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School of Aeronautics and Astronautics

The AAE Fall 2009 Colloquium Series

Multi-Resolution Path- and Motion-Planning for Small UAVs

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Abstract: Operation of autonomous UAVs and other similar unmanned vehicles requires both trajectory design (planning) and trajectory tracking (control) tasks to be completely automated.   Autonomous operation of UAVs poses challenges that are often beyond traditional route optimizers. For small-size UAVs, in particular, the task of autonomous path-planning problem is exacerbated by the lack of sufficient on-board computational capabilities (CPU and memory) to implement some of the sophisticated algorithms proposed in the literature. Given the short response time scales of these small-sized vehicles, this may be an insurmountable undertaking with current computer technology. In the first part of the talk we will review some recent results for path-planning of small UAVs using multi-resolution techniques. The main idea is to focus the on-board computation resources where and when they are needed most, that is, in the vicinity of the vehicle, and for   short future time horizons. We use wavelet decompositions to construct abstractions of the environment of known priori complexity. The algorithm is scalable, efficiently blending the short-term tactical (reflexive) layer and long-term strategic (decision-making) layer in the control hierarchy. The numerical computations are further enhanced by incorporating a lifting wavelet scheme that only makes use of in-place computations in conjunction with integer arithmetic, and by a new algorithm that computes the adjacency relationships directly from the nonzero detail coefficients of the discrete wavelet transform. Since the vehicle dynamics are relevant only within the fine resolution area, they can be dealt with by the use of a library of pre-computed trajectory templates with an efficient B-spline compression scheme to minimize the computational overhead. The results are demonstrated via hardware-in-the-loop (HIL) testing of the whole control architecture in a small autopilot based on a microcontroller with extremely limited CPU and memory resources, as well as during actual flight testing. Fixed-wing UAVs can only follow paths of given maximum local curvature. In the final part of the talk we will therefore present some additional results for consistent kinodynamic motion planning across the geometric and kinodynamic layers of the motion planning hierarchy to guarantee the construction (if they exist) of apriori bounded local curvature paths inside channels of arbitrary geometry. Conversely, the algorithm can be used in any geometric path planner to find channels for which a curvature-bounded path is guaranteed to exist.

Short Bio: Dr. Panagiotis Tsiotras is currently a Professor at the Daniel Guggenheim School of Aerospace Engineering at the Georgia Institute of Technology (Georgia Tech) and the Director of the Dynamics and Control Systems Laboratory in the same department. He is also affiliated with the Center for Robotics and Intelligent Machines (RIM) and the Center for Space Studies at Georgia Tech. His research interests include optimal and robust control of nonlinear systems, vehicle autonomy, and control theory applications to aerospace and mechanical systems. Prior to joining Georgia Tech, he was a faculty member at the University of Virginia (1994-1998). He has also held research appointments with Purdue University, INRIA Rocquencourt, Virginia Tech, and Ecole des Mines de Paris. He holds degrees in Mechanical Engineering (NTUA, Eng. Dipl.), Aerospace Engineering (Virginia Tech, MS) Aeronautics and Astronautics (Purdue, PhD) and Mathematics (Purdue, MS). He is a recipient of the National Science Foundation CAREER Award. He is a Fellow of AIAA and a Senior Member of the IEEE.

An informal coffee & cookie reception will be held prior to the lecture at 2:30 p.m. in the AAE/ARMS undergraduate lounge
(directly in front of ARMS 3rd floor elevators

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