Coding

Balazs B Ujfalussy

2/10/2017

This is a demo for illustrating the Poisson firing of visual cortical neurons in response to grating stimuli. The data is from Ecker et al., *Decorrelated Neuronal Firing in Cortical Microcircuits*, Science, 327, 584 (2010). http://bethgelab.org/datasets/v1gratings/

The RData file contains a list containing 8 preselected cells (>1 Hz firing rates, clear spikes) from a single experiment in given day. The fields of the list contain the following:

date date and time stamp when the session was recorded subject identifies the monkey used in the session conditions specifies the orientation and contrast used, selected for > 0.05 contamination contamination of the single units tetrode specifies the tetrode a single unit was recorded on; for tetrode grid layout, see supplementary material of Ecker et al. (2010) spikes contains binned spikes single units x conditions x time bins x repetitions times times aligned to bin centers

The experimental data is loaded from the `Data/Ecker/` folder - data_v1_binned_static_ses2.RData. First we load the data and see what it contains using the summary command:

```
load("Data/Ecker/data_v1_binned_static_ses2.RData")
summary(data)
```

```
##               Length Class  Mode
## date               1 -none- character
## subject            1 -none- character
## conditions        32 -none- list
## contamination      8 -none- numeric
## tetrode            8 -none- numeric
## spikes        276480 -none- numeric
## times             90 -none- numeric
```

The spikes field contains an array with the spikes recorded: cells x conditions x time bins x repetitions.

```
print(dim(data$spikes))
```

```
## [1]  8 16 90 24
```

We have 8 cells, 16 conditons, 90 time points and 24 repetitions. To see the different conditions we need to look the field conditions:

```
print(data$conditions)
```

```
##             [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## contrast    1    10   1    10   1    10   1    10   1    10    1     10
## orientation 0    0    22.5 22.5 45   45   67.5 67.5 90   90    112.5 112.5
##             [,13] [,14] [,15] [,16]
## contrast    1     10    1     10
## orientation 135   135   157.5 157.5
```

The are two variables for condition: orientation and contrast. We have 8 orientations and 2 contrast levels. Now we will plot the average response of the cells to the different stimuli.

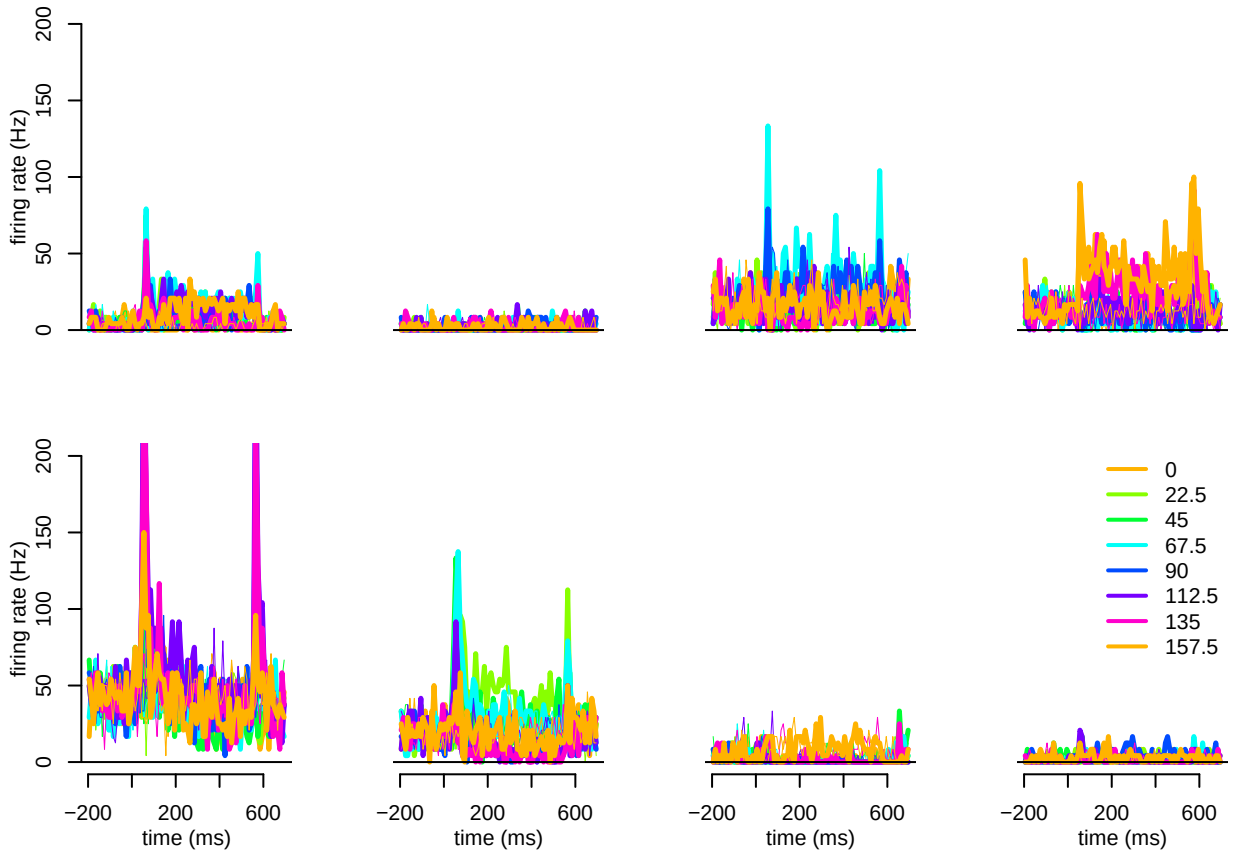
First, we extract contrast and orientation variables for plotting.

```
oris <- unlist(data$condition['orientation',])
contrasts <- unlist(data$condition['contrast',])
range.contrasts <- range(contrasts)
scaled.contrasts <- (contrasts - min(contrasts)) / (max(contrasts)-min(contrasts)) * 2 + 1/2
```

Next, we extract the firing rate - approximated as the average spike count - for each time point:

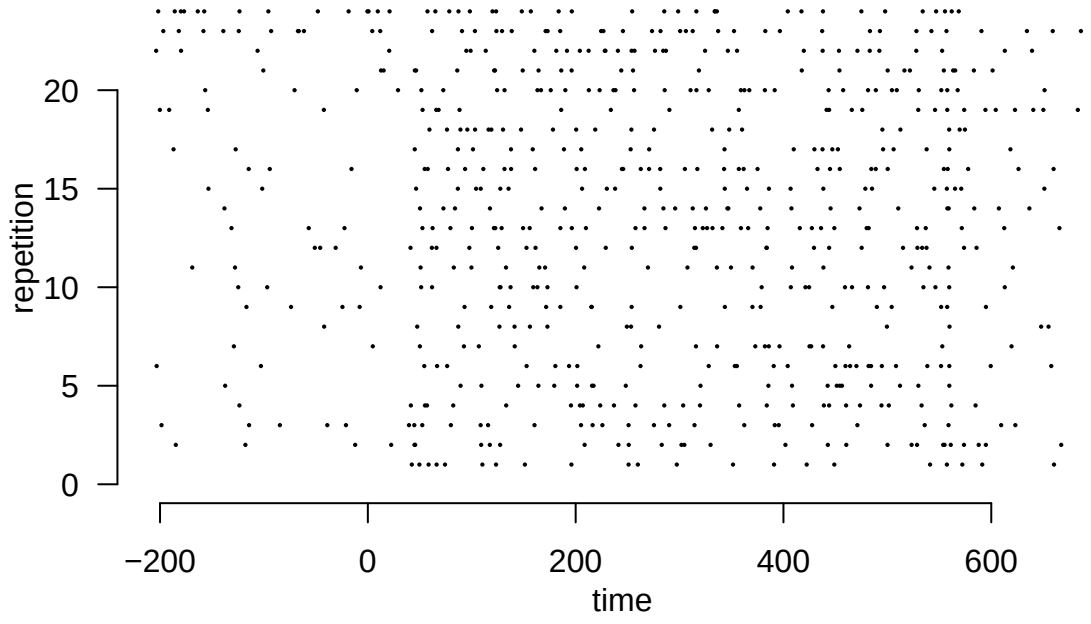
```
n.cells <- dim(data$spikes)[1] # number of cells
n.conditions <- dim(data$spikes)[2] # number of conditions
L <- dim(data$spikes)[3] # length of recordings
par(mfcol=c(2,4)); par(mar=c(3,3,1,1)) # plotting subfigures
for (i.cell in 1:n.cells){
    rates <- matrix(0, L, n.conditions) # this is going to be the rate matrix for the cells
    for (i.condition in 1:n.conditions){
        sp <- data$spikes[i.cell,i.condition,,]
        rates[,i.condition] <- apply(sp, 1, mean)*100 # Hz
    }
    matplot(data$times, rates, t="l", col=rainbow(180)[oris], lty=1, lwd=scaled.contrasts, axes=F, ylim=
    abline(h=0)
    if ((i.cell %% 2) == 0){
      axis(1); mtext('time (ms)', 1, 2, cex=0.7)
    }
    if (i.cell < 3){
      axis(2); mtext('firing rate (Hz)', 2, 2, cex=0.7)
    }
    # readline(i.cell)
}

legend('topright', leg=unique(oris), col=rainbow(180)[unique(oris)], lwd=2, lty=1, bty='n')
```



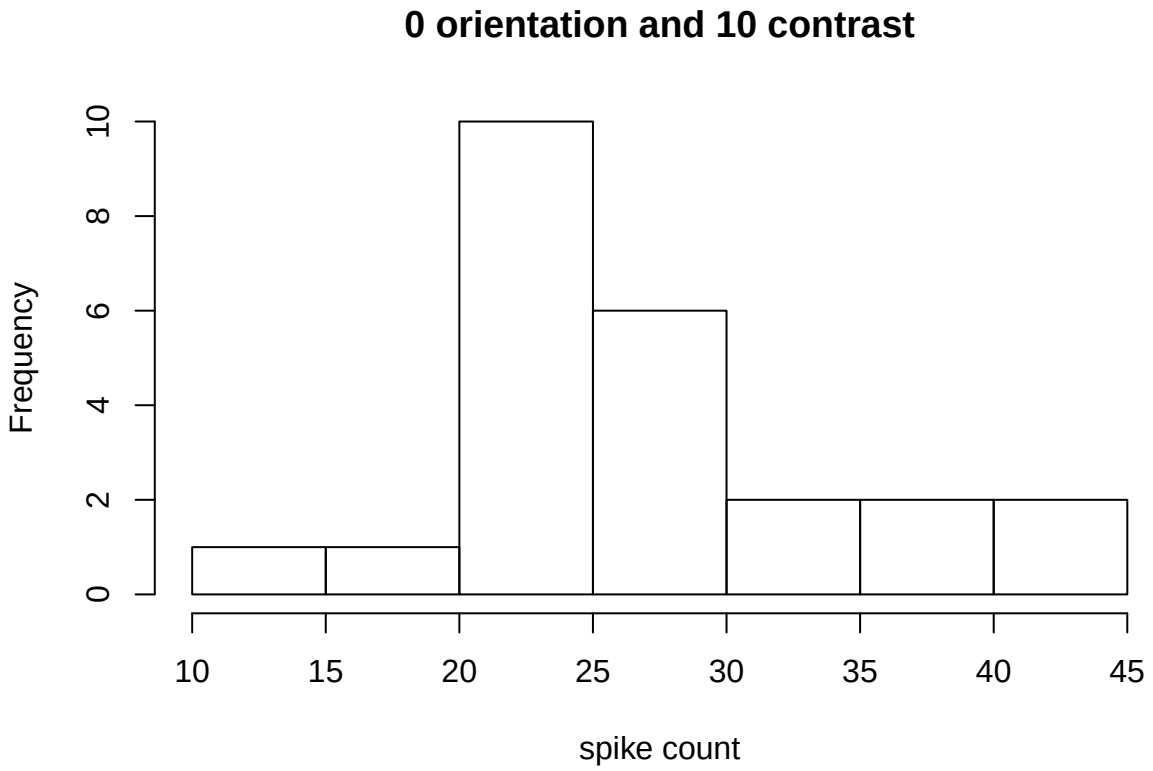
Now I select cell 7 which seems as an active cell showing stimulus-dependent responses. I will plot its activity - spike train - in each trial separately. I first plot the second condition, which is 0 degrees orientation and 10 contrast:

```
source("Data/Ecker/plot_raster.R")
cell <- data$spikes[7,,]
plot.raster(cell[2,], data$times)
```



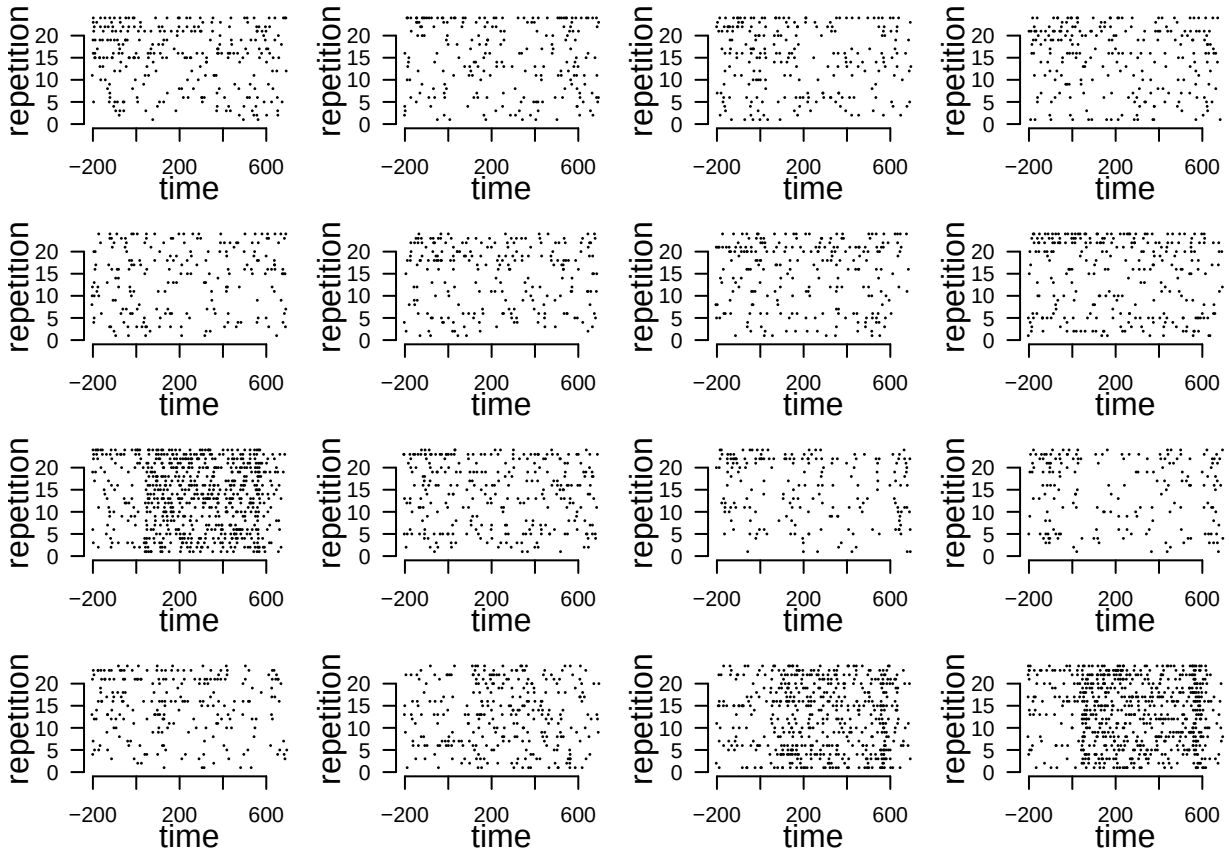
What you need to observe here is that spiking is variable - the number of spikes in any given trial is different, and varies between 14 and 42. Note, that the stimulus is identical in each of these trials! Also note, that there is activity before and after the stimulus is on!

```
hist(colSums(cell[2,,]), xlab='spike count', main='0 orientation and 10 contrast')
```



Now let's see the response to all different conditions - 8 orientations at different 2 contrast levels. First two rows are the low contrast, below are the high contrast stimuli:

```
par(mfrow=c(4,4)); par(mar=c(3,3,1,1))
for (i in seq(1, 15, by=2)){
  plot.raster(cell[i,,], data$times)
}
for (i in seq(2, 16, by=2)){
  plot.raster(cell[i,,], data$times)
}
```



Homework

Estimate the amount of variability in each of the 16 different conditions. Calculate the mean spike count, the variance and the Fano factor (https://en.wikipedia.org/wiki/Fano_factor). You need the following functions to do it: apply(), mean(), var(). Is the variability you observe consistent with Poisson firing? If not, why not? What if you focus on a short period (200 ms) before or after the stimulus onset?