Multiple-Input Multiple-Output Control

Master of Science in Aerospace Engineering

Assignment 1 - Modelling the Flying Chardonnay

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1 Introduction

The goal of this assignment is the development and implementation of the physics-based modelling of the dynamics of the Flying Chardonnay drone, an automatic drink delivery device. For a given set of drone parameters

$$\begin{bmatrix} m_d = 1 & m_c = 1 & l = 1 & l_d = 1 & J = 1 & C_D = 0.01 & g = 10 \end{bmatrix}$$

and system state $\boldsymbol{x}$, the time derivative of the state of the system $\dot{\boldsymbol{x}}$ is computed.

2 Implementation on MATLAB

The equations of motion derived are implemented on MATLAB as follows:

```
%% Dynamics of Flying Chardonnay
% All values are in SI units
% x = [vn; vd; the; thed; gam; gamd]
% u = [T1; T2]
% w = [wn; wd]
% drone = structure containing all drone physical parameters
    function x_dot = drone_dynamics(x,u,w,drone)
%% drone parameters
    md = drone.mass_drone;
    mc = drone.mass_cup;
    l = drone.length_cg_cup;
    ld = drone.length_cg_propeller;
    J = drone.inertia;
    CD = drone.drag;
    g = drone.gravity;

%% State matrix
    A1 = [md 0 0 0 0 0 sin(x(3)+x(5))];
    A2 = [0 md 0 0 0 0 cos(x(3)+x(5))];
    A3 = [mc 0 0 -mc*l*cos(x(3)+x(5)) 0 -mc*l*cos(x(3)+x(5)) -sin(x(3)+x(5))
   ];
    A4 = [0 mc 0 mc*l*sin(x(3)+x(5)) 0 mc*l*sin(x(3)+x(5)) -cos(x(3)+x(5))];
    A5 = [0 0 0 J 0 0 0];
    A6 = [0 0 1 0 0 0 0];
    A7 = [0 0 0 0 1 0 0];
    A = [A1; A2; A3; A4; A5; A6; A7];

%% h matrix
    h1 = -(u(1)+u(2))*sin(x(3)) - CD*(x(1)-w(1));
    h2 = md*g - (u(1) + u(2))*cos(x(3)) - CD*(x(2)-w(2));
    h3 = (-mc*l*(x(4)+x(6))^2)*sin(x(3)+x(5));
    h4 = mc*g - (mc*l*(x(4)+x(6))^2)*cos(x(3)+x(5));
    h5 = (u(2)-u(1))*ld;
    h6 = x(4);
    h7 = x(6);
    h = [h1; h2; h3; h4; h5; h6; h7];

%% solving for [x_dot F]
    y = A\h;
```

```
    x_dot = y(1:6);

end
```

```
%% main code containing input values
    x = [1 0.1 deg2rad(10) deg2rad(10) deg2rad(5) deg2rad(5)];
    u = [4.8, 5.3];
    w = [2 -3];

%% drone parameters
    drone.mass_drone = 1;
    drone.mass_cup = 1;
    drone.length_cg_cup = 1;
    drone.length_cg_propeller = 1;
    drone.inertia = 1;
    drone.drag = 0.01;
    drone.gravity = 10;

%% obtaining solution x_dot from function drone_dynamics
    x_dot = drone_dynamics(x,u,w,drone)
```

The computed value is:

$$\dot{\boldsymbol{x}} = \begin{bmatrix} -0.4471\, m/s^2 & 4.8619\, m/s^2 & 0.1745\, rad/s & 0.50\, rad/s^2 & 0.0873\, rad/s & 0.3980\, rad/s^2 \end{bmatrix}$$