Graduate Colloquium, Aerospace Engineering

WPI

A Few Journeys into the Periodic Optimal Control Discipline

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Nature synchronizes the life cycles of cicadas. Can we synchronize road traffic in a manner inspired by nature, and if so, what could we potentially gain? Is it more energy-efficient for an unmanned aerial vehicle to flap its wings like an insect, or is it more efficient to fly like a helicopter? Is it possible to save fuel by accelerating and decelerating a road vehicle in a periodic manner instead of traveling at a constant velocity? Are there situations where the optimal protocol for delivering drugs to a patient is periodic? If so, what can we learn about the structure of such a protocol? Given a buoyant air turbine, is it possible to harvest more energy from the incoming wind through periodic flight as opposed to stationary flight? If so, how does one optimize the turbine's flight in a robust manner, given the variability of the wind? Given an electrochemical battery, what is the periodic laboratory test trajectory that maximizes this battery's parameter identifiability? Finally, given a pumping-mode tethered underwater energy harvester, what is the shape of the periodic trajectory that maximizes harvested energy? Each of these problems is quite challenging and exciting in its own right, and takes a lifetime of research expertise to truly solve. However, there is one unifying body of fundamental results – namely, periodic optimal control theory – that lies at the foundations of all of these problems, and brings them all together. The goal of this seminar is to take a few glimpses at periodic optimal control theory and some of its many applications. I hope you will find it to be as fascinating and beautiful as I do.

Hosam K. Fathy earned his B.S., M.S., and Ph.D. degrees, all in Mechanical Engineering, from the American University in Cairo (1997), Kansas State University (1999), and the University of Michigan (2003). After working as a control systems engineer in the automotive industry (2003-2004), postdoctoral research fellow at the University of Michigan (2004-2006), and assistant research scientist at Michigan (2006-2010), he joined Penn State university as an assistant professor (2010-2015), the Bryant early career associate professor (2015-2018), and the Bryant early career professor (2018-2019). He then joined the University of Maryland as a Mechanical Engineering professor (2019-present), where he continues to do work in his main area of expertise – namely, the optimal control of energy systems.