

## UTC Institute for Advanced Systems Engineering Distinguished Lecture Series



**A. S. Morse, Ph.D.**  
Yale University

### Undirected Rigid Formations are Problematic

Thursday February 12, 2015      10 – 11:30 a.m.      Storrs Campus, Dodd Center, Konover Auditorium

**Abstract:** By an undirected rigid formation of mobile autonomous agents is meant a formation based on “graph rigidity” in which each pair of “neighboring” agents  $i$  and  $j$  is responsible for maintaining the prescribed distance  $d_{ij}$  between them. Recent research by several different groups has led to the development of an elegant potential function based theory of formation control which provides gradient laws for asymptotically stabilizing a large class of rigid, undirected formations in two dimensional space assuming all agents are described by kinematic point models. This particular methodology is perhaps the most comprehensive currently in existence for maintaining undirected formations based on graph rigidity. The main purpose of this talk is to explain what happens if neighboring agents  $i$  and  $j$  using such gradient controls have slightly different understandings of what the desired distance  $d_{ij}$  between them is supposed to be. The question is relevant because no two positioning controls can be expected to move agents to precisely specified positions because of inevitable imprecision in the physical comparators used to compute the positioning errors. The question is also relevant because it is mathematically equivalent to determining what happens if neighboring agents have differing estimates of what the actual distance between them is. In either case, what one would hope for would be a gradual distortion of the formation from its target shape as discrepancies in desired or sensed distances increase. While this is observed for the gradient laws in question, something else quite unexpected happens at the same time. In this talk we will describe what occurs and explain why. The robustness issues raised here have broader implications extending well beyond formation maintenance to the entire field of distributed optimization and control. In particular, this research illustrates that when assessing the efficacy of a particular distributed algorithm, one must consider the consequences of distinct agents having slightly different understandings of what the values of shared data between them is supposed to be. For without the protection of exponential stability/convergence, it is likely that such discrepancies will cause significant misbehavior to occur.

**Speaker Bio:** A. Stephen Morse was born in Mt. Vernon, New York. He received a BSEE degree from Cornell University, MS degree from the University of Arizona, and a Ph.D. degree from Purdue University. From 1967 to 1970 he was associated with the Office of Control Theory and Application OCTA at the NASA Electronics Research Center in Cambridge, Mass. Since 1970 he has been with Yale University where he is presently the Dudley Professor of Engineering. His main interest is in system theory and he has done research in network synthesis, optimal control, multivariable control, adaptive control, urban transportation, vision-based control, hybrid and nonlinear systems, sensor networks, and coordination and control of large grouping of mobile autonomous agents. He is a Fellow of the IEEE, a Fellow of the International Federation of Automatic Control {IFAC} a past Distinguished Lecturer of the IEEE Control System Society, and a co-recipient of the Society’s 1993 and 2005 George S. Axelby Outstanding Paper Awards. He has twice received the American Automatic Control Council’s Best Paper Award and is a co-recipient of the Automatica Theory/Methodology Prize. He is the 1999 recipient of the IEEE Technical Field Award for Control Systems. He is the 2013 recipient of the American Automatic Control Councils Richard E. Bellman Control Heritage Award. He is a member of the National Academy of Engineering and the Connecticut Academy of Science and Engineering.