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```
%
% In order to run this script you need matlab_rosbag package
% https://github.com/bcharrow/matlab_rosbag (source)
% https://github.com/bcharrow/matlab_rosbag/releases (binary)
%
% In case you face the follosing linking error
% matlab_rosbag-0.5.0-mac64/rosbag_wrapper.mexmaci64,
% 6): Symbol not found: __ZTISt16invalid_argument
% try this re-compiled binary
% https://cmu.app.box.com/s/9hs153nwa19uqvzboglkz7y84r6jzzxg    or
% https://dl.dropboxusercontent.com/u/12446150/matlab_rosbag-0.5.0-
mac64_matlabR2015a.zip
% Tested platform: Mac EI Capitan 10.11.6 with MATLAB R2016a
%

path(path, '../read_bags');

path(path, '../helper_functions');

% two experiments are needed to validate the identification
bagfile_exp1 =  '2016-11-10-14-47-30.bag';
bagfile_exp2 =  '2016-11-10-14-49-11.bag';

topic_imu = '/hawk/fcu/imu';
topic_motor_speed = '/hawk/fcu/motor_speed';
topic_rcdata = '/hawk/fcu/rcdata';
topic_vicon = '/hawk/vrpn_client/estimated_transform';
topic_rpy_thrust_cmd = '/hawk/fcu/command/roll_pitch_yawrate_thrust';

bag1 = ros.Bag(bagfile_exp1);
bag2 = ros.Bag(bagfile_exp2);
```

First experriment info:

```
bag1.info
```

```

ans =

path:     2016-11-10-14-47-30.bag
version:  2.0
duration: 49.5s
start:    Nov 10 2016 14:47:30.76 (1478785650.76)
```

```
end:      Nov 10 2016 14:48:20.31 (1478785700.31)
size:     6.5 MB
messages: 24953
types:    asctec_hl_comm/DoubleArrayStamped
 [fb60495edd59d3fcf90e173153ae8a9a]
          asctec_hl_comm/GpsCustom
 [ea845c87e3fc5ff92a4bebb639327746]
          asctec_hl_comm/MotorSpeed
 [3070a95b3ba41b42ea1ab4ed7544fc82]
          asctec_hl_comm/mav_rcdata
 [2511326b0deceba64dcfc173bba8678e]
          asctec_hl_comm/mav_status
 [f975cbdf223868931f194323c62d7be5]
          diagnostic_msgs/DiagnosticArray
 [60810da900de1dd6ddd437c3503511da]
          dynamic_reconfigure/Config
 [958f16a05573709014982821e6822580]
          dynamic_reconfigure/ConfigDescription
 [757ce9d44ba8ddd801bb30bc456f946f]
          geometry_msgs/PointStamped
 [c63aecb41bfdfd6b7e1fac37c7cbe7bf]
          geometry_msgs/PoseStamped
 [d3812c3cbc69362b77dc0b19b345f8f5]
          geometry_msgs/Vector3Stamped
 [7b324c7325e683bf02a9b14b01090ec7]
          mav_msgs/RollPitchYawrateThrust
 [10a56a30857affade0889a3662fc2bc9]
          rosgraph_msgs/Log
 [acffd30cd6b6de30f120938c17c593fb]
          sensor_msgs/Imu
 [6a62c6daae103f4ff57a132d6f95cec2]
          sensor_msgs/Joy
 [5a9ea5f83505693b71e785041e67a8bb]
          sensor_msgs/NavSatFix
 [2d3a8cd499b9b4a0249fb98fd05cfa48]
          std_msgs/String
 [992ce8a1687cec8c8bd883ec73ca41d1]
          visualization_msgs/Marker
 [18326976df9d29249efc939e00342cde]
topics:   /diagnostics
                        38 msgs  : diagnostic_msgs/DiagnosticArray

          /hawk/fcu/command/roll_pitch_yawrate_thrust
                       993 msgs  : mav_msgs/RollPitchYawrateThrust

          /hawk/fcu/current_pose
                       495 msgs  : geometry_msgs/PoseStamped

          /hawk/fcu/debug
                       495 msgs  : asctec_hl_comm/DoubleArrayStamped

          /hawk/fcu/gps
                       248 msgs  : sensor_msgs/NavSatFix
          /hawk/fcu/gps_custom
                       248 msgs  : asctec_hl_comm/GpsCustom

          /hawk/fcu/imu
                      4964 msgs  : sensor_msgs/Imu

          /hawk/fcu/mag
                      4942 msgs  : geometry_msgs/Vector3Stamped

          /hawk/fcu/motor_speed
                      4942 msgs  : asctec_hl_comm/MotorSpeed

          /hawk/fcu/pressure_height
                      4962 msgs  : geometry_msgs/PointStamped

          /hawk/fcu/rc
                       995 msgs  : sensor_msgs/Joy

          /hawk/fcu/rcdata
                       995 msgs  : asctec_hl_comm/mav_rcdata

          /hawk/fcu/status
                        99 msgs  : asctec_hl_comm/mav_status

          /hawk/hawk_hl_node/fcu/parameter_descriptions
                                1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/hawk_hl_node/fcu/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/hawk_hl_node/ssdk/parameter_descriptions
                                1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/hawk_hl_node/ssdk/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/mav_nonlinear_mpc/NeuralNetworkDisturbanceObserver/
parameter_descriptions     1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/mav_nonlinear_mpc/NeuralNetworkDisturbanceObserver/
parameter_updates          1 msg   : dynamic_reconfigure/Config

          /hawk/mav_nonlinear_mpc/controller/parameter_descriptions
                           1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/mav_nonlinear_mpc/controller/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/reference_trajectory
                       497 msgs  : visualization_msgs/Marker

          /hawk/state_machine/state_info
                         3 msgs  : std_msgs/String
          /rosout
                       15 msgs  : rosgraph_msgs/Log
  (3 connections)
          /rosout_agg
                        14 msgs  : rosgraph_msgs/Log
```

Second experiment info:

```
bag2.info


ans =

path:     2016-11-10-14-49-11.bag
version:  2.0
duration: 42.7s
start:    Nov 10 2016 14:49:11.71 (1478785751.71)
end:      Nov 10 2016 14:49:54.41 (1478785794.41)
size:     5.6 MB
messages: 21503
types:    asctec_hl_comm/DoubleArrayStamped
 [fb60495edd59d3fcf90e173153ae8a9a]
          asctec_hl_comm/GpsCustom
 [ea845c87e3fc5ff92a4bebb639327746]
          asctec_hl_comm/MotorSpeed
 [3070a95b3ba41b42ea1ab4ed7544fc82]
          asctec_hl_comm/mav_rcdata
 [2511326b0deceba64dcfc173bba8678e]
          asctec_hl_comm/mav_status
 [f975cbdf223868931f194323c62d7be5]
          diagnostic_msgs/DiagnosticArray
 [60810da900de1dd6ddd437c3503511da]
          dynamic_reconfigure/Config
 [958f16a05573709014982821e6822580]
          dynamic_reconfigure/ConfigDescription
 [757ce9d44ba8ddd801bb30bc456f946f]
          geometry_msgs/PointStamped
 [c63aecb41bfdfd6b7e1fac37c7cbe7bf]
          geometry_msgs/PoseStamped
 [d3812c3cbc69362b77dc0b19b345f8f5]
          geometry_msgs/Vector3Stamped
 [7b324c7325e683bf02a9b14b01090ec7]
          mav_msgs/RollPitchYawrateThrust
 [10a56a30857affade0889a3662fc2bc9]
          rosgraph_msgs/Log
 [acffd30cd6b6de30f120938c17c593fb]
          sensor_msgs/Imu
 [6a62c6daae103f4ff57a132d6f95cec2]
          sensor_msgs/Joy
 [5a9ea5f83505693b71e785041e67a8bb]
          sensor_msgs/NavSatFix
 [2d3a8cd499b9b4a0249fb98fd05cfa48]
```

```
          std_msgs/String
 [992ce8a1687cec8c8bd883ec73ca41d1]
          visualization_msgs/Marker
 [18326976df9d29249efc939e00342cde]
topics:   /diagnostics
                        32 msgs  : diagnostic_msgs/DiagnosticArray

          /hawk/fcu/command/roll_pitch_yawrate_thrust
                       857 msgs  : mav_msgs/RollPitchYawrateThrust

          /hawk/fcu/current_pose
                       426 msgs  : geometry_msgs/PoseStamped

          /hawk/fcu/debug
                       426 msgs  : asctec_hl_comm/DoubleArrayStamped

          /hawk/fcu/gps
                       214 msgs  : sensor_msgs/NavSatFix

          /hawk/fcu/gps_custom
                       214 msgs  : asctec_hl_comm/GpsCustom

          /hawk/fcu/imu
                      4285 msgs  : sensor_msgs/Imu

          /hawk/fcu/mag
                      4261 msgs  : geometry_msgs/Vector3Stamped

          /hawk/fcu/motor_speed
                      4252 msgs  : asctec_hl_comm/MotorSpeed

          /hawk/fcu/pressure_height
                      4272 msgs  : geometry_msgs/PointStamped

          /hawk/fcu/rc
                       857 msgs  : sensor_msgs/Joy

          /hawk/fcu/rcdata
                       857 msgs  : asctec_hl_comm/mav_rcdata

          /hawk/fcu/status
                        85 msgs  : asctec_hl_comm/mav_status

          /hawk/hawk_hl_node/fcu/parameter_descriptions
                                the1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/hawk_hl_node/fcu/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/hawk_hl_node/ssdk/parameter_descriptions
                                1 msg   : dynamic_reconfigure/
ConfigDescription
```

```
          /hawk/hawk_hl_node/ssdk/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/mav_nonlinear_mpc/NeuralNetworkDisturbanceObserver/
parameter_descriptions     1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/mav_nonlinear_mpc/NeuralNetworkDisturbanceObserver/
parameter_updates          1 msg   : dynamic_reconfigure/Config

          /hawk/mav_nonlinear_mpc/controller/parameter_descriptions
                           1 msg   : dynamic_reconfigure/
ConfigDescription
          /hawk/mav_nonlinear_mpc/controller/parameter_updates
                         1 msg   : dynamic_reconfigure/Config

          /hawk/reference_trajectory
                       428 msgs  : visualization_msgs/Marker

          /hawk/state_machine/state_info
                         3 msgs  : std_msgs/String

          /rosout
                       16 msgs  : rosgraph_msgs/Log
  (3 connections)
          /rosout_agg
                        10 msgs  : rosgraph_msgs/Log
```

```
Experiment1.IMU = readImu(bag1, topic_imu);
Experiment2.IMU = readImu(bag2, topic_imu);
% Experiment1.MotorSpeed = readMotorSpeed(bag1, topic_motor_speed);
% Experiment2.MotorSpeed = readMotorSpeed(bag2, topic_motor_speed);
% Experiment1.Vicon = readTransformStamped(bag1, topic_vicon);
% Experiment2.Vicon = readTransformStamped(bag2, topic_vicon);
% Experiment1.RCData = readRCData(bag1, topic_rcdata);
% Experiment2.RCData = readRCData(bag2, topic_rcdata);
Experiment1.rpy_cmd = readCommnadRollPitchYawRateThrust(bag1,
 topic_rpy_thrust_cmd);
Experiment2.rpy_cmd = readCommnadRollPitchYawRateThrust(bag2,
 topic_rpy_thrust_cmd);

% Write the quaternions from VICON properly

% Experiment1.Vicon.q = [Experiment1.Vicon.q(4,:);
 Experiment1.Vicon.q(1,:);...
%     Experiment1.Vicon.q(2,:); Experiment1.Vicon.q(3,:)];
Experiment1.IMU.q = [Experiment1.IMU.q(4,:);
 Experiment1.IMU.q(1,:); ...
    Experiment1.IMU.q(2,:); Experiment1.IMU.q(3,:)];
% Experiment2.Vicon.q = [Experiment2.Vicon.q(4,:);
 Experiment2.Vicon.q(1,:);...
%     Experiment2.Vicon.q(2,:); Experiment2.Vicon.q(3,:)];
```

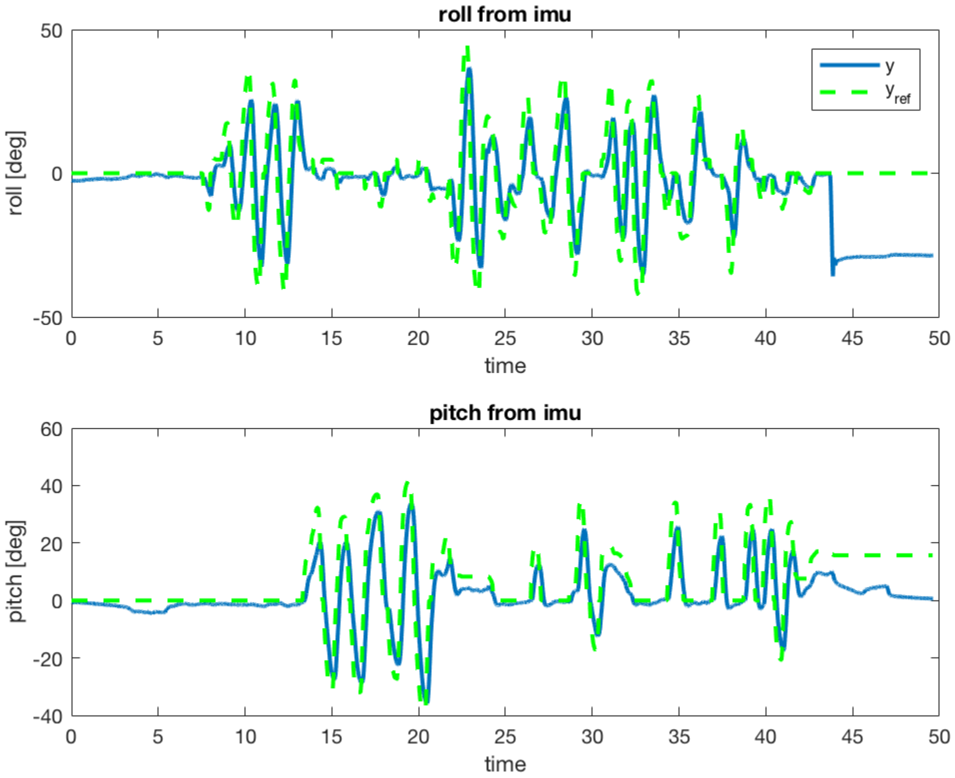
```
Experiment2.IMU.q = [Experiment2.IMU.q(4,:);
 Experiment2.IMU.q(1,:); ...
    Experiment2.IMU.q(2,:); Experiment2.IMU.q(3,:)];


% Experiment1.rpy = quat2rpy(Experiment1.Vicon.q);
Experiment1.rpy_imu = quat2rpy(Experiment1.IMU.q);

% Experiment2.rpy = quat2rpy(Experiment2.Vicon.q);
Experiment2.rpy_imu = quat2rpy(Experiment2.IMU.q);



%time from 0
% Experiment1.Vicon.t = Experiment1.Vicon.t - Experiment1.Vicon.t(1);
% Experiment1.RCData.t = Experiment1.RCData.t -
 Experiment1.RCData.t(1);
Experiment1.IMU.t = Experiment1.IMU.t - Experiment1.IMU.t(1);
Experiment1.rpy_cmd.t = Experiment1.rpy_cmd.t -
 Experiment1.rpy_cmd.t(1);

% Experiment2.Vicon.t = Experiment2.Vicon.t - Experiment2.Vicon.t(1);
% Experiment2.RCData.t = Experiment2.RCData.t -
 Experiment2.RCData.t(1);
Experiment2.IMU.t = Experiment2.IMU.t - Experiment2.IMU.t(1);
Experiment2.rpy_cmd.t = Experiment2.rpy_cmd.t -
 Experiment2.rpy_cmd.t(1);


 %commands
% This conversion is not fixed, change it accordingly
```

Plot position from experiment 1

```
close all;
% figure(1);
% title('Experiment 1 Data');
% subplot(3,1,1);
% plot(Experiment1.Vicon.t, Experiment1.Vicon.p(1,:), 'linewidth', 2);
% xlabel('time');
% ylabel('x [m]');
% title('x from vicon');
%
% subplot(3,1,2);
% plot(Experiment1.Vicon.t, Experiment1.Vicon.p(2,:), 'linewidth', 2);
% xlabel('time');
% ylabel('y [m]');
% title('y from vicon');
%
% subplot(3,1,3);
% plot(Experiment1.Vicon.t, Experiment1.Vicon.p(3,:), 'linewidth', 2);
% xlabel('time');
% ylabel('z [m]');
% title('z from vicon');
```

Plot attitude from experiment 1

```
figure(2);
title('Experiment 1 Data');
subplot(2,1,1);
plot(Experiment1.IMU.t, Experiment1.rpy_imu(1,:)*180/pi, ...
    Experiment1.rpy_cmd.t, Experiment1.rpy_cmd.roll*180/pi, ...
    'g--', 'linewidth', 2);

xlabel('time');
legend('y','y_{ref}');
ylabel('roll [deg]');
title('roll from imu');

subplot(2,1,2);
plot(Experiment1.IMU.t, Experiment1.rpy_imu(2,:)*180/pi, ...
    Experiment1.rpy_cmd.t, Experiment1.rpy_cmd.pitch*180/pi, ...
    'g--', 'linewidth', 2);

xlabel('time');
ylabel('pitch [deg]');
title('pitch from imu');
```



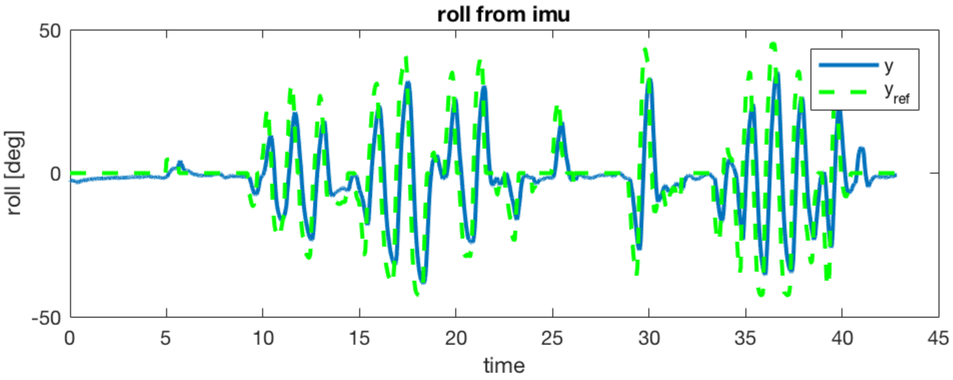
Plot position from experiment 2 figure(3); title('Experiment 2 Data'); subplot(3,1,1); plot(Experiment2.Vicon.t, Experiment2.Vicon.p(1,:), 'linewidth', 2); xlabel('time'); ylabel('x [m]'); title('x from vicon');

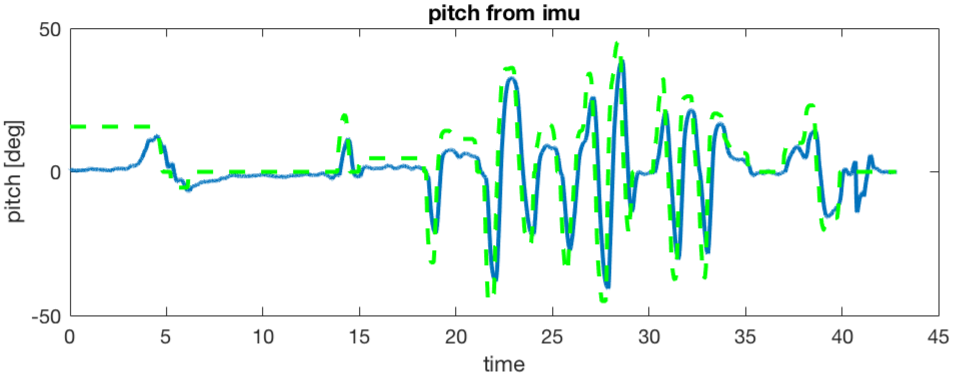
subplot(3,1,2); plot(Experiment2.Vicon.t, Experiment2.Vicon.p(2,:), 'linewidth', 2); xlabel('time'); ylabel('y [m]'); title('y from vicon');

subplot(3,1,3); plot(Experiment2.Vicon.t, Experiment2.Vicon.p(3,:), 'linewidth', 2); xlabel('time'); ylabel('z [m]'); title('z from vicon');

Plot attitude from experiment 2

```
figure(4);
title('Experiment 2 Data');
subplot(2,1,1);
plot(Experiment2.IMU.t, Experiment2.rpy_imu(1,:)*180/pi, ...
    Experiment2.rpy_cmd.t, Experiment2.rpy_cmd.roll*180/pi,...
    'g--', 'linewidth', 2);

legend('y','y_{ref}');
xlabel('time');
ylabel('roll [deg]');
title('roll from imu');

subplot(2,1,2);
plot(Experiment2.IMU.t, Experiment2.rpy_imu(2,:)*180/pi, ...
    Experiment2.rpy_cmd.t, Experiment2.rpy_cmd.pitch*180/pi, ...
    'g--', 'linewidth', 2);

xlabel('time');
ylabel('pitch [deg]');
title('pitch from imu');
```





Identification of roll system

```
if length(Experiment1.IMU.t) > length(Experiment1.rpy_cmd.t)
    Experiment1.t = Experiment1.IMU.t;
else
    Experiment1.t = Experiment1.rpy_cmd.t;
end

Experiment1.u1 = interp1(Experiment1.rpy_cmd.t,
 Experiment1.rpy_cmd.roll, Experiment1.t);
Experiment1.y1 = interp1(Experiment1.IMU.t, Experiment1.rpy_imu(1,:),
 Experiment1.t);

Experiment1.Ts = mean(diff(Experiment1.t));



if length(Experiment2.IMU.t) > length(Experiment2.rpy_cmd.t)
    Experiment2.t = Experiment2.IMU.t;
else
    Experiment2.t = Experiment2.rpy_cmd.t;
end

Experiment2.u1 = interp1(Experiment2.rpy_cmd.t,
 Experiment2.rpy_cmd.roll, Experiment2.t);
```

```
Experiment2.y1 = interp1(Experiment2.IMU.t, Experiment2.rpy_imu(1,:),
 Experiment2.t);

Experiment2.Ts = mean(diff(Experiment2.t));
```

get rid of first and last 10 seconds (to remove ground and transient effects)

```
Experiment1.u1 = Experiment1.u1(Experiment1.t>10 & ...
    Experiment1.t < Experiment1.t(end)-10);
Experiment1.y1 = Experiment1.y1(Experiment1.t>10 &...
    Experiment1.t < Experiment1.t(end)-10);
%Experiment1.t = Experiment1.t(Experiment1.t>10 & Experiment1.t <
 Experiment1.t(end)-10);

roll_data1 =
 iddata(Experiment1.y1',Experiment1.u1',Experiment1.Ts, ...
    'ExperimentName', 'FireFlySysID_1', 'InputName','roll_{cmd}', ...
    'OutputName','roll', 'InputUnit','rad', 'OutputUnit','rad', ...
    'TimeUnit','Second');

roll_data1 = detrend(roll_data1);



%get rid of first and last 10 seconds (to remove ground and transient
 effects)
Experiment2.u1 = Experiment2.u1(Experiment2.t>10 &...
    Experiment2.t < Experiment2.t(end)-10);
Experiment2.y1 = Experiment2.y1(Experiment2.t>10 &...
    Experiment2.t < Experiment2.t(end)-10);

roll_data2 = iddata(Experiment2.y1',Experiment2.u1',Experiment2.Ts,...
    'ExperimentName', 'FireFlySysID_2', 'InputName','roll_{cmd}',...
    'OutputName','roll', 'InputUnit','rad', 'OutputUnit','rad',...
    'TimeUnit','Second');

roll_data2 = detrend(roll_data2);
```

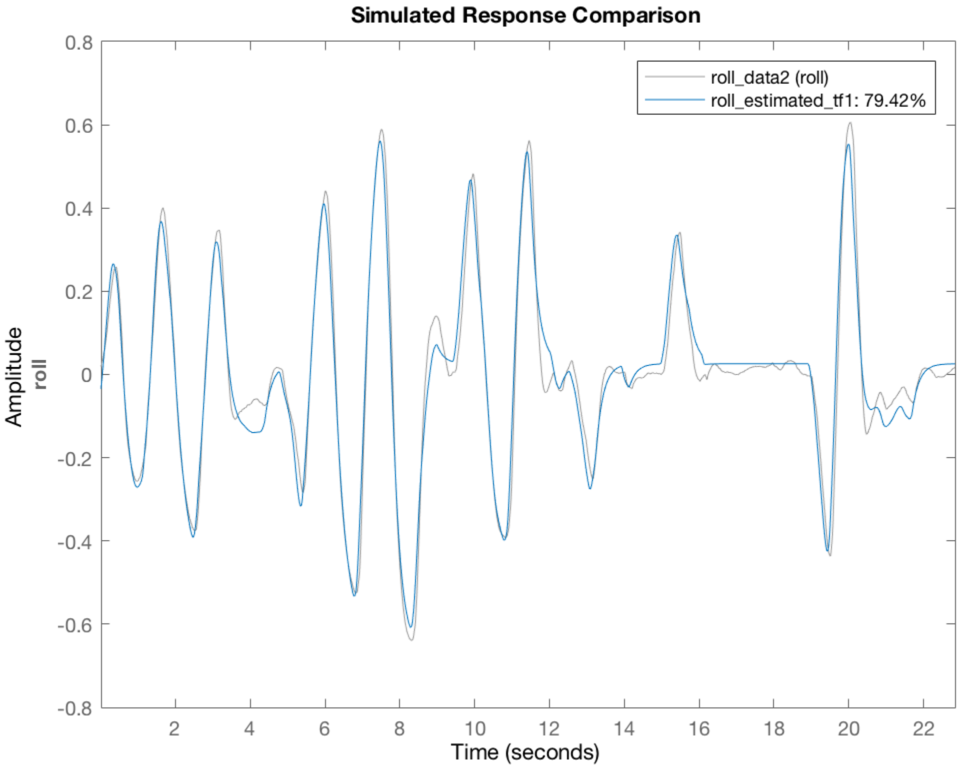
At this point we have 3 options!

1. Estimate a model from both experiments - but cannot validate it on independent dataset
2. Estimate a model from Exp1 and validate it on data from Exp2
3. Estimate a model from Exp2 and validate it on data from Exp1

```
%For now we choose the best model from options 2 and 3


%Assume 2nd order system
np = 1;
nz = 0;

%Generate model using Experiment1 and validate the model with
 Experiment2
```

```
roll_estimated_tf1 = tfest(roll_data1,np, nz);

[~, fit1, ~] = compare(roll_data2, roll_estimated_tf1);

%Generate model using Experiment2 and validate the model with
 Experiment1
roll_estimated_tf2 = tfest(roll_data2,np, nz);

[~, fit2, ~] = compare(roll_data1, roll_estimated_tf2);

if fit1>fit2
    %We pick the first Identification
    roll_estimated_tf = roll_estimated_tf1;
    disp('The roll model is estimated using experiment 1 and validated
 on data from experiment 2');
    figure;
    compare(roll_data2, roll_estimated_tf1);
    disp(strcat('The roll model fits the validation data with **',...
        num2str(fit1), '** %'));
else
    %We pick the second Identification
    roll_estimated_tf = roll_estimated_tf2;
    disp('The roll model is estimated using experiment 2 and validated
 on data from experiment 1');
    figure;
    compare(roll_data1, roll_estimated_tf2);
    disp(strcat('The roll model fits the validation data with **',...
        num2str(fit2), '** %'));
end
```

```
The roll model is estimated using experiment 1 and validated on data
 from experiment 2
The roll model fits the validation data with **79.4238** %
```



Identification of Pitch System

```
Experiment1.u2 = interp1(Experiment1.rpy_cmd.t,
 Experiment1.rpy_cmd.pitch, Experiment1.t);
Experiment1.y2 = interp1(Experiment1.IMU.t, Experiment1.rpy_imu(2,:),
 Experiment1.t);

Experiment2.u2 = interp1(Experiment2.rpy_cmd.t,
 Experiment2.rpy_cmd.pitch, Experiment2.t);
Experiment2.y2 = interp1(Experiment2.IMU.t, Experiment2.rpy_imu(2,:),
 Experiment2.t);

%get rid of first and last 10 seconds (to remove ground and transient
 effects)
Experiment1.u2 = Experiment1.u2(Experiment1.t>10 &...
    Experiment1.t < Experiment1.t(end)-10);
Experiment1.y2 = Experiment1.y2(Experiment1.t>10 &...
    Experiment1.t < Experiment1.t(end)-10);
Experiment1.t = Experiment1.t(Experiment1.t>10 &...
    Experiment1.t < Experiment1.t(end)-10);

pitch_data1 =
 iddata(Experiment1.y2',Experiment1.u2',Experiment1.Ts,...
    'ExperimentName', 'FireFlySysID_1', 'InputName','pitch_{cmd}',...
    'OutputName','pitch', 'InputUnit','rad', 'OutputUnit','rad',...
    'TimeUnit','Second');
```

```
%remove any trend in the data
pitch_data1 = detrend(pitch_data1);
```

```
%get rid of first and last 10 seconds (to remove ground and transient
 effects)
Experiment2.u2 = Experiment2.u2(Experiment2.t>10 &...
    Experiment2.t < Experiment2.t(end)-10);
Experiment2.y2 = Experiment2.y2(Experiment2.t>10 &...
    Experiment2.t < Experiment2.t(end)-10);
Experiment2.t = Experiment2.t(Experiment2.t>10 &...
    Experiment2.t < Experiment2.t(end)-10);

pitch_data2 =
 iddata(Experiment2.y2',Experiment2.u2',Experiment2.Ts, ...
    'ExperimentName', 'FireFlySysID_2', 'InputName','pitch_{cmd}',...
    'OutputName','pitch', 'InputUnit','rad', 'OutputUnit','rad', ...
    'TimeUnit','Second');
pitch_data2 = detrend(pitch_data2);
```

At this point we have 3 options!

1. Estimate a model from both experiments - but cannot validate it on independent dataset

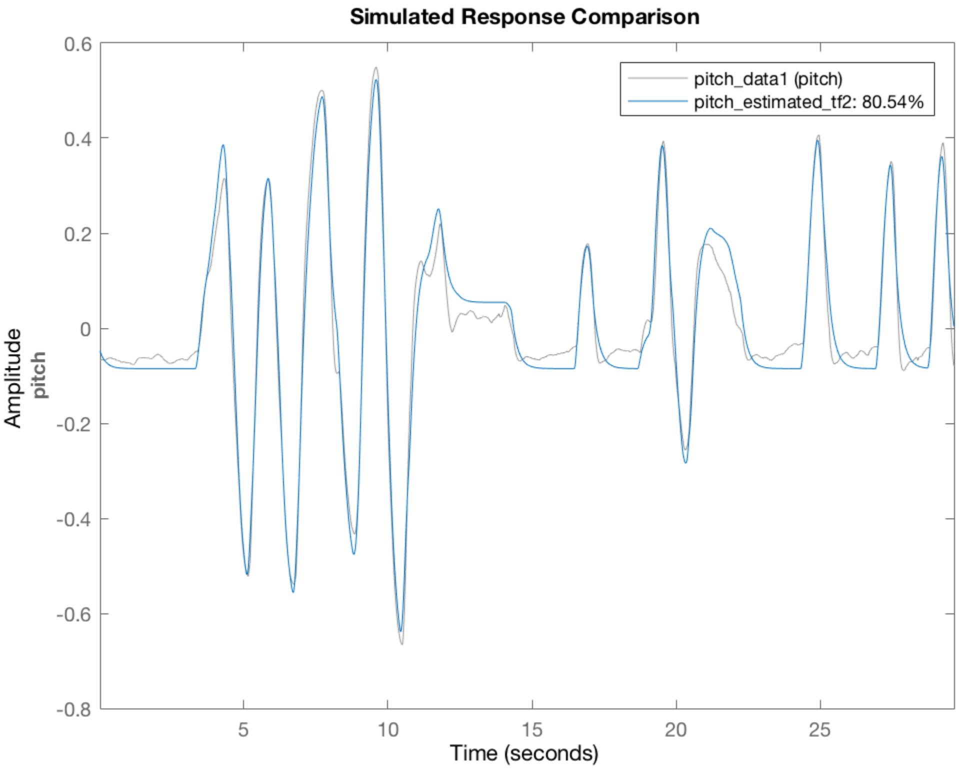
2. Estimate a model from Exp1 and validate it on data from Exp2

3. Estimate a model from Exp2 and validate it on data from Exp1

```
%For now we choose the best model from options 2 and 3

%Assume 2nd order system
np = 1;
nz = 0;

%Generate model using Experiment1 and validate the model with
 Experiment2
pitch_estimated_tf1 = tfest(pitch_data1,np, nz);

[~, fit1, ~] = compare(pitch_data2, pitch_estimated_tf1);

%Generate model using Experiment2 and validate the model with
 Experiment1
pitch_estimated_tf2 = tfest(pitch_data2,np, nz);

[~, fit2, ~] = compare(pitch_data1, pitch_estimated_tf2);

if fit1>fit2
    %We pick the first Identification
    pitch_estimated_tf = pitch_estimated_tf1;
    disp('The pitch model is estimated using experiment 1 and
 validated on data from experiment 2');
```

```
    figure;
    compare(pitch_data2, pitch_estimated_tf1);
    disp(strcat('The pitch model fits the validation data with
 **', ...
        num2str(fit1), '** %'));
else
    %We pick the second Identification
    pitch_estimated_tf = pitch_estimated_tf2;
    disp('The pitch model is estimated using experiment 2 and
 validated on data from experiment 1');
    figure;
    compare(pitch_data1, pitch_estimated_tf2);
    disp(strcat('The pitch model fits the validation data with
 **', ...
        num2str(fit2), '** %'));
end
```

```
The pitch model is estimated using experiment 2 and validated on data
 from experiment 1
The pitch model fits the validation data with **80.5397** %
```



Estimate the Whole System as 2-input 2-output MIMO System

The purpose here is to see of there is coupling

```
Experiment2.Ts = Experiment1.Ts;
Data1 = iddata([Experiment1.y1', Experiment1.y2'], ...
    [Experiment1.u1', Experiment1.u2'], Experiment1.Ts, ...
    'ExperimentName', 'FireFlySysID_1', ...
    'InputName',{'roll_{cmd}','pitch_{cmd}'},...
    'OutputName',{'roll','pitch'}', ...
    'InputUnit',{'rad', 'rad'},...
    'OutputUnit',{'rad', 'rad'},...
    'TimeUnit','Second');



Data2 = iddata([Experiment2.y1', Experiment2.y2'], ...
    [Experiment2.u1', Experiment2.u2'], Experiment2.Ts, ...
    'ExperimentName', 'FireFlySysID_2', ...
    'InputName',{'roll_{cmd}','pitch_{cmd}'},...
    'OutputName',{'roll','pitch'}', ...
    'InputUnit',{'rad', 'rad'},...
    'OutputUnit',{'rad', 'rad'}, ...
    'TimeUnit','Second');


MergedData = merge(Data1, Data2);

np = 2;
nz = 0;
Full_estimated_tf = tfest(MergedData, np,nz);

figure;
bodemag(Full_estimated_tf);
```

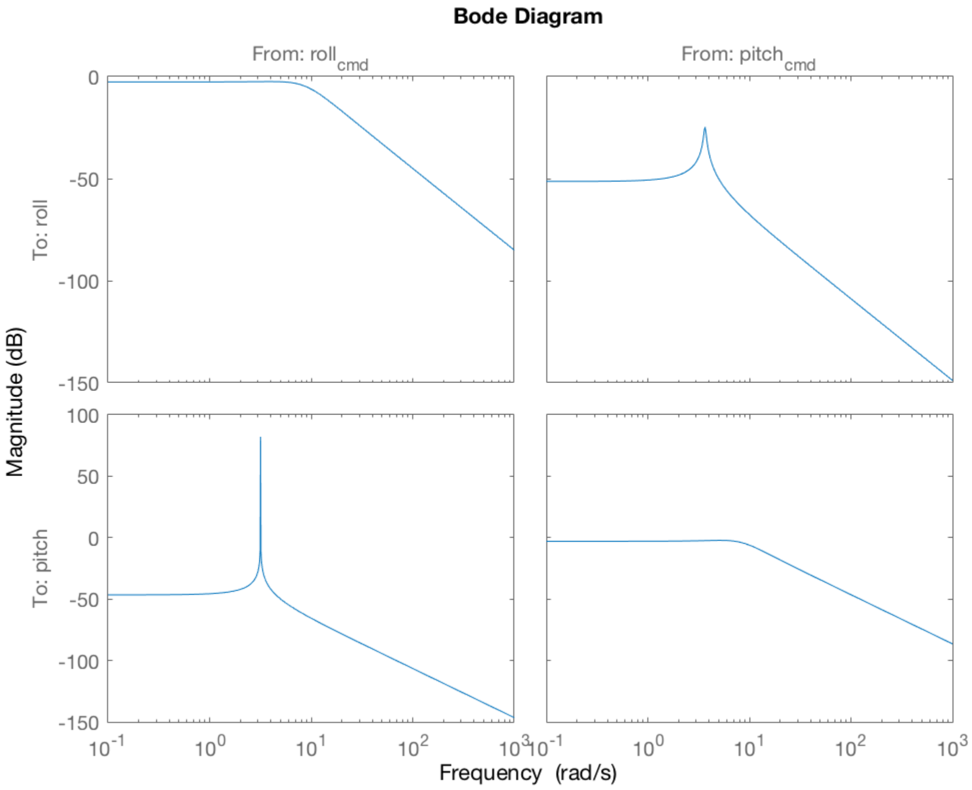
Estimated Transfer Functions

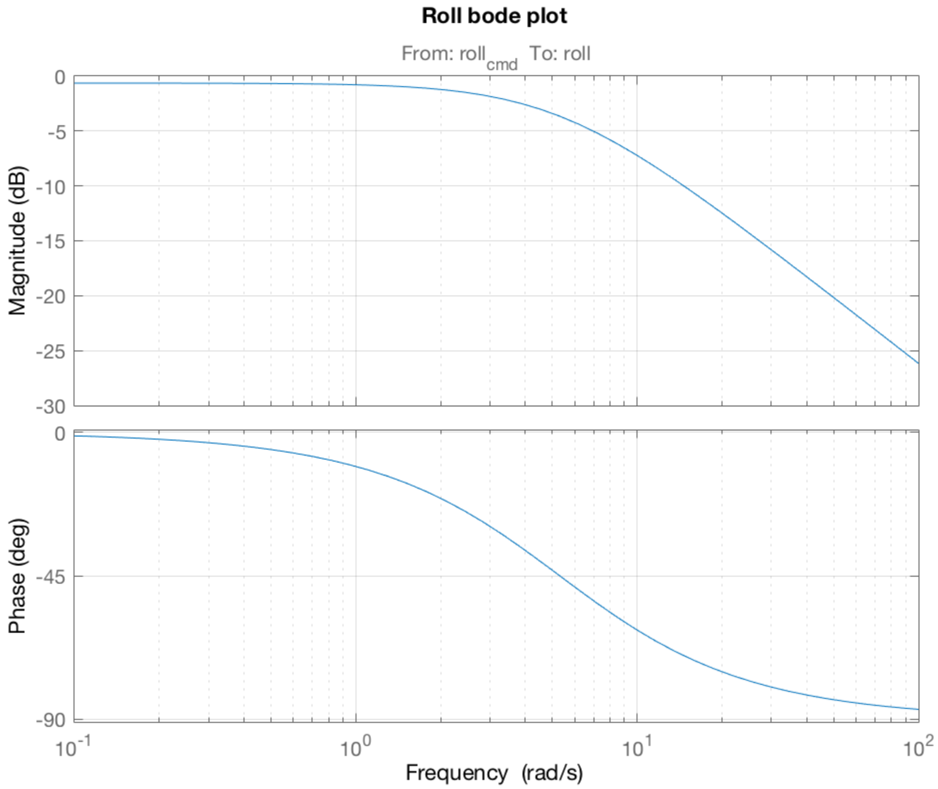
```
disp('Roll estimated transfer function is: ');
    tf(roll_estimated_tf)
disp('Roll time constant is: ')
    disp(1/abs(pole(roll_estimated_tf)));
disp('Roll gain is: ');
    disp(dcgain(roll_estimated_tf));

figure;
bode(roll_estimated_tf); grid;
title('Roll bode plot');

disp('Pitch estimated transfer function is: ');
    tf(pitch_estimated_tf)
disp('Pitch time constant is: ')
    disp(1/abs(pole(pitch_estimated_tf)));
disp('Pitch gain is: ');
    disp(dcgain(pitch_estimated_tf));
figure;
bode(pitch_estimated_tf); grid;
title('Pitch bode plot');
```

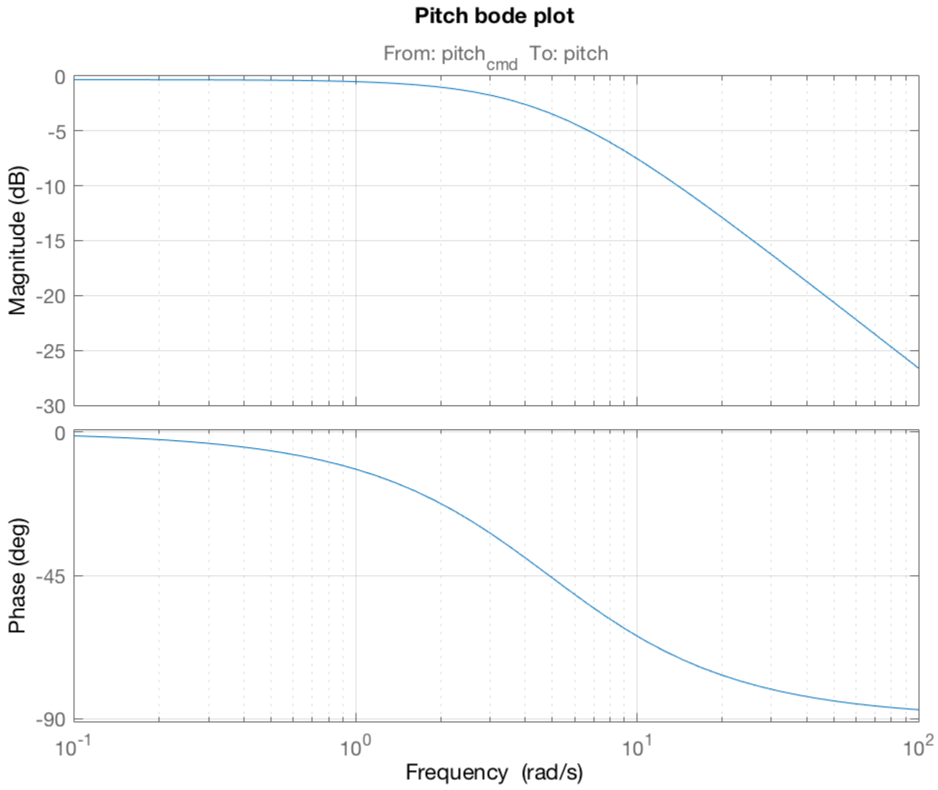
```
% %% Compute total acceleration
%
% N1 = length(Experiment1.Vicon.t);
% Experiment1.Acc = zeros(3,N1);
% N2 = length(Experiment2.Vicon.t);
% Experiment2.Acc = zeros(3,N2);
%
%
% for i=3:N1-2
%     Experiment1.Acc(:,i) = (Experiment1.Vicon.p(:,i+2)...
%         - 2*Experiment1.Vicon.p(:,i) ...
%         + Experiment1.Vicon.p(:,i-2))/(2*Experiment1.Ts^2);
% end
% for i=3:N2-2
%     Experiment2.Acc(:,i) = (Experiment2.Vicon.p(:,i+2)...
%         - 2*Experiment2.Vicon.p(:,i) ...
%         + Experiment2.Vicon.p(:,i-2))/(2*Experiment2.Ts^2);
% end
%
% T1x = diag(sqrt(Experiment1.Acc(1,:)'*Experiment1.Acc(1,:)));
% T1y = diag(sqrt(Experiment1.Acc(2,:)'*Experiment1.Acc(2,:)));
% T1z = diag(sqrt(Experiment1.Acc(3,:)'*Experiment1.Acc(3,:))) + 9.81;
%
% T1_mod = sqrt(T1x.^2 + T1y.^2 + T1z.^2);
%
% T2x = diag(sqrt(Experiment2.Acc(1,:)'*Experiment2.Acc(1,:)));
% T2y = diag(sqrt(Experiment2.Acc(2,:)'*Experiment2.Acc(2,:)));
% T2z = diag(sqrt(Experiment2.Acc(3,:)'*Experiment2.Acc(3,:))) + 9.81;
%
% T2_mod = sqrt(T2x.^2 + T2y.^2 + T2z.^2);
%
% sqr_motor_speed_sum1 =
 sum((Experiment1.MotorSpeed.motor_speed*2*pi).^2,1);
% sqr_motor_speed_sum2 =
 sum((Experiment2.MotorSpeed.motor_speed*2*pi).^2,1);
```

```
Roll estimated transfer function is:

ans =

  From input "roll_{cmd}" to output "roll":
   4.927
  -------
  s + 5.3

Continuous-time transfer function.

Roll time constant is:
    0.1887

Roll gain is:
    0.9295
```

```
Pitch estimated transfer function is:

ans =

  From input "pitch_{cmd}" to output "pitch":
    4.674
  ---------
  s + 4.854

Continuous-time transfer function.

Pitch time constant is:
    0.2060

Pitch gain is:
    0.9628
```




Roll bode plot
From: roll$_{cmd}$ To: roll
Magnitude (dB)
0
-5
-10
-15
-20
-25
-30
Phase (deg)
0
-45
-90
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)


Pitch bode plot
From: pitch$_{cmd}$ To: pitch
Magnitude (dB)
0
-5
-10
-15
-20
-25
-30
Phase (deg)
0
-45
-90
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)

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