Center for Computational Engineering

The Center for Computational Engineering (CCE) was formed in the School of Engineering in 2008 to support computational engineering research and education at MIT. A decade later, 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 and the prediction of mechanical, electrical, chemical, and biological phenomena to the design of complex natural and engineered systems. Computational engineering has now reached the stage in which further progress—to reach full potential as a pervasive enabling technology—requires the development of new interdisciplinary education and research models.

CCE focuses on computational approaches to engineering problems. This involves the formulation and implementation of new methods that are more efficient and the informed application of existing approaches to engineering and scientific questions. CCE's emphasis is on the development of the next generation of innovators and innovations in computational engineering. As of June 30, 2019, more than 80 faculty members and researchers representing 15 academic programs from across the School of Engineering, the School of Science, the Sloan School of Management, and the School of Architecture and Planning were affiliated with CCE.

The 2019 academic year brought a transition in CCE leadership. Early in the academic year, Anantha Chandrakasan, dean of the School of Engineering, named Youssef Marzouk, associate professor of aeronautics and astronautics, and Nicolas Hadjiconstantinou, professor of mechanical engineering, as CCE's co-directors. Anthony Patera, Ford Foundation Professor of Engineering in the Department of Mechanical Engineering, and Karen Willcox, former MIT professor of aeronautics and astronautics, are acknowledged for their leadership of the center as it grew and developed over the past 10 years. The CCE co-directors are grateful for the groundwork that their predecessors provided and happy to have the opportunity to continue the effort of advancing computational science and engineering research and education within the MIT community.

The CCE co-directors' first objective was to focus on soliciting input from CCE's affiliated faculty and researchers regarding the future direction of CCE. As part of this process, CCE has been included as an inaugural component of the MIT Stephen A. Schwarzman College of Computing. A second outcome of this process was the recently constituted industrial engagement program for companies interested in building a working relationship with the CCE research community. A goal for the upcoming academic year is to continue to grow and evolve this program.

Another objective was to expand the scope of the annual CCE Symposium. Historically, this event has involved a student-invited keynote speaker followed by a student poster session and reception. The 2019 CCE Symposium was held on March 18, 2019, at the Samberg Conference Center. This event, which ran in conjunction with the CCE admitted student visit day, featured short talks from five faculty members affiliated with CCE. The speakers and topics follow:

- Ken Kamrin, associate professor, Mechanical Engineering, "Hybridizing discrete and continuum approaches to granular materials simulation"
- Heather Kulik, assistant professor, Chemical Engineering, "Exploiting electronic structure and machine learning models for discovery in transition metal chemistry"
- Mark Bathe, associate professor, Biological Engineering, "In silico design and discovery of next-generation nanoscale materials"
- Carolina Osorio, associate professor, Civil and Environmental Engineering and faculty member at the Operations Research Center, "Computationally efficient optimization algorithms for urban mobility systems of the future"
- Justin Solomon, X-Consortium Career Development Assistant Professor, Electrical Engineering and Computer Science, "Volumetric challenges in shape analysis"

David Keyes, professor of applied mathematics and computational science, and director of the Extreme Computing Research Center of King Abdullah University of Science and Technology, gave the keynote: "Convergence of big data and large-scale simulation." Additionally, MIT CCE MathWorks Prizes for outstanding doctoral research were awarded to recent alumni Pablo Fernandez del Campo (PhD, Computational Science and Engineering) and current student Jon Paul Janet (PhD candidate, Chemical Engineering and Computation). A poster session followed with best poster prizes awarded to students Nisha Chandramoorthy (PhD candidate, Mechanical Engineering and Computation) and Rachel Kurchin (PhD candidate, Materials Science and 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).

Master of Science Program in Computation for Design and Optimization

CDO enrollment at the start of AY2019 was 15 students, seven of whom were first-year students. Two CDO students graduated on the September 2018 degree list, one on the February 2019 list and three graduated in June 2019, increasing the total number of CDO alumni to 173 as of June 2019.

CDO conducted its 15th admissions cycle this past winter and spring. Serving on the admissions committee with the CCE co-directors were Professors Carolina Osorio (Civil and Environmental Engineering and Operations Research Center) and Wim van Rees (Mechanical Engineering). There were 112 applications submitted in January 2019, representing no change in volume from the previous application cycle. Eight of the 112 applicants were offered admission (a 7% admission rate) and seven of those accepted and plan to begin their SM degree in September 2019 (a yield of 87.5%). The eighth admitted student deferred enrollment to September 2020. The seven incoming CDO SM students will be joined by three incoming CSE students who need to complete a master's degree before formally moving into the CSE PhD program.

Doctoral Program in Computational Science and Engineering

CSE began accepting applications for its doctoral program in Computational Science and Engineering in September 2013. In the fall of 2018 the Department of Earth, Atmospheric and Planetary Sciences joined as the seventh home department for students in the CSE program, following the Department of Mathematics as the second home department in the School of Science. CSE enrollment at the start of AY2019 was 40 students; seven were first-year students and an additional 11 current doctoral students in affiliated home departments joined the CSE program over the course of the 2019 academic year. Two CSE students graduated on the September 2018 degree list, three graduated on the February 2019 list, and eight graduated in June 2019, bringing the number of CSE alumni to 35.

CSE conducted its sixth admission cycle this past winter and spring, receiving 117 applications, a 9.4% increase from the previous year. The co-directors served as CCE reviewers, reading all applications and passing the most qualified applicants along to the various home departments for review. Of the 117 applicants, 12 were offered admission (a 10% admission rate); six students accepted and plan to begin their degree work in September 2019 (a yield of 50%).

Distinguished Seminar Series in Computational Science and Engineering

This Institute-wide seminar series hosted by CCE draws a broad audience from mathematics, science, and engineering, but focuses on innovative methods and applications of computation. The 2018–2019 seminar series included the following invited speakers and topics:

- Sidney Yip, MIT professor emeritus, Nuclear Science and Engineering/Materials Science and Engineering, “The richness of computational engineering at MIT: observations on advocacy and stewardship”
- George Karniadakis, The Charles Pitts Robinson and John Palmer Barstow Professor of Applied Mathematics, Brown University, “Physics-informed learning machines for physical systems”
- Saman Amarasinghe, associate department head, MIT Department of Electrical Engineering and Computer Science, “Making sparse fast”
- Tim Colonius, Frank and Ora Lee Marble Professor of Mechanical Engineering, California Institute of Technology, “Spectral POD and resolvent analysis of turbulent flows”
- Efthimios Kaxiras, John Hasbrouck Van Vleck Professor of Pure and Applied Physics, director of the Institute for Applied Computational Science in the School of Engineering and Applied Sciences, Harvard University, “Machine learning for materials”
- Arif Masud, professor in the Departments of Civil and Environmental Engineering, Aerospace Engineering, and Computational Science and Engineering, University of Illinois at Urbana-Champaign, “A new class of variational methods for multiphysics interfacial problems, data driven modeling, and error estimation”

- Lek-Heng Lim, associate professor, Department of Statistics and the College, University of Chicago, "Numerical Differential Geometry"
- Arnaud Doucet, professor of statistics, University of Oxford, research scientist, DeepMind, "Piecewise deterministic Markov chain Monte Carlo"

Nicolas Hadjiconstantinou
Co-director
Professor of Mechanical Engineering

Youssef Marzouk, Co-director
Associate Professor of Aeronautics and Astronautics