Prepare dataset [1]

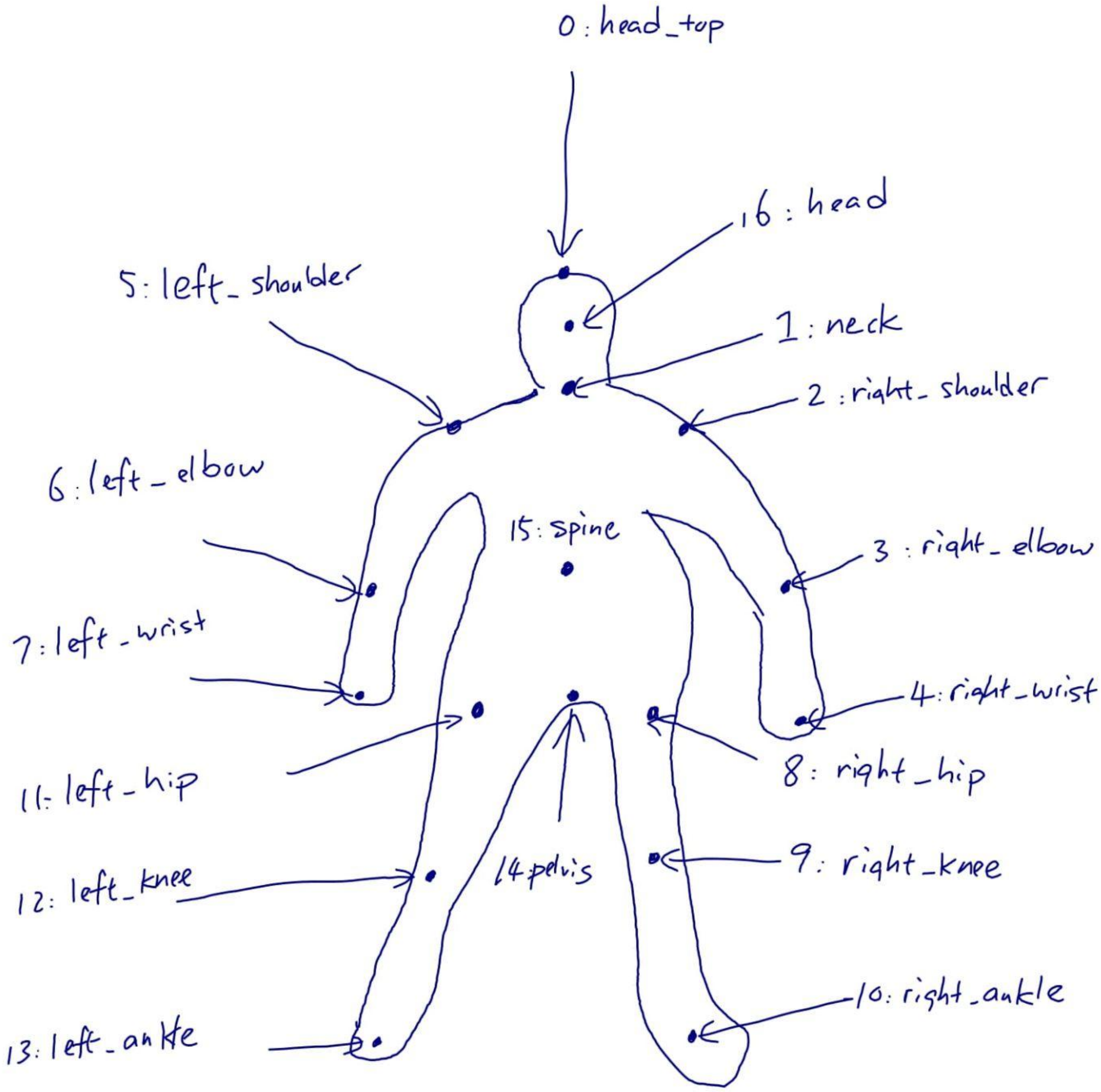
I created a new file prepare_data_mpi_inf_3dhp.py. It is based on prepare_data_h36m.py. I basically structured the file into the same format as described above with one important difference. For Human3.6M, the ground truth 3D joints are recorded with World coordinate. Thus, during the data processing step. The 3D joint coordinates need to be converted into Camera Coordinates. However, Mpi_inf_3dhp is recorded in Camera coordinates already, so I do not need to convert them. Thus, I made some changes to the training script to reflect this.

```
print('Preparing data...')
if args.dataset.startswith('mpi'):
        for subject in dataset.subjects():
            for action in dataset[subject].keys():
                anim = dataset[subject][action]

                if 'positions' in anim:
                    anim['positions_3d'] = anim['positions']
else:
        for subject in dataset.subjects():
            for action in dataset[subject].keys():
                anim = dataset[subject][action]

                if 'positions' in anim:
                    positions_3d = []
                    for cam in anim['cameras']:
                        pos_3d = world_to_camera(anim['positions'], R=cam['orientation'], t=cam['translation'])
                        pos_3d[:, 1:] -= pos_3d[:, :1] # Remove global offset, but keep trajectory in first position
                        positions_3d.append(pos_3d)
                    anim['positions_3d'] = positions_3d

```

Dataset class

Next, I mimic the structure of h36m_dataset.py to make mpi_inf_3dhp_dataset.py. Three important changes I need to make are fps, skeleton, and camera. For fps, the paper [] documents the fps for MPI_INF_3DHP as 25fps.

For skeleton, MPI_INF_3DHP provides a script that can convert the index to Human3.6M style index. Then, I am able to reuse the human3.6M skeleton model since it has the matching joint index. I also made a drawing to show the index.


0: head_top
16: head
5: left_shoulder
1: neck
2: right_shoulder
6: left_elbow
15: spine
3: right_elbow
7: left_wrist
4: right_wrist
11: left_hip
8: right_hip
12: left_knee
14 pelvis
9: right_knee
10: right_ankle
13: left_ankle

Lastly, I need to handle the camera parameters.
To project 3D joints to 2D. It requires camera intrinsic parameters. For visualization purposes, it also needs extrinsic parameters. When looking through the h36m dataset. I found out the following intrinsic parameters are needed.

```
h36m_cameras_intrinsic_params = [
    {
        'id': '54138969',
        'center': [512.54150390625, 515.4514770507812],
        'focal_length': [1145.0494384765625, 1143.7811279296875],
        'radial_distortion': [-0.20709891617298126, 0.24777518212795258, -0.0030751503072679043],
        'tangential_distortion': [-0.0009756988729350269, -0.00142447161488235],
        'res_w': 1000,
        'res_h': 1002,
        'azimuth': 70, # Only used for visualization
    },
```

I need a center, focal length, radial and tangential distortion, width and height.
For extrinsic parameters, I need to specify the orientation and the translation.

```
h36m_cameras_extrinsic_params = {
    'S1': [
        {
            'orientation': [0.1407056450843811, -0.1500701755285263, -0.755240797996521, 0.6223280429840088],
            'translation': [1841.1070556640625, 4955.28466796875, 1563.4454345703125],
        },
        {
            'orientation': [0.6157187819480896, -0.764836311340332, -0.14833825826644897, 0.11794740706682205],
            'translation': [1761.278564453125, -5078.0068359375, 1606.2650146484375],
        },
        {
            'orientation': [0.14651472866535187, -0.14647851884365082, 0.7653023600578308, -0.6094175577163696],
            'translation': [-1846.7777099609375, 5215.04638671875, 1491.972412109375],
        },
        {
            'orientation': [0.5834008455276489, -0.7853162288665771, 0.14548823237419128, -0.14749594032764435],
            'translation': [-1794.7896728515625, -3722.698974609375, 1574.8927001953125],
        },
    ],
```

Within the MPI_INF_3DHP, I've been given the following parameters.

```
name        0
  sensor      10 10
  size        2048 2048
  animated    0
  intrinsic   1497.693 0 1024.704 0 0 1497.103 1051.394 0 0 0 1 0 0 0 0 1
  extrinsic   0.9650164 0.00488022 0.262144 -562.8666 -0.004488356 -0.9993728 0.0351275 1398.138 0.262151 -0.03507521 -0.9643893 3852.623 0 0 0 1
  radial      0
```

We have size, intrinsic matrix and extrinsic matrix.
The size specifies the width and height.
First of all, let's take a look at the extrinsic parameters. I am putting the line into matrix form.

0.9650164	0.00488022	0.262144	-562.8666
-0.004488356	-0.9993728	0.0351275	1398.138
0.262151	-0.03507521	-0.9643893	3852.623
0	0	0	1

In this website [2], it talks about the camera extrinsic:

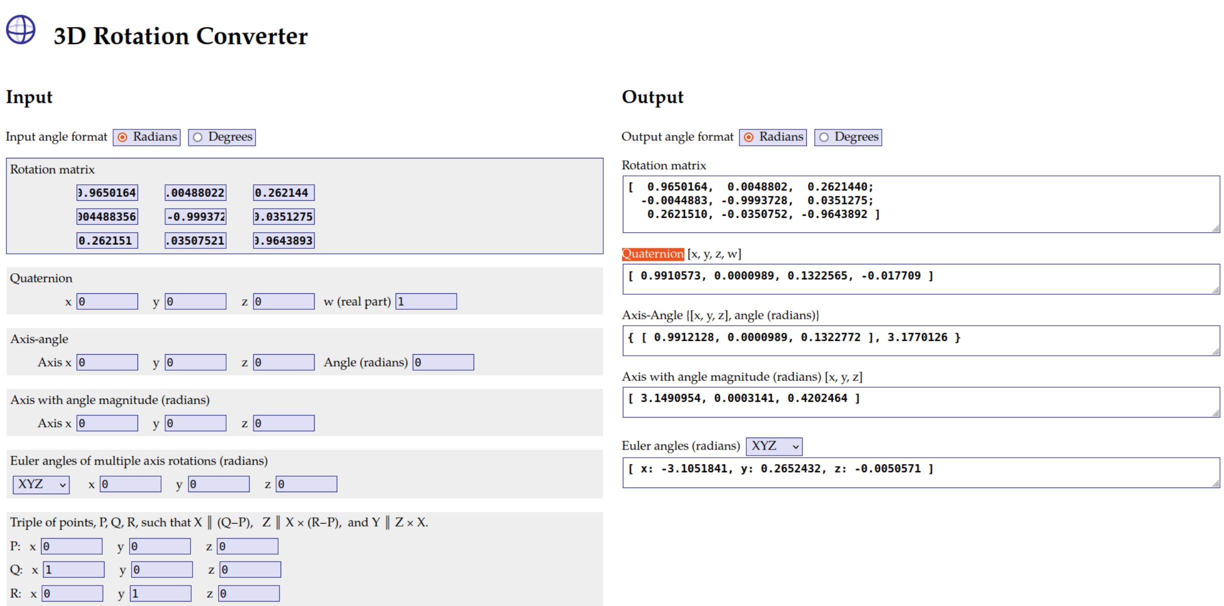
The extrinsic matrix takes the form of a rigid transformation matrix: a 3x3 rotation matrix in the left-block, and 3x1 translation column-vector in the right:

$$[R\,|\,\boldsymbol{t}] = \left[\begin{array}{ccc|c} r_{1,1} & r_{1,2} & r_{1,3} & t_1 \\ r_{2,1} & r_{2,2} & r_{2,3} & t_2 \\ r_{3,1} & r_{3,2} & r_{3,3} & t_3 \end{array}\right]$$

It's common to see a version of this matrix with extra row of (0,0,0,1) added to the bottom. This makes the matrix square, which allows us to further decompose this matrix into a rotation *followed by* translation:

$$\left[\begin{array}{c|c} R & \boldsymbol{t} \\ \hline \boldsymbol{0} & 1 \end{array}\right] = \left[\begin{array}{c|c} I & \boldsymbol{t} \\ \hline \boldsymbol{0} & 1 \end{array}\right] \times \left[\begin{array}{c|c} R & \boldsymbol{0} \\ \hline \boldsymbol{0} & 1 \end{array}\right]$$
$$= \left[\begin{array}{ccc|c} 1 & 0 & 0 & t_1 \\ 0 & 1 & 0 & t_2 \\ 0 & 0 & 1 & t_3 \\ \hline 0 & 0 & 0 & 1 \end{array}\right] \times \left[\begin{array}{ccc|c} r_{1,1} & r_{1,2} & r_{1,3} & 0 \\ r_{2,1} & r_{2,2} & r_{2,3} & 0 \\ r_{3,1} & r_{3,2} & r_{3,3} & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right]$$

Thus, we can see the upper 3*3 is the rotation matrix, while the three variables at right are the translational matrix.
However, this is not the format I wanted. Rather than a 3x3 matrix, I need a Quaternion.
Thanks to this website [3], I am able to make the conversion.



This handles the extrinsic parameters.
As for the intrinsic parameters, I will first put the line into matrix form.

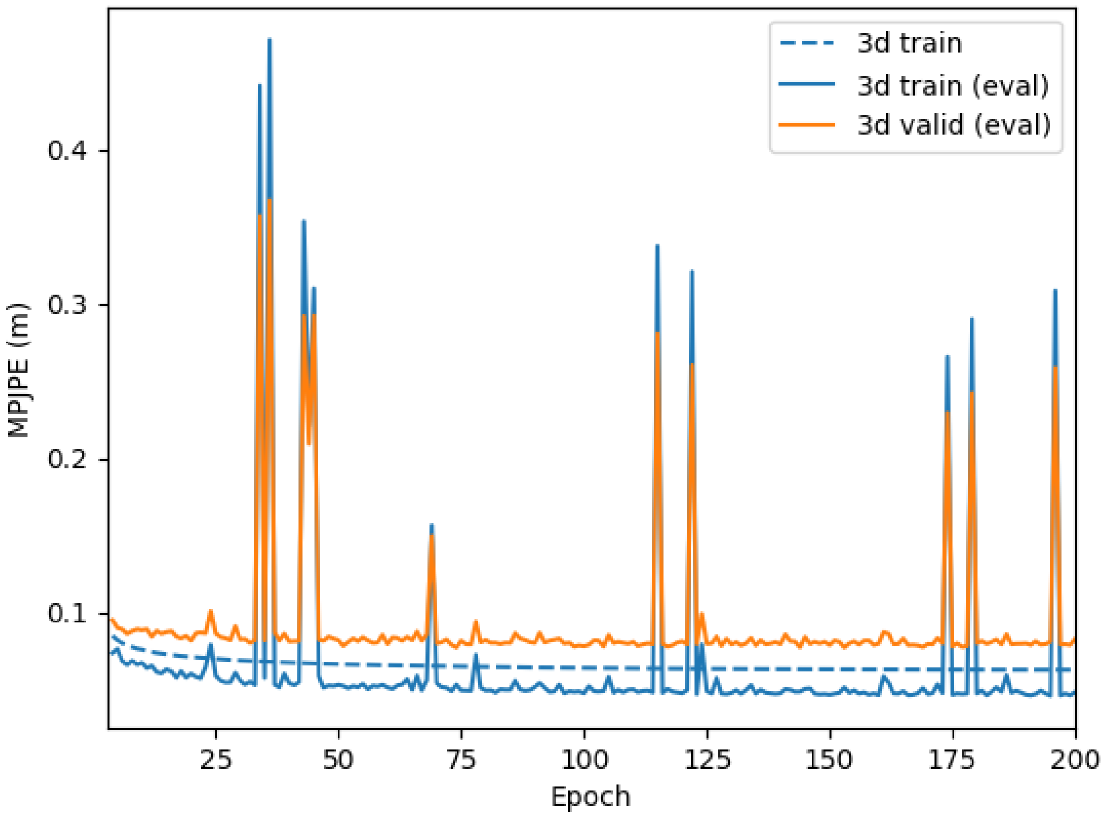
1497.693	0	1024.704	0
0	1497.103	1051.394	0
0	0	1	0
0	0	0	1

This website[4] talks about the intrinsics.

$$K = \begin{pmatrix} f_x & s & x_0 \\ 0 & f_y & y_0 \\ 0 & 0 & 1 \end{pmatrix}$$

f_x and f_y are the focal length, x_0 and y_0 are the center.
The last parameter I need are the radial and tangential distortion.
Radial distortion is specified as 0 in the calibration file. However, it did not specify the tangential distortion, I will assume it is 0. The resulting code is available on my github page:

Result and Discussion



The resulting MPJPE for MPI_INF_3DHP is at around 80mm. The figure above shows the training curve. It does have some spikes which is due to the improper momentum value set for the batch normalization layer. MPI_INF_3DHP is smaller than HumanPose3.6M, thus it needs a higher momentum value which also needs a smaller architecture. The training parameter I set for the above graph is default 3,3,3 arc which is 27 frames. Within the run code, I modified the momentum to be around 0.8 to 0.6. The resulting graph is not that perfect, but it can be fixed with some parameter tuning. Thus, my work shows that VideoPose3D can also be generalized on MPI_INF_3DHP dataset.

References

1. Pavllo, D., Feichtenhofer, C., Grangier, D., & Auli, M. (2019). 3D human pose estimation in video with temporal convolutions and semi-supervised training. In Conference on Computer Vision and Pattern Recognition (CVPR).
2. Simek, K. (2012, August 22). *Dissecting the camera matrix, part 2: The extrinsic matrix*. Retrieved April 29, 2022, from https://ksimek.github.io/2012/08/22/extrinsic/
3. Gaschler, A. (n.d.). 3D Rotation Converter. Retrieved April 29, 2022, from https://www.andre-gaschler.com/rotationconverter/
4. Simek, K. (2013, August 13). *Dissecting the camera matrix, part 3: The Intrinsic matrix*. Retrieved April 29, 2022, from https://ksimek.github.io/2013/08/13/intrinsic/