Gaussian Mean Time Series Filter

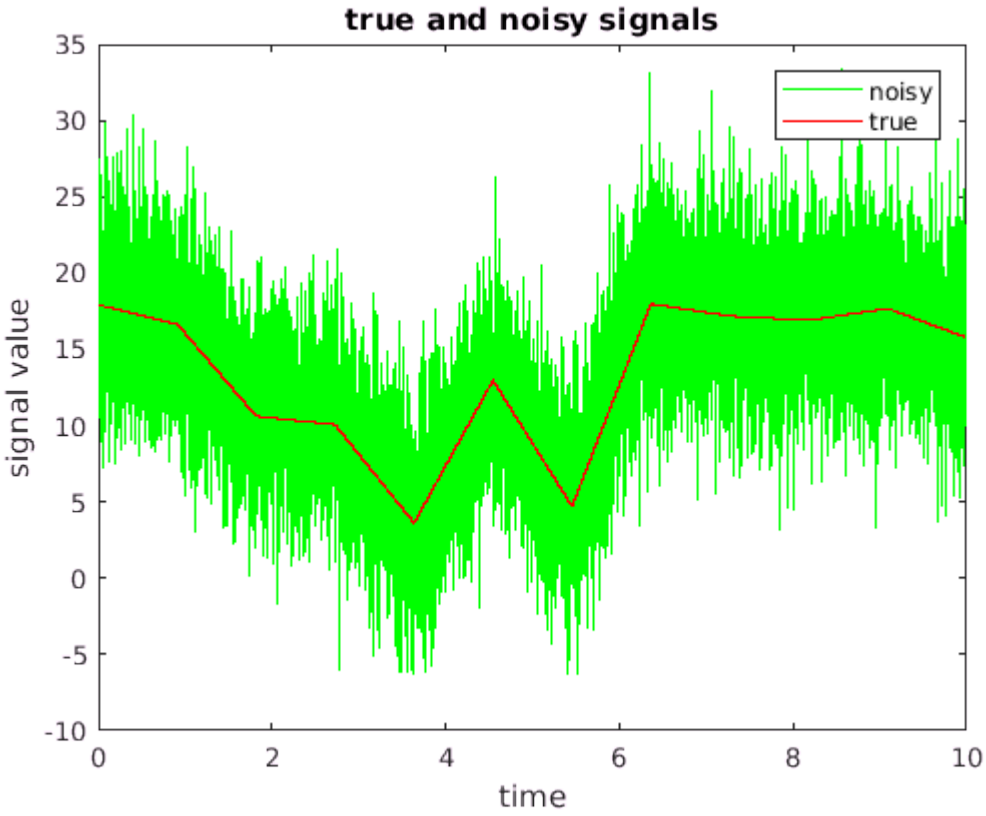
- y(t) = sum(x(i)*g(i)) i=t-k to t+k
- g(i) normalizes y(i)
- g = e^((-4ln(2)*t^2)/w^2) *different formulation! allows for full width at half maximum to be specified.
- smoother filter than running mean filter

create signal

```
freq = 1000; %hz
t    = 0:(1/freq):10; %10 second sample
n    = length(t);
p    = 12; %for interpolation

noise = 4;
sigc  = interp1(rand(p,1)*24, linspace(1,p,n));
noise = noise * randn(size(t));
sign  = sigc + noise; %noisy signal
```

plot the signals

```
noisy = plot(t, sign, 'g');
hold on;
true = plot(t, sigc, 'r-');
hold off;
title("true and noisy signals");
xlabel("time");
ylabel("signal value");
legend([noisy,true], ["noisy", "true"]);
```



create the gaussian filter

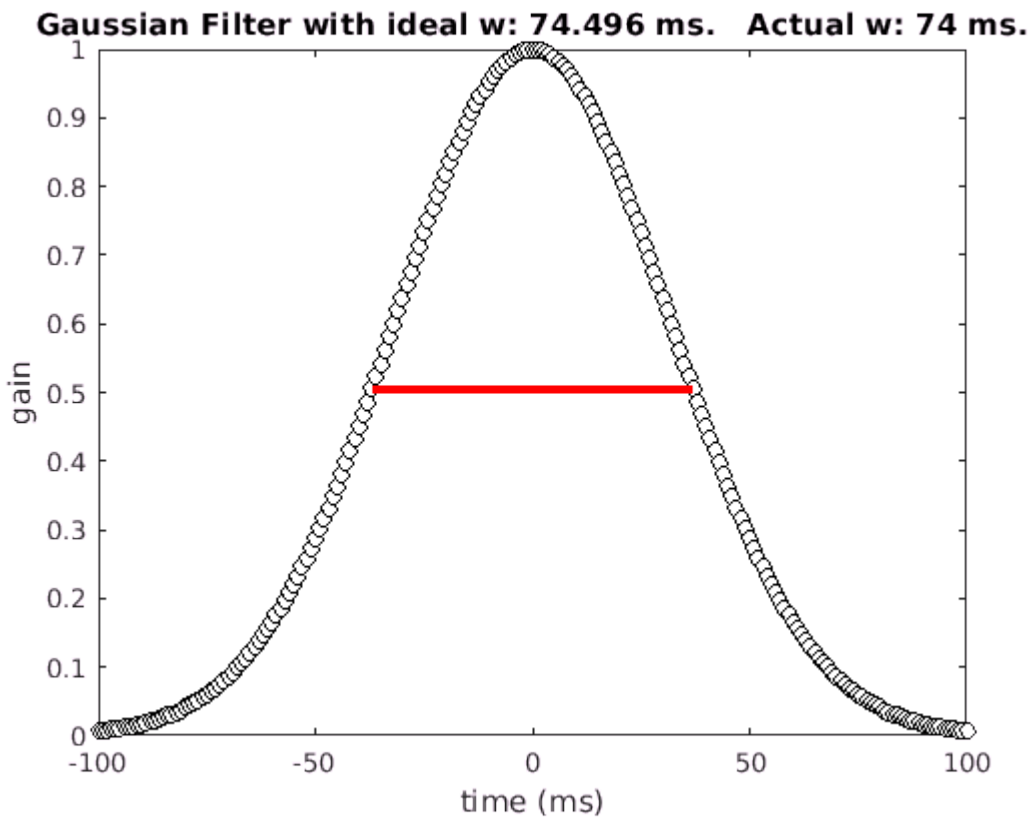
- lower bound for k ensures gaussian approaches 0, upper bound prevents edge effects
- try different values to find a suitable number
- w determines the filter size (higher w, more smoothing)

```
w = 74.49602; %window size in ms
k = 100; %ms, 1/2 range for gaussian to approach 0 (try values between 10 and 100 to see)
gt = 1000*(-k:k)/freq; %time vector by indices

gw = exp(-(4*log(2)*gt.^2)/w^2); %gaussian window

p0 = k+dsearchn(gw(k+1:end)',.5); %find the w line
p1 = dsearchn(gw(1:k)', .5);

w_emp = gt(p0) - gt(p1); %actual w based on sampling
```

Display the gaussian filter

```
figure(1);
plot(gt, gw, 'ko-', 'markerfacecolor', 'w', 'linew',1);
hold on;
plot(gt([p0 p1]), gw([p0 p1]), 'r', 'linew', 3);
hold off;
gw = gw/sum(gw); %normalize to sample size
title(['Gaussian Filter with ideal w: ' num2str(w) ' ms.   Actual w: ' num2str(w_emp) ' ms.'])
xlabel("time (ms)");
```

```
ylabel("gain");
```

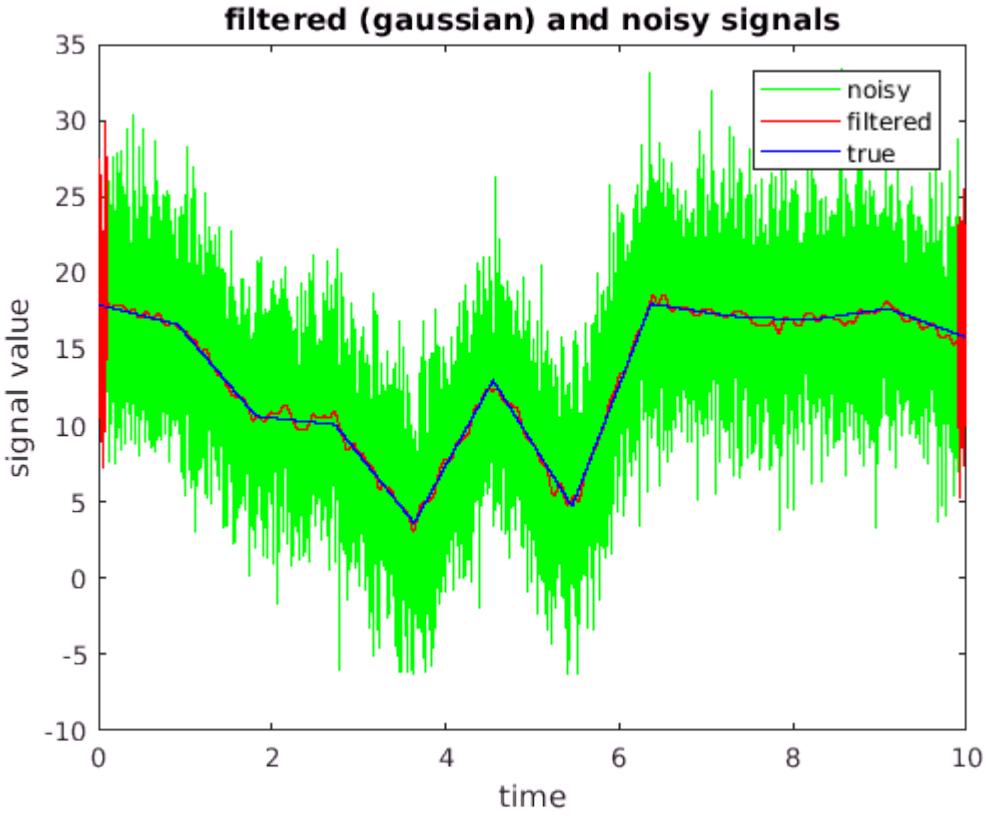


Implement the gaussian filter

```
filtered = sign;

for i = k+1:n-k-1
    filtered(i) = sum(sign(i-k:i+k).*gw);
end
```

Plot the filtered signal

```
figure(2);
noisy = plot(t, sign, 'g');
hold on;
filtered = plot(t, filtered, 'r-');
true = plot(t, sigc, 'b-');
hold off;
title("filtered (gaussian) and noisy signals");
xlabel("time");
ylabel("signal value");
legend([noisy,filtered,true], ["noisy", "filtered", "true"]);
```



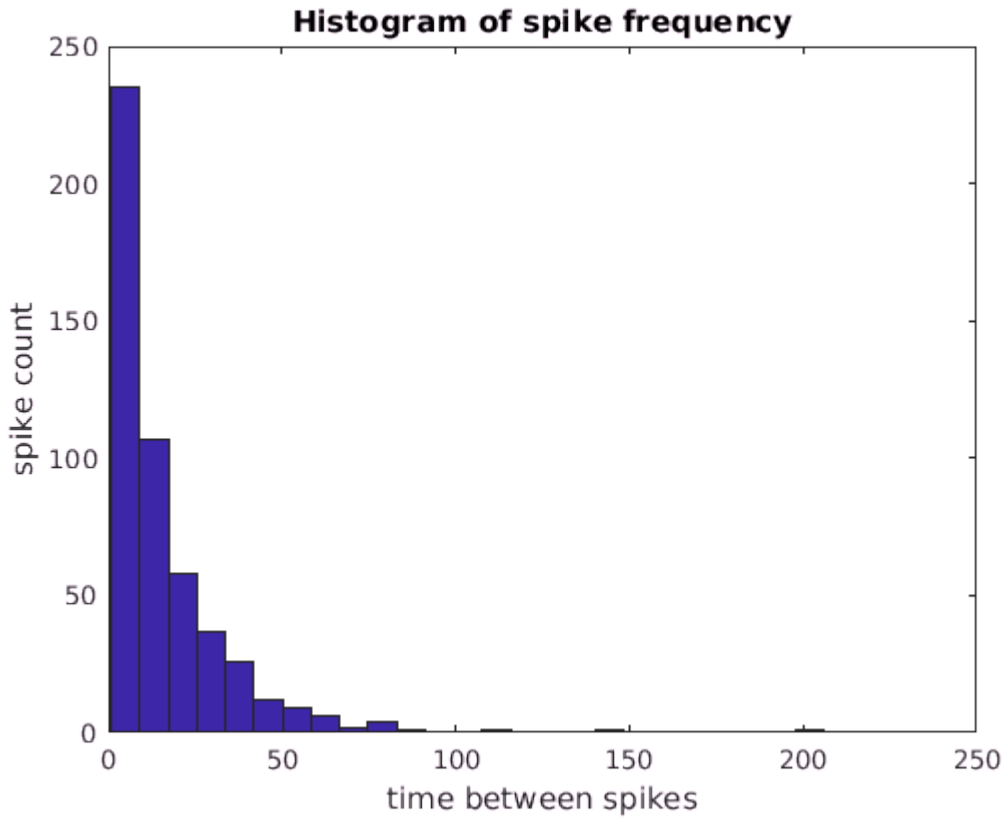
Smooth a spike time series

- generate a time series of random spikes

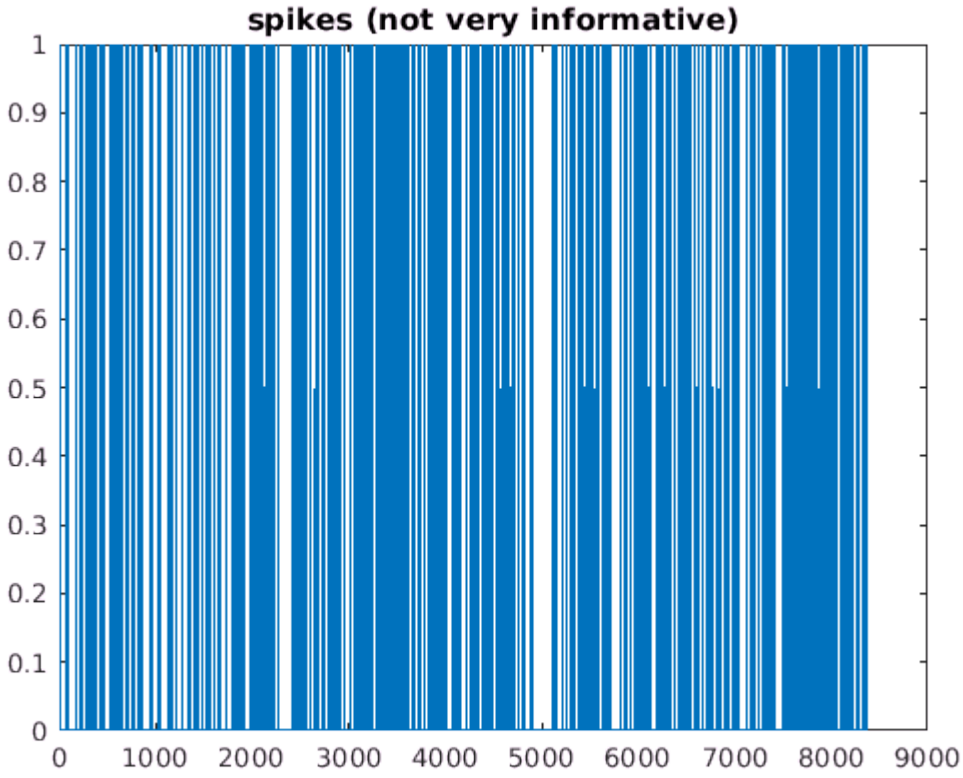
```
n = 500; % number of spikes
spike_interval = round(exp(randn(n,1))*10); %exponential distibution

spikes = 0;
for i = 1:n
    spikes(length(spikes) + spike_interval(i)) = 1;
end
```

- View the spike data

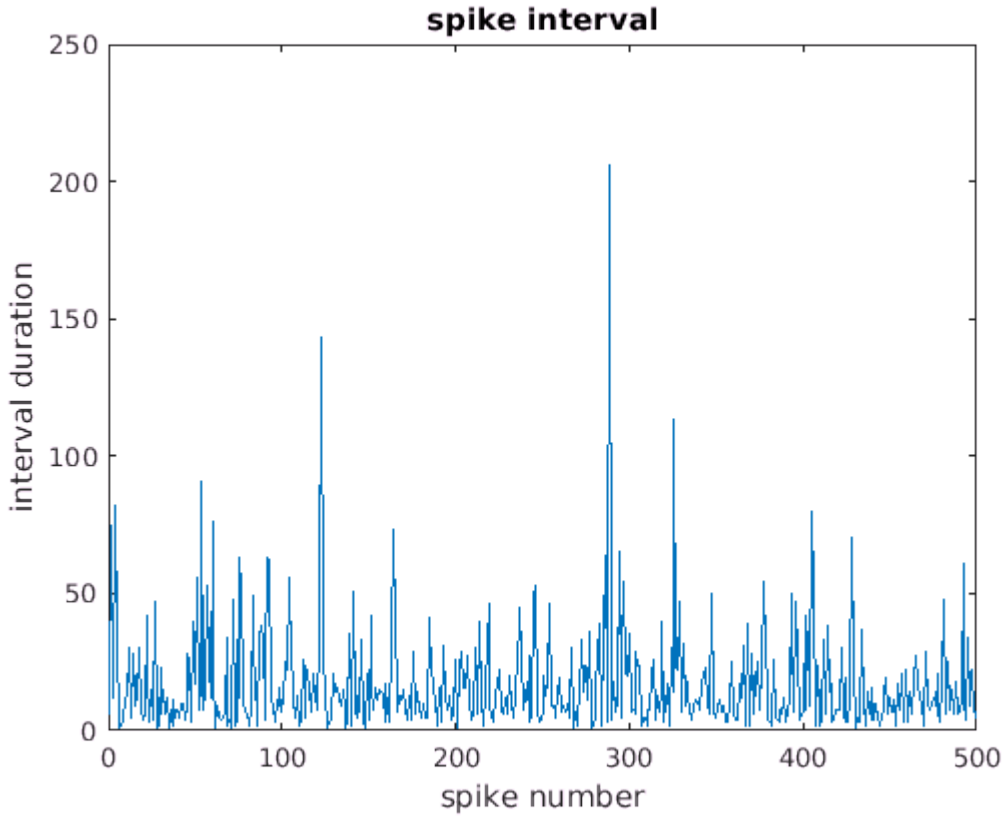
```
figure(3);
hist(spike_interval, 25);
title("Histogram of spike frequency");
xlabel("time between spikes");
ylabel("spike count");
```




```
figure(4);
plot(spikes);
title("spikes (not very informative)");
```




```
figure(5);
plot(spike_interval);
title("spike interval");
xlabel("spike number");
ylabel("interval duration");
```

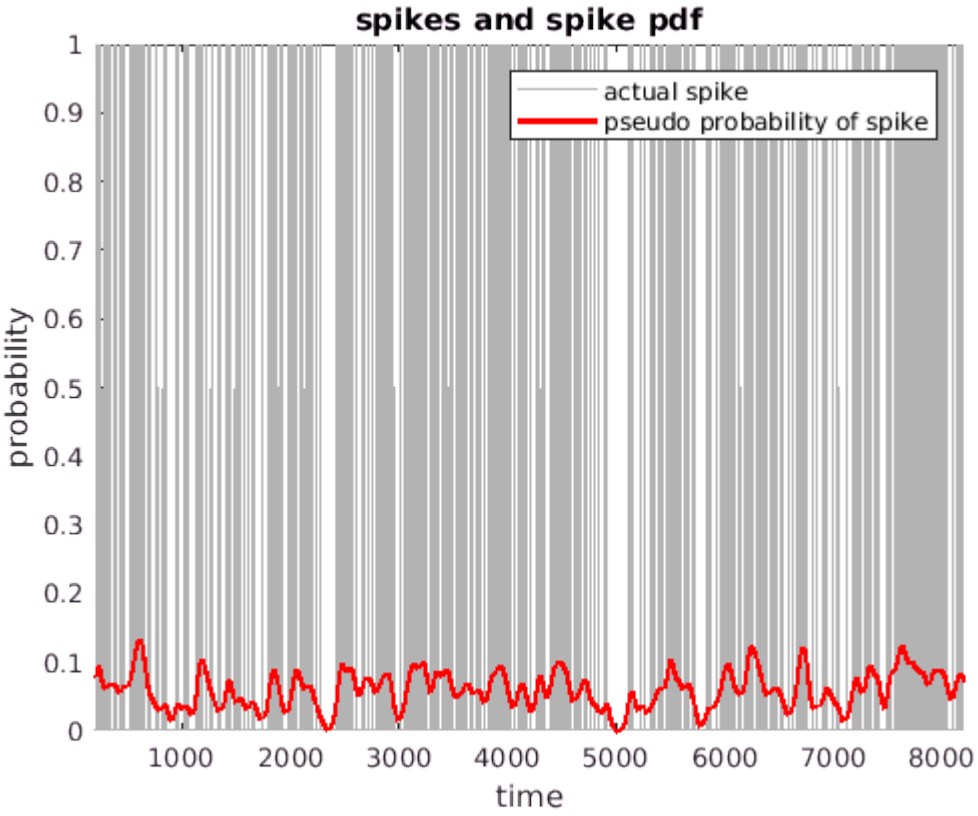


- Apply the filter

```
filtered_spikes = spikes;
for i = k+1:length(spikes)-k-1
    filtered_spikes(i) = sum(spikes(i-k:i+k).*gw);
end
```

- visualize the filtered spikes

```
figure(6);
spk = plot(spikes, 'Color', [.7, .7, .7]);
hold on;
flt = plot(filtered_spikes, 'r', 'linew', 2);
hold off;
title("spikes and spike pdf");
xlabel("time");
xlim([200 8200])
ylabel("probability");
legend([spk,flt], ["actual spike", "pseudo probability of spike"]);
```


spikes and spike pdf
actual spike
pseudo probability of spike
probability
time
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1000
2000
3000
4000
5000
6000
7000
8000