

MAE Seminar Series

Optimal Exploration Systems

Pierre Kabamba

Department of Aerospace Engineering

University of Michigan

Abstract

This talk studies optimal exploration, defined as the optimal collection of information about given objects of interest by a flying, mobile agent (the explorer) using imperfect sensors whose signal-to-noise ratio depends on the ranges to the objects of interest. The key aspects of exploration are kinematics (which determine how the explorer moves in response to steering commands), energetics (which determine how much energy is consumed by motion and maneuvers) and informatics (which determine the rate at which information is collected). These aspects are coupled through the steering commands of the explorer, which makes the exploration problem challenging.

This talk presents a comprehensive model of the exploration problem that, on one hand accounts for the coupling between kinematics, energetics and informatics, and on the other hand is simple enough to allow analytic treatment. The kinematics model assumes bank-to-turn motion with constant speed and altitude. The energetics model uses standard flight mechanics equations assuming quasi-static equilibrium flight. The informatics model uses Shannon's channel capacity equation for the rate of information collection, in which the signal-to-noise ratio is provided by the radar equation.

This talk utilizes the comprehensive model to pose and solve several exploration problems where an objective function is to be minimized. Specific objective functions considered are the duration of the exploration mission and the energy consumed. These exploration problems are formulated as optimal control problems where the states are the coordinates of the explorer and the amount of information acquired about each object of interest, and the control signal is the steering decision of the explorer. Necessary conditions for optimality are obtained in the form of two-point-boundary-value-problems and utilized to derive properties of optimal exploration paths. Several limiting regimes are identified for the optimal paths. Several non-dimensional parameters are shown to predict the optimal regime. Examples are given to illustrate the theoretical results.

Speaker Biography

Pierre Kabamba is currently Professor of Aerospace Engineering and Electrical Engineering and Computer Science at the University of Michigan. He received a Ph.D. degree in Mechanical Engineering from Columbia University in 1981 and joined the Aerospace Engineering Department of the University of Michigan in 1983. His area of teaching and research is flight dynamics and control systems. To date he has published over 190 journal and conference papers, and has supervised or co-supervised 27 past and current Ph.D. students. His awards include the *Class of 1938 E Distinguished Service Award* (from the University of Michigan College of Engineering), a *Best Paper Special Award* (from the Society of Instrumentation and Control Engineers -- SICE, Japan), and Election to the rank of *Fellow of IEEE*.

104 Knox Hall

Thursday, October 29th 2009

3:30 pm – 4:30 pm

Please contact Dr. Puneet Singla (psingla@buffalo.edu) for additional information