MIT MECHE

MechEConnects | Fall 2021

COMPUTING FOR PHYSICAL SYSTEMS

MechEConnects

News from the MIT
Department of Mechanical Engineering

Fall 2021 | ► meche.mit.edu

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In May 2021, department head Professor Evelyn Wang served as officiant for the wedding of MechE graduate student Yajing Zhao and EECS student Shichao Yue, whose doctoral advisor Professor Dina Katabi served as a witness. Credit: Tony Pulsone

MIT MECHE

About MechE

The Department of Mechanical Engineering – MechE – embodies the Massachusetts Institute of Technology's motto *mens et manus*, "mind and hand," as well as "heart" by combining analysis and hands-on discovery with a commitment to making the world a better place. By leveraging our strengths, we aspire to solve some of the biggest challenges facing our world – and train the next generation of mechanical engineers to develop creative products and solutions.

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Cover:
Assistant Professor Faez Ahmed and his team at MIT's Design Computation & Digital Engineering Lab use an AI-driven design method that can generate entirely novel and improved designs for a range of products – including the traditional bicycle. Using a dataset of 4,500 bicycle designs, they've developed algorithms that can generate novel designs based on specific parameters and rider dimensions.

Credit: MIT DeCoDE Lab/Wing Ngan

Have updates or news to share with the MechE community? Have ideas for future issues of MechE Connects?

Email us at mecomms@mit.edu

Dear Alumni, Students, Faculty, Staff, and Friends,

The view from my office in Building 3 as I write this is starting to look more typical for the beginning of the academic year. Students are congregating outside in du Pont Court. The hallways echo with staff greeting each other after eighteen months working remotely. Boats from the MIT Sailing Pavilion are darting along the Charles. For the first time since March 2020, there is a sense of the familiar as we gear up for the upcoming academic year.

At the same time, there is still much uncertainty. By the time you read this letter, it's possible that we will have had to re-adapt in the face of new Covid-19 variants, increased cases, and public health concerns. But if there is one thing the past year and a half has taught me, it's that the mechanical engineering community at MIT rises to the occasion when met with uncertainty.

In many ways, this issue of MechE Connects deals with uncertainty. The explosion in computing, artificial intelligence, and machine learning research over the past decade has helped engineers and researchers tackle issues that were previously uncertain. As a result, technologies that were unimaginable a few short years ago – from face recognition in our phones to amazingly accurate search engine algorithms – are now possible.

Mechanical engineers are responsible for putting algorithms into action. We sit at the interface of computing and physical systems.

Much of the focus on computing has been on the contributions of computer scientists and mathematicians. However, mechanical engineers have played a pivotal role in making these previously unattainable technologies a reality. Mechanical engineers are responsible for putting algorithms into action. We sit at the interface of computing and physical systems – designing models, products, and systems that apply the latest breakthroughs in computing to the physical world.

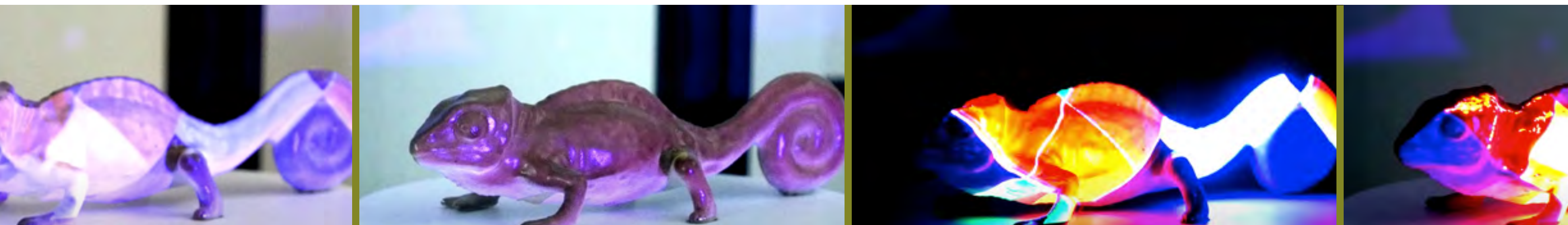
Our department's collaborations with the MIT Schwarzman College of Computing demonstrate the unique contributions mechanical engineers are making in the field of computing. From launching our first "Common Ground" course with the College (which you'll learn more about on page 16) to hiring our first faculty with joint appointments in MechE and the College's Institute for Data, Systems, and Society, we are bridging the gap between the physical world and computing.

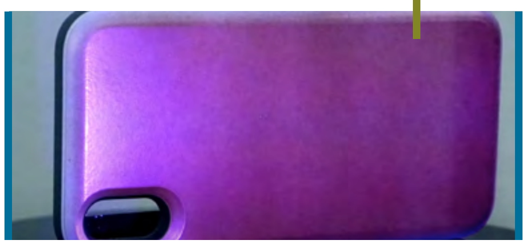
In this issue of MechE Connects, we focus on the ways in which faculty, staff, students, and alumni from MIT's Department of Mechanical Engineering are applying computing to physical systems. From computational design for new bicycles and saving seaweed farms with machine learning to building smart cities and modeling Covid-19's mutation rate, we hope you enjoy learning about some of the innovative ways our mechanical engineering community at MIT has been using computing to transform the physical world we inhabit.

Sincerely,

Evelyn Wang

Evelyn Wang
Ford Professor of Engineering





Design's

Mechanical engineers are using cutting-edge computing and machine learning techniques to reimagine how the products, systems, and infrastructures we use are designed.

By Mary Beth Gallagher

In the 1960s, the advent of computer-aided design (CAD) sparked a revolution in design. For his PhD thesis in 1963, MIT Professor Ivan Sutherland developed Sketchpad, a game-changing software program that enabled users to draw, move, and resize shapes on a computer. Over the course of the next few decades, CAD software reshaped how everything from consumer products to buildings and airplanes was designed.

"CAD was part of the first wave in computing in design. The ability of researchers and practitioners to represent and model designs using computers was a major breakthrough, and still is one of the biggest outcomes of design research in my opinion," says Maria Yang, Gail E. Kendall Professor and director of MIT's Ideation Lab.

Innovations in 3D printing during the 1980s and 1990s expanded CAD's capabilities beyond traditional injection molding and casting methods, providing designers even more flexibility. Designers could sketch, ideate, and develop prototypes or models faster and more efficiently. Meanwhile, with the push of a button, software like that developed by Professor Emeritus David Gossard of

new frontier

Associate Professor Stefanie Mueller and her team have developed personal fabrication techniques that could enable end-users to alter the design and appearance of the products they own on demand. Credit: MIT CSAIL

MIT's CAD Lab could solve equations simultaneously to produce a new geometry on the fly.

In recent years, mechanical engineers have expanded the computing tools they use to ideate, design, and prototype. More sophisticated algorithms and the explosion of machine learning and artificial intelligence technologies have sparked a second revolution in design engineering.

Researchers and faculty at MIT's Department of Mechanical Engineering are utilizing these technologies to reimagine how the products, systems, and infrastructures we use are designed. These researchers are at the forefront of the new frontier in design.

Computational design

Faez Ahmed wants to reinvent the wheel, or at least the bicycle wheel. He and his team at MIT's Design Computation & Digital Engineering Lab (DeCoDE) use an AI-driven design method that can generate entirely novel and improved designs for a range of products – including the traditional bicycle. They create advanced computational methods to blend human-driven design with simulation-based design.

"The focus of our DeCoDE lab is computational design. We are looking at how we can create machine learning and AI algorithms to help us discover new designs that are optimized based on specific performance parameters," says Ahmed, an assistant professor of mechanical engineering at MIT.

For their work using AI-driven design for bicycles, Ahmed and his collaborator Professor Daniel Frey wanted to make it easier to design customizable bicycles, and by extension, encourage more people to use bicycles over transportation methods that emit greenhouse gases.

To start, the group gathered a dataset of 4,500 bicycle designs. Using this massive dataset, they tested the limits of what machine learning could do. First, they developed algorithms to group bicycles that looked similar together and explore the design space. They then created machine learning models that could successfully predict what components are key in identifying a bicycle style, such as a road bike versus a mountain bike.

Once the algorithms were good enough at identifying bicycle designs and parts, the team proposed novel machine learning tools that could use this data to create a unique and creative design for a bicycle based on certain performance parameters and rider dimensions.

Ahmed used a generative adversarial network – or GAN – as the basis of this model. GAN models utilize neural networks that can create new designs based on vast amounts of data. However, using GAN models alone would result in homogenous designs that lack novelty and can't be assessed in terms of performance. To address these issues in design problems, Ahmed has developed a new method which he calls "PaDGAN," performance-augmented diverse GAN.

"When we apply this type of model, what we see is that we can get large improvements in the diversity and quality, as well as novelty of the designs," Ahmed explains.

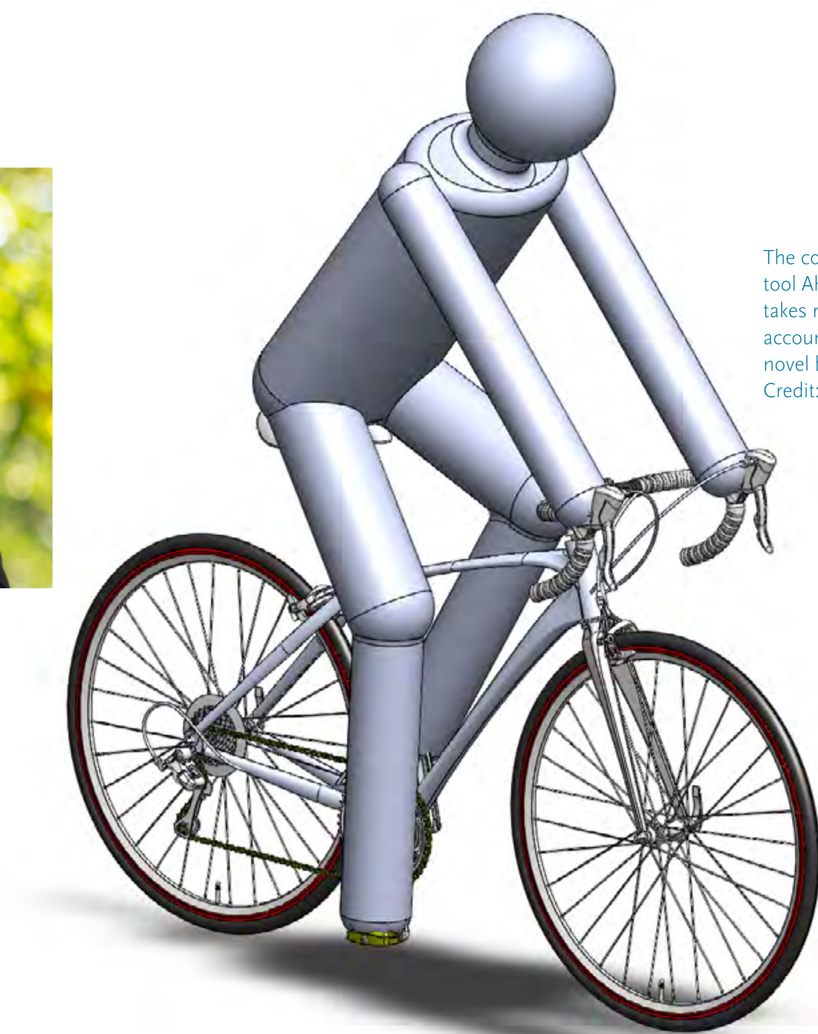
Using this approach, Ahmed's team developed an open-sourced computational design tool for bicycles freely available on their lab website. They hope to further develop a set of generalizable tools that can be used across industries and products.

Longer term, Ahmed has his sights set on loftier goals. He hopes the computational design tools he develops could lead to "design democratization," putting more power in the hands of the end user.

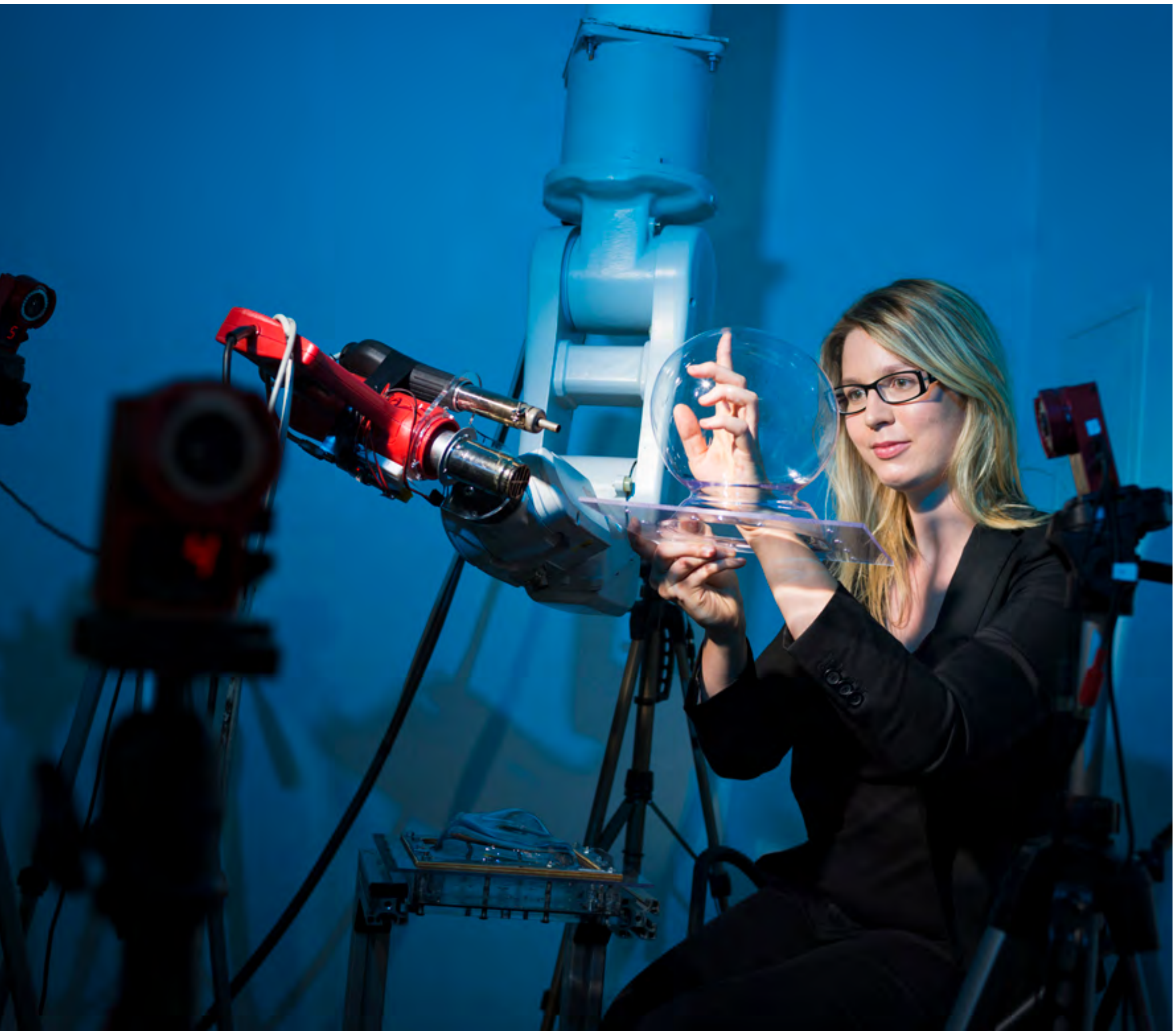
"With these algorithms, you can have more individualization where the algorithm assists a customer in understanding their needs and helps them create a product that satisfies their exact requirements," he adds.

Using algorithms to democratize the design process is a goal shared by Stefanie

Assistant Professor Faez Ahmed
Credit: John Freidah



The computational design tool Ahmed has developed takes rider dimensions into account when generating novel bicycle designs.
Credit: MIT DeCoDE Lab



Associate Professor Stefanie Mueller and her team developed the "Photo-Chromeleon," which utilizes a combination of photochromic dyes, UV and LED lights, and an optimization algorithm to alter the design on a 3D sculpture of a chameleon.
Credit: Kay Herschelmann/MIT CSAIL

Mueller, an associate professor in electrical engineering and computer science (EECS) and mechanical engineering.

Personal fabrication

Platforms like Instagram give users the freedom to instantly edit their photographs or videos using filters. In one click, users can alter the palette, tone, and brightness of their content by applying filters that range from bold colors to sepia toned or black and white. Stefanie Mueller, X-Window Consortium Career Development Professor, wants to bring this concept of the Instagram filter to the physical world.

"We want to explore how digital capabilities can be applied to tangible objects. Our goal is to bring reprogrammable appearance to the physical world," explains Mueller, director of the HCI Engineering Group based out of MIT CSAIL.

Mueller's team utilizes a combination of smart materials, optics, and computation to advance personal fabrication technologies that would allow end users to alter the design and appearance of the products they own. They tested this concept in a project they dubbed "Photo-Chromeleon."

First, a mix of photochromic cyan, magenta, and yellow dyes are airbrushed onto an object – in this instance a 3D sculpture of a chameleon. Using software they developed, the team sketches the exact color pattern they want to achieve on the object itself. A UV light shines on the object to activate the dyes.

To actually create the physical pattern on the object, Mueller has developed an optimization algorithm to use alongside a normal office projector outfitted with red, green, and blue LED lights. These lights shine on specific pixels on the object for a given period of time to physically

Millions of people die each year as a result of soot or smoke inhalation from wood-burning cookstoves. *Top:* A woman in Uganda cooks a meal using a wood-burning cookstove. *Right:* A team led by Deng uses physics-based modeling to better understand the combustion and emission process of cookstoves to help design and manufacture a better performing, low-cost product. Credit: John Freidah

change the makeup of the photochromic pigments.

"This fancy algorithm tells us exactly how long we have to shine the red, green, and blue light on every single pixel of an object to get the exact pattern we've programmed in our software," says Mueller.

Giving this freedom to the end user enables limitless possibilities. Mueller's team has applied this technology to iPhone cases, shoes, and even cars. In the case of shoes, Mueller envisions a shoebox embedded with UV and LED light projectors. Users could put their shoes in the box overnight and the next day have a pair of shoes in a completely new pattern.

Mueller wants to expand her personal fabrication methods to the clothes we wear. Rather than utilize the light projection technique developed in the Photo-Chromeleon project, her team is exploring the possibility of weaving LEDs directly into clothing fibers, allowing people to change their shirt's appearance as they wear it. These personal fabrication technologies could completely alter consumer habits.

"It's very interesting for me to think about how these computational techniques will change product design on a high level," adds Mueller. "In the future, a consumer could buy a blank iPhone case and update the design on a weekly or daily basis."

Another team of mechanical engineers, including Sili Deng, Brit (1961) & Alex (1949) d'Arbeloff Career Development Professor, is developing a different kind of design tool that could have a large impact on individuals in low- and middle-income income countries across the world.

Computational fluid dynamics and participatory design

As Sili Deng walked down the hallway of Building 1 on MIT's campus, a monitor playing a video caught her eye. The video featured work done by mechanical engineers and MIT D-Lab on developing cleaner burning briquettes for cookstoves in Uganda. Deng immediately knew she wanted to get involved.

"As a combustion scientist, I've always wanted to work on such a tangible real-world problem, but the field of combustion tends to focus more heavily on the academic side of things," explains Deng.

After reaching out to colleagues in MIT D-Lab, Deng joined a collaborative effort to develop a new cookstove design tool for the three billion people across the world who burn solid fuels to cook and heat their homes. These stoves often emit soot and carbon monoxide, not only leading to millions of deaths each year, but also worsening the world's greenhouse gas emission problem.

The team is taking a three-pronged approach to developing this solution, using a combination of participatory design, physical modeling, and experimental validation to create a tool that will lead to the production of high-performing, low-cost energy products.

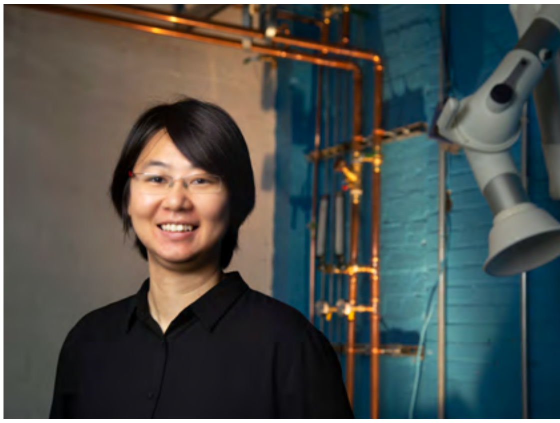
Deng and her team in the Deng Energy and Nanotechnology Group use physics-based modeling for the combustion and emission process in cook stoves.

"My team is focused on computational fluid dynamics. We use computational and numerical studies to understand the flow field where the fuel is burned and releases heat," says Deng.

These flow mechanics are crucial to understanding how to minimize heat loss and make cookstoves more efficient, as well as learning how dangerous pollutants are formed and released in the process.

Using computational methods, Deng's team performs three-dimensional simulations of the complex chemistry and transport coupling at play in the combustion and emission processes. They then use these simulations to build a combustion model for how fuel is burned and a pollution model that predicts carbon monoxide emissions.

> We use computational and numerical studies to understand the flow field where the fuel is burned and releases heat.



Assistant Professor Sili Deng
Credit: John Freidah

Deng's models are used by a group led by Dr. Daniel Sweeney in MIT D-Lab to test the experimental validation in prototypes of stoves. Finally, Professor Maria Yang uses participatory design methods to integrate user feedback, ensuring the design tool can actually be utilized by people across the world.

The end goal for this collaborative team is to not only provide local manufacturers with a prototype they could produce themselves, but to also provide them with a tool that can tweak the design based on local needs and available materials.

Deng sees wide-ranging applications for the computational fluid dynamics her team is developing.

"We see an opportunity to use physics-based modeling, augmented with a machine learning approach, to come up with chemical models for practical fuels that help us better understand combustion. Therefore, we can design new methods to minimize carbon emissions," she adds.

While Deng is utilizing simulations and machine learning at the molecular level to improve designs, others are taking a more macro approach.

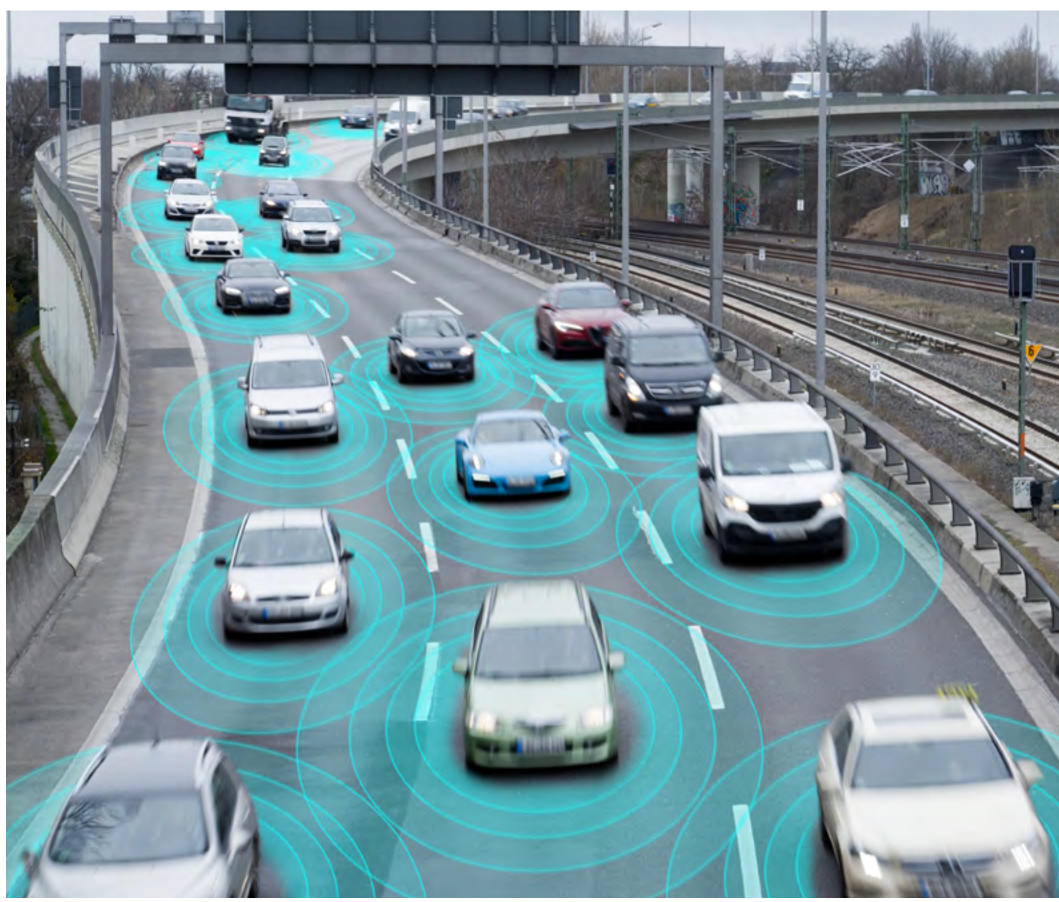
Designing intelligent systems

When it comes to intelligent design, Navid Azizan thinks big. He hopes to help create future intelligent systems that are capable of making decisions autonomously by using the enormous amounts of data emerging from the physical world. From smart robots and autonomous vehicles to smart power grids and smart cities, Azizan focuses on the analysis, design, and control of intelligent systems.

Achieving such massive feats takes a truly interdisciplinary approach that draws upon various fields such as machine learning, dynamical systems, control, optimization, statistics, and network science, among others.

"Developing intelligent systems is a multifaceted problem, and it really requires a confluence of disciplines," says Azizan, assistant professor of mechanical engineering with a dual appointment in

Assistant Professor Navid Azizan
Credit: John Freidah



Azizan and his team are developing algorithms that account for uncertainty in autonomous systems, such as self-driving cars. When uncertainty is high, systems can be switched to a "safe policy" to avoid catastrophic events.

MIT's Institute for Data, Systems, and Society (IDSS). "To create such systems, we need to go beyond standard approaches to machine learning, such as those commonly used in computer vision, and devise algorithms that can enable safe, efficient, real-time decision making for physical systems."

For robot control to work in the complex, dynamic environments that arise in the real world, real-time adaptation is key. If, for example, an autonomous vehicle is going to drive in icy conditions or a drone is going to be operating in windy conditions, they need to be able to adapt to their new environments quickly.

To address this challenge, Azizan and his collaborators at MIT and Stanford University have developed a new algorithm that combines adaptive control, a powerful methodology from control theory, with meta learning, a new machine learning paradigm.

"This 'control-oriented' learning approach outperforms the existing 'regression-oriented' methods, which are mostly focused on just fitting the data, by a wide margin," says Azizan.

Another critical aspect of deploying machine learning algorithms in physical systems that Azizan and his team hope to address is safety. Deep neural networks are a crucial part of autonomous systems. They are used for interpreting complex visual inputs and making data-driven predictions of future behavior in real time. However, Azizan urges caution.

"These deep neural networks are only as good as their training data, and their predictions can often be untrustworthy in scenarios not covered by their training data," he says. Making decisions based on such untrustworthy predictions could lead to fatal accidents in autonomous vehicles or other safety-critical systems.

This algorithm is model agnostic and can be applied to neural networks used in various kinds of autonomous systems whether it's drones, vehicles, or robots.

To avoid these potentially catastrophic events, Azizan proposes that it is imperative to equip neural networks with a measure of their uncertainty. When the uncertainty is high, they can then be switched to a "safe policy."

In pursuit of this goal, Azizan and his collaborators have developed a new algorithm known as SCOD – Sketching Curvature of Out-of-Distribution Detection. This framework could be embedded within any deep neural network to equip it with a measure of its uncertainty.

"This algorithm is model agnostic and can be applied to neural networks used in various kinds of autonomous systems whether it's drones, vehicles, or robots," says Azizan.

Azizan hopes to continue working on algorithms for even larger scale systems. He and his team are designing efficient algorithms to better control supply and demand in smart energy grids. According to Azizan, even if we create the most efficient solar panels and batteries, we can never achieve a sustainable grid powered by renewable resources without the right control mechanisms.

Mechanical engineers like Ahmed, Mueller, Deng, and Azizan serve as the key to realizing the next revolution of computing in design.

"MechE is in a unique position at the intersection of the computational and physical worlds," Azizan says. "Mechanical engineers build a bridge between theoretical algorithmic tools and real physical-world applications."

Sophisticated computational tools coupled with the ground truth mechanical engineers have in the physical world could unlock limitless possibilities for design engineering, well beyond what could have been imagined in those early days of CAD.

Student Spotlight:

Charlene Xia ’17, SM ’20, PhD Candidate

Saving seaweed with machine learning

Last year, Charlene Xia ’17, SM ’20 found herself at a crossroads. She was finishing up her master’s degree in media arts and science from the MIT Media Lab and had just submitted applications to doctoral degree programs. All Xia could do was sit and wait. While waiting, she narrowed down her career options, regardless of whether she was accepted to any program.

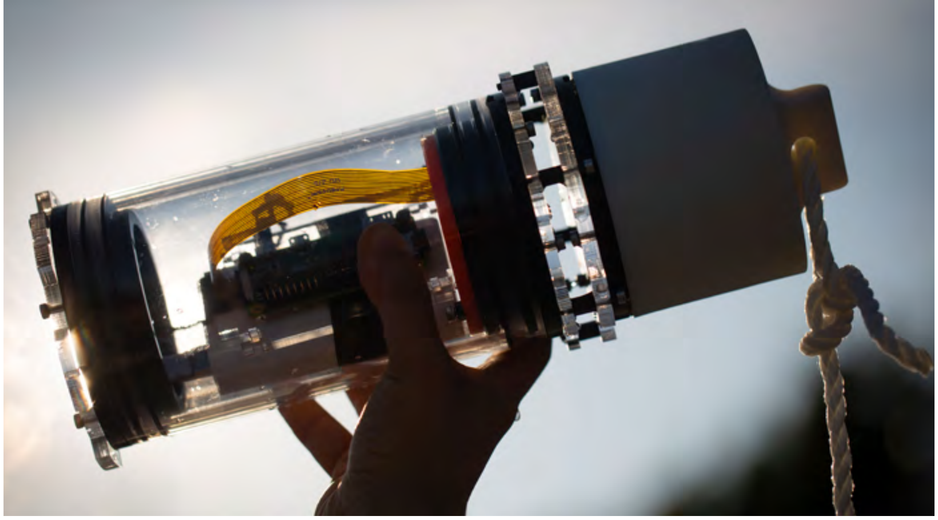
“I had two thoughts: I’m either going to get a PhD to work on a project that protects our planet, or I’m going to start a restaurant,” recalls Xia.

Xia poured over her extensive cookbook collection, researching international cuisines as she anxiously awaited word about her graduate school applications. She looked into the cost of a food truck permit in the Boston area. Just as she started hatching plans to open a plant-based skewer restaurant, Xia received word that she had been accepted into the mechanical engineering graduate program at MIT.

Shortly after starting her doctoral studies, Xia’s advisor, Professor David Wallace, approached her with an interesting opportunity. MathWorks, a computing software company known for developing MATLAB, had announced a new seed-funding program in MIT’s Department of Mechanical Engineering. The program encouraged collaborative research projects focused on the health of the planet.

“I saw this as a super fun opportunity to combine my passion for food, my technical expertise in ocean engineering, and my interest in sustainably helping our planet,” says Xia.

PhD candidate Charlene Xia is using machine learning to monitor the microbiome of seaweed farms in an effort to predict and prevent diseases before they destroy livestock. Credit: John Freidah



Xia and her team have developed a device that includes a submersible digital holographic microscope to take 2D images of an underwater environment. A machine learning neural network is then used to convert the 2D image into a 3D representation of the microbiome present in the water. Credit: John Freidah

Wallace knew Xia would be up to the task of taking an interdisciplinary approach to solve an issue related to the health of the planet. "Charlene is a remarkable, student with extraordinary talent and deep thoughtfulness. She is pretty much fearless, embracing challenges in almost any domain with the well-founded belief that, with effort, she will become a master," says Wallace.

Alongside Wallace and Associate Professor Stefanie Mueller, Xia proposed a project to predict and prevent the spread of diseases in aquaculture. The team focused on seaweed farms in particular.

Already popular in East Asian cuisines, seaweed holds tremendous potential as a sustainable food source for the world's ever-growing population. In addition to its nutritive value, seaweed combats various environmental threats. It helps fight climate change by absorbing excess carbon dioxide in the atmosphere and can also absorb fertilizer run-off, keeping coasts clean.

As with so much of marine life, seaweed is threatened by the very thing it helps mitigate against: climate change. Climate stressors like warm temperatures or minimal sunlight encourage the growth of harmful bacteria such as ice-ice disease. Within days, entire seaweed farms are decimated by unchecked bacterial growth.

To solve this problem, Xia turned to the microbiota present in these seaweed farms as a predictive indicator of any threat to the seaweed or livestock.

"Our project is to develop a low-cost device that can detect and prevent diseases before they affect seaweed or livestock by monitoring the microbiome of the environment," says Xia.

The team pairs old technology with the latest in computing. Using a submersible digital holographic microscope, they take a 2D image. They then use a machine learning neural network to convert the 2D image into a representation of the microbiome present in the 3D environment.

"Using a machine learning network, you can take a 2D image and reconstruct it almost in real time to get an idea of what the microbiome looks like in a 3D space," says Xia.

The software can be run in a small Raspberry Pi that could be attached to the holographic microscope. To figure out how to communicate these data back to the research team, Xia drew upon her master's degree research.

Under the guidance of Professor Allan Adams and Professor Joseph Paradiso in the MIT Media Lab, Xia focused on developing small underwater communication devices that can relay data about the ocean back to researchers for her master's degree. Rather than the usual $4,000, these devices were designed to cost less than $100, helping lower the cost barrier for those interested in uncovering the many mysteries of our oceans. The communication devices can be used to relay data about the ocean environment from the machine learning algorithms.

By combining these low-cost communication devices along with microscopic images and machine learning, Xia hopes to design a low-cost, real-time monitoring system that can be scaled to cover entire seaweed farms.

"It's almost like having the Internet of Things underwater," adds Xia. "I'm developing this whole underwater camera system alongside the wireless communication I developed that can give me the data while I'm sitting on dry land."

Armed with these data about the microbiome, Xia and her team can detect whether or not a disease is about to strike and jeopardize seaweed or livestock before it is too late.

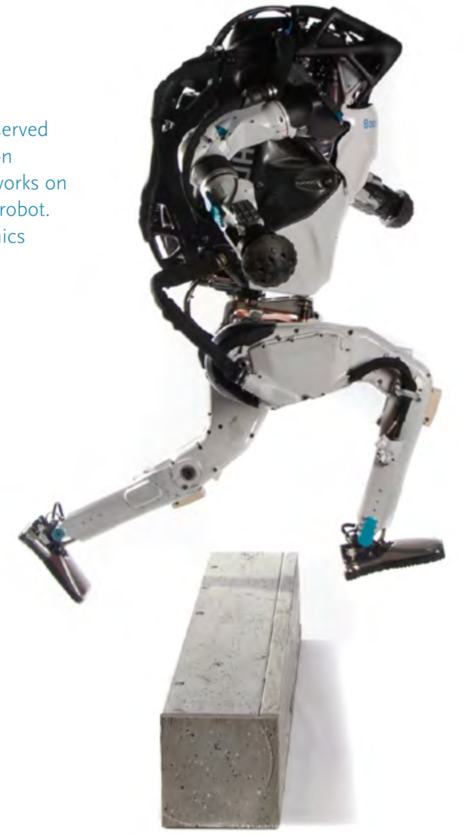
While Xia still daydreams about opening a restaurant, she hopes the seaweed project will prompt people to rethink how they consider food production in general.

"We should think about farming and food production in terms of the entire ecosystem," she says. "My meta-goal for this project would be to get people to think about food production in a more holistic and natural way."

Alumni Profile:

Benjamin Katz '16, SM '18

From "cheetah-noids" to humanoids



Since 2019, Katz has served as a designer at Boston Dynamics, where he works on the ATLAS humanoid robot. Credit: Boston Dynamics

In November 2018, Professor Sangbae Kim brought the mini cheetah robot onto *The Tonight Show's* "Tonight Show-botics" segment. Much to the delight of host Jimmy Fallon, the mini cheetah did some yoga, got back up after falling, and executed a perfect backflip. Behind the stage, Benjamin Katz was remotely controlling the cheetah's nimble maneuvers.

For Katz, waiting in the wings as the robot performed in front of a national audience was the culmination of nearly five years of work.

As an undergraduate at MIT, Katz studied mechanical engineering, opting for the flexible Course 2A degree program with a concentration in controls, instrumentation, and robotics. Toward the end of his first year, he emailed Kim to see if there were any job opportunities in Kim's Biomimetic Robotics Lab. He then spent the summer in Kim's lab as part of the MIT UROP – or Undergraduate Research Opportunities Program.

For his UROP research and undergraduate thesis, he began to look at how to utilize pieces built for the electronics hobby market in robotics. "You can find really high-performance motors built for things like remote control airplanes and drones. I basically thought you could also use these parts for robots, which is something no one was doing," recalls Katz.

Kim was immediately impressed by Katz's abilities an engineer and designer.

"Ben is an extremely versatile engineer who can cover structure and mechanism design, electric motor dynamics, power electronics, and classical control, a range of expertise usually requiring four to five engineers to cover," says Kim.

After deciding to pursue a master's degree in mechanical engineering at MIT, Katz continued working in Kim's lab and developed solutions for actuators in robotics. While working on the third iteration of Kim's robot, known as Cheetah 3, Katz and his labmates shifted their focus to developing a smaller version of the robot.

"There are a lot of nice things about having a smaller robot: if something breaks you can easily fix it, it's cheaper, and it's safe enough for one person to wrangle alone," says Katz. "Even though a small robot may not always be the most practical for real-world applications, its controllers, software, and research can be trivially ported to a big robot that can carry larger payloads."

Drawing upon his undergraduate research, Katz and the research team used twelve motors originally designed for drones to build actuators in each joint of the small quadruped robot that would be dubbed the "mini cheetah."

Armed with this smaller robot, Katz set out to make the mini cheetah more agile and

resilient. Alongside then – EECS student Jared Di Carlo '19, MNG '20, Katz focused on controls related to locomotion in the mini cheetah. In class 6.832, Underactuated Robotics, taught by Professor Russ Tedrake, the pair worked on a project that would allow the mini cheetah to safely backflip from a crouched position.

"It was basically a giant offline optimization problem to get the mini cheetah to backflip," says Katz.

Using offline non-linear optimization to generate the backflip trajectory, he and Di Carlo were able to program the mini cheetah to crouch and rotate 360 degrees around an axis.

While working on the cheetah, Katz was constantly pursuing other engineering projects as a hobby. This included a very different rotating robot as a pet project. Alongside Di Carlo, Katz utilized the MIT community makerspace known as MITERS to develop a robot that could solve a Rubik's Cube in a record-breaking 0.38 seconds.

"That project was purely for fun during MIT's Independent Activities Period," recalls Katz. "We used custom-built actuators on each of the Rubik's Cube's faces alongside webcams to identify the colors and move the blocks accordingly."

He chronicled his other pet projects on his "build-its" blog, which developed a strong following. Projects included planar magnetic headphones, a desktop furuta pendulum, and an electric travel ukulele.

"Ben was constantly building and analyzing something along with our lab and class projects during his entire time at MIT," says Kim. "His incessant desire to learn, build, and analyze is quite remarkable."

After graduating with his master's degree in 2018, Katz worked as a technical associate in Kim's lab before accepting a position at Boston Dynamics in 2019.

As a designer at Boston Dynamics, Katz has transitioned from cheetah robots to humanoid robots on ATLAS, a research platform billed as the "world's most dynamic humanoid robot." Much like the mini cheetah, ATLAS can execute incredibly dynamic maneuvers including backflips and even parkour.

While the mini cheetah holding yoga poses and ATLAS doing parkour seem like entertainment befitting *The Tonight Show*, Katz is quick to remind others that these robots are fulfilling a real-world need. The robots could someday maneuver in areas that are too dangerous for humans – including buildings that are on fire and disaster areas. They could open new possibilities for life-saving disaster relief and first responders in emergencies.

"What we did in Sangbae's lab is going to help make these machines ubiquitous and actually useful in the real world as viable products," adds Katz.

Benjamin Katz '16, SM '18, with the mini cheetah robot. Credit: Bryce Vickmark

Class Close-Up:

2.C161 – Physical Systems Modeling and Design Using Machine Learning

Physics and the machine learning "black box"

Machine learning algorithms are often referred to as a "black box." Once data are put into an algorithm, it's not always known exactly how the algorithm arrives at its prediction. This can be particularly frustrating when things go wrong. A new mechanical engineering course teaches students how to tackle the "black box" problem, through a combination of data science and physics-based engineering.

In class 2.C161, Physical Systems Modeling and Design Using Machine Learning, Professor George Barbastathis demonstrates how mechanical engineers can use their unique knowledge of physical systems to keep algorithms in check and develop more accurate predictions.

"I wanted to take 2.C161 because machine learning models are usually a 'black box,' but this class taught us how to construct a system model that is informed by physics so we can peek inside," explains Crystal Owens, a mechanical engineering graduate student who took the course in the spring of 2021.

As chair of the Committee on the Strategic Integration of Data Science into Mechanical Engineering, Barbastathis has had many conversations with mechanical engineering students, researchers, and faculty to better understand the challenges and successes they've had using machine learning in their work.

"One comment we heard frequently was that these colleagues can see the value of data science methods for problems they are facing in their mechanical engineering-centric research, yet they are lacking the tools to make the most out of it," says Barbastathis. "Mechanical, civil, electrical, and other types of engineers want a fundamental understanding of data principles without having to convert themselves to being full-time data scientists or AI researchers."

Additionally, as mechanical engineering students move on from MIT to their careers, many will need to manage data scientists on their teams someday. Barbastathis hopes to set these students up for success with class 2.C161.

Bridging MechE and the MIT Schwartzman College of Computing

Class 2.C161 is part of the MIT Schwartzman College of Computing "Computing Core." The goal of these classes is to connect data science and physics-based engineering disciplines, like mechanical engineering. Students take the course alongside 6.C402, Modeling with Machine Learning: From Algorithms to Applications, taught by professors of electrical engineering and computer science Regina Barzilay and Tommi Jaakkola.

The two classes are taught concurrently during the semester, exposing students to both fundamentals in machine learning and domain-specific applications in mechanical engineering.

In 2.C161, Barbastathis highlights how complementary physics-based engineering and data science are. Physical laws present a number of ambiguities and unknowns, ranging from temperature and humidity to electromagnetic forces. Data science can be used to predict these physical phenomena. Meanwhile, having an understanding of

In class 2.C161, Professor George Barbastathis teaches mechanical engineering students to use their knowledge of physical systems to develop more accurate models and machine learning algorithms. Credit: Tony Pulsone physical systems helps ensure the resulting output of an algorithm is accurate and explainable.

"What's needed is a deeper combined understanding of the associated physical phenomena and the principles of data science, machine learning in particular, to close the gap," adds Barbastathis. "By combining data with physical principles, the new revolution in physics-based engineering is relatively immune to the "black box" problem facing other types of machine learning."

Equipped with a working knowledge of machine learning topics covered in class 6.C402 and a deeper understanding of how to pair data science with physics, students are charged with developing a final project that solves for an actual physical system.

Developing solutions for real-world physical systems

For their final project, students in 2.C161 are asked to identify a real-world problem that requires data science to address the ambiguity inherent in physical systems. After obtaining all relevant data, students are asked to select a machine learning method, implement their chosen solution, and present and critique the results.

Topics this past semester ranged from weather forecasting to the flow of gas in combustion engines, with two student teams drawing inspiration from the ongoing Covid-19 pandemic.

Owens and her teammates, fellow graduate students Arun Krishnadas and Joshua David John Rathinaraj, set out to develop a model for the Covid-19 vaccine roll-out.

"We developed a method of combining a neural network with a susceptible-infected-recovered (SIR) epidemiological model to create a physics-informed prediction system for the spread of Covid-19 after vaccinations started," explains Owens.

The team accounted for various unknowns including population mobility, weather, and political climate. This combined approach resulted in a prediction of Covid-19's spread during the vaccine rollout that was more reliable than using either the SIR model or a neural network alone.

Another team, including graduate student Yiwen Hu, developed a model to predict mutation rates in Covid-19, a topic that became all too pertinent as the delta variant began its global spread.

"We used machine learning to predict the time-series-based mutation rate of Covid-19, and then incorporated that as an independent parameter into the prediction of pandemic dynamics to see if it could help us better predict the trend of the Covid-19 pandemic," says Hu.

Hu, who had previously conducted research into how vibrations on coronavirus protein spikes affect infection rates, hopes to apply the physics-based machine learning approaches he learned in 2.C161 to his research on de novo protein design.

Whatever the physical system students addressed in their final projects, Barbastathis was careful to stress one unifying goal: the need to assess ethical implications in data science. While more traditional computing methods like face or voice recognition have proven to be rife with ethical issues, there is an opportunity to combine physical systems with machine learning in a fair, ethical way.

"We must ensure that collection and use of data are carried out equitably and inclusively, respecting the diversity in our society and avoiding well-known problems that computer scientists in the past have run into," says Barbastathis.

Barbastathis hopes that by encouraging mechanical engineering students to be both ethics-literate and well-versed in data science, they can move on to develop reliable, ethically sound solutions and predictions for physical-based engineering challenges.

Research Focus:

Computing for ocean environments

There are few environments as unforgiving as the ocean. Its unpredictable weather patterns and limitations in terms of communications have left large swaths of the ocean unexplored and shrouded in mystery.

"The ocean is a fascinating environment with a number of current challenges like microplastics, algae blooms, coral bleaching, and rising temperatures," says Wim van Rees, ABS Career Development Professor. "At the same time, the ocean holds countless opportunities — from aquaculture to energy harvesting and exploring the many ocean creatures we haven't discovered yet."

Ocean engineers and mechanical engineers, like van Rees, are utilizing advances in scientific computing to address the ocean's many challenges and seize its opportunities. These researchers are developing technologies to better understand our oceans, and how both organisms and man-made vehicles can move within them, from the micro-scale to the macro-scale.

Bio-inspired underwater devices

An intricate dance takes place as fish dart through water. Flexible fins flap within currents of water, leaving a trail of eddies in their wake.

"Fish have intricate internal musculature to adapt the precise shape of their bodies and fins. This allows them to propel themselves in many different ways, well beyond what any manmade vehicle can do in terms of maneuverability, agility, or adaptivity," explains van Rees.

According to van Rees, thanks to advances in additive manufacturing, optimization techniques, and machine learning, we are closer than ever to replicating flexible and morphing fish fins for use in underwater robotics. As such, there is a greater need to understand how these soft fins impact propulsion.

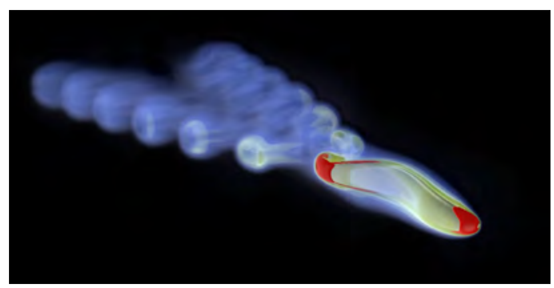
Van Rees and his team are developing and utilizing numerical simulation approaches to explore the design space for underwater devices that have an increase in degrees of freedom, for instance due to fish-like, deformable fins.

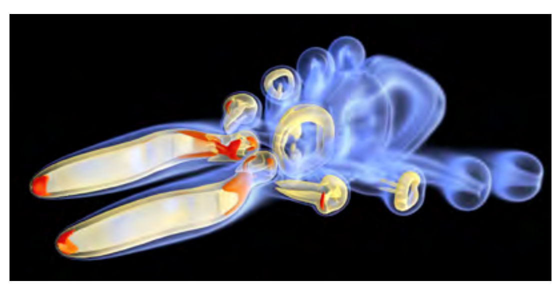
These simulations help the team better understand the interplay between the fluid and structural mechanics of fish's soft, flexible fins as they move through a fluid flow. As a result, they are able to better understand how fin shape deformations can harm or improve swimming performance.

"By developing accurate numerical techniques and scalable parallel implementations, we can use supercomputers to resolve what exactly happens at this interface between the flow and the structure," adds van Rees.

Through combining his simulation algorithms for flexible underwater structures with optimization and machine learning techniques, van Rees aims to develop an automated design tool for a new generation of autonomous underwater devices. This tool could help engineers and designers develop, for example, robotic fins and underwater vehicles that can smartly adapt their shape to better achieve their immediate operational goals – whether it's swimming faster and more efficiently or performing maneuvering operations.

"We can use this optimization and AI to do inverse design inside the whole parameter space and create smart, adaptable devices from scratch, or use accurate individual simulations to identify



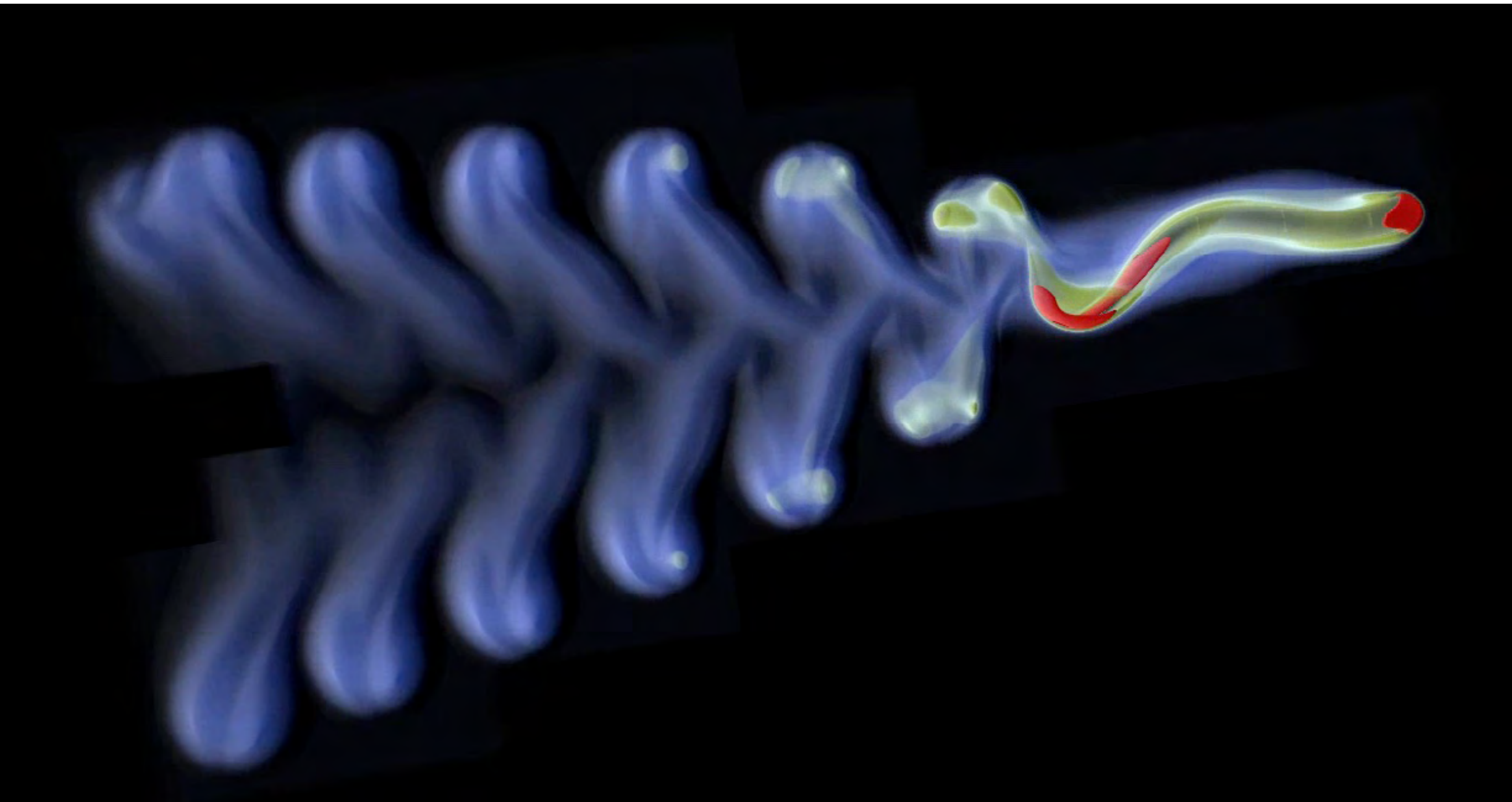


Assistant Professor Wim van Rees and his team have developed simulations of self-propelled undulatory swimmers to better understand how fish-like deformable fins could improve propulsion in underwater devices. Credit: MIT van Rees Lab the physical principles that determine why one shape performs better than another," explains van Rees.

Swarming algorithms for unmanned vehicles

Like van Rees, Principal Research Scientist Dr. Michael Benjamin wants to improve the way vehicles maneuver through the water. In 2006, then a postdoc at MIT, Benjamin launched an open-source software project for an autonomous helm technology he developed. The software, which has been used by companies like Sea Machines, BAE/Riptide, Thales UK, and Rolls Royce, as well as the United States Navy,

> Fish propel themselves in many different ways, well beyond what any manmade vehicle can do in terms of maneuverability, agility, or adaptivity.



Dr. Michael Benjamin has developed swarming algorithms that enable unmanned vehicles, like the ones pictured, to disperse in an optimal distribution and avoid collisions.
Credit: Michael Benjamin

utilizes a novel method of multi-objective optimization. This optimization method, developed by Benjamin during his PhD work, enables a vehicle to autonomously choose the heading, speed, depth, and direction it should go in to achieve multiple simultaneous objectives.

Now, Benjamin is taking this technology a step further by developing swarming and obstacle avoidance algorithms. These algorithms would enable dozens of unmanned vehicles to communicate with one another and explore a given part of the ocean.

To start, Benjamin is looking at how to best disperse unmanned vehicles in the ocean.

“Let’s suppose you want to launch fifty vehicles in a section of the Sea of Japan. We want to know: does it make sense to drop all fifty vehicles at one spot or have a mothership drop them off at certain points throughout a given area?” explains Benjamin.

He and his team have developed algorithms that answer this question. Using swarming technology, each vehicle periodically communicates its location to other vehicles nearby. Benjamin’s software enables these vehicles to disperse in an optimal distribution for the portion of the ocean in which they are operating.

Central to the success of the swarming vehicles is the ability to avoid collisions. Collision avoidance is complicated by international maritime rules known as COLREGS – or “Collision Regulations.” These rules determine which vehicles have the “right of way” when crossing paths, posing a unique challenge for Benjamin’s swarming algorithms.

The COLREGS are written from the perspective of avoiding another single contact, but Benjamin’s swarming algorithm had to account for multiple unmanned vehicles trying to avoid colliding with one another.

To tackle this problem, Benjamin and his team created a multi-object optimization algorithm that ranked specific maneuvers on a scale from zero to one hundred. A zero would be a direct collision, while one hundred would mean the vehicles completely avoid collision.

“Our software is the only marine software where multi-objective optimization is the core mathematical basis for decision making,” says Benjamin.

While researchers like Benjamin and van Rees use machine learning and multi-objective optimization to address the complexity of vehicles moving through ocean environments, others like Pierre Lermusiaux, Nam Pyo Suh Professor, use machine learning to better understand the ocean environment itself.

Improving ocean modeling and predictions

Oceans are perhaps the best example of what’s known as a complex dynamical system. Fluid dynamics, changing tides, weather patterns, and climate change make the ocean an unpredictable environment that is different from one moment to the next. The ever-changing nature of the ocean environment can make forecasting incredibly difficult.

Researchers have been using dynamical system models to make predictions for ocean environments, but as Lermusiaux explains, these models have their limitations.

“You can’t account for every molecule of water in the ocean when developing models. The resolution and accuracy of models and the ocean measurements are limited. There could be a model data point every one hundred meters, every kilometer, or if you are looking at climate models of the global ocean, you may have a data point every ten kilometers or so. That can have a large impact on the accuracy of your prediction,” explains Lermusiaux.

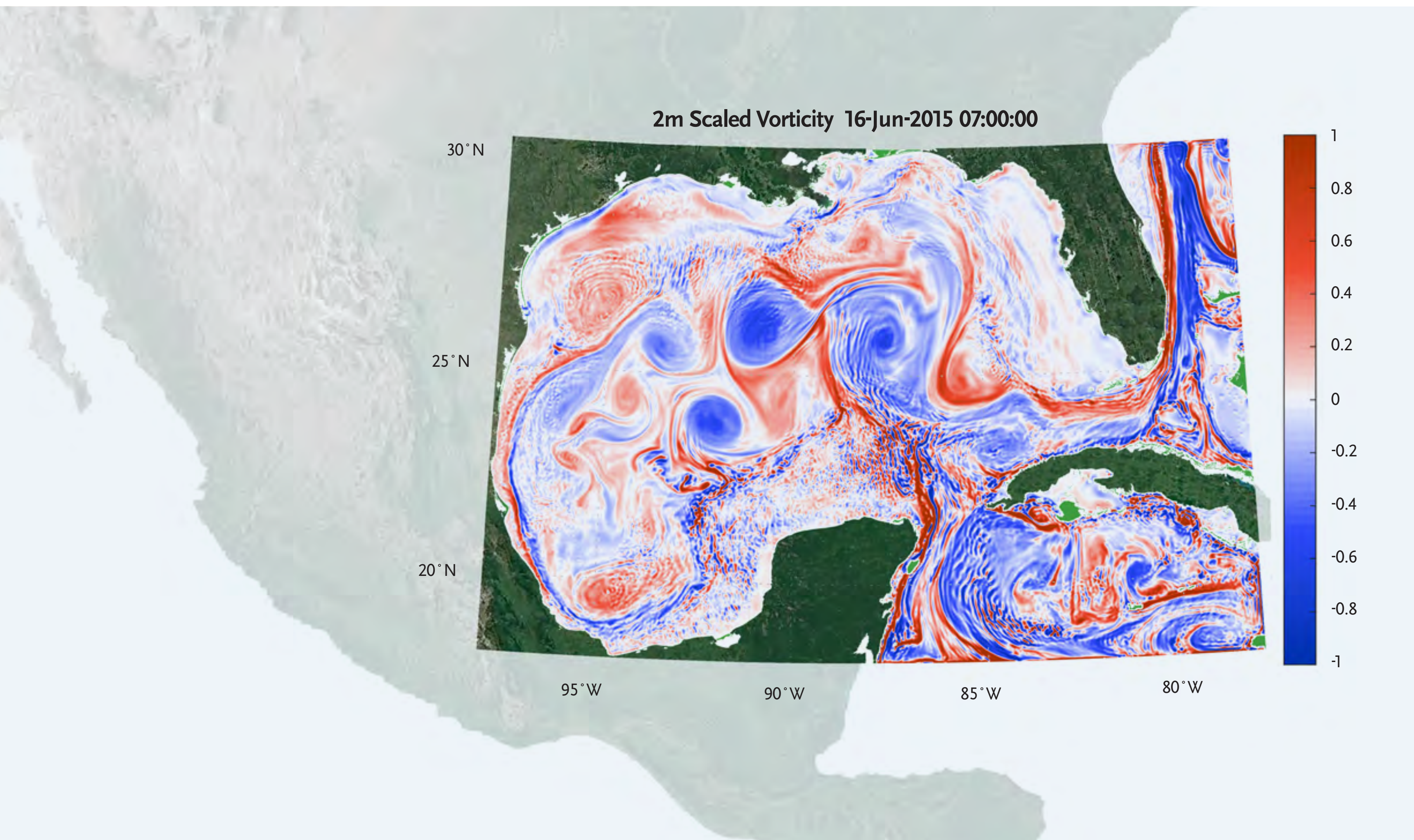
Graduate student Abhinav Gupta and Lermusiaux have developed a new machine learning framework to help make up for the lack of resolution or accuracy in these models. Their algorithm takes a simple model with low resolution and can fill in the gaps, emulating a more accurate, complex model with a high degree of resolution.

For the first time, Gupta and Lermusiaux's framework learns and introduces time-delays in existing approximate models to improve their predictive capabilities.

"Things in the natural world don't happen instantaneously; however, all the prevalent models assume things are happening in real-time," says Gupta. "To make an approximate model more accurate, the machine learning and data you are inputting into the equation need to represent the effects of past states on the future prediction."

The team's "neural closure model," which accounts for these delays, could potentially lead to improved predictions for things such as a Loop Current eddy hitting an oil rig in the Gulf of Mexico, or the amount of phytoplankton in a given part of the ocean.

As computing technologies such as Gupta and Lermusiaux's neural closure model continue to improve and advance, researchers can start unlocking more of the ocean's mysteries and develop solutions to the many challenges our oceans face.



Graduate student Abhinav Gupta and Professor Pierre Lermusiaux have developed a new machine learning framework to help make up for the lack of resolution or accuracy in existing dynamical system models. Their framework can be used for a number of applications, including improved predictions of Loop Current eddies around oil rigs in the Gulf of Mexico. Credit: MIT MSEAS Lab

Talking Shop: Dr. Anuradha Annaswamy

Building smart infrastructures

Much of Anuradha Annaswamy's research hinges on uncertainty. How does cloudy weather affect a grid powered by solar energy? How do we ensure that electricity is delivered to the consumer if a grid is powered by wind and the wind does not blow? What's the best course of action if a bird hits a plane engine on takeoff? How can you predict the behavior of a cyber attacker?

"Almost all of our projects have to do with decision making under uncertainty," explains Annaswamy, a senior research scientist in MIT's Department of Mechanical Engineering. "If we can design smart infrastructures that are resilient to uncertainty and anomalies, then we can have safer, more reliable systems."

Annaswamy serves as the Director of MIT's Active Adaptive Control Laboratory. A world-leading expert in adaptive control theory, she was named president of the Institute of Electrical and Electronics Engineers Control Systems Society for 2020. Her team uses adaptive control and optimization to account for various uncertainties and anomalies in autonomous systems. In particular, they are developing smart infrastructures in the energy and transportation sectors.

Using a combination of control theory, cognitive science, economic modeling, and cyber-physical systems, Annaswamy and her team have designed intelligent systems that could someday transform the way we travel and consume energy. Their research includes a diverse range of topics such as safer auto-pilot systems on airplanes, the efficient dispatch of resources in electrical grids, better ridesharing services, and price-responsive railway systems.

MechE Connects spoke with Annaswamy about how these smart systems could help support a safer and more sustainable future.

> If we can design smart infrastructures that are resilient to uncertainty and anomalies, then we can have safer, more reliable systems.

How is your team using adaptive control to make air travel safer?

We want to develop an advanced autopilot system that can safely recover the airplane in the event of a severe anomaly – such as the wing becoming damaged mid-flight or a bird flying into the engine. In the airplane, you have a pilot and autopilot to make decisions. We're asking: how do you combine those two decision makers?

The answer we landed on was developing a shared pilot-autopilot control architecture. We collaborated with David Woods, an expert in cognitive engineering at The Ohio State University, to develop an intelligent system that takes the pilot's behavior into account. For example, all humans have something known as "capacity for maneuver' and 'graceful command degradation" that inform how we react in the face of adversity. Using mathematical models of pilot behavior, we proposed a shared control architecture where the pilot and the autopilot work together to make an intelligent decision on how to react in the face of uncertainties. In this system, the pilot reports the anomaly to an adaptive autopilot system that ensures resilient flight control.

How does your research on adaptive control fit into the concept of Smart Cities?

Smart Cities are an interesting way we can use intelligent systems to promote sustainability. Our team is looking at

Dr. Anuradha Annaswamy
Credit: David Stella

ridesharing services in particular. Services like Uber and Lyft have provided new transportation options, but their impact on the carbon footprint has to be considered. We're looking at developing a system where the number of passenger miles per unit of energy is maximized through something called "shared mobility on demand services." Using the Alternating Minimization approach, we've developed an algorithm that can determine the optimal route for multiple passengers traveling to various destinations.

As with the pilot-autopilot dynamic, human behavior is at play here. In sociology there is an interesting concept of behavioral dynamics known as Prospect Theory. If we give passengers options with regards to which route their shared ride service will take, we are empowering them with free will to accept or reject a route. Prospect Theory shows that if you can use pricing as an incentive, people are much more loss-averse, so they would be willing to walk a bit extra or wait a few minutes longer to join a low-cost ride with an optimized route. If everyone utilized a system like this, the carbon footprint of ridesharing services could decrease substantially.

What other ways are you using intelligent systems to promote sustainability?

Renewable energy and sustainability are huge drivers for our research. To enable a world where all of our energy is coming from renewable sources like solar or wind, we need to develop a smart grid that can account for the fact that the sun isn't always shining and wind isn't always blowing. These uncertainties are the biggest hurdles to achieving an all-renewable grid. Of course there are many technologies being developed for batteries that can help store renewable energy, but we are taking a different approach.

We have created algorithms that can optimally schedule distributed energy resources within the grid – this includes making decisions on when to use on-site generators, how to operate storage devices, and when to call upon demand response technologies, all in response to the economics of using such resources and their physical constraints. If we can develop an interconnected smart grid where, for example, the air conditioning setting in a house is set to 72 degrees instead of 69 degrees automatically when demand is high, there could be a substantial savings in energy usage without impacting human comfort. In one of our studies, we applied a distributed proximal atomic coordination algorithm to the grid in Tokyo to demonstrate how this intelligent system could account for the uncertainties present in a grid powered by renewable resources.

Why is it important for mechanical engineers in particular to be looking at how to build intelligent systems?

Mechanical engineers have a rich culture of being true to physics. So when we design these intelligent systems, we pay particular attention to the fact that they will live in the physical world. Moving an atom is not the same thing as moving a bit – you need to have an understanding of the fundamental physics at play in these situations. We need to develop systems that have cyber, physical, and human components. Each part is equally important to build successful intelligent systems. And I think mechanical engineers are in the best position to understand how they interconnect.

News & Awards

Departmental News

• In their annual university rankings, US News & World Report has named MIT's Department of Mechanical Engineering the number one undergraduate program in mechanical engineering for 2022 and the number one graduate program in mechanical engineering for 2022.

• QS World University Rankings honored MIT with a number one ranking in the subject area of Mechanical, Aeronautical, and Manufacturing Engineering.

Research News

• A team of engineers led by Professor Nicholas Fang has designed a new touch-sensing glove that can "feel" pressure and other tactile stimuli. The glove could help restore motor function after stroke or enhance virtual gaming experiences. The work was published in *Nature Communications*.

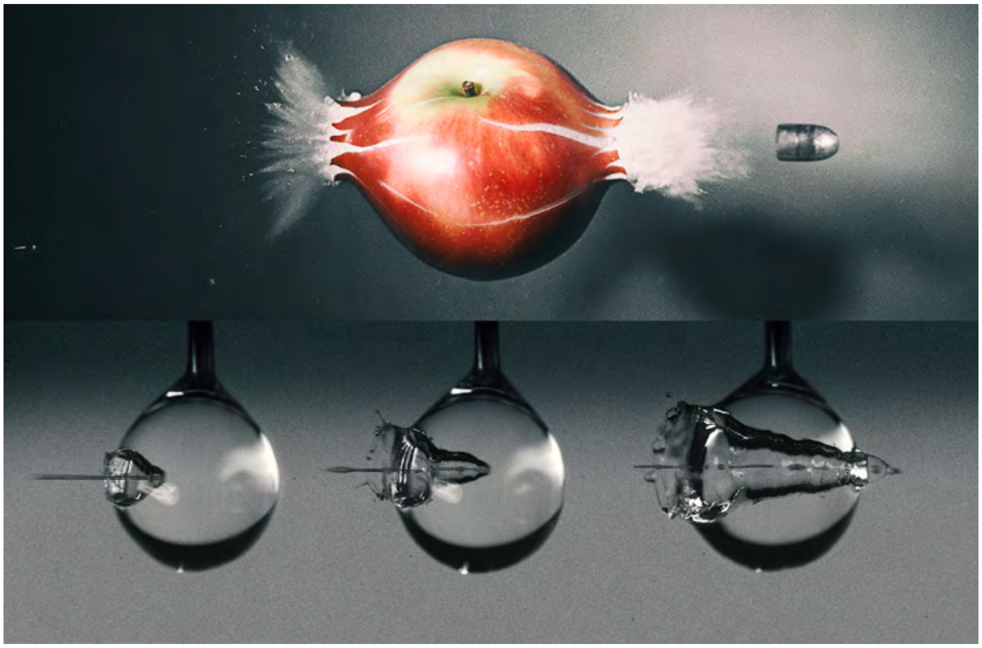
• A *Joule* study from MIT engineers, including Professor Evelyn Wang, Associate Professor Betar Gallant, and grad student Lenan Zhang, has for the first time analyzed and quantified how bubbles form on porous electrodes. They found that the wettability of porous electrode surfaces is key to making efficient water-splitting or carbon-capturing systems.

• MIT engineers led by Professor Xuanhe Zhao, Dr. Hyunwoo Yuk, and Dr. Jingjing Wu have designed a strong, biocompatible glue that can seal injured tissues and stop bleeding, inspired by the sticky substance that barnacles use to cling to rocks. Their work was published in *Nature Biomedical Engineering*.

• A *Nature Materials* study by engineers, including Assistant Professor Carlos Portela, shows that "nanoarchitected" materials may be a promising route to lightweight armor, protective coatings, blast shields, and other impact-resistant materials.

• Researchers, including Professor Yang Shao-Horn, have found a novel electrolyte that could enable a significant leap in the power-per-weight of next-generation batteries, without sacrificing the cycle life. Their study was published in *Nature Energy*.

Professor Nicholas Fang has designed a new touch-sensing glove that can "feel" pressure and other tactile stimuli. Credit: Courtesy of the researchers



A team, including Professor Ian Hunter, used high-speed cameras to capture a water jet's impact as it pierces a droplet. Their work resembles Harold "Doc" Edgerton's high-speed photos of a bullet fired through an apple. Credit: Courtesy of the researchers, and Tiny Giants

- MIT engineers led by Associate Professor Ming Guo have found that a biological membrane that's tough as plastic wrap but elastic like a balloon could be a target for therapies to limit cancer cells from spreading. The work was published in *PNAS*.

- MIT researchers, including Dr. Svetlana Boriskina, have designed a new kind of sustainable textile from polyethylene fibers that may help humans adapt to and combat the effects of climate change.

- A team, including Assistant Professor Giovanni Traverso, has designed a new type of stent that could be used to deliver drugs to the gastrointestinal tract, respiratory tract, or other tubular organs in the body. The research was published in *Nature Materials*.

- A model developed by researchers, including Professor Ian Hunter, predicts how a fluid jet will impact a droplet of a certain viscosity and elasticity. The results could help tune drug injections without needles. The study was published in *Soft Matter*.

- A group of researchers led by Professor Kripa Varanasi have found that crystallizing salts can grow "legs," then tip over and fall away, potentially helping to prevent fouling of metal surfaces. Their work was published in *Science Advances*.

Faculty Promotions

- Alberto Rodriguez was promoted to Associate Professor with Tenure. Rodriguez is a leader in the field of robotic manipulation, a fundamental function of robots interacting with the physical world.

- Betar Gallant has been promoted to Associate Professor without Tenure. Gallant specializes in advanced chemistries and materials for electrochemical energy storage and CO_2 emissions mitigation.

- Ellen Roche has been promoted to Associate Professor without Tenure. Roche is a rising star at the interfaces of biomechanics, medical devices, soft robotics, and engineering design and modeling.

Faculty & Staff News

- Dr. Simona Socrate was selected as a recipient of the inaugural MIT School of Engineering Distinguished Educator Award. This award was newly launched to recognize exemplary faculty and teaching staff for outstanding contributions to MIT's educational mission. Socrate is known to be caring, engaging, funny, and inspiring, and is key to enabling students to firmly grasp the fundamentals.

Dr. Simona Socrate was selected as a recipient of the inaugural MIT School of Engineering Distinguished Educator Award. Credit: John Freidah

Dr. Barbara Hughey has been awarded a Mechanical Engineering Exceptional Educator Award.
Credit: Tony Pulsone

• Administrative Assistant Alexandra Cabral received the Joseph (Tiny) Caloggero Service Award, given annually to a member or members of the support staff for outstanding service to the Department of Mechanical Engineering.

• Professor Linda Griffith was elected to the American Academy of Arts and Sciences, one of the nation's most prestigious honorary societies.

• Professor Yang Shao-Horn has received a Humboldt Research Award, given to researchers who work outside of Germany in recognition of their lifetime's research achievements.

• Professor Warren Seering has been awarded the ASME Design Theory and Methodology Award in recognition of sustained and meritorious contributions to research, education, service, and overall leadership in advancing the field of design theory and methodology.

• Professor Rohik Karnik has been appointed to the Tata Professorship. Karnik is internationally recognized for his pioneering and innovative work in the areas of water filtration, water quality measurement, and desalination.

• Professor Cullen Buie has been elected to the American Institute for Medical and Biological Engineering's College of Fellows.

• Professor John Lienhard has been named a fellow of the American Society of Thermal and Fluids Engineers for outstanding contributions to thermal and fluids engineering.

• Technical Instructor Dr. Steve Banzaert was given a 2021 Teaching with Digital Technology Award.

• Dr. Barbara Hughey has been awarded a Mechanical Engineering Exceptional Educator Award for sustained excellence in teaching, managing, and shaping class 2.671, Measurement and Instrumentation; always striving to help students; and inspiring future women engineers through the Women's Technology Program.

Professor Cullen Buie was elected to the American Institute for Medical and Biological Engineering's College of Fellows for leveraging microfluidics to produce innovative biotechnology solutions for applications ranging from microbial communities to engineered cellular therapies.
Credit: The Engine

Student News

• Graduate student Hilary Johnson was awarded the 2021 "Eat it!" Lemelson-MIT Student Prize. Johnson won for inventing a variable volute pump, a new category of centrifugal pumps that may significantly improve efficiency and operating range across applications such as crop irrigation and water distribution.

• Recent alumni Orisa Coombs '21 and Max Kessler '20 have been selected for the newest cohort of the prestigious Knight-Hennessy Scholars program and will begin graduate studies at Stanford University this fall.

Graduate student Hilary Johnson was awarded the 2021 "Eat it!" Lemelson-MIT Student Prize for inventing a variable volute pump.
Credit: Gurkaran Singh

- Graduate student Georgia Van de Zande received the 2021 Goodwin Teaching Award for outstanding and effective teaching. Van de Zande, who serves as a teaching assistant, has been praised for her dedication to students, as well as her special ability to empathize with them when they are struggling.

Alumni News

- Madeline Salazar '13 has been named one of Forbes 30 Under 30 – Manufacturing & Industry. Currently a technology manager for additive and digital manufacturing development at Northrop Grumman, Salazar has worked on satellite production for Boeing and a smart factory portfolio initiative to develop automation at Northrop.

- David Dellal '17 was named one of Forbes 30 Under 30 in Energy. Dellal founded the start-up Floe, which is developing an automated and sustainable solution to prevent the extensive water damage caused by ice dams.

- Mick Mountz '87 has been elected to the National Academy of Engineering for advancing industrial mobile robotic material handling systems for order fulfillment.

- Asha Balakrishnan SM '99, PhD '07 has been appointed to serve on the National Oceanic and Atmospheric Administration's Advisory Committee on Commercial Remote Sensing (ACCRES) for the next two years.

- MechE alum Thomas Popik '82 traveled to Montclair, NJ, this summer to save a pedal-powered mower built by Mike Shakespear '73 and the late Professor David Gordon Wilson from being lost. The mower will be displayed at the MIT Museum when it opens in its new location this spring. Popik has been spearheading outreach to MechE alumni to raise money for the David Gordon Wilson Memorial Fund, which was created with the goal of establishing an endowed fund as a permanent remembrance to Wilson. For additional information, contact Bonny Kellermann at bonnyk@mit.edu.

Graduate student Georgia Van de Zande, seen here hugging a life-size bandsaw plushie she made while teaching class 2.00b, Toy Product Design, received the 2021 Goodwin Teaching Award for outstanding and effective teaching.
Credit: Manuel Gutierrez

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MIT's Department of Mechanical Engineering is excited to welcome our three newest faculty members.

Kaitlyn Becker

Starting Summer 2022
Working on soft robots for grasping and manipulation of delicate structures from the desktop to the deep sea.

Loza Tadesse

Anticipated Start: Summer 2023
Developing a rapid all-optical and label-free bacterial diagnostic and antibiotic susceptibility testing system.

Ritu Raman

Started August 2021
Building adaptive machines powered by living biological materials.