Introduction to linear control theory

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Control theory has numerous applications in various fields such as engineering, biology, medicine, aerospace, robotics and so on. This course provides a brief introduction to the classical control theory [1–4]. In the first part, we will study a finite-dimensional system

$$\begin{aligned} \dot{x} &= A(t)x + B(t)u, \\ y &= C(t)x + D(t)u, \end{aligned} \tag{1}$$

where $x : [0, +\infty) \to \mathbb{R}^n$ is the state, $u : [0, +\infty) \to \mathbb{R}^m$ is the input, and $y : [0, +\infty) \to \mathbb{R}^r$ is the output of a control system. The following fundamental topics of linear control theory will be discussed:

- Controllability and observability criteria,
- Controllability and observability Gramians and the balancing problem,
- Duality principle,
- Transfer matrix and its minimal realization for time-invariant control systems,
- Lyapunov and input-output stability of control systems,
- Stabilizability and detectability problems,
- The optimal control problem,
- $\mathcal{H}_2$ and $\mathcal{H}_\infty$ optimization, etc.

In the second part of the course, we will discuss to what extent the above concepts can be extended to the case of infinite-dimensional systems [5]. As a special class of infinite-dimensional systems, a class of delay equations will be considered.

Prerequisites: basic knowledge of elementary ODEs and linear algebra.

References

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[3] J.P. Hespanha. *Linear Systems Theory.* Princeton University Press, 2018.
[4] H.K. Khalil. *Nonlinear Systems.* Prentice Hall, 2002.
[5] R.F. Curtain, & H. Zwart. *Introduction to Infinite-Dimensional Systems Theory: A State-Space Approach.* Vol. 71. Springer Nature, 2020.