Distinguished Lecture Series

Robust Ant Colony Algorithms: Density Estimation and House-Hunting

Nancy Lynch

NEC Professor of Software Science and Engineering
Massachusetts Insitute of Technology

Wednesday, October 30th
BYENG 209
1:30PM - 3:30PM

Abstract: My research group has been studying Biological Distributed Algorithms for around six years, focusing mainly on algorithms for social insect colonies and recently also on brain networks. Biological algorithms have many interesting characteristics: They tend to be simple to describe, though hard to analyze. They are typically probabilistic, and solve problems only approximately. They are flexible (i.e., they can work in different environments), robust (to failures), and adaptive (to changes during operation). These are interesting features for distributed algorithms to have---not just biological algorithms but also engineered distributed algorithms.

We study biological distributed algorithms for two reasons: in order to understand the behavior of biological systems from an algorithmic viewpoint, and in order to extract ideas from biological systems that may help in designing and analyzing algorithms for engineered systems. Throughout this work, we emphasize issues of robustness and adaptiveness. Another general issue of interest is composition of algorithms: we would like to understand how one can combine (probabilistic, approximate) biological distributed algorithms for simple problems to obtain algorithms for more complex problems.

In this talk, I will focus on algorithms for social insect colonies, for which the closest engineering parallels are wireless network algorithms and robot swarm algorithms. In general, our insect colony work addresses problems of foraging (a searching problem), house-hunting (a consensus problem), density estimation, and task allocation. Specifically, in this talk, I will describe an ant colony density estimation algorithm developed by [Lynch, Musco, and Su, 2017, updated 2019] and an ant colony house-hunting algorithm from [Radeva's PhD thesis, 2017]. I will first describe these algorithms and their guarantees separately, and then show how they can be combined.

The results yield some insights into compositional design and analysis of robust systems. This work suggests many new directions for further research, both for insect colonies and for wireless networks and robot swarms.

Bio: Nancy Lynch is the NEC Professor of Software Science and Engineering in MIT's EECS department, and until recently, an Associate Department Head. She heads the Theory of Distributed Systems research group in the MIT Computer Science and Artificial Intelligence Laboratory. She received her PhD from MIT and her B.S. from Brooklyn College, both in Mathematics.

Lynch has (co-)written many research articles about distributed algorithms and impossibility results, and about formal modeling and verification of distributed systems. Her best-known contribution is the "FLP" impossibility result for reaching consensus in asynchronous distributed systems in the presence of failures, with Fischer and Paterson, followed by results with Dwork and Stockmeyer on algorithms for reaching consensus under restricted failure assumptions. Other contributions include the I/O automata system modeling frameworks, with Tuttle, Kaynar, Segala, and Vaandrager.

Lynch is the author of the textbook "Distributed Algorithms" and a co-author of "The Theory of Timed I/O Automata" and "Atomic Transactions". She is an ACM Fellow, a member of both National Academies (Engineering and Sciences), and a Fellow of the American Academy of Arts and Sciences. She has been awarded the Dijkstra Prize (twice), the van Wijngaarden prize, the Knuth prize, the Piore award, the Athena Lecturer award, and an IEEE Technical Achievement award for distributed computing. She has supervised approximately 100 PhD students, Masters students, and postdocs.

Lynch is interested in all aspects of distributed computing theory, including modeling, algorithm design, analysis, lower bounds, and applications. Currently, she is especially interested in algorithms for "difficult" platforms, which are subject to noise, failures, and changes. Recently, her work has focused on wireless network algorithms and biological distributed algorithms (insect colonies and brains).

CIDSE Host: Andrea Richa

ASU Ira A. Fulton Schools of Engineering
Arizona State University