      Successfully uninstalled nvidia-cusparse-cu12-12.5.1.3
  Attempting uninstall: nvidia-cudnn-cu12
    Found existing installation: nvidia-cudnn-cu12 9.3.0.75
    Uninstalling nvidia-cudnn-cu12-9.3.0.75:
      Successfully uninstalled nvidia-cudnn-cu12-9.3.0.75
  Attempting uninstall: nvidia-cusolver-cu12
    Found existing installation: nvidia-cusolver-cu12 11.6.3.83
    Uninstalling nvidia-cusolver-cu12-11.6.3.83:
      Successfully uninstalled nvidia-cusolver-cu12-11.6.3.83
Successfully installed jiwer-3.1.0 nvidia-cublas-cu12-12.4.5.8 nvidia-cuda-
cupti-cu12-12.4.127 nvidia-cuda-nvrtc-cu12-12.4.127 nvidia-cuda-runtime-
cu12-12.4.127 nvidia-cudnn-cu12-9.1.0.70 nvidia-cufft-cu12-11.2.1.3 nvidia-
curand-cu12-10.3.5.147 nvidia-cusolver-cu12-11.6.1.9 nvidia-cusparse-
cu12-12.3.1.170 nvidia-nvjitlink-cu12-12.4.127 openai-whisper-20240930
rapidfuzz-3.12.2 tiktoken-0.9.0
```

Step2: Import Libraries and load transcriptions

[16]:
```
# Load Whisper model (medium for balance of speed/ accuracy)

model = whisper.load_model("medium")
```

```
100%|                    | 1.42G/1.42G [00:30<00:00, 50.8MiB/s]
```

[17]:
```
# Transcribe first 50 samples (adjust based on Colab resources)

subset = validated_df.head(50)
transcripts = []

for idx, row in subset.iterrows():
    audio_path = os.path.join(audio_dir, row['path'])
    result = model.transcribe(audio_path)
    transcripts.append(result['text'])

subset["ai_transcript"] = transcripts
subset.to_csv("ai_transcripts.csv", index=False)
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:

FP16 is not supported on CPU; using FP32 instead
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:
FP16 is not supported on CPU; using FP32 instead
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```

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FP16 is not supported on CPU; using FP32 instead
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```

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/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:
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```

```
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FP16 is not supported on CPU; using FP32 instead
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:
FP16 is not supported on CPU; using FP32 instead
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:
FP16 is not supported on CPU; using FP32 instead
```

```
/usr/local/lib/python3.11/dist-packages/whisper/transcribe.py:126: UserWarning:

FP16 is not supported on CPU; using FP32 instead

<ipython-input-17-9e611312a6ab>:11: SettingWithCopyWarning:


A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

[20]:
```
print(subset['ai_transcript'])
```

```
0      The out of rim has undergone some erosion due…
1      For the purposes of this definition, the inte…
2      Bennett was educated at Lonswood High School,…
3      These little spochondras are mirror- Dais Mou…
4      The grouping traditionally called apes is bra…
5      The track, Coca Leaf, is made up of vocal sam…
6                He also taught at the same university.
7      Most Naruto video games have been released on…
8      Bold denotes players currently active in inte…
9      At Southside, Greer was an all-state selectio…
10                  Riley and Buffy pursue in his car.
11     The combined company was later renamed Kimbal…
12     It also features puzzles and platforming elem…
13                             It has three platforms.
14     After graduation, she became the administrato…
15           It airs in North America via Dish Network.
16     Instead of signing artists, he makes one-time…
17     After this, the town was rebuilt and simply r…
18                     That was enough for a conflict.
19     In Korea, the carnations express admiration, …
20                         Naval Academy in Annapolis.
21     It also likes flower, nectar, fruit and some …
22     After graduation he served with the Royal Pru…
23     He worked as a builder and was later employed…
24     It has also been proposed as a possible expla…
25        He later attended the University of Maryland.
26                  Cuttings are slow to strike roots.
27     The undergraduate program in Theological Stud…
28     Balanjiga can be reached through public utili…
29     The old comedy was awkward and poor in its ve…
30        Considered a shining star of the core worlds.
31     A win earns a two-year exemption for most eve…
```

```
32     These may also be forgeries to conceal identi…
33                                Moore lives in Toronto.
34                    In Laos, represents a double word.
35     Many of the illustrations he created for the …
36     You just didn't bother saying this sucks anym…
37     Its headquarters are in the town of Dematru, …
38
39
40     He experienced weightlessness and saw the cur…
41        Holmes vs. Cooney was refereed by Mills Lane.
42                It is a freeway for its entire length.
43      This group became legendary in the dance world.
44     The mountains separate Luzon's central plain …
45     Fundamental justice was thus seen as having b…
46     A mosque is situated inside Sitio Bolangan on…
47     The river bearing this name was renamed Pagan…
48     A similar example is Charlotte Perkins Gilman…
49     The establishment was commanded by an officer…
Name: ai_transcript, dtype: object
```

[25]:
```
# Import Word Error(WER) and Character Error (CER)
!pip install -U jiwer
from jiwer import wer, cer
```

```
Requirement already satisfied: jiwer in /usr/local/lib/python3.11/dist-packages
(3.1.0)
Requirement already satisfied: click>=8.1.8 in /usr/local/lib/python3.11/dist-
packages (from jiwer) (8.1.8)
Requirement already satisfied: rapidfuzz>=3.9.7 in
/usr/local/lib/python3.11/dist-packages (from jiwer) (3.12.2)
```

[35]:
```
#Load the dataset with AI-generated transcripts
df = pd.read_csv('/content/drive/MyDrive/Colab_Notebooks/M2M Tech/Mozilla␣
 ↪Common Voice/ai_transcripts.csv')

# Ensure columns exist
df = df.dropna(subset=["sentence", "ai_transcript"])
df.head(10)
```

[35]:
```
                                          client_id  \
0  031903093b6fa1aeb0a243843eb9ed57baf6e99d1f8f92…
1  058fe5b1170aa09ef3f1092b179384639bc46ac53c1675…
2  08190396a5c298331813531d1a832b56d8ffe44aaedcb7…
3  14698ee63cabe08b43f0faa93304202d1e6ffeaa2cdf86…
4  28d8f8a88afad9eb9e5b36ee84bd4c5ba84137310da15f…
5  29f0a09db1abdd5ad550cc754834822748ab17043e7b51…
6  302b51de89ba0e815cce38bba05ee858e556375d19c745…
```

```
7  31a787d9d9c7203d20fbd2b9590c92dda91ef69e2b36f7…
8  40ef8f7ec5e58f2ba7b9c934cf57ae928bae5b13662b8f…
9  4af8321a13399a2662bef236a736ad5329cb2edfe01eee…

                          path  \
0  common_voice_en_41383256.mp3
1  common_voice_en_41823983.mp3
2  common_voice_en_41881685.mp3
3  common_voice_en_41799514.mp3
4  common_voice_en_41552032.mp3
5  common_voice_en_41827319.mp3
6  common_voice_en_41526838.mp3
7  common_voice_en_41435787.mp3
8  common_voice_en_41633128.mp3
9  common_voice_en_41586424.mp3

                                        sentence_id  \
0  f19a785911b1a3b1338e3eb5cc785e58b8381d21ec7c33…
1  f50360e1be367d8155b3c8340f0b3d38d1e6701df79dc5…
2  f4f3a5714cc36a9abbabf78a33feb4a9c368005f1f4bf5…
3  f4d04f6e48777c3ad180c629858a19fdfa4cb875d2bb22…
4  f262ed293fa5fe0986d1e7a80b5bbae11205f8089a1857…
5  f506be20f56b00999c323469c384114e27bb5fa0372d0e…
6  f21bd922ee542930c8c3914edad64557f31004a22a80a1…
7  f1b86bcf63efc1b0117b5587f8803741a5a6917ab44421…
8  f2d2020fe97305b41d4c626ee2963f0984e255e5599105…
9  f2872bf6e9d312de78bdcc664bc348936d9039966c4104…

                                           sentence sentence_domain  \
0  The outer rim has undergone some erosion due t…         Unknown
1  For purposes of this definition, the intent ma…         Unknown
2  Bennett was educated at Lawnswood High School,…         Unknown
3  These rules became known as Admiral-Lord Mount…         Unknown
4  The grouping traditionally called apes is brac…         Unknown
5  The track "Coca Leaf" is made up of vocal samp…         Unknown
6             He also taught at the same university.           Unknown
7  Most "Naruto" video games have been released o…         Unknown
8  Bold denotes players currently active in inter…         Unknown
9  At South Side, Greer was an all state selectio…         Unknown

   up_votes  down_votes   age   gender  \
0         2           0   NaN  Unknown
1         3           0  55.0   Female
2         2           0  45.0   Female
3         2           0  25.0  Unknown
4         2           0   NaN  Unknown
5         2           0   NaN  Unknown
```

```
6         4           0  65.0   Female
7         3           0   NaN  Unknown
8         2           0  35.0   Female
9         2           0  55.0   Female

                                        accents  variant locale  segment  \
0                                       Unknown  Unknown     en  Unknown
1                                    US English  Unknown     en  Unknown
2                          US English (Southern)  Unknown     en  Unknown
3                               Japanese English  Unknown     en  Unknown
4  Canadian English (Eastern European influence)  Unknown     en  Unknown
5                                       Unknown  Unknown     en  Unknown
6                          United States English  Unknown     en  Unknown
7                                       Unknown  Unknown     en  Unknown
8                          United States English  Unknown     en  Unknown
9                          United States English  Unknown     en  Unknown

                                      ai_transcript
0   The out of rim has undergone some erosion due…
1   For the purposes of this definition, the inte…
2   Bennett was educated at Lonswood High School,…
3   These little spochondras are mirror- Dais Mou…
4   The grouping traditionally called apes is bra…
5   The track, Coca Leaf, is made up of vocal sam…
6             He also taught at the same university.
7   Most Naruto video games have been released on…
8   Bold denotes players currently active in inte…
9   At Southside, Greer was an all-state selectio…
```

Step 3: Compute WER and CER for Each sample

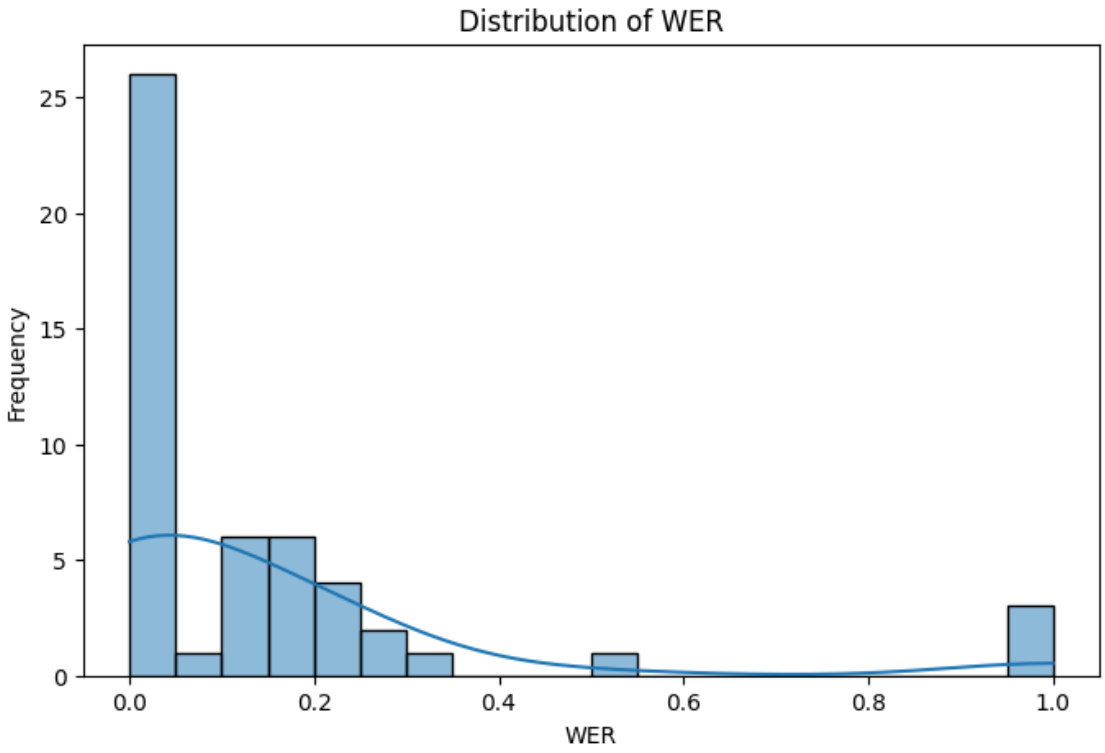
[34]:
```
# Ensure subset is a new copy of the DataFrame
subset = subset.copy()

# Compute WER and CER
subset.loc[:, "wer"] = subset.apply(lambda row: wer(row["sentence"],␣
 ↪row["ai_transcript"]), axis=1)
subset.loc[:, "cer"] = subset.apply(lambda row: cer(row["sentence"],␣
 ↪row["ai_transcript"]), axis=1)

# Save updated results
subset.to_csv("ai_transcripts_with_metrics.csv", index=False)

# Display average WER and CER
average_wer = subset["wer"].mean()
average_cer = subset["cer"].mean()
```

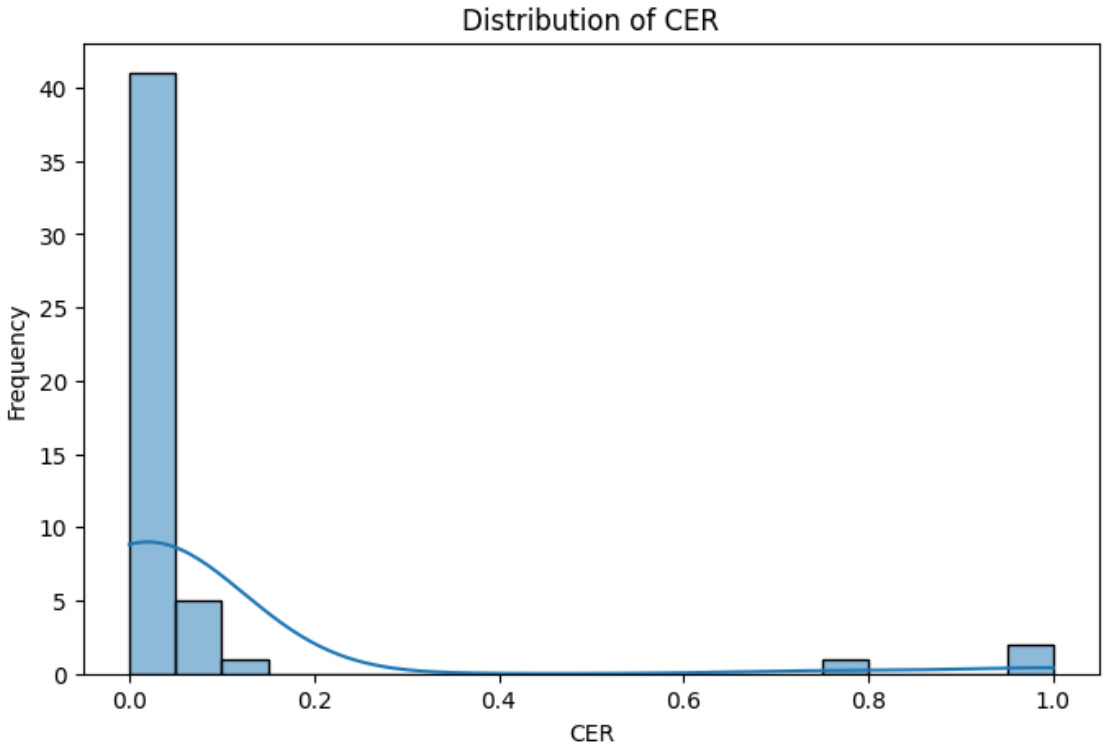
```
print(f"Average WER: {average_wer:.2%}")
print(f"Average CER: {average_cer:.2%}")
```

```
Average WER: 14.23%
Average CER: 7.52%
```

Step 4: Visualize the Error Rates

[37]:
```
import seaborn as sns
import matplotlib.pyplot as plt

# Plot WER distribution
plt.figure(figsize=(8,5))
sns.histplot(subset['wer'], bins=20, kde=True)
plt.title('Distribution of WER')
plt.xlabel('WER')
plt.ylabel('Frequency')
plt.show()

# Plot CER distribution
plt.figure(figsize=(8, 5))
sns.histplot(subset['cer'], bins=20, kde=True)
plt.title('Distribution of CER')
plt.xlabel('CER')
plt.ylabel('Frequency')
plt.show()
```





Summary:

1. **Most transcriptions have low CER and WER** • The majority of the data points are concentrated around low error rates (close to 0).

   • This suggests that the ASR (Automatic Speech Recognition) model performs well on most of the dataset.

2. **Long-Tail Distribution (Presence of Outliers)** • There are some high CER and WER values, creating a long tail towards the right. • This means that some transcriptions are significantly worse than others, possibly due to: • Poor audio quality • Strong accents • Background noise • Rare words not well represented in the training set

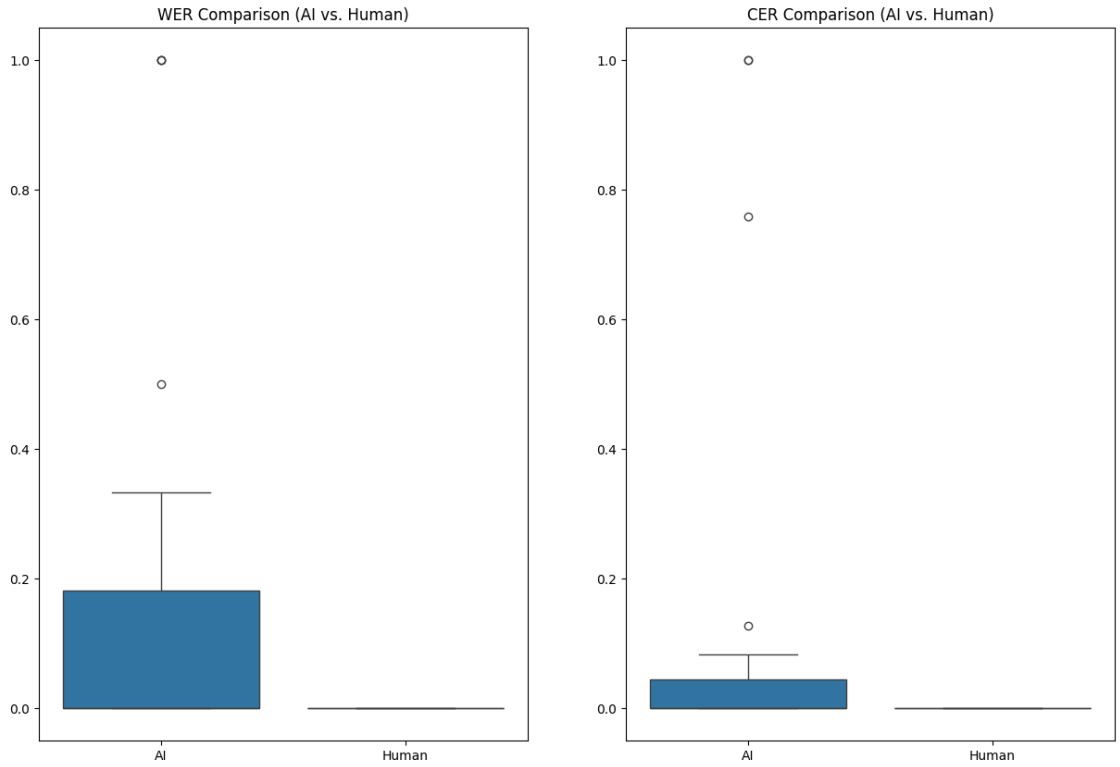
3. **CER is lower than WER on average** • This is expected because CER measures errors at the character level, whereas WER measures errors at the word level.

   • A small character-level mistake (e.g., missing a single letter) may not necessarily cause a word-level mistake.

Step 5: Process and Compare AI vs Human Transcriptions

[41]:
```
# Load dataset
df = pd.read_csv('/content/drive/MyDrive/Colab_Notebooks/M2M Tech/Mozilla␣
↪Common Voice/ai_transcripts_with_metrics.csv')
```

```
# Rename columns for clarity
df.rename(columns={'sentence': 'ground_truth'}, inplace=True)

# Compute WER & CER for AI
df['WER_AI'] = df.apply(lambda row: wer(row['ground_truth'],␣
 ↪row['ai_transcript']), axis=1)
df['CER_AI'] = df.apply(lambda row: cer(row['ground_truth'],␣
 ↪row['ai_transcript']), axis=1)

# Assign WER & CER = 0 for human reference (since it's the ground truth)
df['WER_Human'] = 0
df['CER_Human'] = 0

# Plot boxplots to visualize the difference
plt.figure(figsize=(15, 10))

# WER Comparison
plt.subplot(1, 2, 1)
sns.boxplot(data=df[['WER_AI', 'WER_Human']])
plt.xticks([0, 1], ['AI', 'Human'])
plt.title("WER Comparison (AI vs. Human)")

# CER Comparison
plt.subplot(1, 2, 2)
sns.boxplot(data=df[['CER_AI', 'CER_Human']])
plt.xticks([0, 1], ['AI', 'Human'])
plt.title("CER Comparison (AI vs. Human)")

plt.show()
```



Summary of the Graphs (WER & CER Distribution)

1. Most AI-generated transcriptions have low error rates, with WER(Word Error Rate) and CER(Character Error Rate) Concentrated around 0.

This means AI performs well on most samples

2. A smaller portion of cases has extremely high WER(nearly 1.0).

These colud be outliers, possibly due to noisy audio, uncommon words or poor AI recognition in certain scenarious.

3. The distribution is right-skewed (more low-error cases, fewer high-error cases).

AI is mostly accurate than WER but fails significantly on some difficult samples.

4. CER is lower than WER, indicating that AI tend to make more word-level mistakes rather han character-level mistakes.

Example: " The cat ran fast" -> "The cats run fast" (presents word-level error but few character changes: The tense of the verb has changed from past to present, and the subject has changed from singular to plural. WER is more sensitive to these types of errors than CER.)

[45]:
```
!sudo apt-get update
!sudo apt-get install texlive-xetex pandoc
```

```
0% [Working]              Hit:1 https://cloud.r-project.org/bin/linux/ubuntu
```

```
jammy-cran40/ InRelease
Hit:2 https://developer.download.nvidia.com/compute/cuda/repos/ubuntu2204/x86_64
InRelease
Hit:3 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:4 https://r2u.stat.illinois.edu/ubuntu jammy InRelease
Hit:5 http://archive.ubuntu.com/ubuntu jammy InRelease
Hit:6 http://archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:7 http://archive.ubuntu.com/ubuntu jammy-backports InRelease
Hit:8 https://ppa.launchpadcontent.net/deadsnakes/ppa/ubuntu jammy InRelease
Hit:9 https://ppa.launchpadcontent.net/graphics-drivers/ppa/ubuntu jammy
InRelease
Hit:10 https://ppa.launchpadcontent.net/ubuntugis/ppa/ubuntu jammy InRelease
Reading package lists… Done
W: Skipping acquire of configured file 'main/source/Sources' as repository
'https://r2u.stat.illinois.edu/ubuntu jammy InRelease' does not seem to provide
it (sources.list entry misspelt?)
Reading package lists… Done
Building dependency tree… Done
Reading state information… Done
pandoc is already the newest version (2.9.2.1-3ubuntu2).
texlive-xetex is already the newest version (2021.20220204-1).
0 upgraded, 0 newly installed, 0 to remove and 35 not upgraded.
```

[44]:
```
!jupyter nbconvert --to pdf "/content/drive/MyDrive/Colab_Notebooks/M2M Tech/
↪Capstone 1: Data Analysis of speech-to-text accuracy.ipynb"
```

```
[NbConvertApp] Converting notebook /content/drive/MyDrive/Colab_Notebooks/M2M
Tech/Capstone 1: Data Analysis of speech-to-text accuracy.ipynb to pdf
/usr/local/share/jupyter/nbconvert/templates/latex/display_priority.j2:32:
UserWarning: Your element with mimetype(s) dict_keys(['text/html']) is not able
to be represented.
  ((*- endblock -*))
[NbConvertApp] Support files will be in Capstone 1: Data Analysis of speech-to-
text accuracy_files/
[NbConvertApp] Making directory ./Capstone 1: Data Analysis of speech-to-text
accuracy_files
[NbConvertApp] Writing 137047 bytes to notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', 'notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', 'notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 325276 bytes to
/content/drive/MyDrive/Colab_Notebooks/M2M Tech/Capstone 1: Data Analysis of
speech-to-text accuracy.pdf
```