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## Table of Contents

.....	1
Identification of roll system .....	10
Identification of Pitch System .....	13
Estimate the Whole System as 2-input 2-output MIMO System .....	15
Estimated Transfer Functions .....	16

```
%
% 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/9hs153nwa19uqvzboglcz7y84r6jzzxg 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

```

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```

/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

```

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```
      /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
          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
            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');

```

---

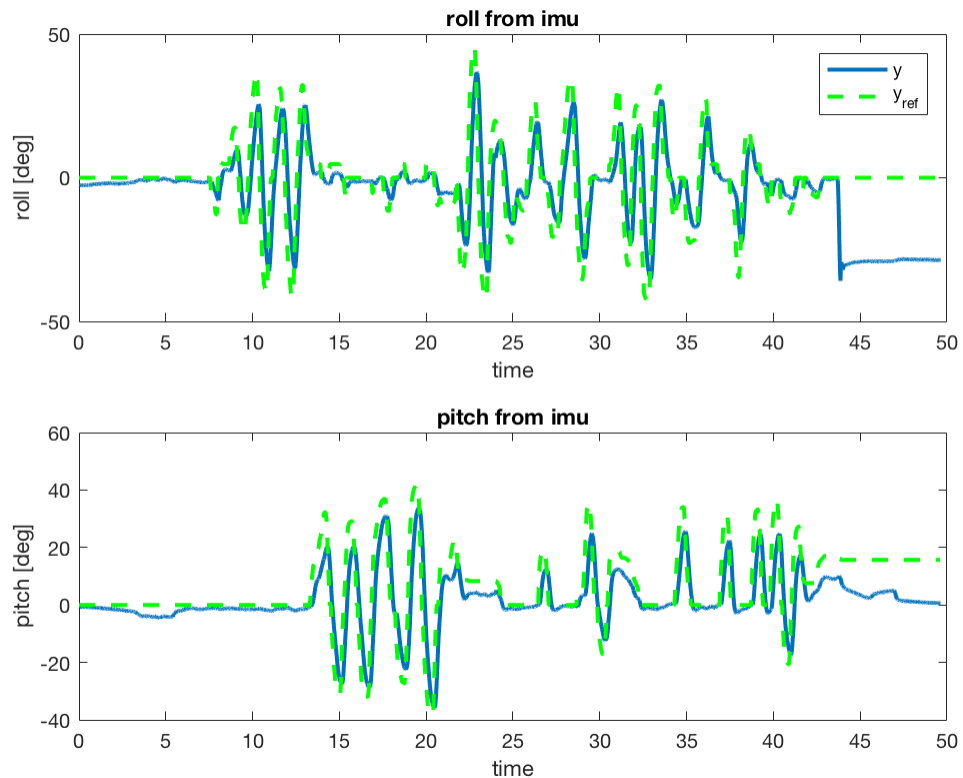
### Plot attitude from experiment 1

```
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');



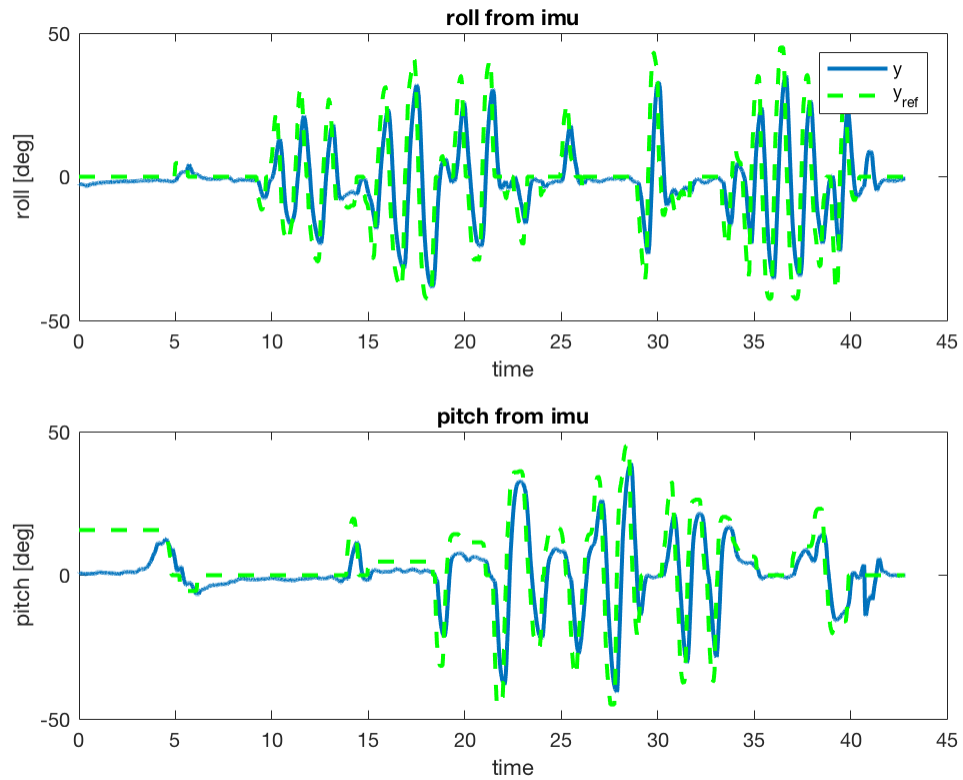
---

```
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);

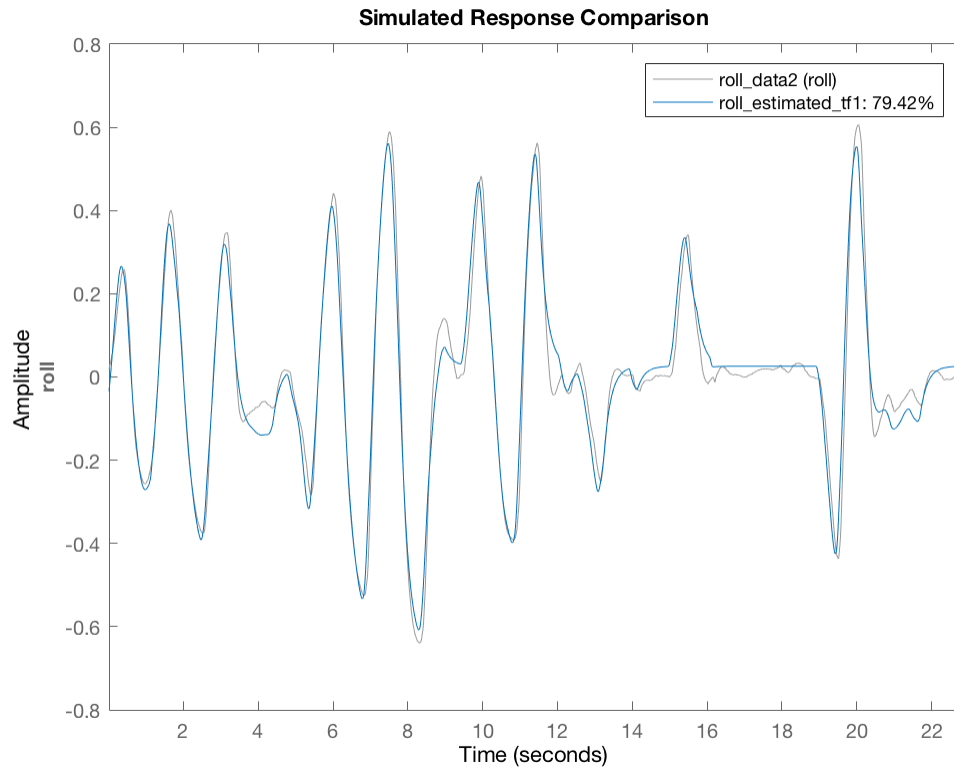
%Generate model using Experiment2 and validate the model with
Experiment1
roll_estimated_tf2 = tfest(roll_data2,np, nz);

[~, 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');

```

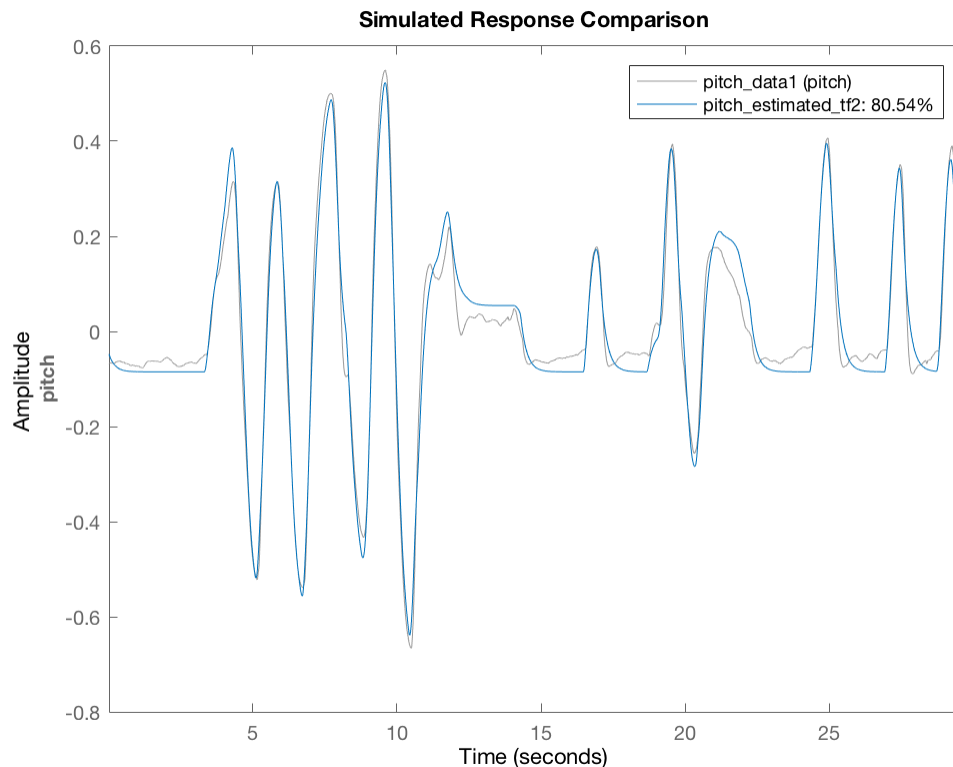
```

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

disp('Pitch estimated transfer function is: ');
tf(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.*

*Pitch estimated transfer function is:*

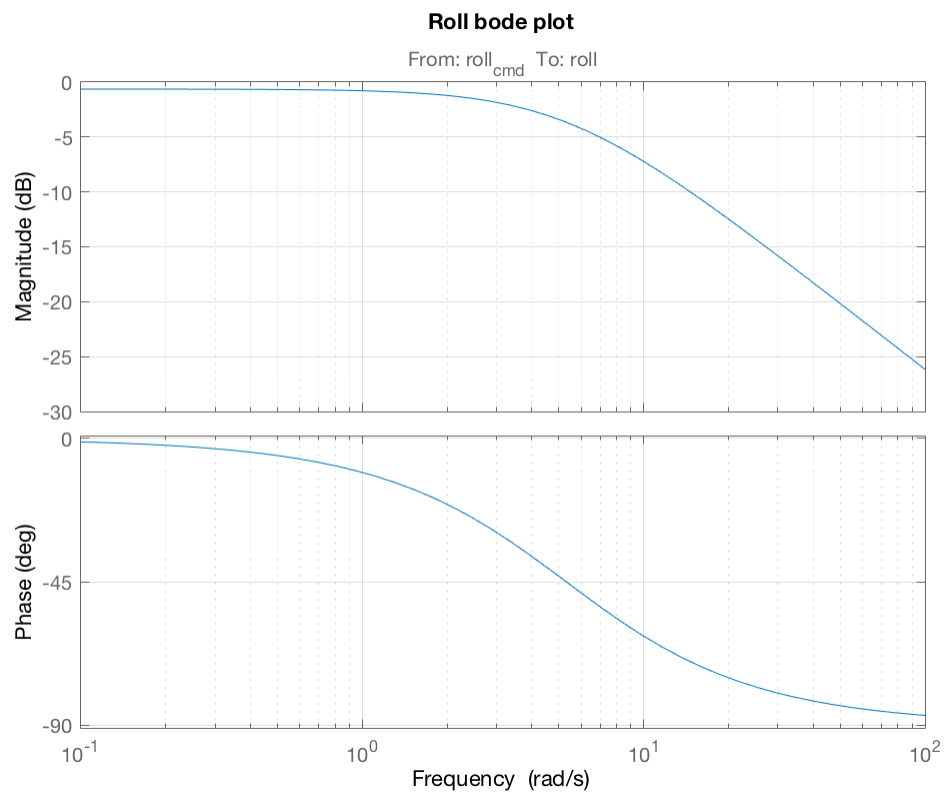
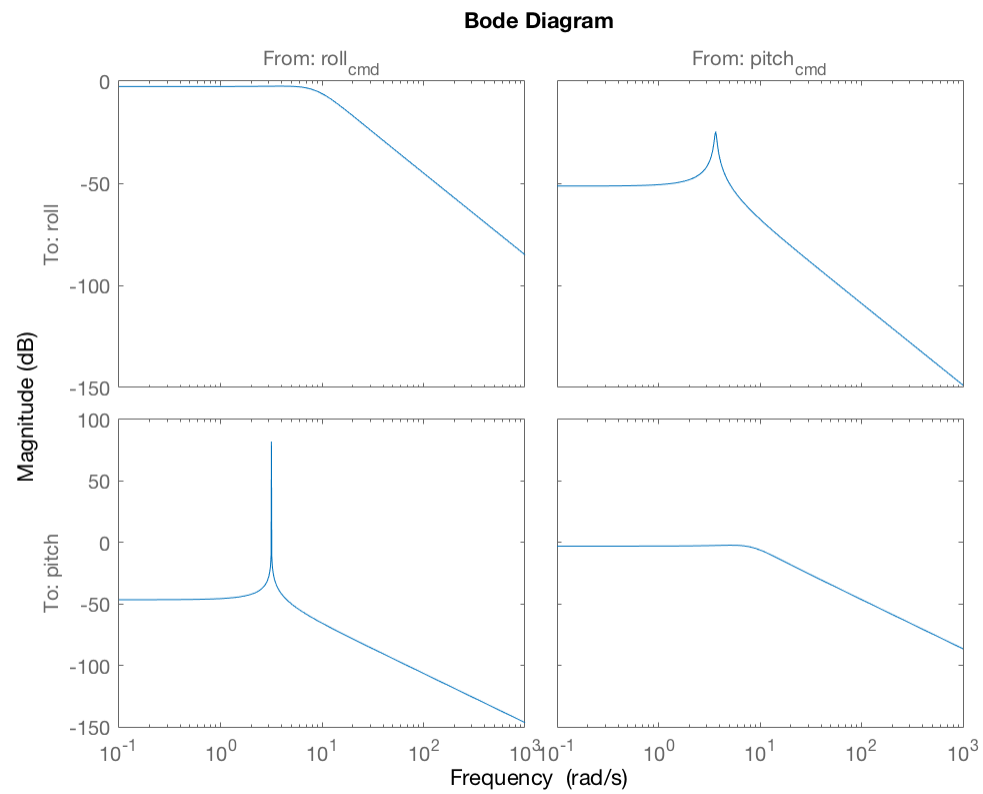
*ans =*

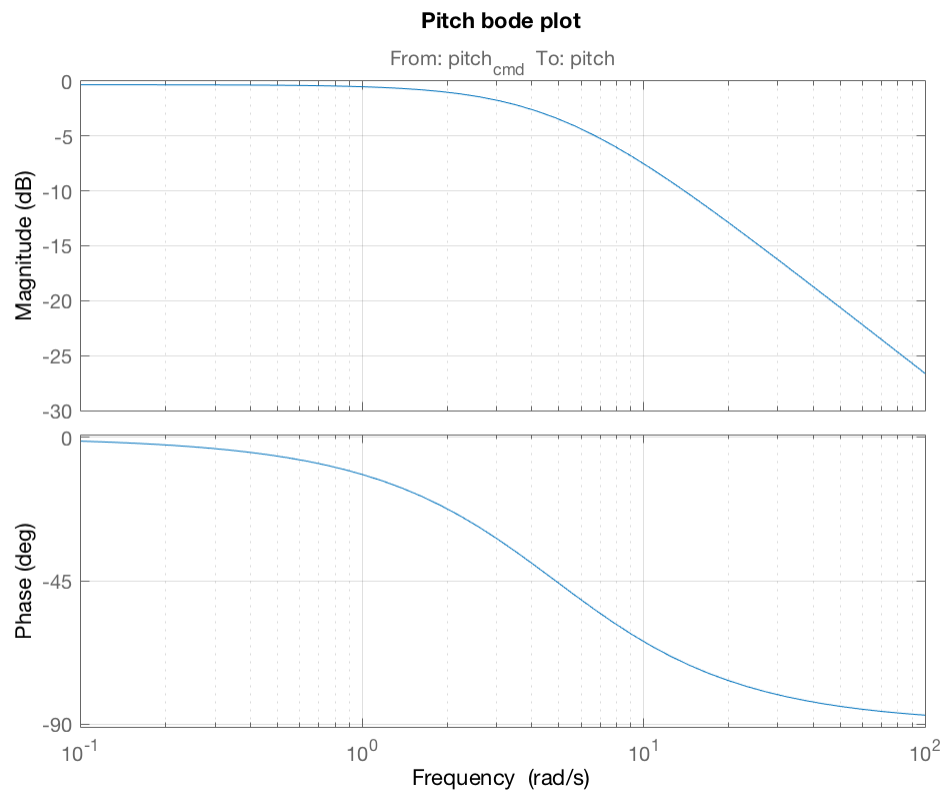
```

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

```

*Continuous-time transfer function.*





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