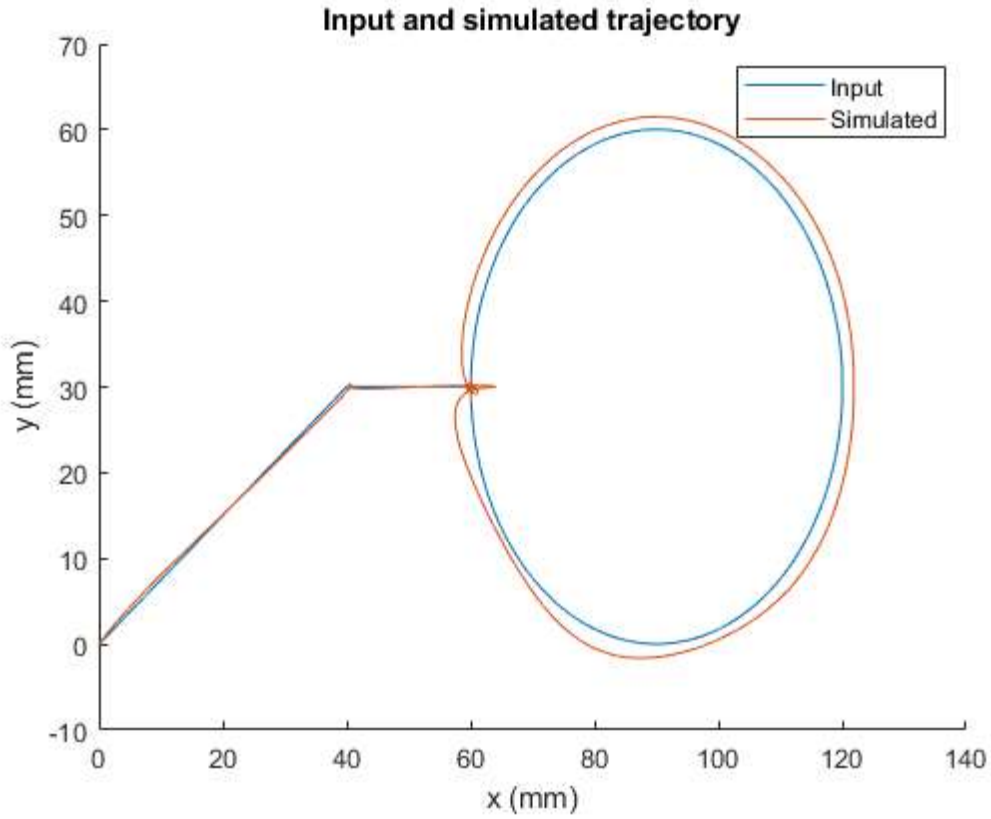
Contents

1

```
% init variables to be loaded into simulink model
T = 0.0001;
Ka = 1;
Kt = 0.49;
Ke = 1.59;
Jx = 0.000436;
Bx = 0.0094;
Jy = 0.0003;
By = 0.0091;

% use LBW LLI controller
a = 13.9282;
T_ = 0.0021323;
Kx = 0.75858;
Ky = 0.82224;
Ki = 12.5664;

LL = tf([a*T_ 1],[T_ 1]);
I = tf([1 Ki],[1 0]);
LLI_Lx_z = Kx*c2d(LL*I, T, 'tustin');
LLI_Ly_z = Ky*c2d(LL*I, T, 'tustin');

data = load('sampleTraj.mat');
Tplot = data.txy.t;
xplot = data.txy.x;
yplot = data.txy.y;

% run this in console after simulink is finished
% output = out.sim
% save simTraj output

% run after simulink sim finished
toPlot = load('simTraj.mat');
clf;
hold on;
title('Input and simulated trajectory');
plot(toPlot.output.Data(:,2), toPlot.output.Data(:,4));
plot(toPlot.output.Data(:,3), toPlot.output.Data(:,5));
xlabel('x (mm)');
ylabel('y (mm)');
legend('Input', 'Simulated');
saveas(gcf, 'qC1.png');
```



2

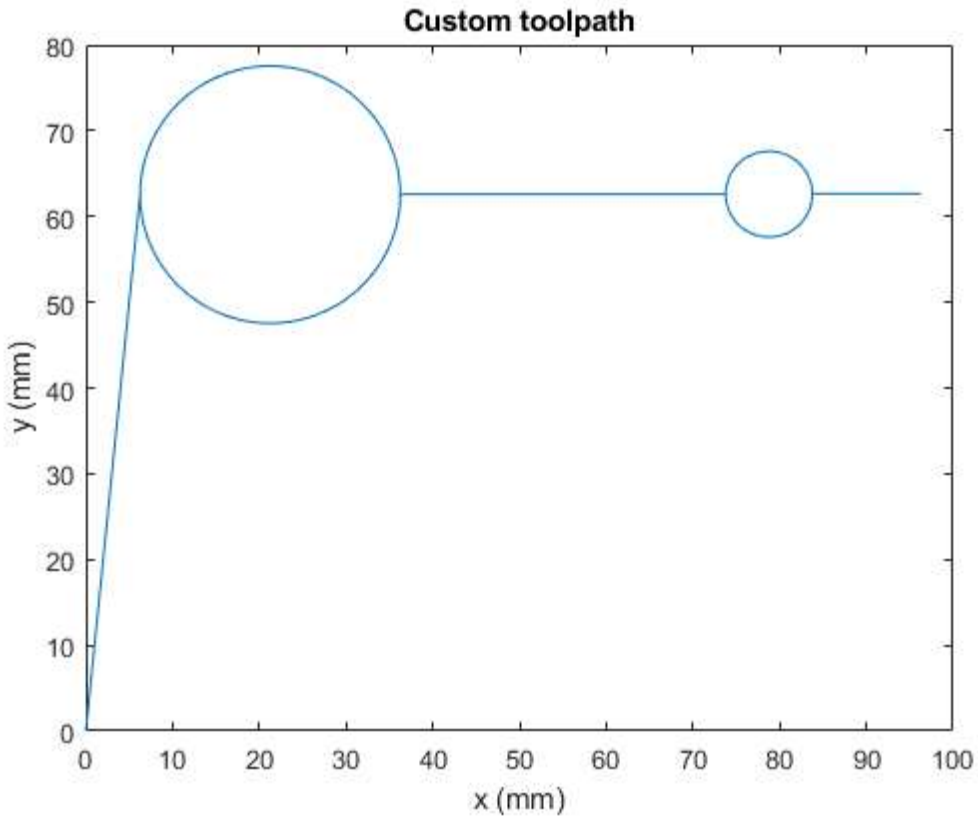
```
data = linearFromZero(5, 50);
ti = data(end, 1);
xi = data(end, 5);
yi = data(end, 6);
data = [data; circleCut(xi, yi, ti, 15)];
ti = data(end, 1);
xi = data(end, 5);
yi = data(end, 6);
data = [data; circleCut(xi, yi, ti, 5)];
traj.t = data(:,1);
traj.x = data(:,5);
traj.y = data(:,6);
save myTraj traj;
clf;
plot(data(:,5), data(:,6));
title('Custom toolpath');
xlabel('x (mm)');
ylabel('y (mm)');
saveas(gcf, 'qC2.png');

function data1 = linearFromZero(xf, yf)
    A = 250;
    T = 0.1;
    T = T * 0.001;

    xf = xf/2;
    yf = yf/2;

    L = ceil(sqrt(xf^2 + yf^2));
    [T1, T2, T3] = calc(L);
    T_total = T1+T2+T3;
```

```
    x_ratio = xf/L;
    y_ratio = yf/L;

    t = 0;
    s = 0;
    sdot = 0;
    sdotdot = A;
    xr = 0;
    yr = 0;
    vxr = 0;
    vyr = 0;
    axr = A*x_ratio;
    ayr = A*y_ratio;

    count = 1;
    data1 = zeros(T_total/T, 10);
    while t <= T_total
        data1(count, 1) = t;
        data1(count, 2) = s;
        data1(count, 3) = sdot;
        data1(count, 4) = sdotdot;
        data1(count, 5) = xr;
        data1(count, 6) = yr;
        data1(count, 7) = vxr;
        data1(count, 8) = vyr;
        data1(count, 9) = axr;
        data1(count, 10) = ayr;

        if t < T1
            sdotdot = A;
        elseif t >= T1 && t < T1+T2
            sdotdot = 0;
        else
            sdotdot = -A;
        end

        sdot = sdot + T*sdotdot;
        s = s + sdot*T;

        xr = s*x_ratio;
        yr = s*y_ratio;
        vxr = sdot*x_ratio;
        vyr = sdot*y_ratio;
        axr = sdotdot*x_ratio;
        ayr = sdotdot*y_ratio;

        t = t + T;
        count = count + 1;
    end
end

function data = circleCut(xi, yi, ti, r)
    A = 250;
    T = 0.1;
    T = T * 0.001;

    L = 2*3.1415*r;
    [T1, T2, T3] = calc(L);
    T_total = T1+T2+T3;
```

```
x_ratio = 1;
y_ratio = 0;

t = 0;
s = 0;
sdot = 0;
sdotdot = A;
xr = 0;
yr = 0;
vxr = 0;
vyr = 0;
axr = A*x_ratio;
ayr = A*y_ratio;

count = 1;
data1 = zeros(T_total/T, 10);
while t <= T_total
    if t < T1
        sdotdot = A;
    elseif t >= T1 && t < T1+T2
        sdotdot = 0;
    else
        sdotdot = -A;
    end

    sdot = sdot + T*sdotdot;
    s = s + sdot*T;

    [x_ratio, y_ratio] = getRatios(s/L);

    vxr_prev = vxr;
    vyr_prev = vyr;
    vxr = sdot*x_ratio;
    vyr = sdot*y_ratio;

    xr = xr + vxr*T;
    yr = yr + vyr*T;

    axr = (vxr - vxr_prev)/T;
    ayr = (vyr - vyr_prev)/T;

    data1(count, 1) = t+ti;
    data1(count, 2) = s;
    data1(count, 3) = sdot;
    data1(count, 4) = sdotdot;
    data1(count, 5) = xr+xi;
    data1(count, 6) = yr+yi;
    data1(count, 7) = vxr;
    data1(count, 8) = vyr;
    data1(count, 9) = axr;
    data1(count, 10) = ayr;

    t = t + T;
    count = count + 1;
end

[T1, T2, T3] = calc(r); % 60-40=20
T_total = T1+T2+T3;

x_ratio = 1;
y_ratio = 0;
```

```
    t = 0;
    s = 0;
    sdot = 0;
    sdotdot = A;
    xr = 0;
    yr = 0;
    vxr = 0;
    vyr = 0;
    axr = A*x_ratio;
    ayr = A*y_ratio;

    count = 1;
    data2 = zeros(T_total/T, 10);
    while t <= T_total
        data2(count, 1) = t+data1(end, 1);
        data2(count, 2) = s+data1(end, 2);
        data2(count, 3) = sdot+data1(end, 3);
        data2(count, 4) = sdotdot;
        data2(count, 5) = xr+data1(end, 5);
        data2(count, 6) = yr+data1(end, 6);
        data2(count, 7) = vxr+data1(end, 7);
        data2(count, 8) = vyr+data1(end, 8);
        data2(count, 9) = axr;
        data2(count, 10) = ayr;

        if t < T1
            sdotdot = A;
        elseif t >= T1 && t < T1+T2
            sdotdot = 0;
        else
            sdotdot = -A;
        end

        sdot = sdot + T*sdotdot;
        s = s + sdot*T;

        xr = s*x_ratio;
        yr = s*y_ratio;
        vxr = sdot*x_ratio;
        vyr = sdot*y_ratio;
        axr = sdotdot*x_ratio;
        ayr = sdotdot*y_ratio;

        t = t + T;
        count = count + 1;
    end

    data = [data1; data2];
end

function [x_r, y_r] = getRatios(r)
    x_r = 0;
    y_r = 0;
    if r < .25
        theta = (pi/2)*(r/.25);
        x_r = sin(theta);
        y_r = -cos(theta);
    elseif r >= .25 && r < 0.5
        theta = (pi/2)*((r-0.25)/.25);
        x_r = cos(theta);
```

```
        y_r = sin(theta);
    elseif r >= 0.5 && r < 0.75
        theta = (pi/2)*((r-0.5)/.25);
        x_r = -sin(theta);
        y_r = cos(theta);
    else
        theta = (pi/2)*((r-0.75)/.25);
        x_r = -cos(theta);
        y_r = -sin(theta);
    end
end

function [T1, T2, T3] = calc(L)
    A = 100; % mm/s^2
    fc = 250; % mm/s
    T = 0.1; % ms
    T = T * 0.001; % s

    T1 = fc/A;
    T3 = T1;
    s_init = A*T1*T1/2; % this is 20
    T2 = (L-2*s_init)/fc;
    T2 = ceil(T2/T)*T;
    if T2 < 0
        T2 = 0;
        s_init = L/2;
        T1 = sqrt(2*s_init/A);
        T1 = ceil(T1/T)*T;
        T3 = T1;
    end
end
```



Published with MATLAB® R2020b