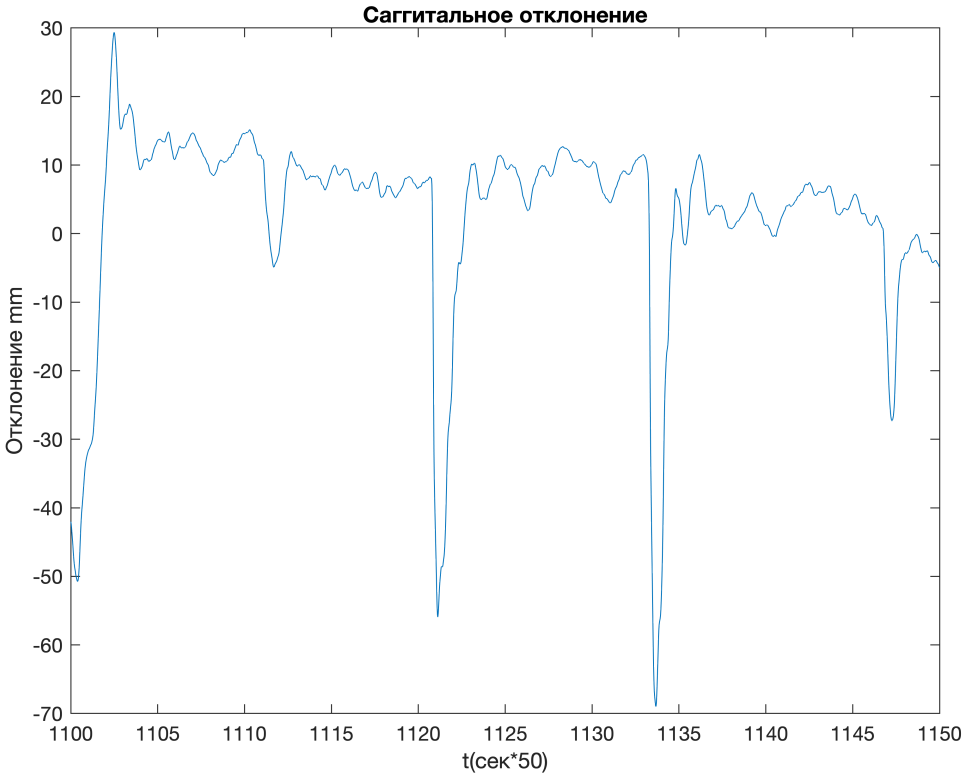
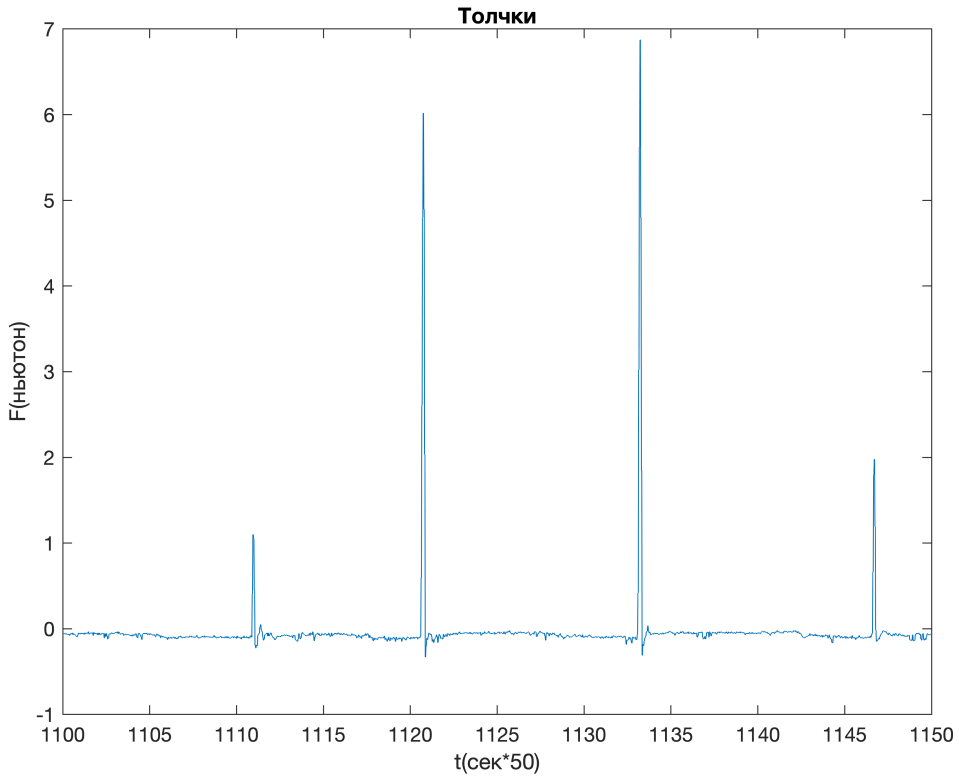
Data localization

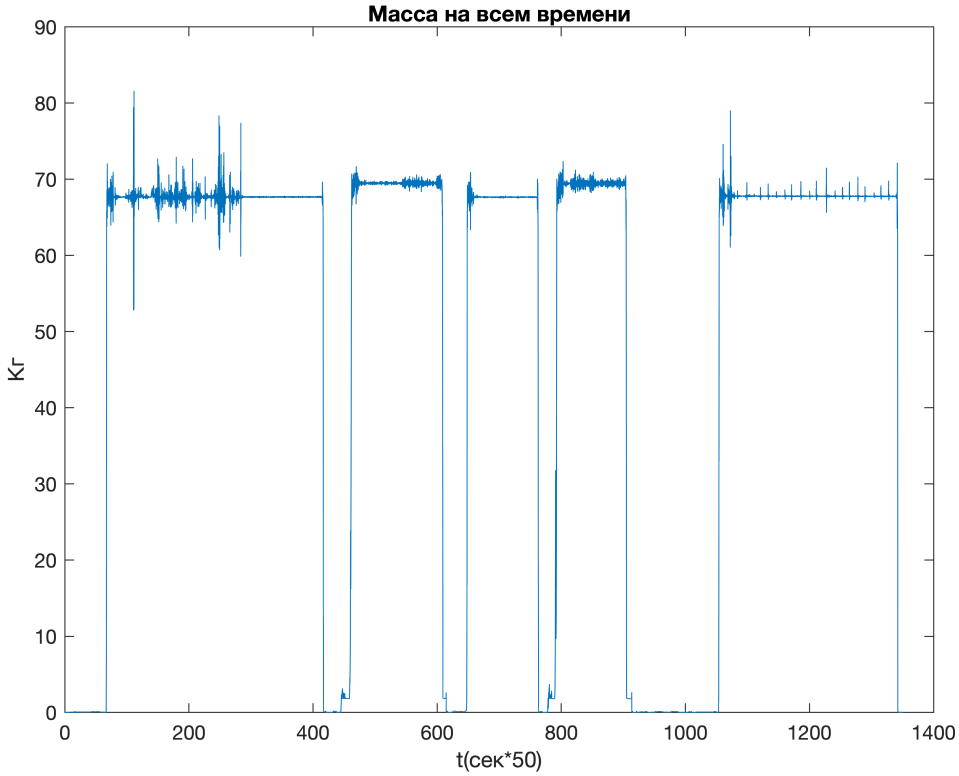
```
fur=@furiermy;

ymy1=load('R1_my');
Y_my=ymy1(:,2);


plot(0.02:0.02:length(Y_my)/50,Y_my');
title("Саггитальное отклонение");xlabel('t(сек*50)');ylabel("Отклонение mm")
xlim([1100 1150]);
```



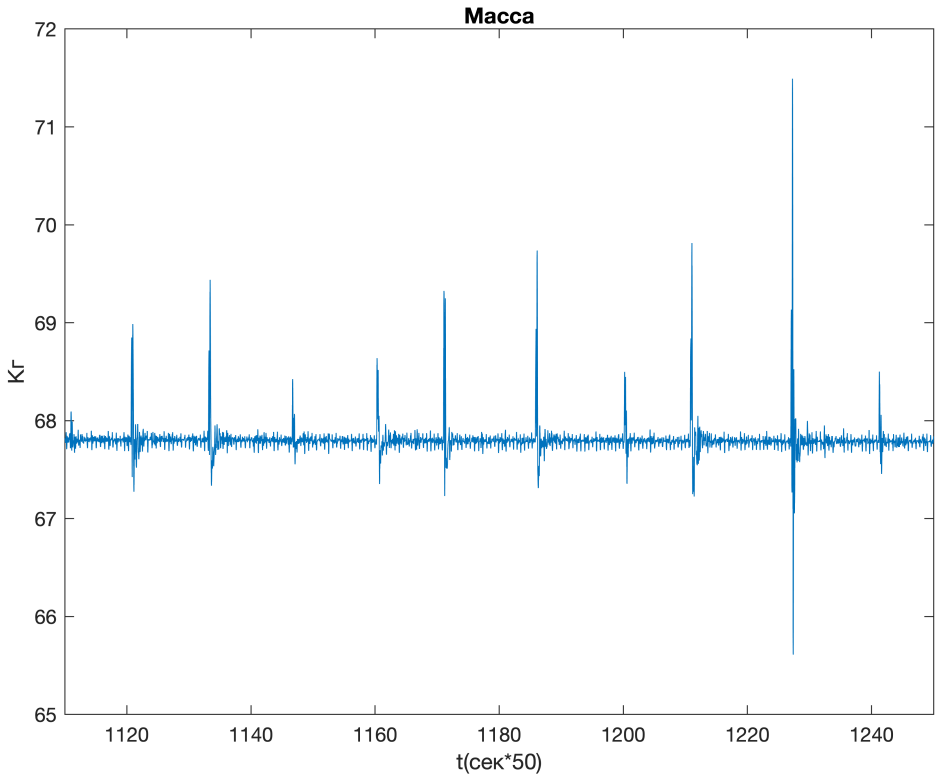

```
plot(0.02:0.02:length(Y_my)/50,ymy1(:,4));
title("Толчки");xlabel('t(сек*50)');ylabel("F(ньютон)")
xlim([1100 1150]);
```




```
plot(0.02:0.02:length(Y_my)/50,ymy1(:,3));
title("Масса на всем времени");xlabel('t(сек*50)');ylabel("Кг")
```




```
plot(0.02:0.02:length(Y_my)/50,ymy1(:,3));
title("Масса");xlabel('t(сек*50)');ylabel("Кг")
xlim([1110 1250]);
```



Mean mass

```
massWindow=ymy1(:,3);
m=mean(massWindow(1110*50:1250*50))
```

```
m = 67.8015
```

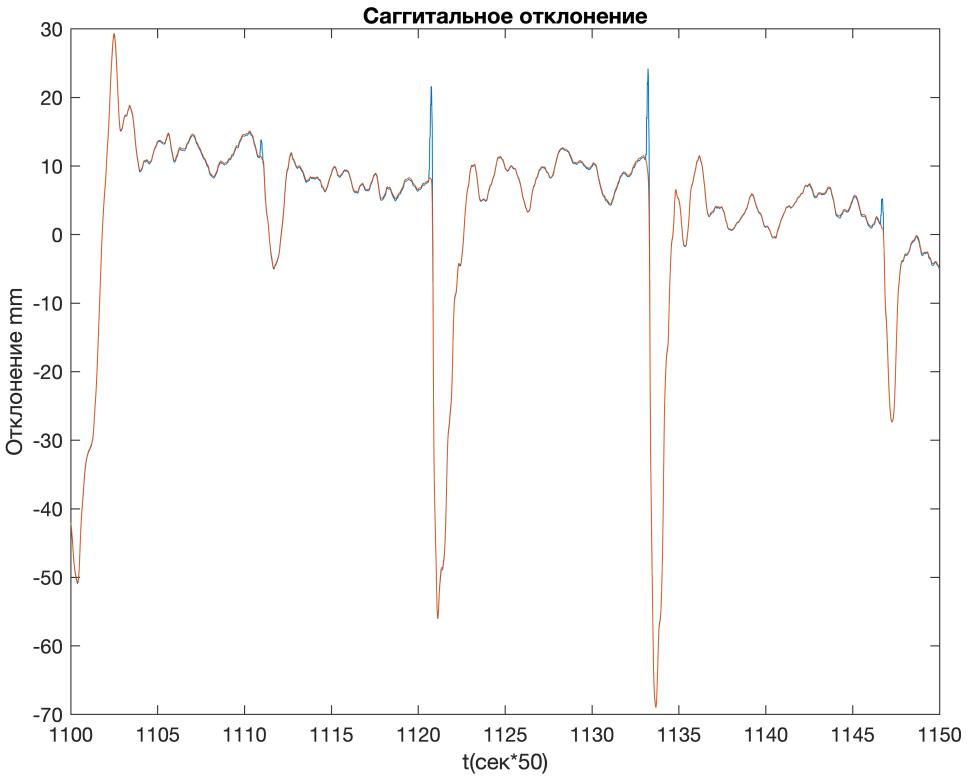
Apply algo for real data

```
l=0.88;
l1=1.3
```

```
l1 = 1.3000
```

```
h=l*2;
hp = 0.07 * (1 + h);
g=9.81;
J = m * l^2 / 3 + hp * m * l;
mgh=m*g*h;
ticks=512;
t=1:512;
F=ymy1(:,4);
fur2=@COPMfftfilt;

yCorrected=Y_my+1000*F*(l1+hp)/(m*g);
```

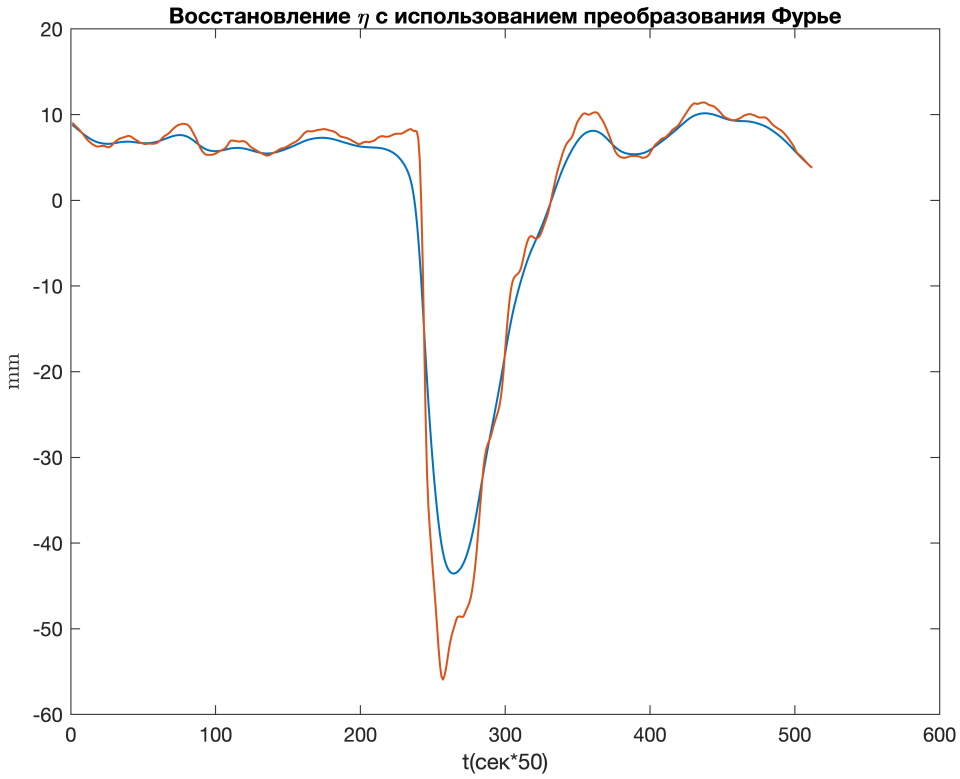
```
plot(0.02:0.02:length(Y_my)/50,yCorrected,0.02:0.02:length(Y_my)/50,Y_my');
title("Саггитальное отклонение");xlabel('t(сек*50)');ylabel("Отклонение mm")
xlim([1100 1150]);
```




```
yCorrected=yCorrected(1116*50:1116*50+511);
yOrig=Y_my(1116*50:1116*50+511);

% ycorrected=ybase2-Fnum*(l+hp)/(m*g);
% ycorrected=ybase2-Fnum*(l+hp)/(m*g);
afterfur2=COPMfftfilt(yCorrected,ticks,J,mgh);
```

Plot after FFT filtering

```
plot(t,afterfur2,t,yOrig,'LineWidth',1);
title("Восстановление \eta с использованием преобразования Фурье")
xlabel("t(сек*50)");ylabel('mm','Interpreter','latex')
```



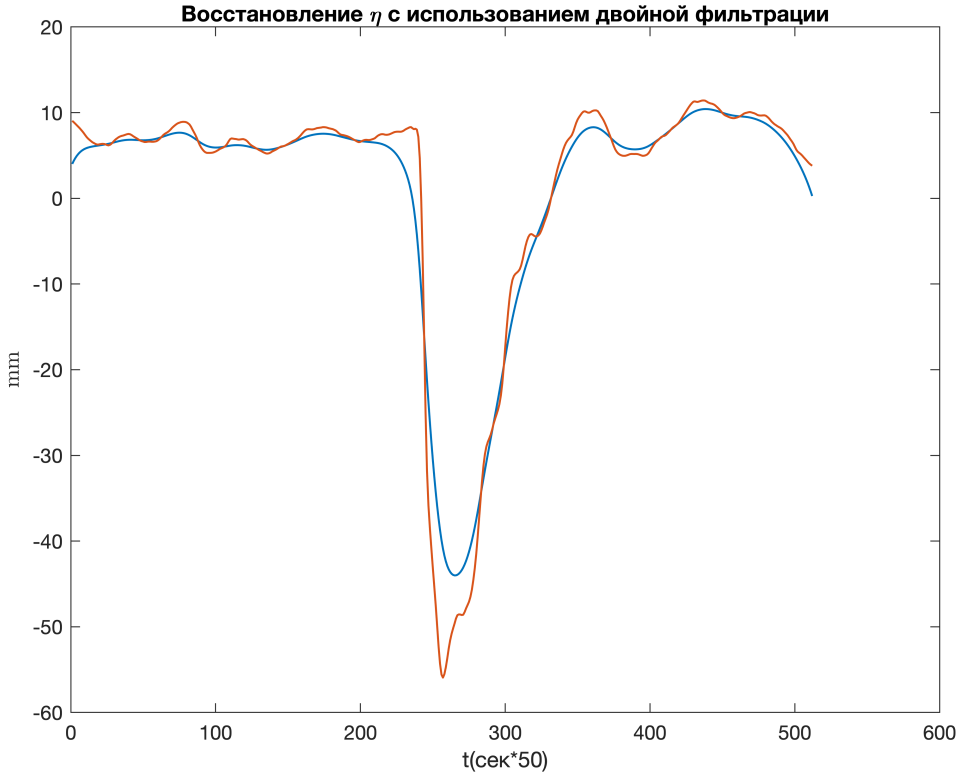

```
% legend('$\eta$','t','Interpreter','latex')
```

Apply algo double filtering for real data

```
doubleFilt=@COPMdoublefilt;
afterDoubleFilter=doubleFilt(yCorrected,J,m,g,l);
```

Plot after double filtering

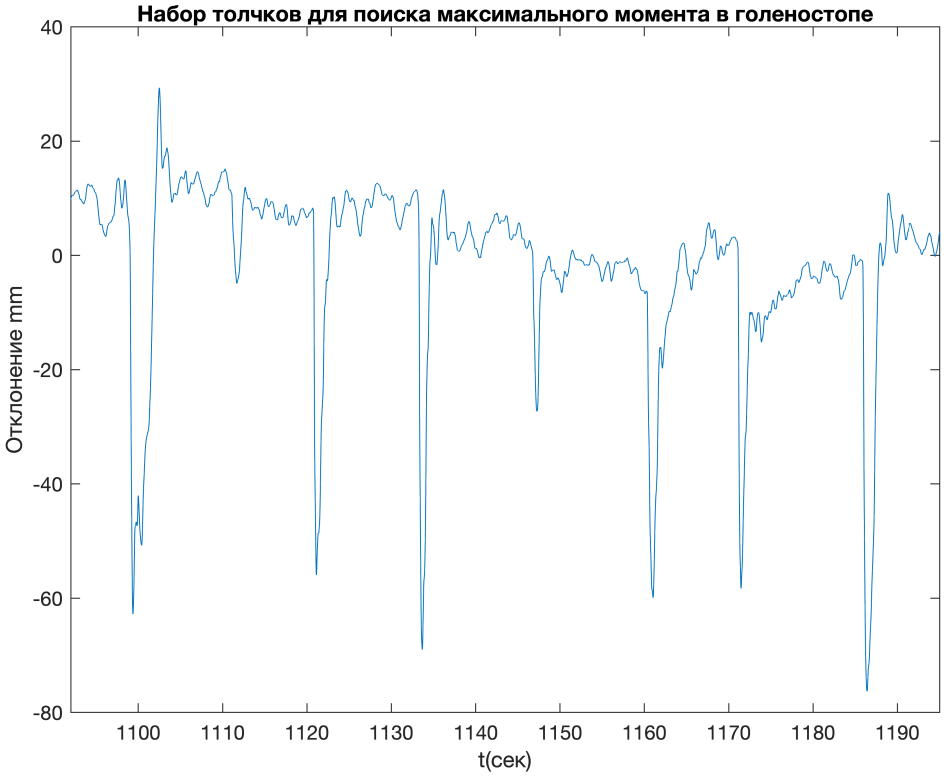
```
plot(t,afterDoubleFilter,t,yOrig,'LineWidth',1);
title("Восстановление \eta с использованием двойной фильтрации")
xlabel("t(сек*50)");ylabel('mm','Interpreter','latex')
```




```
% legend('$\eta$','t','Interpreter','latex')
```

Find average M values by eyes

```
plot(0.02:0.02:length(Y_my)/50,Y_my');
title("Набор толчков для поиска максимального момента в голеностопе");xlabel('t(сек)')
xlim([1092 1195]);
```




```
% ax = gca;
% chart = ax.Children(1);
% datatip(chart,1122,-9.523);
% datatip(chart,1134,-16.25);
% datatip(chart,1134,-54.84);
% datatip(chart,1121,-47.84);
```

Calcualte median values for mom and momDerivatives

```
points=[1121.44 1122.08 -9.52344-(-47.8438);
    1101.24 1102.38 26.53-(-30.04);
    1186.68 1187.74 -2.39-(-70.0859);
    1278.64 1279.48 -7.67-(-75.50);
    1133.98 1134.58 -1.14-(-53.5959);
    ]
```

```
points = 5×3
10^3 ×
    1.1214    1.1221    0.0383
    1.1012    1.1024    0.0566
    1.1867    1.1877    0.0677
    1.2786    1.2795    0.0678
    1.1340    1.1346    0.0525
```

```
mom=m*g*points(:,3)/1000;
momDeriv=mom./abs(points(:,1)-points(:,2));
```

```
meanMom=mean(mom)
```

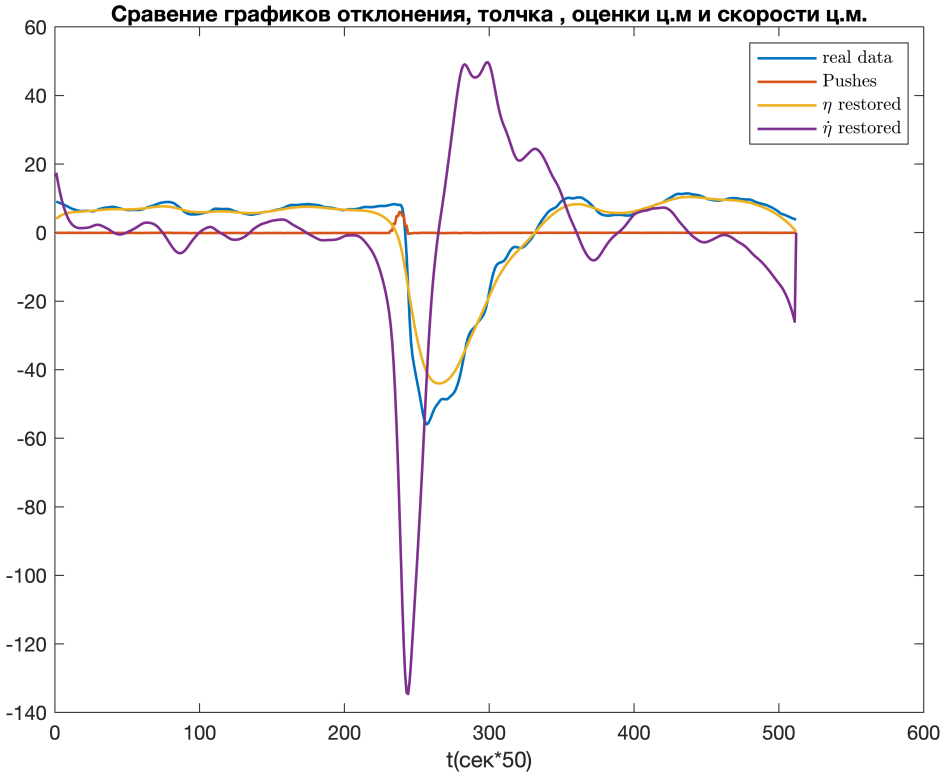
```
meanMom = 37.6295
```

```
meanMomDerivative=mean(momDeriv)
```

```
meanMomDerivative = 45.4338
```

Compare pushes and Y_coord

```
pushesData=ymy1(:,4);
pushesData;
plot(1:length(yOrig),yOrig,1:length(yOrig),pushesData(1116*50:1116*50+511),1:length(yO
% plot(1:length(yCorrected),yCorrected)
title("Сравение графиков отклонения, толчка , оценки ц.м и скорости ц.м.");xlabel('t(c
legend('real data','Pushes','$\eta$ restored','$\dot{\eta}$ restored','Interpreter','la
```




```
% xlim([1120 1135]);
```

Find \eta and derivative \eta

```
etaDerivative=diff(afterDoubleFilter)/0.02;
initialEtaDeriv=etaDerivative(245);
initialEta=afterDoubleFilter(245);
theta0=rad2deg(-initialEta/1000/l);
omega0=rad2deg(-initialEtaDeriv/1000/l);
```

```
theta0=-initialEta/1000/l
```

```
theta0 = 0.0212
```

```
omega0=-initialEtaDeriv/1000/l
```

```
omega0 = 0.1490
```

Find some variables for control problem

```
tast=sqrt(l/(3*g)) %simplfy eq
```

```
tast = 0.1729
```

```
u=tast*meanMomDerivative/(m*g*l*theta0)
```

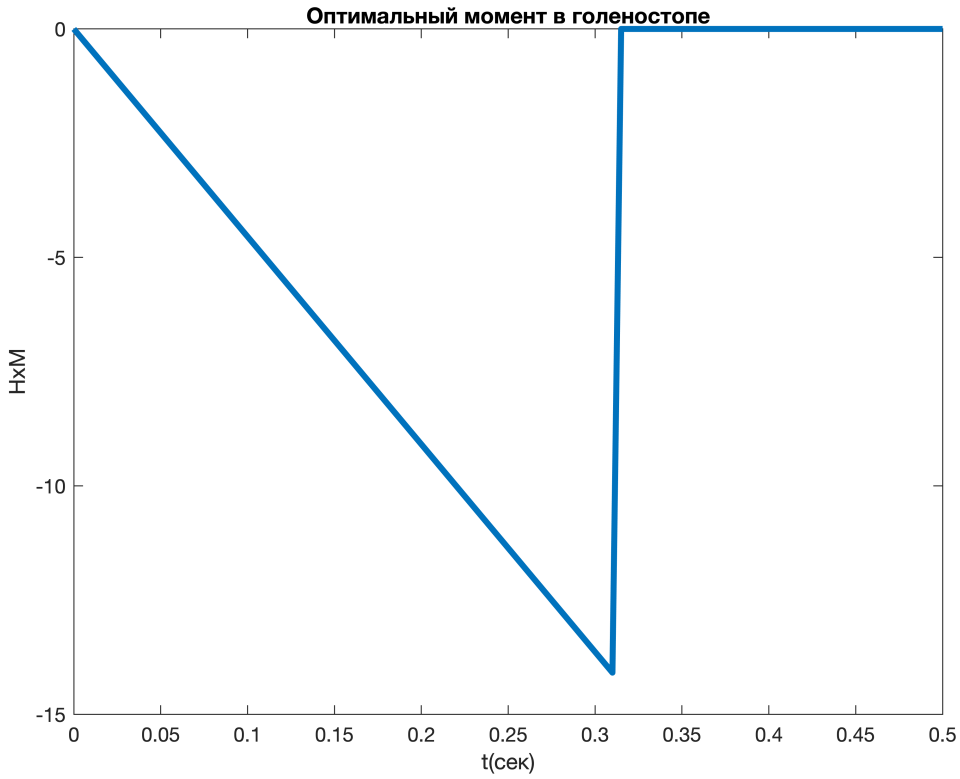
```
u = 0.6331
```

Modeling moment with calculated data

```
Tauf=0.31
```

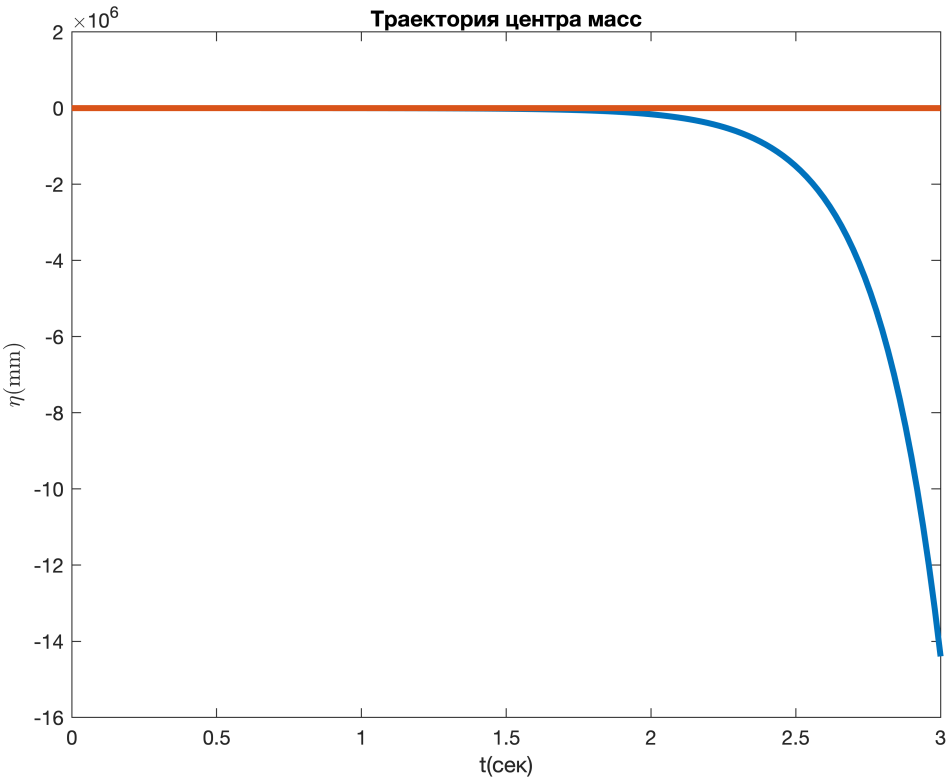
```
Tauf = 0.3100
```

```
syms M(t);
% M(t)=heaviside(t-Tauf)*Tauf*meanMomDerivative

M(t)=-meanMomDerivative*t*heaviside(Tauf-t);
t=0:0.005:0.5;

plot(t,M(t),'LineWidth',3);title("Оптимальный момент в голеностопе");xlabel('t(сек)');
```



Compare trajectory

```
syms y(t);
Dy = diff(y,t);
cond = [y(0)==0.02, Dy(0)==0.149];
eqn = diff(y,t,2)-m*g*l/J*y(t)-M(t)/J==0;
theta(t) = dsolve(eqn,cond);
t=linspace(0,3,150);

plot(t,-l*1000*double(theta(t)),t,afterDoubleFilter(245:245+149),'LineWidth',3);
title("Траектория центра масс");
xlabel("t(сек)");ylabel('$\eta$(mm)','Interpreter','latex')
```




```
% plot(t,-l*1000*double(theta(t)),'LineWidth',3);
% title("Траектория центра масс");
% xlabel("t(сек)");ylabel('$\eta$(mm)','Interpreter','latex')
```

```
function xn=COPMfftfilt(sy,N,J,mgh)

nt=(1:N)';
a=(sy(N)-sy(1))/(N-1);
b=(sy(N)-sy(1))/2;
x=sy(1:N)-a*nt-b;
f=(1:N)/N*50*2*pi;
kw=-mgh./(J*f(1:(N/2+1)).^2+mgh);
S=fft(x,N);
Sn=S(1:(N/2+1)).*kw';
Sn((N/2+2):N)=flipud(conj(Sn(2:(N/2))));
xn=ifft(Sn)-a*nt-b;
xn=-1*xn;
end

function enddata=COPMdoublefilt(y,J,m,g,l)

numerator=1;
denominator=[sqrt((J)/(m*g*l)) 1];
H = tf(numerator,denominator);
Hd = c2d(H,12/512,'foh');
```

```
miidledata=filter(cell2mat(Hd.numerator),cell2mat(Hd.denominator),y);


numerator=1;
denominator=[sqrt((J)/(m*g*l)) 1];
H = tf(numerator,denominator);
Hd2 = c2d(H,12/512,'foh');

enddata=flip(filter(cell2mat(Hd2.numerator),cell2mat(Hd2.denominator),flip(miidledata)
end
```