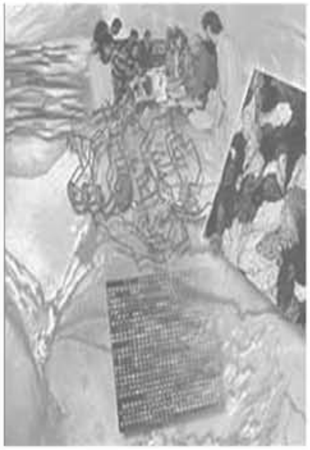

CCEC Seminars
Presents
Teamwork vs. congestion: the role of scale in multi-robot systems

with

Emilio Frazzoli

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Friday, May 20th, 2005 4:00 - 5:00 PM Engineering I Room 2162

Abstract:

A very active research area today addresses coordination of several robots: robotic teams and large-scale swarms are being considered for a broad class of applications, ranging from environmental monitoring to national security. While these concepts are undoubtedly fascinating, it is not clear what are the benefits of scale in such systems. In this seminar, I will present some recent work on two related classes of problems involving the coordination of possibly large numbers of robots. The focus of this work is to investigate the relation between the number of robots and the collective performance; as an additional outcome, we design coordination algorithms with provable performance guarantees.

The first part of the talk will address the following problem. Consider a team of robots free to move within a convex and bounded region in the plane. Assume that "service requests" are generated within the region by a Poisson point process; a service request is fulfilled when one of the robots visits the corresponding point. We present an algorithm that provably minimizes the expected waiting time between the issuance and fulfillment of a service request, in the asymptotic cases of light and heavy load (i.e., when the service requests are issued very rarely or very often). The proposed algorithm is spatially decentralized, and combines tools and results from geometric optimization, combinatorial optimization, and nonlinear control theory. In particular, we will show that the performance of the team increases quadratically with the number of robots in the heavy-load case. This provides a strong motivation for large-scale robotic networks.

The second part of the talk will address the other face of the coin, showing how traffic congestion imposes severe limitations on the performance of large multi-robot systems. More specifically, we will address the following basic problem: Given n robots and n origin-destination pairs in the plane, what is the minimum time needed to transfer each robot from its origin to its destination, avoiding conflicts with other robots? The environment is free of obstacles and a conflict occurs when the distance between any two robots is smaller than a velocity-dependent safety distance. We will show that, even in the case in which the size of the robots vanishes as n increases, the transfer requires Theta(n^(1/2)) time in the best possible case (i.e., the average speed of the robots decreases at least as 1/n^(1/2)). Moreover, we will present an algorithm that solves the problem for a random choice of origin/destination points in O(n^(1/2)) time, with high probability.

About the Speaker:

Emilio Frazzoli joined the faculty of the Mechanical and Aerospace Engineering Department at the Univ. of California, Los Angeles, in July, 2004. He received the Laurea degree in Aeronautical Engineering, magna cum laude, from the University of Rome La Sapienza , Rome, Italy, in 1994, and a Ph. D. from the Aeronautics and Astronautics Department of the Massachusetts Institute of Technology in 2001. Between 2001 and 2004, Dr. Frazzoli was on the faculty of the Aerospace Engineering Department of the University of Illinois at Urbana-Champaign; before going back to school for his doctorate, he served as an officer in the Italian Navy, and was a flight dynamics specialist in the spacecraft control center of Telespazio (Rome, Italy).

Current research interests include algorithmic, computational and geometric approaches to the design and development of decision and control architectures for complex networked and autonomous systems, in aerospace and other domains. Application areas include distributed cooperative control of multiple vehicle systems, guidance and control of agile vehicles, high-confidence software engineering for high-performance dynamical systems, verification of hybrid systems.