2011 FUZZ-IEEE Conference

Competition Problem 2 - A Fuzzy Modeling Problem

Designed by

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1. An Introduction to the Competition Problem – Model a Multi-Input, Multi-Output (MIMO) Coupling System

Many systems in practice are nonlinear and MIMO with output couplings. An important feature of such a system is that each of the system's output variables may depend on all the input variables. A daily life example is the coupling between temperature and humidity in the air. A means for adjusting temperature (e.g., an air conditioner) will inevitably affect humidity at the same time, and vice versa. Fig. 1 shows the block diagram of this example coupling MIMO system, where $f_{11}(u_1)$, $f_{12}(u_1)$, $f_{21}(u_2)$, and $f_{22}(u_2)$ can be linear or nonlinear, with or without time delay. All the system issues associated with their single-input, single-output (SISO) counterparts, such as stability and robustness, are applicable to any MIMO system. With the extra issue of the output coupling, MIMO systems are usually much harder to model and control.

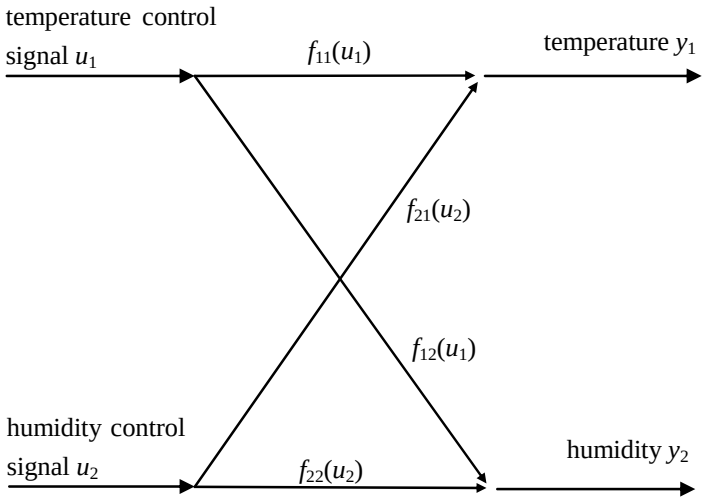

Fig. 1. An example coupling system with two input variables and two output variables.

This competition involves a nonlinear coupling system with four inputs and four outputs. It is from a real-world continuous-time system whose more detailed information is not to be revealed for the sake of this competition and our intention to keep the problem simpler. Through data acquisition 1,000 input-output data points (namely, $u_1(n)$, $u_2(n)$, $u_3(n)$, $u_4(n)$, $y_1(n)$, $y_2(n)$, $y_3(n)$, $y_4(n)$, n = 1,2,…,1,000) were collected from the system with the sampling period $T_s = 0.0005s$. All these data points were saved in an Excel file named "data for modeling.xls" for system identification. The file is downloadable from the conference website. In the file each column represents the measured values for a variable in the following order (from column 1 to column 8): $u_1(n)$, $u_2(n)$, $u_3(n)$, $u_4(n)$, $y_1(n)$, $y_2(n)$, $y_3(n)$ and $y_4(n)$.

2. Fuzzy Modeling Performance Criteria

You need to develop an **innovative** fuzzy-logic-based dynamic system model. Assume that the output variables of your model are $\hat{y}_k(n)$, k = 1, 2, 3, 4. To avoid physical damage to the actual system, it is required that $-3.5 \le \hat{y}_k(n) \le 3.5$ for all k's all the time (i.e., any n). The fuzzy model performance should be assessed according to the following measure:

$$\hat{e}_{total} = \hat{e}_1 + \hat{e}_2 + \hat{e}_3 + \hat{e}_4 = \sum_{n=1}^{1000} \left(y_1(n) - \hat{y}_1(n) \right)^2 + \sum_{n=1}^{1000} \left(y_2(n) - \hat{y}_2(n) \right)^2$$

$$+ \sum_{n=1}^{1000} \left(y_3(n) - \hat{y}_3(n) \right)^2 + \sum_{n=1}^{1000} \left(y_4(n) - \hat{y}_4(n) \right)^2$$

The lesser the value of $\hat{e}_{total}$, the better the model.

3. Reporting Requirements

Please submit the following results to the Task Force along with your paper through the conference paper submission web site:

1. Plot $y_k(n)$ and $\hat{y}_k(n)$, k = 1, 2 in one figure and $y_k(n)$ and $\hat{y}_k(n)$, k = 3, 4 in another. The above-mentioned constraints on $\hat{y}_k(n)$ should be displayed in the figures as two dotted lines. Use different colors for different curves (i.e., different k's) and use the colors consistently from figure to figure. Insert legends for the curves.
2. Please make a Microsoft Word file with the name *readme.doc*. Use it to list the names of all the plot files with brief descriptions of their contents. Also, give the values of $\hat{e}_1$, $\hat{e}_2$, $\hat{e}_3$, $\hat{e}_4$, and $\hat{e}_{total}$ for your model.

3. All the computer programs related to your fuzzy model presented in the paper should be submitted to the Task Force. A reasonable amount of documentation is required to enable the Task Force to understand not only the functionality of each of the programs but also the line-by-line code in each program. The more detailed the documentation is, the better. Furthermore, the author should provide the operation instruction detailing how to set up the programs and their operating environment so that the programs will run correctly and produce the exactly same results given in the paper and the plots mentioned above. Enough information should be available so that the Task Force will be able to replicate the results when it wants to.
4. All the files mentioned above should be zipped into one file, with the file extension of either ZIP or RAR, before uploaded with the paper manuscript.

Please read this section carefully and prepare all the files item by item to make sure no file will be missing. Once the submission deadline passes, the Task Force will not accept any addition to its files. Please make your files as self-explanatory as possible. Failure to understand your results can dampen Task Force's enthusiasm on your work.

Thank you for your interest. We look forward to receiving your paper!