Center for Computational Engineering

Computational engineering plays an increasingly important role in economic competitiveness, national security, environmental stewardship, and public safety. Indeed, computational engineering is central to all engineering endeavors—from the development of appropriate mathematical models, to the prediction of mechanical, electrical, chemical, and biological phenomena, to the design of complex natural and engineered systems. Computational engineering has now reached a stage at which—if it is to reach full potential as a pervasive enabling technology—further progress requires the development of new interdisciplinary education and research models.

In fall 2008, the Center for Computational Engineering (CCE) was formed in the School of Engineering to support computational engineering research and education at MIT. The center comprises 74 faculty and research partners representing 14 academic programs from across the School of Engineering, the School of Science, and the Sloan School of Business. CCE's focus is on computational approaches for engineering problems—the formulation and implementation of new approaches that are more efficient and capable than current methods and the informed application of existing approaches to important engineering questions. The emphasis is on the development of the next generation of innovators and innovations in computational engineering.

Graduate Education

CCE offers two educational programs, the interdisciplinary master of science program in computation for design and optimization (CDO) and the doctoral program in computational science and engineering (CSE). Nicolas Hadjiconstantinou and Youssef Marzouk serve as co-directors of the graduate programs.

Computation for Design and Optimization

Total enrollment in academic year 2014 for CDO was 28 students, 14 of whom were first-year students. One CDO student was on the September degree list; no CDO students graduated in February; three graduated in June, increasing the total number of CDO alumni to 124 as of June 2014. We are sad to report the sudden death of one of our students during the spring 2014 term.

CDO conducted its 10th admissions cycle this past winter and spring. Serving on the admissions committee were Youssef Marzouk (chair), Nicolas Hadjiconstantinou, Saurabh Amin, and Laurent Demanet. Of the 85 students who applied, 16 were offered admission. Twelve students accepted and plan to begin work on their SM degrees in September 2014; one student deferred admission to September 2015.

Computational Science and Engineering

In September 2013, CCE began accepting applicants for the new doctoral program, CSE. Students enrolled in this program are able to specialize at the doctoral level in a computation-related field of their choice through focused coursework and a doctoral thesis. The program is offered through five participating departments: civil and environmental engineering (Course 1), mechanical engineering (Course 2), chemical engineering (Course 10), aeronautics and astronautics (Course 16), and nuclear science and engineering (Course 22).

Applicants to the CSE program must be accepted by both the participating department and the CCE admission committee. Serving on the committee this admission cycle were Nicolas Hadjiconstantinou and Youssef Marzouk. Of the 23 students who applied, 10 were offered admission; 8 students accepted and plan to begin their degree work in September 2014.

Research

The emphasis of CCE research activities is on the development of new computational methods and on the innovative application of computational techniques to important problems in engineering and science.

CCE research projects are focused on several major methodology themes and several major applications themes. The methodology themes are high-performance computation and computational foundations; multi-scale, multi-physics, multi-fidelity simulations; computational design, optimization, and control; integration of data and simulation; and computational geometry and scientific visualization. The applications themes are materials and manufacturing; nano- and microsystems; biological and biomedical processes and systems; infrastructure systems and services; and energy, environment, and transportation.

CCE faculty members are recognized in the national computational science and engineering community through leadership positions in professional societies such as the Society of Industrial and Applied Mathematics (SIAM) and through senior editorial positions in the leading computational science and engineering journals. In addition, the DiaMonD center (funded by the US Department of Energy) includes CCE faculty Karen Willcox, Youssef Marzouk, and Ruben Juanes; in its second year of operation; the center continues to bring visibility to MIT's computational science and engineering presence in the nation.

Accomplishments

During academic year 2014, the MIT SIAM chapter ran a student seminar series in collaboration with CCE. These seminars served as a means of bringing together the members of the diverse MIT community who hold a common interest in applied mathematics and computational sciences. Thirteen students from six different departments presented their research during this year-long series. CCE also assisted SIAM in offering a small-group faculty talk for 15 graduate students and postdoctoral researchers from a range of departments.

The fourth CCE Student Symposium was held on March 13, 2014. This year's event was coordinated to coincide with the Open House for newly admitted students. Cleve Moler, creator of MATLAB and co-founder of MathWorks, gave a keynote address on "How Mathematics Impacts Your Daily Life." Several students participated in the poster session, presenting their work in a two-minute overview. More than 80 students and faculty attended the talk and poster session.

Honors and Recognitions

Faculty

In July 2013, Stephen C. Graves received the Zaragoza Logistics Center Medal of Distinction.

In July 2013, Anthony T. Patera was awarded the US Association for Computational Mechanics Thomas J. R. Hughes Medal.

This spring, Georgia Perakis received one of two 2014 Jamieson Teaching Awards from the MIT Sloan School of Management.

In January 2014, the Air Force Office of Scientific Research announced that Qiqi Wang will receive a 2014 Young Investigator Program award for his project, "Gradient-Based Optimization and Control of Chaotic Multidisciplinary Systems via Least Squares Shadowing Adjoint Method."

In early 2014, Carolina Osorio was awarded the 100 Colombians Award by the Fusionarte Association of Colombia. The award recognizes the work of Colombians who excel in their fields and live outside the country. Osorio was honored for her work using operations research techniques to improve the design and operation of transportation systems. In March 2014, the National Science Foundation announced that Carolina Osorio will receive a 2014 Early Career Award for her project, "Simulation-Based Optimization Techniques for Urban Transportation Problems." In May 2014, Carolina Osorio won the Department of Civil and Environmental Engineering's Maseeh Award for Excellence as a Teacher.

Graduate Students

In August 2013, Jean Aoussou was awarded an Office of the Dean for Graduate Education Minority Fellowship.

Future Plans

CCE's plans for the coming year include building a solid foundation to ensure the future success of the new CSE PhD program. This includes targeted outreach in publicizing the program, both within and outside MIT. We will also explore other opportunities to increase the number of departments participating in the CSE program and focus on strengthening connections among the CCE community, particularly for CCE students. We will continue to support the student seminar series and the annual student symposium, and will hold a new community social event in the fall semester. We will also encourage and support the formation of a CCE graduate student body spanning both the CDO SM program and the CSE PhD program.

Anthony T. Patera, Co-director
Ford Professor of Engineering
Professor of Mechanical Engineering

Karen Willcox, Co-director
Professor of Aeronautics and Astronautics