Time-Delay Systems (0510.7315)
Credits: 2.
Prerequisites: Introduction to Modern Linear Control.

1. *Models of systems with time-delay*: networked-control systems, communication network models, models of lasers, vehicular traffic flow models, models in biology.

2. *Basic theory*: solution concept and step method. Classification of systems with time-delay (retarded, neutral type systems). Existence of solutions. Linear time-invariant systems with delay: characteristic equation, solution of linear non-homogenous equations. Effects of delay on stability: frequency domain methods. Controllability, observability of linear systems.

3. *Stability and performance analysis*: time domain methods. Direct Lyapunov approach: Krasovskii and Razumikhim methods. An LMI approach to stability: delay-independent/delay-dependent conditions. Stabilization by using delays and general Lyapunov functional. Exponential bounds and L_2-gain analysis. Input-to-state stability and control under quantization.

4. *Control design*: predictor-based control, LQR problem. LMI approach to robust stabilization and H_∞ control. Systems with saturated actuators. H_∞ control.

5. *Sampled-data and networked control systems*: a time-delay approach.

Textbooks:

1. E. Fridman, *Introduction to Time-Delay Systems: Analysis and Control*. Birkhauser, Basel, 2014.

2. K. Gu, V. L. Kharitonov, and J. Chen, *Stability of Time-Delay Systems*. Boston: Birkhauser, 2003.

3. J. K. Hale and S. M. V. Lunel, *Introduction to Functional Differential Equations*, Springer-Verlag, New-York, 1993.

4. V. Kolmanovskii and A. Myshkis, *Introduction to the Theory and Applications of Functional Differential Equations* , Kluwer, 1999.

5. S. I. Niculescu, "Delay effects on stability: A robust control approach," *Lecture Notes in Control and Information Sciences*, 269, Springer-Verlag, London, 2001.