Master of science degree in Mechatronic Engineering
Academic Year 2018-2019, First Semester

Laboratory of Robust Identification and Control (01PDXOV-01PDXQW-01PDXND)

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Surname	**Name**
Student ID	

The student is required to solve the following two exercises:

Exercise 1

(A) **4 Points** — Formulate the problem of identifying the mathematical model of the plant in the set-membership framework, on the basis of the following information:

(a) the plant can be modeled by a nonlinear Hammerstein system where the discrete-time linear time-invariant subsystem is described by the following transfer function

$$G(z) = \frac{\beta_1 z + \beta_2}{z + \alpha_1}$$

and the nonlinear block $\mathcal{N}$ is such that:

$$x_t = \gamma_1 u_t + \gamma_2 u_t^3$$

(b) A set of 20 input-output data pair (available in the data file *S:\LRIC\data_exam_2A_hammer*) has been collected to describe the input-output behavior of the plant.

(c) Output data sequence is known to be corrupted by additive noise signals $\eta(t)$, having absolute value of amplitude bounded by $\Delta_\eta = 0.02$.

(B) **3 Points** — Provide a mathematical formulation of the optimization problems to be solved for the computation of the PUIs.

(C) **5 Points** — Provide a accurate description of the data structure to be built in order to solve the problem with the sparsePOP software.

(D) **6 Points** — Write a MATLAB script for the computation of the PUIs.

Remark 1: Use the *'active-set'* POP solver.

Exercise 2

1. **3 Points** - Formulate the problem of designing a direct-data driven controller in the set-membership framework, on the basis of the following information:

   (a) The linear discrete-time controller of order n has to match a reference model described by the following transfer function:

   $$M(z) = \frac{0.7009z - 0.5005}{z^2 - 1.123z + 0.3234}$$

   (b) A set of 100 input-output data pair (available in the data file *data_exam_2A*) has been collected to describe the input-output behavior of the plant.

   (c) The input sequence is assumed to be exactly known, while the output data are known to be corrupted by an additive noise $\eta(t)$ having absolute value of amplitude bounded by $\Delta\eta = 1$.

2. **3 Points** - Provide a mathematical formulation of the optimization problems to be solved for the computation of the controller uncertainty intervals (CPUIs).

3. **3 Points** - Provide an accurate description of the data structure to be built in order to solve the problem with the sparsePOP software.

4. **3 Points** - Write a MATLAB script for the computation of the CPUIs and the Chebyshev center of the extended feasible controller parameter set (EFCPS).

5. **3 Points** - Discuss how to force the zeros of the controller to be inside the unitary-circle. Provide the new EFCPS and additional SparsePOP structure to be used for enforcing such conditions.

6. **3 Points** - Discuss how to force stability constraints on the parameters of the designed controller. Provide the new EFCPS and additional SparsePOP structure to be used for enforcing such conditions.

Remark 1: The assessment of the controller order n has to be performed by trail and error starting from $n = 1$ until the EFCPS is not empty ($exitflag > 0$).

Remark 2: Use the *'active-set'* POP solver.

All the details of student's solution must be reported on the written examination papers. Each step of the proposed solution must be properly discussed.