UMass Boston Research

Solutions for the Future

Inside

UMass Boston™

A Message from the **Provost**

This is an exciting and dynamic time for research and scholarship at UMass Boston.

UMass Boston's research is more important than ever before as we generate cutting-edge knowledge and develop contributions to the solutions that are needed to address the vexing challenges of our times.

We continue - through the dedicated work of PIs, their teams, and ORSP - to excel in generating record amounts of sponsored research. Our ascension into the ranks of R1 universities is a testament to our productivity and impact. We are particularly proud that the quality of our work and its impact at local, national, and global levels is the hallmark of UMass Boston's significant research accomplishments.

I applaud the achievements of our researchers as they continue to excel in this vitally important mission-driven work.

Joseph Berger, PhD
Provost and Vice Chancellor for Academic Affairs

A Message from the **Vice Provost** for Research and Strategic Initiatives

Traditionally, research activity was confined to silos defined by subject matter expertise. However, current and future challenges require the need to emphasize research convergence, where perspectives from multiple disciplines act as inputs targeting a single or set of meaningful outputs. This has long been a motivation at UMass Boston, where many researchers focus on meaningful research with real world implications. Of course, an important qualification is that the timeline for realizing significance can be quite varied depending on the problem being addressed. In this issue, we spotlight a sampling of the compelling work our faculty and their teams are focused on that impact either our understanding of the past or opportunities for the future.

Areas such as quantum physics, artificial intelligence, environmental challenges, and education for the future are some instances where our researchers are growing programs, collaborating with external partners, developing learning and career opportunities for students, and uncovering creative ways to solve urgent and complex problems.

Impact often begins with a spark of connection. We hope these articles inspire you and, if you notice synergies, we welcome you to reach out and engage with the campus community.

Bala Sundaram, PhD
Vice Provost for Research and Strategic Initiatives
Professor of Physics

Vol. 3

This research magazine is published by the Office of the Vice Provost for Research and Strategic Initiatives at the University of Massachusetts Boston.

Vice Provost for Research and Strategic Initiatives
Bala Sundaram, PhD

Associate Vice Provost for Research and Director of the Office of Research and Sponsored Programs
Matthew Meyer

Online Research Magazine

umb.edu/research-magazine

UMass Boston Research

We welcome your inquiries and comments. Please direct them to:

UMass Boston Research Magazine
Office of the Vice Provost for Research and Strategic Initiatives

University of Massachusetts Boston
100 Morrissey Boulevard
Boston, MA 02125-3393
umb.edu/research
research.news@umb.edu

Table of Contents

The Era of Climate Resilience

Marcelo Suárez-Orozco, PhD
Chancellor, UMass Boston

We are in the age of climate resilience. The climate crisis is transforming where and how we live and challenging human health, economic well-being, and planetary support systems.

As one scholar recently noted, its accelerating pace "...is outstripping the rate of technological advance" and, in turn, our ability to mitigate its most dire, catastrophic impacts.

In our recently published volume *From Climate Crisis to Climate Resilience*, Scripps Institute of Oceanography scientist Ram Ramanathan and I articulate a plea for a new way to navigate the climate crisis and protect people and ecosystems. It is known as MAST – **M**itigation, **A**daptation, and **S**ocial **T**ransformation. While mitigation of emissions is essential, it is insufficient by itself. "We need to complement mitigation with adaptation to cope with the additional heating of the planet in the coming decades. And we need to complement mitigation and adaptation with societal transformation to survive, thrive, and evolve into a sustainable way of living. An evolution to a sustainable way of living is essential to build and protect a habitable planet for our progenies and future generations."

Image by: Javier Rivas

When I became chancellor of UMass Boston in 2020, I designated building climate resilience as a top priority. I understood that Boston's premier public research university, overlooking Boston Harbor, was duty-bound to advance public understanding of the climate crisis and generate scalable solutions to support urban climate resilience in the region through our research, teaching, and service.

Our strategic plan, *For the Times*, sets out four Grand Scholarly Challenges – issues of great consequence and relevance to individuals, families, and communities – that embody the values that underpin UMass Boston's scholarly excellence. One of them is Climate Equity and Urban Coastal Areas.

A theme that drives our climate research is cultivating an ethic of environmental care: research that examines what it means for people and communities to experience the impacts of extreme climate fluctuations and informs real-time solutions that are both nature-based and technology-smart to bolster resilience.

UMass Boston has emerged as a key partner in city and statewide efforts focused on climate resilience planning. Our collaboration with Climate Ready Boston – and now, Boston's Office of Climate Resilience – has helped produce one of the nation's most robust city-led climate programs in our country.

At a seminar on warming oceans, UMass Boston faculty researchers explained the university's keen interest in contributing research and best practices to the development of resilience strategies for Boston and the Commonwealth – integrating climate adaptation into municipal planning and helping shape "resilience marketplaces" of innovative businesses, products, and services.

For example, faculty research at our School for the Environment has generated tools and insights that advance carbon cycling in coastal wetlands, renewable energy technologies, remote sensing of climate impacts on ocean ecosystems, and other climate adaptation and mitigation areas.

At our Urban Harbor Institute, faculty and students have partnered with municipalities to research issues of concern such as fisheries and access to water resources, provide technical assistance in assessing local strengths and vulnerabilities, and prioritize action plans to enhance coastal resilience.

Our Stone Living Lab has spearheaded the historic installation of Living Seawalls panels at two Boston Harbor locations, designed to create habitat for marine life on what would otherwise be inhospitable flood barriers. The Living Seawalls will potentially improve water quality and soften wave impact.

During her 2023 Convocation speech, UMass Boston alumna and former EPA administrator Gina McCarthy noted the inherent unfairness that those least responsible for the climate crisis are being forced to cope with its worst impacts. "We can't fix the planet and leave the most impacted communities behind," she said. "Climate mitigation and environmental justice are two sides of the same coin."

UMass Boston faculty have also addressed this dimension of the climate crisis. A study from our Sustainable Solutions Lab explored climate resilience from the perspectives of Asian American, Black, Latino, and Native American residents in Boston, noting health impacts, preparedness, and responses. The Lab also received an NSF grant to assist in establishing the Climate Inequality and Integrative Resilience Center at UMass Boston, which will aim to research the links between inequality and climate resilience.

To deepen the climate conversation at UMass Boston, I led scientists, social scientists, researchers, governors, and mayors worldwide in developing a Planetary Protocol for Climate Resilience at a three-day global climate summit at the Vatican in May 2024.

I also established the Chancellor's Lecture Series to engage distinguished thought leaders. The series opened with Dr. Ram Ramanathan, who presented a strategy for bending the emissions curve and building resilience to climate stress. Dr. Vanessa Kerry discussed the profound impacts of climate stress on global public health. And Dr. Kongjian Yu, a renowned landscape architect and urban planner, discussed engineering sustainable, climate-resilient sponge cities.

As the climate crisis continues to unfold, UMass Boston research will play an increasingly important role in fighting the one battle we cannot afford to lose.

The Brain Stimulation and Simulation Lab

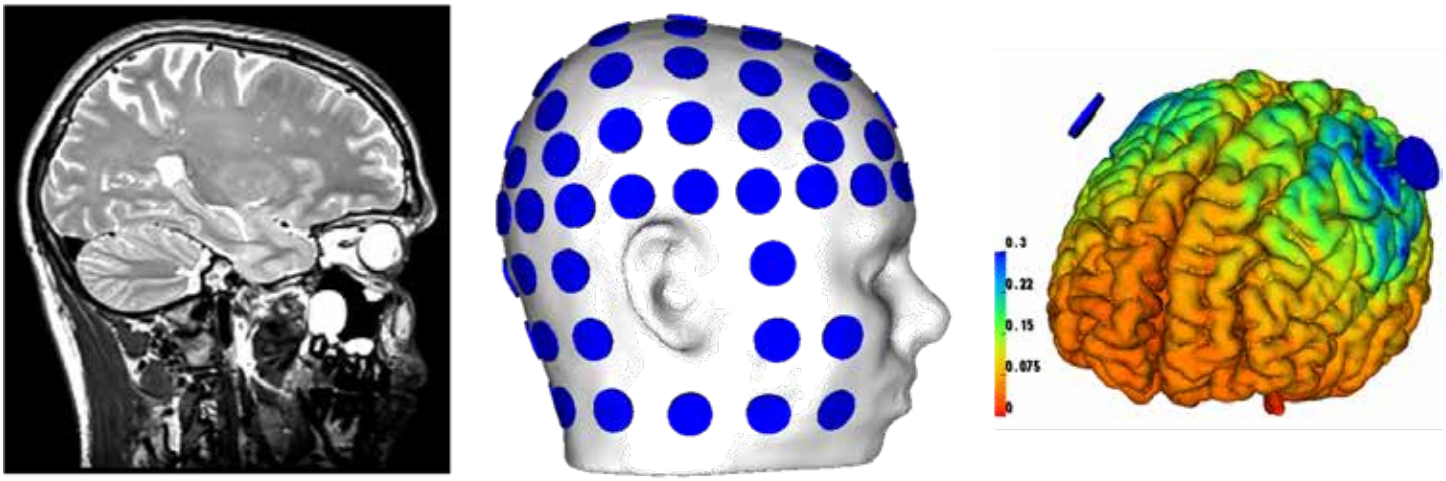
Sumientra Rampersad, PhD
Assistant Professor of Physics

Cognitive deficits associated with aging and neurodegenerative diseases pose major challenges to health care around the world.

Nearly 46 million people worldwide suffered from dementia in 2015, with this number estimated to reach 115 million in 2050*. This points to a growing need for efficacious therapeutics to mitigate cognitive decline and effective methods for early detection of neurodegeneration. In the Brain Stimulation and Simulation Lab, we combine physics, neuroscience, and biomedical engineering to investigate new diagnostic and treatment methods for neuropathologies across the life span.

In our lab, we use electromagnetic brain stimulation to temporarily change the activity of neurons, which can improve memory, executive, and motor function. These methods are safe, cheap, and have few side effects, but the effects are

For the development of our smartphone app, we perform EEG measurements that we later correlate to other lab tests and smartphone data.
Image by: Javier Rivas



From MRI scans, we build computational head models that we then use to calculate the electric fields induced in the brain by stimulation applied through electrodes on the scalp. *Image by: Sumientra Rampersad*

short-lived. Through computational modeling and neuroscientific experimentation, we try to understand and improve how brain stimulation works. The first step in our studies is to make a magnetic resonance imaging (MRI) scan of a study participant. We use this scan to build a computer model of the head and all the tissues within. With this model, we can calculate the electric fields induced in the brain by stimulation applied to the scalp. After identifying which brain regions to target on the MRI scan, we use the model to find the electrode placement that optimally delivers current to those regions.

At this point, our research transfers from computational to experimental. We bring the participant to the lab for participation in a clinical trial. Before and after receiving five days of brain stimulation, they complete a series of cognitive tests and scans. Differences in performance between the two sessions demonstrate the effects of stimulation. We recently completed a clinical trial with three different stimulation groups and a placebo group to investigate the role of motivation in memory function. The results of this study may open a new avenue toward prevention and treatment of dementia with safe and targeted noninvasive brain stimulation.

The prospects of successful treatment are dramatically improved when decline is detected early. Currently, the effectiveness of neuropsychological assessments is thwarted by low sensitivity, sporadicity, and subjective reports. Our lab is developing a smartphone app that estimates changes in cognitive function from information such as app use, typing speed, and location data. By comparing this data to existing models, the app can detect and predict cognitive decline before users notice the changes themselves. In an initial study, we acquired lab testing and app data for one year to construct the models, and we are planning multi-year follow-up studies to finalize the app. Success of our app would transform current approaches to monitoring cognitive function and augment existing clinical assessments, paving the way to earlier, more accurate, and individualized therapies.

Our lab welcomes students of all levels, high school through PhD, and all majors, as research assistants. Students interested in medical imaging or computational work are taught basic neuroanatomy and learn how to construct MRI-based head models that will be used in our studies. Students wishing to do experimental work learn how to perform MRI, electroencephalography (EEG), cognitive and motor tests, and how to apply brain stimulation. They then independently perform experiments for one or more of our studies. If interested, please reach out.

*Source: Prince, M. World Alzheimer Report 2015: the global impact of dementia: an analysis of prevalence, incidence, cost and trends.

Beyond Survival:
Sustainable Solutions Lab's Drive for Transformative Adaptation

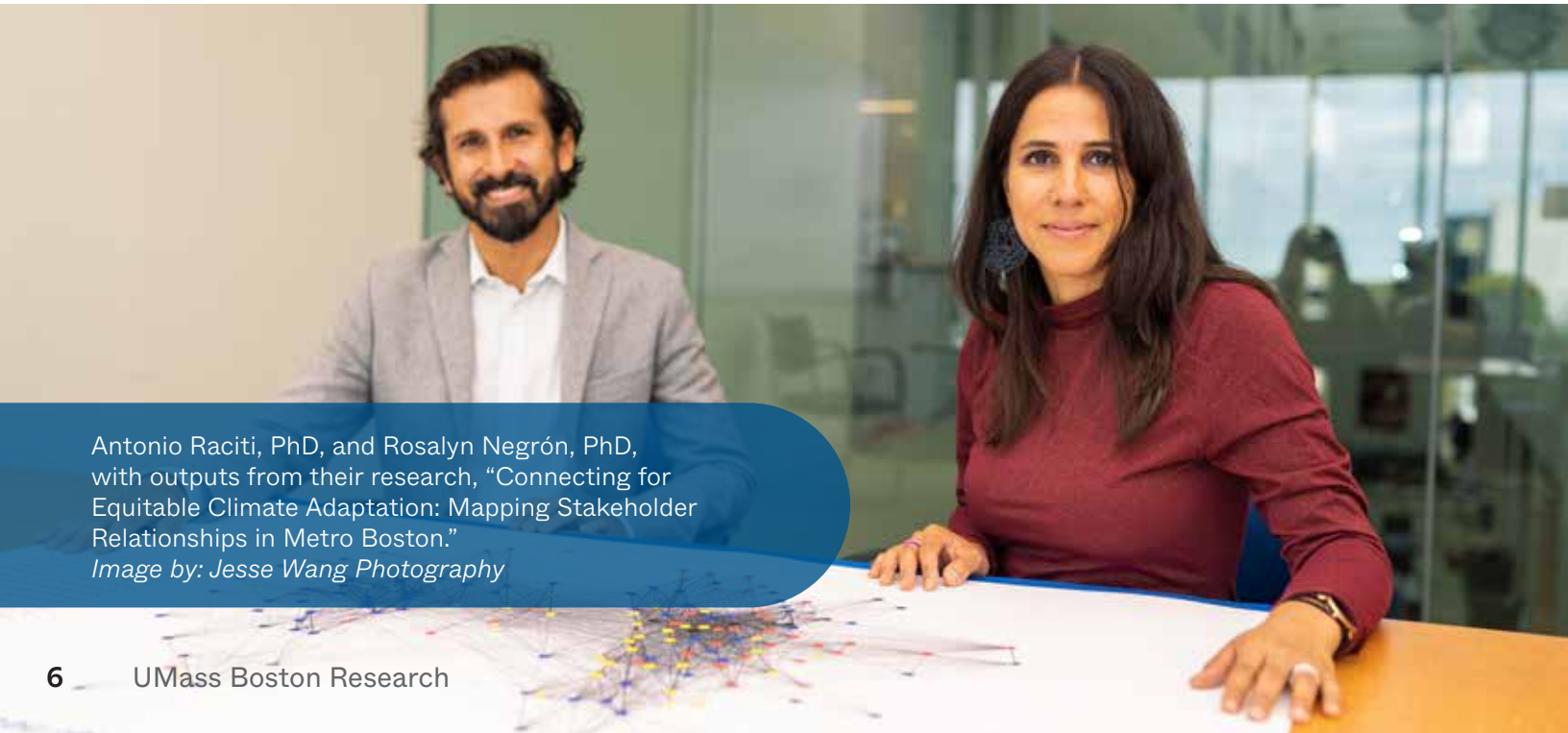
Bala Balachandran, PhD
Executive Director, Sustainable Solutions Lab

Step into the transformative world of the Sustainable Solutions Lab (SSL), where cutting-edge transdisciplinary research meets action-driven solutions in the fight against climate change.

Our mission is clear: to spark transformative climate adaptation grounded in justice and equity. Spanning all schools and colleges and four institutes at our university, SSL brings together diverse perspectives to address the pressing challenges of our time.

From investigating the feasibility of a harbor-wide barrier system for Boston to uncovering the climate impacts on transient populations and mapping the climate adaptation stakeholder network in metro Boston, SSL's research extends far beyond academia. Our studies serve as blueprints for real-world resilience, guiding communities toward a more sustainable future. This commitment to practical solutions is evident in our diverse range of projects, from infrastructure resilience to workforce development.

But SSL is more than just a research hub; it's a catalyst for change. Our Northeast Climate Justice Research Collaborative, led by Associate Director Gabriela Boscio Santos, empowers researchers to leverage their work to inform and shape policies



Antonio Raciti, PhD, and Rosalyn Negrón, PhD, with outputs from their research, "Connecting for Equitable Climate Adaptation: Mapping Stakeholder Relationships in Metro Boston."
Image by: Jesse Wang Photography

SSL-funded researchers like Evans Kyei (left), Konstantina Ploumi, and Michael Johnson, bring a diversity of approaches and expertise to their climate work. *Image by: Jesse Wang Photography*

that prioritize historically excluded communities. Through collaborative events and specialized training, we're nurturing a broad array of climate leaders equipped to drive transformative change.

Looking ahead, SSL is charting an ambitious path. With a planning grant from the National Science Foundation, our research director, Rosalyn Negrón, is spearheading the Climate Inequality and Integrative Resilience (CLIIR) Center, an initiative for transdisciplinary research on climate migration, climate and health, and Indigenous knowledge and governance, supported by cross-cutting research on decision support systems. The CLIIR team is exploring emerging approaches to resilience research and conceptualizing SSL's research agenda to set the foundation for a future center grant application.

Another exciting project seeks to facilitate access to technical assistance and funding for water infrastructure in vulnerable communities that usually find it difficult to get to the funding table for such initiatives. SSL collaborates with the New England Environmental Finance Center on this U.S. Environmental Protection Agency (EPA)-funded project, which seeks to undertake community-engaged action research.

SSL continues to expand its impact through groundbreaking projects and partnerships. A $2 million collaboration with MassDOT focuses on innovative research to enhance the climate resilience of rail embankments. The Barr Foundation has committed $700,000 over two years to develop community-engaged action research programs, further strengthening SSL's commitment to participatory approaches. Additionally, the Liberty Mutual Foundation's forthcoming $540,000 grant over three years will support the new "Climate Careers Curricula (C3) Initiative," aimed at improving access to green economy jobs for youth in disadvantaged communities.

As executive director, I'm committed to breaking down barriers and empowering communities to drive their own adaptation efforts. Drawing on my experience in international development and climate adaptation research in coastal Louisiana, I understand the importance of addressing the root causes of vulnerability. At SSL, we believe that true resilience goes beyond survival; it's about thriving in the face of adversity.

But our vision extends far beyond our university walls. Climate change is forcing us to reconsider prevailing paradigms of our relationship with nature and each other. This is a time for communities worldwide to learn from one another. We hope to bring the world to SSL and take SSL to the world by fostering collaborative research and knowledge exchange across the region, the United States, and the world. Together, we can accelerate the transition to a more equitable, just, and sustainable future.

Looking to the Past to Help Guide the Future

David Landon, PhD
Associate Director, Andrew Fiske Memorial Center for Archaeological Research and Adjunct Associate Professor of Anthropology

The Andrew Fiske Memorial Center for Archaeological Research undertakes a wide variety of projects that support the university's research, education, and community outreach goals.

The center embraces anthropology's broad interest in the development and diversity of human cultures, using the unique perspective of archaeology to study the historical roots of contemporary social and environmental issues. Our research projects often include close collaboration with tribal governments, heritage museums, and other community partners. The center's projects are supported by the nation's most prestigious funding institutions, including the National Science Foundation (NSF), National Endowment for the Humanities (NEH), National Park Service (NPS), and Mellon Foundation, underscoring the center's reputation as a leader in archaeological research and cultural heritage preservation.

Using anthropological perspectives, multiple center projects have studied sites of past social and cultural change, especially those related to colonialism. In New Mexico, projects supported by NSF have explored the complex relationships between Spanish and native Pueblo peoples in the 17th century, and the development of a regional Spanish-colonial identity in the 18th century. In Plymouth, Massachusetts, projects

Overview of excavation at Burial Hill, Plymouth, Massachusetts.
Image by: John Schoenfelder

supported by NEH have expanded the story of the early colonial settlement and the cultural interactions between the native Wampanoag and the English colonists. And in Grafton, Massachusetts, a long-term collaborative project with the Hassanamisco Nipmuc has documented the homestead where five generations of Nipmuc women raised their families and worked to preserve their tribal heritage and autonomy.

Graduate students Claire Norton and Mikayla Roderick mapping at Las Golondrinas. *Image by: Heather Trigg*

Three of our recent projects have studied impacts of climate change and coastal erosion on archaeological sites. In Iceland, a collaborative project with Icelandic archaeologists, funded by NSF, is investigating and documenting a complex Viking-era fishing site threatened by climate change in the Arctic. On Cape Cod, Massachusetts, a collaborative project with NPS evaluated threatened sites on Wellfleet's Great Island, recording and assessing sites to guide preservation priorities for park planners. Closer to home, a collaborative project with the City of Boston, the Public Archaeology Lab, and the Massachusetts Tribe is recataloguing multiple collections of artifacts from sites on the Harbor Islands. This effort will create accessible artifact catalogs and expand the public understanding of Boston's Native heritage. It will also provide archaeologists with new details about site chronology and significance, informing the future testing strategy at Harbor Islands sites impacted by climate change.

Much of the center's funding supports graduate student research, creating hands-on research experiences, promoting experiential learning, and fostering professional development. Our projects fund summer travel to field research sites for archaeological excavations and sample collection. During the academic year the emphasis shifts to the labs, where the artifacts, animal bones, and other samples are cleaned, identified, and catalogued. This laboratory work is typically undertaken by graduate research assistants in UMass Boston's master's program in historical archaeology. A master's degree in archaeology meets national standards for work as a professional archaeologist, and our graduates have successful careers in academia, government, museums, and private cultural resource management companies. In these positions, they apply the skills gained at UMass Boston to promote and protect our country's archaeological heritage in a way that is responsive to diverse stakeholder communities.

These examples highlight the Fiske Center's successful implementation of UMass Boston's goals for holistic student success, impactful research and scholarship, and community collaboration.

Accelerating the Development of Low-Cost Rapid Diagnostics for Infectious Disease

Kimberly Hamad-Schifferli, PhD
Professor of Engineering

Infectious diseases are a global health threat that is worsening, where major outbreaks are occurring more frequently.

As we saw with COVID-19, outbreaks are getting larger in scale, with far-reaching catastrophic effects. One critical tool for infectious disease is the diagnostic test, which enables decision-making for quarantining, patient treatment, and disease surveillance. While diagnostics have many forms, rapid tests that can be used at point of care have revolutionized global health. This is the format of the over-the-counter pregnancy tests and home COVID-19 tests. A biological fluid like a nasal swab is added to the paper test. If two red lines appear, the result is positive; one line, negative. Paper diagnostics are low cost, fully self-contained, and do not require power or specialized instruments. Consequently, they can be distributed on a massive scale, which is unfeasible for other diagnostics such as polymer chain reaction (PCR) tests.

However, current approaches for making paper diagnostics have several bottlenecks. They rely on antibodies specific for the virus, and generating antibodies must be produced in animals and then screened for those that bind to the target. The process is expensive and time-consuming, and significantly delays diagnostic distribution.

Paper test that can detect a variant of SARS-CoV-2 that it has not encountered before using antibodies only for the alpha variant. a) Schematic of the test that uses two different-colored nanoparticles. b) Images of test strips when run with different variants of SARS-CoV-2, which result in different-colored signals at two test areas. The test produces a signal when run with BA.1., a variant it has not seen before. c) Data analysis of the signal by principal component analysis shows that the new variant clusters separately from the other variants.
Image by: Kimberly Hamad-Schifferli

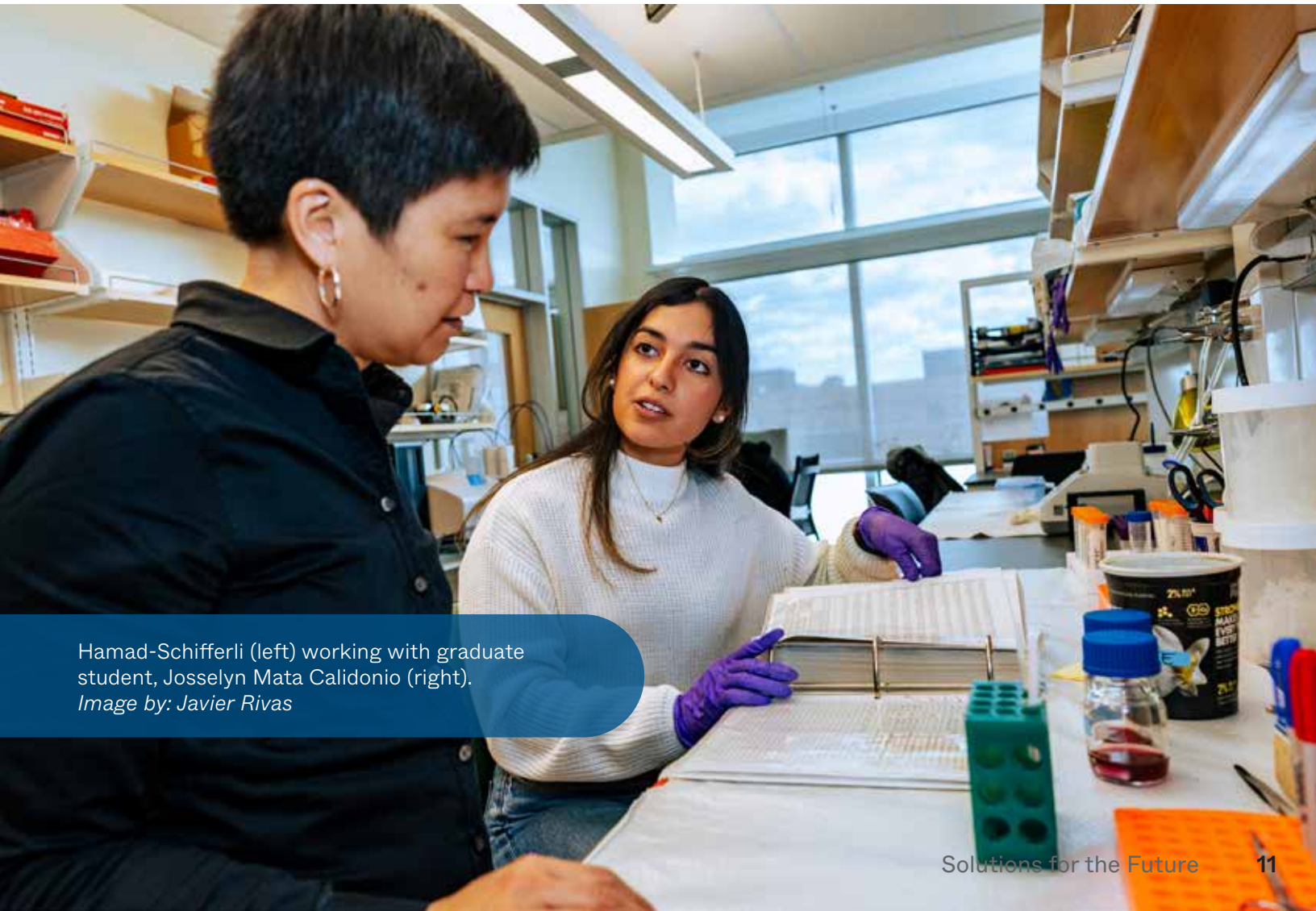
Unfortunately, this limits our ability to respond quickly to diseases when they first emerge, the period when curbing its spread is most critical.

To address this problem, we are devising ways to get paper diagnostics on the ground sooner. First, to circumvent the generation of new antibodies every time an outbreak occurs, we are exploring a short cut and repurposing currently available antibodies that tend to bind off target. We demonstrated this by using antibodies intended for dengue and Zika viruses to detect yellow fever. We also used different-colored nanoparticles, so the test produced a range of colors instead of just red, and then used machine learning to train the system. By doing so, we could hack a commercial dengue diagnostic and convert it to a yellow fever test without any yellow fever antibodies.

Optimization of diagnostic performance is usually by trial and error, so we are also using machine learning to accelerate test development. We demonstrated this on a SARS-CoV-2 antibody test, which can distinguish whether a patient was infected vs. vaccinated based on the colorimetric pattern.

Finally, we are extending these strategies to design paper tests to detect unknown targets. When a new disease emerges, the only way to identify it is by DNA sequencing, which is slow, and samples must be sent to a centralized lab. To achieve this with paper tests, we use pattern recognition of the test lines to pick up disease targets that have not been identified before. We have demonstrated this on variants of SARS-CoV-2, where we used antibodies for the alpha variant to pick up unknown Omicron ones.

All of these strategies could be used in the field as they do not require instrumentation other than a mobile phone camera. Moreover, these strategies can be dispersed in communities to teach them how to make tests themselves using reagents that are on hand. Democratization of test production could make it more accessible and aid in curtailing outbreaks when they newly emerge.



Hamad-Schifferli (left) working with graduate student, Josselyn Mata Calidonio (right).
Image by: Javier Rivas

UMass Boston's EQUIP-UMB Program:
A Strategic Development in Quantum Information Science and Engineering

Robin Côté, PhD
Distinguished Professor of Physics, Director of the Data & Quantum Science (DataQS) Center, College of Science and Mathematics

Quantum Information Science and Engineering (QISE) is an emerging and fast-evolving field identified as a priority in the 2022 CHIPS and Science Act, and UMass Boston is gearing up to play a growing role to accelerate research and innovation and develop the workforce.

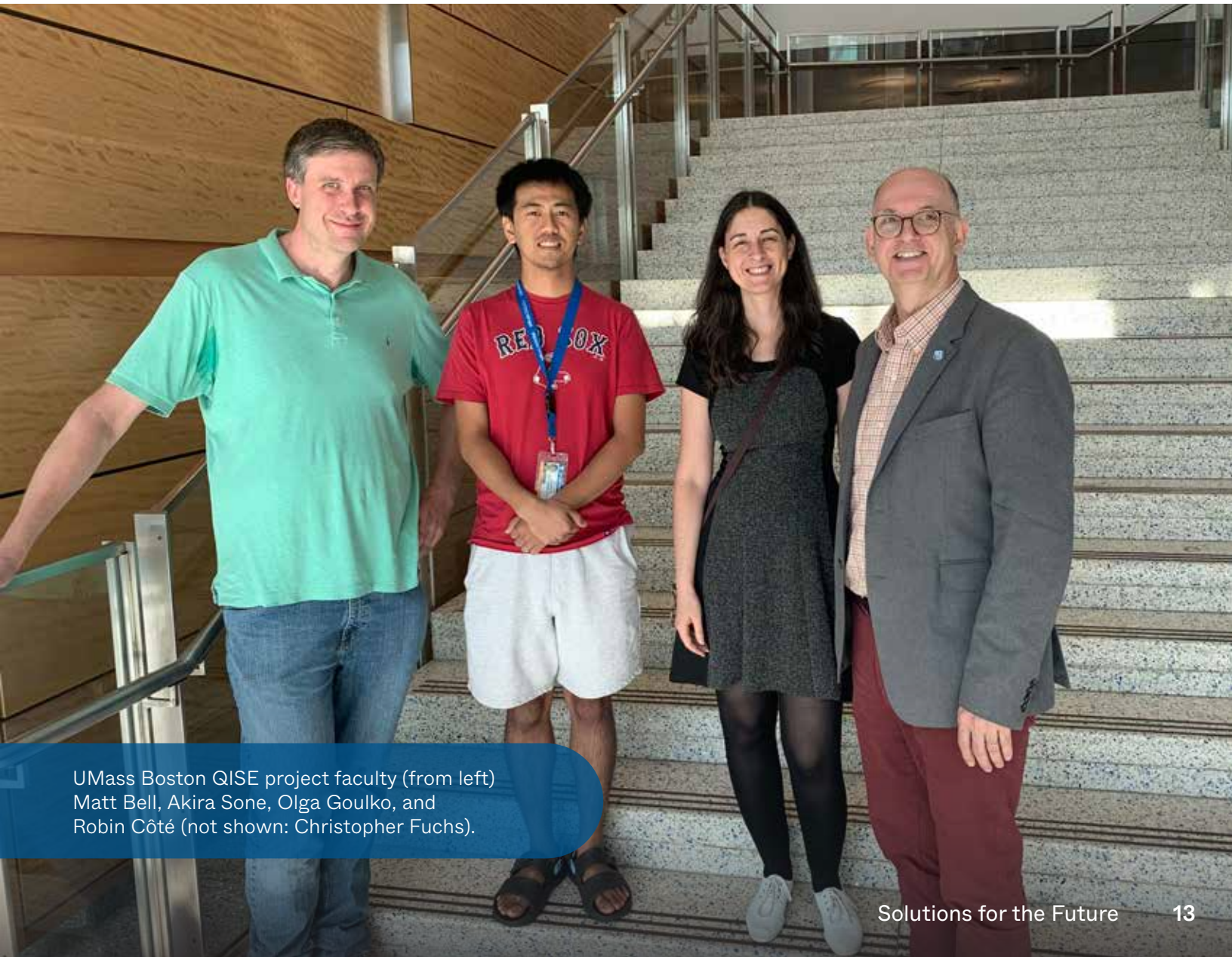
New devices and technological applications promise to form the basis of one of the major technological revolutions of the 21st century, with the potential to impact a range of disciplines such as biology, chemistry, computer science, device engineering, materials science, mathematics, physics, and several others.

UMass Boston was awarded a $5 million grant, Expand QUantum Information Programs at UMass Boston (EQUIP-UMB), from the National Science Foundation (NSF) through its ExpandQISE program, which aims to develop a diverse and multidisciplinary talent pool primed for active participation in the U.S. QISE workforce. The vision of EQUIP-UMB is to establish a vibrant and sustainable QISE program at UMass Boston. The 5-year EQUIP-UMB award will enable the UMass Boston group to tackle three main objectives. The first is to conduct high-quality research within three focus areas: quantum fundamentals, quantum metrology and control, and codesign and quantum systems. Secondly, the program seeks to expand the university's QISE program by creating three new tenure-track positions. The third objective is workforce development through student engagement and partnership with industry.

As part of the UMass Boston team, led by Robin Côté (Director of the Data & Quantum Science (DataQS) Center, and Past Dean, College of Science and Mathematics) as principal investigator, and comprised of Associate Professor Matthew Bell (Engineering), Assistant Professor Olga Goulko (Physics), Assistant Professor Akira Sone (Physics), and Professor Christopher Fuchs (Physics), we are working together on topics ranging from foundation of quantum mechanics, to many-body dynamics, to quantum thermodynamics, to hybrid quantum platforms, and superconducting systems. In addition to providing funding for advanced research equipment, UMass Boston's $4.5 million share will cover two years of salary for the three new faculty positions (two experimentalists and one theorist) and provide two-year support for four postdocs and five graduate students, seeding a robust start for the EQUIP-UMB program. The remaining $0.5 million is shared between our collaborators' groups at MIT (Professor Paola Cappellaro) and Harvard (Professor Mikhail Lukin).

To develop a diverse and multidisciplinary QISE workforce, EQUIP-UMB builds on various education initiatives designed to lower the barriers to entry into the quantum workforce, such as the undergraduate Quantum Information Certificate (QIC) introduced in the 2021–2022 academic year to provide foundational knowledge in QISE with minimal scientific background required. Plans for a graduate-level certificate (QuIC) are underway, which will offer advanced study including the experimental realization of quantum devices. UMass Boston also plans to integrate QISE tracks into its computational sciences and applied physics PhD programs to enhance interdisciplinary collaboration. In addition, our industry partners such as Atlantic Quantum, Millimeter Wave Systems, QuEra, Quantum Microwave, and Riverlane will contribute to these efforts by providing guidance on industry needs and with internships for our students.

EQUIP-UMB at UMass Boston represents a concerted effort to advance QISE through focused research, educational programs, and collaborative partnerships. This investment in QISE will be leveraged to seek additional resources from federal and state agencies, in particular the Massachusetts Technology Collaborative (MassTech), to increase the capabilities of our Quantum Hardware Development & Commercialization Core Facility and DataQS Center. This initiative is expected to contribute significantly to the development of a skilled workforce in the emerging field of quantum information science and set UMass Boston to become a Beacon of quantum education and innovation for Massachusetts.



UMass Boston QISE project faculty (from left) Matt Bell, Akira Sone, Olga Goulko, and Robin Côté (not shown: Christopher Fuchs).

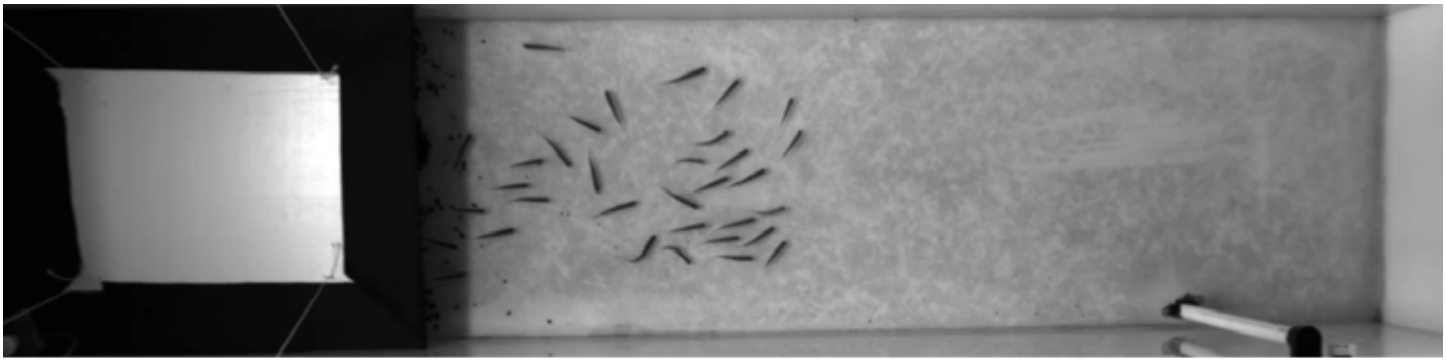
Collective Decision-Making

Albert Kao, PhD
Assistant Professor of Biology

How does one make sense of a complicated system?

Traditionally, scientists take apart such a system and study each of its components in detail—this is the reductionist approach. However, we are realizing that many natural phenomena, particularly in biology, are more than the sum of their parts. For example, it is not possible to understand consciousness by studying a single neuron or the V formation of migrating Canada geese by studying a single bird. We call these complex systems, and fascinating emergent properties (like consciousness or group structure) often arise from the multitude of interactions between the individual components. To have any hope of understanding these emergent properties, we need to study these systems in all of their complicated glory.

Our lab is particularly interested in how group-living animals make decisions together. From the mummichog fish schools swimming in Savin Hill Cove, to the ant trails seeking out bits of food outside of the Campus Center, to the geese flying



A school of golden shiner fish emerge from their shelter to explore the experimental arena in our lab in the Integrated Sciences Complex at UMass Boston. *Image by: Fritz Francisco and Shoubhik Banerjee*

overhead, such collective decision-making abounds across the UMass Boston campus. Reaching a consensus is important for the simple purpose of staying together, but there is a more intriguing possibility, too: animals in groups may be able to make better decisions together than they could alone. This is because each individual comes with its own sensory information and past experiences, so a collective, in theory, could pool its information together and make a more informed decision, a phenomenon called the "wisdom of crowds."

We study collective decision-making at UMass Boston in three ways. First, we develop mathematical models of how we think social animals make decisions and run computer simulations to generate predictions of what real animal groups might do in different situations. Then, we test these theoretical predictions in our lab. Currently, we have been focused on a small minnow species, the golden shiner, which we house by the thousands on campus. Our lab—including several UMass Boston undergraduates—have built a custom experimental set-up to study these fish, which allows us to stimulate the fish at particular times, record their behavior with an overhead camera, and follow their movements using state-of-the-art deep-learning tracking algorithms. Lastly, we study collective decision-making in the field by recording the behavior of migrating sockeye salmon in Alaska, which move together hundreds of miles from the ocean back to the same ponds that they were born in years ago. Together, these different methodologies (models, lab experiments, and field observations) help us to paint a picture of how animals in groups make decisions together.

Collective decision-making is relevant to countless species across the tree of life, from herds of elephants, to schools of herring, and even to microscopic bacterial clusters. However, it is also highly relevant to us humans, too. We exchange information and opinions with our local community and even globally through social media, and we make collective decisions when we vote or when public opinion coalesces around an idea. Indeed, by learning how animal groups make decisions—using strategies that were honed over millions of years of evolution—we may gain new ideas about how to improve our own information sharing systems.

A brown bear preparing to hunt a group of sockeye salmon at our field site. The bear and each salmon labeled with a colored dot which corresponds to the speed to which animal is traveling, the result of a deep-learning automated tracking algorithm.
Image by: Albert Kao and Ben Koger

The Proteomics Core Facility:
A Catalyst for Collaboration, Engagement, and Training

Jason Evans, PhD
Proteomics Core Facility Director, Department Chairman,
Associate Professor of Chemistry

The Proteomics Core Facility has been offering mass spectrometry services using state-of-the art instrumentation since 2017.

Our Proteomics Core Facility serves both internal and external clients of the greater Boston biotech community and beyond. The core is led by Professor Jason Evans, an associate professor in the Chemistry Department, who has been at UMass Boston since 2001. The core facility is run under his direction by a team of graduate students led by Rachel Muriph and Mynaja Ferguson.

The centerpieces of the core facility are two state-of-the-art nanoflow liquid chromatography/mass spectrometry (LC-MS) instruments, both of which were purchased with funding from the Massachusetts Life Sciences Center (MLSC). The first instrument is a nLC-Orbitrap Fusion Lumos Tribrid mass spectrometer purchased in 2016. This was provided to us through the initial seed funding that supported the development of the Center for Personalized Cancer Therapy at UMass Boston. The second instrument is an nLC-timsTOF purchased in January 2023 with funds we received from MLSC through a Bits to Bytes award.

(continued on page 16)

The EvoSep nanoHPLC that is used in conjunction with our timsTOF.
Image by: Javier Rivas

Workforce Development

Rachel Muriph, a PhD student in the Chemistry Department, works in the Proteomics Core Facility.

Muriph in the Proteomics Core Facility.
Image by: Javier Rivas

"Working in the Proteomics Core Facility has exposed me to countless different projects and clients. For example, the core has done work with many local biotech companies to aid in ongoing research into nanoparticle drug delivery systems, the same technology used in the Pfizer and Moderna COVID-19 vaccines.

This work focuses on both payload delivery efficiency, which involved thoughtful and careful sample preparation, as well as characterization of the proteins that amass on nanoparticles when they are placed in biological fluids, such as when they come into contact with a patient's blood during administration.

Working so closely with these clients, among many others, fosters relationships between UMass Boston and local biotech companies, which has helped me prosper as a collaborative researcher.

These collaborations, along with the guidance of the director of the Proteomics Core Facility, Professor Evans, has given me exposure to a myriad of scientific projects, each requiring a unique approach. Our core facility model offers collaboration-based services rather than a simple fee-for-service model. This has given me the opportunity to be involved in initial consultations with clients, experimental planning, collecting and analyzing data, generating reports, and finally meeting again with the client to present them with their data.

Throughout my time working in the Proteomics Core Facility my benchtop skills, analytical mind, business skills, and customer service training have been expertly curated to make me a well-rounded and appealing applicant for job opportunities postgraduation."

These instruments excel at analyzing complex samples obtained from cultured cells or tissue samples. The Orbitrap is a high-resolution mass spectrometer equipped with electron-transfer dissociation (ETD) capabilities allowing for customized analyses tailored to sample identity/complexity. On a typical HeLa cell digest, we confidently identify 4,000 unique proteins in 90 minutes. The timsTOF offers 4D separation by leveraging gas phase separation of ions based on their mobility. This, in conjunction with the speed of the TOF, yields 4,500 confident protein IDs in just 45 minutes.

The Proteomics Core Facility has worked on a large variety of projects, such as antibody characterization, location of post-translational modifications, and characterization and quantification of proteins attached to nanoparticles. However, we specialize in measuring differential protein expression patterns. Proteins are the drivers of cellular function. Proteins that are differentially expressed in a disease state can provide a window to understanding the biological pathways that are impacted by the disease. These differentially expressed proteins are potential targets for developing a therapeutic that can relieve the symptoms of the disease.

The core facility has worked with many different clients, including small biotech start-ups, local hospitals and universities, larger biotech

companies, and a handful of academic collaborators across the United States. Some of these interactions have led to research collaborations and MLSC-funded projects, where the MLSC provides funding to support new capital equipment for the core facility, and the company supports a salary for a postdoctoral research assistant to work on the project. We are in the middle of a three-year project with Pinetree Therapeutics that focuses on developing a cancer therapeutic. Another proposal was recently funded by MLSC with Covaris serving as our industry partner. This new award will improve and automate our sample preparation procedures, provide advanced computational performance for data analysis and support a new collaborative project between UMass Boston and Tufts University that focuses on designing nanoparticles for drug delivery. In addition to local biotech companies, we also engage in outreach to local high school students, providing them access to state-of-the-art instrumentations and mentorship otherwise inaccessible to them.

The formation of the Proteomics Core Facility at UMass Boston has been a catalyst for collaboration on internal research projects, for engagement with the local biotech community, and for specialized training of UMass Boston students. The core has been instrumental in the progression of numerous projects thus far and we look forward to continuing to serve the scientific community of greater Boston for many years to come.

Evans and Ferguson working in the Proteomics Core Facility.
Image by: Javier Rivas

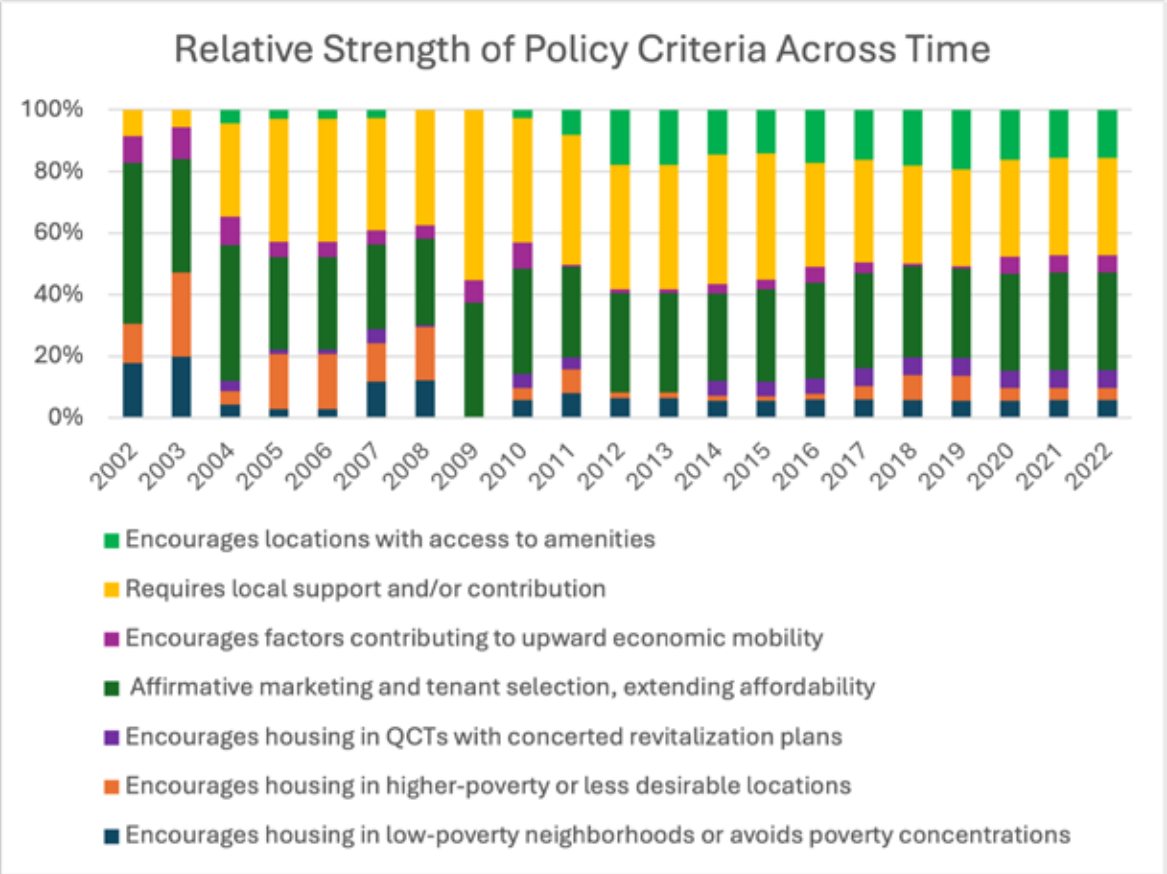
Navigating the Nexus of Policy and Opportunity:
A Comprehensive Study of Texas' LIHTC Evolution

Sowmya Balachandran, PhD
Assistant Professor of Urban Planning and Community Development

The quest for fair housing in the United States has long been fraught with complexities, with the Low-Income Housing Tax Credit (LIHTC) program at the heart of many debates.

As a pivotal mechanism for financing affordable housing, the LIHTC program's impact on fostering equitable communities is under continuous scrutiny. This critical examination comes into sharp focus in the research I am conducting at the School for the Environment, along with colleagues from the University of North Texas and graduate student Madeline Sovie. The research is titled "From Litigation to Integration: The Evolution of Texas' LIHTC Policies for Fair Housing." The study delves into the intricate dynamics of LIHTC neighborhoods, drawing upon a rich blend of qualitative and quantitative data to unravel the effects of policy changes over time, especially in light of fair housing litigation.

Together, we are conducting a longitudinal analysis of Texas' Qualified Allocation Plans (QAPs) across 21 years, segmented into four phases: pre-litigation, litigation, remedial action, and post-remedial action. This temporal framework enables a detailed examination of policy shifts and their repercussions on housing development. By leveraging a mixed-methods approach, combining document analysis with in-depth interviews and project-level data from the U.S. Department of Housing and Urban Development (HUD), the study offers a nuanced understanding of the operationalization of fair housing principles within LIHTC policies. In addition, we interviewed multiple institutional stakeholders and conducted focus groups with



Bar graph of 'Relative Strength of Policy Criteria Over Time' created by the author and sourced from Balachandran et al. (Manuscript Under Review in the Journal of Housing Policy Debate)

LIHTC residents. Data extraction from individual developer applications and their appraisals further add to our analyses.

The study's findings reveal a significant, albeit unintended, policy shift: a five-percentage point decrease in criteria strength aimed at promoting access to neighborhoods with high economic mobility potential and dismantling barriers for underserved groups during and post-litigation. Despite these shifts intending to simplify project approval processes and potentially increase affordable housing development, developers report mounting challenges stemming from intensified but potentially misaligned deconcentrating poverty criteria. This misalignment has led to a scarcity of viable low-poverty locations willing to accommodate tax credit housing, indicating an unintended consequence of the policy's evolution. Finally, while tax credit units are increasingly located in lower-poverty neighborhoods, there is considerable variation in access to better schools, jobs, transportation, and local factors vital for upward economic mobility.

The research critiques the oversimplified conception of "opportunity" as merely the reduction of poverty. It argues that such a narrow definition neglects the multifaceted reality of accessing significant opportunity structures—like educational and employment resources—crucial for genuine economic mobility. The study's findings highlight a nuanced policy landscape where intentions to foster fair housing collide with the practical challenges of implementation, yielding mixed outcomes in terms of equitable community development.

Our research not only deepens understanding of the LIHTC's impact on fair housing; it also encourages a rethinking of policy design and implementation. It suggests that Texas' experiences can inform broader strategies, pushing for policies that embrace a wider view of opportunity and community inclusivity. This work underscores the need for ongoing dialogue among policymakers, planners, and communities to refine affordable housing initiatives, aiming for truly equitable urban growth.

Partnering to Encourage Age-Friendly Communities Across the Commonwealth

Caitlin Coyle, PhD '14
Director of UMass Boston's Center for Social and Demographic Research on Aging (CSDRA)

Setarreh Massihzadegan, MS, PhD Candidate
Gerontology; Research Assistant, Gerontology Institute's Center for Social and Demographic Research on Aging (CSDRA)

An interview with Caitlyn Coyle, PhD '14, Director of UMass Boston's Center for Social and Demographic Research on Aging (CSDRA).

Setarreh Massihzadegan (SM): The aging of our country's population is often discussed in the context of the impact it will have on the health care system and social services. In what context do you most often think about population aging?

Caitlin Coyle (CC): To me, population aging is an exciting opportunity for our whole society. We are seeing a lengthening in the amount of time spent "in later life," which means opportunities for all of us to think about how we want to spend those years. As a society, it pushes us to expand ways of leveraging human potential—not just those who contribute reproductively or via labor force participation. We stand to benefit from a huge amount of accumulated expertise, knowledge, and experience from older people to an extent that was not possible in earlier times; they can contribute a lot to charting the future. Instead of reading about history makers, we have the opportunity to work directly with them.

A CSDRA listening session in South Boston 2016.
Image by: Andrea Burns, Director of Age-Friendly Boston Initiative

SM: What are the key areas of your current research portfolio, and what methods do you use to understand them?

CC: An overarching question that guides my research is: How can we transform local environments to optimize well-being for diverse populations of older adults and families? Currently, this looks like projects to promote information equity among diverse groups of older Bostonians. We're looking at how they receive information, what messaging they find compelling, and how trust is built between people and the organizations and government agencies that offer benefits and services that can improve the aging experience. At the CSDRA, we work with senior centers, the government, and nongovernmental organizations across the Commonwealth to engage older adult populations to document—using both quantitative and qualitative methods— their needs and preferences for facets of aging such as health and wellness services, financial security, social and recreational programming, transportation, communication, and information. Based on the data we collect, we make recommendations for how municipalities can improve local operations to accommodate and leverage population aging.

What makes the CSDRA special is our community-engaged research approach to these topics. We invite community members to participate throughout the research process, from identifying research questions to implementing interventions and analyzing results. In the context of aging, this means bringing older adults, caregivers, and community organizations together to identify needs and develop solutions to improve quality of life. It can be a slow and sometimes nonlinear process, but the effort is always worth it. I am proud of using this process in projects with more than 80 cities and towns over the past twelve years.

Aging is a complex and multidimensional process that requires input from various disciplines and sectors, including health care, social services, urban planning, and policy. When it comes to making recommendations, we prioritize collaboration, inclusivity, and empowerment, aiming to create sustainable solutions that enhance the health, well-being, and dignity of older adults within their communities.

SM: Having worked with so many communities, how unique are their challenges? What makes a community successful at becoming age-friendly?

CC: The elements of livability that need to be in place for a community to thrive are relatively universal—housing, transportation, accessibility of the built environment, and things like opportunities to engage socially and contribute meaningfully. That said, communities vary widely in their capacity and preference for accomplishing age inclusivity across these topics. I have observed that implementation of change has been most successful for communities that have leaned into their local context and taken the time needed to authentically engage the community and create realistic ways for local leaders and community partners to work together. From my perspective, it is not about how fast progress is made, nor is it about how innovative the idea, but rather, the embracing of the concept and the flexibility to chart their own path.

SM: Following the COVID-19 pandemic, the public seems to be more attuned to issues of social isolation and loneliness. How do you describe these concepts and how does your research address them?

CC: Gerontologists have been exploring how social relationships shape an individual's development across the life course and, subsequently, affect outcomes in later life since well before the pandemic. For me, this stretches back to my dissertation topic that explored the impact of social isolation and loneliness on chronic disease self-management among older people. It also includes cofounding the Massachusetts Coalition to Build Community & End Loneliness in 2019. We were well down the path of understanding the consequences of social disconnection before the pandemic.

That said, the global shutdown caused by COVID-19 spotlighted the experiences of social isolation—an objective lack of social contact—and loneliness, a distressing feeling that stems from an inequity between one's desired and actual levels of social connection. Since 2020, we've seen an explosion of attention paid to the public health aspect of this for people of all ages, including the 2023 Surgeon General's warning about the epidemic of loneliness and isolation.

The CSDRA and Massachusetts coalition have focused most recently on promoting "social health" in the same way we attend to our physical and mental health. A lot of this work involves building public awareness and eroding the stigma around loneliness. We are also working to develop models for evaluating how existing programs, services, policies, and activities increase or improve social connection and a sense of belonging and perceived connections to contexts beyond one-on-one relationships. In essence, we are widening the lens from reducing the personal experience of social isolation and loneliness towards promoting social health outcomes for a wide range of people and across settings.

Building Health Equity:
The Power of Community-Engaged Research

Ana Cristina Terra de Souza Lindsay, DrPH, DDS, MPH
Professor, Department of Urban Public Health, MCNHS

Community-engaged research brings together members of a community to participate in research that impacts their own community. It is critical to achieving health equity and is at the heart of several projects currently underway in the Department of Urban Public Health at the Donna M. and Robert J. Manning College of Nursing and Health Sciences.

As a community-based public health researcher, my research program focus is on understanding and reducing disparities in health to achieve health equity among minority, multiethnic Latinx populations living in the United States and Latin America. We use a community-engaged approach to provide insights for identifying economic, social, and systemic barriers to good health as well as interventions that are effective in improving health outcomes and equity.

Professor Lindsay and research assistants preparing for meetings with community members.
Image by: UMass Boston Office of Communications

Throughout my years of work, I have reaffirmed that it is only when communities are truly engaged together in inquiry that we can substantially impact the lives and health of individuals and their communities. Communities provide the best road map for meeting their needs in culturally sensitive and sustainable ways. While this article discusses our program's work with human papillomavirus (HPV), we have seen its impact extend to health issues such as childhood obesity, gestational weight gain, and more recently oral health.

Three of our current research studies seek to understand how to increase HPV vaccine uptake in minoritized, immigrant populations with a focus on Central American, Brazilian, and Cabo Verdean immigrant communities. The Centers for Disease Control and Prevention estimates that the vaccination can prevent over 90% of the cancer cases caused by HPV infections. Our research explores how to create an environment in which the vaccination rates increase to reduce the incidence of preventable HPV-related cancers.

For a project with Central Americans, we hired Latinx student researchers to interview parents of pre-adolescent and adolescent girls and boys. The interviews are designed to understand the parents' hesitancy to have their children vaccinated for HPV. In the interviews, parents provide recommendations for interventions tailored to their community such as improving community-wide dissemination of culturally and linguistically relevant information about the risks of HPV and the benefits of the vaccines targeting not only parents of age-eligible participants but also the wider community. Additionally, they have asked for educational campaigns about the impact of HPV vaccines to be delivered through social media and schools.

By developing interventions tailored to meet the needs of minoritized, immigrant populations, we improve the likelihood that children in immigrant families will receive the HPV vaccine and HPV infections will decrease.

Community-engaged research often includes training and experiences that empower community members to address future health issues, too. For example, we created a program called "Avancemos!: Advancing Research Skills and Professional Career Opportunities in Health Sciences for Latinx Undergraduate Students"

A research assistant meeting with a mother as part of a two-year HPV research called "Toward Racial Equity and Justice in Human Papillomavirus (HPV) Vaccination: An Exploratory Study with Cabo Verdean Parents" funded by the National Institute on Minority Health and Health Disparities (NIMHD).
Image by: Ariane DePina

designed to increase students' interest and connection with academia through community-engaged research within the Latinx communities where the students come from. As part of our transnational collaborations with academic institutions, including student exchange programs with Latin American countries that reflect the immigrant populations, we work within the United States.

We have seen positive outcomes with our student researchers who, through their work, have been motivated to complete degree programs, work in STEM careers, and secure jobs that increase their upward mobility and economic security. On a systems level, this increases workforce diversity, which is a solution for the future in building health systems that support health equity and improve health outcomes for diverse communities.

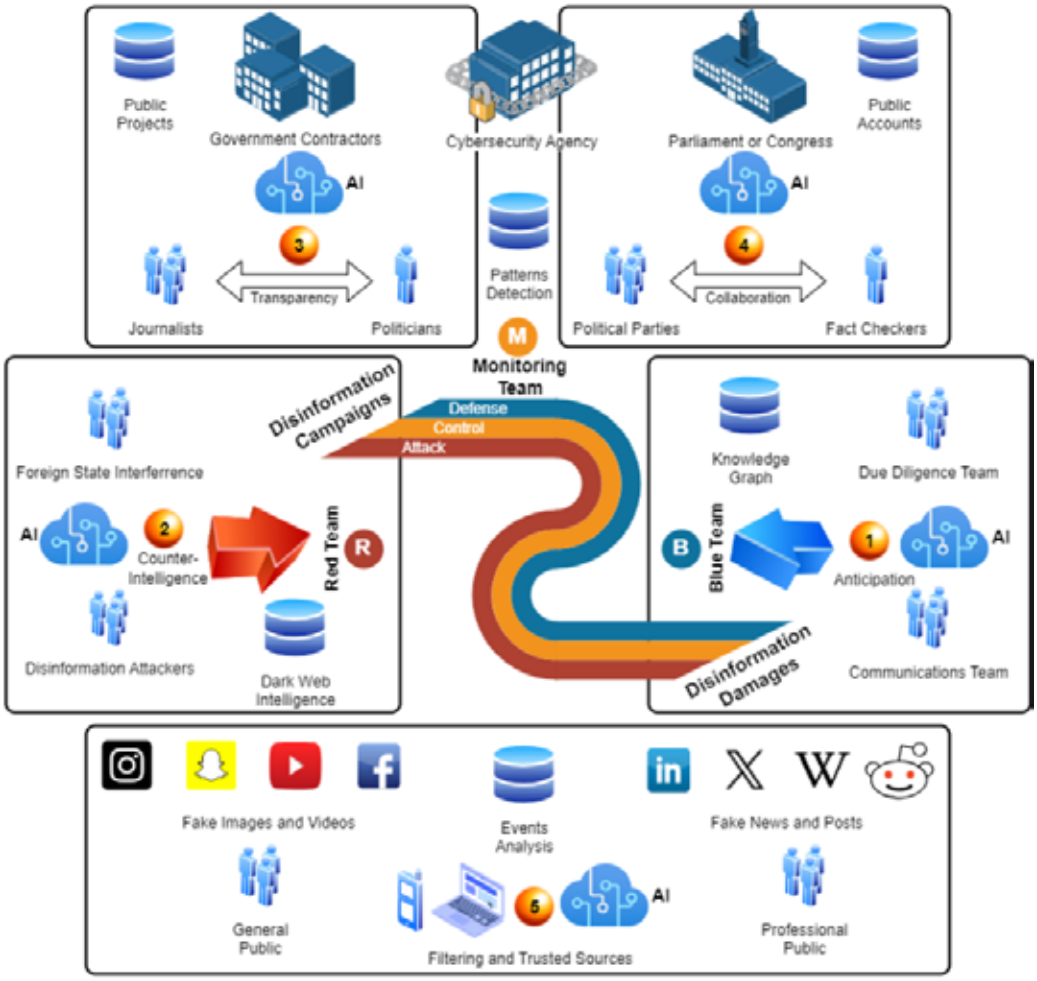
Design of AI Applications to Counter Disinformation as a Strategic Threat Within the Field of Cybersecurity

Romilla Syed, PhD
Associate Professor of Information Systems

Romilla Syed, associate professor in the College of Management, and Stéphane Gagnon, at the Université du Québec en Outaouais, along with a team of researchers, are investigating the use of artificial intelligence (AI) to counter disinformation as a strategic threat within the field of cybersecurity.

Our team is focused on a very specific type of disinformation: false allegations against politicians in their governance roles. The project is supported by grants from the Human-Centric Cybersecurity Partnership (HC2P) (CAN$25,000) and Fonds de recherche du Québec (CAN$175,000).

Disinformation, whether in text, video, or image modality, can target public sector projects with the goal of tarnishing an otherwise well-functioning government initiative. These threats include false claims of conflicts of interest, nepotism, bribery, and corruption. The claims rely on assumptions and/or fabricated facts, both very difficult to verify beyond a reasonable doubt. Mismanagement of this disinformation can damage



The diagram shows the wide scope of actors, information, and technologies involved. We identify five areas: (1) blue team fighting disinformation damages; (2) red team running disinformation campaigns; (3) government projects targeted; (4) parliaments where attacks are impacting; (5) public to whom disinformation is distributed. Cybersecurity agencies and monitoring teams are "in the middle." The team is taking a "whole campaign" perspective to disinformation monitoring to provide at least five major functionalities: (1) anticipation of "next events" in a chain of fake news so as to help blue teams fight more strategically; (2) counterintelligence about dark web actors to deter and disarm; (3) transparency enhancement by linking public project information with politicians' actions and formal news; (4) collaboration between political parties and their network of fact-checkers, ensuring no false information is propagated in parliaments or used for decision-making; (5) filtering and trusted sources systems to support end users, whether general public or professionals.

democracy for several years with the risk of irrecoverable trust in our institutions and leaders. It could cause projects or programs to be canceled, thereby depriving citizens of services and impeding national development. It could also lead to falsified decision-making processes, especially if referenced during congressional and parliamentary hearings or other intervention committees. Thus, our team focuses on the design of a formal model to monitor and detect misinformation and guide decision-making in the realm of political disinformation.

As of 2024, our team is collecting case study data on several corruption cases, some where allegations proved true, and others false. The team also develops new disinformation ontologies (formal machine-readable conceptual models) and knowledge graphs (KGs; a vast network of logical relationships, including decision rules) to help model disinformation campaigns and attack patterns, which will then be integrated into graph-augmented large language models (LLMs). Finally, a set of use cases is developed in collaboration with political communications experts, who will help identify how to use AI, especially KGs and LLMs, to overcome disinformation impact in their work and ensure faster and more accurate due diligence to solve corruption allegations against politicians.

Physics:
New Approaches for AI Research

Rahul Kulkarni, PhD
Department Chairman, Physics

Jacob Adamczyk, PhD Student
Physics

A conversation about research in Physics and AI at UMass Boston.

Jacob Adamczyk (JA): To begin, can you summarize the exciting and innovative research happening in the Department of Physics?

Rahul Kulkarni (RK): The Department of Physics at UMass Boston currently has two broad areas of research focus: biological physics and quantum science and technology. The application of fundamental concepts and results from statistical physics informs our research in both these areas. A field of research that we are currently looking into is the application of statistical physics to a new frontier: artificial intelligence (AI) research. Some of the new ideas in this field are being developed in our department, which is particularly exciting as we have a unique opportunity to forge new directions in current AI research.

JA: How did the connection with AI research develop within the Department of Physics?

RK: Typically, such a connection emerges from AI being used as a tool to study scientific datasets and classification problems in physics. However, we also saw the potential to follow a road less traveled: using physics insights to lead to new developments in AI research. More specifically, we saw reinforcement learning (RL) as a point for application of our ideas from studying nonequilibrium statistical physics. A surprising discovery we have made in this context is that diverse optimization problems in RL research can be mapped on to the physics of rare events.

JA: What is the physics of rare events, and what does it have to do with AI research?

RK: In RL, the goal is to learn how to optimize long-term rewards in problems involving sequential decision-making. If the agent employs an uninformed or random strategy for decision-making, high rewards will be obtained only very rarely. Take for example the game of chess, where a reward is obtained only at the end of a game for a win. Winning a game of chess by adopting a random strategy would clearly be a rare event against any reasonable opponent. The goal of reinforcement learning is to effectively discover policies that access such rare events. It turns out that in nonequilibrium statistical physics, approaches have been developed to characterize the “least unlikely of all unlikely ways” for such rare events to occur. Remarkably, these approaches also lead to optimal decision-making policies in reinforcement learning.

JA: What are the insights and successes that have emerged from this connection between AI and physics?

RK: We have used this bridge between nonequilibrium physics and AI research to develop new algorithms and theory for RL. Although we are still in the initial stages, we have solved some theoretical open problems in RL research and developed new algorithms for the field. There is still much more to explore, though. The exciting prospect is that these theoretical connections have the potential to speed up RL, making the algorithms more applicable to real-world scenarios.

Beyond theoretical and algorithmic advances, this connection also can provide a new understanding or intuition for AI algorithms from a physics perspective. At a more fundamental level, having a bridge between two previously unconnected disciplines means that deep insights, concepts, and approaches from one discipline can be potentially used to address currently challenging problems in the other discipline. For example, fundamental results from nonequilibrium statistical physics can now be used to derive new relationships between quantities of interest in AI research. On the flip side, novel approaches from AI research can now be used to address challenging problems of current interest such as quantum control and quantum circuit optimization.

JA: Both AI and quantum are seen as drivers of the next "Industrial Revolution." What unique contributions does the physics department bring to the table?

RK: The research done across the department is well-poised to contribute to research at the intersection of quantum physics and AI. Across the department, tools from statistical physics are used in a variety of applications (quantum systems, computational physics, nonequilibrium systems) and can thus contribute further to the bridge we have been discussing. Another exciting avenue that is ripe for exploration is the extension of ideas involving RL to the quantum domain, which many of our faculty have experience with. At the quantum foundations level, the department has started looking into whether AI approaches such as RL can be used to learn the fundamental rules of quantum mechanics. Our faculty are also looking into the extension of generative AI to the quantum domain and their connections to information-theoretic extensions of fundamental results in quantum statistical mechanics.

JA: Do we have plans to make changes to the curriculum to emphasize new tracks or courses related to these interdisciplinary connections?

RK: Absolutely. We already have an undergraduate Quantum Information Certificate (QIC) established, and one of our top priorities is building on this to develop a graduate version of the QIC. The graduate version will include modules on quantum machine learning and course material that integrates AI approaches with current advances in quantum information science. Initially, we plan to add AI-based modules to our existing courses, and we also want to develop a new class focusing on the intersection of AI research and physics. Eventually, the plan is to develop an AI and physics track that will build on some of the research being developed in the department. The goal would be to better prepare our students to be effective contributors to the modern workforce by developing expertise using AI tools, with a perspective that is guided by research in physics. As a matter of fact, the informal course that you have developed on physics and deep learning is an important first step in this direction, and we are looking into ways of offering the course more formally. Overall, the efforts in this direction are well-aligned with the University's Strategic Priorities, including "Accelerating Interdisciplinary Scholarship" and "Education for the Future."

JA: What might you say to a prospective student who is considering joining our department in light of these interdisciplinary connections?

RK: The UMass Boston Department of Physics has a unique offering of cutting-edge research directions. We currently have and are further developing specific tracks that will prepare you for a successful career in quantum information science, biophysics, and/or AI. The research within our department is also very interdisciplinary in its nature, allowing for collaborations with other fields such as computer science and biology.

Furthermore, there is a strong tradition of undergraduate research, with the department having nominated three Goldwater Scholars over the past five years. The American Physical Society (APS) has recognized our mentorship of undergraduate research with an award after one of our undergraduate students (Joseph Farah) was awarded the highest APS award for undergraduate research: the Leroy Apker Award.

Our graduate students are carrying out amazing research on a range of topics from quantum foundations and the physics of AI to cancer biophysics and soft matter physics. As part of their graduate training, students will benefit from hands-on experience with our labs as well as high-performance computing facilities. The interdisciplinary connections that we have discussed are being developed as we speak by graduate students in the department; this opens exciting possibilities for incoming students. The department is welcoming and supportive, and the faculty and existing students are eager to work with new students interested in exploring new frontiers.

JA: Finally, what are some of the open questions at the intersection of physics and AI that you're most excited to address next?

RK: Indeed, there are many exciting and open questions at this intersection. Currently, research in AI is in an exponential growth phase with new ideas and related research questions arising much faster than solutions. Remarkably, some of the answers to the questions being posed can be obtained from old insights in physics and mathematics research. For example, generative AI is one of the biggest drivers of the current excitement in AI. The original motivation for generative AI came from insights from physics-based models (diffusion models). One of the most promising ideas for current developments in this area harks back to an idea discussed by Schrödinger in the 1930s: the eponymous Schrödinger bridge.

In 1931, Schrödinger presented a paper to the Prussian Academy of Science entitled "On the reversal of natural laws" in which he considered the evolution of N independent Brownian particles. In the limit of large N, the evolution of the distribution of Brownian particles can be predicted using the Fokker–Planck equation. However, for finite N, the observed distribution can differ significantly from the predicted distribution. As N increases, such deviations from the predicted distribution are rare events. Given that such a rare event has been observed, Schrödinger posed the following question: What is the least unlikely way this rare event could have taken place? Schrödinger went on to propose a solution to this problem by deriving a set of equations that are now referred to as the "Schrödinger bridge." It was only decades later that it was realized that Schrödinger had posed and studied the problem of large deviations of the empirical distribution of Brownian particles. Recent research has further explored connections of the Schrödinger bridge to related fields of research such as optimal transport and generative AI. Given the mapping we have established between large deviation theory and RL, it appears that RL approaches can now be applied to Schrödinger bridge problems and generative AI, opening up exciting new avenues for future research.

Apart from this representative example, there are a host of interdisciplinary research projects that can now be approached using this mix of modern tools

and older insights. Areas the department is planning to explore include applications to quantum sensing and control, AI approaches for quantum computing, and new methods for studying nonequilibrium systems. Beyond these exciting research directions, we also look forward to developing collaborations with neighboring institutions. We are currently collaborating with the Institute of Artificial Intelligence and Fundamental Interactions (IAIFI) at MIT on a project that has recently been funded by the National Science Foundation. The research focus of this partnership is on the development of novel RL approaches for the analysis of quantum systems. We plan on building on these ties to train the next generation of graduate students to carry out innovative research at the interface of physics and AI.

Image by: Danielle Fontaine

From Idea to Impact:
Innovative Ideas and Research Into Commercial Ventures

Shubhro Sen
Executive Director, Venture Development Center and Assistant Vice Provost for Research and Strategic Initiatives

Maria Vasilevsky
Manager of Operations and Outreach, Venture Development Center

A vibrant entrepreneurial community is thriving right here on our campus in Boston.

As the business incubator at UMass Boston, the Venture Development Center (VDC) fosters a strong culture of entrepreneurship and innovation. The VDC acts as a catalyst, connecting fledgling entrepreneurs and start-ups with a range of resources they need to transform ideas and translational research into breakthrough innovation and commercially viable businesses.

The VDC model is unique when you compare it to other university entrepreneurship centers. Instead of limiting program eligibility to those with a UMass Boston affiliation, the VDC strives to attract innovative industry disrupters, help them clear their early-stage hurdles, and connect them with our rich and vibrant UMass Boston ecosystem. The VDC also hosts Global Entrepreneurs in Residence (GEIRs) in a program that provides work visas to qualified entrepreneurs from overseas working on ventures. We connect the GEIRs with opportunities to serve the UMass Boston community with their expertise. The VDC hosts monthly showcases featuring the work of current GEIRs giving UMass Boston students, faculty, and staff opportunities to learn from GEIRs while they launch and grow their businesses.

Working in the VDC. *Image by: Javier Rivas*

Events and opportunities for networking are an integral part of the VDC's programming.
Image by: UMass Boston Office of Communications

As a sector-agnostic incubator, our participants can operate in fields such as the life sciences, health care, artificial intelligence (AI), machine learning (ML), robotics, quantum computing, additive manufacturing, augmented and virtual reality, renewable energy (i.e., clean tech, green tech, and blue tech), cybersecurity, and more. The VDC's resources for start-up ventures include a peer network, mentor support, fully equipped coworking and meeting spaces, and the availability of student workers. Our members also have access to the Office of Research and Strategic Initiatives ecosystem including wet and dry labs, research core facilities, intellectual property (IP) services, and the award application and management expertise of the Office of Research and Sponsored Programs (ORSP). Through our services and support to researchers commercializing their translational discoveries, global innovators, early-stage ventures, student, staff, and faculty start-ups and businesses, the VDC is having impact on campus, across the Commonwealth, and beyond.

Artificial Intelligence: Shaping the Future

Wei Ding, PhD
Distinguished Professor of Computer Science & Executive Director of the Paul English Applied Artificial Intelligence Institute

Artificial intelligence (AI) is ushering in a new era, revolutionizing fields such as protein structure prediction and medical imaging with groundbreaking advancements.

The broader scientific community is recognizing AI's potential to revolutionize science, opening new pathways, sparking innovative inquiries, and driving profound leaps forward with significant societal impact.

AI and Scientific Research

In my research, I focus on AI-enabled scientific discoveries. AI can be leveraged to drive breakthroughs in science, and scientific principles can be applied to advance AI methodologies. The convergence of these fields accelerates innovation.

I am one of the principal investigators for a National Institutes of Health-funded Research Project Grant (R01) study with Exercise Physiology Professor Scott Crouter from the University of Tennessee Knoxville. Professor Crouter, our student researchers, and I are focusing on how AI and machine learning (ML) can be used to measure physical behavior in adults as they go about their day in their natural environments. Through our collaboration, we are creating highly accurate methods for measuring physical activity based on physics-driven AI algorithms guided by physical knowledge.

The ActiGraph GT9X, a device for tracking motion. Data collected from the devices provide the physical knowledge driving breakthroughs in the AI algorithms. *Image by: Steven Bridges*

Soccer play while wearing the COSMED K5 to measure energy expenditure. *Image by: Steven Bridges*

It has become common to measure steps with our phones or to use wearable devices to track how many flights of stairs we climb, miles we run, and the number of hours we sleep. Have you ever wondered how devices detect and differentiate activities such as running versus jumping? The key to this starts with data from two types of sensors, accelerometers and gyroscopes. An accelerometer tracks how fast people's movements are speeding up or slowing down as they move side to side, up and down, and forward and backward. A gyroscope measures how quickly and in which direction an object is rotating.

Our research explores ways to develop and validate AI and ML algorithms using raw accelerometer and gyroscope sensor data collected at the hip and wrist. The aim of this work is to find highly effective ways to translate unprocessed data detected by the sensors and to turn it into information that accurately describes the physical behaviors that took place.

The development of AI/ML methodology to assess physical activity is a high priority for public health because it enables health care providers to customize exercise prescriptions to closely align with what an individual is doing. These AI/ML algorithms can be used to inform innovations in the development of wearable devices. They can also benefit those examining dose response relationships between sedentary behaviors, physical activity, and health outcomes in adults.

Ethical Considerations in AI Applications

As we advance AI technologies in health monitoring and other sensitive areas, it's crucial to address ethical concerns such as privacy, consent, data security, and bias. Collecting and analyzing personal health data raises questions about how this information is stored, who has access to it, and how it may be used beyond its original intent. Ensuring that AI systems are designed with ethical principles in mind helps protect individual rights and fosters trust between users and technology.

In our work, we prioritize

- Data Privacy and Security: Implementing robust measures to safeguard personal information against unauthorized access and breaches
- Informed Consent: Ensuring participants are fully aware of how their data will be used and have the option to opt out
- Bias Mitigation: Developing algorithms that are fair and do not disproportionately affect any group based on race, gender, age, or other characteristics
- Transparency and Explainability: Creating AI models whose decision-making processes can be understood and scrutinized by stakeholders

AI Fluency: Preparing for Today's Workforce

Understanding both the opportunities and hazards of AI enables everyone to contribute to its informed, equitable, and ethical integration into society, maximizing benefits while managing risks. Recognizing AI's growing importance, UMass Boston established the Paul English Applied AI Institute (PEAAII) to unify the efforts around AI taking place throughout our campus.

The PEAAII is driving efforts to incorporate AI into the curricula at UMass Boston; the initial focus is on supporting students as they develop their AI literacy. The PEAAII offers programs designed to move students beyond thinking of generative AI (GenAI) as a shortcut for doing assignments. Instead, our students are becoming skilled at leveraging AI as a tool for increasing their creative, analytical, and problem-solving skills. For example, in an "AI for All: Demystifying AI in Creative Problem Solving" session, Communications Professor Gamze Yilmaz presents ways to use AI for creative problem solving. In the session, students learn about GenAI, ethical considerations, effective prompting techniques, and how to critically evaluate AI-generated content.

The PEAAII is instrumental in preparing our students, and other members of the UMass Boston community, for a world in which AI will inevitably continue to grow and shape industries and daily life.

Artificial Intelligence and Community-Oriented Decision-Making for the Climate Crisis

Pratyush Bharati, PhD
Professor of Management Information Systems

Impacts of climate change, such as mortality due to floods, droughts, and storms, are much greater for highly vulnerable regions. More than 3.3 billion people are living in countries classified as very highly or highly vulnerable.

Low-lying waterfront Boston neighborhoods, such as Dorchester and East Boston, will be impacted by coastal and riverine flooding due to climate change-induced sea level rise during storm events and high tides. This is a major climate hazard for coastal areas.

Globally, a billion people are projected to be at risk from coastal-specific climate hazards in low-lying areas. One of the severe threats of coastal change is the frequency and magnitude of coastal disasters due to sea level rise. For example, an increase in the frequency and intensity of tropical cyclones and floods in low-lying flat land, such as Bangladesh, has devastated local agriculture, its activities, and put local communities at risk over the past few years.

One of UMass Boston's Grand Scholarly Challenges is on "Climate Equity and Urban Coastal Areas." It focuses on "... a clear, urgent environmental challenge that touches upon health and wellness, our economic future, and the very livelihood affecting every individual, family, and community in Boston and beyond. UMass Boston will research, design, and implement leading-edge, equitable, and restorative adaptations to ... climate change."

Artificial intelligence (AI) has the potential to address climate adaptation in vulnerable coastal communities. I am leveraging information systems (IS) and AI technologies (e.g., big data and machine learning) for novel and sustainable practices within the context of social, business, and policy domains to achieve sustainability-related objectives.

My team, consisting of current and former UMass Boston PhD students, and I are developing a coastal adaptation artifact that analyzes climate adaptation datasets, including social data from communities vulnerable to coastal hazards in the greater Boston area in the United States. This research aims to provide a more comprehensive coastal adaptation decision-making system that integrates the coastal communities' voices.

The research team thinks that unless inclusive decision-making and equitable collaboration with climate change-impacted vulnerable communities is given priority, adaptation strategies and actions can worsen social inequities. They have

An aerial view of the City of Boston. *Image by: UMass Boston Office of Communications*

identified key community stakeholders, needs, and actions and are developing a coastal resilience engine for community members and policy makers. They are incorporating AI into a flexible analytical approach to assess coastal community needs and demands from social data.

The prototype being developed captures and stores unstructured data, for example, text data from social media platforms. The collected data undergoes systematic classification using topic modeling and AI-based techniques. The classified content illustrates key climate adaptation themes that can be employed by community members or policy makers to take decisions.

The research approach can accommodate various sets of social attributes to help understand coastal risks in vulnerable communities. The outcomes of this research can help community members and policy makers understand and develop robust sustainability and climate focused decisions using a coastal resilience decision approach. The research will advance coastal adaptation research with a focus on climate justice using big data analytics and AI.

AI Ethics at UMass Boston

Nir Eisikovits, PhD
Applied Ethics Center, Director and Professor of Philosophy

Alec Stubbs, PhD
Applied Ethics Center, Postdoctoral Research Fellow 2022–24

A conversation about the Applied Ethics Center at UMass Boston.

Alec Stubbs (AS): Nir, tell me how the Applied Ethics Center (AEC) began focusing on artificial intelligence (AI) ethics.

Nir Eisikovits (NE): A few years ago, I met James Hughes, the Executive Director of the Institute for Ethics and Emerging Technologies (IEET).

James has been doing pioneering work on the ethics of cutting-edge technologies for years, first as a bioethicist and more recently with a focus on the ethics of AI. He is what we call a techno progressive—someone interested in harnessing technology for realizing socially progressive aims.

I'm a bit of a techno skeptic. We hit it off right away and had a lot of interesting conversations. We decided to start a collaboration between the IEET and UMass Boston that would explore some of the ethical challenges and opportunities that come about from increasing engagement with artificial intelligence.

As part of that process, we initiated an ambitious postdoctoral fellowship program, where each fellow would, for a period of two years, focus on a key challenge presented by AI and automation. The first fellowship, which you were hired for, Alec, was focused on automation, AI, and the future of work.

The second fellowship, which began in the fall of 2024, and for which we hired Dr. Cody Turner from the University of Connecticut, is focusing on the ethics of brain-machine interfaces, such as Neuralink.

In addition to this work mapping out the ethical challenges of AI applications, we have also written a series of policy papers, or white papers, on areas such as the influence of AI on higher education, the potential of the metaverse for work and play and the potential and risks of using chatbots for psychotherapy. Most recently James and I have started a new podcast called Prosthetic Gods, in which we debate emerging technologies – from chatbots to genetic engineering.

AS: Very cool! Tell us a little bit about your own research interests on the ethics of AI.

NE: In the last few years, my colleague, Dan Feldman, who is a senior research fellow at the center, and I have been working on an area we have framed as "AI and experience."

The question we are asking is: If you solve some of the fairness and justice questions around AI, such as concerns related to algorithmic bias, is there anything left to worry about with the technology? In other words, if the usual liberal-, democratic, distributive, justice-type concerns are put to rest, are there any worries left? Our argument has been that technology has the potential for changing key capacities and features that we value ourselves.

For example, the increased prevalence of algorithmic decision-making has the potential to undermine our capacity for everyday practical judgments—what the Greeks have called phronesis.

Also, the advent of effective and fair AI decision-making might end up undermining the philosophical grounds for human rights, all of which are intrinsically tied to our capacities for rationality and decision-making.

Of course, you and I have recently started working on a new project focused on the role of AI as a wish-fulfillment machine, meant to decrease the role of friction in our lives.

This can be seen in the rise of chatbot friendships and the use of grief-bots, as well as in the rise of generative AI, which in some areas is meant to take the drudgery out of creative endeavors.

NE: Alec, if I might ask you a question, what has your recent research on AI and the future of work been focused on? And, more broadly, how has your time with us prepared you for your next adventure, leading Northeastern University's Program in Politics, Philosophy, and Economics on the west coast?

AS: Broadly speaking, my work has focused on several key themes related to AI and the future of work. On the one hand, my research has investigated the impact of AI and automation on issues of labor justice. These technologies come with the promise of increased productivity, but we need to investigate the ways in which the structures of our economic system shape who gets access to the productive outputs. With the way things are currently organized, I worry that such technologies will simply benefit the wealthy few who have ownership over decisions at the site of production and in investment decisions. In recent years, for example, we know that the introduction of automating technologies has a downward pressure on wages due to its deskilling effects on workers.

I believe we need to move away from economic structures built on nondemocratic ownership and control. My suggestion is that we advocate for a system of economic democracy, where workers own and operate their own workplaces and where widespread investment decisions are made democratically. These kinds of structures exist already, although they are few and far between in our contemporary economy. Worker cooperatives, community land trusts, public investment banks—these are all possible solutions to our antidemocratic economy. But we need a political movement to build, back, and sustain such alternatives.

And you might be asking: what effect would these alternatives have on the AI and the future of work? Simply put, technological advances in AI and automation can have liberating effects for our working lives only if those who are directly affected by these technologies have a say over their development and implementation. Workplaces that are run democratically are much more likely to use labor-saving technologies to reduce the working week, freeing up time for community, family, exercise, education, and other things that contribute to human well-being. But

insofar as workers themselves have no say over what and how such technologies are implemented, they are more likely to be laid off, face competition from robots, or have their work devalued and deskilled without their input.

NE: And what other themes are you working on?

AS: I'm interested in these questions of economic democratization for this simple reason: I believe that our contemporary lives are so dominated by the capitalist work ethic and economic inequalities that we often miss out on the most important aspects of the good life. So for me, I also am interested in thinking about what constitutes meaningful work, what makes for meaningful leisure, and how we can envision a future world in which the right balance is struck. We know that some people find their work deeply meaningful, but only if it is relatively autonomous, allows them to develop their capabilities, gives them a sense of purpose and community, and, of course, gives them adequate access to resources that will allow them to flourish. Our current world of work provides us with very few of these things, and so part of my work is to think about finding that sweet spot where one can engage in deeply meaningful work but under circumstances in which that work does not dominate one's entire life.

NE: Where has your work taken you after your time at UMass Boston?

AS: As you mentioned, I am an assistant teaching professor at Northeastern Oakland, and I'm the program coordinator for their Politics, Philosophy, and Economics program. Our goal is to grow a program that allows students to engage in issues of economic and social justice, so it aligns perfectly with my own goals and the work I've done while here. My time at UMass Boston has been instrumental in building a strong platform to take on this kind of work. I've had the freedom to research, write, teach, and engage in public scholarship—opportunities that I would not have had elsewhere. I'm proud to have been a part of such a forward-thinking group of folks at the AEC and IEET, and I can't wait to see where it goes from here!

UMass Boston is home to dozens of interdisciplinary centers and institutes that bring faculty, students, and staff together to pursue research, teaching, and service on scholarly and social topics.

umb.edu/centers

Pension Action Center

Tyler Compton, Esq.
Director & Managing Attorney, Pension Action Center

The Pension Action Center (PAC), a nonprofit initiative within UMass Boston's Gerontology Institute, is dedicated to helping workers and retirees secure their earned retirement benefits.

Founded over 30 years ago, PAC provides free legal counseling to individuals who currently live in or have worked in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, and Illinois.

PAC's team of experienced lawyers and pension counselors help clients navigate complex pension laws and regulations. Clients receive assistance with issues such as:

- finding out if they are eligible to receive benefits
- receiving benefits after the death of a spouse
- knowing their rights when their Plan overpays them and tries to reduce their pension
- handling matters involving retirement benefits during divorce
- finding missing and lost pensions

Some clients come to PAC ahead of their retirement, and others have been retired for years, struggling to find their pensions. Typically, half of PAC's clients each year are low to moderate income. All assistance is free of charge; PAC is funded by federal and private grants and individual donations.

In addition to working directly with clients, PAC engages in educational outreach, offering informational materials, workshops, and public events to raise awareness about pension rights and fraud prevention.

Impact: Since its founding in 1994, PAC has returned more than **$72 million** to **12,000+ individuals**.

UMass Boston | **Pension Action Center**

umb.edu/pensionaction
pension@umb.edu

THE RESEARCH CORE FACILITIES AT UMASS BOSTON

Offering unparalleled in-house expertise, methodologies, and cutting-edge instrumentation to researchers from academia, industry, and government on a fee-for-service basis.

umb.edu/research/cores
orsp@umb.edu

UMass Boston

umb.edu