EDA_Bin

December 11, 2023

```
[ ]: from google.colab import drive
     drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
[ ]: !pip install -q pandas pyarrow
     !pip install -q mediapipe
```

```
                                      34.5/34.5 MB
45.3 MB/s eta 0:00:00
```

```
[ ]: # Data Folder Directry
     main_dir = '/content/drive/MyDrive/Colab Notebooks/Data/asl-signs/'
```

```
[ ]: import pandas as pd
     import os

     metadata_sub_dir = 'train.csv'
     metadata_full_file_path = os.path.join(main_dir, metadata_sub_dir)
     df_metadata = pd.read_csv(metadata_full_file_path)
     # Read the .parquet file
     #df = pd.read_parquet(file_path)
     df_metadata
```

```
[ ]:                                                 path  participant_id  \
     0      train_landmark_files/26734/1000035562.parquet           26734
     1      train_landmark_files/28656/1000106739.parquet           28656
     2       train_landmark_files/16069/100015657.parquet           16069
     3      train_landmark_files/25571/1000210073.parquet           25571
     4      train_landmark_files/62590/1000240708.parquet           62590
     …                                                …             …
     94472   train_landmark_files/53618/999786174.parquet           53618
     94473   train_landmark_files/26734/999799849.parquet           26734
     94474   train_landmark_files/25571/999833418.parquet           25571
     94475   train_landmark_files/29302/999895257.parquet           29302
     94476   train_landmark_files/36257/999962374.parquet           36257

            sequence_id    sign
```

```
0      1000035562    blow
1      1000106739    wait
2       100015657   cloud
3      1000210073    bird
4      1000240708    owie
…             …     …
94472   999786174   white
94473   999799849    have
94474   999833418  flower
94475   999895257    room
94476   999962374   happy

[94477 rows x 4 columns]
```

[ ]:

```python
N_SAMPLES = len(df_metadata)
```

[ ]:

```python
import json

signmap_sub_dir = 'sign_to_prediction_index_map.json'
signmap_full_file_path = os.path.join(main_dir, signmap_sub_dir)

# Load the sign to index mapping
with open(signmap_full_file_path, 'r') as file:
    sign_to_index = json.load(file)

# Map the labels in the dataframe
df_metadata['sign_index'] = df_metadata['sign'].map(sign_to_index)
```

[ ]:

```python
df_metadata
```

[ ]:

```
                                                path  participant_id  \
0      train_landmark_files/26734/1000035562.parquet           26734
1      train_landmark_files/28656/1000106739.parquet           28656
2       train_landmark_files/16069/100015657.parquet           16069
3      train_landmark_files/25571/1000210073.parquet           25571
4      train_landmark_files/62590/1000240708.parquet           62590
…                                                …              …
94472   train_landmark_files/53618/999786174.parquet           53618
94473   train_landmark_files/26734/999799849.parquet           26734
94474   train_landmark_files/25571/999833418.parquet           25571
94475   train_landmark_files/29302/999895257.parquet           29302
94476   train_landmark_files/36257/999962374.parquet           36257

       sequence_id    sign  sign_index
0       1000035562    blow          25
1       1000106739    wait         232
2        100015657   cloud          48
```

```
3       1000210073    bird          23
4       1000240708    owie         164
…             …     …         …
94472    999786174   white         238
94473    999799849    have         108
94474    999833418  flower          86
94475    999895257    room         188
94476    999962374   happy         105

[94477 rows x 5 columns]
```

[ ]:

```
samplefile_dir = df_metadata['path'][0]
samplefile_full_file_path = os.path.join(main_dir, samplefile_dir)
print(samplefile_full_file_path)

# Read the .parquet file
df_samplefile = pd.read_parquet(samplefile_full_file_path)
df_samplefile
```

```
/content/drive/MyDrive/Colab Notebooks/Data/asl-
signs/train_landmark_files/26734/1000035562.parquet
```

[ ]:

```
       frame            row_id        type  landmark_index         x  \
0         20         20-face-0        face               0  0.494400
1         20         20-face-1        face               1  0.496017
2         20         20-face-2        face               2  0.500818
3         20         20-face-3        face               3  0.489788
4         20         20-face-4        face               4  0.495304
…      …             …           …              …        …
12484     42  42-right_hand-16  right_hand              16  0.001660
12485     42  42-right_hand-17  right_hand              17  0.042694
12486     42  42-right_hand-18  right_hand              18  0.006723
12487     42  42-right_hand-19  right_hand              19 -0.014755
12488     42  42-right_hand-20  right_hand              20 -0.031811

              y         z
0      0.380470 -0.030626
1      0.350735 -0.057565
2      0.359343 -0.030283
3      0.321780 -0.040622
4      0.341821 -0.061152
…         …       …
12484  0.549574 -0.145409
12485  0.693116 -0.085307
12486  0.665044 -0.114017
12487  0.643799 -0.123488
12488  0.627077 -0.129067
```

```
[12489 rows x 7 columns]
```

```
[ ]: df_samplefile['type'].unique()
```

```
[ ]: array(['face', 'left_hand', 'pose', 'right_hand'], dtype=object)
```

```
[ ]: df_samplefile['frame'].unique()
```

```
[ ]: array([20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36,
            37, 38, 39, 40, 41, 42], dtype=int16)
```

```
[ ]: df_singleframe = df_samplefile[df_samplefile['frame']==20]
     df_singleframe
```

```
[ ]:      frame             row_id        type  landmark_index         x         y  \
     0       20          20-face-0        face               0  0.494400  0.380470
     1       20          20-face-1        face               1  0.496017  0.350735
     2       20          20-face-2        face               2  0.500818  0.359343
     3       20          20-face-3        face               3  0.489788  0.321780
     4       20          20-face-4        face               4  0.495304  0.341821
     ..     …                  …           …             …         …         …
     538     20  20-right_hand-16  right_hand              16  0.422241  0.390434
     539     20  20-right_hand-17  right_hand              17  0.282980  0.457257
     540     20  20-right_hand-18  right_hand              18  0.313736  0.412344
     541     20  20-right_hand-19  right_hand              19  0.350728  0.399582
     542     20  20-right_hand-20  right_hand              20  0.385796  0.401101

                 z
     0   -0.030626
     1   -0.057565
     2   -0.030283
     3   -0.040622
     4   -0.061152
     ..        …
     538 -0.049388
     539 -0.038326
     540 -0.052699
     541 -0.060217
     542 -0.064718

     [543 rows x 7 columns]
```

```
[ ]: df_singleframe['type'][522]
```

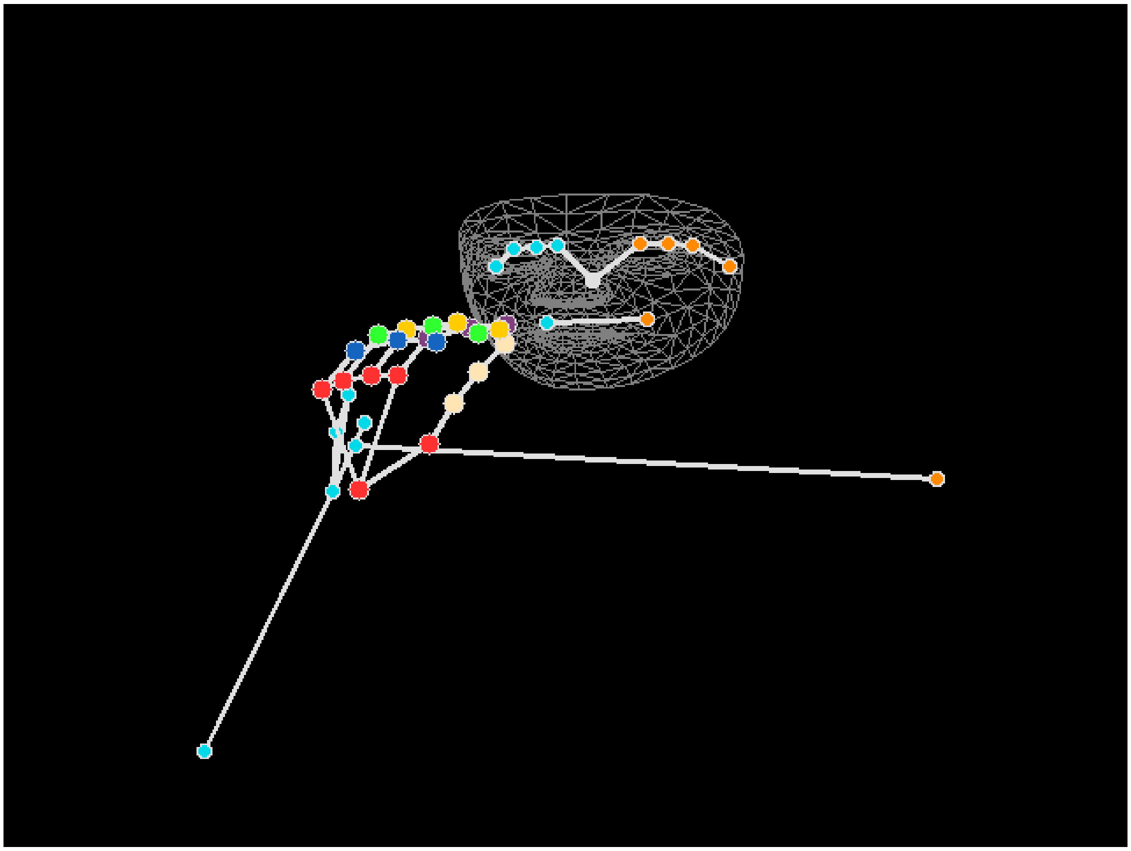
```
[ ]: 'right_hand'
```

```
[ ]: df_singleframe[df_singleframe['type']=='left_hand']
[ ]:      frame            row_id       type  landmark_index   x   y   z
     468     20   20-left_hand-0  left_hand               0 NaN NaN NaN
     469     20   20-left_hand-1  left_hand               1 NaN NaN NaN
     470     20   20-left_hand-2  left_hand               2 NaN NaN NaN
     471     20   20-left_hand-3  left_hand               3 NaN NaN NaN
     472     20   20-left_hand-4  left_hand               4 NaN NaN NaN
     473     20   20-left_hand-5  left_hand               5 NaN NaN NaN
     474     20   20-left_hand-6  left_hand               6 NaN NaN NaN
     475     20   20-left_hand-7  left_hand               7 NaN NaN NaN
     476     20   20-left_hand-8  left_hand               8 NaN NaN NaN
     477     20   20-left_hand-9  left_hand               9 NaN NaN NaN
     478     20  20-left_hand-10  left_hand              10 NaN NaN NaN
     479     20  20-left_hand-11  left_hand              11 NaN NaN NaN
     480     20  20-left_hand-12  left_hand              12 NaN NaN NaN
     481     20  20-left_hand-13  left_hand              13 NaN NaN NaN
     482     20  20-left_hand-14  left_hand              14 NaN NaN NaN
     483     20  20-left_hand-15  left_hand              15 NaN NaN NaN
     484     20  20-left_hand-16  left_hand              16 NaN NaN NaN
     485     20  20-left_hand-17  left_hand              17 NaN NaN NaN
     486     20  20-left_hand-18  left_hand              18 NaN NaN NaN
     487     20  20-left_hand-19  left_hand              19 NaN NaN NaN
     488     20  20-left_hand-20  left_hand              20 NaN NaN NaN
```

[ ]:

```python
import cv2
import mediapipe as mp
import pandas as pd
import numpy as np
from google.colab.patches import cv2_imshow
from mediapipe.framework.formats import landmark_pb2

# Initialize MediaPipe solutions
mp_drawing = mp.solutions.drawing_utils
mp_drawing_styles = mp.solutions.drawing_styles
mp_face_mesh = mp.solutions.face_mesh
mp_pose = mp.solutions.pose
mp_hands = mp.solutions.hands  # Add this line for hand landmarks

# Load the landmark data (replace this with your actual file path)
df_landmark = df_samplefile

# Create a black image
image_height, image_width = 480, 640
image = np.zeros((image_height, image_width, 3), dtype=np.uint8)

# Function to draw landmarks using MediaPipe's utility
def draw_mediapipe_landmarks(image, df, landmark_type):
    # Convert DataFrame to MediaPipe Landmark list
    landmarks = []
    for _, row in df.iterrows():
        if pd.isna(row['x']) or pd.isna(row['y']):
            continue
        landmark = landmark_pb2.NormalizedLandmark(
            x=row['x'], y=row['y'], z=row.get('z', 0))
        landmarks.append(landmark)

    landmark_list = landmark_pb2.NormalizedLandmarkList(
        landmark=landmarks)

    # Draw landmarks
    if landmark_type == 'face':
        mp_drawing.draw_landmarks(
            image, landmark_list,
            mp_face_mesh.FACEMESH_TESSELATION,
            landmark_drawing_spec=None,
            connection_drawing_spec=mp_drawing_styles.get_default_face_mesh_tesselation_style())
    elif landmark_type == 'pose':
        mp_drawing.draw_landmarks(
            image, landmark_list,
            mp_pose.POSE_CONNECTIONS,
            landmark_drawing_spec=mp_drawing_styles.get_default_pose_landmarks_style())
    elif landmark_type == 'right_hand':
        mp_drawing.draw_landmarks(
            image, landmark_list,
            mp_hands.HAND_CONNECTIONS,
            landmark_drawing_spec=mp_drawing_styles.get_default_hand_landmarks_style())
    elif landmark_type == 'left_hand':
        mp_drawing.draw_landmarks(
            image, landmark_list,
            mp_hands.HAND_CONNECTIONS,
            landmark_drawing_spec=mp_drawing_styles.get_default_hand_landmarks_style())

# Draw landmarks for a specific frame and type
frame_number = 20  # Example frame number
df_frame = df_landmark[df_landmark['frame'] == frame_number]

# Example: Drawing face landmarks
draw_mediapipe_landmarks(image, df_frame[df_frame['type'] == 'face'], 'face')

# Example: Drawing pose landmarks
draw_mediapipe_landmarks(image, df_frame[df_frame['type'] == 'pose'], 'pose')
```

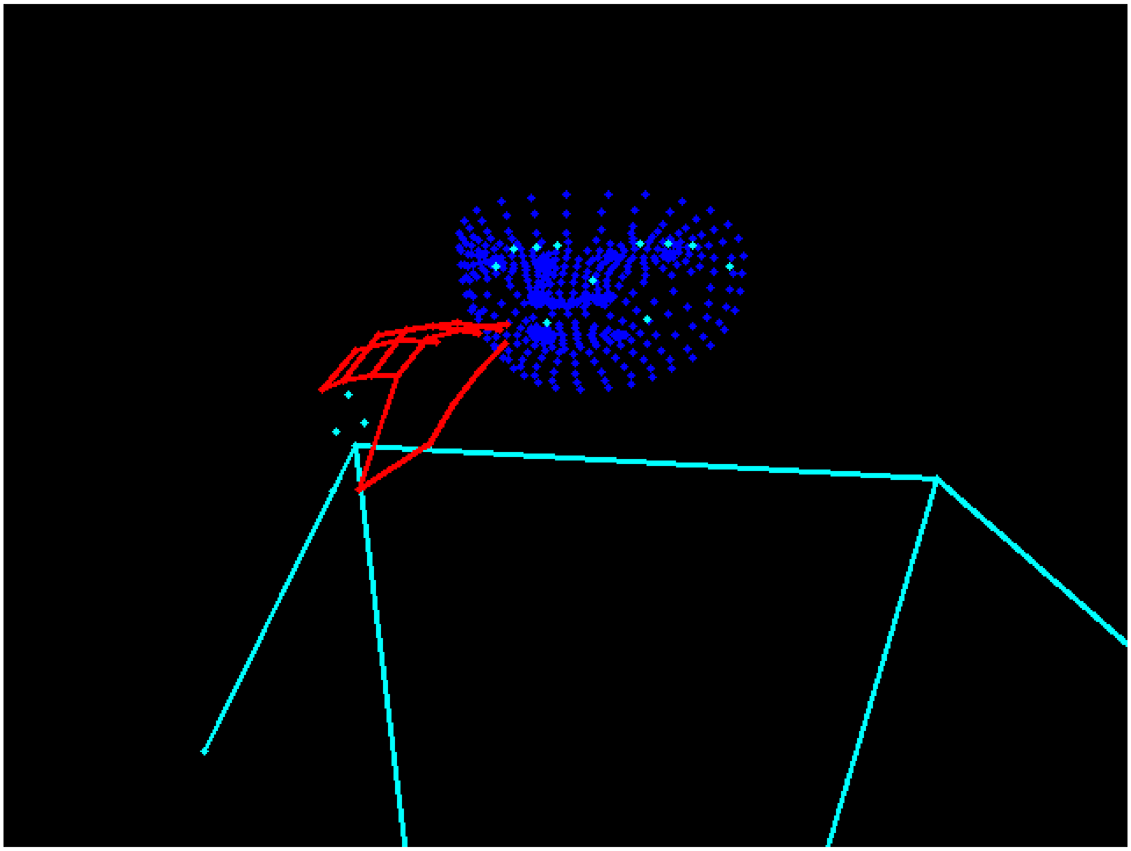
```
# Example: Drawing left hand landmarks
#draw_mediapipe_landmarks(image, df_frame[df_frame['type'] == 'left_hand'],␣
 ↪'left_hand')

# Example: Drawing right hand landmarks
draw_mediapipe_landmarks(image, df_frame[df_frame['type'] == 'right_hand'],␣
 ↪'right_hand')
#draw_mediapipe_landmarks(image, df_frame[df_frame['type'] == 'left_hand'],␣
 ↪'left_hand')
# Display the image
cv2_imshow(image)
```



[ ]:
```
import cv2
import pandas as pd
import numpy as np
from google.colab.patches import cv2_imshow

# Load the landmark data
df_landmark = df_samplefile
```

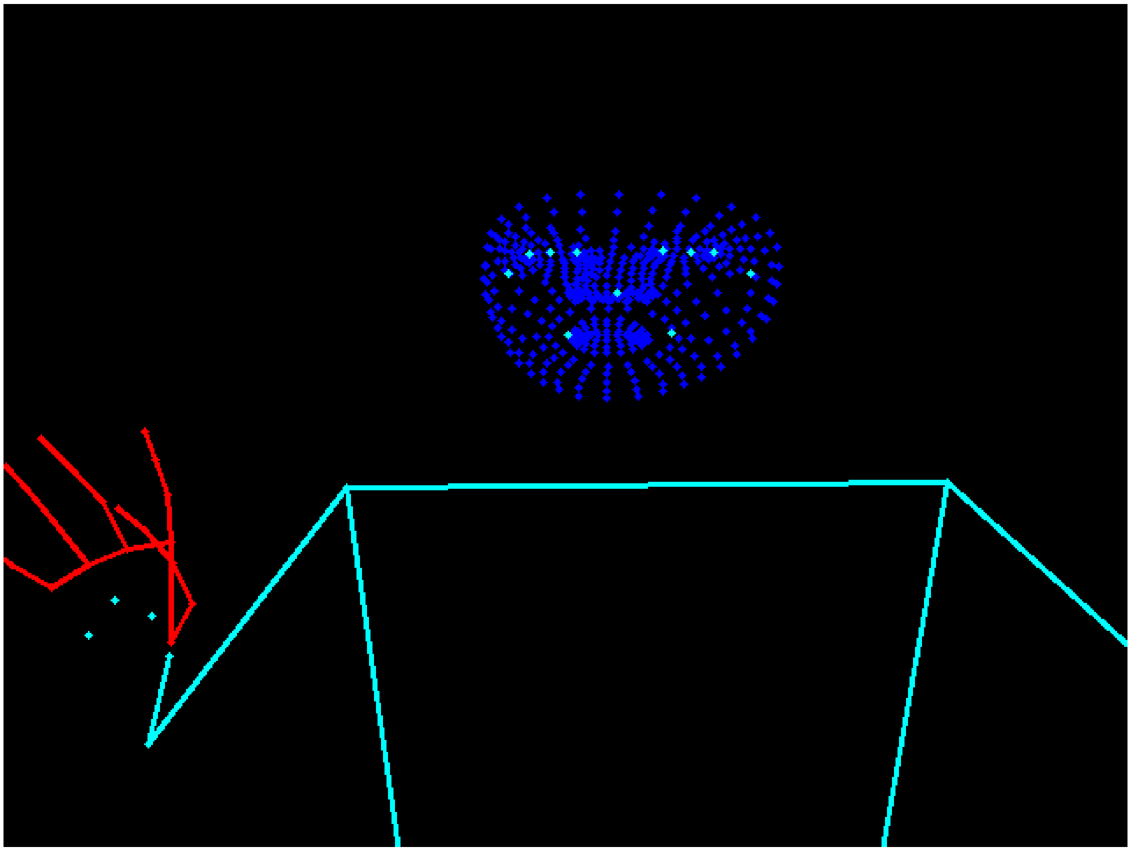
```
# Create a black image
image_height, image_width = 480, 640
image = np.zeros((image_height, image_width, 3), dtype=np.uint8)

# Define connections for face, pose, and hands
# Define the face connections here
#"""
FACE_CONNECTIONS = [
    # Face oval
    #*(list(zip(range(0, 151), range(1, 152))) + [(151, 0)]),

    # Eyebrows
    #*list(zip(range(152, 157), range(153, 158))), # Right eyebrow
    #*list(zip(range(158, 163), range(159, 164))), # Left eyebrow

    # Eyes
    #*list(zip(range(133, 141), range(134, 142))) + [(141, 133)], # Right eye
    #*list(zip(range(362, 370), range(363, 371))) + [(370, 362)], # Left eye

    # Lips (outer and inner)
    #*list(zip(range(61, 67), range(62, 68))) + [(67, 61)], # Outer top lip
    #*list(zip(range(146, 152), range(147, 153))) + [(152, 146)], # Outer bottom lip
    #*list(zip(range(78, 82), range(79, 83))) + [(82, 78)], # Inner top lip
    #*list(zip(range(87, 91), range(88, 92))) + [(91, 87)], # Inner bottom lip

    # Nose
    #*list(zip(range(234, 238), range(235, 239))), # Nose bridge
    #*list(zip(range(308, 314), range(309, 315)))  # Lower nose
]
#"""
#FACE_CONNECTIONS = []
# Define the pose connections here
POSE_CONNECTIONS = [
    # Torso
    (11, 12), (11, 23), (12, 24), (23, 24),

    # Arms
    (11, 13), (13, 15), (12, 14), (14, 16),

    # Legs
    (23, 25), (25, 27), (27, 31), (24, 26), (26, 28), (28, 32),

    # Shoulders to hips
    (11, 23), (12, 24)
]
```

```
# Hand connections based on MediaPipe hand landmark model
HAND_CONNECTIONS = [
    (0, 1), (1, 2), (2, 3), (3, 4),          # Thumb
    (0, 5), (5, 6), (6, 7), (7, 8),          # Index finger
    (5, 9), (9, 10), (10, 11), (11, 12),     # Middle finger
    (9, 13), (13, 14), (14, 15), (15, 16),   # Ring finger
    (13, 17), (17, 18), (18, 19), (19, 20)   # Little finger
]

def draw_landmarks(image, df):
    colors = {
        'face': (255, 0, 0),
        'left_hand': (0, 255, 0),
        'right_hand': (0, 0, 255),
        'pose': (255, 255, 0)
    }

    grouped = df.groupby('type')

    for group_name, group_df in grouped:
        connections = None
        if group_name == 'face':
            connections = FACE_CONNECTIONS
        elif group_name == 'pose':
            connections = POSE_CONNECTIONS
        elif group_name in ['left_hand', 'right_hand']:
            connections = HAND_CONNECTIONS

        if connections:
            for connection in connections:
                pt1 = group_df[group_df['landmark_index'] == connection[0]].
 ↪iloc[0]
                pt2 = group_df[group_df['landmark_index'] == connection[1]].
 ↪iloc[0]

                if not (pd.isna(pt1['x']) or pd.isna(pt1['y']) or pd.
 ↪isna(pt2['x']) or pd.isna(pt2['y'])):
                    x1, y1 = int(pt1['x'] * image_width), int(pt1['y'] *␣
 ↪image_height)
                    x2, y2 = int(pt2['x'] * image_width), int(pt2['y'] *␣
 ↪image_height)
                    cv2.line(image, (x1, y1), (x2, y2), colors[group_name], 2)

        # Draw landmarks
        for _, row in group_df.iterrows():
            if pd.isna(row['x']) or pd.isna(row['y']):
                continue
            x, y = int(row['x'] * image_width), int(row['y'] * image_height)
            color = colors.get(group_name, (255, 255, 255))
            cv2.circle(image, (x, y), 2, color, -1)

# Draw landmarks for a specific frame
frame_number = 20
df_frame = df_landmark[df_landmark['frame'] == frame_number]
draw_landmarks(image, df_frame)

# Display the image
cv2_imshow(image)
```



[ ]:
```
# Draw landmarks for a specific frame
image = np.zeros((image_height, image_width, 3), dtype=np.uint8)
frame_number = 42
df_frame = df_landmark[df_landmark['frame'] == frame_number]
draw_landmarks(image, df_frame)

# Display the image
```

```
cv2_imshow(image)
```



During our study of the data and research on the possible model solutions, there is one transformer model approach caught our eye. This transformer model approach was designed by Wijkhuizen, M., in the Kaggle competition (2023). Our project team decided to follow Wijkhuizen, M.'s approach to create a transformer model as one of the models to test for this project. Our goal with this approach is to get a better understanding of the transformer model since Wijkhuizen, M.'s approach is to build a transformer model from scratch and not fine-turn a base model.

```
[ ]: # Code From https://www.kaggle.com/code/markwijkhuizen/
      ↪gislr-tf-data-processing-transformer-training
     import pandas as pd
     import numpy as np
     from tqdm import tqdm
     SEED=1234
     # Assuming df_metadata is already defined
     N = min(1000, len(df_metadata))  # Sample size, adjust as needed
     print(N)

     # Arrays to store analysis results
     N_UNIQUE_FRAMES = np.zeros(N, dtype=np.uint16)
```

```
N_MISSING_FRAMES = np.zeros(N, dtype=np.uint16)
MAX_FRAME = np.zeros(N, dtype=np.uint16)

# Sample a subset of the dataset for analysis
sampled_metadata = df_metadata.sample(N, random_state=SEED)

# Loop over the sampled metadata
for idx, (_, row) in enumerate(tqdm(sampled_metadata.iterrows(), total=N)):
    # Load the landmark data
    samplefile_dir = row['path']
    samplefile_full_file_path = os.path.join(main_dir, samplefile_dir)
    df_landmark = pd.read_parquet(samplefile_full_file_path)

    # Analysis of frames
    N_UNIQUE_FRAMES[idx] = df_landmark['frame'].nunique()
    N_MISSING_FRAMES[idx] = (df_landmark['frame'].max() - df_landmark['frame'].
 ↪min()) - df_landmark['frame'].nunique() + 1
    MAX_FRAME[idx] = df_landmark['frame'].max()

# Printing the first elements for inspection
print(N_UNIQUE_FRAMES[0], N_MISSING_FRAMES[0], MAX_FRAME[0])
```

```
1000
```

```
100%|      | 1000/1000 [14:40<00:00,  1.14it/s]
```

```
109 0 148
```

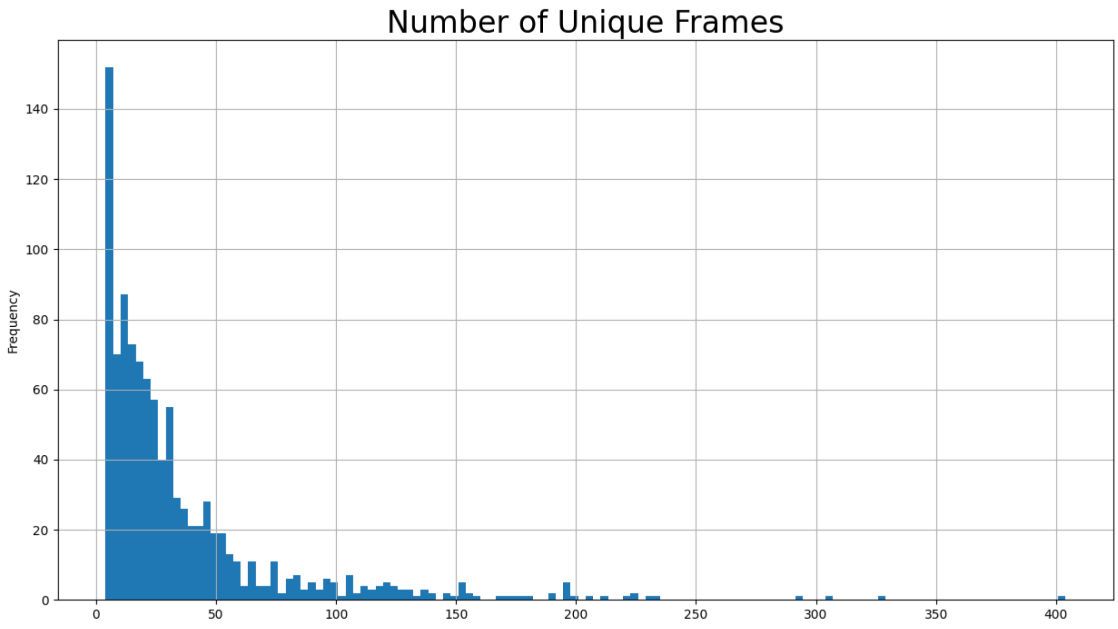
[ ]:

```
# Code From https://www.kaggle.com/code/markwijkhuizen/
 ↪gislr-tf-data-processing-transformer-training
import matplotlib.pyplot as plt
PERCENTILES = [0.01, 0.05, 0.25, 0.50, 0.75, 0.95, 0.99, 0.999]
# Number of unique frames in each video
display(pd.Series(N_UNIQUE_FRAMES).describe(percentiles=PERCENTILES).
 ↪to_frame('N_UNIQUE_FRAMES'))

plt.figure(figsize=(15,8))
plt.title('Number of Unique Frames', size=24)
pd.Series(N_UNIQUE_FRAMES).plot(kind='hist', bins=128)
plt.grid()
xlim = math.ceil(plt.xlim()[1])
plt.xlim(0, xlim)
plt.xticks(np.arange(0, xlim+25, 25))
plt.show()
```

```
       N_UNIQUE_FRAMES
count       1000.000000
```

```
mean          36.253000
std           42.776054
min            4.000000
1%             6.000000
5%             6.000000
25%           11.000000
50%           22.000000
75%           42.000000
95%          123.000000
99%          206.070000
99.9%        328.076000
max          404.000000
```

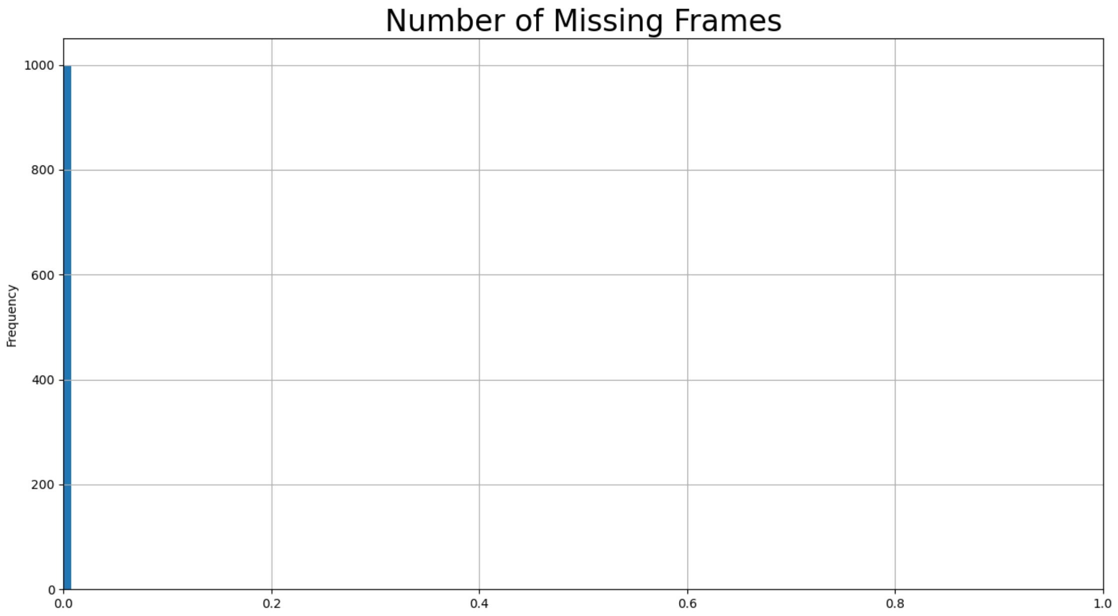
```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-17-2709d42446f0> in <cell line: 10>()
      8 pd.Series(N_UNIQUE_FRAMES).plot(kind='hist', bins=128)
      9 plt.grid()
---> 10 xlim = math.ceil(plt.xlim()[1])
     11 plt.xlim(0, xlim)
     12 plt.xticks(np.arange(0, xlim+25, 25))

NameError: name 'math' is not defined
```



[ ]:
```
# Code From https://www.kaggle.com/code/markwijkhuizen/
↪gislr-tf-data-processing-transformer-training
```

```python
import math
# Number of missing frames, consecutive frames with missing intermediate frame, i.e. 1,2,4,5 -> 3 is missing
display(pd.Series(N_MISSING_FRAMES).describe(percentiles=PERCENTILES).to_frame('N_MISSING_FRAMES'))

plt.figure(figsize=(15,8))
plt.title('Number of Missing Frames', size=24)
pd.Series(N_MISSING_FRAMES).plot(kind='hist', bins=128)
plt.grid()
plt.xlim(0, math.ceil(plt.xlim()[1]))
plt.show()
```

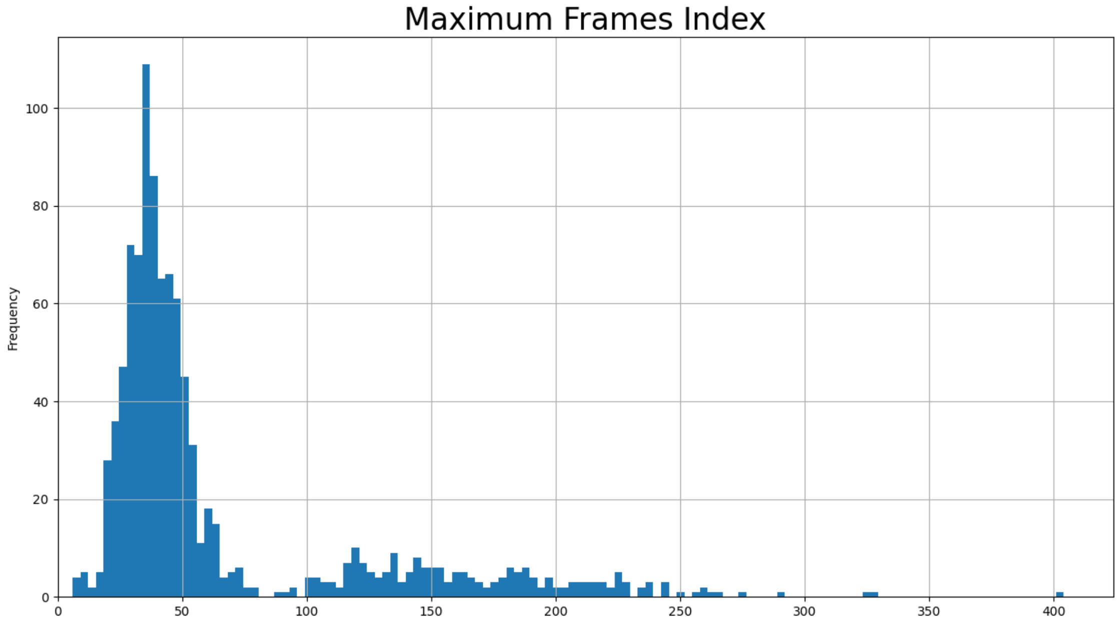
```
       N_MISSING_FRAMES
count            1000.0
mean                0.0
std                 0.0
min                 0.0
1%                  0.0
5%                  0.0
25%                 0.0
50%                 0.0
75%                 0.0
95%                 0.0
99%                 0.0
99.9%               0.0
max                 0.0
```



[ ]:

```
# Code From https://www.kaggle.com/code/markwijkhuizen/
 ↪gislr-tf-data-processing-transformer-training
# Maximum frame number
display(pd.Series(MAX_FRAME).describe(percentiles=PERCENTILES).
 ↪to_frame('MAX_FRAME'))

plt.figure(figsize=(15,8))
plt.title('Maximum Frames Index', size=24)
pd.Series(MAX_FRAME).plot(kind='hist', bins=128)
plt.grid()
plt.xlim(0, math.ceil(plt.xlim()[1]))
plt.show()
```

```
         MAX_FRAME
count  1000.000000
mean     65.221000
std      57.220559
min       6.000000
1%       15.000000
5%       22.000000
25%      33.000000
50%      42.000000
75%      60.000000
95%     196.000000
99%     249.070000
99.9%   327.077000
max     404.000000
```



Reference:

Wijkhuizen, M. (2023, April 04). GISLR TF Data Processing & Transformer Training. Kaggle. https://www.kaggle.com/code/markwijkhuizen/gislr-tf-data-processing-transformer-training