

# Gaussian Mean Time Series Filter

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

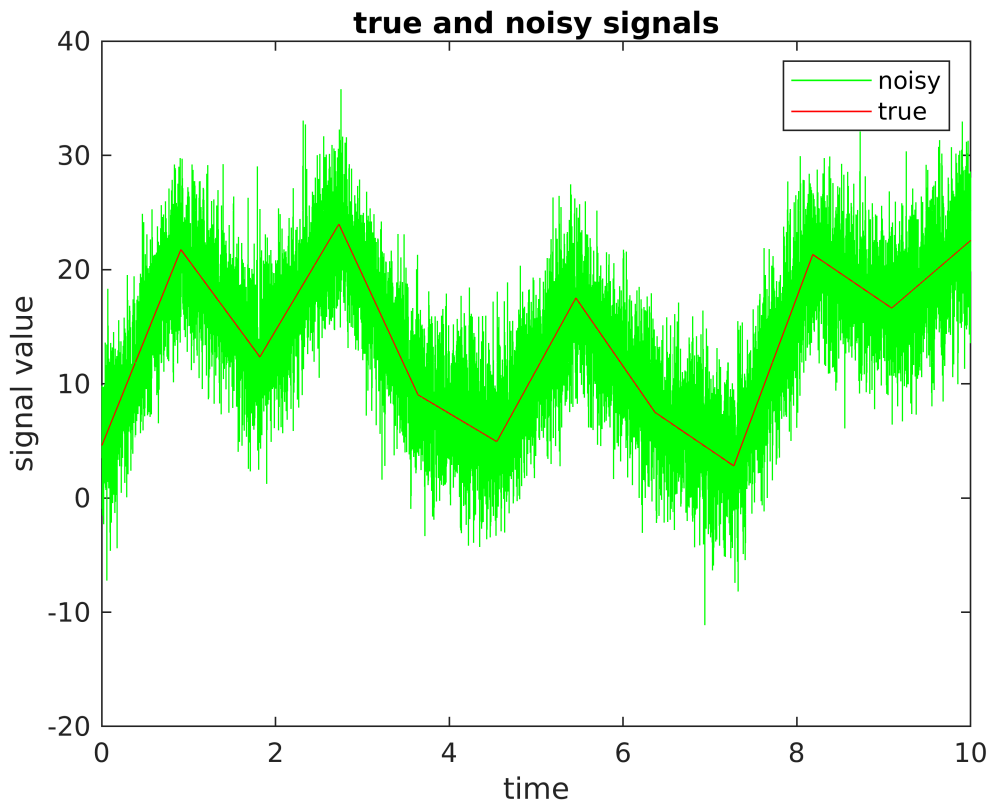
## create signal

```
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 = 50.49602; %window size in ms
k = 70; %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
```

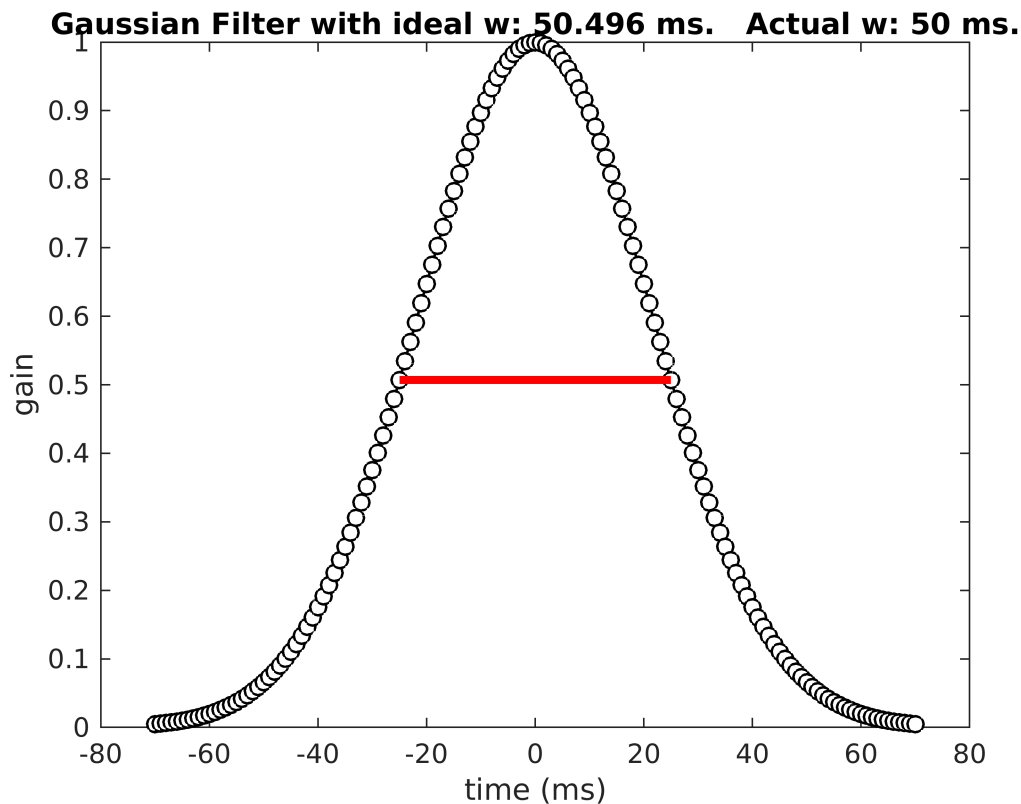
## Display the gaussian filter

```
figure(1);
plot(gt, gw, 'ko-', 'markerfacecolor', 'w', 'linewidth',1);
hold on;
plot(gt([p0 p1]), gw([p0 p1]), 'r', 'linewidth', 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)
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

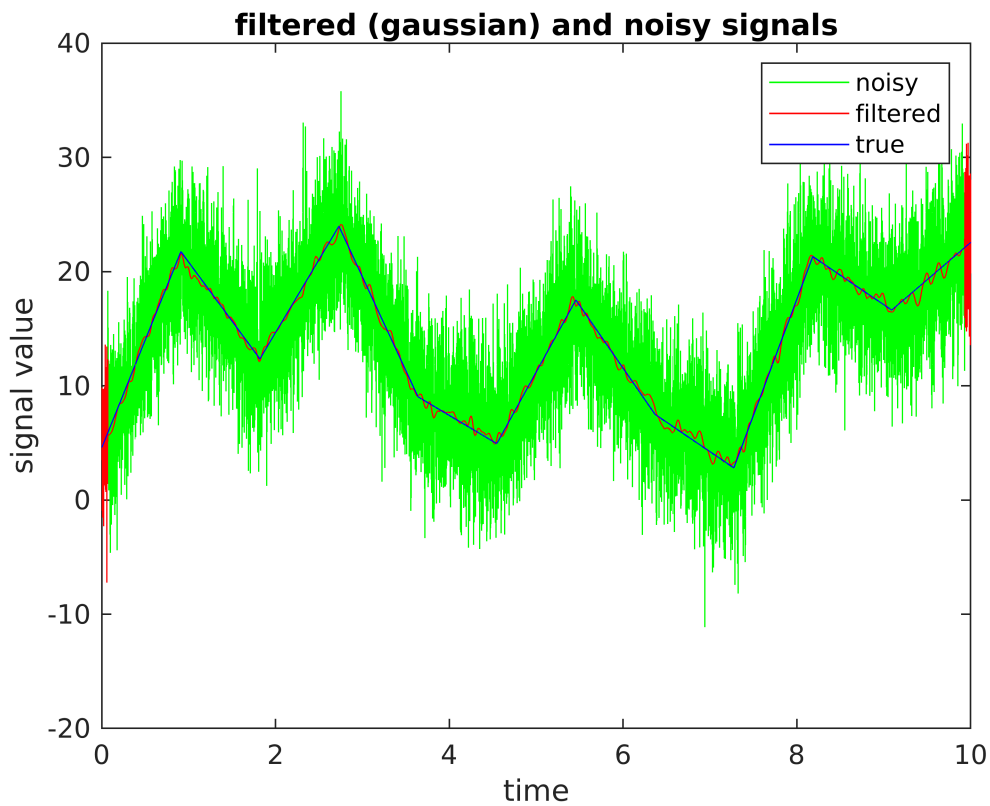
```

## 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

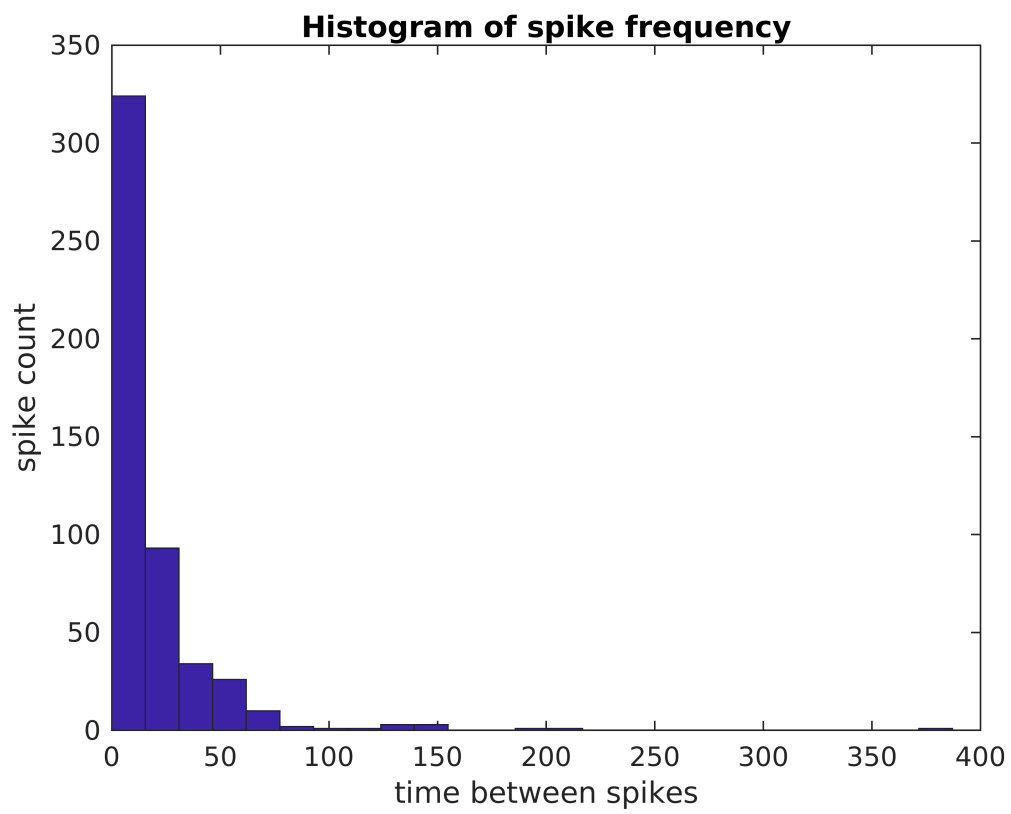
- generate a time series of random spikes

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

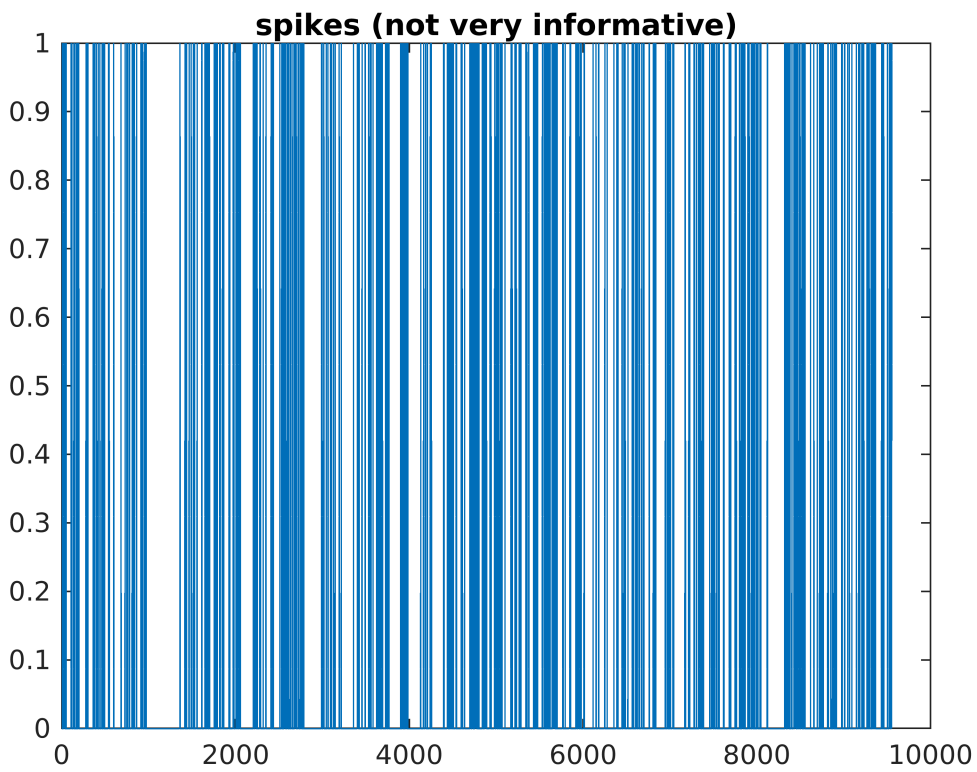
spikes = 0;
for i = 1:n
    spikes(length(spikes) + spike_interval(i)) = 1;
end
```

- View the spike data

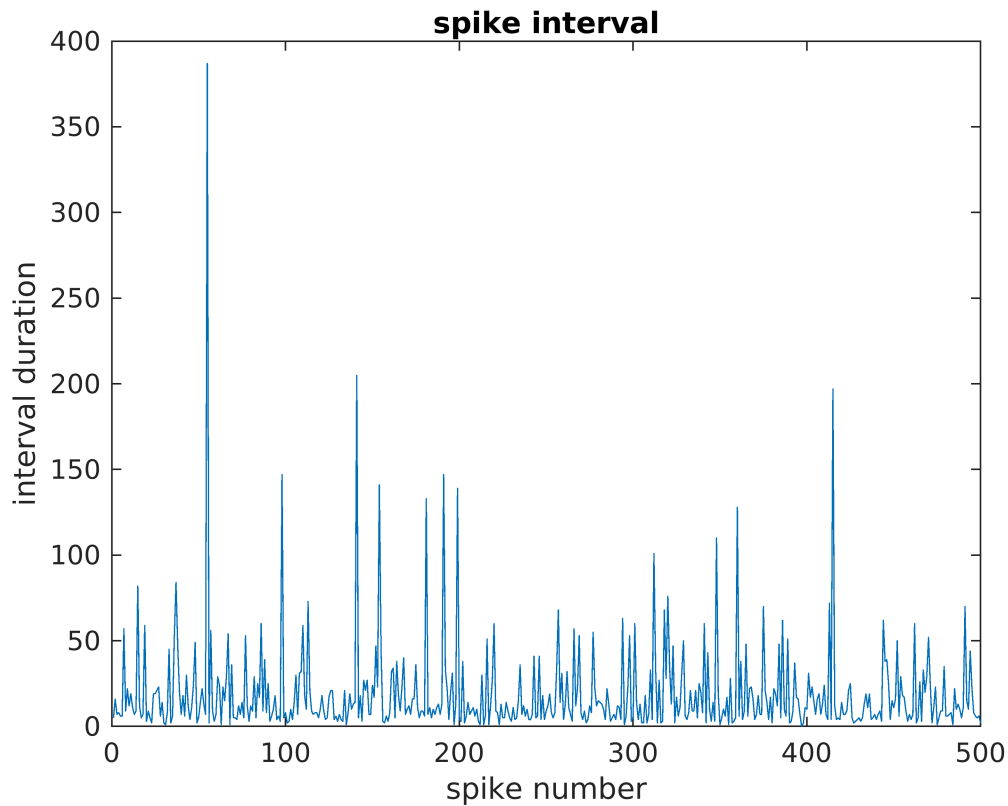
```
figure(3);
hist(spike_interval, 25);
title("Histogram of spike frequency");
xlabel("time between spikes");
ylabel("spike count");
```



```
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', 'linewidth', 2);
hold off;
title("spikes and spike pdf");
xlabel("time");
xlim([100 9500]);
ylabel("probability");
legend([spk,flt], ["actual spike", "probability of spike"]);
```

