20402024_Neuron_Responses_assignment

March 6, 2016

In [156]:
```
get_ipython().magic('matplotlib inline')
import pandas;
import matplotlib;
import matplotlib.pyplot as plt
import scipy.io;
import numpy as np
from matplotlib.pylab import rcParams
import math
from scipy import signal
from scipy.fftpack import fft, fftshift
import scipy.stats
from scipy.ndimage import filters

from scipy.stats import norm
from sklearn.neighbors import KernelDensity

rcParams['figure.figsize'] = 10, 10
rcParams['figure.dpi'] = 300;
rcParams['lines.linewidth'] = 2.2;
plt.style.use('ggplot')
# get_ipython().magic('pdb')
```

In [117]:
```
plt.style.available
```

Out[117]:
```
['seaborn-whitegrid',
 'seaborn-bright',
 'seaborn-deep',
 'seaborn-ticks',
 'dark_background',
 'ggplot',
 'seaborn-dark-palette',
 'seaborn-white',
 'seaborn-dark',
 'bmh',
 'seaborn-talk',
 'fivethirtyeight',
 'seaborn-paper',
 'seaborn-poster',
 'seaborn-muted',
 'seaborn-pastel',
 'seaborn-colorblind',
 'seaborn-darkgrid',
 'classic',
```

```
            'grayscale',
            'seaborn-notebook']
```

```
In [14]: def synthetic_neuron(drive):
             """
             Simulates a mock neuron with a time step of 1ms.
             Arguments:
             drive - input to the neuron (expect zero mean; SD=1)
             Returns:
             rho - response function (0=non-spike and 1=spike at each time step)
             """
             dt = .001
             T = dt*len(drive)
             time = np.arange(0, T, dt)
             lagSteps = .02/dt
             drive = np.concatenate((np.zeros(lagSteps), drive[lagSteps:]))
             system = scipy.signal.lti([1], [.03**2, 2*.03, 1])
             _, L, _ = scipy.signal.lsim(system, drive[:,np.newaxis], time)
             rate = np.divide(30, 1 + np.exp(50*(.05-L)))
             spikeProb = rate*dt
             return np.random.rand(len(spikeProb)) < spikeProb

         def gaussian(x, mu, var):
             return np.exp(-np.power(x-mu, 2.)/(2*var))

         def plot_spike_raster(trial, spikeTimes, ax):
             rep_trials = np.repeat(trial, np.size(spikeTimes))
             sizes = np.ones(len(spikeTimes))*60;
             ax.axhline(y=trial, linewidth=0.3);
             ax.scatter(spikeTimes, np.array([rep_trials]), marker='|', alpha=0.9,
                        color='black', s=sizes);

         def plot_psth(spikeTimes, num_bins, ax2, **kwargs):
             counts = ax2.hist(spikeTimes, bins = num_bins, **kwargs);
             hist1, bin1 = np.histogram(spikeTimes, bins=num_bins)
             bincens = 0.5*(bin1[1:] + bin1[:-1])
             ax2.plot(bincens, hist1, alpha=0.8);
             return counts;

         def set_axis_range(series, func):
             minmax = scipy.stats.describe(series).minmax;
             func([math.floor(minmax[0]-minmax[0]/5), math.ceil(minmax[1]+minmax[1]/5)])
```

0.1 1a

Load the synthetic data file MT direction tuning. The file contains two variables: "direction" is a list of stimulus directions for 200 trials.

```
In [3]: tuning_data = scipy.io.loadmat('MT direction tuning.mat');
```

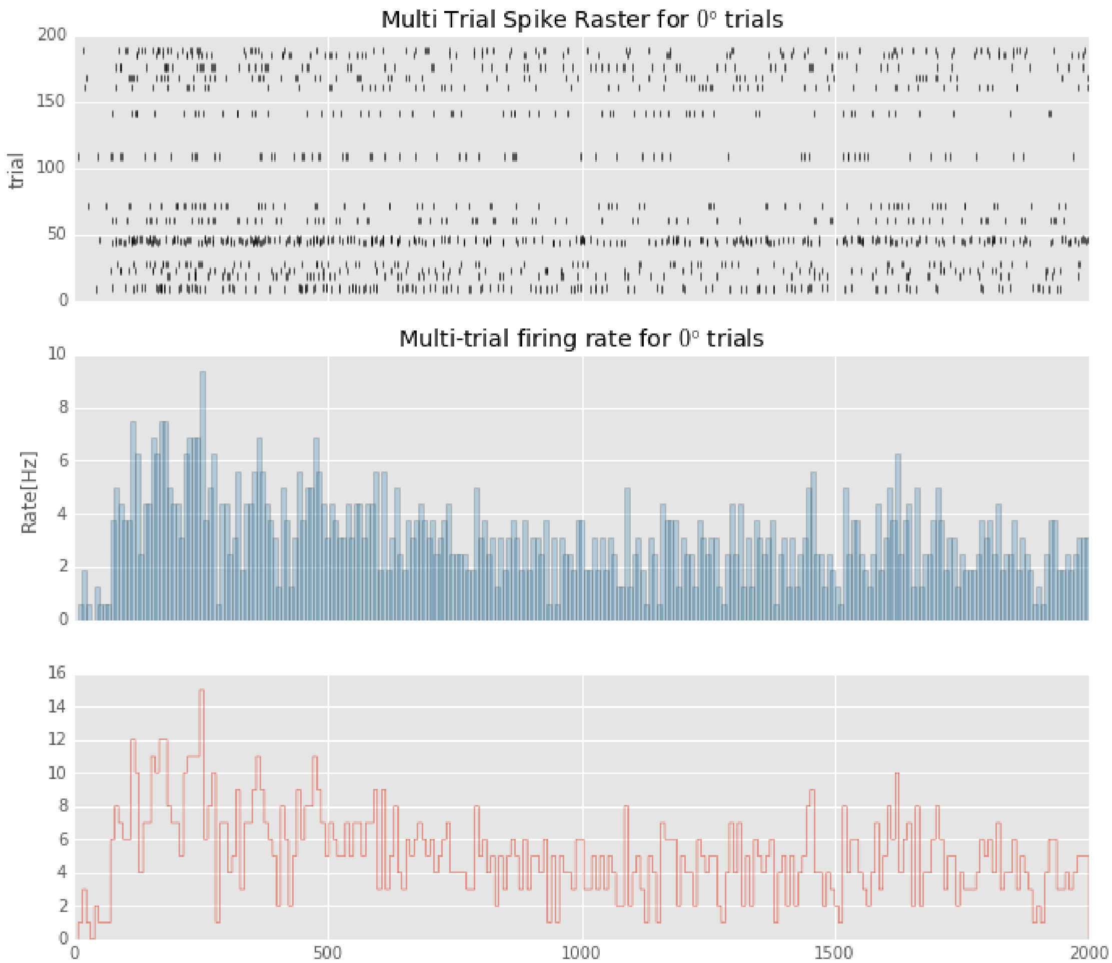
```
In [4]: sptimes = 1000*tuning_data['spikeTimes'][0];
        directions = tuning_data['direction'];
        # print(directions.shape, sptimes.shape)
        num_rows = np.array([x.shape[1] for x in sptimes]).sum();
        df_cols = ['trial','direction', 'timestamp'];
```

```
sp_tr_list = [];
for j in range(0, directions.shape[1]):
    sp_tr = sptimes[j].T;
    direcn = directions[:, j];
    for k in range(0, sp_tr.shape[0]):
        sp = sp_tr[k,:];
        dict1 = {'trial': j+1, 'direction': direcn.tolist()[0],
                 'timestamp': sp.tolist()[0]};
        sp_tr_list.append(dict1);
df = pandas.DataFrame(sp_tr_list, index=np.arange(0, num_rows), columns = df_cols);
```

0.2 1b

Plot the spike raster and multi trial firing rate (5ms bins) for 0° trials. Trial length is 2s.

```
In [180]: zrdf = df[df.direction==0]; zrdf.shape
          f, ax = plt.subplots(3,1, sharex=True)
          # f.tight_layout();
          ax[0].set_xlim([0,2000])
          ax[0].set_ylim([0,200])
          ax[0].set_title('Multi Trial Spike Raster for $0\degree$ trials')

          dt = 8; #5ms sampling
          num_bins = 2000/dt; #5 ms bins
          t_plot = np.arange(0, 2005, dt)
          zrdf.plot.scatter(ax=ax[0], x='timestamp', y='trial', marker='|', alpha=0.8,
                            s=np.ones(len(zrdf))*20, linewidth=.8, color='k');


          counts, binedges = np.histogram(zrdf['timestamp'], bins=int(num_bins));
          # print(counts)
          counts = counts/(200*(dt/1000));
          center = (binedges[:-1] + binedges[1:]) / 2;
          ax[1].set_title('Multi-trial firing rate for $0\degree$ trials')
          ax[1].bar(center, counts, align='center', width=dt*1.2, edgecolor='black', alpha=0.3);
          ax[1].set_ylabel('Rate[Hz]')

          zrdf.timestamp.hist(ax=ax[2], bins=num_bins, histtype='step')

Out[180]: <matplotlib.axes._subplots.AxesSubplot at 0x1d0831860>
```




```
In [152]: width
```

```
Out[152]: 3.4860000000000002
```

Use Gaussian window functions to generate single trial rate estimates

0.3 1c

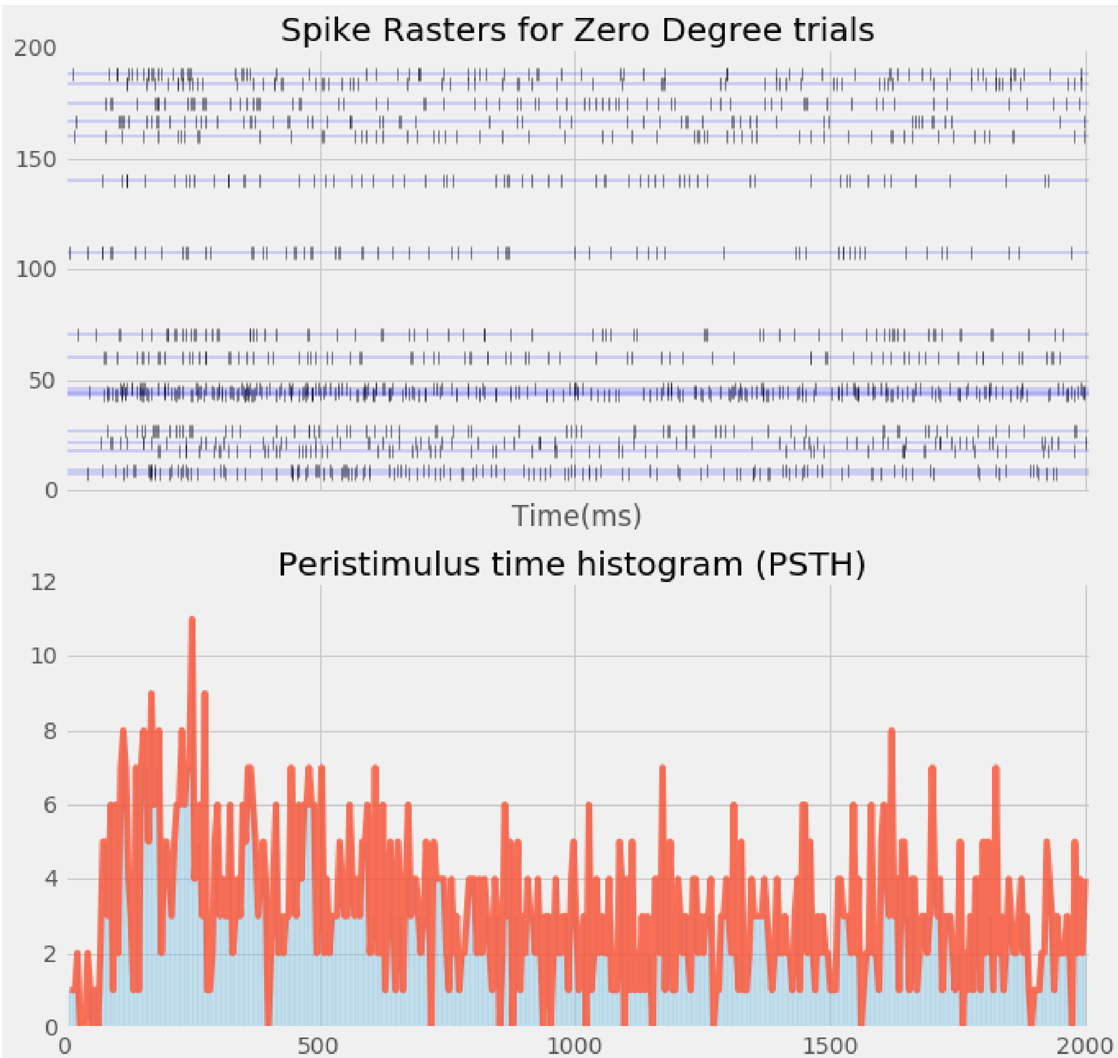
Plot together the single trial rate estimate for trial 9 using a Gaussian kernels with SD=5ms and SD=50ms. (Use an appropriate sampling period of your choice for which the rate fluctuations are not visibly distorted in the plot.)

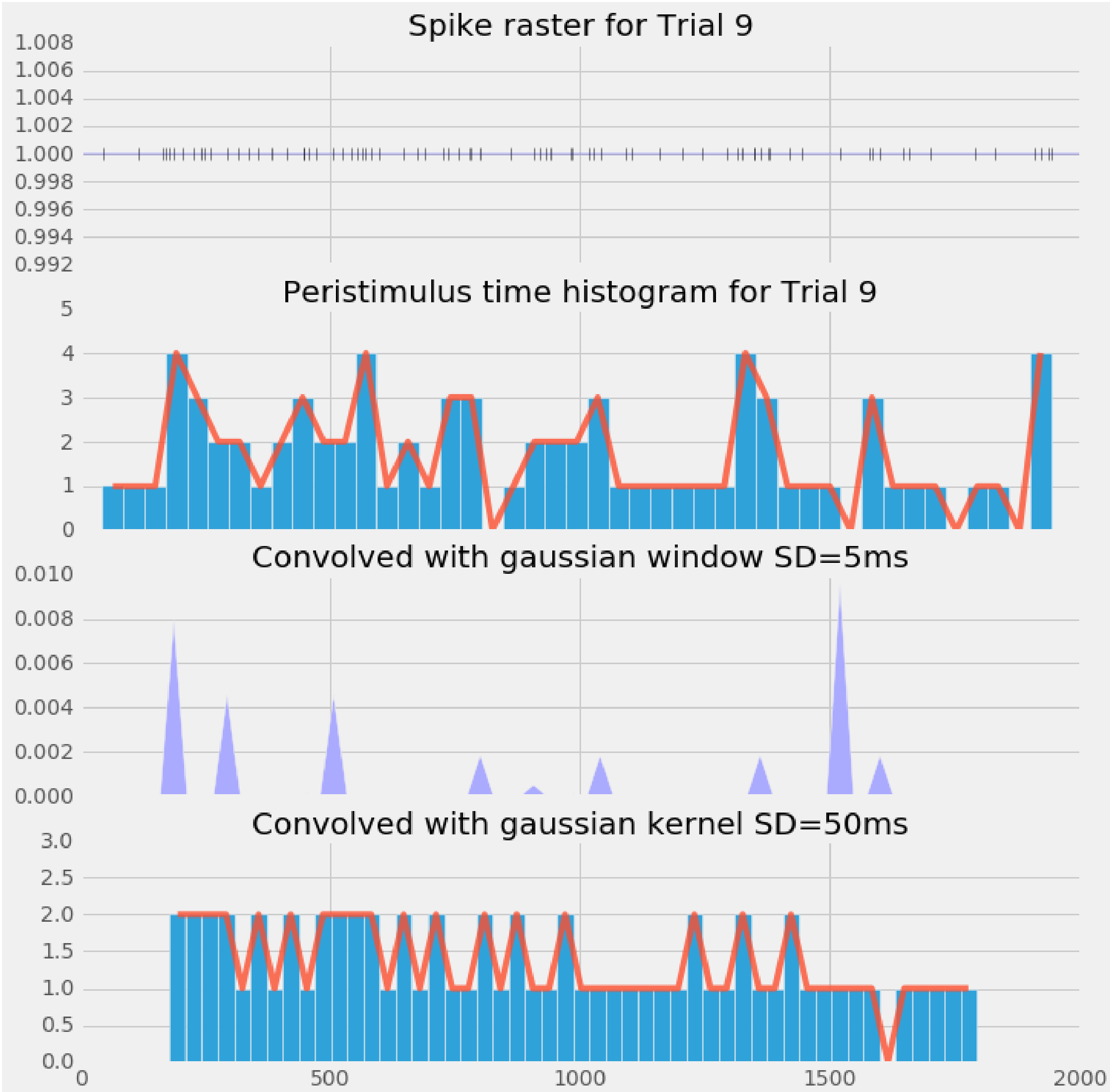
```
In [131]: zero_deg_trial_indices = np.where(directions==0)[1];
          zer_deg_trial_spike_times = sptimes[zero_deg_trial_indices];
          fig, (ax, ax2) = plt.subplots(2, 1, sharex=True);

          # fig.tight_layout();
          # ax.grid('on');
          for trial, spikeTimes in zip(zero_deg_trial_indices, zer_deg_trial_spike_times):
              plot_spike_raster(trial, spikeTimes, ax);
```

```
ax.set_xlim([-0.05,2010])
ax.set_ylim([-1, 200])
ax.set_title("Spike Rasters for Zero Degree trials")
ax.set_xlabel('Time(ms)')
all_spikes = np.array(zer_deg_trial_spike_times[0])
for i in range(1, len(zer_deg_trial_spike_times)):
    all_spikes = np.concatenate((all_spikes, zer_deg_trial_spike_times[i]), axis=1);

pp = plot_psth(all_spikes[0], num_bins, ax2, alpha=0.3)
ax2.set_title('Peristimulus time histogram (PSTH) ')
# ax2.set_xlabel

num_bins = 45;
# trial_nine = zer_deg_trial_spike_times[zero_deg_trial_indices[1]].tolist()[0]
trial_nine = sptimes[8][0];

std_dev1 = 5;
std_dev2 = 50;
len_gauss = 10;

window1 = scipy.signal.gaussian(len_gauss, std=std_dev1, sym=True)
window1 /= window1.sum()
# window1 = KernelDensity(kernel='gaussian', bandwidth=0.75).fit(trial_nin)

window2 = scipy.signal.gaussian(len_gauss, std=std_dev2, sym=True)
window2 /= window2.sum()



# import pdb; pdb.set_trace();
smoothed = np.convolve(trial_nine, window1, 'valid');

kde = KernelDensity(kernel='gaussian', bandwidth=0.55).fit(trial_nine[:, np.newaxis])
x_plot = np.linspace(0,2000,num=len(trial_nine))[:, np.newaxis]
smoothed = np.exp(kde.score_samples(x_plot));

smoothed2 = np.convolve(trial_nine, window2, 'valid');
# smoothed = smoothed[(len_gauss/2-1):-(len_gauss/2)]
# smoothed2 = smoothed2[(len_gauss/2-1):-(len_gauss/2)]

print(scipy.stats.describe(trial_nine).mean, scipy.stats.describe(trial_nine).minmax, len(tria
print(scipy.stats.describe(smoothed).mean, scipy.stats.describe(smoothed).minmax, smoothed.sha
print(scipy.stats.describe(smoothed2).mean, scipy.stats.describe(smoothed2).minmax, smoothed2

f, (ax2,ax3,ax4,ax5) = plt.subplots(4,1, sharex=True);
f.tight_layout()

plot_spike_raster(1, trial_nine, ax2);
ax2.set_title('Spike raster for Trial 9');


pp = plot_psth(trial_nine, num_bins, ax3); cnts3 = pp[0]; bins3 = pp[1];
ax3.set_title('Peristimulus time histogram for Trial 9');
set_axis_range(cnts3, ax3.set_ylim)
```

```python
ax3.set_ylabel('')

num_bins += 5;
# pp = plot_psth(smoothed, num_bins, ax4, alpha=0.4); cnts4 = pp[0]; bins4 = pp[1];
ax4.fill(x_plot[:, 0], smoothed, fc='#AAAAFF')
ax4.set_title('Convolved with gaussian window SD=5ms');
# set_axis_range(cnts4, ax4.set_ylim)

pp = plot_psth(smoothed2, num_bins, ax5); cnts5 = pp[0]; bins5=pp[1];
ax5.set_title('Convolved with gaussian kernel SD=50ms')
set_axis_range(cnts5, ax5.set_ylim);
```

```
902.815789474 (44.0, 1942.0) 76
0.000456479258072 (0.0, 0.0095440736938141781) (76,)
888.708304414 (178.52026427446697, 1793.3190725004847) (67,)
```






```
In [101]: xx = zrdf['timestamp'].tolist();
          print(len(xx)); print(all_spikes[0].shape)
```

```
1275
(1275,)
```