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position: Assistant Professor, Tenure-Track
department: Electrical Engineering, Computer Engineering or Computer Science

Teaching Statement

Although research and teaching should be regarded as complementary activities, the two are often quite separate in academia. This is, to some extent, unavoidable. During the short span of four years, undergraduates must be inculcated in the core concepts of the field. They cannot be submerged in advanced topics before they have mastered the fundamentals. Moreover, it would be a mistake for teaching to follow every research fad. And yet, undergraduates can benefit greatly from some exposure to the research activities of the faculty. Student projects, in particular, can convey some of the excitement of research and serve as a bridge to graduate school.

Teaching Experience

For the past two years, I have been the **instructor** for the graduate-level course "**Computation Theory and Neural Systems**" at Caltech. The course investigates a variety of computational models for neural and biological systems. It focuses on the theoretical capabilities and limitations of the models, studying each with considerable mathematical rigor. The students learn relevant concepts and techniques from disparate fields such as biology, circuit theory, and distributed computing. Many of the topics are at the leading edge of research.

When teaching any subject, I feel that it is important to point out, if possible, what is *not* known – for instance, the open problems and the ongoing research in the field. Otherwise, students may get the impression that they are being taught a subject about which every minute detail has been worked out. This is particularly true in disciplines of computer science and engineering where the focus is on design. Beginning with introductory courses on digital logic, students are taught increasingly sophisticated constructs. By the time they reach upper-level project courses, they might conclude that the design of optimal circuits is an open-and-shut case. As a lab project, I give students some simple circuits to feed as inputs to CAD packages. Comparing the outputs to circuits that have been designed by experts, they can quickly judge how far from optimal the results are.

The reality is that many important theoretical questions regarding circuit optimality are still open. I teach the following result: There is a lower bound of $2n - 1$ on the number of AND gates required to compute the EXOR of n variables (assuming that negations are free and that the gates have an unbounded number of inputs). The proof employs a forcing argument. Given a circuit computing the EXOR of n variables, one can always eliminate *two* gates by fixing *one* of the variables to the constant value 0. In doing so, one obtains a circuit computing the EXOR of $n - 1$ variables. The proof is non-trivial, requiring the better part of a one-hour lecture, but it is within the students' grasp. Afterward, the students are very surprised to learn that the best-known construction for computing the EXOR of n variables is a circuit with $O(2.5n)$ AND gates. As a research problem, I suggest that the students try to prove that one can always eliminate *five* gates by fixing *two* variables simultaneously. Such a proof would close the gap between the lower bound and the construction – a result worthy of publication. The students have come up with good ideas; I am convinced that they will produce a complete proof in the near future.

Teaching Interests

I have found all aspects of teaching to be stimulating and rewarding: lecturing, interacting with the students, formulating the problem sets and lab experiments – even grading homework. As a junior faculty, I would be pleased to teach any topic in the curriculum of electrical engineering, computer engineering, computer science, or discrete mathematics. In particular, I have a strong background in logic design, information and coding theory, distributed computing, algorithms, and complexity. I would welcome the opportunity to teach freshmen basic topics such as circuit analysis, digital system design, and calculus. I would also enjoy directing lab and project courses in software or hardware design. At the graduate level, I would be interested in teaching courses in electronic design automation, computer architecture, asynchronous circuits, and systems biology.