GRENOBLE INP UGA

LCIS
Laboratoire de Conception et d'Intégration des Systèmes

UGA Université Grenoble Alpes

Seminar

Thursday, October 10, 2024
Time: 15:00-16:00, Room: D030
lcis.grenoble-inp.fr

Title: Elegant Motion Enabled by Feedback and Systems Calculations

Abstract:
Systems exhibiting elegant motion abound in the physical world in nature as well as in human transformed environments.

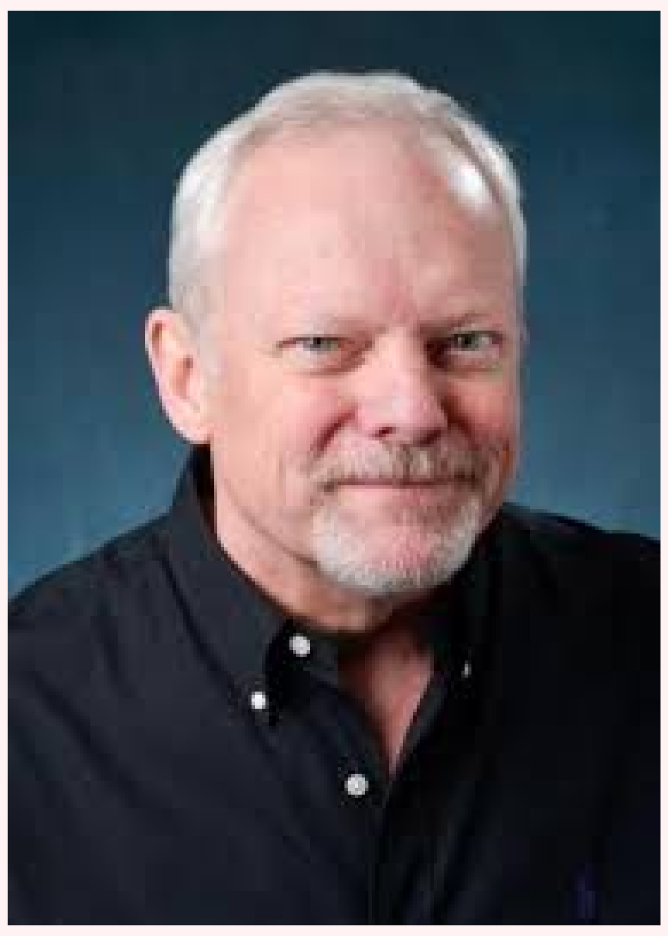
Using skiing, rocket landing, and motorcycle racing as motivating examples, we will explore the dynamical features that must be mastered to obtain desired elegant motions. Indeed, each of these examples possesses an unstable inverted pendulum subsystem which contributes significant dynamic challenges to planning and regulation of their motions. When done well, these systems display an *elegant motion*.

Audience participation will be employed to develop some insights into the dynamics of pendula, inverted and otherwise and, in particular, the need for feedback. We will even see that simple (unconstrained) rigid bodies may exhibit surprising unstable phenomena.

These features will be explored more deeply in the context of motorcycle maneuvering. After some remarks about how to work with highly complex motorcycle models with suspension, tires, etc., we will employ a simple motocycle model consisting of an inverted pendulum mounted on a (single track) nonholonomic car. With this system, we can even discover a feature that every canyon loving motorcyclist *must* employ: countersteering.

Given a ground track and velocity profile, the calculation of the state and control trajectory of the nonholonomic car is straightforward. However, the inverted pendulum trajectory, driven by the lateral acceleration at its pivot point and with instability present as well, is far from it. We will show how the addition of a ficticious *hand of god* input to the driven inverted pendulum together with feedback and/or some optimal control calculations can be used to determine the motorcycle *lean* trajectory. Similar strategies can be developed with higher complexity models and have been used to create nonlinear virtual pilots for maneuvering virtual motorcycles, with realistic physics, aggressively around (virtual) Grand Prix racetracks.

Copious videos with explanations will be used to help illustrate these interesting phenomena.



John Hauser received BS degrees from the United States Air Force Academy and MS and PhD degrees from the University of California at Berkeley, all in Electrical Engineering and Computer Science. From 1980 to 1984, he flew Air Force jets throughout the United States and Canada participating in active Air Defense exercises. In 1989, he joined the Department of EE-Systems at the University of Southern California as the Fred Green Assistant Professor of Engineering.
Since 1992, he has been at the University of Colorado at Boulder in the Department of Electrical, Computer and Energy Engineering. He has held visiting positions at University of Padova (Italy), Caltech (USA), Instituto Superior Tecnico in Lisbon (Portugal), Lund Institute of Technology (Sweden) and Supélec (France). He received the Presidential Young Investigator award from the National Science Foundation in 1991.

His research interests include nonlinear dynamics and control, optimization and optimal control, aggressive maneuvering for high performance motorcycles and aircraft and other vehicles, and dynamic visualization. Recent work has focused on the development of optimization (and optimal control) tools and techniques for trajectory exploration with an eye toward characterizing the trajectory space (with limitations) of highly maneuverable nonlinear systems. This work finds application in the control of highly configurable UAVs (with propulsion vectoring) and in the analysis of racing motorcycles. See also Google scholar.