
```

clc;
clear all;

% Real Kinematic Parameters
sReal = [96.6610, 22.2476, -122.4519, -120.6859, 24.7769, 91.3462;
          81.7602, 125.2511, 36.6453, -34.4565, -125.0489, -80.9866;
          1.0684, -0.5530, 4.3547, -4.9014, -4.8473, 0.2515];

uReal = [305.2599, -55.2814, -244.7954, -252.5755, -53.9678, 302.4266;
          115.0695, 322.9819, 208.0087, -211.8783, -320.6115, -109.4351;
          2.6210, 4.2181, 3.9365, -3.0128, 4.3181, 3.3812];

LMinReal = [604.4299;
            607.2473;
            600.4441;
            605.9031;
            604.5251;
            600.0616];

realKinematicParameters = [sReal(:,1)', uReal(:,1)', LMinReal(1,1);
                           sReal(:,2)', uReal(:,2)', LMinReal(2,1);
                           sReal(:,3)', uReal(:,3)', LMinReal(3,1);
                           sReal(:,4)', uReal(:,4)', LMinReal(4,1);
                           sReal(:,5)', uReal(:,5)', LMinReal(5,1);
                           sReal(:,6)', uReal(:,6)', LMinReal(6,1)];

% Nominal Kinematic Parameters
s = [92.1597, 27.055, -119.2146, -119.2146, 27.055, 92.1597;
     84.4488, 122.037, 37.5882, -37.5882, -122.037, -84.4488;
     0, 0, 0, 0, 0, 0];

u = [305.4001, -56.4357, -248.9644, -248.9644, -56.4357, 305.4001;
     111.1565, 320.0625, 208.9060, -208.9060, -320.0625, -111.1565;
     0, 0, 0, 0, 0, 0];

LMinNominal = [604.8652;
               604.8652;
               604.8652;
               604.8652;
               604.8652];

nominalKinematicParameters = [s(:,1)', u(:,1)', LMinNominal(1,1);
                              s(:,2)', u(:,2)', LMinNominal(2,1);
                              s(:,3)', u(:,3)', LMinNominal(3,1);
                              s(:,4)', u(:,4)', LMinNominal(4,1);
                              s(:,5)', u(:,5)', LMinNominal(5,1);
                              s(:,6)', u(:,6)', LMinNominal(6,1)];

options = optimoptions('lsqnonlin');
options.Display = 'iter-detailed';
options.Algorithm = 'levenberg-marquardt';

```

```

% options.FiniteDifferenceType = 'central';
[identifiedKinematicParameters,resnorm,residual,exitflag,output] =
    lsqnonlin(@CF, nominalKinematicParameters,[],[],options);

% disp(nominalKinematicParameters);
% disp(realKinematicParameters);
% disp(identifiedKinematicParameters);

errorBeforeCalibration = zeros(42,1);
errorAfterCalibration = zeros(42,1);

for i = 0 : 5
    for j = 1 : 7
        % eBC(i+1,j) = norm(realKinematicParameters(i+1, j) -
        nominalKinematicParameters(i+1,j),2);
        % eAC(i+1,j) = norm(realKinematicParameters(i+1, j) -
        identifiedKinematicParameters(i+1,j),2);
        errorBeforeCalibration(i*7 + j) = norm(realKinematicParameters(i+1,
        j) - nominalKinematicParameters(i+1,j),2);
        errorAfterCalibration(i*7 + j) = norm(realKinematicParameters(i+1, j)
        - identifiedKinematicParameters(i+1,j),2);
    end
end
% disp(eBC);
% disp(eAC);
% disp(errorBeforeCalibration);
% disp(errorAfterCalibration);
calibrationData = [errorAfterCalibration, errorBeforeCalibration];
bar3(calibrationData);
ylabel('Kinematic Parameters')
zlabel('Error (mm)')
title('Kinematic Parameter Error')
legend('After Calibration', 'Before Calibration')
set(gca,'ytick',1:7:42,'yticklabel',compose('Leg %d',1:6))

% Note that unlike in the original paper, the bars in the bar graph are
% grouped by leg for easier readability.

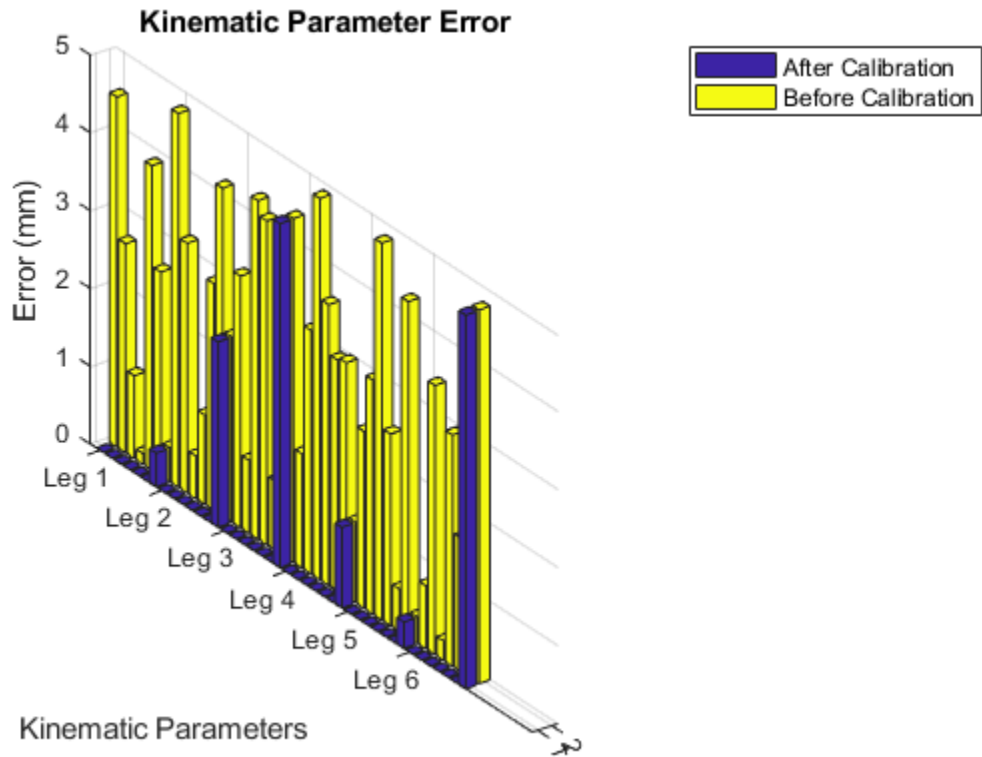
% Something that immediately stands out in this graph is that the initial
% leg lengths before and after calibration are the same. After spending a
% few hours searching for the problem, I have concluded that lsqnonlin has
% most likely simply found a local minimum at the nominal leg lengths, as
% it varies very slightly between iterations.

```

			First-Order	Norm	
of					
Iteration	Func-count	Residual	optimality	Lambda	step
0	43	8.95748e+17	8.07e+16	0.01	
1	86	5.64272e+16	1.02e+16	0.001	9.24933
2	129	3.54067e+15	1.28e+15	0.0001	4.6223
3	172	2.21732e+14	1.61e+14	1e-05	2.31089
4	215	1.3872e+13	2.01e+13	1e-06	1.15543
5	258	8.67432e+11	2.51e+12	1e-07	0.577719

6	301	5.42278e+10	3.14e+11	1e-08	0.288862
7	344	3.38964e+09	3.93e+10	1e-09	0.144431
8	387	2.11863e+08	4.91e+09	1e-10	0.0722156
9	430	1.32416e+07	6.14e+08	1e-11	0.0361079
10	473	827569	7.67e+07	1e-12	0.018054
11	516	51718.4	9.58e+06	1e-13	0.00902687
12	559	3231.81	1.2e+06	1e-14	0.00451324

Optimization completed: The relative first-order optimality measure,
1.481711e-11,
is less than 1e-4*options.FunctionTolerance = 1.000000e-10.



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