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Title: Delays, Interconnections and Control.

Abstract: To better grasp the heterogeneity of the temporal phenomena in systems' dynamics, knowledge of "past" may appear as essential to derive appropriate models, and there exists a wide variety of processes in nature with such characteristics as, for example, transport and propagation phenomena, population dynamics or (deterministic) car-following traffic models. In these cases, the use of delays in the representation of such phenomena and/or processes may help to better understand the underlying interactions/coupling mechanisms with other (eventually spatial) phenomena. A particular case study is represented by the interconnection of dynamical systems.

It is well-known that the interconnection of two or more dynamical systems leads to an increasing complexity of the behavior of the global system due to the effects induced by the emerging dynamics (in the presence or not of feedback loops) in strong interactions (sensing, communication) with environment changes. As expected, one of the major problems appearing in such interconnection schemes is related to the propagation, transport, and communication delays acting "through" and/or "inside" the interconnections leading to unexpected and, in some cases, counter-intuitive behaviors. There are several ways to represent the overall systems' dynamics and we restrict the scope of the course to the analysis of dynamical models represented by delay-differential equations and more precisely to the so-called parameter-based approach.

In this frame, the purpose of these lectures is to briefly present some "user-friendly" (frequency-domain) methods and techniques for the analysis and control of the dynamical systems in the presence of constant (pointwise) delays by emphasizing how the delay, seen as a parameter, can affect the exponential stability of the system. As a by-product of such an analysis, the use of the delay as a control parameter opens interesting perspectives to exploit further. The presentation is as simple as possible, emphasizing the main intuitive ideas to develop theoretical results, and their potential use in practical applications. Various illustrative examples complete the presentation, and a few applications close the course.