System Identification 07 - Grey box models

Professor: Helon Vicente Hultmann Ayala

Felipe da Costa Pereira
felipecostapereira@gmail.com

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1 Activity

- Rodar o código de identificação do EMPS fornecido e analisar linha por linha o funcionamento.
- Trocar o modelo de Coulomb pelo modelo de Tustin (eq 10 do artigo abaixo):
  https://www.sba.org.br/open_journal_systems/index.php/cba/article/view/1570
  Comparar os resultados: Coulomb vs. Tustin (em termos de erro, parâmetros identificados, etc)
- Caso tenham interesse em se aprofundar nos modelos de atrito, podem testar com demais opções no artigo de revisão abaixo:
  https://link.springer.com/content/pdf/10.1007/s11071-016-2999-3.pdf
  Sugiro tentar o Lugre (secao 3.5 deste artigo) - atividade extra (para os interessados).

2 Code Changes

In order to use the Tustin model for the friction force as proposed, the torque expression changes from equation 1 to equation 2 described below:

Torque expression using Coulomb friction force model:

$$\tau(t) = M\ddot{q}(t) + F_v\dot{q}(t) + F_c sign(\dot{q}(t)) + offset \tag{1}$$

Torque expression using Tustin friction force model:

$$\tau(t) = M\ddot{q}(t) + F_v\dot{q}(t) + F_c sign(\dot{q}(t)) + (F_s - F_c)e^{-\frac{|\dot{q}|}{v_s}} + offset \tag{2}$$

Parameters and $\dot{x_2} = \ddot{q}$ expresion on the state vector:

```
Mn     = MX.sym('Mn');
Fvn    = MX.sym('Fvn');
Fcn    = MX.sym('Fcn');
Fsn    = MX.sym('Fsn');
vsn    = MX.sym('vsn');
ofstn  = MX.sym('ofstn');

params    = [Mn;Fvn;Fcn;Fsn;vsn;ofstn];
parammax = [150;  300;  40;  40;  1e-3;  15];
parammin = [ 30;  100;   0;   0;  1e-4;  -15];

% rhs = [dq; (u-Fv*dq-Fc*sign(dq)-ofst)/M];
rhs = [dq;(u-Fv*dq-Fc*sign(dq)+(Fc-Fs)*exp(-(abs(dq))/vs)-ofst)/M];
```

The range for the v_s parameter was based on the respecitve value given by the IDIM model ($v_s = 0.006464$). The rest of the code is kept exactly the same.

3 Results

After performing the grey box identification using the casadi library, we compare the parameters values estimated by the inverse dynamic model (IDM) and the grey box casadi model. The values of the estiamted parameters, for both the Coulomb and the Tustin friction forces are shown in tables 1 and 2.

Table 1: Coulomb Model parameters

Model	M	Fv	Fc	ofst
casadi	95.1089	203.5034	20.3935	-3.1648
IDIM	96.0014	213.8943	19.4167	-3.2790

Table 2: Tustin Model parameters

Model	M	Fv	Fc	Fs	vs	ofst
casadi	97.001	222.01	18.606	36.3311	0.000900	-3.29
IDIM	95.681	203.36	17.023	17.0230	0.006464	-4.12

The simulated responses and the associeted errors, for both force models (Coulomb and Tustin) and parameters estimation methods (casadi amd IDIM) are show in figures 1 and 2.

As we can notice, casadi models estimate have a good fit for both force models, while IDIM models have a poor performace (higher error) when estimating the Tustin force model parameters.

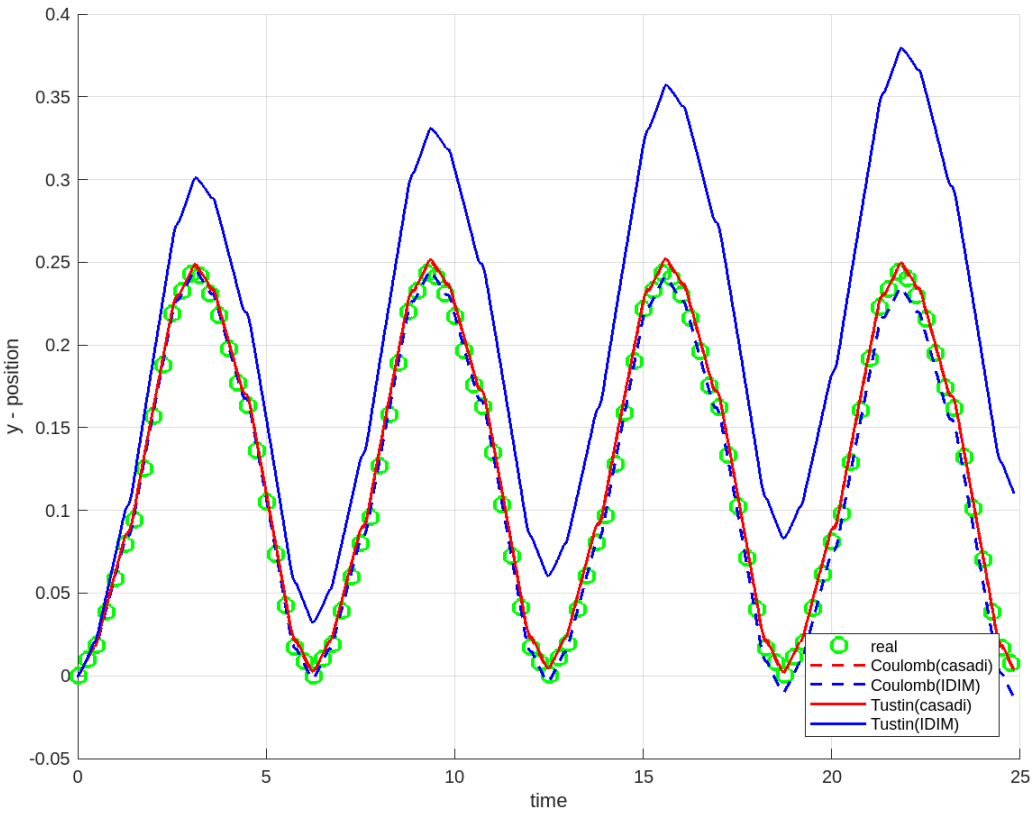

Figure 1: Position (y) - real and estimated data

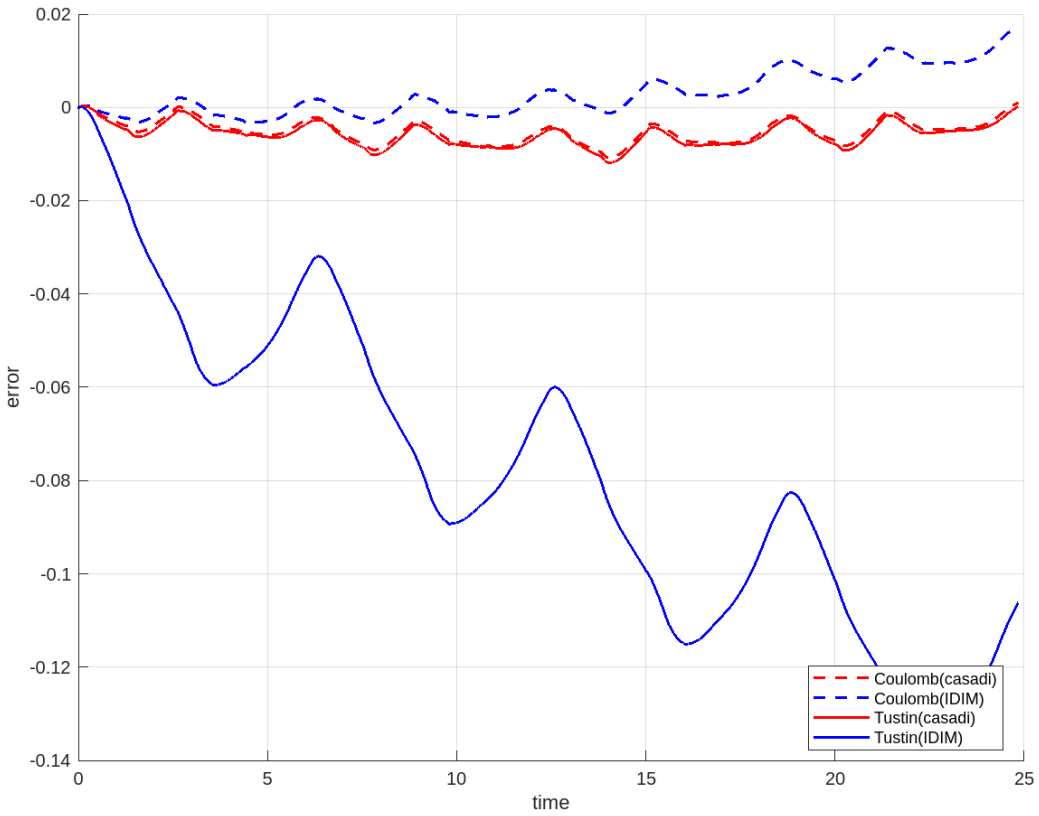

Figure 2: Error between estimated and real data