Script

March 21, 2019

1 This demo uses dataset of raw T1 structual MRI images. ABIDE dataset.

573 subjects on control in total.
from 6 to 56 years old.
10% for test, 90% for training.

```
In [2]: %load_ext autoreload
        %autoreload 2
        %matplotlib inline
```

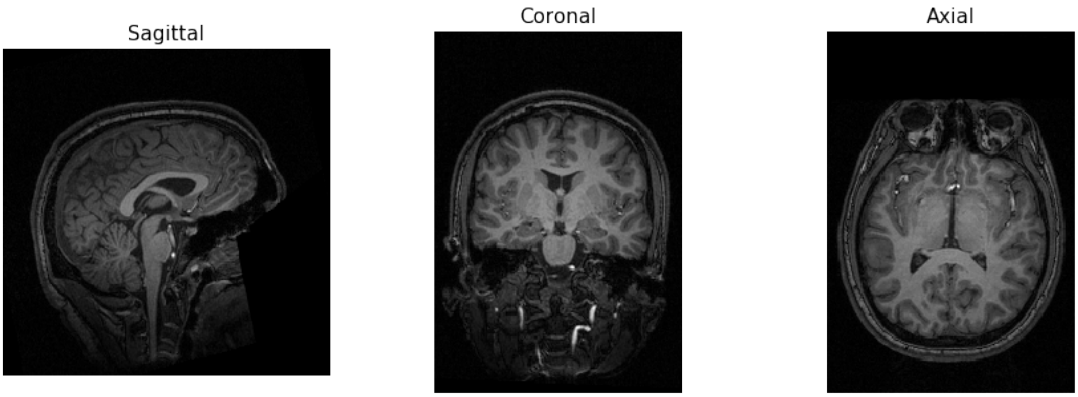
```
In [3]: from preprocess import *
```

1.1 1. The raw image

1.1.1 Some images looks like this:

```
In [4]: nii_img = nib.load('/media/woody/Elements/age_data/ABIDE_I/anat_data/50002.nii.gz')
        npy_img = nii_img.get_data()
        print2d(npy_img)
```

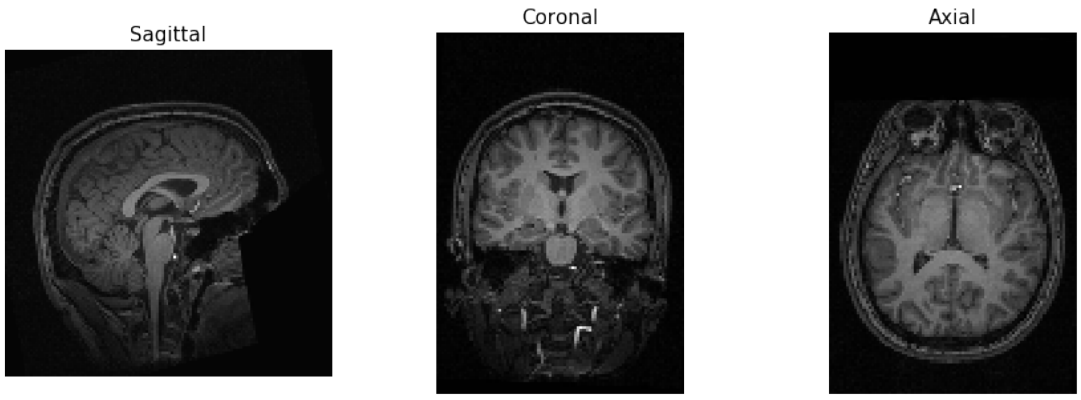
```
Dimension:  (176, 256, 256)
```



1.1.2 It goes through the resampling and padding process

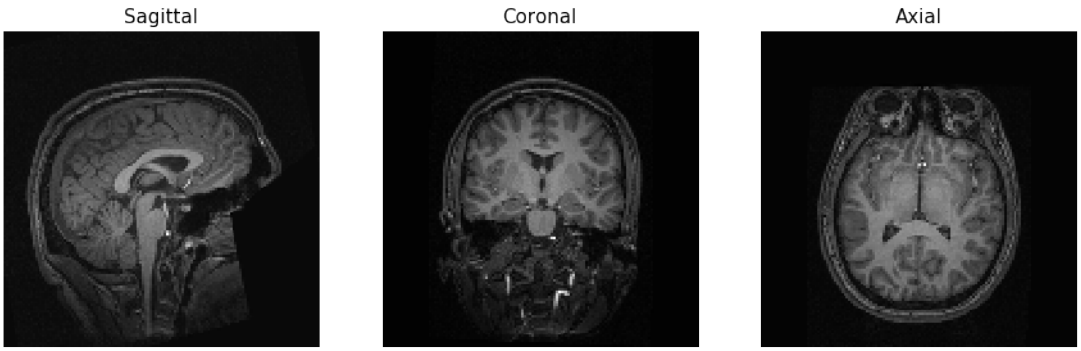
```
In [5]: header = nii_img.header
        pixdim = np.round(header['pixdim'][1:4])
        resampled_img = resample(npy_img, pixdim, [2,2,2])
        print2d(resampled_img)
```

```
Dimension:  (88, 128, 128)
```




```
In [6]: crop_padded_img = np.load('./data_npy/origin/50002.npy')
        print2d(crop_padded_img)
```

```
Dimension:  (130, 130, 130)
```



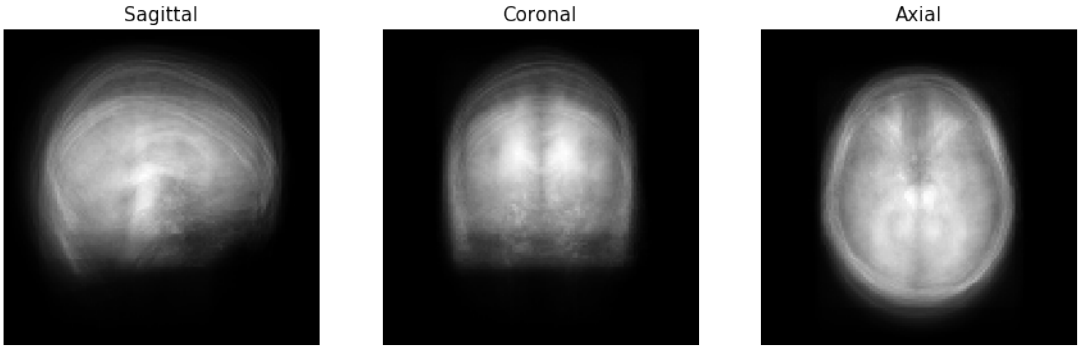
1.1.3 The mean image of all the training data is computed and is subtracted from all training and test data.

1.1.4 It is worth noting that the test data does not contribute to the mean image. This is because the training data, and only training data, needs to have zero mean for better training performance.

1.1.5 How does the mean values look like:

```
In [7]: mean_npy = np.load('./data_npy/mean_npy.npy')
        print2d(mean_npy)
```

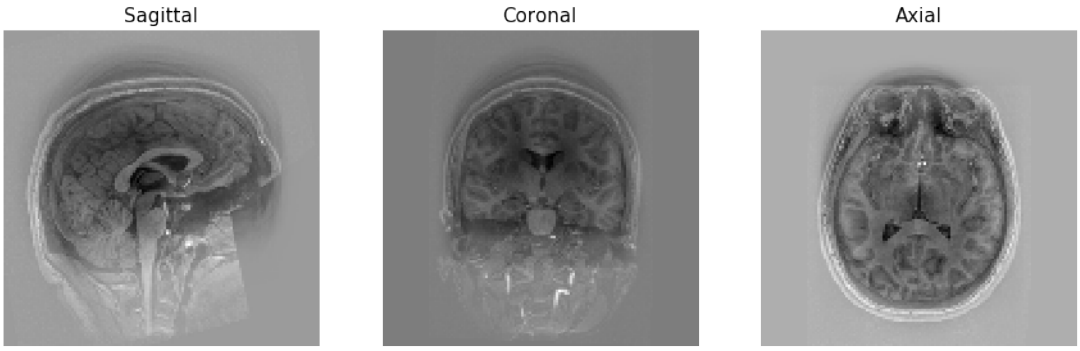
```
Dimension:  (130, 130, 130)
```



1.1.6 Finally, the images fed into the model look like this:

```
In [8]: final_img = np.load('./data_npy/mean_subtracted/50002.npy')
        print2d(final_img)
```

```
Dimension:  (130, 130, 130)
```



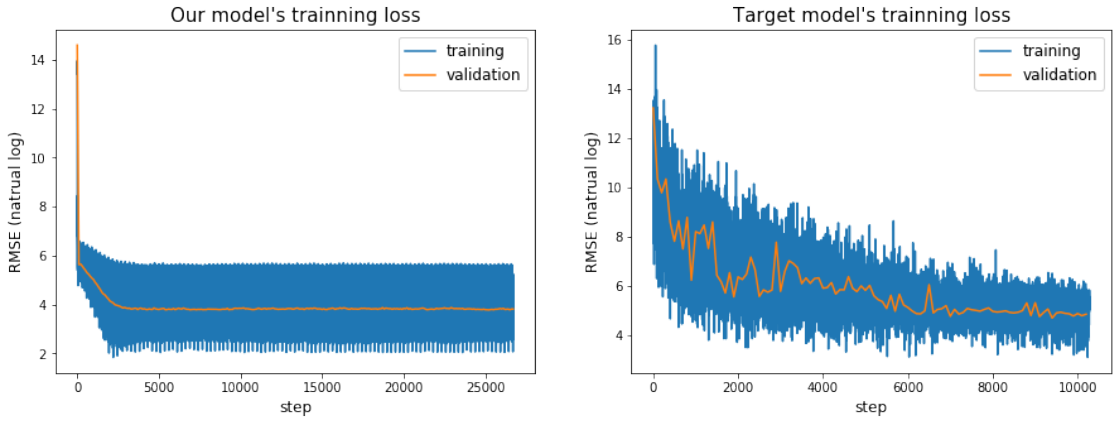
1.2 2. Training and test results

- We collect the best shot who has the smallest loss value (RMSE) in the training process.
- The validation uses the test dataset.
- Our model uses 3D-CNN with dropout, batch normalization and L2 regularization.
- Target model uses 3D-CNN with dropout.

```
In [10]: def subdraw(ax,filename):
             arr = np.load(filename)
             ax.plot(arr[0], np.log(arr[1]),label='training')
             ax.plot(arr[2], np.log(arr[3]),label='validation')
             ax.legend(fontsize=12)
             ax.set_xlabel('step',fontsize=12)
             ax.set_ylabel('RMSE (natrual log)',fontsize=12)

         f, (ax1, ax2) = plt.subplots(1, 2, figsize=(15,5))
         subdraw(ax=ax1,filename='./img/demo_1_1_pltdata_2019.03.19.07:14:05.npy')
         ax1.set_title('Our model\'s trainning loss',fontsize=15)
         subdraw(ax=ax2,filename='./img/demo_1_2_pltdata_2019.03.19.20:22:06.npy')
         ax2.set_title('Target model\'s trainning loss',fontsize=15)
```

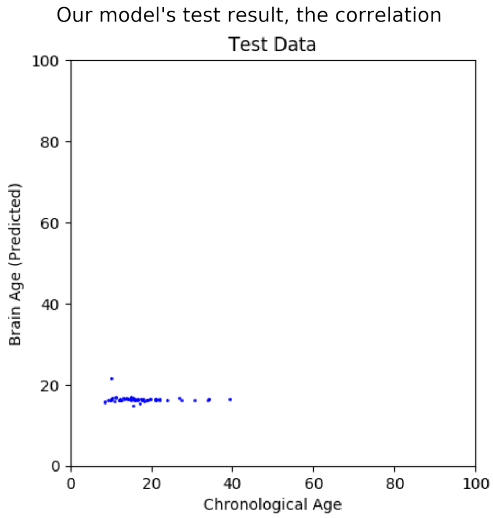
```
Out[10]: Text(0.5, 1.0, "Target model's trainning loss")
```

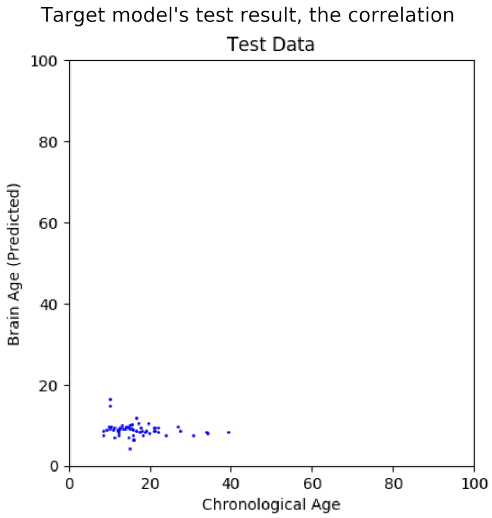


1.2.1 Let's check the correlation between the predicted age and the chronological age.

```
In [11]: f, (ax1, ax2) = plt.subplots(1, 2, figsize=(40,20))
         ax1.imshow(plt.imread('./img/demo_1_1_test.png'))
         ax1.axis('off')
         ax1.set_title('Our model\'s test result, the correlation',fontsize=40)
         ax2.imshow(plt.imread('./img/demo_1_2_test.png'))
         ax2.axis('off')
         ax2.set_title('Target model\'s test result, the correlation',fontsize=40)
```

```
Out[11]: Text(0.5, 1.0, "Target model's test result, the correlation")
```





1.3 Conclusion

1.3.1 It seems there is something wrong with the model code.

1.3.2 We have to fix the code first.

1.3.3 Let's figure out where to start with.

1.4 Appendix:

Predicted age of some test subjects.

```
In [4]: from preprocess import *
        from my_tools import *
        import tensorflow as tf
        from PIL import Image
        import matplotlib.pyplot as plt
        import numpy as np
        import time
        import argparse
        import sys


        def print_activations(t):
            print(t.op.name, ' ', t.get_shape().as_list())


        def inference(X, keep_prob, is_training_forBN, trivial=True):
            l2_loss = 0
```

```
    with tf.name_scope('l1_conv3d') as scope:
        w = tf.Variable(tf.truncated_normal([5,5,5,1,16], stddev=0.1), name='kernel')
        b = tf.Variable(tf.constant(0.1,shape=[16]),name='b')
        temp_output = tf.nn.bias_add(tf.nn.conv3d(X,w,strides=[1,1,1,1,1],\
                                                  padding='SAME',name='conv3d'),b)
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        conv3d = tf.nn.relu(temp_output)

        max_pool = tf.nn.max_pool3d(conv3d,ksize=[1,2,2,2,1],strides=[1,2,2,2,1],\
                                    padding='SAME',name='max_pool3d')

#         l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(conv3d)
            print_activations(max_pool)
    with tf.name_scope('l2_conv3d') as scope:
        w = tf.Variable(tf.truncated_normal([3,3,3,16,32], stddev=0.1), name='kernel')
        b = tf.Variable(tf.constant(0.1,shape=[32]),name='b')
        temp_output = tf.nn.bias_add(tf.nn.conv3d(max_pool,w,strides=[1,1,1,1,1],\
                                                  padding='SAME',name='conv3d'),b)
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        conv3d = tf.nn.relu(temp_output)

        max_pool = tf.nn.max_pool3d(conv3d,ksize=[1,2,2,2,1],strides=[1,2,2,2,1],\
                                    padding='SAME',name='max_pool3d')

#         l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(conv3d)
            print_activations(max_pool)
    with tf.name_scope('l3_conv3d') as scope:
        w = tf.Variable(tf.truncated_normal([3,3,3,32,64], stddev=0.1), name='kernel')
        b = tf.Variable(tf.constant(0.1,shape=[64]),name='b')
        temp_output = tf.nn.bias_add(tf.nn.conv3d(max_pool,w,strides=[1,1,1,1,1],\
                                                  padding='SAME',name='conv3d'),b)
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        conv3d = tf.nn.relu(temp_output)

        max_pool = tf.nn.max_pool3d(conv3d,ksize=[1,2,2,2,1],strides=[1,2,2,2,1],\
                                    padding='SAME',name='max_pool3d')

#         l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(conv3d)
            print_activations(max_pool)
```

```
    with tf.name_scope('l4_conv3d') as scope:
        w = tf.Variable(tf.truncated_normal([3,3,3,64,64], stddev=0.1), name='kernel')
        b = tf.Variable(tf.constant(0.1,shape=[64]),name='b')
        temp_output = tf.nn.bias_add(tf.nn.conv3d(max_pool,w,strides=[1,1,1,1,1],\
                                                  padding='SAME',name='conv3d'),b)
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        conv3d = tf.nn.relu(temp_output)

        max_pool = tf.nn.max_pool3d(conv3d,ksize=[1,2,2,2,1],strides=[1,2,2,2,1],\
                                    padding='SAME',name='max_pool3d')

#         l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(conv3d)
            print_activations(max_pool)
    with tf.name_scope('l5_conv3d') as scope:  # temp
        w = tf.Variable(tf.truncated_normal([3,3,3,64,64], stddev=0.1), name='kernel')
        b = tf.Variable(tf.constant(0.1,shape=[64]),name='b')
        temp_output = tf.nn.bias_add(tf.nn.conv3d(max_pool,w,strides=[1,1,1,1,1],\
                                                  padding='SAME',name='conv3d'),b)
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        conv3d = tf.nn.relu(temp_output)

        max_pool = tf.nn.max_pool3d(conv3d,ksize=[1,2,2,2,1],strides=[1,2,2,2,1],\
                                    padding='SAME',name='max_pool3d')

#         l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(conv3d)
            print_activations(max_pool)
    with tf.name_scope('l6_fc') as scope:
        max_pool_shape = max_pool.get_shape().as_list()
        temp_shape = 1
        for i in max_pool_shape[1:]:
            temp_shape *= i
        fc_input = tf.reshape(max_pool, [-1, temp_shape])
        w = tf.Variable(tf.truncated_normal([temp_shape,512],stddev=0.1),name='w')
        b = tf.Variable(tf.constant(0.1,shape=[512]),name='b')
        temp_output = tf.matmul(fc_input,w) + b
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        fc_out = tf.nn.relu(temp_output, name='fc_out1')
        dropout = tf.nn.dropout(fc_out,keep_prob=keep_prob, name='dropout1')

        l2_loss += tf.nn.l2_loss(w)

        if trivial:
```

```
            print_activations(fc_out)
            print_activations(dropout)
    with tf.name_scope('l7_fc') as scope:
        w = tf.Variable(tf.truncated_normal([512,128],stddev=0.1),name='w')
        b = tf.Variable(tf.constant(0.1,shape=[128]),name='b')
        temp_output = tf.matmul(fc_out,w) + b
        temp_output = tf.layers.batch_normalization(temp_output,training=is_training_for
        fc_out = tf.nn.relu(temp_output, name='fc_out2')
        dropout = tf.nn.dropout(fc_out,keep_prob=keep_prob, name='dropout2')

        l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(fc_out)
            print_activations(dropout)
    with tf.name_scope('l8_fc') as scope:
        w = tf.Variable(tf.truncated_normal([128,1],stddev=0.1),name='w')
        b = tf.Variable(tf.constant(0.1,shape=[1]),name='b')

        final_output = tf.add(tf.matmul(dropout,w), b, name='final_output')

        l2_loss += tf.nn.l2_loss(w)

        if trivial:
            print_activations(final_output)

    return final_output, l2_loss

def get_loss(predict_batches,label_batches,l2_loss):
    with tf.name_scope('cross_entropy'):
        cost = tf.reduce_mean(tf.square(predict_batches - label_batches)) + 1e-6 * l2_lo
    return cost



def test_single_subject(phe_index):
    with tf.Graph().as_default():
        phe = pd.read_csv('./phenotypics.csv', sep=',',header=0)
        sub_id = phe['id'][phe_index]
#         arr = np.load('./data_npy/mean_subtracted/'+sub_id+'.npy')
        arr = np.load('./data_npy/origin/'+str(int(sub_id))+'.npy')
        arr = arr.astype(np.float32)
        arr_shape = arr.shape
        label = phe['age'][phe_index]

        tf_arr = tf.placeholder(tf.float32,shape=arr_shape)
        tf_label = tf.placeholder(tf.float32)
        X = tf.reshape(arr, [-1]+list(arr_shape)+[1])
```

```
            keep_prob = tf.placeholder(tf.float32, name='keep_prob')

            is_training_forBN = tf.placeholder(tf.bool, name='is_training_forBN')

            predicted_age,l2_loss = inference(X,keep_prob,is_training_forBN,trivial=False)

        #         loss = get_loss(predicted_age,label_batch,l2_loss)
        #         acc = get_accuracy(predicted_age,label_batch)

            saver = tf.train.Saver()
        #         pdb.set_trace()


            with tf.Session() as sess:
                saver.restore(sess, './log/demo1.1_mine_model.ckpt')
        #             saver.restore(sess, './backup/demo1.1_mine_model.ckpt')
                print('Model loaded successfully.')

                p_age = sess.run(predicted_age,feed_dict={keep_prob:1.0,
                                                          is_training_forBN:False,
                                                          tf_arr:arr,
                                                          tf_label:label})
                print('Subject: ',sub_id,', chronological age is ',label,', predicted age is
        return
    for i in range(40):
        test_single_subject(i)
```

```
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51075.0 , chronological age is  14.2 , predicted age is  [[14.720013]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50562.0 , chronological age is  10.83 , predicted age is  [[14.934543]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51078.0 , chronological age is  6.47 , predicted age is  [[14.817]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50656.0 , chronological age is  28.0 , predicted age is  [[15.375941]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50269.0 , chronological age is  14.66 , predicted age is  [[15.061264]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50375.0 , chronological age is  11.6 , predicted age is  [[16.420721]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50198.0 , chronological age is  15.28 , predicted age is  [[17.631477]] .
```

```
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50781.0 , chronological age is  9.3 , predicted age is  [[15.122624]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51360.0 , chronological age is  7.0 , predicted age is  [[15.255686]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51036.0 , chronological age is  8.04 , predicted age is  [[15.003778]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50164.0 , chronological age is  8.86 , predicted age is  [[14.886364]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50339.0 , chronological age is  18.0 , predicted age is  [[14.8812475]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51370.0 , chronological age is  32.0 , predicted age is  [[15.103536]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51196.0 , chronological age is  11.8816 , predicted age is  [[18.227041]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50201.0 , chronological age is  13.77 , predicted age is  [[17.004206]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50368.0 , chronological age is  17.9 , predicted age is  [[15.796626]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50666.0 , chronological age is  31.0 , predicted age is  [[15.246569]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50209.0 , chronological age is  16.57 , predicted age is  [[17.203913]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50723.0 , chronological age is  13.8 , predicted age is  [[15.036725]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50102.0 , chronological age is  14.0 , predicted age is  [[15.077769]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51052.0 , chronological age is  14.18 , predicted age is  [[14.931774]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50722.0 , chronological age is  13.8 , predicted age is  [[15.036471]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51108.0 , chronological age is  15.71 , predicted age is  [[15.02925]] .
```

```
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50366.0 , chronological age is  8.2 , predicted age is  [[15.991329]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50051.0 , chronological age is  12.83 , predicted age is  [[14.790754]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50038.0 , chronological age is  13.95 , predicted age is  [[14.834432]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51153.0 , chronological age is  26.17 , predicted age is  [[14.879248]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51044.0 , chronological age is  10.86 , predicted age is  [[15.009398]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50114.0 , chronological age is  20.0 , predicted age is  [[15.025734]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50432.0 , chronological age is  18.2806 , predicted age is  [[14.871307]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50437.0 , chronological age is  14.9432 , predicted age is  [[15.323397]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51182.0 , chronological age is  10.6927 , predicted age is  [[28.60697]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51089.0 , chronological age is  10.76 , predicted age is  [[15.016782]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50780.0 , chronological age is  9.82 , predicted age is  [[15.228842]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50355.0 , chronological age is  10.9 , predicted age is  [[15.769344]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51114.0 , chronological age is  22.48 , predicted age is  [[14.838302]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51369.0 , chronological age is  32.0 , predicted age is  [[15.085896]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50710.0 , chronological age is  27.0 , predicted age is  [[15.102472]] .
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  50703.0 , chronological age is  29.0 , predicted age is  [[15.056898]] .
```

```
INFO:tensorflow:Restoring parameters from ./log/demo1.1_mine_model.ckpt
Model loaded successfully.
Subject:  51308.0 , chronological age is  9.79 , predicted age is  [[14.862834]] .
```

In [ ]: