Drive link to folder: https://drive.google.com/open?id=1gXSpe_apJCECgjwwdjzIn7hRvdRXkXJ1

# CSE527 Homework 6

**Due date: 23:59 on Dec. 5, 2019 (Thursday)**

In this semester, we will use Google Colab for the assignments, which allows us to utilize resources that some of us might not have in their local machines such as GPUs. You will need to use your Stony Brook (*.stonybrook.edu) account for coding and Google Drive to save your results.

## Google Colab Tutorial

Go to https://colab.research.google.com/notebooks/, you will see a tutorial named "Welcome to Colaboratory" file, where you can learn the basics of using google colab.

Settings used for assignments: ***Edit -> Notebook Settings -> Runtime Type (Python 3)***.

## Description

In this homework we are going to work on estimating the 3D pose of a person given their 2D pose. Turns out, just regressing the 3D pose coordinates using the 2D pose works pretty well [1] (you can find the paper here). In Part One, we are going to work on reproducing the results of the paper, in Part Two, we are going to try to find a way to handle noisy measurement.

## Some Tutorials (PyTorch)

- You will be using PyTorch for deep learning toolbox (follow the link for installation).
- For PyTorch beginners, please read this tutorial before doing your homework.
- Feel free to study more tutorials at http://pytorch.org/tutorials/.
- Find cool visualization here at http://playground.tensorflow.org.

## Starter Code

In the starter code, you are provided with a function that loads data into minibatches for training and testing in PyTorch.

## Benchmark

Train for a least 30 epochs to get a least 44mm avg error. The test result(mm error) should be in the following sequence **direct. discuss. eat. greet. phone photo pose purch. sit sitd. somke wait walkd. walk walkT avg**

# Problem 1:

{60 points} Let us first start by trying to reproduce the testing accuracy obtained by in the paper above using PyTorch. The 2D pose of a person is represented as a set of 2D coordinates for each of their $n = 32$ joints i.e $P_i^{2D}$ = $\{(x_i^1, y_i^1), \ldots, (x_i^{32}, y_i^{32})\}$, where $(x_i^j, y_i^j)$ are the 2D coordinates of the $j$'th joint of the i'th sample. Similarly, the 3D pose of a person is $P_i^{3D}$ = $\{(x_i^1, y_i^1, z_i^1), \ldots, (x_i^{32}, y_i^{32}, z_i^{32})\}$, where $(x_i^j, y_i^j, z_i^j)$ are the 3D coordinates of the $j$'th joint of the $i$'th sample. The only data given to you is the ground truth 3D pose and the 2D pose calculated using the camera parameters. You are going to train a network $f_\theta : R^{2n} \rightarrow R^{3n}$ that takes as input the $P_i^{2D}$ and tries to regress the ground truth 3D pose $P_i^{3D}$. The loss function to train this network would be the $L2$ loss between the ground truth and the predicted pose

$$L(\theta) = \sum_{i=1}^{M} (P_i^{3D} - f_\theta(P_i^{2D}))^2; \qquad \text{for a minibatch of size M} \qquad (2)$$

Download the Human3.6M Dataset here.

**Bonus**: Every 1mm drop in test error from 44mm till 40mm gets you 2 extra points, and every 1mm drop below 40mm gets you 4 extra points.

```
# Mount your google drive where you've saved your assignment folder
from google.colab import drive
drive.mount('/content/gdrive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&r

Enter your authorization code:
··········
Mounted at /content/gdrive
```

```
# Set your working directory (in your google drive), '/content/gdrive/My Drive/CSE-527-Intro-To-Computer-Vision/hw06/src' is just an example,
#   change it to your specific homework directory and src.
# Note that Surname_Givenname_SBUID_hw6.ipynb is in the same level of the folder src.

# The structure is like
# Surname_Givenname_SBUID_hw6
#        |---Surname_Givenname_SBUID_hw6.ipynb
#        |---src/*
cd '/content/gdrive/My Drive/Y2019Fall/CSE-527-Intro-To-Computer-Vision/Paratkar_Shreyash_112673930_hw6/src'
```

```
/content/gdrive/My Drive/Y2019Fall/CSE-527-Intro-To-Computer-Vision/Paratkar_Shreyash_112673930_hw6/src
```

```
!ls
```

```
bar.py      data_process.py  log.py         progress     viz.py
camera.py   data_utils.py    misc.py        __pycache__
cameras.py  __init__.py      procrustes.py  utils.py
```

```
pip install pykalman
```

```
Collecting pykalman
  Downloading https://files.pythonhosted.org/packages/2f/62/a4adc4516bd5974aa5583090199dd4b78d1e87018d14e9279f72ccbf0b9b/pykalman-0.9.5.tar.gz (228kB)
     |████████████████████████████████| 235kB 38.7MB/s
Building wheels for collected packages: pykalman
  Building wheel for pykalman (setup.py) ... done
  Created wheel for pykalman: filename=pykalman-0.9.5-cp36-none-any.whl size=48464 sha256=47d9350c9734234a4efb5b599543174e783bf9b56c1531aa2c3d28b439e283ca
  Stored in directory: /root/.cache/pip/wheels/d9/e8/6a/553d9832679cb74a8434fa597c3abdb07313e40054a0adf9ac
Successfully built pykalman
Installing collected packages: pykalman
Successfully installed pykalman-0.9.5
```

```
1  !pip install procrustes
```

```
Collecting procrustes
  Downloading https://files.pythonhosted.org/packages/cc/6a/27c922e36e81616fedfe6f66b77b800639148b26dd18ada15e0b63872731/procrustes-0.2.1.tar.gz
Collecting ordereddict
  Downloading https://files.pythonhosted.org/packages/53/25/ef88e8e45db141faa9598fbf7ad0062df8f50f881a36ed6a0073e1572126/ordereddict-1.1.tar.gz
Building wheels for collected packages: procrustes, ordereddict
  Building wheel for procrustes (setup.py) ... done
  Created wheel for procrustes: filename=procrustes-0.2.1-cp36-none-any.whl size=7450 sha256=798fe58f07460a36a97b3c049f1f9954922240863079e94a28a7f3eff1a54359
  Stored in directory: /root/.cache/pip/wheels/a8/17/e6/07c92dbf46f1f553f5ba64ec09bc7ba12cf3db2391b8e1756b
  Building wheel for ordereddict (setup.py) ... done
  Created wheel for ordereddict: filename=ordereddict-1.1-cp36-none-any.whl size=3555 sha256=c9825f7a5ad49e824451ac40de016ef2fa5dd38621011b192381adbfa3cb6700
  Stored in directory: /root/.cache/pip/wheels/78/d3/a8/9f52c7a389a0ffba6f575a3886b5f7a55461fb6ec34aa5fd38
Successfully built procrustes ordereddict
Installing collected packages: ordereddict, procrustes
Successfully installed ordereddict-1.1 procrustes-0.2.1
```

```
1  from __future__ import print_function, absolute_import, division
2
3  import os
4  import sys
5  import time
6  from pprint import pprint
7  import numpy as np
8
9  import torch
10 import torch.nn as nn
11 import torch.optim
12 import torch.backends.cudnn as cudnn
13 from torch.utils.data import DataLoader
14 from torch.autograd import Variable
15
16 # Locate to the src folder to import the following functions.
17 from procrustes import get_transformation
18 import data_process as data_process
19 import data_utils
20 import progress.progress.bar as pBar
21 import utils as utils
22 import misc as misc
23 import log as log
24 import cameras
25
26 from pykalman import KalmanFilter
```

```
from sklearn.metrics import mean_squared_error
import matplotlib.pyplot as plt
```

```
# Feel free to use more cells if necessary.
```

```
# Define actions
actions = data_utils.define_actions("All")
```

```
# Load camera parameters
SUBJECT_IDS = [1,5,6,7,8,9,11]
cameras_path = '../h36m/h36m/cameras.h5'
rcams = cameras.load_cameras(cameras_path, SUBJECT_IDS)
```

```
# Load data
data_dir = '../h36m/h36m/'
camera_frame = True
predict_14 = False
# Load 3d data and load (or create) 2d projections
train_set_3d, test_set_3d, data_mean_3d, data_std_3d, dim_to_ignore_3d, dim_to_use_3d, train_root_positions, test_root_positions = data_utils.read_3d_data(
    actions, data_dir, camera_frame, rcams, predict_14 )
```

```
Reading subject 1, action Directions
../h36m/h36m/S1/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Directions 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Directions.h5
Reading subject 1, action Discussion
../h36m/h36m/S1/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Discussion.h5
Reading subject 1, action Eating
../h36m/h36m/S1/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Eating 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/Eating.h5
Reading subject 1, action Greeting
../h36m/h36m/S1/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S1/MyPoses/3D_positions/Greeting 1.h5
Reading subject 1, action Phoning
../h36m/h36m/S1/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Phoning.h5
Reading subject 1, action Photo
../h36m/h36m/S1/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Photo.h5
Reading subject 1, action Posing
../h36m/h36m/S1/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Posing.h5
Reading subject 1, action Purchases
../h36m/h36m/S1/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Purchases.h5
Reading subject 1, action Sitting
../h36m/h36m/S1/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Sitting 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/Sitting 1.h5
Reading subject 1, action SittingDown
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown.h5
Reading subject 1, action Smoking
../h36m/h36m/S1/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Smoking.h5
Reading subject 1, action Waiting
../h36m/h36m/S1/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S1/MyPoses/3D_positions/Waiting 1.h5
Reading subject 1, action WalkDog
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog.h5
Reading subject 1, action Walking
../h36m/h36m/S1/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Walking.h5
../h36m/h36m/S1/MyPoses/3D_positions/Walking 1.h5
Reading subject 1, action WalkTogether
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether 1.h5
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../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 5, action Directions
../h36m/h36m/S5/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Directions 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Directions 1.h5
Reading subject 5, action Discussion
../h36m/h36m/S5/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Discussion 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Discussion 3.h5
Reading subject 5, action Eating
../h36m/h36m/S5/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S5/MyPoses/3D_positions/Eating 1.h5
Reading subject 5, action Greeting
../h36m/h36m/S5/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Greeting 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Greeting 1.h5
Reading subject 5, action Phoning
../h36m/h36m/S5/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Phoning.h5
../h36m/h36m/S5/MyPoses/3D_positions/Phoning 1.h5
Reading subject 5, action Photo
../h36m/h36m/S5/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Photo 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Photo.h5
Reading subject 5, action Posing
../h36m/h36m/S5/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Posing.h5
../h36m/h36m/S5/MyPoses/3D_positions/Posing 1.h5
Reading subject 5, action Purchases
../h36m/h36m/S5/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Purchases.h5
../h36m/h36m/S5/MyPoses/3D_positions/Purchases 1.h5
Reading subject 5, action Sitting
../h36m/h36m/S5/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Sitting 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Sitting.h5
Reading subject 5, action SittingDown
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown.h5
Reading subject 5, action Smoking
../h36m/h36m/S5/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Smoking.h5
Reading subject 5, action Waiting
../h36m/h36m/S5/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Waiting 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Waiting 1.h5
Reading subject 5, action WalkDog
../h36m/h36m/S5/MyPoses/3D_positions/WalkDog*.h5
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Reading subject 5, action Walking
../h36m/h36m/S5/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Walking.h5
Reading subject 5, action WalkTogether
../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether 1.h5

../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether.h5
Reading subject 6, action Directions
../h36m/h36m/S6/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S6/MyPoses/3D_positions/Directions 1.h5
Reading subject 6, action Discussion
../h36m/h36m/S6/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Discussion.h5
Reading subject 6, action Eating
../h36m/h36m/S6/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Eating 2.h5
../h36m/h36m/S6/MyPoses/3D_positions/Eating 1.h5
Reading subject 6, action Greeting
../h36m/h36m/S6/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Greeting 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Greeting.h5
Reading subject 6, action Phoning
../h36m/h36m/S6/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Phoning.h5
Reading subject 6, action Photo
../h36m/h36m/S6/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Photo.h5
../h36m/h36m/S6/MyPoses/3D_positions/Photo 1.h5
Reading subject 6, action Posing
../h36m/h36m/S6/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Posing.h5
../h36m/h36m/S6/MyPoses/3D_positions/Posing 2.h5
Reading subject 6, action Purchases
../h36m/h36m/S6/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Purchases.h5
../h36m/h36m/S6/MyPoses/3D_positions/Purchases 1.h5
Reading subject 6, action Sitting
../h36m/h36m/S6/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Sitting 2.h5
../h36m/h36m/S6/MyPoses/3D_positions/Sitting 1.h5
Reading subject 6, action SittingDown
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 6, action Smoking
../h36m/h36m/S6/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Smoking.h5
Reading subject 6, action Waiting
../h36m/h36m/S6/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Waiting 3.h5
../h36m/h36m/S6/MyPoses/3D_positions/Waiting.h5
Reading subject 6, action WalkDog
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog.h5
Reading subject 6, action Walking
../h36m/h36m/S6/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Walking.h5
Reading subject 6, action WalkTogether
../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether.h5

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../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 7, action Directions
../h36m/h36m/S7/MyPoses/3D_positions/Directions*.h5
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../h36m/h36m/S7/MyPoses/3D_positions/Directions 1.h5
Reading subject 7, action Discussion
../h36m/h36m/S7/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Discussion.h5
../h36m/h36m/S7/MyPoses/3D_positions/Discussion 1.h5
Reading subject 7, action Eating
../h36m/h36m/S7/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S7/MyPoses/3D_positions/Eating 1.h5
Reading subject 7, action Greeting
../h36m/h36m/S7/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S7/MyPoses/3D_positions/Greeting 1.h5
Reading subject 7, action Phoning
../h36m/h36m/S7/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Phoning 2.h5
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Reading subject 7, action Photo
../h36m/h36m/S7/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Photo.h5
../h36m/h36m/S7/MyPoses/3D_positions/Photo 1.h5
Reading subject 7, action Posing
../h36m/h36m/S7/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Posing.h5
../h36m/h36m/S7/MyPoses/3D_positions/Posing 1.h5
Reading subject 7, action Purchases
../h36m/h36m/S7/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/Purchases.h5
Reading subject 7, action Sitting
../h36m/h36m/S7/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Sitting.h5
../h36m/h36m/S7/MyPoses/3D_positions/Sitting 1.h5
Reading subject 7, action SittingDown
../h36m/h36m/S7/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S7/MyPoses/3D_positions/SittingDown 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/SittingDown.h5
Reading subject 7, action Smoking
../h36m/h36m/S7/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Smoking.h5
../h36m/h36m/S7/MyPoses/3D_positions/Smoking 1.h5
Reading subject 7, action Waiting
../h36m/h36m/S7/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Waiting 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/Waiting 2.h5
Reading subject 7, action WalkDog
../h36m/h36m/S7/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S7/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/WalkDog.h5
Reading subject 7, action Walking
../h36m/h36m/S7/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Walking 2.h5
../h36m/h36m/S7/MyPoses/3D_positions/Walking 1.h5
Reading subject 7, action WalkTogether
../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether 1.h5
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../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether.h5
Reading subject 8, action Directions
../h36m/h36m/S8/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S8/MyPoses/3D_positions/Directions 1.h5
Reading subject 8, action Discussion
../h36m/h36m/S8/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Discussion.h5
../h36m/h36m/S8/MyPoses/3D_positions/Discussion 1.h5
Reading subject 8, action Eating
../h36m/h36m/S8/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Eating 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Eating.h5
Reading subject 8, action Greeting
../h36m/h36m/S8/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S8/MyPoses/3D_positions/Greeting 1.h5
Reading subject 8, action Phoning
../h36m/h36m/S8/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Phoning.h5
Reading subject 8, action Photo
../h36m/h36m/S8/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Photo.h5
Reading subject 8, action Posing
../h36m/h36m/S8/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Posing.h5
Reading subject 8, action Purchases
../h36m/h36m/S8/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Purchases.h5
Reading subject 8, action Sitting
../h36m/h36m/S8/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Sitting 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Sitting.h5
Reading subject 8, action SittingDown
../h36m/h36m/S8/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S8/MyPoses/3D_positions/SittingDown 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/SittingDown.h5
Reading subject 8, action Smoking
../h36m/h36m/S8/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Smoking.h5
Reading subject 8, action Waiting
../h36m/h36m/S8/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S8/MyPoses/3D_positions/Waiting 1.h5
Reading subject 8, action WalkDog
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog 1.h5
Reading subject 8, action Walking
../h36m/h36m/S8/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Walking.h5
Reading subject 8, action WalkTogether
../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether 2.h5
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../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 9, action Directions
../h36m/h36m/S9/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Directions 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Directions.h5
Reading subject 9, action Discussion
../h36m/h36m/S9/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Discussion 2.h5
Reading subject 9, action Eating
../h36m/h36m/S9/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S9/MyPoses/3D_positions/Eating 1.h5
Reading subject 9, action Greeting
../h36m/h36m/S9/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Greeting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Greeting.h5
Reading subject 9, action Phoning
../h36m/h36m/S9/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Phoning.h5
../h36m/h36m/S9/MyPoses/3D_positions/Phoning 1.h5
Reading subject 9, action Photo
../h36m/h36m/S9/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Photo.h5
Reading subject 9, action Posing
../h36m/h36m/S9/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Posing.h5
Reading subject 9, action Purchases
../h36m/h36m/S9/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Purchases.h5
Reading subject 9, action Sitting
../h36m/h36m/S9/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Sitting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Sitting.h5
Reading subject 9, action SittingDown
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 9, action Smoking
../h36m/h36m/S9/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Smoking.h5
Reading subject 9, action Waiting
../h36m/h36m/S9/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Waiting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Waiting.h5
Reading subject 9, action WalkDog
../h36m/h36m/S9/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S9/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/WalkDog.h5
Reading subject 9, action Walking
../h36m/h36m/S9/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Walking.h5
Reading subject 9, action WalkTogether
../h36m/h36m/S9/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S9/MyPoses/3D_positions/WalkTogether.h5
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../h36m/h36m/S9/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 11, action Directions
../h36m/h36m/S11/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S11/MyPoses/3D_positions/Directions 1.h5
Reading subject 11, action Discussion
../h36m/h36m/S11/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Discussion 2.h5
Reading subject 11, action Eating
../h36m/h36m/S11/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Eating 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Eating.h5
Reading subject 11, action Greeting
../h36m/h36m/S11/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S11/MyPoses/3D_positions/Greeting 2.h5
Reading subject 11, action Phoning
../h36m/h36m/S11/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Phoning 3.h5
../h36m/h36m/S11/MyPoses/3D_positions/Phoning 2.h5
Reading subject 11, action Photo
../h36m/h36m/S11/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Photo.h5
Reading subject 11, action Posing
../h36m/h36m/S11/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Posing.h5
Reading subject 11, action Purchases
../h36m/h36m/S11/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Purchases.h5
Reading subject 11, action Sitting
../h36m/h36m/S11/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Sitting.h5
../h36m/h36m/S11/MyPoses/3D_positions/Sitting 1.h5
Reading subject 11, action SittingDown
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 11, action Smoking
../h36m/h36m/S11/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Smoking.h5
../h36m/h36m/S11/MyPoses/3D_positions/Smoking 2.h5
Reading subject 11, action Waiting
../h36m/h36m/S11/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S11/MyPoses/3D_positions/Waiting 1.h5
Reading subject 11, action WalkDog
../h36m/h36m/S11/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S11/MyPoses/3D_positions/WalkDog.h5
../h36m/h36m/S11/MyPoses/3D_positions/WalkDog 1.h5
Reading subject 11, action Walking
../h36m/h36m/S11/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Walking.h5
../h36m/h36m/S11/MyPoses/3D_positions/Walking 1.h5
Reading subject 11, action WalkTogether
../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether.h5

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../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether 1.h5
/content/gdrive/My Drive/Y2019Fall/CSE-527-Intro-To-Computer-Vision/Paratkar_Shreyash_112673930_hw6/src/data_utils.py:462: FutureWarning: arrays to stack must be passed as a "sequence" type such as list o
  complete_train = copy.deepcopy( np.vstack( train_set.values() ))
```

```
# Read stacked hourglass 2D predictions if use_sh, otherwise use groundtruth 2D projections
use_sh = False
if use_sh:
    train_set_2d, test_set_2d, data_mean_2d, data_std_2d, dim_to_ignore_2d, dim_to_use_2d = data_utils.read_2d_predictions(actions, data_dir)
else:
    train_set_2d, test_set_2d, data_mean_2d, data_std_2d, dim_to_ignore_2d, dim_to_use_2d = data_utils.create_2d_data( actions, data_dir, rcams )
print( "done reading and normalizing data." )

stat_3d = {}
stat_3d['mean'] = data_mean_3d
stat_3d['std'] = data_std_3d
stat_3d['dim_use'] = dim_to_use_3d
```

```
Reading subject 1, action Directions
../h36m/h36m/S1/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Directions 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Directions.h5
Reading subject 1, action Discussion
../h36m/h36m/S1/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Discussion.h5
Reading subject 1, action Eating
../h36m/h36m/S1/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Eating 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/Eating.h5
Reading subject 1, action Greeting
../h36m/h36m/S1/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S1/MyPoses/3D_positions/Greeting 1.h5
Reading subject 1, action Phoning
../h36m/h36m/S1/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Phoning.h5
Reading subject 1, action Photo
../h36m/h36m/S1/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Photo.h5
Reading subject 1, action Posing
../h36m/h36m/S1/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Posing.h5
Reading subject 1, action Purchases
../h36m/h36m/S1/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Purchases.h5
Reading subject 1, action Sitting
../h36m/h36m/S1/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Sitting 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/Sitting 1.h5
Reading subject 1, action SittingDown
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown 2.h5
../h36m/h36m/S1/MyPoses/3D_positions/SittingDown.h5
Reading subject 1, action Smoking
../h36m/h36m/S1/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/Smoking.h5
Reading subject 1, action Waiting
../h36m/h36m/S1/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S1/MyPoses/3D_positions/Waiting 1.h5
Reading subject 1, action WalkDog
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkDog.h5
Reading subject 1, action Walking
../h36m/h36m/S1/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S1/MyPoses/3D_positions/Walking.h5
../h36m/h36m/S1/MyPoses/3D_positions/Walking 1.h5
Reading subject 1, action WalkTogether
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether.h5
../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether 1.h5
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../h36m/h36m/S1/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 5, action Directions
../h36m/h36m/S5/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Directions 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Directions 1.h5
Reading subject 5, action Discussion
../h36m/h36m/S5/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Discussion 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Discussion 3.h5
Reading subject 5, action Eating
../h36m/h36m/S5/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S5/MyPoses/3D_positions/Eating 1.h5
Reading subject 5, action Greeting
../h36m/h36m/S5/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Greeting 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Greeting 1.h5
Reading subject 5, action Phoning
../h36m/h36m/S5/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Phoning.h5
../h36m/h36m/S5/MyPoses/3D_positions/Phoning 1.h5
Reading subject 5, action Photo
../h36m/h36m/S5/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Photo 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Photo.h5
Reading subject 5, action Posing
../h36m/h36m/S5/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Posing.h5
../h36m/h36m/S5/MyPoses/3D_positions/Posing 1.h5
Reading subject 5, action Purchases
../h36m/h36m/S5/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Purchases.h5
../h36m/h36m/S5/MyPoses/3D_positions/Purchases 1.h5
Reading subject 5, action Sitting
../h36m/h36m/S5/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Sitting 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Sitting.h5
Reading subject 5, action SittingDown
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/SittingDown.h5
Reading subject 5, action Smoking
../h36m/h36m/S5/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Smoking.h5
Reading subject 5, action Waiting
../h36m/h36m/S5/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Waiting 2.h5
../h36m/h36m/S5/MyPoses/3D_positions/Waiting 1.h5
Reading subject 5, action WalkDog
../h36m/h36m/S5/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S5/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/WalkDog.h5
Reading subject 5, action Walking
../h36m/h36m/S5/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S5/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S5/MyPoses/3D_positions/Walking.h5
Reading subject 5, action WalkTogether
../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether 1.h5

../h36m/h36m/S5/MyPoses/3D_positions/WalkTogether.h5
Reading subject 6, action Directions
../h36m/h36m/S6/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S6/MyPoses/3D_positions/Directions 1.h5
Reading subject 6, action Discussion
../h36m/h36m/S6/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Discussion.h5
Reading subject 6, action Eating
../h36m/h36m/S6/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Eating 2.h5
../h36m/h36m/S6/MyPoses/3D_positions/Eating 1.h5
Reading subject 6, action Greeting
../h36m/h36m/S6/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Greeting 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Greeting.h5
Reading subject 6, action Phoning
../h36m/h36m/S6/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Phoning.h5
Reading subject 6, action Photo
../h36m/h36m/S6/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Photo.h5
../h36m/h36m/S6/MyPoses/3D_positions/Photo 1.h5
Reading subject 6, action Posing
../h36m/h36m/S6/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Posing.h5
../h36m/h36m/S6/MyPoses/3D_positions/Posing 2.h5
Reading subject 6, action Purchases
../h36m/h36m/S6/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Purchases.h5
../h36m/h36m/S6/MyPoses/3D_positions/Purchases 1.h5
Reading subject 6, action Sitting
../h36m/h36m/S6/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Sitting 2.h5
../h36m/h36m/S6/MyPoses/3D_positions/Sitting 1.h5
Reading subject 6, action SittingDown
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S6/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 6, action Smoking
../h36m/h36m/S6/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/Smoking.h5
Reading subject 6, action Waiting
../h36m/h36m/S6/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S6/MyPoses/3D_positions/Waiting 3.h5
../h36m/h36m/S6/MyPoses/3D_positions/Waiting.h5
Reading subject 6, action WalkDog
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkDog.h5
Reading subject 6, action Walking
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../h36m/h36m/S6/MyPoses/3D_positions/Walking.h5
Reading subject 6, action WalkTogether
../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether.h5

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../h36m/h36m/S6/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 7, action Directions
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../h36m/h36m/S7/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S7/MyPoses/3D_positions/Directions 1.h5
Reading subject 7, action Discussion
../h36m/h36m/S7/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Discussion.h5
../h36m/h36m/S7/MyPoses/3D_positions/Discussion 1.h5
Reading subject 7, action Eating
../h36m/h36m/S7/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S7/MyPoses/3D_positions/Eating 1.h5
Reading subject 7, action Greeting
../h36m/h36m/S7/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S7/MyPoses/3D_positions/Greeting 1.h5
Reading subject 7, action Phoning
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../h36m/h36m/S7/MyPoses/3D_positions/Phoning.h5
Reading subject 7, action Photo
../h36m/h36m/S7/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Photo.h5
../h36m/h36m/S7/MyPoses/3D_positions/Photo 1.h5
Reading subject 7, action Posing
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Reading subject 7, action Purchases
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Reading subject 7, action Sitting
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../h36m/h36m/S7/MyPoses/3D_positions/Sitting 1.h5
Reading subject 7, action SittingDown
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../h36m/h36m/S7/MyPoses/3D_positions/SittingDown 1.h5
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Reading subject 7, action Smoking
../h36m/h36m/S7/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Smoking.h5
../h36m/h36m/S7/MyPoses/3D_positions/Smoking 1.h5
Reading subject 7, action Waiting
../h36m/h36m/S7/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S7/MyPoses/3D_positions/Waiting 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/Waiting 2.h5
Reading subject 7, action WalkDog
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../h36m/h36m/S7/MyPoses/3D_positions/WalkDog 1.h5
../h36m/h36m/S7/MyPoses/3D_positions/WalkDog.h5
Reading subject 7, action Walking
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../h36m/h36m/S7/MyPoses/3D_positions/Walking 2.h5
../h36m/h36m/S7/MyPoses/3D_positions/Walking 1.h5
Reading subject 7, action WalkTogether
../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether 1.h5
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../h36m/h36m/S7/MyPoses/3D_positions/WalkTogether.h5
Reading subject 8, action Directions
../h36m/h36m/S8/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S8/MyPoses/3D_positions/Directions 1.h5
Reading subject 8, action Discussion
../h36m/h36m/S8/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Discussion.h5
../h36m/h36m/S8/MyPoses/3D_positions/Discussion 1.h5
Reading subject 8, action Eating
../h36m/h36m/S8/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Eating 1.h5
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Reading subject 8, action Greeting
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../h36m/h36m/S8/MyPoses/3D_positions/Greeting.h5
../h36m/h36m/S8/MyPoses/3D_positions/Greeting 1.h5
Reading subject 8, action Phoning
../h36m/h36m/S8/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Phoning 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Phoning.h5
Reading subject 8, action Photo
../h36m/h36m/S8/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Photo.h5
Reading subject 8, action Posing
../h36m/h36m/S8/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Posing.h5
Reading subject 8, action Purchases
../h36m/h36m/S8/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Purchases.h5
Reading subject 8, action Sitting
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../h36m/h36m/S8/MyPoses/3D_positions/Sitting.h5
Reading subject 8, action SittingDown
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../h36m/h36m/S8/MyPoses/3D_positions/SittingDown 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/SittingDown.h5
Reading subject 8, action Smoking
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../h36m/h36m/S8/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Smoking.h5
Reading subject 8, action Waiting
../h36m/h36m/S8/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S8/MyPoses/3D_positions/Waiting 1.h5
Reading subject 8, action WalkDog
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog*.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkDog 1.h5
Reading subject 8, action Walking
../h36m/h36m/S8/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S8/MyPoses/3D_positions/Walking 1.h5
../h36m/h36m/S8/MyPoses/3D_positions/Walking.h5
Reading subject 8, action WalkTogether
../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether 2.h5
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../h36m/h36m/S8/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 9, action Directions
../h36m/h36m/S9/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Directions 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Directions.h5
Reading subject 9, action Discussion
../h36m/h36m/S9/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Discussion 2.h5
Reading subject 9, action Eating
../h36m/h36m/S9/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Eating.h5
../h36m/h36m/S9/MyPoses/3D_positions/Eating 1.h5
Reading subject 9, action Greeting
../h36m/h36m/S9/MyPoses/3D_positions/Greeting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Greeting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Greeting.h5
Reading subject 9, action Phoning
../h36m/h36m/S9/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Phoning.h5
../h36m/h36m/S9/MyPoses/3D_positions/Phoning 1.h5
Reading subject 9, action Photo
../h36m/h36m/S9/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Photo.h5
Reading subject 9, action Posing
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../h36m/h36m/S9/MyPoses/3D_positions/Posing 1.h5
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Reading subject 9, action Purchases
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../h36m/h36m/S9/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Purchases.h5
Reading subject 9, action Sitting
../h36m/h36m/S9/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Sitting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Sitting.h5
Reading subject 9, action SittingDown
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S9/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 9, action Smoking
../h36m/h36m/S9/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Smoking 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Smoking.h5
Reading subject 9, action Waiting
../h36m/h36m/S9/MyPoses/3D_positions/Waiting*.h5
../h36m/h36m/S9/MyPoses/3D_positions/Waiting 1.h5
../h36m/h36m/S9/MyPoses/3D_positions/Waiting.h5
Reading subject 9, action WalkDog
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Reading subject 9, action Walking
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../h36m/h36m/S9/MyPoses/3D_positions/Walking.h5
Reading subject 9, action WalkTogether
../h36m/h36m/S9/MyPoses/3D_positions/WalkTogether*.h5
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../h36m/h36m/S9/MyPoses/3D_positions/WalkTogether 1.h5
Reading subject 11, action Directions
../h36m/h36m/S11/MyPoses/3D_positions/Directions*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Directions.h5
../h36m/h36m/S11/MyPoses/3D_positions/Directions 1.h5
Reading subject 11, action Discussion
../h36m/h36m/S11/MyPoses/3D_positions/Discussion*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Discussion 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Discussion 2.h5
Reading subject 11, action Eating
../h36m/h36m/S11/MyPoses/3D_positions/Eating*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Eating 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Eating.h5
Reading subject 11, action Greeting
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../h36m/h36m/S11/MyPoses/3D_positions/Greeting 2.h5
Reading subject 11, action Phoning
../h36m/h36m/S11/MyPoses/3D_positions/Phoning*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Phoning 3.h5
../h36m/h36m/S11/MyPoses/3D_positions/Phoning 2.h5
Reading subject 11, action Photo
../h36m/h36m/S11/MyPoses/3D_positions/Photo*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Photo 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Photo.h5
Reading subject 11, action Posing
../h36m/h36m/S11/MyPoses/3D_positions/Posing*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Posing 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Posing.h5
Reading subject 11, action Purchases
../h36m/h36m/S11/MyPoses/3D_positions/Purchases*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Purchases 1.h5
../h36m/h36m/S11/MyPoses/3D_positions/Purchases.h5
Reading subject 11, action Sitting
../h36m/h36m/S11/MyPoses/3D_positions/Sitting*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Sitting.h5
../h36m/h36m/S11/MyPoses/3D_positions/Sitting 1.h5
Reading subject 11, action SittingDown
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown*.h5
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown.h5
../h36m/h36m/S11/MyPoses/3D_positions/SittingDown 1.h5
Reading subject 11, action Smoking
../h36m/h36m/S11/MyPoses/3D_positions/Smoking*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Smoking.h5
../h36m/h36m/S11/MyPoses/3D_positions/Smoking 2.h5
Reading subject 11, action Waiting
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../h36m/h36m/S11/MyPoses/3D_positions/Waiting.h5
../h36m/h36m/S11/MyPoses/3D_positions/Waiting 1.h5
Reading subject 11, action WalkDog
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../h36m/h36m/S11/MyPoses/3D_positions/WalkDog 1.h5
Reading subject 11, action Walking
../h36m/h36m/S11/MyPoses/3D_positions/Walking*.h5
../h36m/h36m/S11/MyPoses/3D_positions/Walking.h5
../h36m/h36m/S11/MyPoses/3D_positions/Walking 1.h5
Reading subject 11, action WalkTogether
../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether*.h5
../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether.h5

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../h36m/h36m/S11/MyPoses/3D_positions/WalkTogether 1.h5
/content/gdrive/My Drive/Y2019Fall/CSE-527-Intro-To-Computer-Vision/Paratkar_Shreyash_112673930_hw6/src/data_utils.py:419: FutureWarning: arrays to stack must be passed as a "sequence" type such as list o
  complete_train = copy.deepcopy( np.vstack( train_set.values() ))
done reading and normalizing data.
```

```
# ============================
#   Define Train/Test Methods
# ============================
def train(train_loader, model, criterion, optimizer,
          lr_init=None, lr_now=None, glob_step=None, lr_decay=None, gamma=None,
          max_norm=True):

    # Write you code here
    losses = utils.AverageMeter()

    model.train()

    start_time = time.time()
    batch_time = 0

    for i, (inps, tars) in enumerate(train_loader):
        glob_step += 1
        if glob_step%lr_decay == 0 or glob_step == 1:
            lr_now = utils.lr_decay(optimizer, glob_step, lr_init, lr_decay, gamma)

        inputs = Variable(inps.cuda())
        targets = Variable(tars.cuda(async=True))

        outputs = model(inputs)

        # calculate loss
        optimizer.zero_grad()
        loss = criterion(outputs, targets)
        losses.update(loss.item(), inputs.size(0))
        loss.backward()
        if max_norm:
            nn.utils.clip_grad_norm(model.parameters(), max_norm=1)
        optimizer.step()
        del outputs, targets, inputs


    print("Time taken for 1 epoch = ", round(time.time() - start_time), ' seconds')
    return glob_step, lr_now, losses.avg


def test(test_loader, model, criterion, stat_3d, procrustes=False):
    losses = utils.AverageMeter()

    model.eval()

    all_dist = []
```

```
    start = time.time()
    batch_time = 0

    for i, (inps, tars) in enumerate(test_loader):
        inputs = Variable(inps.cuda())

        targets = Variable(tars.cuda(async=True))

        outputs = model(inputs)

        # calculate loss
        outputs_coord = outputs
        loss = criterion(outputs_coord, targets)

        losses.update(loss.item(), inputs.size(0))

        tars = targets

        # calculate erruracy
        targets_unnorm = data_process.unNormalizeData(tars.data.cpu().numpy(), stat_3d['mean'], stat_3d['std'], stat_3d['dim_use'])
        outputs_unnorm = data_process.unNormalizeData(outputs.data.cpu().numpy(), stat_3d['mean'], stat_3d['std'], stat_3d['dim_use'])

        # remove dim ignored
        dim_use = np.hstack((np.arange(3), stat_3d['dim_use']))

        outputs_use = outputs_unnorm[:, dim_use]
        targets_use = targets_unnorm[:, dim_use]

        if procrustes:
            for ba in range(inps.size(0)):
                gt = targets_use[ba].reshape(-1, 3)
                out = outputs_use[ba].reshape(-1, 3)
                _, Z, T, b, c = get_transformation(gt, out, True)
                out = (b * out.dot(T)) + c
                outputs_use[ba, :] = out.reshape(1, 51)

        sqerr = (outputs_use - targets_use) ** 2

        distance = np.zeros((sqerr.shape[0], 17))
        dist_idx = 0
        for k in np.arange(0, 17 * 3, 3):
            distance[:, dist_idx] = np.sqrt(np.sum(sqerr[:, k:k + 3], axis=1))
            dist_idx += 1
        all_dist.append(distance)

        # update summary
        if (i + 1) % 100 == 0:
            batch_time = time.time() - start
            start = time.time()

    all_dist = np.vstack(all_dist)
    joint_err = np.mean(all_dist, axis=0)
    ttl_err = np.mean(all_dist)
    print (">>> error: {} <<<".format(ttl_err))
```

```
    return losses.avg, ttl_err


# ==================
#   Dataset class
# ==================
from __future__ import print_function, absolute_import

import os
import torch
from torch.utils.data import Dataset
TRAIN_SUBJECTS = [1, 5, 6, 7, 8]
TEST_SUBJECTS = [9, 11]

class Human36M(Dataset):
    def __init__(self, actions, train_set_3d, train_set_2d, test_set_3d, test_set_2d, use_hg=True, is_train=True):
        """
        :param actions: list of actions to use
        :param data_path: path to dataset
        :param use_hg: use stacked hourglass detections
        :param is_train: load train/test dataset
        """

        # Write you code here

        self.actions = actions

        self.is_train = is_train
        self.use_hg = use_hg

        self.train_inp, self.train_out, self.test_inp, self.test_out = [], [], [], []
        self.train_meta, self.test_meta = [], []

        if self.is_train:
            # load train data using the existing variable directly
            self.train_3d = train_set_3d
            self.train_2d = train_set_2d
            for k2d in self.train_2d.keys():
                (sub, act, fname) = k2d
                k3d = k2d
                k3d = (sub, act, fname[:-3]) if fname.endswith('-sh') else k3d
                num_f, _ = self.train_2d[k2d].shape
                assert self.train_3d[k3d].shape[0] == self.train_2d[k2d].shape[0], 'shapes did not match in training'
                for i in range(num_f):
                    self.train_inp.append(self.train_2d[k2d][i])
                    self.train_out.append(self.train_3d[k3d][i])

        else:
            # load test data using the existing variable directly
            self.test_3d = test_set_3d
            self.test_2d = test_set_2d
            for k2d in self.test_2d.keys():
                (sub, act, fname) = k2d
                if act not in self.actions:
```

```
                    continue
                k3d = k2d
                k3d = (sub, act, fname[:-3]) if fname.endswith('-sh') else k3d
                num_f, _ = self.test_2d[k2d].shape
                assert self.test_2d[k2d].shape[0] == self.test_3d[k3d].shape[0], ' shapes did not match in testing'
                for i in range(num_f):
                    self.test_inp.append(self.test_2d[k2d][i])
                    self.test_out.append(self.test_3d[k3d][i])

    def __getitem__(self, index):
        if self.is_train:
            inputs = torch.from_numpy(self.train_inp[index]).float()
            outputs = torch.from_numpy(self.train_out[index]).float()

        else:
            inputs = torch.from_numpy(self.test_inp[index]).float()
            outputs = torch.from_numpy(self.test_out[index]).float()

        return inputs, outputs

    def __len__(self):
        if self.is_train:
            return len(self.train_inp)
        else:
            return len(self.test_inp)

        # Write you code here
```

```
# ========================================
#       Define Network Architecture
# ========================================

from __future__ import absolute_import
from __future__ import print_function

import torch.nn as nn

def weight_init(m):
    if isinstance(m, nn.Linear):
        nn.init.kaiming_normal(m.weight)

class Linear(nn.Module):
    def __init__(self, linear_size, p_dropout=0.5):
        super(Linear, self).__init__()
        self.l_size = linear_size

        self.relu = nn.ReLU(inplace=True)
        self.dropout = nn.Dropout(p_dropout)

        self.w1 = nn.Linear(self.l_size, self.l_size)
        self.batch_norm1 = nn.BatchNorm1d(self.l_size)

        self.w2 = nn.Linear(self.l_size, self.l_size)
```

```
        self.batch_norm2 = nn.BatchNorm1d(self.l_size)

    def forward(self, x):
        y = self.w1(x)
        y = self.batch_norm1(y)
        y = self.relu(y)
        y = self.dropout(y)

        y = self.w2(y)
        y = self.batch_norm2(y)
        y = self.relu(y)
        y = self.dropout(y)

        out = x + y

        return out


class LinearModel(nn.Module):
    def __init__(self, linear_size=1024, num_stage=2, p_dropout=0.5):
        super(LinearModel, self).__init__()

        self.linear_size = linear_size
        self.p_dropout = p_dropout
        self.num_stage = num_stage

        # 2d joints
        self.input_size =  16 * 2
        # 3d joints
        self.output_size = 16 * 3

        # process input to linear size
        self.w1 = nn.Linear(self.input_size, self.linear_size)
        self.batch_norm1 = nn.BatchNorm1d(self.linear_size)

        self.linear_stages = []
        for l in range(num_stage):
            self.linear_stages.append(Linear(self.linear_size, self.p_dropout))
        self.linear_stages = nn.ModuleList(self.linear_stages)

        # post processing
        self.w2 = nn.Linear(self.linear_size, self.output_size)

        self.relu = nn.ReLU(inplace=True)
        self.dropout = nn.Dropout(self.p_dropout)

    def forward(self, x):
        # pre-processing
        y = self.w1(x)
        y = self.batch_norm1(y)
        y = self.relu(y)
        y = self.dropout(y)

        # linear lavers
```

```
        for i in range(self.num_stage):
            y = self.linear_stages[i](y)

        y = self.w2(y)

        return y
```

```
# ==========================================
#         load dadasets for training
# ==========================================
job = 8
use_hg = False

test_loader = DataLoader(
        dataset=Human36M(actions=actions,train_set_3d= train_set_3d, train_set_2d = train_set_2d,test_set_3d = test_set_3d, test_set_2d = test_set_2d, use_hg=use_hg, is_train=False),
        batch_size=2048,
        shuffle=False,
        num_workers=job,
        pin_memory=True)
train_loader = DataLoader(
    dataset=Human36M(actions=actions, train_set_3d= train_set_3d, train_set_2d = train_set_2d,test_set_3d = test_set_3d, test_set_2d = test_set_2d, use_hg=use_hg),
    batch_size=2048,
    shuffle=True,
    num_workers=job,
    pin_memory=True)

print("Data loading completed")
```

```
Data loading completed
```

```
# ==========================================
#         Optimize/Train Network
# ==========================================

# Write you code here
model = LinearModel()
model = model.cuda()
model.apply(weight_init)
criterion = nn.MSELoss(size_average=True).cuda()
optimizer = torch.optim.Adam(model.parameters(), lr=0.01)
cudnn.benchmark = True
lr_now = 0.001
lr_init = lr_now
lr_decay = 100000
start_epoch = 0
err_best = 9999
glob_step = 0
gamma = 0.99
for epoch in range(0, 30):
    print('\nEpoch ', epoch+1, ' started ----------------------------------')

    # per epoch
    glob_step, lr_now, loss_train = train(
```

```
    glob_step, lr_now, loss_train = train(
        train_loader, model, criterion, optimizer,
        lr_init=lr_init, lr_now=lr_now, glob_step=glob_step, lr_decay=lr_decay, gamma=gamma,
        max_norm=False)
    loss_test, err_test = test(test_loader, model, criterion, stat_3d, procrustes=False)

    print("Epoch: ", (epoch + 1), " Learning rate: ", lr_now, " Train Loss: ",loss_train, " Test Loss: ",loss_test," Test Error: " ,err_test)

    is_best = err_test < err_best
    err_best = min(err_test, err_best)
    if is_best:
        print("Best till now: Epoch: ", (epoch + 1)," Learning rate: ", lr_now," Step: " , glob_step," Error: ", err_best)
```

```
Epoch  1  started ----------------------------------
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:9: UserWarning: nn.init.kaiming_normal is now deprecated in favor of nn.init.kaiming_normal_.
  if __name__ == '__main__':
/usr/local/lib/python3.6/dist-packages/torch/nn/_reduction.py:43: UserWarning: size_average and reduce args will be deprecated, please use reduction='mean' instead.
  warnings.warn(warning.format(ret))
Time taken for 1 epoch =  58  seconds
>>> error: 70.0746279873324 <<<
Epoch:  1  Learning rate:  0.0009999998994966466  Train Loss:  0.5981659131388896  Test Loss:  0.09832980940035287  Test Error:  70.0746279873324
Best till now: Epoch:  1  Learning rate:  0.0009999998994966466  Step:  762  Error:  70.0746279873324

Epoch  2  started ----------------------------------
Time taken for 1 epoch =  55  seconds
>>> error: 58.66991897848325 <<<
Epoch:  2  Learning rate:  0.0009999998994966466  Train Loss:  0.13933759679311603  Test Loss:  0.0689724754069378  Test Error:  58.66991897848325
Best till now: Epoch:  2  Learning rate:  0.0009999998994966466  Step:  1524  Error:  58.66991897848325

Epoch  3  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 54.35907804733804 <<<
Epoch:  3  Learning rate:  0.0009999998994966466  Train Loss:  0.10062170109815229  Test Loss:  0.05896353111160962  Test Error:  54.35907804733804
Best till now: Epoch:  3  Learning rate:  0.0009999998994966466  Step:  2286  Error:  54.35907804733804

Epoch  4  started ----------------------------------
Time taken for 1 epoch =  55  seconds
>>> error: 51.76232924936439 <<<
Epoch:  4  Learning rate:  0.0009999998994966466  Train Loss:  0.08433835419671619  Test Loss:  0.052785205150085765  Test Error:  51.76232924936439
Best till now: Epoch:  4  Learning rate:  0.0009999998994966466  Step:  3048  Error:  51.76232924936439

Epoch  5  started ----------------------------------
Time taken for 1 epoch =  55  seconds
>>> error: 49.90318630051258 <<<
Epoch:  5  Learning rate:  0.0009999998994966466  Train Loss:  0.07449303708729377  Test Loss:  0.049609694211187584  Test Error:  49.90318630051258
Best till now: Epoch:  5  Learning rate:  0.0009999998994966466  Step:  3810  Error:  49.90318630051258

Epoch  6  started ----------------------------------
Time taken for 1 epoch =  52  seconds
>>> error: 48.402799462157255 <<<
Epoch:  6  Learning rate:  0.0009999998994966466  Train Loss:  0.06768513806202288  Test Loss:  0.04706298345652752  Test Error:  48.402799462157255
Best till now: Epoch:  6  Learning rate:  0.0009999998994966466  Step:  4572  Error:  48.402799462157255

Epoch  7  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 48.575164667092544 <<<
Epoch:  7  Learning rate:  0.0009999998994966466  Train Loss:  0.062461883442449635  Test Loss:  0.0468761672253968  Test Error:  48.575164667092544

Epoch  8  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 47.79658996585098 <<<
Epoch:  8  Learning rate:  0.0009999998994966466  Train Loss:  0.05845518997446977  Test Loss:  0.046154589699884827  Test Error:  47.79658996585098
Best till now: Epoch:  8  Learning rate:  0.0009999998994966466  Step:  6096  Error:  47.79658996585098

Epoch  9  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 46.34627079579745 <<<
Epoch:  9  Learning rate:  0.0009999998994966466  Train Loss:  0.05551664490989484  Test Loss:  0.04390725081180082  Test Error:  46.34627079579745
Best till now: Epoch:  9  Learning rate:  0.0009999998994966466  Step:  6858  Error:  46.34627079579745

Epoch  10  started ----------------------------------
Time taken for 1 epoch =  53  seconds
```

Time taken for 1 epoch =  55  seconds
>>> error: 45.791338125001054 <<<
Epoch:  10  Learning rate:  0.0009999998994966466  Train Loss:  0.05314131511523971  Test Loss:  0.042849117595708336  Test Error:  45.791338125001054
Best till now: Epoch:  10  Learning rate:  0.0009999998994966466  Step:  7620  Error:  45.791338125001054

Epoch  11  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 46.06971432995637 <<<
Epoch:  11  Learning rate:  0.0009999998994966466  Train Loss:  0.051177129484269605  Test Loss:  0.04334271806957843  Test Error:  46.06971432995637

Epoch  12  started ----------------------------------
Time taken for 1 epoch =  55  seconds
>>> error: 44.789073983778934 <<<
Epoch:  12  Learning rate:  0.0009999998994966466  Train Loss:  0.04963177993501699  Test Loss:  0.04163830742896352  Test Error:  44.789073983778934
Best till now: Epoch:  12  Learning rate:  0.0009999998994966466  Step:  9144  Error:  44.789073983778934

Epoch  13  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 45.63984147508792 <<<
Epoch:  13  Learning rate:  0.0009999998994966466  Train Loss:  0.04840217352943554  Test Loss:  0.04233696200124854  Test Error:  45.63984147508792

Epoch  14  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 45.21634018891311 <<<
Epoch:  14  Learning rate:  0.0009999998994966466  Train Loss:  0.0473932113804029  Test Loss:  0.04063684496094676  Test Error:  45.21634018891311

Epoch  15  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 44.9309470476872 <<<
Epoch:  15  Learning rate:  0.0009999998994966466  Train Loss:  0.04625932163070757  Test Loss:  0.041613557074862806  Test Error:  44.9309470476872

Epoch  16  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 44.23158592982147 <<<
Epoch:  16  Learning rate:  0.0009999998994966466  Train Loss:  0.045637952633916797  Test Loss:  0.03995911506621298  Test Error:  44.23158592982147
Best till now: Epoch:  16  Learning rate:  0.0009999998994966466  Step:  12192  Error:  44.23158592982147

Epoch  17  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 44.891895622195975 <<<
Epoch:  17  Learning rate:  0.0009999998994966466  Train Loss:  0.04491767353798597  Test Loss:  0.04028274241264886  Test Error:  44.891895622195975

Epoch  18  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 44.56138101328599 <<<
Epoch:  18  Learning rate:  0.0009999998994966466  Train Loss:  0.04424311784471301  Test Loss:  0.04022611218215545  Test Error:  44.56138101328599

Epoch  19  started ----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 43.81095587316496 <<<
Epoch:  19  Learning rate:  0.0009999998994966466  Train Loss:  0.04369681043642631  Test Loss:  0.03942216212099146  Test Error:  43.81095587316496
Best till now: Epoch:  19  Learning rate:  0.0009999998994966466  Step:  14478  Error:  43.81095587316496

Epoch  20  started ----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 44.096064160672526 <<<
Epoch:  20  Learning rate:  0.0009999998994966466  Train Loss:  0.04338717620986669  Test Loss:  0.039638011835017514  Test Error:  44.096064160672526

Epoch  21  started ----------------------------------
Time taken for 1 epoch =  54  seconds

```
>>> error: 44.796178110554685 <<<
Epoch:  21  Learning rate:  0.0009999998998994966466  Train Loss:  0.0428627517382028  Test Loss:  0.04087054521169229  Test Error:  44.796178110554685

Epoch  22  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 45.14715236237681 <<<
Epoch:  22  Learning rate:  0.0009999998998994966466  Train Loss:  0.04238660447172418  Test Loss:  0.040889991369095206  Test Error:  45.14715236237681

Epoch  23  started -----------------------------------
Time taken for 1 epoch =  55  seconds
>>> error: 44.04524801971725 <<<
Epoch:  23  Learning rate:  0.0009999998998994966466  Train Loss:  0.04223566647546574  Test Loss:  0.039740467329322175  Test Error:  44.04524801971725

Epoch  24  started -----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 44.0800384583586 <<<
Epoch:  24  Learning rate:  0.0009999998998994966466  Train Loss:  0.0417953717525557  Test Loss:  0.03945787450724517  Test Error:  44.0800384583586

Epoch  25  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 43.921289654910765 <<<
Epoch:  25  Learning rate:  0.0009999998998994966466  Train Loss:  0.04120632509567572  Test Loss:  0.03934926203303355  Test Error:  43.921289654910765

Epoch  26  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 45.240028218896946 <<<
Epoch:  26  Learning rate:  0.0009999998998994966466  Train Loss:  0.04118486065219483  Test Loss:  0.04084763426934076  Test Error:  45.240028218896946

Epoch  27  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 43.65813432805078 <<<
Epoch:  27  Learning rate:  0.0009999998998994966466  Train Loss:  0.04092500917106213  Test Loss:  0.03924143504801651  Test Error:  43.65813432805078
Best till now: Epoch:  27  Learning rate:  0.0009999998998994966466  Step:  20574  Error:  43.65813432805078

Epoch  28  started -----------------------------------
Time taken for 1 epoch =  54  seconds
>>> error: 42.94456927410147 <<<
Epoch:  28  Learning rate:  0.0009999998998994966466  Train Loss:  0.04060829685378501  Test Loss:  0.03809526841219515  Test Error:  42.94456927410147
Best till now: Epoch:  28  Learning rate:  0.0009999998998994966466  Step:  21336  Error:  42.94456927410147

Epoch  29  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 43.903073487167966 <<<
Epoch:  29  Learning rate:  0.0009999998998994966466  Train Loss:  0.040353057721600416  Test Loss:  0.03904494349854327  Test Error:  43.903073487167966

Epoch  30  started -----------------------------------
Time taken for 1 epoch =  53  seconds
>>> error: 44.07771028910041 <<<
Epoch:  30  Learning rate:  0.0009999998998994966466  Train Loss:  0.04010824366634121  Test Loss:  0.0398663547332852  Test Error:  44.07771028910041
```

```
# ========================================
#            Evaluating Network
# ========================================

err_set = []
for action in actions:
    print ("Test on {}".format(action))
    test_loader = DataLoader(
```

```
                dataset=Human36M(actions=action,train_set_3d= train_set_3d, train_set_2d = train_set_2d,test_set_3d = test_set_3d, test_set_2d = test_set_2d, use_hg=use_hg, is_train=False),
                batch_size=2048,
                shuffle=False,
                num_workers=job,
                pin_memory=True)
    _, err_test = test(test_loader, model, criterion, stat_3d, procrustes=False)
    err_set.append(err_test)

print ("Test results:")
for action in actions:
    print ("{}".format(action), end='\t')
print ("\n")
for err in err_set:
    print ("{:.4f}".format(err), end='\t')
print ("\nErrors: {}".format(np.array(err_set).mean()))
```

```
Test on Directions
>>> error: 35.45761416204111 <<<
Test on Discussion
>>> error: 42.43654787979646 <<<
Test on Eating
>>> error: 39.44880264138595 <<<
Test on Greeting
>>> error: 40.74898696138523 <<<
Test on Phoning
>>> error: 45.813939511711666 <<<
Test on Photo
>>> error: 53.06417229916588 <<<
Test on Posing
>>> error: 42.95849687656092 <<<
Test on Purchases
>>> error: 37.86601495257409 <<<
Test on Sitting
>>> error: 54.76434853676929 <<<
Test on SittingDown
>>> error: 57.52032771463763 <<<
Test on Smoking
>>> error: 43.91451977408759 <<<
Test on Waiting
>>> error: 42.643538394477034 <<<
Test on WalkDog
>>> error: 45.491809205201164 <<<
Test on Walking
>>> error: 33.85777928595775 <<<
Test on WalkTogether
>>> error: 36.53412099398327 <<<
Test results:
Directions      Discussion      Eating  Greeting        Phoning Photo   Posing  Purchases       Sitting SittingDown     Smoking Waiting WalkDog Walking WalkTogether

35.4576 42.4365 39.4488 40.7490 45.8139 53.0642 42.9585 37.8660 54.7643 57.5203 43.9145 42.6435 45.4918 33.8578 36.5341
Errors: 43.50140127931567
```

Report the test result(mm error) in the following sequence **direct. discuss. eat. greet. phone photo pose purch. sit sitd. somke wait walkd. walk walkT avg**

Below resources have been referred for implementing the code of this question:

https://github.com/weigq/3d_pose_baseline_pytorch

https://arxiv.org/pdf/1705.03098.pdf

## Problem 2:

{40 points} In this task, we're going to tackle the situation of having a faulty 3D sensor. Since the sensor is quite old it's joint detections are quite noisy:

$$\hat{x} = x_{GT} + \epsilon_x$$
$$\hat{y} = y_{GT} + \epsilon_y$$
$$\hat{z} = z_{GT} + \epsilon_z$$

Where, $(x_{GT}, y_{GT}, z_{GT})$ are the ground truth joint locations, $(\hat{x}, \hat{y}, \hat{z})$ are the noisy measurements detected by our sensor and $(\epsilon_x, \epsilon_y, \epsilon_z)$ are the noise values. Being grad students, we'd much rather the department spend money for free coffee and doughnuts than on a new 3D sensor. Therefore, you're going to denoise the noisy data using a linear Kalman filter.

**Modelling the state using velocity and acceleration**: We assume a simple, if unrealistic model, of our system - we're only going to use the position, velocity and acceleration of the joints to denoise the data. The underlying equations representing our assumptions are:

$$x_{t+1} = x_t + \frac{\partial x_t}{\partial t}\delta t + 0.5 * \frac{\partial^2 x_t}{\partial t^2}\delta t^2 \qquad (1)$$

$$y_{t+1} = y_t + \frac{\partial y_t}{\partial t}\delta t + 0.5 * \frac{\partial^2 y_t}{\partial t^2}\delta t^2 \qquad (2)$$

$$z_{t+1} = z_t + \frac{\partial z_t}{\partial t}\delta t + 0.5 * \frac{\partial^2 z_t}{\partial t^2}\delta t^2 \qquad (3)$$

The only measurements/observations we have (i.e our 'observation space') are the noisy joint locations as recorded by the 3D sensors $o_t = (\hat{x}_t, \hat{y}_t, \hat{z}_t)$. The corresponding state-space would be $z_t = (x_t, y_t, z_t, \frac{\partial x_t}{\partial t}, \frac{\partial y_t}{\partial t}, \frac{\partial z_t}{\partial t}, \frac{\partial^2 x_t}{\partial t^2}, \frac{\partial^2 y_t}{\partial t^2}, \frac{\partial^2 z_t}{\partial t^2})$.

Formallly, a linear Kalman filter assumes the underlying dynamics of the system to be a linear Gaussian model i.e.

$$z_0 \sim N(\mu_0, \Sigma_0)$$
$$z_{t+1} = Az_t + b + \epsilon_t^1$$
$$o_t = Cz_t + d + \epsilon_t^2$$
$$\epsilon_t^1 \sim N(0, Q)$$
$$\epsilon_t^2 \sim N(0, R)$$

where, $A$ and $C$ are the `transition_matrix` and `observation_matrix` respectively, that you are going to define based on equations (1), (2) and (3). The intitial estimates of other parameters can be assumed as:

$$\texttt{initial\_state\_mean} := \mu_0 = mean(given\ data)$$
$$\texttt{initial\_state\_covariance} := \Sigma_0 = Cov(given\ data)$$
$$\texttt{transition\_offset} := b = 0$$
$$\texttt{observation\_offset} := d = 0$$
$$\texttt{transition\_covariance} := Q = I$$
$$\texttt{observation\_covariance} := R = I$$

The covariance matrices $Q$ and $R$ are hyperparameters that we initalize as identity matrices. In the code below, you must define $A$ and $C$ and use pykalman, a dedicated library for kalman filtering in python, to filter out the noise in the data.

(**Hint:**
Gradients could be calculated using `np.gradient` or manually using finite differences
You can assume the frame rate to be 50Hz)

For more detailed resources related to Kalman filtering, please refer to:
http://web.mit.edu/kirtley/kirtley/binlustuff/literature/control/Kalman%20filter.pdf
https://www.bzarg.com/p/how-a-kalman-filter-works-in-pictures/
https://stanford.edu/class/ee363/lectures/kf.pdf

```
'''=================Function definition of the Kalman filter, which will return the filtered 3D world coordinates============================'''
'''=================Students need to fill this part================================'''
from pykalman import KalmanFilter
freq = 50
dt = 1 / freq
dt_sq = dt*dt
A = np.hstack((np.identity(3),np.identity(3)*dt,np.identity(3)*0.5*dt_sq))
C = np.hstack((np.identity(3),np.identity(3)*0,np.identity(3)*0))
def KF_filter(full_data):


    '''------------------TO DO--------------------
    '''
    '''--------Define the Kalman filter and filter the noisy signal------------'''
    freq = 50
    dt = 1 / freq
    dt_sq = dt*dt
    A = np.hstack((np.identity(3),np.identity(3)*dt,np.identity(3)*0.5*dt_sq))
    A = np.vstack((A, np.hstack((np.identity(3)*0,np.identity(3),np.identity(3)*dt))))
    A = np.vstack((A, np.hstack((np.identity(3)*0,np.identity(3)*0,np.identity(3)))))
    # print('A shape = ', A.shape)
    C = np.hstack((np.identity(3),np.identity(3)*0,np.identity(3)*0))
    # print('C shape = ', C.shape)
    # full_data = np.random.rand(1383,48)
    # print('Full data shape = ', full_data.shape)
    n_cols = full_data.shape[1]
    # print('Number of columns = ', n_cols)
    velocities = np.gradient(full_data[:,0], dt)
    for i in range(1, n_cols):
```

```
        velocities = np.vstack((velocities, np.gradient(full_data[:,i], dt)))
    velocities = np.transpose(velocities)
    # print('Velocities shape = ', velocities.shape)

    acceleration = np.gradient(velocities[:,0])
    for i in range(1, n_cols):
        acceleration = np.vstack((acceleration, np.gradient(velocities[:,i], dt)))
    acceleration = np.transpose(acceleration)
    # print('Acceleration shape = ', acceleration.shape)
    #
    cnt = 1
    filtered_data = np.zeros(shape = (full_data.shape[0], C.shape[0]))
    # print('Filtered data shape = ', filtered_data.shape)
    for i in range(0, n_cols, 3):
        zt = full_data[:,i]
        zt = np.vstack((zt, full_data[:,i+1]))
        zt = np.vstack((zt, full_data[:,i+2]))
        zt = np.vstack((zt, velocities[:, i]))
        zt = np.vstack((zt, velocities[:, i + 1]))
        zt = np.vstack((zt, velocities[:, i + 2]))
        zt = np.vstack((zt, acceleration[:, i]))
        zt = np.vstack((zt, acceleration[:, i + 1]))
        zt = np.vstack((zt, acceleration[:, i + 2]))
        zt_mean = np.mean(zt, axis=1)
        zt_cov = np.cov(zt)
        kf = KalmanFilter(transition_matrices=A,
                          observation_matrices=C,
                          transition_covariance=np.identity(A.shape[0]),
                          observation_covariance=np.identity(C.shape[0]),
                          initial_state_mean=zt_mean,
                          initial_state_covariance=zt_cov,
                          transition_offsets=np.zeros(A.shape[0]),
                          observation_offsets=np.zeros(C.shape[0])
                          )
        zt = np.transpose(zt)
        # print(zt[:,:3].shape)
        kf_output, _ = kf.filter(zt[:,:3])
        # print('kf output shape = ', kf_output[:,:3].shape)
        filtered_data = np.hstack((filtered_data, kf_output[:,:3]))

    filtered_data = filtered_data[:,3:]
    print('filtered data shape = ', filtered_data.shape)

    return filtered_data


noisy_stat = []
recovered_stat = []

for keys in list(train_set_3d.keys())[:40]:

    true_state = train_set_3d[keys]
    cov = np.cov(true_state.T)
```

```
    noise = np.random.multivariate_normal(mean = np.zeros(true_state.shape[1]), cov = cov, size = true_state.shape[0])
    noisy_observation = true_state + noise

    filtered_onservation = KF_filter(noisy_observation)
    noisy_stat.append(mean_squared_error(true_state, noisy_observation))
    recovered_stat.append(mean_squared_error(true_state, filtered_onservation))
```

```
filtered data shape =  (1383, 48)
filtered data shape =  (1383, 48)
filtered data shape =  (1383, 48)
filtered data shape =  (1383, 48)
filtered data shape =  (1612, 48)
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filtered data shape =  (2636, 48)
filtered data shape =  (2266, 48)
filtered data shape =  (2266, 48)
filtered data shape =  (2266, 48)
filtered data shape =  (2266, 48)
```
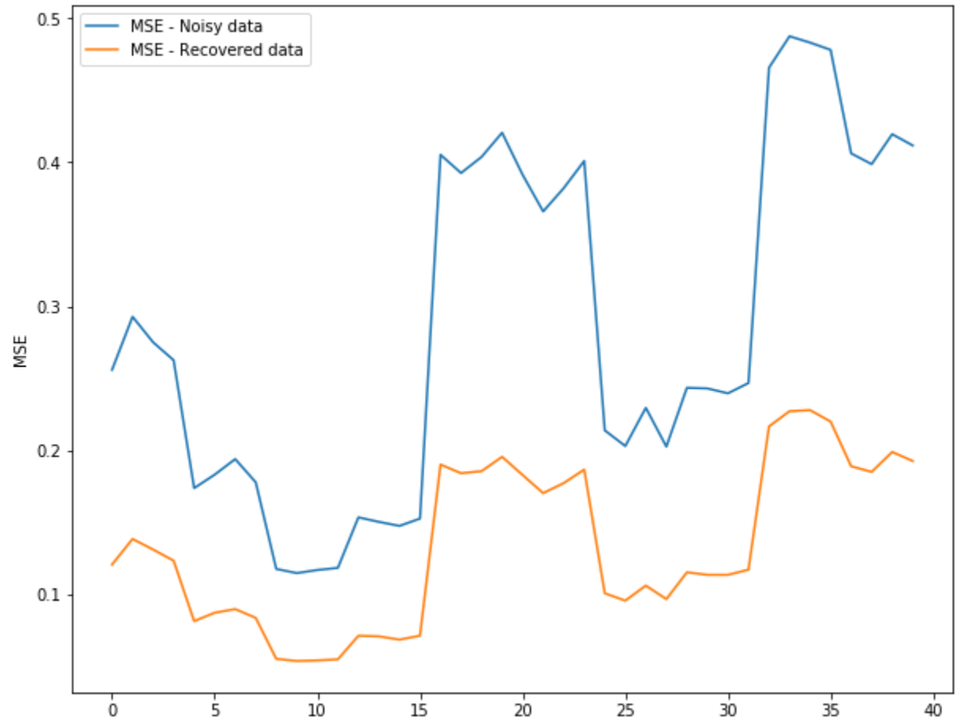

```
## Plotting the results (tentetive)
# complete this
fig = plt.figure(figsize=(10,8))
plt.plot(noisy_stat, label = 'MSE - Noisy data')
plt.plot(recovered_stat, label = 'MSE - Recovered data')
plt.ylabel('MSE')
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7effea17ac18>
```




## Submission guidelines

Extract the downloaded .zip file to a folder of your preference. The input and output paths are predefined and **DO NOT** change them, (we assume that 'Surname_Givenname_SBUID_hw6' is your working directory, and all the paths are relative to this directory). The image read and write functions are already written for you. All you need to do is to fill in the blanks as indicated to generate proper outputs. **DO NOT** zip and upload the dataset on blackboard due to size limit.

When submitting your .zip file through blackboard, please -- name your .zip file as **Surname_Givenname_SBUID_hw*.zip**.

This zip file should include:

```
Surname_Givenname_SBUID_hw*
        |---Surname_Givenname_SBUID_hw*.ipynb
        |---Surname_Givenname_SBUID_hw*.py
```

where Surname_Givenname_SBUID_hw.*py is the Python code of Surname_Givenname_SBUID_hw*.ipynb, which can be dowloaded by File->Download .py.

For instance, student Michael Jordan should submit a zip file named "Jordan_Michael_111134567_hw6.zip" for homework6 in this structure:

```
Jordan_Michael_111134567_hw6
        |---Jordan_Michael_111134567_hw6.ipynb
        |---Jordan_Michael_111134567_hw6.py
```

The **Surname_Givenname_SBUID_hw*.pdf** should include a **google shared link**. To generate the **google shared link**, first create a folder named **Surname_Givenname_SBUID_hw*** in your Google Drive with your Stony Brook account. The structure of the files in the folder should be exactly the same as the one you downloaded. If you alter the folder structures, the grading of your homework will be significantly delayed and possibly penalized.

Then right click this folder, click ***Get shareable link***, in the People textfield, enter two TA's emails: ***bo.cao.1@stonybrook.edu*** and ***sayontan.ghosh@stonybrook.edu***. Make sure that TAs who have the link **can edit**, ***not just*** **can view**, and also **uncheck** the **Notify people** box.

Colab has a good feature of version control, you should take advantage of this to save your work properly. However, the timestamp of the submission made in blackboard is the only one that we consider for grading. To be more specific, we will only grade the version of your code right before the timestamp of the submission made in blackboard.

You are encouraged to post and answer questions on Piazza. Based on the amount of email that we have received in past years, there might be dealys in replying to personal emails. Please ask questions on Piazza and send emails only for personal issues.

Be aware that your code will undergo plagiarism check both vertically and horizontally. Please do your own work.

**Late submission penalty:**
There will be a 10% penalty per day for late submission. However, you will have 4 days throughout the whole semester to submit late without penalty. Note that the grace period is calculated by days instead of hours. If you submit the homework one minute after the deadline, one late

## References

[1] J. Martinez, R. Hossain, J. Romero, and J. J. Little, “A simple yet effective baseline for 3d human pose estimation,” in ICCV, 2017.

Drive link to folder: https://drive.google.com/open?id=1gXSpe_apJCECgjwwdjzIn7hRvdRXkXJ1

Acknowledgement:

Abdullah Mitkar

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