Mathematical Problems in Engineering

Hindawi

Special Issue on

Time-Delay Systems: Modeling, Analysis, Estimation, Control, and Synchronization

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Time-delay systems are infinite-dimensional systems describing a large class of biological, chemical, and physical phenomena. In applied mathematics, many mathematical models in biosciences (population dynamics, ecological and chemostat systems, cell kinetics, etc.) and in medicine (neural networks, regulation of blood concentration, hormone regulation in the endocrine system, epidemiology, tumor growth, HIV infection, immune response, etc.) are based on delay-differential equations. Such models are generally used to understand their dynamics and study their unstable patterns (periodic solutions and chaotic regimes). In these fields, the numerical approaches are generally the major tool whereas the analytic results are still largely lacking and are still expected.

In chemical reaction process, time delays often take place in the mass transmission in serial reactors, recycles, intermediate storage tanks, or heat transmission. Delays can appear either in the state variables, the control inputs, or the measurement outputs. The neglect of time delays might give rise to oscillation dynamics and instability. Several results on analysis and control design approaches of time-delay chemical processes are proposed, but many other challenging results are yet expected and must focus on the design of robust controllers for uncertain multiple time-delay models.

Delays emerge in many engineering applications such as rolling mills, pneumatic and hydraulic systems, automotive systems, aircrafts, and robotic systems. They generally describe propagation phenomena, material and energy transfer in intercommoned systems, and data transmission in communication systems. It is well known that delays are often source of bifurcation and chaos dynamics, instability, and poor control performances. Since the 1950s, the topic of time-delayed systems is considered as an important research topic. Solutions are always divided into two main classes: delay-independent and delay-dependent approaches. Results are based either on Lyapunov methods or on frequency domain considerations. However, until now, many problems related to this topic remain unsolved and a lot of challenging issues of theoretical and practical importance are yet expected in modeling, identification, analysis, and synthesis approaches.

The aim of this special issue is to improve the current state of the art and highlight significant recent developments on the topics of linear and nonlinear time-delay systems, either continuous or discrete in time.

Potential topics include but are not limited to the following:

- Identification, modeling, and approximation of multiple time-delay systems
- Stability analysis and stabilization of time-delay systems via frequency domain and Lyapunov approaches
- Observer design and synchronization of time-delay systems subject to uncertainties and disturbances
- Bifurcation and chaos phenomena for nonlinear time-delay systems
- PID, predictive, and robust control design for multiple time-delay systems
- Applications:
  - Biosciences and medical dynamical models
  - Chemical and biochemical processes
  - Pneumatic and hydraulic systems
  - Automotive, aircraft, and robotic systems
  - Communication systems

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