In [2]:

```
from __future__ import print_function
import librosa
import numpy as np
import matplotlib.pyplot as plt
import json
%matplotlib inline
#from songloader import *
#from slidingwindowgen import *
```

In [3]:

```
samples_per_chunk = 300
num_chunks_per_slice = 65
num_chunks_per_beat = 8
```

In [4]:

```
def loadbeatmap_3dout(beatmap, num_beats, num_chunks_per_beat=8):
    if beatmap[len(beatmap)-5:len(beatmap)] != ".json":
        print("Beatmap file " + audio + " is not of type .json")
        return -1

    with open(beatmap) as f:
        data = json.load(f)

    notes = "_notes"
    time = "_time"
    line_index = "_lineIndex" #column number
    line_layer = "_lineLayer" #row number
    note_color = "_type" #0 is one color and 1 is the other
    cut_direction = "_cutDirection"#9 cut directions

    dim_0 = num_beats * num_chunks_per_beat

    # number of rows and columns in the playfield
    # number of cells in the playfield (each cell can hold at most 1 note)
    playfield_rows = 3
    playfield_cols = 4
    playfield_cell_count = playfield_rows * playfield_cols

    # number of colors (2): red, blue (order unknown)
    # number of directions notes can face (9):
    # up, down, left, right, up-left, up-right, down-left, down-right, dot (order unknown)
    note_color_count = 2
    note_direction_count = 9

    # dimensions for a 'one-hot' representation of a single time unit (chunk)
    dim_1 = playfield_rows
    dim_2 = playfield_cols
    dim_3 = (note_color_count + 1) + note_direction_count

    # initialize matrix to zeros, then set the "no note" bit for each block at each timestep to 1
    outMatrix = np.zeros(shape=(dim_0, dim_1, dim_2, dim_3))
    outMatrix[:,:,:,0] = 1


    # for every note in the beatmap, set the color and direction bits for the proper cell to 1
    for n in range(len(data[notes])):
        entry = int(np.round(data[notes][n][time]*num_chunks_per_beat)) #convert time to row index by rounding to neare
st 1/8 beat
        if data[notes][n][note_color] < 2:
            outMatrix[entry] \
                     [data[notes][n][line_layer]] \
                     [data[notes][n][line_index]] \
                     [data[notes][n][note_color]+1] = 1
            outMatrix[entry] \
                     [data[notes][n][line_layer]] \
                     [data[notes][n][line_index]] \
                     [0] = 0
            outMatrix[entry] \
                     [data[notes][n][line_layer]] \
                     [data[notes][n][line_index]] \
                     [data[notes][n][cut_direction]+3] = 1

    return outMatrix
```

In [5]:

```
def mean_center(x):
    #return x - np.mean(x)
    return (x - np.apply_along_axis(np.mean, 0, x) )#/ np.apply_along_axis(np.std, 0, x)
```

In [6]:

```
def encode_note_color(x):
    return (np.max(x[:,:,0])*1+ np.max(x[:,:,1])*2)
```

In [7]:

```
def loadsong(audio, samples_per_chunk=300, num_chunks_per_slice=65, num_chunks_per_beat=8, verbose=0):
    if audio[len(audio)-4:len(audio)] != ".ogg":
        print("Audio file " + audio + " is not of type .ogg")
        return -1

    y, sr = librosa.load(audio)

    song_length = librosa.get_duration(y=y,sr=sr) / 60.0
    tempo = np.round(librosa.beat.tempo(y, sr=sr))
    new_sample_rate = (tempo/200)*8000

    y = librosa.resample(y, sr, new_sample_rate)

    number_of_beats = int(tempo * song_length)

    #y = transformsong(y, number_of_beats, song_length, num_chunks_per_beat)

    #y_bm = loadbeatmap_3dout(beatmap, number_of_beats)


    return y[0:(len(y)//(samples_per_chunk*num_chunks_per_beat)*(samples_per_chunk*num_chunks_per_beat))], new_sample_r
ate, number_of_beats#, y_bm
```

In [8]:

```
#song1_y, song1_sr, song1_num_beats = loadsong("song.ogg")
song0_y, song0_sr, song0_num_beats = loadsong("song.ogg")
```

```
/nfshome/apps/python-3.6.7/lib/python3.6/site-packages/scipy/fftpack/basic.py:160: FutureWarning: Using a
 non-tuple sequence for multidimensional indexing is deprecated; use `arr[tuple(seq)]` instead of `arr[se
q]`. In the future this will be interpreted as an array index, `arr[np.array(seq)]`, which will result ei
ther in an error or a different result.
  z[index] = x
```

In [9]:

```
song1_y = song0_y
song1_sr = song0_sr
song1_num_beats = song0_num_beats
```

In [10]:

```
np.shape(song1_y)
```

Out[10]:

```
(1233600,)
```

In [11]:

```
song1_y = song1_y.reshape(len(song1_y)//300,300)
```

In [12]:

```
np.shape(song1_y)
```

Out[12]:

```
(4112, 300)
```

In [13]:

```
song1_fft = np.abs(np.apply_along_axis(np.fft.fft, 1, song1_y))[:,0:(int)(samples_per_chunk/2)+1]
```

In [14]:

```
np.shape(song1_fft)
```

Out[14]:

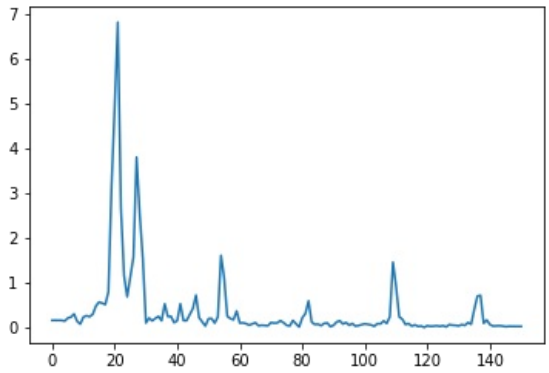
```
(4112, 151)
```

In [15]:

```
plt.plot(range(len(song1_fft[100])),song1_fft[50])
```

Out[15]:

```
[<matplotlib.lines.Line2D at 0x7ff39d0ae518>]
```



fig,axes = plt.subplots(50)

fig.set_figwidth(12)

fig.set_figheight(20) for x in range(50):

```
    #data = plt.plot(range(len(song1_fft[100])),song1_fft[50+x])
    axes[x].plot(range(len(song1_fft[100])),song1_fft[1000+x])
```

plt.show()

In [16]:

```
beatmap1 = loadbeatmap_3dout("Expert.json", song1_num_beats)
```

In [17]:

```
beatmap1[644]
```

Out[17]:

```
array([[[1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.]],

       [[1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [0., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.]],

       [[1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
        [1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.]]])
```

In [18]:

```
np.shape(beatmap1)
```

Out[18]:

```
(4112, 3, 4, 12)
```

In [19]:

```
beatmap1_slice = beatmap1[:,:,:,1:3]
```

In [20]:

```
beatmap1_slice[644]
```

Out[20]:

```
array([[[0., 0.],
        [1., 0.],
        [0., 0.],
        [0., 0.]],

       [[0., 0.],
        [0., 0.],
        [0., 1.],
        [0., 0.]],

       [[0., 0.],
        [0., 0.],
        [0., 0.],
        [0., 0.]]])
```

In [21]:

```
np.shape(beatmap1_slice)
```

Out[21]:

```
(4112, 3, 4, 2)
```

In [22]:

```
beatmap1_encoded = np.apply_along_axis(encode_note_color, 0, beatmap1_slice)
```

```
---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
<ipython-input-22-24619c98691b> in <module>
----> 1 beatmap1_encoded = np.apply_along_axis(encode_note_color, 0, beatmap1_slice)

/nfshome/apps/python-3.6.7/lib/python3.6/site-packages/numpy/lib/shape_base.py in apply_along_axis(func1d
, axis, arr, *args, **kwargs)
    355     except StopIteration:
    356         raise ValueError('Cannot apply_along_axis when any iteration dimensions are 0')
--> 357     res = asanyarray(func1d(inarr_view[ind0], *args, **kwargs))
    358
    359     # build a buffer for storing evaluations of func1d.

<ipython-input-6-b7cb620fd023> in encode_note_color(x)
      1 def encode_note_color(x):
----> 2     return (np.max(x[:,:,0])*1+ np.max(x[:,:,1])*2)

IndexError: too many indices for array
```

In [23]:

```
beatmap1_encoded = np.array([encode_note_color(x) for x in beatmap1_slice])
```

In [24]:

```
np.shape(beatmap1_encoded)
```

Out[24]:

```
(4112,)
```

In [25]:

```
beatmap1_encoded[600:650]
```

Out[25]:

```
array([0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 3., 0., 0., 0., 0.,
       0., 0., 0., 3., 0., 0., 0., 0., 0., 0., 0., 3., 0., 0., 0., 0., 0.,
       0., 0., 3., 0., 0., 0., 0., 0., 0., 0., 3., 0., 0., 0., 0., 0.])
```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```
```

In [ ]:

```
```

In [ ]:

```
```

In [26]:

```
np.max(beatmap1_slice[644][:,:,0])*1+ np.max(beatmap1_slice[644][:,:,1])*2
```

Out[26]:

```
3.0
```

In [27]:

```
np.max(beatmap1_slice[644][1])
```

Out[27]:

```
1.0
```

In [28]:

```
song1_fft = song1_fft[:,0:(int)(samples_per_chunk/2)+1]
```

In [29]:

```
np.shape(np.apply_along_axis(np.mean, 0, song1_fft))
```

Out[29]:

```
(151,)
```

In [ ]:

```
```

In [30]:

```
np.shape(song1_fft[0])
```

Out[30]:

```
(151,)
```

In [31]:

```
song1_fft_mc = np.apply_along_axis(mean_center, 0, song1_fft)
```

In [32]:

```
song1_fft_mc_norm = np.apply_along_axis(mean_center, 0, song1_fft_mc )
```

In [33]:

```
song1_fft[1000:1002,0:10]
```

Out[33]:

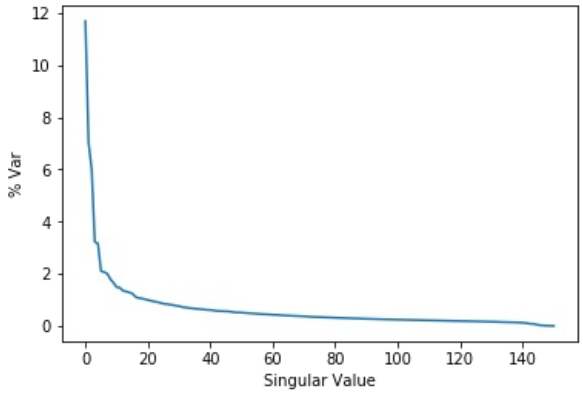
```
array([[ 2.60249719,  5.55299721, 14.24073188, 58.52945863, 44.67561485,
        16.69044402, 11.44465889, 19.65340455,  9.26986225,  9.67416591],
       [ 8.5659462 ,  8.93780402, 15.89725549, 59.76338357, 44.70495964,
        18.77857799, 13.57545113,  3.81930936,  4.27320044,  5.3479457 ]])
```

In [34]:

```
U,S,V = np.linalg.svd(song1_fft_mc_norm,full_matrices=True)
# Percent variance accounted for
```

In [35]:

```
plt.plot(100.0*S/np.sum(S))
plt.ylabel('% Var')
plt.xlabel('Singular Value')
plt.show()
```



In [54]:

```
# Variance accounted for in the first two principal components
100.0*(np.sum(S[:17]))/np.sum(S)
```

Out[54]:

```
50.01654263386964
```

In [43]:

```
X = song1_fft_mc_norm
Y = beatmap1_encoded

D = np.zeros([X.shape[0],X.shape[1]])
np.fill_diagonal(D,S)
Xrotated = np.dot(U,D)

PCs = Xrotated[:,0:150]
PCs.shape
```

Out[43]:

```
(4112, 150)
```

In [44]:

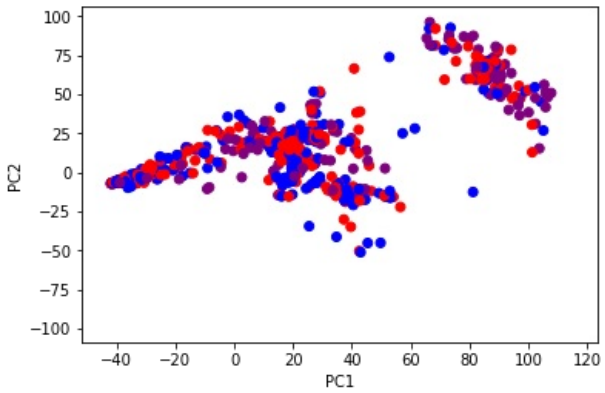
```
PCs
```

Out[44]:

```
array([[-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04],
       [-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04],
       [-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04],
       ...,
       [-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04],
       [-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04],
       [-4.35772953e+01, -8.14753949e+00, -4.03042799e+00, ...,
         6.61577237e-04,  9.66236688e-04, -6.04891118e-04]])
```

In [45]:

```
plt.scatter(PCs[:,0],PCs[:,1],
            color=[['none','red','blue','purple'][i] for i in Y.astype(int)])
plt.xlabel("PC1")
plt.ylabel("PC2")
plt.show()
```

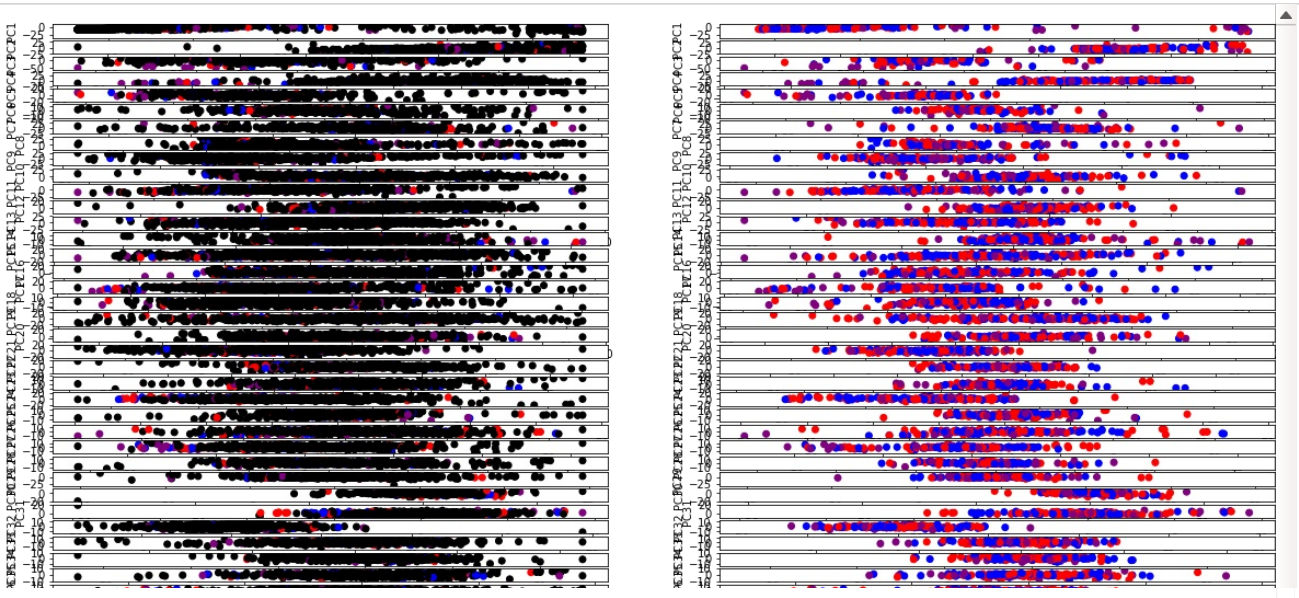


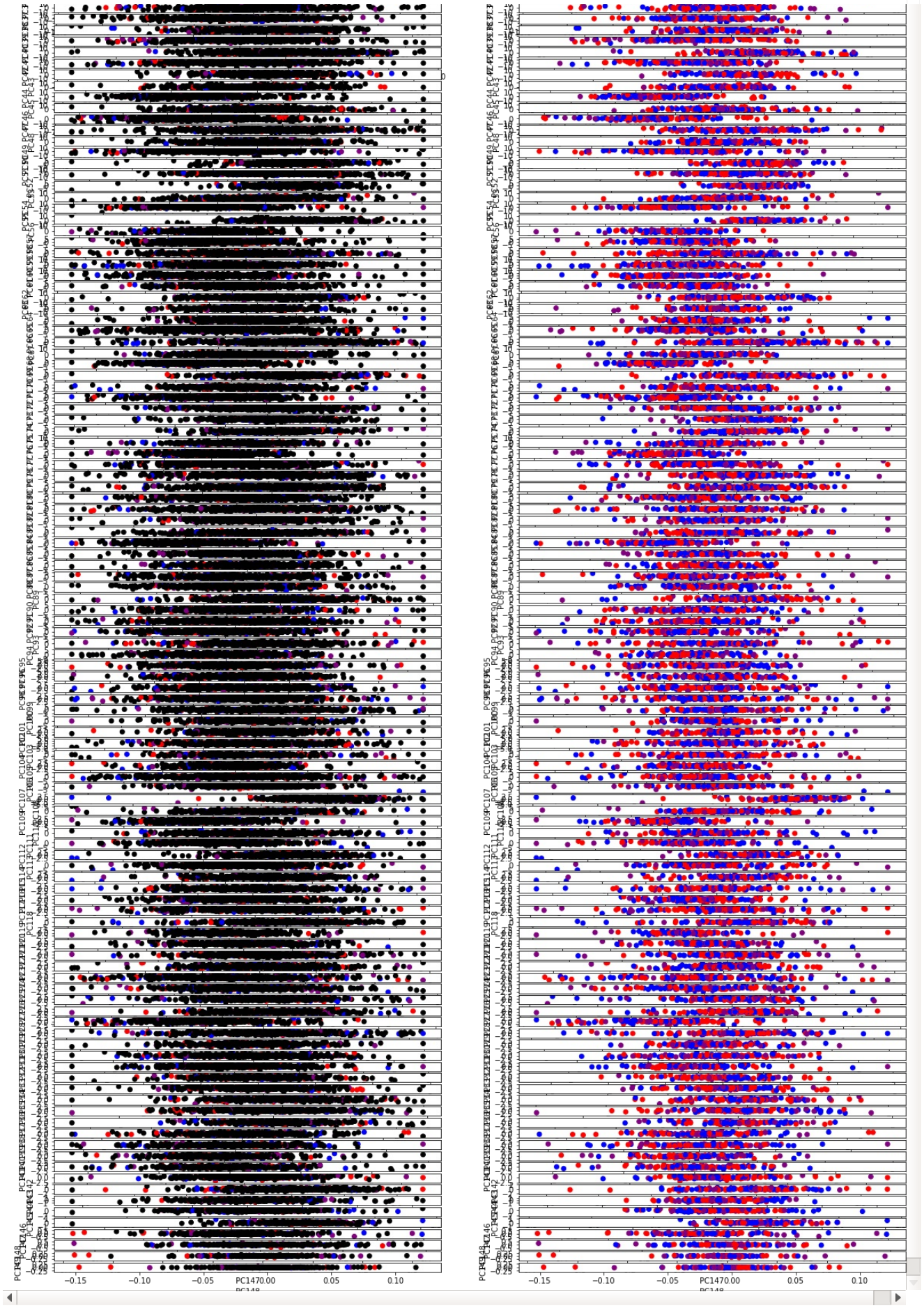
In [46]:

```
PCs_2_X = np.array([x for x in PCs if x[0] < 16 and x[1] < 6])
PCs_2_Y = np.array([Y[i] for i in range(len(Y)) if PCs[i,0] < 16 and PCs[i,1] < 6] )
```

In [47]:

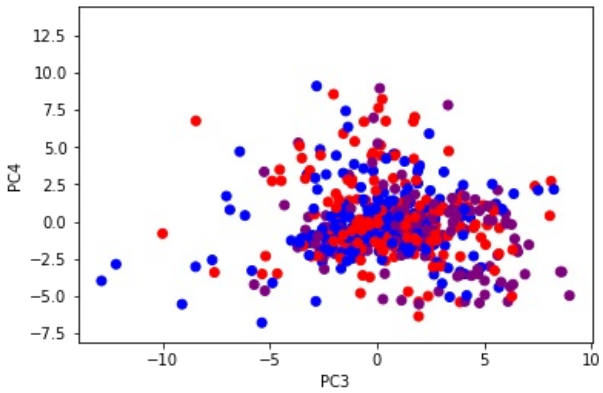
```
fig,axes = plt.subplots(149,2)
fig.set_figwidth(20)
fig.set_figheight(40)
for x in range(149):
    for y in range(2):
        start = x
        slice = (start, start+1)
        if y == 0:
            axes[x,y].scatter(PCs_2_X[:,slice[0]],PCs_2_X[:,slice[1]],
                    color=[['black','red','blue','purple'][i] for i in PCs_2_Y.astype(int)])
            axes[x,y].set_xlabel(str("PC"+str(slice[0])))
            axes[x,y].set_ylabel(str("PC"+str(slice[1])))
        else:
            axes[x,y].scatter(PCs_2_X[:,slice[0]],PCs_2_X[:,slice[1]],
                    color=[['none','red','blue','purple'][i] for i in PCs_2_Y.astype(int)])
            axes[x,y].set_xlabel(str("PC"+str(slice[0])))
            axes[x,y].set_ylabel(str("PC"+str(slice[1])))



plt.show()

#start = 5
#slice = (start, start+1)
#plt.scatter(PCs_2_X[:,slice[0]],PCs_2_X[:,slice[1]],
#            color=[['none','red','blue','purple'][i] for i in PCs_2_Y.astype(int)])
#plt.xlabel(str("PC"+str(slice[0])))
#plt.ylabel(str("PC"+str(slice[1])))
#plt.show()
```





In [340]:

```
plt.scatter(PCs[:,2],PCs[:,3],
            color=[['none','red','blue','purple'][i] for i in Y.astype(int)])
plt.xlabel("PC3")
plt.ylabel("PC4")
plt.show()
```



In [ ]:

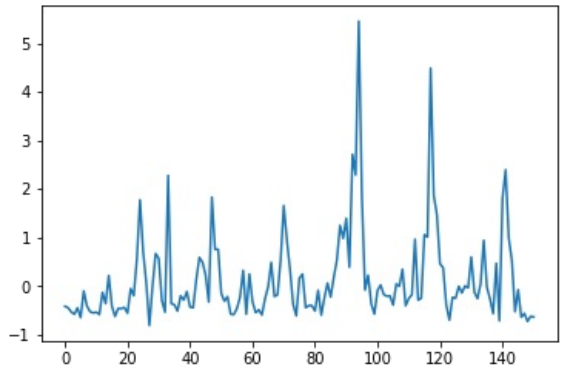
```

```

In [274]:

```
plt.plot( range(len(song1_fft_mc_norm[1000])) , song1_fft_mc_norm[2000] )
```

Out[274]:

```
[<matplotlib.lines.Line2D at 0x7fef3fe90f98>]
```

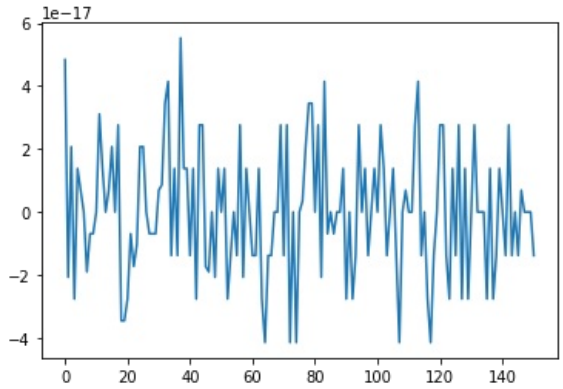


In [268]:

```
plt.plot( range(len(song1_fft_mc_norm[0])) , np.apply_along_axis(np.mean, 0, song1_fft_mc_norm) )
```

Out[268]:

```
[<matplotlib.lines.Line2D at 0x7fef3fed7748>]
```

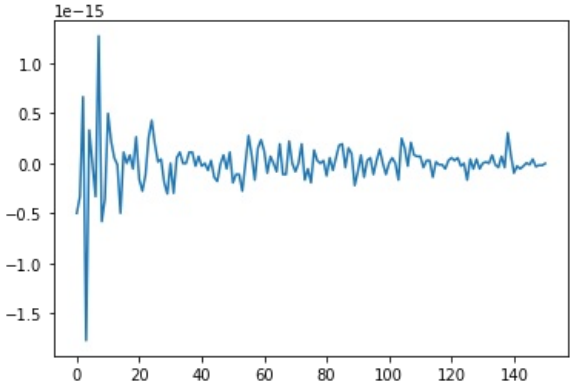


In [265]:

```
plt.plot( range(len(song1_fft_mc[0])) , np.apply_along_axis(np.mean, 0, song1_fft_mc) )
```

Out[265]:

```
[<matplotlib.lines.Line2D at 0x7fef3ff7c048>]
```

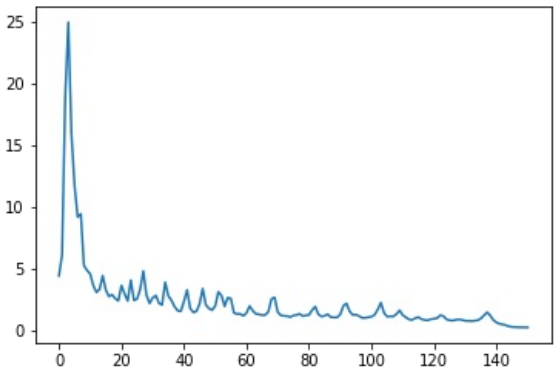


In [250]:

```
plt.plot( range(len(song1_fft[0])) , np.apply_along_axis(np.mean, 0, song1_fft) )
```

Out[250]:

```
[<matplotlib.lines.Line2D at 0x7fef401aff98>]
```



In [251]:

```
np.shape(song1_fft)
```

Out[251]:

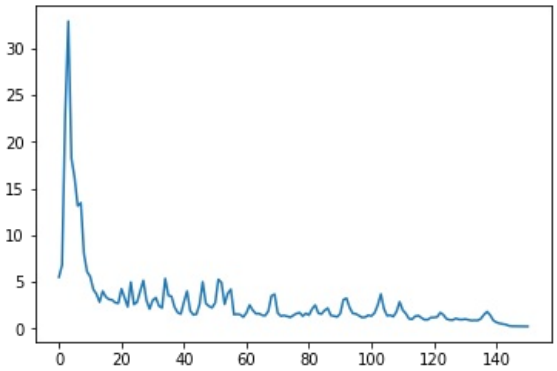
```
(4112, 151)
```

In [254]:

```
plt.plot(range(len(song1_fft[0])),np.apply_along_axis(np.std, 0, song1_fft))
```

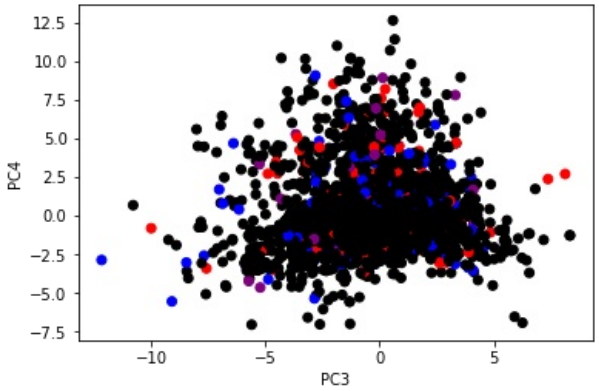
Out[254]:

```
[<matplotlib.lines.Line2D at 0x7fef4009c128>]
```



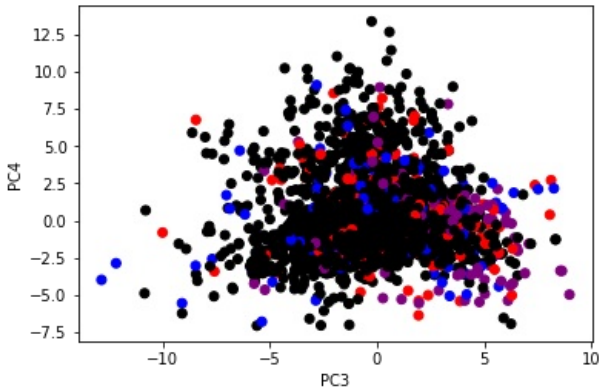
In [337]:

```
plt.scatter(PCs_3_4_X[:,2],PCs_3_4_X[:,3],
            color=[['black','red','blue','purple'][i] for i in PCs_3_4_Y.astype(int)])
plt.xlabel("PC3")
plt.ylabel("PC4")
plt.show()
```



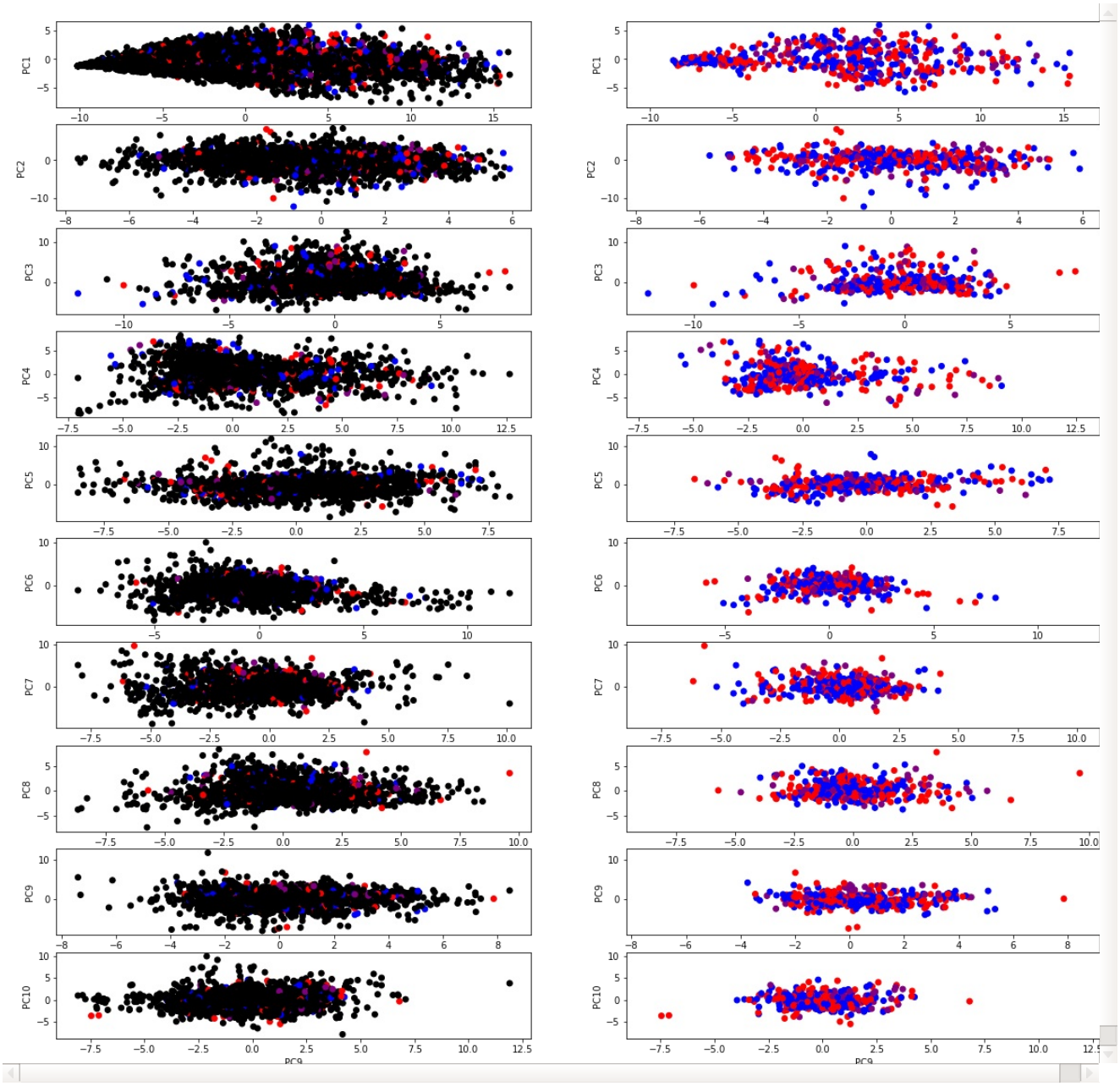
In [338]:

```
plt.scatter(PCs[:,2],PCs[:,3],
            color=[['black','red','blue','purple'][i] for i in Y.astype(int)])
plt.xlabel("PC3")
plt.ylabel("PC4")
plt.show()
```



In [367]:

```
fig,axes = plt.subplots(10,2)
fig.set_figwidth(20)
fig.set_figheight(20)
for x in range(10):
    for y in range(2):
        start = x
        slice = (start, start+1)
        if y == 0:
            axes[x,y].scatter(PCs_2_X[:,slice[0]],PCs_2_X[:,slice[1]],
                    color=[['black','red','blue','purple'][i] for i in PCs_2_Y.astype(int)])
            axes[x,y].set_xlabel(str("PC"+str(slice[0])))
            axes[x,y].set_ylabel(str("PC"+str(slice[1])))
        else:
            axes[x,y].scatter(PCs_2_X[:,slice[0]],PCs_2_X[:,slice[1]],
                    color=[['none','red','blue','purple'][i] for i in PCs_2_Y.astype(int)])
            axes[x,y].set_xlabel(str("PC"+str(slice[0])))
            axes[x,y].set_ylabel(str("PC"+str(slice[1])))



plt.show()
```



In [ ]:

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