System identification, Estimation and Filtering

Model identification for a water heater (real data).

The system to be modeled is a water heater, where:
- Input: resistor voltage (measured in percentage).
- Output: water temperature (measured in Celsius degree).

Problem:
1) Identify ARX, OE and NARX models of different orders using experimental data.
2) Compare the identified models on a set of data not used for identification. To assess the model quality, consider the following criteria:
- $RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(y(t)-\widehat{y}(t)\right)^2}$, where $y(t)$ = measured output, $\widehat{y}(t)$ = simulated (or predicted) output.
- Trade-off between $RMSE$ and model order na+nb (nf+nb for OE models).

Procedure:

Data organization:
1) Load data from the file "heater.mat". The complete data set can be partitioned into two subsets:
• Estimation data set (ES):
- ue: 2000 input measurements.
- ye: 2000 output measurements.
• Validation data set (VS):
- uv: 1000 input measurements.
- yv: 1000 output measurements.
The measurements have been collected with a sampling time of 3 s.
2) Remove the mean from all the measured signals.

Model identification (data set ES)
3) Identify several ARX(na,nb,nk) and OE(nb,nf,nk) models considering different values of na, nf, nb and nk.
4) Identify several NARX(na,nb,nk) neural models considering different values of na, nb and nk, and different values of the number r of basis functions (neurons) in the interval $[1, 20]$.

Model validation (data set VS)
5) Compare the identified models in one-step ahead prediction and in simulation, considering the plot of simulated (or predicted) and measured data, the RMSE error, and the model order na+nb (nf+nb for OE models).