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CS199

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### 3D Pose Estimation and Visualization

In this project, the task is to estimate a person's 3D pose from 2D images by projecting 3D skeleton coordinates. Each pose contains the relative location of body joints (referred to as a "skeleton"). The challenge lies in visualizing these 3D skeletons (with a given camera position/angle) in a 3D space and ensuring that the connections between joints form a meaningful representation of the human body, comparable to the 2D images given.

My solution to this problem was created utilizing Python and the Matplotlib library for graphing, as well as NumPy for mathematical calculations and Json for file dumping. I created 2 scripts, "inputParser.py" and "poseEstimation.py."

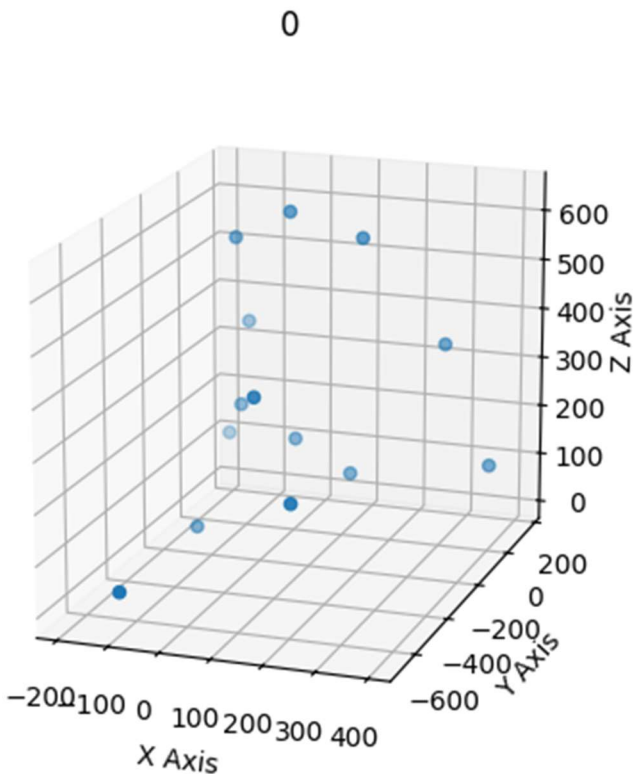
```
def parse_focal_length(filename):
    with open(filename, 'r') as file:
        focal_length = float(file.readline().strip()) # Read and convert to float
    return focal_length

def parse_joint_names(filename):
    joint_names = {}
    with open(filename, 'r') as file:
        for line in file:
            ident, name = line.strip().split() # Split into two parts
            joint_names[int(ident)] = name # Convert ID to int and store in dictionary
    return joint_names

def parse_poses(filename):
    poses = []
    with open(filename, 'r') as file:
        for line in file:
            values = list(map(float, line.strip().split())) # Convert each value to float
            camera_position = values[:3] # First 3 values are camera position
            joint_coordinates = values[3:] # Remaining values are joint coordinates
            poses.append({
                'camera_position': camera_position,
                'joint_coordinates': joint_coordinates
            })
    return poses
```

inputParser was, as its name suggests, a script for reading and formatting the input data into dictionaries and lists for easier access in the poseEstimation script. For example, in poses.txt, the first 3 coordinates of each pose is the position of the camera, so the data for each pose is parsed into a list of dictionaries, storing the camera position with the respective pose but still separating them enough for easier access to the individual parts when graphing.

poseEstimation utilizes NumPy and Matplotlib for processing the poses (creating tuples of each set of coordinates), calculating the viewpoint angle, graphing, and projecting the 3D coordinates into a 2D format. In the initial solution, the points were graphed without connections, in order to see if the joints themselves were properly graphed before worrying about connections. The first few attempts looked similar to the image below:

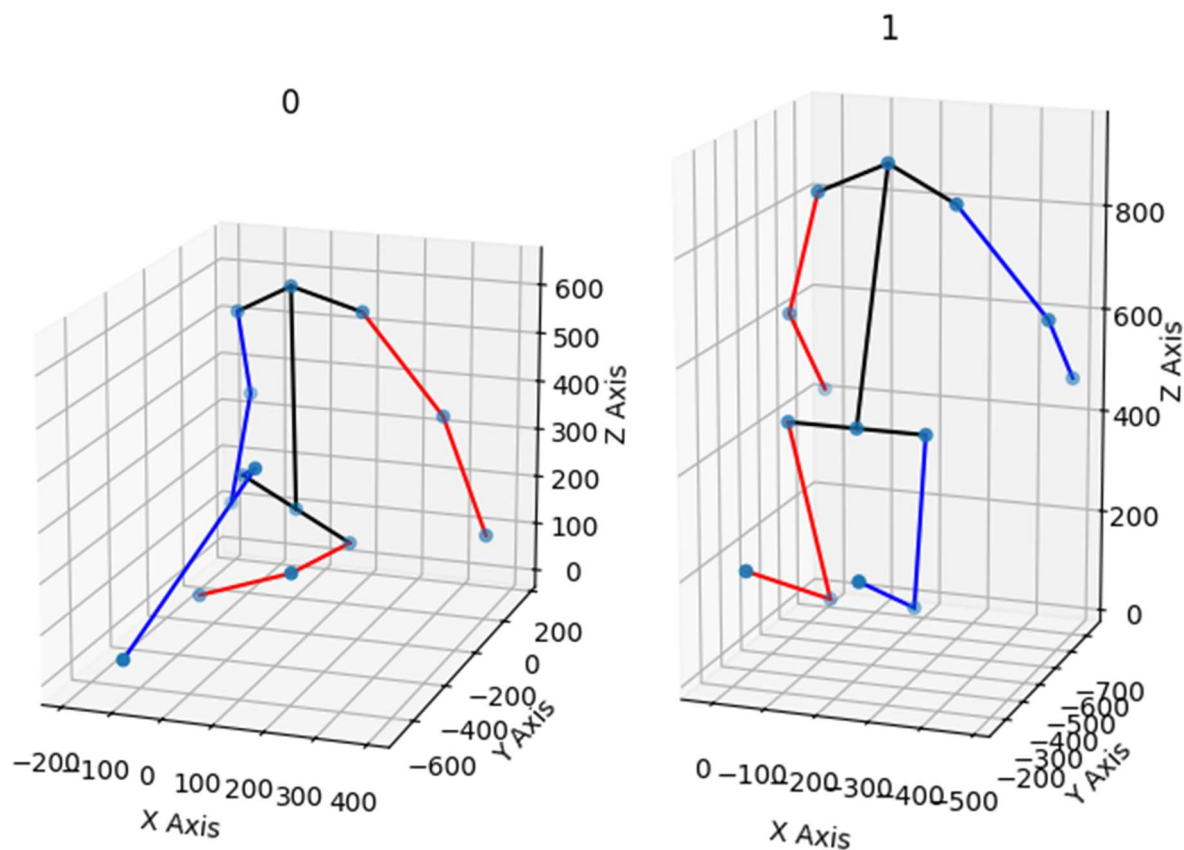


Once a satisfactory result was achieved, I moved on to angling the camera. I did this by using the x,y, and z coordinates to calculate the elevation angle and the azimuth angle for Matplotlib:

```
elev = np.degrees(np.arctan2(z, np.sqrt(x**2 + y**2))) # Elevation angle
azim = np.degrees(np.arctan2(y, x)) # Azimuth angle
```

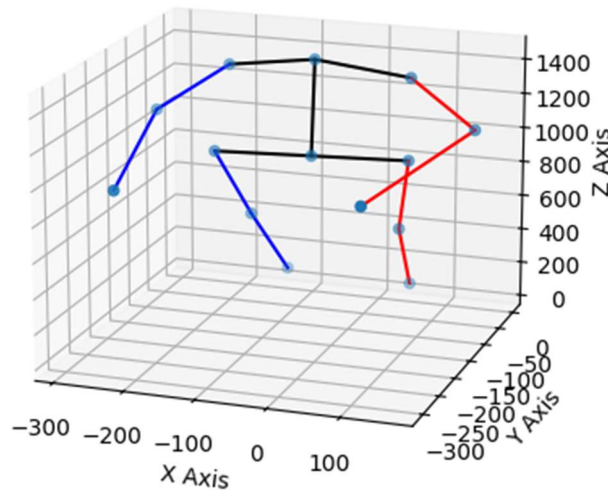
Then, after a satisfactory camera angle was achieved, I began adding the connections. The first few seemed fine (See below) but some of the poses appeared stretched and/or disformed.

Normal:

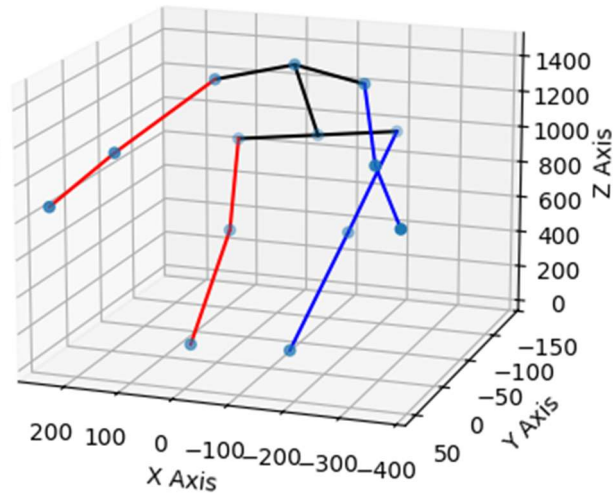


Disfigured:

5



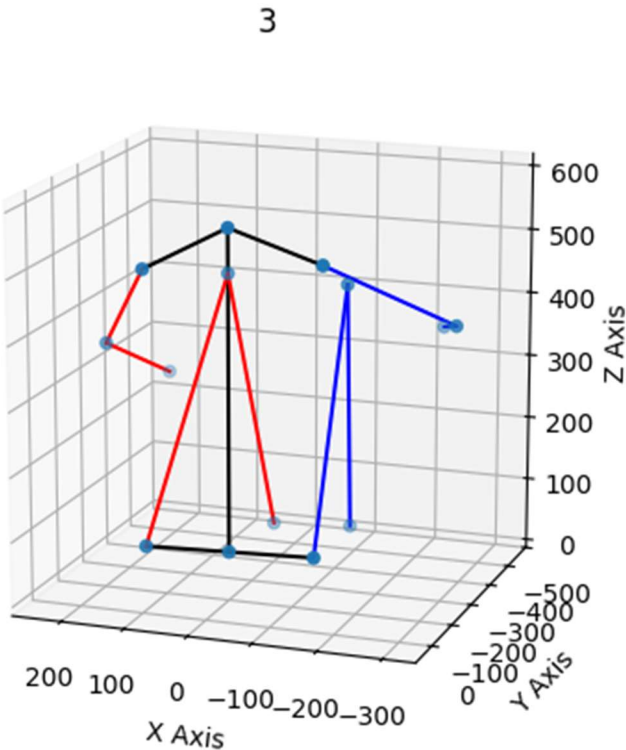
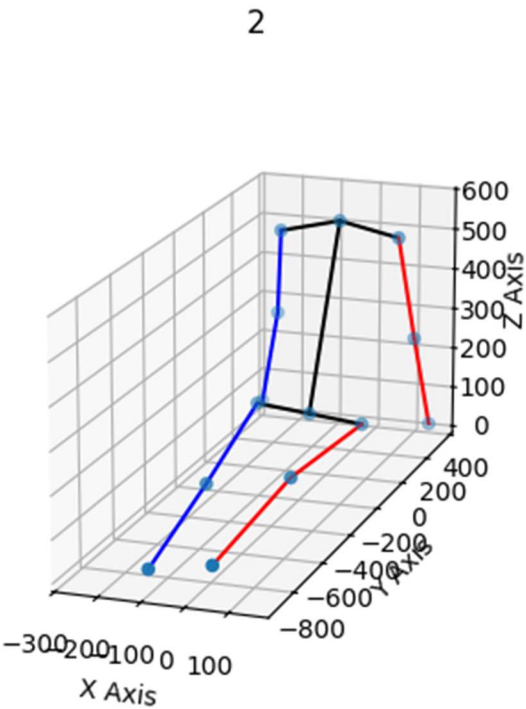
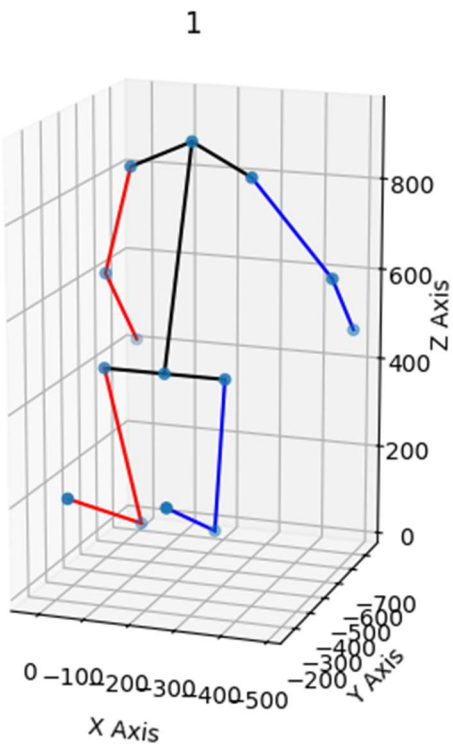
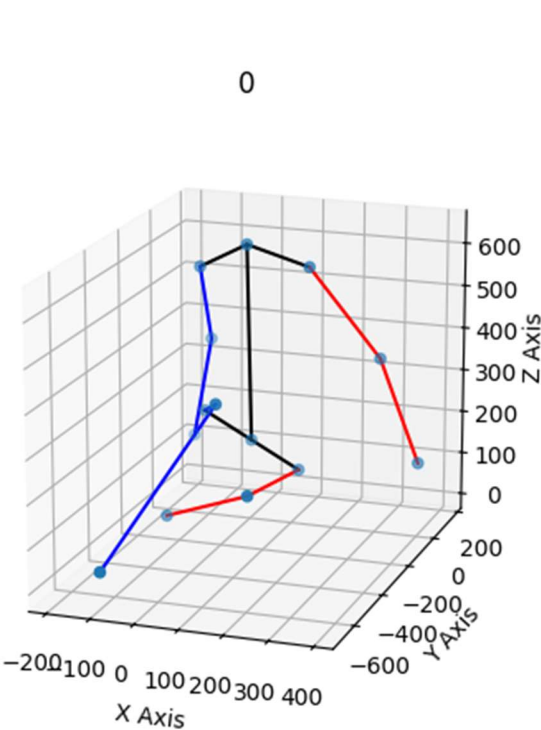
18



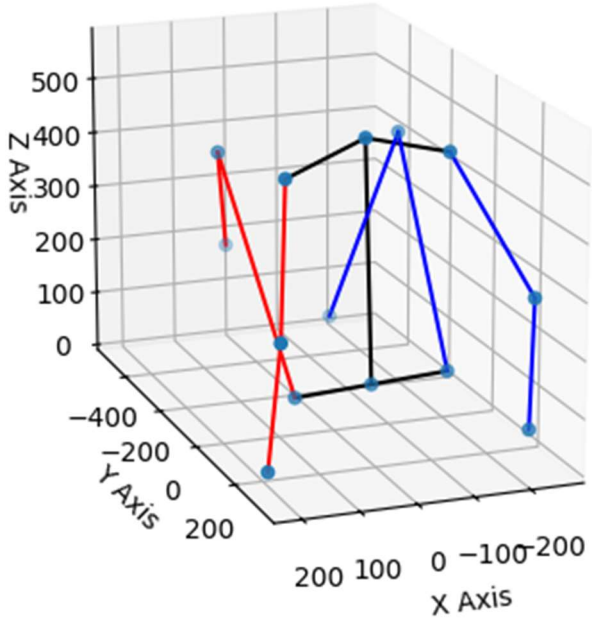
When comparing them to the pictures, they seemed accurate enough, but the viewing of the graph was unsatisfactory. The solution to this was to balance the ranges for each plane (x, y, z) using `np.max()` and `np.min()`, and then setting the box aspect based on the maximum range of the 3, resulting in less deformation.

Lastly, I converted the pose coordinates using a 2D projection formula based on the focal point and the xyz coordinates ( $x = f * \frac{X}{Z}$ ,  $y = f * \frac{Y}{Z}$ ) to create a dictionary of 2D coordinates, which I then dumped to a text file utilizing `json.dump()`. I also saved the processed 3D coordinates in the same manner, as seen below.

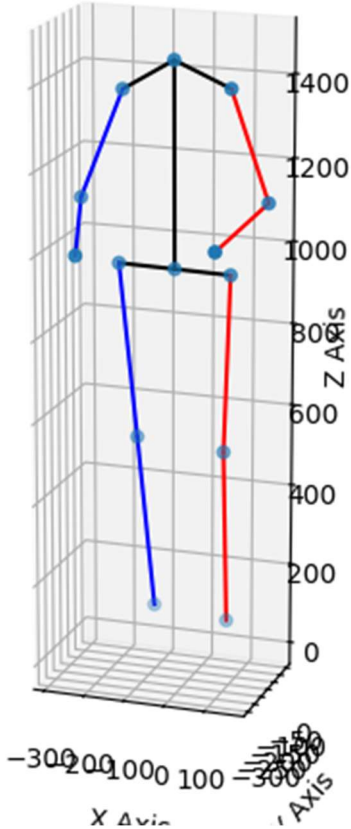
Final Graphs:



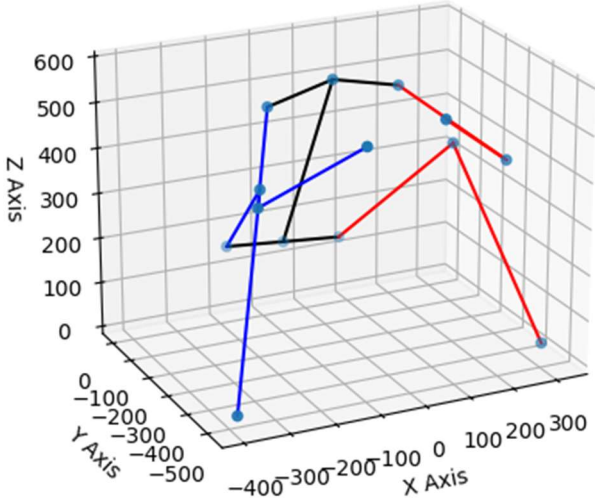
4



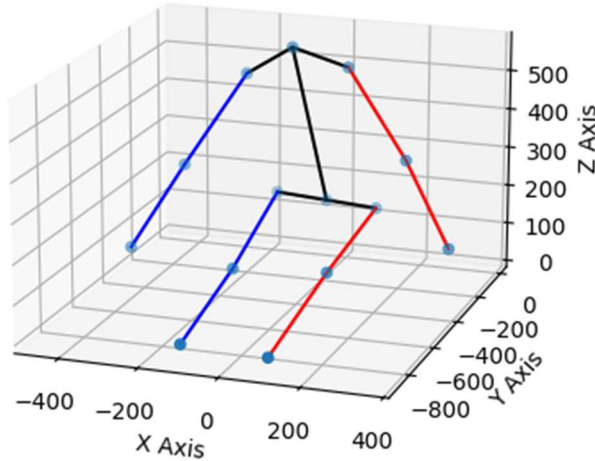
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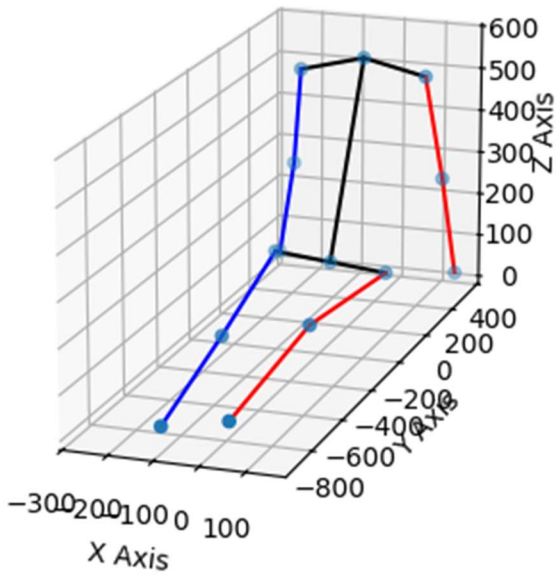


7

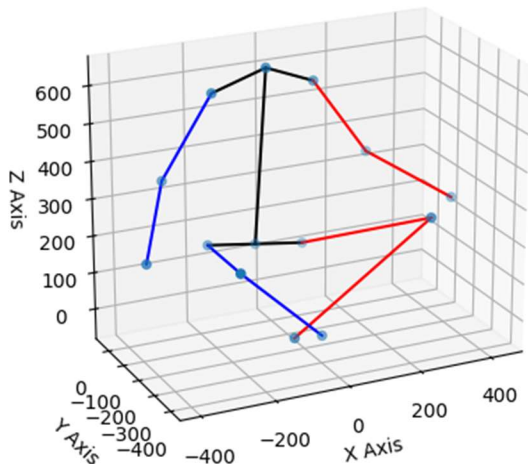




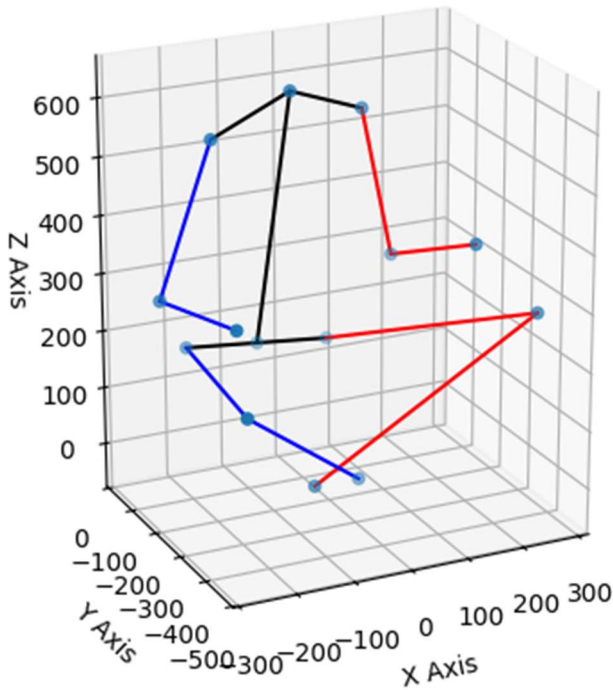
9



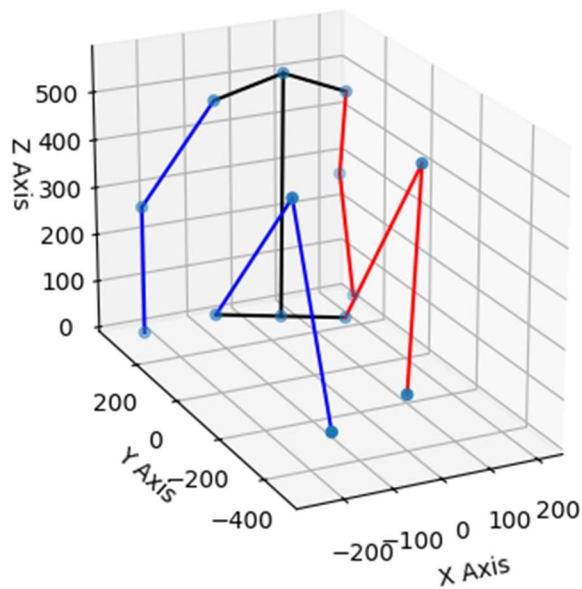
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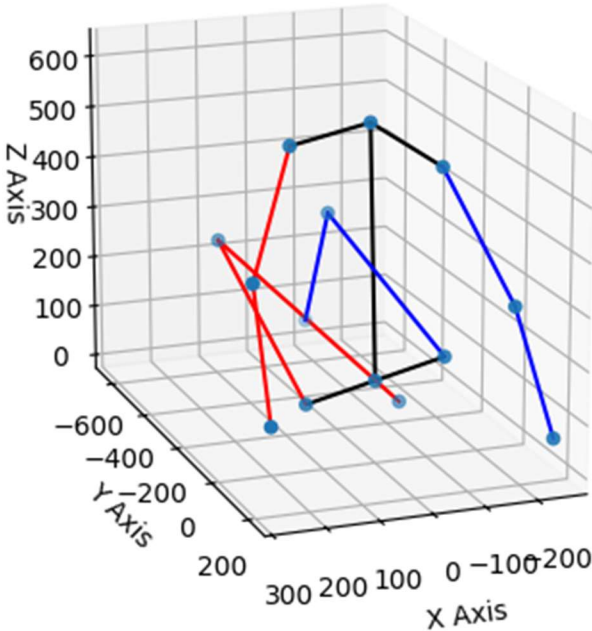
11



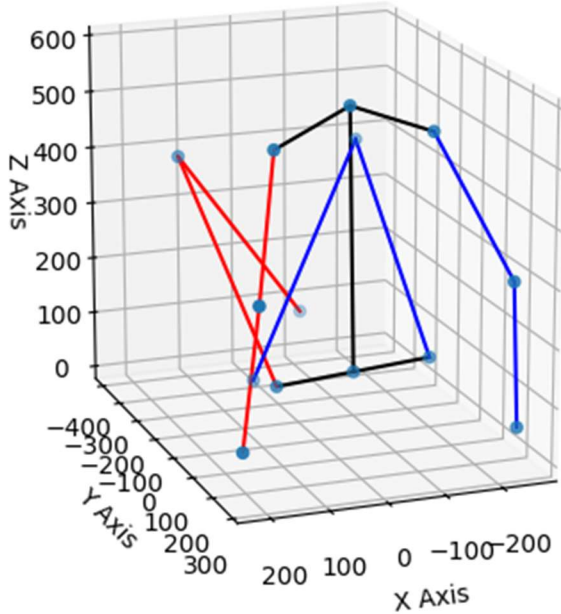
10



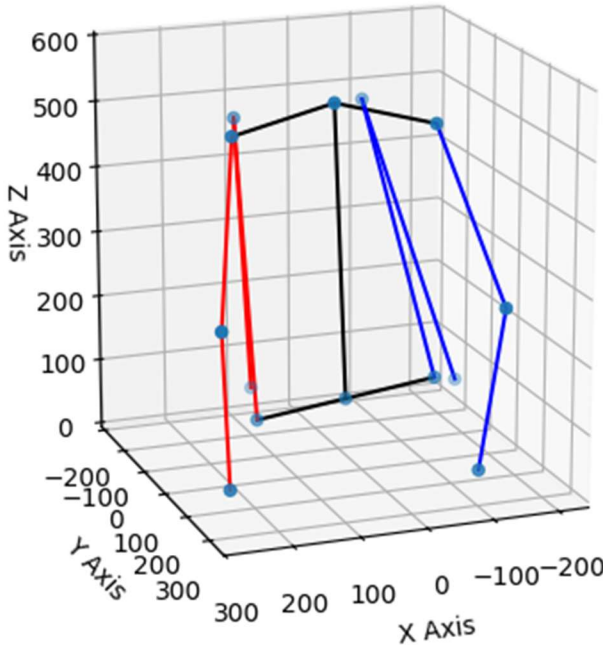
12



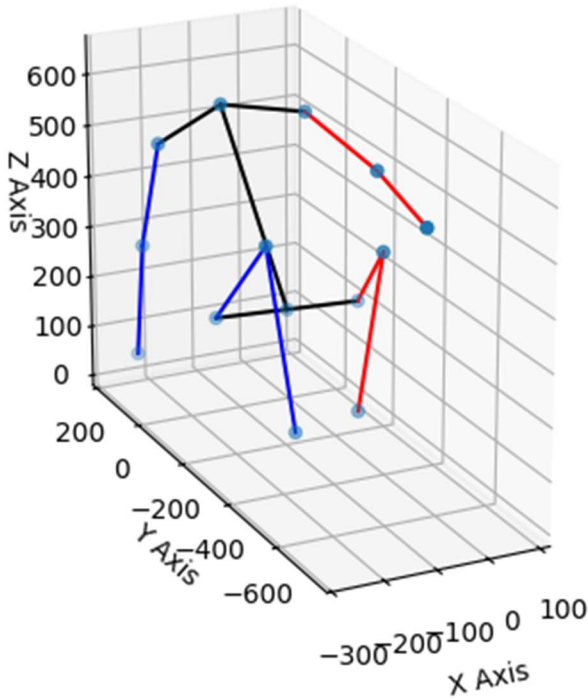
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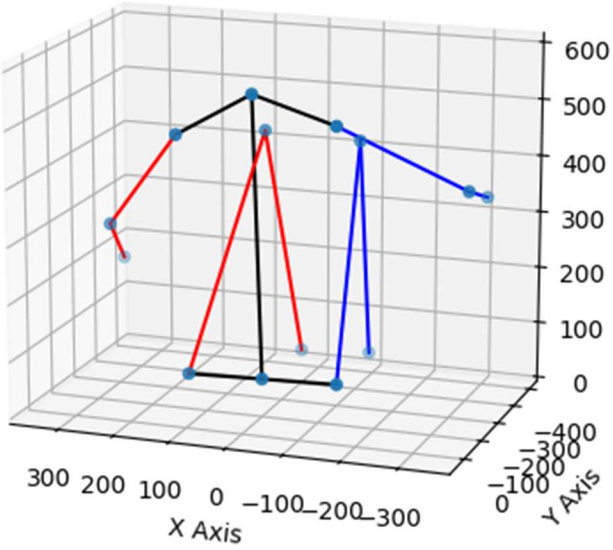


15

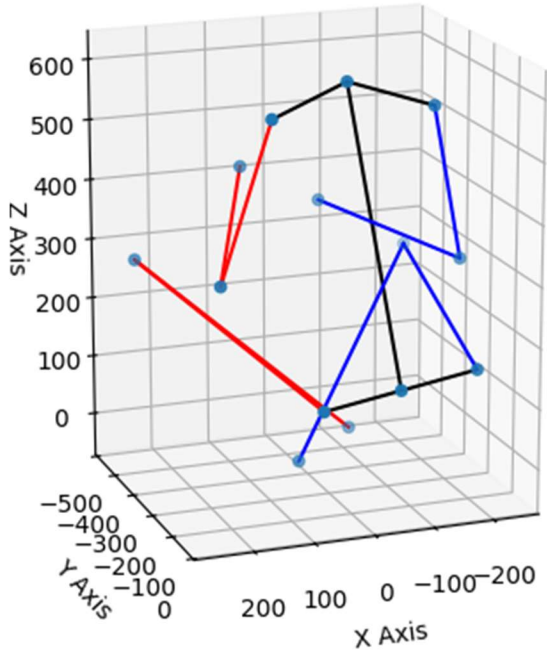




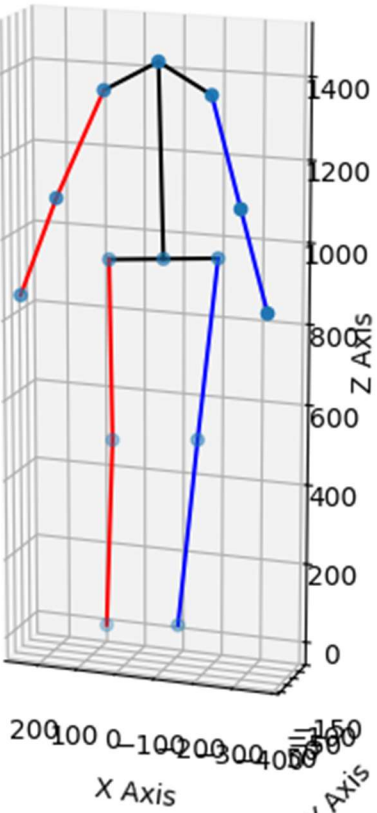
16



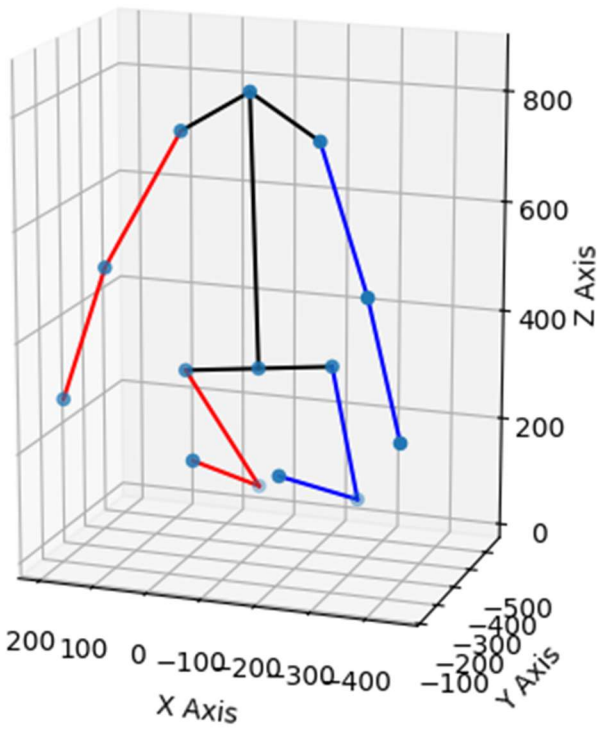
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## Pposes (3D Coordinates):

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## Projections (2D Coordinates):

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