Table of Contents

```
clc
clear all

z31 = zeros(3,1);
z_151 = zeros(15,1);
```

pos

```
syms px_n py_n pz_n real
p_hat = [px_n; py_n; pz_n];
syms d_px_n d_py_n d_pz_n real
d_p = [d_px_n; d_py_n; d_pz_n];
p = p_hat + d_p
```

$p =$

```
 d_px_n + px_n
 d_py_n + py_n
 d_pz_n + pz_n
```

vel

```
syms vx_n vy_n vz_n real
v_hat = [vx_n; vy_n; vz_n];
syms d_vx_n d_vy_n d_vz_n real
d_v = [d_vx_n; d_vy_n; d_vz_n];

v = v_hat + d_v
```

$v =$

```
 d_vx_n + vx_n
 d_vy_n + vy_n
 d_vz_n + vz_n
```

acc

```
syms b_accx_b b_accy_b b_accz_b real
b_acc_b_hat = [b_accx_b; b_accy_b; b_accz_b];
syms d_b_accx_b d_b_accy_b d_b_accz_b real
d_b_acc = [d_b_accx_b; d_b_accy_b; d_b_accz_b];

b_acc_b = b_acc_b_hat + d_b_acc


b_acc_b =

 b_accx_b + d_b_accx_b
 b_accy_b + d_b_accy_b
 b_accz_b + d_b_accz_b
```

att

```
syms d_theta_x d_theta_y d_theta_z real
d_theta = [d_theta_x; d_theta_y; d_theta_z];
d_R = eye(3) + Smtrx(d_theta)
%syms q_w q_x q_y q_z real
%q = [q_w; q_x; q_y; q_z];
%R_hat = quat2rotMat_fast(q )
syms R11 R12 R13 R21 R22 R23 R31 R32 R33 real
R_hat = [...
    R11 R12 R13;
    R21 R22 R23;
    R31 R32 R33 ]
R = R_hat*d_R;


d_R =

[        1, -d_theta_z,  d_theta_y]
[  d_theta_z,         1, -d_theta_x]
[ -d_theta_y,  d_theta_x,         1]


R_hat =

[ R11, R12, R13]
[ R21, R22, R23]
[ R31, R32, R33]
```

ars

```
syms b_arsx_b b_arsy_b b_arsz_b real
```

```
b_ars_b_hat = [b_arsx_b; b_arsy_b; b_arsz_b];
syms d_b_arsx_b d_b_arsy_b d_b_arsz_b real
d_b_ars = [d_b_arsx_b; d_b_arsy_b; d_b_arsz_b];

b_ars_b = b_ars_b_hat + d_b_ars


b_ars_b =

 b_arsx_b + d_b_arsx_b
 b_arsy_b + d_b_arsy_b
 b_arsz_b + d_b_arsz_b
```

error state def

```
d_x = [d_p; d_v; d_b_acc; d_theta; d_b_ars];
```

imu

```
syms ox_b oy_b oz_b real omega_nb = [ox_b oy_b oz_b]; syms wx_ars_b wy_ars_b wz_ars_b real
w_ars_b = [wx_ars_b; wy_ars_b; wz_ars_b]

syms ox_imu_b oy_imu_b oz_imu_b real
omega_imu_b = [ox_imu_b; oy_imu_b; oz_imu_b]


omega_imu_b =

 ox_imu_b
 oy_imu_b
 oz_imu_b
```

lever arm

```
syms rx_b ry_b rz_b real
r_b = [rx_b; ry_b; rz_b ]


r_b =

 rx_b
 ry_b
 rz_b
```

simple measurement

```
H_alloc = [1 0 0];
y_gss = H_alloc*( R'*v + Smtrx( omega_imu_b - b_ars_b)*r_b );
y_hat = subs(y_gss, d_x, z_151 )
```

```
H = jacobian( y_gss, d_x );
H = simplify( subs( H, d_x, zeros(15,1) ));
H_pos = H(:,1:3)
H_vel = H(:,4:6)
H_acc = H(:,7:9)
H_att = H(:,10:12)
H_ars = H(:,13:15)

% matriseregne sjekk, svar skal bli null
delta_H_pos = H(:,1:3) - H_alloc*z31
delta_H_vel = H(:,4:6) - H_alloc*R_hat'
delta_H_acc = H(:,7:9) - H_alloc*z31
delta_H_att = H(:,10:12) - H_alloc*Smtrx( R_hat'*v_hat )
delta_H_ars = H(:,13:15) - [1 0 0]*Smtrx(r_b)
```

y_hat =

R11*vx_n + R21*vy_n + R31*vz_n - rz_b*(b_arsy_b - oy_imu_b) +
 ry_b*(b_arsz_b - oz_imu_b)

H_pos =

[0, 0, 0]

H_vel =

[R11, R21, R31]

H_acc =

[0, 0, 0]

H_att =

[0, - R13*vx_n - R23*vy_n - R33*vz_n, R12*vx_n + R22*vy_n + R32*vz_n]

H_ars =

[0, -rz_b, ry_b]

delta_H_pos =

[0, 0, 0]

delta_H_vel =

[0, 0, 0]

delta_H_acc =

[0, 0, 0]

delta_H_att =

[0, 0, 0]

delta_H_ars =

[0, 0, 0]

measurement

```
H_alloc = [1 0 0; 0 1 0; 0 0 0];
velocity_gss = H_alloc*( R'*v + Smtrx( omega_imu_b - b_ars_b)*r_b );
y_gss = norm( velocity_gss );
y_hat = simplify( subs(y_gss, d_x, z_151 ) );
H = jacobian( y_gss, d_x );
H = simplify( subs( H, d_x, zeros(15,1) ) )

%
H_pos = H(:,1:3)
H_vel = H(:,4:6)
H_acc = H(:,7:9)
H_att = H(:,10:12)
H_ars = H(:,13:15)

% se på forskjellen til
H_alloc = [1 0 0];
y_gss = H_alloc*( R'*v + Smtrx( omega_imu_b - b_ars_b)*r_b )
% og
H_alloc = [1 0 0; 0 1 0; 0 0 0];
velocity_gss = H_alloc*( R'*v + Smtrx( omega_imu_b - b_ars_b)*r_b );
y_gss = norm( velocity_gss );
% i simulatoren
```

H =

[0, 0, 0, (R12(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b +*
*b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) + R11*(R11*vx_n +*
*R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b*
*- oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b*
*+ b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 + (R11*vx_n +*
*R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b*
*- oz_imu_b*ry_b)^2)^(1/2), (R22*(R12*vx_n + R22*vy_n + R32*vz_n -*

b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) +
R21*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
+ oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n
- b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2
+ (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), (R32*(R12*vx_n + R22*vy_n
+ R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
oz_imu_b*rx_b) + R31*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
- b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n +
R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b
+ oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
- b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), 0,
0, 0, ((R13*vx_n + R23*vy_n + R33*vz_n)*(R12*vx_n + R22*vy_n
+ R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
oz_imu_b*rx_b))/((R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b
+ b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 + (R11*vx_n +
R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b -
oz_imu_b*ry_b)^2)^(1/2), -((R13*vx_n + R23*vy_n + R33*vz_n)*(R11*vx_n
+ R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n -
b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 +
(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), -(2*(R11*vx_n + R21*vy_n
+ R31*vz_n)*(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b +
b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) - 2*(R12*vx_n +
R22*vy_n + R32*vz_n)*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
- b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b))/(2*((R12*vx_n +
R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b
+ oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
- b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2)),
(rz_b*(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b
- ox_imu_b*rz_b + oz_imu_b*rx_b))/((R12*vx_n + R22*vy_n + R32*vz_n
- b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2
+ (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
+ oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), -(rz_b*(R11*vx_n +
R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b
- oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b
+ b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 + (R11*vx_n +
R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b
- oz_imu_b*ry_b)^2)^(1/2), -(rx_b*(R12*vx_n + R22*vy_n + R32*vz_n
- b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) -
ry_b*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
+ oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n
- b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2
+ (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2)]

H_pos =

[0, 0, 0]

H_vel =

```
[ (R12*(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b
  - ox_imu_b*rz_b + oz_imu_b*rx_b) + R11*(R11*vx_n + R21*vy_n
  + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b -
  oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b
  + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 + (R11*vx_n +
  R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b
  - oz_imu_b*ry_b)^2)^(1/2), (R22*(R12*vx_n + R22*vy_n + R32*vz_n -
  b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) +
  R21*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
  + oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n
  - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2
  + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
  oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), (R32*(R12*vx_n + R22*vy_n
  + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
  oz_imu_b*rx_b) + R31*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
  - b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n +
  R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
  oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b -
  b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2)]


H_acc =

[ 0, 0, 0]


H_att =

[ ((R13*vx_n + R23*vy_n + R33*vz_n)*(R12*vx_n + R22*vy_n + R32*vz_n
  - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b))/
  ((R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b
  - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n +
  R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b + oy_imu_b*rz_b -
  oz_imu_b*ry_b)^2)^(1/2), -((R13*vx_n + R23*vy_n + R33*vz_n)*(R11*vx_n
  + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
  oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n -
  b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2 +
  (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b +
  oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), -(2*(R11*vx_n + R21*vy_n
  + R31*vz_n)*(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b +
  b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b) - 2*(R12*vx_n +
  R22*vy_n + R32*vz_n)*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
  - b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b))/(2*((R12*vx_n +
  R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
  oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b -
  b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2))]


H_ars =

[ (rz_b*(R12*vx_n + R22*vy_n + R32*vz_n - b_arsz_b*rx_b +
  b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b))/((R12*vx_n +
  R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b
```

```
 + oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
 - b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), -
(rz_b*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
 + oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n + R22*vy_n + R32*vz_n
 - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b + oz_imu_b*rx_b)^2
 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b - b_arsy_b*rz_b
 + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2), -(rx_b*(R12*vx_n +
R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
oz_imu_b*rx_b) - ry_b*(R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b
 - b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b))/((R12*vx_n +
R22*vy_n + R32*vz_n - b_arsz_b*rx_b + b_arsx_b*rz_b - ox_imu_b*rz_b +
oz_imu_b*rx_b)^2 + (R11*vx_n + R21*vy_n + R31*vz_n + b_arsz_b*ry_b -
b_arsy_b*rz_b + oy_imu_b*rz_b - oz_imu_b*ry_b)^2)^(1/2)]


y_gss =

(d_vx_n + vx_n)*(R11 + R12*d_theta_z - R13*d_theta_y) + (d_vy_n +
 vy_n)*(R21 + R22*d_theta_z - R23*d_theta_y) + (d_vz_n + vz_n)*(R31
 + R32*d_theta_z - R33*d_theta_y) - rz_b*(b_arsy_b + d_b_arsy_b -
 oy_imu_b) + ry_b*(b_arsz_b + d_b_arsz_b - oz_imu_b)
```

Published with MATLAB® R2018b