edX

Course > Week 6 > Proble... > Poinca...

Poincare Analysis (Compass Gait)

Poincare Analysis on Compass Gait (Part I)

0.0/10.0 points (graded)

In this problem we will investigate a limit cycle for the unactuated compass gait model. To see the compass gait model in action, navigate to drake/examples/CompassGait and call CompassGaitPlant.run(). Look around in CompassGaitPlant and try to understand how the hybrid system is set up using modes, guards, and transitions.

In the rest of this problem, keep in mind that the compass gait model is a hybrid system, which has both discrete state $x_d \in \mathbb{Z}$ (the mode that the system is in) and continuous state $x_c \in \mathbb{R}^4$ (the joint angles and velocities). The complete state vector is $x = [x_d; x_c]$.

First, write a function with the signature **xf = strideFunction(p, x0)**, where p is a CompassGaitPlant, x0 is the initial continuous state and xf is the continuous state right after a single step has been taken. In the function, you may assume that the initial discrete state is 1 and that no step will ever take longer than 1 second.

Hint 1: you can pass in the initial state of the system as the third argument to the simulate function.

Hint 2: the output of simulate will be a HybridTrajectory. The traj field of a HybridTrajectory is a cell array of PPTrajectories (piecewise polynomial trajectories) corresponding to the sequence of discrete modes that the system goes through. A PPTrajectory can be evaluated at a given time using the eval method.

Note: For this problem, please make sure to NOT round off your answers in intermediate steps. In other words, please keep around all the digits you computed in Matlab since numerical errors can propagate quickly and cause problems later down the line. To be safe, set your tolerances much tighter than the ones we list in the problems (since there is almost no computational cost to doing this).

(a) What is the output of strideFunction(p, [0; 0; 2; -0.4])? Type in your answer below (xf must

Generating Speech Output **tolerance for this answer is 0.001.**

```
xf = ;

```

Unanswered

```
%% Stride function:
% function xf = strideFunction(p, x0)
% traj = simulate(p,[0 1], [1; x0]); % Simulate from x0 with mode = 1
% xf = traj.traj{2}.eval(traj.traj{2}.tspan(1)); % Get state right after collision
% end

% For [0;0;2;-0.4], we have:
xf = [-0.32600174
       0.22128199
      -0.38086431
      -1.0879922];
```

Run Code

Submit You have used 0 of 2 attempts

Answers are displayed within the problem

Poincare Analysis on Compass Gait (Part II)

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(b) The state x = [1; 0; 0; 2; -0.4] is attracted to a stable limit cycle of the system. Use your strideFunction to find this stable limit cycle, identified by the continuous state x_0 just after a step has been taken. What is x_0? Type in your answer below (it must have size 4×1). **Our tolerance for this answer is 0.001.**

```
x0 = ;

```

Unanswered

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```
%% The fixed point can be found by repeatedly simulating the system using strideFunction as foll
%
%% find fixed point
% p = CompassGaitPlant();
% x0 = p.getInitialState();
% x0 = x0(2:end);
% epsilon = 1e-12;
% while true
%   x0_new = strideFunction(p, x0);
%   if norm(x0_new - x0) < epsilon
%     break;
%   end
%   x0 = x0_new;
% end
% disp('x0:');
% fprintf('%0.8g\n', x0');
% fprintf('\n');

% Then, we get:
x0 =  [-0.32338855
        0.21866879
       -0.37718213
       -1.0918269];
```

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Answers are displayed within the problem

Poincare Analysis on Compass Gait (Part III)

0.0/10.0 points (graded)

(c) Next, use your strideFunction to numerically find the monodromy matrix A. This is the linearization of the Poincare map at the point x_0. Type in your answer below. **Our tolerance for this answer is 0.01.**

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```
2
```

Unanswered

```
%% The A matrix can be computed by numerical differentiation. So, for example, the first
%% column can be computed as follows:
% x1 = strideFunction(p,x0);
% x2 = strideFunction(p,x0+[1e-5;0;0;0]);
% A_1 = (x2-x1)/1e-5;

% Computing the other columns in a similar way, we get:
A = [0.3185    1.5933   -0.0259    0.5646;
    -0.3185   -1.5933    0.0259   -0.5646;
    -2.3383   -2.7989    0.0954   -1.3183;
    -0.1686    2.5803   -0.0633    0.9116];
```

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Answers are displayed within the problem

Poincare Analysis on Compass Gait (Part IV)

0.0/5.0 points (graded)

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(d) What are the Floquet multipliers (eigenvalues of the monodromy matrix) corresponding to the stable limit cycle? Type in your answer below as a 4×1 vector of complex numbers. Don't worry about ordering the multipliers in any particular order. **Our tolerance for this answer is 0.05 (in terms of the magnitude of each element in the vector).** (Check that the linearized Poincare map is stable, as expected).

```
f = ;

```

Unanswered

```
% Computing the eigenvalues of A using eig(A), we get:
f = [-0.1997 + 0.5445i;-0.1997 - 0.5445i;0.1316 + 0.0000i;-0.0+0.0000i];
% As expected, one of the eigenvalues is 0
```

Run Code

Submit You have used 0 of 3 attempts

Answers are displayed within the problem

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