October 25, 2021 - October 26, 2021

Day 1: Monday, October 25, 2021
Dr. Edelman has been a central leader in the field of translational medicine. He has served on the editorial boards of numerous prestigious journals, including the Journal of the American College of Cardiology, Circulation, and the New England Journal of Medicine. He is a member of the National Academy of Medicine and the National Academy of Engineering, and has received numerous awards for his contributions to science and medicine, including the Presidential Early Career Award for Scientists and Engineers.

His research interests combine his scientific and medical training. His laboratory has earned the highest teaching honor. He completed his Electrical Engineering B.S.E. and Ph.D. degrees at Princeton University.

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Towards interventions for improving hemodynamics in single ventricle physiology patients - Benchtop, computational, and clinical models

Ellen Roche
Associate Professor, MIT Mechanical Engineering

The prevalence of single ventricle physiology is estimated to be ~1 in 3000 live births. Currently, the preferred treatment is a series of surgeries resulting in a palliative Fontan physiology. The Fontan circulation connects systemic and pulmonic circuits in series, rather than in parallel, via a surgical connection called the Fontan shunt located in the inferior vena cava (IVC). While this treatment allows patients to survive with a single ventricle, there are a myriad of deleterious effects associated with the Fontan circulation that are precipitated from the abnormal hemodynamics.

Recently, respiratory mechanics have been identified as the governing contributor to changes in Fontan flow patterns and resulting retrograde flow. Development in therapies for Fontan patients, and Fontan survival rates has stagnated over the past 20 years. While there is great interest in identifying and developing interventions for these patients, both invasive and non-invasive, the ability to explore and test potential therapies remains limited. There is no working animal model, nor are there any sophisticated in vitro or in silico models that can recreate the complex Fontan physiology. This gap in the field limits the development of therapeutic solutions.

Roche will discuss how her group builds quantitative tools that can serve as test platforms for interventions for the single ventricle physiology. Her group builds physical testbeds that allow them to quantify the effect of breathing mechanics on hemodynamics in silico, in vitro and validate them with a clinical imaging study in patients at Boston Children's Hospital. By monitoring critical hemodynamic indicators like IVC retrograde flow, hepatic venous pressure, and cardiac return, they aim to predict potentially beneficial interventions on the benchtop that can allow them to predict the impact of invasive and non-invasive interventions on this patient group.
Long-term reliable physical health monitoring by sweat pore–inspired perforated electronic skins

Jeehwan Kim
Associate Professor, MIT Mechanical Engineering

In this talk, Kim will present a sweat pore–inspired perforated e-skin that can effectively suppress sweat accumulation and allow inorganic sensors to obtain physical health information without malfunctioning. The auxetic dumbbell through-hole patterns in perforated e-skins lead to synergistic effects on physical properties including mechanical reliability, conformability, areal mass density, and adhesion to the skin. The perforated e-skin allows one to laminate onto the skin with consistent homeostasis, enabling multiple inorganic sensors on the skin to reliably monitor the wearer’s health over a period of weeks.

The challenge of measuring human motor behavior

Neville Hogan
Professor, MIT Mechanical Engineering; Professor, MIT Brian & Cognitive Sciences

Humans are supremely adaptive. That makes measurement difficult because the act of measuring may change the behavior to be measured. With a view to improving devices to treat balance disorders, we try to quantify the neuro-mechanical dynamics of upright human balance. The usual approach to dynamic system identification applies perturbations and observes their consequences, but perturbing upright balance induces humans to change how they balance (e.g. they crouch).

A solution Hogan pursued takes advantage of the noisiness (stochasticity) of the neuromotor system. Humans cannot stand perfectly still. However, the temporal fluctuations of their ground reaction force vectors are not entirely random—they exhibit surprising patterns when mapped to the frequency domain. By modeling this phenomenon Hogan successfully estimated the net multi-variable neuro-mechanical impedance (stiffness and damping) about the hip and ankle—without perturbing the subjects.

Panel Q&A

Break

Peek into research: Flexible nanoelectronic sensors to enable long-term reliable physical health monitoring

Samantha Cheung
Undergraduate Researcher
3:10 PM  
Peek into research: Towards the development of an adaptive balance rehabilitation device  
Kaymie Shiozawa  
Graduate Research Assistant

3:15 PM  
Session Introduction

3:20 PM  
Functional genomics through the microscope  
Paul Blainey  
Associate Professor, MIT Biological Engineering

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Associate Professor, MIT Biological Engineering

Paul Blainey is a core member of the Broad Institute of MIT and Harvard and an associate professor in the Department of Biological Engineering at MIT. An expert in microanalysis systems for studies of individual molecules and cells, Blainey is applying such technologies to advance understanding of functional properties of molecules and cells and the mechanisms underlying these properties. Broadly, research in the Blainey group integrates molecular, optical, microfluidic, and computational tools to understand and engineer cellular activities related to a wide range of health challenges.

Genetic screens are important life science research tools that can teach us how genetic elements in our bodies' cells relate to normal health, disease, and the way drug therapies work by checking the effects of engineered genetic changes in laboratory samples. Recently, CRISPR and other technologies have enabled screening of many genetic elements at once in ‘pooled’ formats.

Here, Blainey will present optical pooled screening — a new method of pooled genetic screening – which enables researchers to link pooled genetic ‘perturbations’ with visually observable phenotypes in human cells. This works by sequencing a tag inside each cell that identifies the genetic perturbations present. Microscopy-based readout enables genetic screens for new types of biological functions and at scales needed for comprehensive ‘genome-wide’ screens of tens or hundreds of millions of cells.

3:35 PM  
Multimodal representation learning via maximization of local mutual information  
Ruizhi (Ray) Liao  
Postdoctoral Associate, MIT Computer Science & Artificial Intelligence Lab

Liao proposes and demonstrates a representation learning approach by maximizing the mutual information between local features of images and text. The goal of this approach is to learn useful image representations by taking advantage of the rich information contained in the free text that describes the findings in the image. Liao’s method trains image and text encoders by encouraging the resulting representations to exhibit high local mutual information. He makes use of recent advances in mutual information estimation with neural network discriminators. Liao argues that the sum of local mutual information is typically a lower bound on the global mutual information. His experimental results in the downstream image classification tasks demonstrate the advantages of using local features for image-text representation learning.
Detection of low-abundance pathogens via selective electrokinetics concentration

Jongyoon Han
Professor of Electrical Engineering and Professor of Biological Engineering

Dr. Jongyoon Han is currently a professor in the Department of Electrical Engineering and Computer Science and the Department of Biological Engineering, Massachusetts Institute of Technology. He received B.S. (1992) and M.S. (1994) degree in physics from Seoul National University, Seoul, Korea, and Ph.D. degree in applied physics from Cornell University in 2001. He was a research scientist in Sandia National Laboratories (Livermore, CA), until he joined the MIT faculty in 2002. He received NSF CAREER award (2003) and Analytical Chemistry Young Innovator Award (ACS, 2009). His research is mainly focused on applying micro/nanofabrication techniques to a very diverse set of fields and industries, including biosensing, desalination/water purification, biomanufacturing, dentistry, and neuroscience. He is currently the lead PI for MIT’s participation for NIHBL (The National Institute for Innovation in Manufacturing Biopharmaceuticals).

In the diagnostics and surveillance of COVID-19 and many other pathogens, it is necessary to be able to detect the lowest abundance virus or bacterial cells, often contained in a large volume of original sample. Current sample preparation workflow is not adequate to handle this challenge, therefore limiting the lower limit of detection around ~10 copies/μL, regardless of the downstream sensing methodologies used.

In this presentation, Han will demonstrate that we can address this sample preparation challenge directly by introducing an efficient electrokinetic concentration system, which can concentrate dilute detection targets (viruses, cells, biomolecules) from a large sample volumes (~100mL) into a small volume (as small as ~10pL), achieving extremely high level of effective signal enhancement for downstream detection. This may allow direct, non-amplifying detection of the target biomolecules, which could enable rapid, real-time monitoring of various targets.

Using the system, Han has demonstrated that low abundance viral and bacterial targets below ~1CFU/ml can be concentrated and detected reliably, by collecting low abundance targets from a large volume of original sample (1~100mL). This system could impact not only the disease diagnostics and monitoring, but also the detection of adventitious agents in standard bioprocessing, which is an ongoing challenge in pharmaceutical industry.

Day 2: Tuesday, October 26, 2021
Welcoming Remarks
Brian Anthony
Associate Director, MIT.nano
Faculty Lead, Industry Immersion Program in Mechanical Engineering

Dr. Anthony has over 25 years of commercial, research, and teaching experience in product realization and information enabled manufacturing. He has extensive experience in market driven technology innovation, product realization, and business entrepreneurship and commercialization at the intersection between information technology and advanced manufacturing. His research and product development interests cross the boundaries of manufacturing and design, medical imaging, computer vision, acoustic and ultrasonic imaging, large-scale computation and simulation, optimization, metrology, autonomous systems, sensors, and robotics. His teaching interests include the modeling of large-scale systems in a wide variety of decision-making domains and the development of optimization algorithms and software for analyzing and designing such systems. He teaches on-line and on-campus professional programs in Smart Manufacturing and Sensory Systems Beyond IoT.

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Vladimir Bulovic
Director, MIT.nano
Fariborz Maseeh (1990) Chair in Emerging Technology
Professor of Electrical Engineering, MIT

Vladimir Bulovi? is a Professor of Electrical Engineering at the Massachusetts Institute of Technology, holding the Fariborz Maseeh Chair in Emerging Technology. He directs the Organic and Nanostructured Electronics Laboratory, co-leads the MIT-Eni Solar Frontiers Center, leads the Tata GridEdge program, and is the Founding Director of MIT.nano, MIT's new 200,000 sqft nano-fabrication, nano-characterization, and prototyping facility. He is an author of over 250 research articles (cited over 50,000 times and recognized as the top 1% of the most highly cited in the Web of Science). He is an inventor of over 100 U.S. patents in areas of light emitting diodes, lasers, photovoltaics, photodetectors, chemical sensors, programmable memories, and micro-electro machines, majority of which have been licensed and utilized by both start-up and multinational companies. The three start-up companies Bulovi? co-founded jointly employ over 350 people, and include Ubiquitous Energy, Inc., developing nanostructured solar technologies, Kateeva, Inc., focused on development of printed electronics, and QD Vision, Inc. (acquired in 2016) that produced quantum dot optoelectronic components. Products of these companies have been used by millions. Bulovi? was the first Associate Dean for Innovation of the School of Engineering and the Inaugural co-Director of MIT’s Innovation Initiative, which he co-led from 2013 to 2018. For his passion for teaching Bulovi? has been recognized with the MacVicar Fellowship, MIT’s highest teaching honor. He completed his Electrical Engineering B.S.E. and Ph.D. degrees at Princeton University.
12:15 PM

Presenting the MIT Center for Clinical and Translational Research

Catherine Ricciardi | DNP, ANP-BC, MIT Institute for Medical Engineering and Science
Tatiana Urman | Clinical Research Nurse Coordinator, MIT Institute for Medical Engineering and Science
Xiang (Shawn) Zhang | Postdoctoral Associate

12:20 PM

Startups: Introduction to the Sandbox
Brian Anthony
Associate Director, MIT.nano
Faculty Lead, Industry Immersion Program in Mechanical Engineering

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The Innovation Ecosystem at MIT
Vladimir Bulovic
Director, MIT.nano
Fariborz Maseeh (1990) Chair in Emerging Technology
Professor of Electrical Engineering, MIT

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Pison Technology: Neural interface gesture control for robots
Dexter Ang
Executive Chairman & Co-founder

Enabling humans to efficiently and naturally interact with robot and IoT systems will be critical to the future success and adoption of these emerging technologies. Neural interface wearables represent an advancing field of human-machine interface (HMI) technologies with the potential to overcome limitations that have previously been restrictive in these industries. For example, interacting with a smartphone while on the move, while gloves or PPE are donned, and when maintaining heads-up situational awareness causes user error and delays decision and action times. Pison's patented wearable neural interface gesture control technology allows users to quickly and accurately interact with electronic systems- e.g., indicating and sharing points of interest for robot waypoints by simply pointing and gesturing where the waypoint is desired. Gesture control expands the spectrum of when users can interact with robotic endpoints. As a result, these systems become accessible to 5x-10x more users throughout the course of a mission, allowing robots to realize their full potential as force multipliers.

Strategen Bio: Novel tissue oxygen sensors to enable personalized care
Gregory Ekchian
CEO & Co-founder
Leuko: Non-invasive at-home white blood cell monitoring

Ian Butterworth
CTO & Co-founder

Leuko is developing PointCheck, the first device to provide noninvasive neutropenia screening in the home, set to improve safety, efficacy and economics for chemotherapy. Started by Leuko’s co-founders in the MIT M+Vision/LinQ programme, since spinning out, Leuko has been developing PointCheck with the support of developmental usability and performance studies at sites including the MIT CRC, to ensure a product that meets regulatory requirements around performance and usability, and is set to make impact.

1:00 PM
Panel Q&A

1:30 PM
 Peek into research: Identifying natural human balance dynamics and control
Rika Sugimoto-Dimitrova
Graduate Research Assistant

1:35 PM
Break

1:50 PM
Session Introduction
Chronic liver diseases developing from fatty liver constitute an evolving public health problem. We strategically combine 808 nm excitation with near infrared (NIR) and shortwave infrared (SWIR) detection to reliably monitor liver injury \textit{in vivo} in mice by label-free imaging of the endogenous biomarker, lipofuscin, which is surprisingly bright under these conditions. In the NIR/SWIR optical window, tissue is rendered translucent while interfering background signals are suppressed, allowing for noninvasive imaging. As a result, we show that NIR/SWIR imaging of lipofuscin can discern pathology from normal liver processes with high specificity and high sensitivity. We monitor the longitudinal progression and regression of liver necroinflammation and fibrosis \textit{in vivo} in models of non-alcoholic fatty liver disease and advanced fibrosis. Furthermore, we show that human tissue can also be clearly distinguished as non-alcoholic steatohepatitis (NASH) or NASH-cirrhosis by lipofuscin autofluorescence in the NIR/SWIR. We develop computational methods to remove lipofuscin autofluorescence from pre-clinical and clinical tissue slices stained for immunofluorescence.
Imaging through flat fisheye lenses
Juejun (JJ) Hu
Associate Professor, Department of Materials Science & Engineering

Juejun (JJ) Hu received the B.S. degree from Tsinghua University, China, in 2004, and the Ph.D. degree from Massachusetts Institute of Technology, Cambridge, MA, USA, in 2009, both in materials science and engineering. He is currently the Merton C. Flemings Career Development Associate Professor at MIT's Department of Materials Science and Engineering. His primary research interest is enhanced photonmatter interactions in nanophotonic structures, with an emphasis on on-chip spectroscopy and chemical sensing applications using novel infrared glasses. Prior to joining MIT, he was an Assistant Professor at the University of Delaware from 2010 to 2014. Hu has authored and coauthored more than 60 refereed journal publications since 2006 and has been awarded six U.S. patents. He has been recognized with the National Science Foundation Faculty Early Career Development award, the Gerard J. Mangone Young Scholars Award, the University of Delaware College of Engineering Outstanding Junior Faculty Member, the University of Delaware Excellence in Teaching Award, among others. Dr. Hu is currently the Deputy Editor of the OSA journal Optical Materials Express, and he is a Member on technical program committees for conferences including MRS, CLEO, OSA Congress, ACerS GOMD, ICG, and others. (Based on document published on 13 September 2016)

View full bio

Wide field-of-view (FOV) optics are important for many biomedical imaging applications spanning microscopy, endoscopic imaging, and fundus photography. The traditional approach for widefield imaging entails complex optics with multiple cascaded lens elements, which significantly increases the size, weight, and cost of the system.

Here, Hu describes a lens design based on optical metasurfaces which transforms a flat piece of glass into a “fisheye” lens capable of high-quality imaging over near 180° FOV. The lens features a simple, compact architecture and can be manufactured at low cost leveraging standard Si microfabrication technologies. Hu will discuss the theory and experimental demonstration of the lens and highlight potential biomedical sensing applications of the technology.

Equivariant filters for efficient tracking in 3D imaging
Daniel Moyer
Postdoctoral Associate, MIT Computer Science & Artificial Intelligence Lab

This talk will cover our recent MICCAI 2021 paper. We demonstrate an object tracking method for 3D volumetric images with fixed computational cost and state-of-the-art performance. Previous methods predicted transformation parameters from convolutional layers. We instead propose an architecture that neither flattens convolutional features nor uses fully connected layers, but instead relies on equivariant filters to preserve transformations between inputs and outputs (e.g., rotations/translations of inputs rotate/translate outputs). The transformation is then derived in closed form from the outputs of the filters. This method is useful for applications requiring low latency, such as real-time tracking. We demonstrate our model on synthetically augmented adult brain MRI, as well as fetal brain MRI, which is the intended use-case.
3:00 PM  Peek into research: Miniaturization of a frequency domain near infrared spectroscopy (fdNIRS) Instrument
Alper Kilic
Research Assistant

3:05 PM  Session Introduction

3:10 PM  Dance-inspired investigation of human locomotor coordination
Praneeth Namburi
Research Scientist, MIT Institute for Medical Engineering and Science

Trained dancers move elegantly as a stable and coordinated whole. Even though most untrained individuals are unable to move like trained dancers, they produce coordinated movements during walking and running. Our goal is to understand which aspects of coordination generalize across locomotion and more specialized human pursuits such as dancing. Motivated by the idea that dancers represent rhythm in their body, we chose to focus on how muscles represent rhythm. In this talk, I will outline our approach to investigating how rhythm is represented in muscles, and how this can be used to better understand stability and coordination in the body.

3:25 PM  HemoSensis: A non-invasive, point-of-care device for absolute tissue and cerebral oximetry
Valencia Koomson
Visiting Associate Professor, MIT Electrical Engineering & Computer Science

Near-infrared spectroscopy (NIRS) techniques are creating pathways toward new applications to study biological tissue, including functional brain imaging, cerebral oximetry, stroke assessment, and optical mammography. NIRS methods are used to compute the concentrations of biological chromophores, such as oxygenated and deoxygenated hemoglobin, that have specific absorption spectra and indicate tissue oxygen perfusion.

Koomson will present a non-invasive device implementing frequency-domain NIRS techniques for real-time monitoring of cerebral perfusion at the point of care. In the area of pediatric neurology, this tool enables assessment of hemorrhage. The HemoSensis tool implements advanced NIRS methods in a compact form factor by employing low-power solid-state optical devices and a patented system-on-chip (SoC) platform.

Koomson will present the core technology and present system validation results. This tool advances the field of diffuse optical imaging by developing special techniques for data collection and analysis of NIRS data and enables dual-task measurements on ambulating subjects.

3:40 PM  A new ultrasound based framework for dynamic muscle functional imaging
Micha Feigin-Almon
Research Scientist, MIT Mechanical Engineering

Assessing muscle health and muscle function is essential for diagnostics of a multitude of musculoskeletal and neurological afflictions. These encompass such conditions as degenerative muscle diseases, muscle atrophy due to bed rest or neurological conditions, return to play after muscle injuries, and neurological related conditions such as traumatic brain injuries, neurological afflictions, and spasticity.

Currently, there are no imaging solutions capable of assessing muscle health and function during dynamic motion. This means that we either try to extrapolate the required information from images at rest, and/or resort to alternate methods including clinical examination, electrophysiological methods (Electromyography - EMG), and biomechanical methods. Feigin-Almon will present a novel ultrasound-based imaging solution capable of assessing muscle function in motion. To this end, he utilizes a deep-learning approach applied to pre-imaging raw ultrasound signals to recover speed of sound maps in tissue. Feigin-Almon will show that these can provide interactive, real-time, functional full-slice EMG-like images.

3:55 PM  Panel Q&A
4:15 PM  Peek into research | Acoustically-driven optical-interferometric microscope for cell characterization
Rebecca Zubajlo
Ph.D. Candidate

4:20 PM  Closing Remarks