Chapter 15: Robotic systems

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% Chapter 15: Robotic manipulators
%
% Example ML1    MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML1: forward transformation for 2 joint-robot manipulator' % Display
label.
% Forward two joints
clf % clear graph on screen
L0=525;
L1=425;
L2=50;
thetastarting=0;%specify angle of the third link to the horizontal
thetafinishing=pi; %specify dummy values ( > starting condition)
for i=(thetastarting-pi/4):(thetafinishing+pi/4)
   theta1=i;
   theta2=i+pi/4;
   x=[L1*cos(theta1)+L2*cos(theta1+theta2)]
   z=[L0+L1*sin(theta1)+L2*sin(theta1+theta2)]
   X=[0 (L1*cos(theta1)) (L1*cos(theta1)+L2*cos(theta1+theta2))]
   Z=[L0 (L0+L1*sin(theta1)) (L1*sin(theta1)+L0+L2*sin(theta1+theta2))]
plot(X,Z,'g-','LineWidth',2)
axis([-500 500 -500 1000])
Grid on
hold on
end


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% Example ML2   MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning
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```
'Example ML2: forward transformation for 3 joint-robot manipulator' % Display
label.
% Forward three joints
clf % clear graph on screen
L1=525;
L2=425;
L3=50;
thetastarting=0;%specify angle of the third link to the horizontal
thetafinishing=pi; %specify dummy values ( > starting condition)
for i=(thetastarting-pi/4):(thetafinishing+pi/4)
   theta1=[i];
   theta2=[i+pi/4];
   theta3=[i+pi/2];
   x=[L1*cos(theta1)+L2*cos(theta1+theta2)+L3*cos(theta1+theta2+theta3)]
   z=[L1*sin(theta1)+L2*sin(theta1+theta2)+L3*sin(theta1+theta2+theta3)]
   X=[0 (L1*cos(theta1)) (L1*cos(theta1)+L2*cos(theta1+theta2))...

(L1*cos(theta1)+L2*cos(theta1+theta2)+L3*cos(theta1+theta2+theta3))]
   Z=[0 (L1*sin(theta1)) (L1*sin(theta1)+L2*sin(theta1+theta2))...
         (L1*sin(theta1)+L2*sin(theta1+theta2)+L3*sin(theta1+theta2+theta3))]
plot(X,Z,'y-','LineWidth',2)
axis([-1000 1000 -1000 1000])
Grid on
hold on
end


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% Example ML2   MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML2: forward transformation for 3 joint-robot manipulator' % Display
label.
% Forward three joints
clf % clear graph on screen
L1=100;
%L1=525;
L2=150;
%L2=425;
L3=20;
thetastarting=0;%specify angle of the third link to the horizontal
thetafinishing=pi; %specify dummy values ( > starting condition
```

```
%change the middle term to see changes
for i=(thetastarting-pi/4):(thetastarting+pi/8):(thetafinishing+pi/4)
    theta1=[i];
    theta2=[i+pi/4];
    theta3=[i+pi/2];
    t1=theta1;
    t2=(theta1+theta2);
    t3=(theta1+theta2+theta3);

    %c1=(exp(i*angle)+exp(-i*angle))/2;       formula for cosine
    %s1=(exp(i*angle)-exp(-i*angle))/(2*i);   formula for sine

    c_t1=(exp(i*t1)+exp(-i*t1))/2; %cos
    s_t1=(exp(i*t1)-exp(-i*t1))/(2*i); %sin
    c_t2=(exp(i*t2)+exp(-i*t2))/2; %cos
    s_t2=(exp(i*t2)-exp(-i*t2))/(2*i); %sin
    c_t3=(exp(i*t3)+exp(-i*t3))/2; %cos
    s_t3=(exp(i*t3)-exp(-i*t3))/(2*i); %sin

    X=[-1000 (L1*c_t1) (L1*c_t1+L2*c_t2) (L1*c_t1+L2*c_t2+L3*c_t3)]
    Z=[0 (L1*s_t1) (L1*s_t1+L2*s_t2) (L1*s_t1+L2*s_t2+L3*s_t3)]

%   Previous version
    %x=[L1*cos(theta1)+L2*cos(theta1+theta2)+L3*cos(theta1+theta2+theta3)]
    %z=[L1*sin(theta1)+L2*sin(theta1+theta2)+L3*sin(theta1+theta2+theta3)]
    %X=[0 (L1*cos(theta1)) (L1*cos(theta1)+L2*cos(theta1+theta2))...
    %
(L1*cos(theta1)+L2*cos(theta1+theta2)+L3*cos(theta1+theta2+theta3))]
    %Z=[0 (L1*sin(theta1)) (L1*sin(theta1)+L2*sin(theta1+theta2))...
    %
(L1*sin(theta1)+L2*sin(theta1+theta2)+L3*sin(theta1+theta2+theta3))]
plot(X,Z,'y-','LineWidth',2)
axis([-1000 1000 -1000 1000])
Grid on
hold on
end
```

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%
% Example ML3   MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML43 forward transformation for 4 joint-robot manipulator' % Display
label.
% Forward three joints
clf % clear graph on screen
L1=525;
L2=425;
L3=575;
L4=50;
lamda=900;
thetastarting=0;%specify angle of the third link to the horizontal
thetafinishing=pi; %specify dummy values ( > starting condition)
for i=(thetastarting-pi/4):(thetafinishing+pi/4)
    theta1=[i];
    theta2=[i+pi/4];
    theta4=[i+pi/2];
    alpha=[theta4+theta2];
    X=[cos(theta1)*(lamda*cos(theta2)+L4*cos(alpha))]
    Y=[sin(theta1)*(lamda*cos(theta2)+L4*cos(alpha))]
    Z=[L1+lamda*sin(theta2)+L4*sin(alpha)]
%plot(X,Z,'y-','LineWidth',2)
%axis([-1000 1000 -1000 1000])
%Grid on
%hold on
end


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% Example ML4    MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML4: backward transformation for 2 joint-robot manipulator' %
Display label.
% backward transformation for 2 joints
'Industrial robots'
L0=0;
L1=350;
L2=250;
L3=50;
```

```
xs=300;
xf=400;
zs=400;
zf=500;
%Conversion of angles
%sin(z)=(e(i*z)-e(-i*z))/(2*i); cos(z)=(e(i*z)+e(-i*z))/2;
%tan(z)=sin(z)/cos(z)
Alpha=30;
rads=Alpha*pi/180;
sin_Ang=(exp(i*rads)-exp(-i*rads))/(2*i); %sin of angle
cos_Ang=(exp(i*rads)+exp(-i*rads))/(2); %cos of angle
'print initial positions'
x1=xs-L3*cos_Ang
z1=zs-L3*sin_Ang

%start looping
w=5
%count=floor((xf-x1)/w)
wx=floor((xf-x1)/w);
wz=floor((zf-z1)/w);

x=x1:wx:xf; % Let x1 < x < xf in steps of w
z=z1:wz:zf; % Let z1 < z < zf in steps of w

for j=1:1:w
   ang2=(x(j)^2+z(j)^2-L1^2-L2^2)/(2*L1*L2);
   theta2=acos(ang2)*180/pi; %convert to angle

   sin_theta2=(exp(i*theta2)-exp(-i*theta2))/(2*i); %sin of angle
   cos_theta2=(exp(i*theta2)+exp(-i*theta2))/(2); %cos of angle

   ang1=((z(j)-L0)*(L1+L2*cos_theta2)-...
   (x(j)*L2*sin_theta2))/(x(j)*(L1+L2*cos_theta2)+(z(j)-L0)*L2*sin_theta2);

   sin_theta1=(exp(i*ang1)-exp(-i*ang1))/(2*i); %sin of angle
   cos_theta1=(exp(i*ang1)+exp(-i*ang1))/(2); %cos of angle

   theta1=(sin_theta1/cos_theta1)*180/pi;

   theta3=Alpha-theta2-theta1;

   'Print angles'
   Angle_1=theta1
   Angle_2=theta2
   Angle_3=theta3


end
```

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% Example ML5    MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML5: backward transformation for 3 joint-robot manipulator' %
Display label.
% backward transformation for 3 joints
%L1=500;
%L2=400;
%L3=50;
%alpha=25;
%xstarting=500;
%xfinal=850;
%zstarting=350;
%zfinal=700;
L1=350;
L2=250;
L3=50;
alpha=30;
xstarting=300;
xfinal=400;
zstarting=400;
zfinal=500;
%start looping
w=(xfinal-xstarting)/50
for i=1:w+1
   x(i)=xstarting+(i-1)*50
   z(i)=zstarting+(i-1)*50
   x3=x(i)-L3*cos(alpha);
   z3=z(i)-L3*sin(alpha);
   theta2=acos((x3^2+z3^2-L1^2-L2^2)/(2*L1*L2))
   alpha1=atan(x3/z3);
   beta=asin((L2*sin(theta2))/sqrt(x3^2+z3^2));
   theta1=90-alpha1-beta
   theta3=alpha-theta1-theta2

end


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% Example ML5    MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML5: backward transformation for 3 joint-robot manipulator' %
Display label.
% backward transformation for 3 joints
%L1=500;
%L2=400;
%L3=50;
%alpha=25;
%xstarting=500;
%xfinal=850;
%zstarting=350;
%zfinal=700;
L1=350;
L2=250;
L3=50;
alpha=30;
angle=alpha*pi/180;
xstarting=300;
xfinal=400;
zstarting=400;
zfinal=500;
%start looping
w=(xfinal-xstarting)/50
for j=1:w+1
   x(j)=xstarting+(j-1)*50
   z(j)=zstarting+(j-1)*50
   c1=(exp(i*angle)+exp(-i*angle))/2;
   s1=(exp(i*angle)-exp(-i*angle))/(2*i);
   x3=x(j)-L3*c1;
   z3=z(j)-L3*s1;
   ang=(x3^2+z3^2-L1^2-L2^2)/(2*L1*L2);
   theta2=i*log10(ang+i*sqrt(1-ang^2))*180/pi
   z=(L2*(exp(i*ang)-exp(-i*ang))/(2*i))/sqrt(x3^2+z3^2);
   beta=i*log10(i*z+ sqrt(1-z^2))*180/pi; %asin(z);
   alpha1=atan(x3/z3)*180/pi;
   theta1=90-alpha1-beta
   theta3=alpha-theta1-theta2
end


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% Example ML6    MATLAB's calculating power is demonstrated by analyzing
% robotic manipulator path planning

'Example ML6'              % Display label.
% manipulator path planning
A=[234 81 27; 405 108 27; 540 108 18;];
Y=[90 0 0;];

% A*X=Y;
'Position vector'
X=A\Y'
%Velocity
pause
```