HW 2 (due May 31 at etl.snu.ac.kr)

1. The roll dynamics θ of a launch vehicle is controlled by the thruster angle δ according to the following:

$$\dot{\theta} = \mu \sin \delta$$

where μ is the parameter depending on the thrust, the moment of inertia, and the length between the main motor and thruster. For known constants μ_1, μ_2, $0 < \mu_1 < \mu < \mu_2$. Actuator dynamics is given by

$$\frac{\delta}{\delta_c} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

   (a) Given a desired trajectory θ_r, design a controller so that $\theta - \theta_r \to 0$. Assume that μ is accurately known

   (b) Then, design an adaptive controller assuming that μ is uncertain.

2. Design a backstepping control for the following system:

$$\begin{aligned} \dot{x} &= ax - x^3 + \xi \\ \dot{\xi} &= u \end{aligned}$$

   (a) Let $a = 1$, and design a backstepping control such that $x(t) \to x_d(t)$.

   (b) Let a be an unknown constant, and design an adaptive backstepping control such that $x(t) \to x_d(t)$.

   (c) Simulate (b) with your choice of x_d, and check the state/parameter convergence.

3. Consider the nonlinear system:

$$\begin{aligned} \dot{x}_1 &= x_1 + x_1 x_2 - x_2^2 + u \\ \dot{x}_2 &= x_1 x_2 - x_2^2 + u \\ \dot{x}_3 &= x_1 + x_1 x_2 - x_2^2 - (x_3 - x_1)^3 + u \\ y &= x_1 - x_2 \end{aligned}$$

   (a) Show that the system has relative degree two.

   (b) Define the internal variable, and transform the system into the normal form.

   (c) Show that the origin of the zero dynamics is globally asymtotically stable.

   (d) Design a feedback law that achieves global asymptotic stability.

4. (Term project proposal) The course project may be:
   A. an independent research project that can utilize any of the techniques covered in the course, or
   B. a review of the literature in an area covered in or related to the course.
   You may choose a project related to your area of research, and/or you may choose to apply any of the techniques from class to a system that you are interested in.

   - In the case of an independent research project, you should submit a paper which summarizes related work, describes your problem and method, and presents your results.
   - In the case of a literature review, you should submit a report which provides the background review, presents a clear description of the results presented in the papers that you are reviewing, and gives your own assessment of these results.
   - The projects will be evaluated according to correctness and depth of your analysis or review, and your written presentation.
   - Please submit a brief (less than 1 page) proposal with this HW, describing your topic and what you plan to accomplish in your project.
   - The final course project papers or reports are due **11:59 pm, June 18**. Recommended length: 8–12 single-column pages, or 4–6 double-column pages.