Controle TRMS

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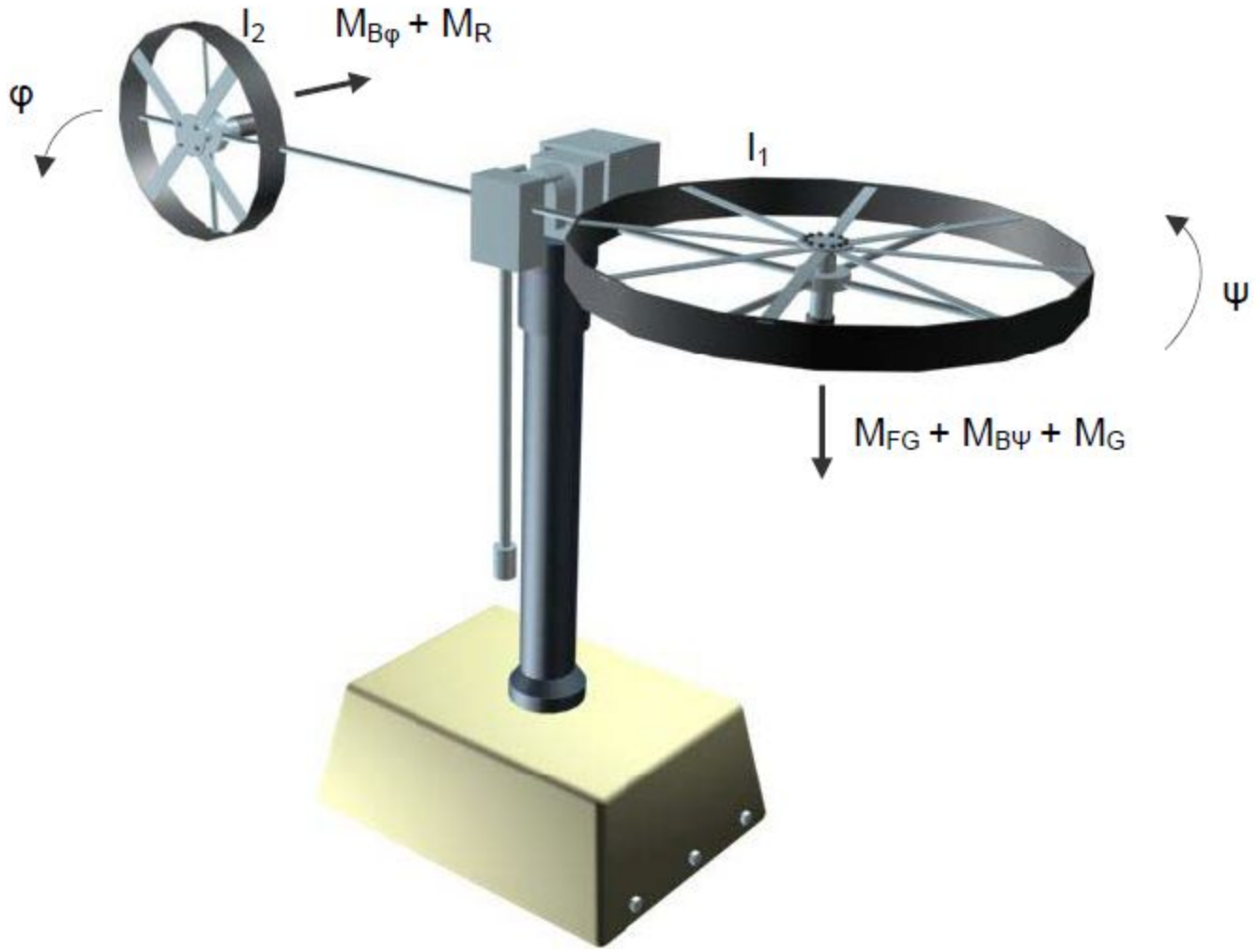
I_2
$M_{B\varphi} + M_R$
φ
I_1
ψ
$M_{FG} + M_{B\psi} + M_G$

Características do sistema

- MIMO;
- Não Linear;
- Dependendo da trajetoria o sistema muda com o tempo.

Equações:

$$I_1 \cdot \ddot{\psi} = M_1 - M_{FG} - M_{B\psi} - M_G, \qquad (1)$$

$$M_1 = a_1 \cdot \tau_1^2 + b_1 \cdot \tau_1, \quad - \textit{nonlinear static characteristic} \qquad (2)$$

$$M_{FG} = M_g \cdot \sin\psi, \quad - \textit{gravity momentum} \qquad (3)$$

$$M_{B\psi} = B_{1\psi} \cdot \dot{\psi} + B_{2\psi} \cdot sign(\dot{\psi}), \quad - \textit{friction forces momentum} \qquad (4)$$

$$M_G = K_{gy} \cdot M_1 \cdot \dot{\varphi} \cdot \cos\psi. \quad - \textit{gyroscopic momentum} \qquad (5)$$

Equações:

$$I_2 \cdot \ddot{\varphi} = M_2 - M_{B\varphi} - M_R$$

$$M_2 = a_2 \cdot \tau_2^2 + b_2 \cdot \tau_2, \qquad \text{– nonlinear static characteristic}$$

$$M_{B\psi} = B_{1\varphi} \cdot \dot{\psi} + B_{2\varphi} \cdot sign(\dot{\varphi}), \qquad \text{– friction forces momentum}$$

$$\tau_1 = \frac{k_1}{T_{11}s + T_{10}} \cdot u_1 .$$

$$\tau_2 = \frac{k_2}{T_{21}s + T_{20}} \cdot u_2 .$$

Matriz A e B linearizados na trajetória

```
[0,       1,              0,    0,            0,          0;
 alpha1,-B_1P/I_1,        0,    alpha2,       alpha3,     0;
 0,       0,              0,    1,            0,0;
 0,       0,              0,   -B_1Y/I_2,     alpha4,     alpha5;
 0,       0,              0,    0,           -T10/T11,    0;
 0,       0,              0,    0,            0,         -T20/T21]
```

B =

```
[ 0,          0;
  0,          0;
  0,          0;
  0,          0;
k1/T11,       0;
  0,        k2/T21]
```

alpha1=-(2*B_2P*cos(2*x1d)*x4d^2 - K_gy*sin(x1d)*(a_1*x5d^2 + b_1*x5d)*x4d + M_g*cos(x1d))/I_1, -B_1P/I_1;
alpha2=-(2*B_2P*x4d*sin(2*x1d) + K_gy*cos(x1d)*(a_1*x5d^2 + b_1*x5d))/I_1;
alpha3=(b_1 + 2*a_1*x5d - K_gy*x4d*cos(x1d)*(b_1 + 2*a_1*x5d))/I_1;
alpha4=-(K_c*T_O*(b_1 + 2*a_1*x5d))/(I_2*T_P);
alpha5= (b_2 + 2*a_2*x6d)/I_2;

Matrix Ck

C = [B(1) A*B - diff(B(1)) A*B*B - diff(B(1),2) B(1) A*B - diff(B(1)) A*B*B - diff(B(1),2)

[0 0 , alpha_1, 1, 0, 0;
0, alpha_2, alpha_3, 0, 0, alpha_4;
0, 0, Alpha_5, 0,0,(k2*(b_2 + 2*a_2*x6d))/(I_2*T21);
0, alpha_5, Alpha_6, 0, alpha_7, alpha8;
k1/T11,-(T10*k1)/T11^2,(T10^2*k1)/T11^3, 0, 0, 0;
0, 0, 0, k2/T21, -(T20*k2)/T21^2,(T20^2*k2)/T21^3

Determinante de C

(k1^3*k2^3*(b_2 + 2*a_2*x6d)^2*(b_1 + 2*a_1*x5d

- K_gy*b_1*x4d*cos(x1d)

- 2*K_gy*a_1*x4d*x5d*cos(x1d))^2)/(I_1^2*I_2^2*T11^3*T21^3)

Existe regiões não controláveis mas no repouso é controlável:

k1^3*k2^3*(b_2)^2*(b_1)/(I_1^2*I_2^2*T11^3*T21^3)

Saidas Planas

FO1 = Cte*Psi = Cte*X1

FO1_1p = Cte*X1

FO1_2p = a3*X1+b3*X2+c3*X3+d3*X4+e3*X5+f3*X6

FO1_3p = a4*X1+b4*X2+c4*X3+d4*X4+e4*X5+f4*X6+ g4*U1+h4*U2

FO2 = Cte*Psi + Cte*Yaw = Cte*X1 + Cte*X3

FO2_1p = a6*X1+b6*X2+c6*X3+d6*X4+e6*X5+f6*X6

FO2_2p = a7*X1+b7*X2+c7*X3+d7*X4+e7*X5+f7*X6

FO2_3p = a8*X1+b8*X2+c8*X3+d8*X4+e8*X5+f8*X6+ g8*U1+h8*U2