National Health Symposium 2020

Operationalizing AI: From Innovation to Impact

September 14 & 15, 2020

Event Summary

Johns Hopkins
Applied Physics Laboratory

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ACKNOWLEDGEMENTS

We thank the symposium speakers for their insightful presentations and the participants for their thoughtful discussions. We are grateful to the APL National Health Mission Area staff members for their support of the event, including assistance with planning, graphics design, and documentation.

SAVE THE DATE 2021

The third annual National Health Symposium is scheduled for November 9–10, 2021. The symposium will bring together civilian, military, and government leaders from diverse organizations in health research to discuss the most pressing topics in the field.

Please look for updates regarding plans and logistics as the environment continues to evolve. We hope to see you there!

On September 14–15, 2020, nearly 300 civilian, military, and government leaders attended the second annual Johns Hopkins Applied Physics Laboratory (APL) National Health Symposium. The theme of the symposium was “Operationalizing Artificial Intelligence (AI) in Health.” Presenters and attendees from more than 40 organizations in health care delivery, health research, and industry shared early successes and lessons learned, and left energized by the promise of a smarter, safer, and more equitable health system.

Symposium Summary

The 2020 National Health Symposium convened leaders in health care technology to explore emerging applications of artificial intelligence (AI) across the health care continuum. The speakers discussed applications ranging from disease prevention, disease detection, case triage, and patient treatment to health monitoring. A variety of emerging AI-enabled capabilities were presented, including patient-generated data analysis, image analysis, and electronic health record embedded applications — aimed at enhancing and even automating critical aspects of clinical workflows.

The keynote addresses provided inspiration and set the tone for each day. Christine Fox, the assistant director for policy at APL, and Dr. Jim Weinstein, senior vice president of Microsoft Healthcare, emphasized the importance of collaborative and iterative system design approaches.

The symposium focused on the intersection of AI and health care, exploring the continuum from research and development through translation — from innovation to operational impact. Participants learned about real-world AI applications for health care, harnessing AI technologies to accelerate advances while attempting to “do no harm,” ensuring the safety and security of health care while realizing AI’s full potential. In the exploration of these topics, tools and techniques that participants could leverage to advance their health care capabilities were discussed.

As symposium participants considered the challenges of this new frontier in health, three themes emerged: develop thoughtfully; go beyond algorithms to create systems; and don’t overpromise.

Develop Thoughtfully.

Technology is ultimately about people. The health care community must ensure that the advancement of technology is aligned with our goals for human society and prioritize the role of people in every part of the technology lifecycle. Introduced by Christine Fox in her keynote address, the charge to "develop thoughtfully" was echoed throughout subsequent presentations. Fox defined this approach as one where scientists and engineers pursue the rewards of advanced technologies while anticipating and mitigating potential risks. To illustrate potential mitigation strategies, Fox referenced the introduction of cyber security requirements during the initial technology design phase rather than adding them retrospectively. Carefully identifying and controlling for sources of bias in data and algorithms was another key theme.

The thoughtful development of AI will also require new approaches to policy, ethics, and governance. Technology development is challenging; however, many implementation obstacles tend to be non-technical and are centered on creating organizational structures to ensure compliance and accountability. Speakers addressed open questions in this area, including: When can data be shared without compromising privacy? Will AI introduce errors and biases that degrade the standard of care or cause inconsistent application across populations? If something goes wrong, who's to blame? To realize AI's potential in clinical practice, challenges must be addressed during development and before implementation. M. Khair ElZarrad reinforced that, in addition to the technical milestones, policy and ethics infrastructure relevant to AI must be developed and translated into actionable frameworks and processes in order to scale innovation. Many speakers also discussed ways their organizations are integrating ethical review of AI applications and agreed with Efthimios Parasidis that "legal requirements are the floor and not the ceiling" of AI stewardship.

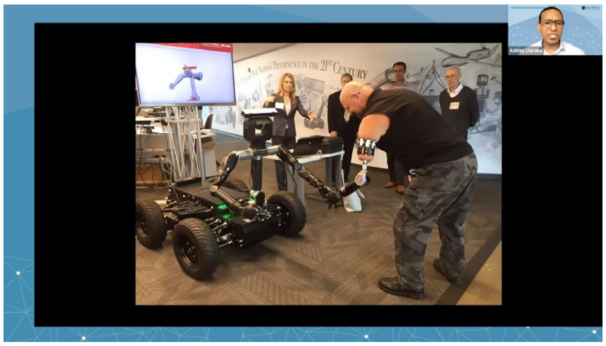
Christine Fox, Assistant Director for Policy and Analysis,
Johns Hopkins Applied Physics Laboratory

AI is emerging as a transformational force in health care, but there are obstacles to realizing its full potential. During the question and answer session following her talk, Fox also addressed organizational challenges to adoption of health technologies, including decentralized decision-making. In her DoD experiences, she found acceptance of innovation to require a "combination of cajoling, inspiring, and directing. And it's going to have to be inspiring in health because there is less directing." Ultimately, with careful incorporation of users and stakeholders into the process she encouraged, "Once people see it, they won't go back."

Go Beyond Algorithms: Create Systems.

Successfully applying AI to health requires creating systems, not just algorithms, and discussions at the symposium returned to this frequently. A component-level view of AI, such as an individual neural network, can lead to poor or unanticipated outcomes.

Ashley Llorens advocated for a focus on developing intelligent systems where machines are "empowered by AI to act on our behalf [and] be our agent, [...] always part of a human-machine team."



The panelists and presenters offered multiple examples of AI enhancing human workflows. The proliferation of health analytics illustrated that machines may outperform humans in recognizing complex patterns in data, such as laboratory and imaging results. For example, Fred Streitz described how cancer researchers use high-performance computing to iteratively explore the distribution of mutated proteins on multiple scales of size and time simultaneously, as well as with precision down to microseconds and nanometers. Others shared how AI components aid us by evaluating a vast space of possible actions, such as complex treatment decisions, and recommending the one that best achieves our goals. In some cases, machines act to perform health-related tasks like image-guided robotic interventions with improved speed and accuracy. Mathias Unberath gave a powerful example of how this can improve health outcomes, applying quantitative imaging approaches in which AI autonomously adjusts intraoperative imaging to improve quality of screw placement during sensitive spinal fusion procedures. And to have impact, discussions returned to the fact that all machines must integrate into overarching workflows and ecosystems in this way.

Don't Overpromise.

A third emerging theme cautioned technology developers to ensure transparency for opportunities and risks, safety and security, explainability, application validation, and information assurance. Dr. Jim Weinstein reminded the group to keep an important multi-part question at the forefront: "Are we making things better, by what measures, and for whom?" A broad survey of existing AI applications recently launched was on display across both days of the symposium; however, presenters shared their challenges to assure net impact is positive and measureable. While AI can help manage variation among a heterogeneous panel of patients, classifiers and algorithms are often trained on specialized populations and therefore may not extrapolate well to broader population health conclusions.

The critical challenge of properly calibrating trust in AI-enabled systems was prevalent throughout both days. Fox discussed ways in which unbalanced data and bias in analytics could lead to poor outcomes for large subpopulations. In the pursuit of precision medicine, subpopulations can differ across communities, and algorithms can reflect the bias of those training them. Cynthia Rudin cautioned against overreliance on black box models for high-stakes decisions because they may be misleading. As an alternative, she shared some examples of interpretable machine learning (ML) models with accompanying explanations that are faithful to what the model actually computes. Visibility into the variables driving the ML models helps to build trust with the physicians using them, as well as non-physician stakeholders and patients themselves.

Beyond overgeneralizing results and applicability, Weinstein summarized community concerns for risks of ML algorithms encoding racial bias and AI exacerbating current health inequities as an unintended consequence of hasty implementation. Many other speakers chimed in on this challenge extending to the integration of education to traditional health providers. Weinstein raised the suggestion of a revised Hippocratic Oath for AI Practitioners saying, "It's a different space that we didn't learn about in medical school."

Another gap area frequently discussed was data validity and integrity. Dr. Oscar Marroquin was among those who recommended robust investments in non-obtrusive data collection and related analytical infrastructure, emphasizing that it is important to know and advertise both the strengths and weaknesses of the data assets involved. Approaches like these mitigate exaggeration of proven capabilities and overly hasty deployment of these tools. As Dr. Peter McCaffrey reminded the group, biases and imperfections may persist in these applications for quite some time, but "you are always just acceptably deployed," and it requires a perspective of continuous improvement, as a "work in progress, in perpetuity."

Conclusions

On balance, the contributions from symposium presenters supported an optimistic view that human knowledge and AI can be effectively combined to enhance health outcomes if we develop solutions thoughtfully and take a systems approach. Participants were offered frameworks and strategies for expanding the art of the possible while responsibly operationalizing AI. The symposium reinforced the need for this health research community to continue to connect and communicate across disciplines and organizational boundaries to advance human health through AI-enabled intelligent systems.

Videos of the Keynotes, Technical Talks, and Panel Discussions are available by clicking on the titles below:

Sept. 14 Keynote Address: Christine Fox [LINK]

Sept. 14 Technical Talk: Achieving Thought-Based Control of a Prosthetic Limb [LINK]

Sept. 14 Panel Discussion: Unlocking the Power of AI for Health Care [LINK]

Sept. 15 Keynote Address: Jim Weinstein [LINK]

Sept. 15 Technical Talk: Medical Machine Learning in Difficult Clinical Settings with Biased/Unbalanced/Limited Data [LINK]

Sept. 15 Panel Discussion: Ensuring Responsible Implementation of AI in Health Care [LINK]

AGENDA

Date: Sept. 14, 2020

Location:	Online via ZoomGov
1:00–1:10 p.m.	Welcome and Introductory Remarks Sezin Palmer, Mission Area Executive, National Health Mission Area, Johns Hopkins Applied Physics Laboratory
1:10–1:45 p.m.	Keynote Address Christine Fox, Assistant Director for Policy and Analysis, Johns Hopkins Applied Physics Laboratory Keynote Discussion Moderated by Adam Cohen, M.D., Army Medical Response Program Manager, Johns Hopkins Applied Physics Laboratory
1:45–1:50 p.m.	Technical Talk: Achieving Thought-Based Control of a Prosthetic Limb Francesco Tenore Ph.D., Luke Osborn Ph.D., and Matthew Fifer Ph.D., Johns Hopkins Applied Physics Laboratory
1:50–3:20 p.m.	Panel: Unlocking the Power of AI for Health Care Led by Ashley Llorens, Chief, Intelligent Systems Center, Johns Hopkins Applied Physics Laboratory Peter McCaffrey, M.D., Chief Technology Officer/Co-founder, VastBiome Fred Streitz, Ph.D., Chief Science Advisor, Artificial Intelligence and Technology Office, U.S. Department of Energy Mathias Unberath, Ph.D., Assistant Professor, Department of Computer Science, Johns Hopkins University Cynthia Rudin, Ph.D., Professor of Computer Science, Electrical and Computer Engineering and Statistical Science Principal Investigator, Prediction Analysis Lab, Duke University

3:20–3:25 p.m. Closing Remarks

3:25–3:30 p.m. 5-Minute Break

3:30–4:30 p.m. Demo and Poster Session: Unlocking the Power of AI for Health Care

	ROOM 1 Moderator: Ashley Llorens	ROOM 2 Moderator: Adam Cohen	ROOM 3 Moderator: Erin Hahn
3:30–3:45 p.m.	Bioinspired Touch Sensor for Intelligent Robots in Health Care (Luke Osborn, Ph.D. and Jared Wormley, APL)	Technology for Automated Feedback on Intraoperative Surgical Care (S. Swaroop Vedula, Ph.D., JHU)	Concept for Real-time Feedback to Prevent Overuse Injuries of the Human Musculoskeletal System (Connor Pyles, APL)
3:45–4:00 p.m.	Uncovering Novel Patterns in Ovarian Cancer Using Tensor Decomposition Methods (Anna Konstorum, Ph.D., UCHC)	Butterfly Lung Ultrasound (Gioel Molinari, Butterfly)	Statistical Shape Atlases for Population-Level Human Anatomical Modeling and Applications (Nathan Drenkow, APL)
4:00–4:15 p.m.	PINE: PMAP Interface for NLP Experimentation (Brant Chee, Ph.D., APL)	Environmental Localization and Guidance for Visual Prosthesis Users (Seth Billings, Ph.D., APL)	Telehealth for Intubation (Nick Dalesio, M.D., Johns Hopkins Medicine)
4:15–4:30 p.m.	Virtual and Robotic Medic Assistants for Rapid Injury Response (David Handelman, Ph.D., APL)	A Data-Driven Framework for Identifying Intensive Care Unit Admissions Colonized with Multidrug-Resistant Organisms (Çağlar Çağlayan, Ph.D., APL)	Remote Sensing for Humanitarian AI (Ryan Mukherjee and Gordon Christie, Ph.D., APL)

Date: Sept. 15, 2020

Location:	Online via ZoomGov
1:00–1:10 p.m.	Welcome and Introductory Remarks Sezin Palmer, Mission Area Executive, National Health Mission Area Johns Hopkins Applied Physics Laboratory
1:10–1:45 p.m.	Keynote Address Jim Weinstein, D.O., Senior Vice President, Microsoft Healthcare Keynote Discussion Moderated by Adam Cohen, M.D., Army Medical Response Program Manager, Johns Hopkins Applied Physics Laboratory
1:45–1:50 p.m.	Technical Talk: Medical Machine Learning in Difficult Clinical Settings with Biased/Unbalanced/Limited Data Philippe Burlina, Ph.D., Johns Hopkins Applied Physics Laboratory
1:50–3:20 p.m.	Panel: Ensuring Responsible Implementation of AI in Health Care Led by Erin Hahn, Group Supervisor, Concepts and Assessments, Johns Hopkins Applied Physics Laboratory Efthimios Parasidis, Professor of Law and Public Health, Moritz College of Law and the College of Public Health, Ohio State University Oscar C. Marroquin, M.D., FACC, Chief Healthcare Data and Analytics Officer, University of Pittsburgh Medical Center, Associate Professor of Medicine, Epidemiology, and Clinical and Translational Science M. Khair ElZarrad, Ph.D., MPH, Deputy Director of the Office of Medical Policy, Center for Drug Evaluation and Research, U.S. Food and Drug Administration

3:20–3:25 p.m. Closing Remarks

3:25–3:30 p.m. 5-Minute Break

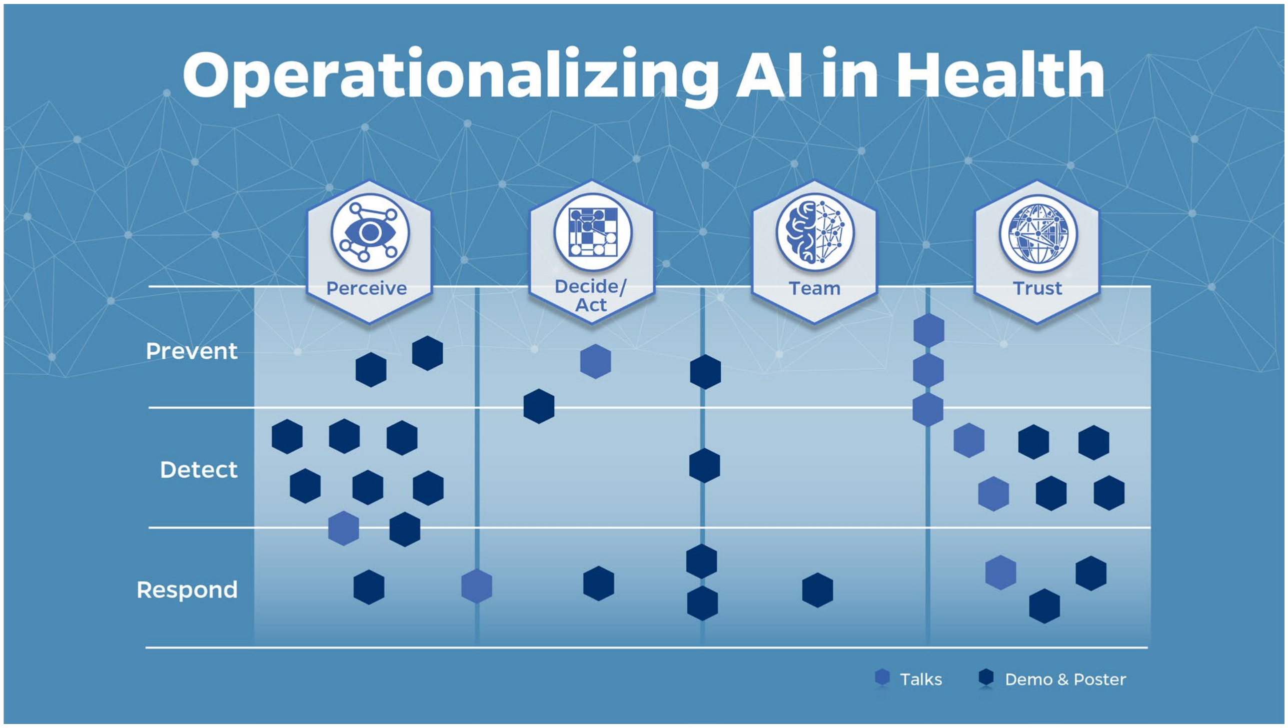
3:30–4:30 p.m. Demo and Poster Session: Ensuring Responsible Implementation and Explaining the Performance of AI in Health Care

	ROOM 1 Moderator: Ashley Llorens	ROOM 2 Moderator: Adam Cohen	ROOM 3 Moderator: Erin Hahn
3:30–3:45 p.m.	Guidance and Tools to Build Regulatory Research Environment Using Data and AI (Bill Campman and John Brown, Microsoft)	Autonomous Data Operations for COVID-19 Dashboard (Tamara Goyea, Ph.D., Ryan Lau, and Tim Ng, APL)	Newton: A Fairness Case Approach for Justified Confidence in Health Care Machine Learning (Chuck Howell, Mitre)
3:45–4:00 p.m.	Towards Benchmarking Intelligent Algorithms Against Existing Medical Device Alarms (David O. Nahmias, Ph.D., FDA)	APL Active Sensing Testbed (Lee Stearns, Ph.D., Mary Luongo, and Neil Fendely, APL)	Big Data Neuroscience and Applications to Health Care (Will Gray-Roncal, Ph.D., APL)
4:00–4:15 p.m.	Data-Driven Predictive Analytics (Hannah Cowley, APL)	Intelligent Unmanned Systems to Address Health Care Delivery in Challenged Environments (Bob Chalmers, APL)	Nanoscale Connectomics for Robust, Adaptable AI (Erik Johnson, Ph.D., APL)

Operationalizing AI in Health Framework

At the beginning of the symposium, event organizers presented a framework to consider the topics covered to guide the exploration of operationalizing AI. The “Operationalizing AI in Health Framework” organizes the symposium content across Health Applications and AI Capabilities continuums to contextualize the breadth of how artificial intelligence can be applied to health care.

The framework is illustrated below and described in more detail on the following page. Health Applications are considered for **Prevent**, **Detect** and **Respond**. How intelligent systems contribute to these Health Applications is considered for AI Capabilities **Perceive**, **Decide**, **Act**, **Team** and **Trust**. A streamlined mapping of symposium talks to the framework, presented below, shows the representation of content over the two days across these continuums.



Health Applications

This symposium considered applications to AI-powered health, including: **Prevent**, **Detect**, and **Respond**. **Prevent** refers to predicting the risk of specific health events and taking action to keep the events from happening.[1] **Detect** refers to the identification of a health event or diagnosis of a health condition.[1] **Respond** refers to health courses of action or interventions.[1] Examples of the application of AI to health for **predict**, **detect**, and **respond** in a typical clinical setting may include recommendations for lifestyle choices optimized for an individual, or triage and risk assessment upon hospital admission, including the prediction of specific events, precision diagnosis at initial onset of disease, and selection of clinical courses of action relevant to the patient's context with forecasted outcomes. We can extend these applications to more austere environments: consider a natural disaster scenario in which AI can **prevent** negative health outcomes by providing early warning and informing evacuation strategies, **detect** escalation with near-immediate identification of subsequent events such as fires or floods, and ultimately **respond** with guided or autonomous rescue.

1. Matheny, M., S. Thadaney Israni, M. Ahmed, and D. Whicher, Editors. 2019. Artificial Intelligence in Health Care: The Hope, the Hype, the Promise, the Peril. NAM Special Publication. Washington, DC: National Academy of Medicine.

AI Capabilities

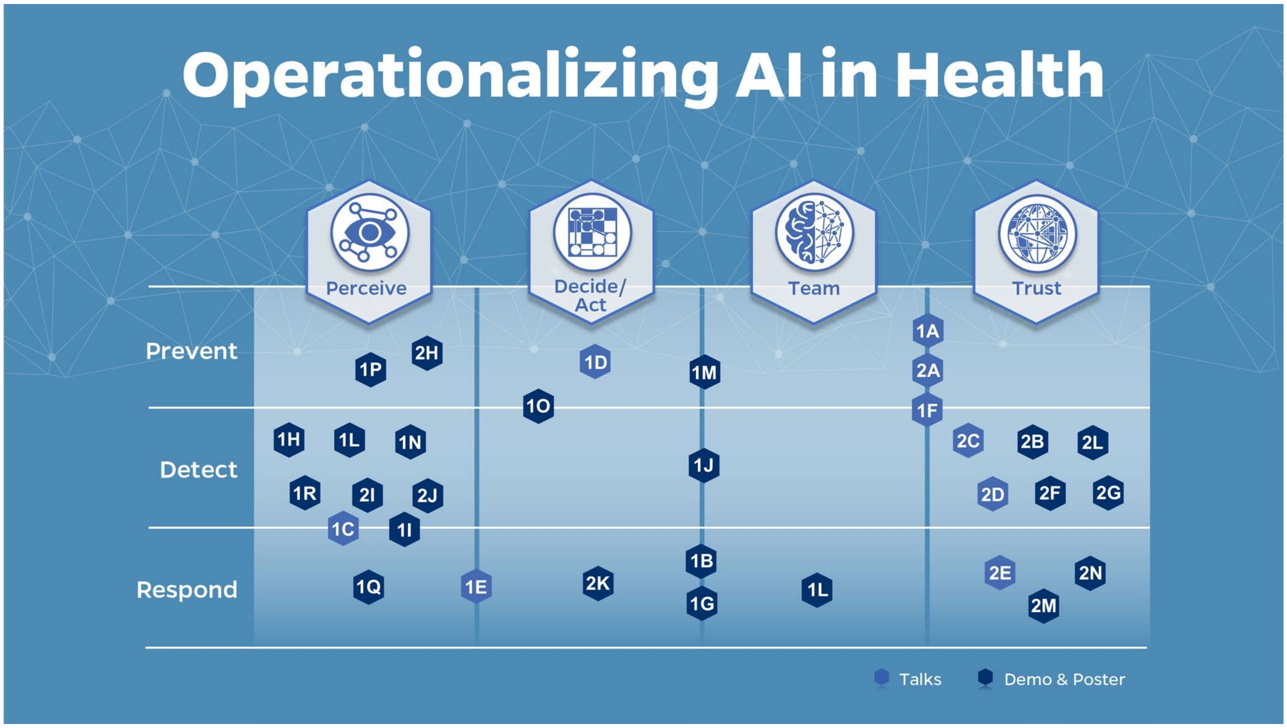
AI gives machines the ability to perform actions considered intelligent when humans do them, such as recognizing objects in images, interacting through speech, or autonomously achieving complex goals. For the purposes of this symposium, an **intelligent system** is an agent that has the ability to **perceive** its environment, **decide** upon a course of action, **act** within a framework of acceptable actions, and **team** with humans and other agents to accomplish a human-specified mission. In addition to these qualities, humans must be able to **trust** that the AI agent will achieve its objectives.

Perceive its environment: AI will help predict, detect, and diagnose clinically significant deviations from a healthy baseline in individuals and populations. Driven by a diverse set of data, and combined with medical research, AI will help researchers discover new indicators and provide efficient detection of changes to individual and population health. **Decide** on a course of action: AI will be able to identify a range of options to respond to the perceived environment, supported by data-informed predictions of application-specific efficacy and risk. In some cases, these options can be automatically acted on to make a preventative adjustment or provide immediate care anywhere. **Act** within a framework of acceptable actions: In some cases, AI will assist individuals and providers with health and disease tracking, as well as care reinforcement and feedback. AI will team with providers to combine data-driven insights with human intuition and empathy to provide the best available courses of care. **Team** with humans and other agents to accomplish a human-specified mission. Adaptive human-robotic teams will provide robotic medical and surgical assistance. Brain-computer interfaces will combine man and machine to teleoperate prosthetics and enhance vision to provide amputees and those that are vision impaired capabilities once thought impossible. Achieve its objectives with an appropriate level of **Trust**. The long-established expectation in medicine that something be "trusted, proven, and approved" will apply to AI as well. Clinicians and patients will need to have confidence in the advice provided, and autonomous interventions will require regulatory approval. New standards and practices are needed for health AI.

SUMMARY OF PRESENTATIONS

The content presented at this symposium has been summarized for ease of future reference.

Each keynote, presentation, demonstration, and poster discussion has been assigned an alphanumeric code and plotted within the AI in Health Framework in alignment with the Health Applications and AI Capabilities it addressed. A graphic of that mapping and short text summaries are provided here.



1A: "Operationalizing AI for Health Care," Keynote (Christine Fox, Johns Hopkins Applied Physics Laboratory)

Artificial intelligence is one of the most exciting aspects of health care research today, inextricably linking people (through their personal health) and math. Innovation in this space can be directed with bold envisioned futures in which health care is available everywhere, health interventions are precise and proactive, and health threats are preempted. These powerful visions are much needed as shifting population demographics, priorities, and distribution of health knowledge and resources exacerbate current gaps. AI enables realization of those visions through levers such as telemedicine, precision health, wearables, and new methods for data and pattern analysis. The introduction of AI also presents risks to privacy, security, health disparities, and bias. We must "develop thoughtfully" — to go full speed after the "good" while anticipating the "bad" that could happen and building in mitigations. This will involve requirement-driven thinking, risk management, and partnership with clinicians and subject matter expert communities within health and health care. To get this right — and it is essential that we do — operationalizing AI for health must be aligned with our vision *and* our values.

1B: "Achieving Thought-Based Control of a Prosthetic Limb," (Francesco Tenore, Ph.D., Luke Osborn, Ph.D., and Matthew Fifer, Ph.D., Johns Hopkins Applied Physics Laboratory)

Researchers at APL have developed state-of-the-art robotic systems and advanced ML techniques that have pushed the boundaries of what is possible. Using signals from the body and brain, individuals who have lost their limbs or suffered spinal cord injuries are now able to regain function and independence.

1C: "Overcoming Data Scarcity," (Peter McCaffrey, M.D., VastBiome)

Despite a popular perception that health care AI leverages nearly unbounded datasets, developing health care AI is often limited by a lack of sufficiently large sample sizes or a lack of samples that are similar enough to the problem at hand to be useful for training. An example of this phenomenon from genomics showed that, despite the large size of genomes, many studies actually have few samples. McCaffrey discussed the "virtuous cycle" in health care AI wherein models can be matched to data generation or collection platforms to help address issues of data scarcity.

1D: "Machine Learning and Predictive Simulations: Towards Predictive Biology with AI and High Performance Computing," (Fred Streitz, Ph.D., U.S. Department of Energy)

The marriage of experimental science with simulation has been a fruitful one. The fusion of high-performance computing (HPC)-based simulation and experimentation moves science forward faster than either discipline alone by enabling rapid hypothesis testing and identification of promising directions for future research. The emergence of ML at scale is bringing a new type of thinking into the mix, incorporating data analytics techniques alongside traditional HPC to accompany experiment. Streitz discussed the convergence of ML, predictive simulation, and experiment in the context of one element of the U.S. Cancer Moonshot — a detailed investigation of the RAS protein, mutations of which are responsible for many human cancers.

1E: "Towards Patient-Specific Imaging to Advance Clinical Decision Making," (Mathias Unberath, Ph.D., Johns Hopkins University)

Medical imaging modalities combined with powerful image processing algorithms are emerging as an essential component of clinical routine to enable effective triage or guide minimally invasive treatment. Unberath highlighted how recent advances in computer vision, including leaps in ML, enable patient-specific image acquisition to better inform clinical decision making.

1F: "Interpretable Machine Learning for Health Care," (Cynthia Rudin, Ph.D., Duke University)

With widespread use of ML, there have been serious societal consequences from using black box models for high-stakes decisions. Explanations for black box models are unreliable and can be misleading. Interpretable ML models come with their own explanations, which are faithful to what the model actually computes. Rudin provided examples of interpretable ML in health, including the 2HELPS2B model for predicting seizures in critically ill patients and interpretable neural networks for computer vision for the analysis of mammograms.

1G: "Bioinspired Touch Sensor for Intelligent Robots in Health Care," (Luke Osborn, Ph.D., and Jared Wormley, Johns Hopkins Applied Physics Laboratory)

As robotic manipulators become more dexterous and functional, providing the sense of touch becomes critical for enabling advanced systems such as prosthetic limbs and robotic medical assistants. Flexible materials are used to make an artificial electronic dermis (e-dermis) that conforms to robotic manipulators for capturing tactile information, which can be used as input to ML-based algorithms. Recently, the e-dermis was integrated with intelligent robotic systems for health care applications.

1H: "Uncovering Novel Patterns in Ovarian Cancer Using Tensor Decomposition Methods," (Anna Konstorum, Ph.D., University of Connecticut Health Center)

Ovarian cancer (OVC) is the most lethal of gynecological malignancies, with a 5-year survival rate of ~45%. High-grade serous ovarian cancer (HGSOC) is the most common and the deadliest subtype of OVC, and it has also been recognized as a highly heterogeneous disease, thereby requiring novel methods to categorize and classify the malignancy for differential treatment planning. The unfolding "omics" era provides clinicians and researchers unprecedented opportunity to probe tumors using genetic and epigenetic information, and can help lead the way to improve personalized treatment planning. Nevertheless, there exists a major challenge in the field regarding how to efficiently, and with maximal information retrieval, synthesize different omics datasets. This presentation summarized work that employed the technology of tensor decompositions to simultaneously incorporate multi-omics clinical data, including RNA-Seq gene expression and copy number variation, to detect novel patterns and distinguishing features of HGSOC. Konstorum showed that this approach holds potential to forward multi-omics integration of patient data for stratification and treatment planning.

1I: "PINE: PMAP Interface for NLP Experimentation," (Brant Chee, Ph.D., Johns Hopkins Applied Physics Laboratory)

This session provided a demonstration of tooling to facilitate natural language processing (NLP) developed for the Precision Medicine Analytics Platform (PMAP), a joint program between APL and Johns Hopkins Medicine. PINE is a collaborative annotation environment for document and named entity recognition labeling. PINE provides an extensible architecture supporting various NLP libraries and pluggable active learning ranking functions.

1J: "Virtual and Robotic Medic Assistants for Rapid Injury Response," (David Handelman, Ph.D., Johns Hopkins Applied Physics Laboratory)

Advances in robotics, AI, and human-machine teaming hold the potential to significantly augment the capabilities of medics. Objectives include enabling a lightly-trained medic to perform procedures that would otherwise exceed their expertise and extending the golden hour to accommodate difficult evacuation scenarios. Handelman presented concepts and on-going APL research that intend to serve as stepping stones to competent and trusted virtual and robotic medic assistants.

1K: "Technology for Automated Feedback on Intraoperative Surgical Care," (S. Swaroop Vedula, Ph.D., Johns Hopkins Applied Physics Laboratory)

This presentation summarized novel efforts to minimize error and improve care in the operating room through technology for automated feedback for surgeons. Preventing complications from surgical errors in the operating room is estimated to lead to reduction of up to 41,846 readmissions and save $620.3 million per year. Most surgical errors in the operating room are related to technical and cognitive skill deficiencies. Based upon the hypothesis that videos of the surgical field contain information on surgeons' skill and offer specific pertinent feedback to support improvement in care, this work produced algorithms to classify pre-segmented videos of cataract surgical procedures into constituent phases and an assessment of task-specific technical skill for capsulorhexis as well as global technical skill together with corresponding feedback. Vedula also introduced ongoing research.

1L: "Butterfly Lung Ultrasound," (Gioel Molinari, Butterfly Network, Inc.)

Butterfly is working at the intersection of ultrasound and innovative hardware technology and AI to make it easier and more reliable to stratify COVID-19 patients by lung ultrasound. Lung ultrasound is a new technology that has emerged over this year as European physicians started adopting it for stratification of patients as they were coming into care settings. There have been improvements in the quantity of patients that can be screened, as well as cost savings. A lung ultrasound makes it easy to identify the lung wetness associated with an infection such as that which happens with COVID. During a simple one- to two-minute examination, physicians can now stratify and determine whether a patient has a severe lung infection and needs to be admitted or if they can be treated at home. This technology is being used around the world; it is easy to use and can be brought to patients at point of care, at home, or at a clinical setting.

1M: "Environmental Localization and Guidance for Visual Prosthesis Users," (Seth Billings, Ph.D., Johns Hopkins Applied Physics Laboratory)

Under NIH funding, APL is working with the Wilmer Eye Institute and Carnegie Mellon University to enhance the Argus II retinal prosthesis, which consists of a head-mounted camera, an electrode array, and a vision processing system. Researchers are leveraging the latest advances in sensors, processing, and computer vision algorithms to integrate an autonomous navigational aid that supports volitional action for independent navigation with minimal cognitive load.

1N: "A Data-Driven Framework for Identifying Intensive Care Unit Admissions Colonized with Multidrug-Resistant Organisms," (Çağlar Çağlayan, Ph.D., Johns Hopkins Applied Physics Laboratory)

Leveraging electronic health care records, this presentation summarized a data-driven framework to predict colonization of multidrug-resistant organisms (MDRO), such as Methicillin-resistant Staphylococcus aureus (MRSA), Vancomycin-resistant Enterococci (VRE), and Carbapenem-resistant Enterobacteriaceae (CRE) upon admission to an intensive care unit (ICU). It also identified associated socio-demographic and clinical factors using logistic regression (LR), random forest (RF), and XGBoost algorithms. The sensitivity and specificity of the best performing models was: 80% and 66% for VRE with LR, 73% and 77% for CRE with XGBoost, 76% and 59% for MRSA with RF, and 82% and 83% for MDRO (i.e., VRE or CRE or MRSA) with RF. Additionally, this work found several predictors of MDRO colonization, including long-term care facility exposure, current diagnosis of skin/subcutaneous tissue or infectious/parasitic disease, and recent isolation precaution procedures before ICU admission.

1O: "Concept for Real-time Feedback to Prevent Overuse Injuries of the Human Musculoskeletal System," (Connor Pyles, Johns Hopkins Applied Physics Laboratory)

Overuse injuries to the human musculoskeletal (MSK) system are prevalent in the military and other physically demanding jobs. A concept was proposed for providing quantitative biomechanical feedback (e.g., stress fracture probability, fatigue state, gait characteristics) to operators in real-time by using a ML approach to predict these factors from raw wearable sensor data, using a validated non-deterministic MSK model to provide training and validation data. Pyles shared details about the MSK model development and validation and provided a conceptual overview for the real-time feedback framework.

1P: "Statistical Shape Atlases for Population-Level Human Anatomical Modeling and Applications," (Nathan Drenkow, Johns Hopkins Applied Physics Laboratory)

The inherent variability of human anatomy precludes the use of average or individual geometries when developing population-representative human models. For the purpose of human modeling for injury prediction or medical training, models must ideally account for internal differences that exist because of patient demographics (e.g., race, age, gender) and/or external physical anthropometry (e.g., height, weight). Statistical shape atlases for a variety of anatomical structures have been successfully developed and used in applications ranging from population-level studies to finite element modeling and simulation.

1Q: "Expert Telepresence to Optimize Patient Care," (Nick Dalesio, M.D., Johns Hopkins Medicine)

Technologies in development by Johns Hopkins Medicine clinicians and researchers have facilitated patient care during the existing COVID crisis and beyond. Current projects include expanding technology, augmented reality, and AI to improve physician efficiency and overall patient care. Ongoing projects include creating wearable technology for patient transport, teaching computers normal airway anatomy, and providing mobile, hands-free, live-streaming platforms for on-demand medical consultations between frontline health care workers and remote experts. Although COVID has been very difficult to navigate, technologies developed within this pandemic will significantly improve health care in the future.

1R: "Remote Sensing for Humanitarian AI," (Ryan Mukherjee and Gordon Christie, Ph.D., Johns Hopkins Applied Physics Laboratory)

AI combined with remote sensing has unlocked new possibilities for the humanitarian sector. Two APL efforts were detailed in this session: (1) the training and deployment of models to map flooding and damaged buildings in post-disaster scenes for first responders and (2) automated analysis of displacement camps (e.g., population estimation) to help with longer-term consequences.

2A: "Don't Overpromise," Keynote (Jim Weinstein, D.O., Microsoft Healthcare)

AI efforts in clinical applications have received much attention and at times have led to over-projecting, or even over-promising, what AI can do. Many factors weave into the successful design and implementation of AI clinical applications. How does variation in patients and their care impact AI design and implementation? Why are measures to promote security and trust paramount in AI applications for health care? There are a few AI applications that have been launched into the health care environment; however, work remains to fully deliver on the outcomes that providers, payers, and patients are hoping for.

2B: "Medical Machine Learning in Difficult Clinical Settings with Biased/Unbalanced/Limited Data," (Phillipe Burlina, Ph.D., Johns Hopkins Applied Physics Laboratory)

Researchers from APL and collaborators at the Johns Hopkins School of Medicine have developed image analysis and ML tools to detect age-related macular degeneration, a condition that causes lesions on the part of the eye called the retina. Burlina discussed issues that are important for deploying AI-based retinal analytics, including bias in AI, learning with very little training data, and issues of privacy in AI.

2C "Ensuring Responsible Implementation of AI in Health Care," (Efthimios Parasidis, The Ohio State University)

The integration of AI in FDA-regulated products is well underway, and Parasidis discussed some powerful use cases. For example, Electronic Health Record-integrated control arms of clinical trials can significantly increase the power of studies of rare diseases and enable virtual cohort participation. In thinking about how best to ensure responsible use of these technologies, the community must develop and adhere to ethical principles that move beyond legal requirements. There are well-documented limitations of HIPAA jurisdiction; to fill these gaps, institutions should be thinking about formal implementation of rigorous ethics review within and across organizations. One incarnation may be data ethics officers and committees. Historically, institutional review boards (IRBs) conduct ethics reviews in alignment with legal requirements and guidelines originally developed for studies of in-person clinical trials and primary data collection and use only. Parasidis discussed his experience as an inaugural member of the first-of-its-kind clinical data science IRB led by the National Heart, Lung, and Blood Institute at NIH, which conducts robust ethical reviews of secondary data use proposals and is concerned with new challenges such as triangulation of de-identified data and use of data sources outside the scope of HIPAA law.

2D "Ensuring Responsible Implementation of AI in Health Care," (Oscar Marroquin, M.D., FACC, University of Pittsburgh Medical Center)

This presentation summarized principles employed in the systematic development of a growing toolkit that enables clinicians to more powerfully use the data in Electronic Medical Records to augment their work and decisions. Naturally, there is a prerequisite for quantity and availability of data, but the quality of those data assets needs to be understood and accepted to support trust in derived models. Additionally, infrastructure needs to be in place to apply the insights derived from ML and other analyses responsibly. A "bottom-up" approach that incorporates early and frequent engagement of all categories of users and stakeholders to build transparency, and ultimately trust, is recommended. A learning health system is created via a closed loop continuum of clinical care, health care specific analytics, applied ML, and data-driven clinical program development. When this loop is supported with thoughtful oversight and governance, clinicians can understand and willingly use AI models as a guide and enablement (but not a replacement) for their human capabilities and teammates.

2E "Therapeutic Development in the Age of Exponential Technologies," (M. Khair ElZarrad, Ph.D., MPH, U.S. Food and Drug Administration)

Exponential technologies are those that enable change at a rapidly accelerating, nonlinear pace facilitated by substantial progress (and cost reduction) in areas such as computer power, bandwidth, and data storage. To reap the rewards of this potential, innovation is needed, particularly around randomized clinical trials. The current trial methodologies, which are the bedrock of intervention development and approval, take 10–15 years to launch a new therapeutic asset, and clinical development is costly. The regulatory ecosystem is quite complex and evolving; advanced analytics, including AI, are improving the collection of real-world data from various sources and formats and the conversion of data into reliable evidence. An important area of AI-enabled innovation is AI-supported clinical trial design, allowing decentralization of studies. These new study designs are characterized by decreased reliance on intermediary data entry and physical location of the participants, early identification and incorporation of biomarkers, and cohort management strategies, including recruitment and retention. The community needs frameworks and processes that support these new methods; the regulatory space is very active right now with development and publication of guidelines for benchmarking, interface, transparency, and documentation across the translation spectrum.

2F "Guidance and Tools to Build a Regulatory Research Environment Using Data and AI," (Bill Campman and John Brown, Microsoft)

Data and AI are the keys to unlocking scientific discoveries that will lead to accelerated medical therapies. This session offered guidance on how to build a secure research environment that meets today's regulatory compliance and provide researchers with scalable AI tools in the cloud and the architecture for their data models.

2G "Towards Benchmarking Intelligent Algorithms Against Existing Medical Device Alarms," (David O. Nahmias, Ph.D., U. S. Food and Drug Administration)

Current patient monitoring is known to have high false-alarm rates leading to alarm fatigue as well as a lack of interpretive and predictive functionality about a patient's clinical condition. Intelligent medical device algorithms that analyze physiologic data from multiple sources, using AI techniques from look-up tables to deep learning models, are being developed. These systems have the potential to identify and minimize false alarms while enabling predictive alarms about future physiologic events. The former raises risks about missing critical events, and the latter raises existing concerns with false alarm rates and alarm fatigue. Since such algorithms may be integrated into existing patient monitoring environments, we may need to consider their relationship with existing alarm systems to explain the performance of these new systems. Our work seeks to establish methods to evaluate patient monitoring algorithms through retrospective analysis of existing physiologic monitoring and clinical datasets. We develop a computational method to understand the performance of a new alarm algorithm in relation to existing medical device alarm systems.

2H: "Data-Driven Predictive Analytics," (Hannah Cowley, Johns Hopkins Applied Physics Laboratory)

Data scientists and ML experts from APL work with clinicians at Johns Hopkins Medicine to explore data-driven approaches to identify personalized approaches to diagnosis, prognosis, and treatment. The team has built a prediction framework with the Johns Hopkins Multiple Sclerosis Center to explore latent features predictive of disease course and are focusing on predicting mobility loss (i.e., "time to cane") and need for routine MRI scans. This is envisioned as a more generalized framework, and these tools have been applied to COVID-19 patient records to triage patient care, and soon will be applied to Alzheimers patient care.

2I: "Autonomous Data Operations for COVID-19 Dashboard," (Tamara Goyea, Ph.D., Ryan Lau, and Tim Ng, Johns Hopkins Applied Physics Laboratory)

Highlights of this work include the development of an automated pipeline for data collection, data fusion, anomaly detection and error correction, and data dissemination; national and global sourcing of data relevant to operational decision making; and collection and dissemination of U.S. county-level and sub-national data pertaining to the Coronavirus pandemic. Data are provided publicly through Github and can be viewed on the JHU Center for Systems Science and Engineering (CSSE) COVID-19 Global Dashboard.

2J: "APL Active Sensing Testbed," (Lee Stearns, Ph.D., Mary Luongo, Neil Fendley, Johns Hopkins Applied Physics Laboratory)

Novel breakthroughs in machine vision and AI have expanded the way systems can build and maintain an internal model of the world and actively form hypotheses about that world model through active perception. The Active Sensing Testbed is an APL-developed framework and physical testbed for research into active perception combined with world-view reasoning. The system consists of three components: (1) a cloud server framework that handles the processing and data routing for customizable workflows, and which includes several prebuilt video analytics and transformations; (2) an Application Programming Interface (API) for accessing the server functions and operator station software that wraps the API and provides tools for visualization, controls, and recording capabilities; and (3) a physical testbed that can be reserved for data collection sessions.

2K: "Intelligent Unmanned Systems to Address Health Care Delivery in Challenged Environments," (Bob Chalmers, Johns Hopkins Applied Physics Laboratory)

This session discussed development of a fixed-wing delivery system for medical supplies and test samples in poorly served regions. The concept was extended to a broader set of supporting capabilities achievable through the use of distributed AI applied to larger numbers of autonomous unmanned aircraft. Chalmers also discussed the prior research and experimentation that enabled this work. Such delivery systems can be combined with capabilities such as collective search and self-forming communications networks in an integrated whole that can address health care challenges in environments either underserved or disrupted by natural or other effects.

2L: "Newton: A Fairness Case Approach for Justified Confidence in Health Care Machine Learning," (Chuck Howell, Mitre)

There is strong agreement that AI in general and ML in particular can introduce unintended bias into consequential systems. Across the research community, technical solutions are being explored to enable increased transparency and understanding of ML systems and to mitigate risks of bias. However, these solutions tend to provide insight only late in the ML development cycle — during model training, testing, and deployment. They do not address how to establish consensus on the operational definition of fairness for the proposed system, identify fairness violations potentially introduced by the system, and gather evidence to make an overall case to stakeholders about justified confidence in the system's fairness before deployment and use. The development of safety-critical systems in domains such as avionics, transportation systems, medical devices, and weapons systems is subject to extensive scrutiny for obvious reasons. Over the years, a variety of system engineering tools, techniques, and practices (TTPs) have evolved to facilitate safety-critical software development and to support the communication and review of reasons why the developers assert that the system is adequately safe for use. We are exploring adapting and extending structured assurance case or safety case frameworks to produce a fairness case. An assurance case is a documented body of evidence that provides a compelling argument that the system satisfies certain critical properties for specific contexts. There are TTPs to facilitate the development and communication of claims, arguments, and evidence in a rigorous manner to support critical developments. We call our approach Newton because we aspire to accelerate the adoption of fair ML-based systems by standing on the shoulders of giants, adapting and extending existing TTPs. To our knowledge, no one has seriously investigated the use of fairness cases derived from assurance case TTPs to established justified confidence in the fairness of a consequential ML system in health care. This talk described our approach and how the various safety TTPs can be adapted and extended.

2M: "Big Data Neuroscience and Applications to Health Care," (Will Gray-Roncal, Ph.D., Johns Hopkins Applied Physics Laboratory)

Several teams at APL are working on large-scale neuroanatomical and connectomics datasets, which promise to reveal details of brain structure never seen before. This includes large-scale storage, processing, and visualization of datasets that can reach into the petabyte scale. The APL team builds advanced cloud systems for processing and understanding these data, which can provide new insights for understanding both disease states and information processing in nervous systems.

2N: "Nanoscale Connectomics for Robust, Adaptable AI," (Erik Johnson, Ph.D., Johns Hopkins Applied Physics Laboratory)

APL is a leader in the field of connectomics, an emerging research discipline focused on estimating and understanding the wiring diagram of the brain at a single-synapse level. This information is leveraged to better understand neurological diseases and conditions, as well as to generate biologically-inspired solutions for the next generation of AI technologies. This session shared an early success that used the network diagram of a C. elegans nematode to power a robot, observing emergent behaviors similar to that of the model organism. This has been extended into models using fruit fly and mouse connectivity to explore elegant operations for navigation and learning.

NATIONAL HEALTH SPEAKER SERIES

Originally planned as a larger and in-person symposium in April 2020, Operationalizing AI in Health was converted to a virtual format and delayed until September 2020. Additionally, the full original agenda was split so that key content could be shared virtually in April, July, and August 2020. These events, together referred to as the National Health Speaker Series, are summarized below. The planning committee thanks all speakers and attendees for their flexibility and participation despite alternate logistics.

Operationalizing AI in Health Virtual Symposium, Session I

April 21, 2020

More than 400 people tuned in to the April 21 virtual symposium, the first session of the 2020 National Health Speaker Series, which explored Operationalizing Artificial Intelligence in Health. Adam Cohen, NHMA's Army Medical Response Program Manager, moderated a discussion on the challenges of operationalizing AI in health. Panel members included Col. Jeremy Pamplin, Director, U.S. Army Telemedicine and Advanced Technology Research Center, Associate Professor of medicine and Associate Professor of military and emergency medicine at the Uniformed Services University of the Health Sciences; Gioel Molinari, President, Butterfly Network; and M. Brandon Westover, Director, Massachusetts General Hospital's Data Animation Center and Critical Care EEG Monitoring Service. Molinari discussed how the Butterfly Network is leveraging its handheld ultrasound system, Butterfly iQ, to develop a lung ultrasound device to safely, quickly, and even remotely stratify patients displaying symptoms of COVID-19. Westover — a neurologist who usually works on automating the analysis and interpretation of brain data for critically ill patients — was pulled into the COVID response effort to advise doctors on when patients should be tested, followed up closely, or sent home. His team is developing AI solutions for assessing whether a newly diagnosed patient — over the ensuing three to seven days — would need to be hospitalized; and, for those admitted, whether they would need to be admitted to an intensive care unit or intubated; and from there, whether they were likely to go home or to die. “The idea is that if we know these risks better, then we might be able to intervene and change the trajectory in a positive direction,” he said. Following the panel discussion, Nicholas Dalesio, a pediatric anesthesiologist, assistant professor of anesthesiology and critical care medicine and otolaryngology-head and neck surgery at the Johns Hopkins School of Medicine, presented a “lightning talk” about the challenges Hopkins faces in treating COVID-19 patients and how AI can assist in clinician guidance and patient monitoring. The event also featured an interview about the Johns Hopkins interactive, Web-based dashboard that has become one of the world´s most referenced sources for coronavirus numbers and trends. Conducted by Erin Hahn, a senior national security analyst and group supervisor in the National Security Analysis Department at APL, the interview featured Lauren Gardner, Associate Professor of civil and systems engineering at Johns Hopkins and dashboard founder, and APL's Aaron Katz, who leads a team of data analysts at the Laboratory supporting the dashboard. A video of this event is available at https://www.youtube.com/watch?v=mNzfxMhyQbQ&feature=youtu.be.

National Health Virtual Speaker Series, Session II

July 14, 2020

The second event in the 2020 National Health Speaker Series featured M. Khair ElZarrad, Ph.D., the Deputy Director of the Office of Medical Policy in the Center for Drug Evaluation and Research at the Food and Drug Administration (FDA). ElZarrad discussed the FDA's work in operationalizing AI in health. He touched on the evolving ecosystem of regulation and policy around health, the need for continued innovation, FDA's Real World Evidence Program, the potential of technology and digitization, and AI. This event also featured a discussion with ElZarrad on current events and their impact on operationalizing AI in health. The discussion was co-moderated by Erin Hahn, a senior national security analyst in the National Security Analysis Department at APL, and Henry Farrell, a professor of international studies at the Johns Hopkins Stavros Niarchos Foundation SNF Agora Institute. A video of this event is available at https://www.youtube.com/watch?v=Ifp9GgPGWoY&feature=youtu.be.

National Health Virtual Speaker Series, Session III

August 18, 2020

The August installment of the 2020 National Health Speaker Series featured Gil Alterovitz, Ph.D., Director, National Artificial Intelligence Institute at the U.S. Department of Veterans Affairs (VA). Alterovitz talked about the development of the National Artificial Intelligence Institute at the VA and some of their initiatives. This event also featured a discussion on current events and their impact on operationalizing AI in health, led by Adam Cohen, M.D., Army Medical Response Program Manager for APL's National Health Mission Area and John Piorkowski, Ph.D., Chief Engineer and Applied Information Sciences Branch Head for APL's Asymmetric Operations Sector. A video of this event is available at https://www.youtube.com/watch?v=VhbjXXMkSoA.

SPEAKER BIOS

Gil Alterovitz

Director, National Artificial Intelligence Institute
U.S. Department of Veterans Affairs

Gil Alterovitz, Ph.D., is the director of the National Artificial Intelligence Institute (NAII) at the U.S. Department of Veterans Affairs (VA). NAII seeks to develop AI research and development capabilities at the VA as a means to support veterans, their families, survivors, and caregivers. The Institute also designs and collaborates on large-scale AI research and development initiatives, national AI policy, and partnerships across agencies, industries, and academia. He has led national and international collaborative initiatives for developing novel informatics methods and approaches for integrating clinical, pharmaceutical, and genomic information, from research to point-of-care. He is a member of the Precision Medicine Task Force under the White House's Office of the National Coordinator. He is also one of the core writers of the White House Office of Science Technology and Policy's National Artificial Intelligence Research and Development Strategic Plan, which was recently updated. The policy supports a national AI initiative and includes an additional strategic priority for public-private partnerships. Dr. Alterovitz has degrees from the Massachusetts Institute of Technology and Carnegie Mellon in electrical, biomedical, and computer engineering (including a doctorate). He's a professor at Harvard Medical School and the director of the Biocybernetics Laboratory at Brigham & Women's Hospital. His work on integrative methods for "big data" in the biomedical informatics space has been published or presented in more than 50 peer-reviewed publications, ranging from academic journals and international conferences to three books (including "Systems Bioinformatics: An Engineering Case-based Approach," ranked #1 in new Amazon bioinformatics category).

Adam Cohen

Program Manager, Army Medical Response
Johns Hopkins Applied Physics Laboratory

Adam Cohen, M.D., is a program manager in APL's National Health Mission Area and an Assistant Professor of Neurology at Johns Hopkins Hospital where he practices inpatient neurology. His teams bring diverse science and engineering capabilities to high-burden clinical problems, deploying varied novel solutions and approaches. In this context, he has experience designing and implementing research program strategies to align research pursuits and high-priority problems. He currently works across a variety of efforts: device interoperability, novel sensors, AI, digital health, clinical decision support technology, and autonomous medical systems, including health technology, to enable self-care or care by non-traditional providers. He works with military, academic, and industry partners to focus on high-impact innovations. Prior to Hopkins, he was the Inpatient Neurology Director and Teleneurology Director at Massachusetts General Hospital where he practiced inpatient neurology, neuro-ophthalmology, and neuroradiology. He has done extensive work in health care quality improvement and digital health.

Nick Dalesio

Assistant Professor of Anesthesiology and Critical Care Medicine
Johns Hopkins University School of Medicine

Nicholas Michael Dalesio, M.D., is an assistant professor of anesthesiology and critical care medicine and otolaryngology-head and neck surgery at the Johns Hopkins University School of Medicine. His area of clinical expertise is pediatric anesthesiology. He received his undergraduate degree in cell biology/molecular genetics from the University of Maryland. He earned his medical degree from the Virginia Commonwealth University School of Medicine and completed his anesthesiology residency at Yale-New Haven Hospital. Dalesio performed a fellowship in pediatric anesthesiology at the Children's Hospital of Philadelphia before joining the faculty at Johns Hopkins. In addition to pediatric anesthesiology, Dalesio has a special interest in sleep-disordered breathing and obstructive sleep apnea in children, difficult airway management in children, and craniofacial reconstructive surgery in children. He is a member of the Society of Pediatric Anesthesia, the American Society of Anesthesiologists, the American Board of Anesthesiology, and the Maryland Society of Anesthesiologists.

Khair ElZarrad

Deputy Director of the Office of Medical Policy, Center for Drug Evaluation and Research
U.S. Food and Drug Administration

Khair ElZarrad, Ph.D., MPH, leads the development, coordination, and implementation of medical policy programs and strategic initiatives at FDA's Center for Drug Evaluation and Research. Prior to joining the FDA, he served as Acting Director of the Clinical and Healthcare Research Policy Division with the Office of Science Policy at the National Institutes of Health (NIH). At NIH he worked on policies related to human subject protections; the design, conduct, and oversight of clinical research; and enhancing quality assurance programs at pharmaceutical development and production facilities. Dr. ElZarrad currently leads multiple projects focused on exploring the potential utility of real-world evidence, innovative clinical trial designs, and the integration of technological advances in pharmaceutical development. He earned a doctoral degree in medical sciences with a focus on cancer metastases from the University of South Alabama and a master's degree in public health from the Johns Hopkins Bloomberg School of Public Health.

Henry Farrell

Stavros Niarchos Foundation Agora Institute Professor of International Affairs
Johns Hopkins University School of Advanced International Studies

Henry Farrell, Ph.D., is the Stavros Niarchos Foundation Agora Institute Professor of International Affairs at SAIS, 2019 winner of the Friedrich Schiedel Prize for Politics and Technology, and Editor in Chief of the Monkey Cage blog at the Washington Post. Previously, he served as a professor of political science and international affairs at George Washington University. He works on a variety of topics, including democracy, the politics of the internet, and international and comparative political economy. He is the author of *Of Privacy and Power: The Transatlantic Fight over Freedom and Security* (with Abraham Newman, 2019) and *The Political Economy of Trust: Interests, Institutions and Inter-Firm Cooperation* (2009).

Christine Fox

Assistant Director for Policy and Analysis
Johns Hopkins Applied Physics Laboratory
Former Acting Deputy Secretary of Defense

The Honorable Christine H. Fox became the Assistant Director for Policy and Analysis of the Johns Hopkins Applied Physics Laboratory on May 12, 2014. Previously, she served as Acting Deputy Secretary of Defense between December 2013 and May 2014. With her appointment, she became the highest-ranking female official in history to serve in the Department of Defense. From 2009 to 2013, Fox served as the Director, Cost Assessment and Program Evaluation in the Office of the Secretary of Defense. In that position, she was the principal civilian advisor to the Secretary of Defense for analyzing and evaluating plans, programs, and budgets in relation to U.S. defense objectives and resource constraints. Prior to her Government service, she served as the President of the Center for Naval Analyses (CNA), a Federally Funded Research and Development Center, and as the scientific analyst to the Chief of Naval Operations. During her 28-year career at CNA, Fox oversaw analysis of real- world operations, from the first Gulf War and the operations in Bosnia and Kosovo in the 1990s to the operations in Afghanistan immediately following the September 11th attacks, and the operation in Iraq in early 2003. From 2003–2005, she served as a member of NASA's Return to Flight Task Group, chartered by the NASA Administrator to certify the recommendations made by the Columbia Accident Investigation Board.

Lauren Gardner

Associate Professor, Department of Civil and Systems Engineering
Johns Hopkins University Whiting School of Engineering

Lauren Gardner, Ph.D., is the creator of the interactive web-based dashboard being used by public health authorities, researchers, and the general public around the globe to track the outbreak of the novel coronavirus. The dashboard, which debuted on January 22, 2020, became the authoritative source of global COVID-19 epidemiological data for public health policy makers and many major news outlets worldwide. Because of her expertise, Dr. Gardner was one of six Johns Hopkins experts who briefed congressional staff about the outbreak during a Capitol Hill event in early March 2020. She is co-director of the Center for Systems Science and Engineering and affiliated faculty in the Johns Hopkins Bloomberg School of Public Health. Prior to joining Johns Hopkins University in 2019, she was a senior lecturer in civil engineering at the University of New South Wales (UNSW) Sydney, in Australia. Her research expertise is in integrated transport and epidemiological modeling. She has previously led related interdisciplinary research projects which utilize network optimization and mathematical modeling to progress the state of the art in global epidemiological risk assessment. Beyond mobility, her work focuses more holistically on virus diffusion as a function of climate, land use, mobility, and other contributing risk factors. On these topics, Gardner has received research funding from organizations including NIH, the National Science Foundation, NASA, the Australian Government National Health and Medical Research Council, Australian Research Council, Commonwealth Scientific and Industrial Research Organization, Queensland Health Department, Transport for New South Wales, and GoGet CarShare. Outcomes from her research projects have led to publications in leading interdisciplinary and infectious disease journals, presentations at international academic conferences, and invited seminar presentations and keynote talks at universities and various events. Gardner is also an invited member of multiple international professional committees, a reviewer for top-tier journals and grant funding organizations, and an invited participant of various scientific advisory committees. She has also supervised more than 30 students and post-docs, and teaches undergraduate and graduate-level courses on network modeling and transport systems.

Erin Hahn

Senior National Security Analyst
Johns Hopkins Applied Physics Laboratory

Erin Hahn, J.D., supervises APL’s Concepts and Assessments Group — a team that focuses on operational readiness and counterforce issues with technology development and implementation, as well as future threats and the strategic and policy issues that underlie problems faced by decision makers. Her work covers a range of topics, with an emphasis on legal, policy, or normative issues in the context of operational or technology challenges. She serves as the co-chair for the International Panel on the Regulation of Autonomous Weapons, the work of which has been influential in shaping the ongoing discussions of the United Nations Group of Government Experts for Lethal Autonomous Weapons Systems. She has authored or co-authored several works, including a book chapter (with Jesse Kirkpatrick, et al.), “Trust and Human-Robot Interactions,” in *Robot Ethics 2.0*. Hahn was formerly the Associate Director of the University of Maryland Center for Health and Homeland Security in Baltimore, Maryland. Prior to that, she was an attorney in private practice doing complex civil litigation.

Aaron Katz

Supervisor, Large Scale Analytics Group
Johns Hopkins Applied Physics Laboratory

Aaron Katz leads the Large-Scale Analytics Systems Group in the Asymmetric Operations Sector at the Johns Hopkins Applied Physics Laboratory. During his 20-year career at APL, his work has focused on the development of systems and techniques to improve data analytics capabilities across a broad range of areas related to national security and infectious disease surveillance. In 2016 he was awarded APL’s Hart Prize for Excellence in Independent Research and Development for his work as a principal investigator on the Enhanced WMD Analytics Project.

Ashley Llorens

Chief, Intelligent Systems Center
Johns Hopkins Applied Physics Laboratory

Ashley Llorens is the founding chief of the Intelligent Systems Center at the Johns Hopkins Applied Physics Laboratory, where he directs research and development activities in ML, robotic and autonomous systems, and applied neuroscience toward addressing the nation’s most critical challenges from defense to health. Since joining the Laboratory in 2003, Llorens has served as a principal investigator for various applied research programs focused on advancing autonomous perception and navigation capabilities for the U.S. Navy. His work has been recognized by the Office of Naval Research and by APL for innovation and mission impact. His current research interests include lifelong learning systems and understanding the theoretical limitations of ML algorithms. He currently serves on various strategic advisory boards, including the Center for a New American Security Artificial Intelligence Task Force, the Defense Science Board Task Force on Counter Autonomy, the Artificial Intelligence Working Group of the Secretary of Energy Advisory Board, and the advisory board of the Evidence Initiative, a collaborative program by the Economist and Pew Charitable Trusts. In addition, Llorens chairs the Diversity Leadership Council, an advisory body to the president of Johns Hopkins

University that advances diversity and inclusion across the university and health system. Llorens received his B.S. and M.S. in electrical and computer engineering from the University of Illinois at Urbana-Champaign and is a Senior Member of the Institute of Electrical and Electronics Engineers, a member of the Association for the Advancement of Artificial Intelligence, and a voting member of the Recording Academy, the organization that hosts the Grammy Awards. He currently serves as an AI technology consultant for a growing number of Hollywood movies as part of the Science & Entertainment Exchange of the National Academy of Sciences.

Oscar C. Marroquin

Chief Healthcare Data and Analytics Officer, Associate Professor of Medicine, Epidemiology, and Clinical and Translational Science
University of Pittsburgh Medical Center

Oscar C. Marroquin, M.D., FACC, is the Chief Healthcare Data and Analytics Officer for University of Pittsburgh Medical Center (UPMC). He is also a practicing cardiologist at the UPMC Heart and Vascular Institute and an associate professor of medicine, epidemiology, and clinical and translational sciences at the University of Pittsburgh. His academic career has been focused on outcomes research in interventional cardiology and heart disease in women, and his research has been rewarded in the form of grants and numerous publications. In his current role, he leads UPMC's health care data and analytics activities, where he oversees a team of IT infrastructure architects, analysts, statisticians, and data scientists focused on applying "big data" approaches to measure and predict clinical outcomes. Marroquin completed his internship and residency in internal medicine at the Presbyterian Medical Center of the University of Pennsylvania and did his general cardiology and interventional cardiology fellowships at UPMC. He is a member of the American Medical Association, the American College of Physicians, and a fellow of the American College of Cardiology and the Society of Cardiovascular Angiography and Interventions.

Peter McCaffrey

Chief Technology Officer/Co-founder
VastBiome

Peter McCaffrey, M.D., is a board-certified pathologist as well as co-founder and CTO of VastBiome, a drug discovery company mining the human gut microbiome for novel cancer therapeutics. He completed his medical training at the Johns Hopkins University School of Medicine and his residency training in pathology at Massachusetts General Hospital, where he also served as Chief Resident. After residency, he completed a fellowship in Biodesign at the Texas Medical Center in Houston where VastBiome originated. McCaffrey's interests in microbiology stem from his time as a research fellow at the KwaZulu-Natal Research Institute for Tuberculosis and HIV (now Africa Health Research Institute) in Durban, South Africa, where his work focused on applying computational biology to define personalized antibiotic resistance profiles based on bacterial and viral sequence data for individual patients. At VastBiome, he applies these skills to map the mechanisms through which gut microbes control the host immune system in the setting of cancer immunotherapy and autoimmune disease.

Gioel Molinari

President
Butterfly Network

Gioel Molinari is a technology entrepreneur and president of Butterfly Network, a medical device company dedicated to democratizing ultrasound. He began his career in industrial automation and was then founder, president, and chief technology officer of ClariFI Inc., a software platform to simplify quantitative equity investing. ClariFI was acquired by S&P Capital IQ in 2007. Subsequently, he held senior product and technology leadership roles at Bloomberg L.P., and Bridgewater Associates. He holds a Bachelor of Science in chemical engineering from Carnegie Mellon University.

Sezin Palmer

Mission Area Executive, National Health Mission Area
Johns Hopkins Applied Physics Laboratory

Sezin Palmer is the first mission area executive for National Health at APL, which was recognized by Fast Company in 2016 as one of the most innovative companies in Healthcare. As the nation's largest University Affiliated Research Center, APL performs research and development on behalf of the Department of Defense, the Department of Health and Human Services, the intelligence community, the National Aeronautics and Space Administration, and other federal agencies. The National Health Mission Area takes a systems approach to understanding health determinants to better predict and prevent illness, injury, and disease and applying this knowledge to develop novel capabilities to rapidly detect and respond to changes in health status. Prior to her current appointment, Palmer served as the Mission Area Executive for Research and Exploratory Development. Under her leadership, APL made significant contributions to the fields of neuroscience, biomechanics, intelligent systems, and materials science. Previously, she held leadership positions in the Laboratory's Undersea Warfare Mission Area, and was responsible for the technical and programmatic oversight of numerous Navy programs in submarine warfare, anti-submarine warfare, and mine-countermeasures capability development. She earned a Bachelor of Science degree in electrical engineering from the University of Maryland and a Master of Science degree in electrical engineering from Johns Hopkins University.

Jeremy C. Pamplin

Director, Telemedicine and Advanced Technology Research Center
U.S. Army Medical Research and Development Command
Associate Professor of Medicine and Associate Professor of Military/Emergency Medicine
Uniformed Services University of the Health Sciences

U.S. Army Col. Jeremy Pamplin, M.D., FCCM, FACP, has been the director of the Telemedicine and Advanced Technology Research Center since June 2019, a position he assumed following his role as deputy director starting in August 2018. Prior to this assignment, he was the director of Virtual Critical Care at Madigan Army Medical Center. During that assignment, he began the first Army Tele-Critical Care service and integrated it with the Navy's Tele-Critical Care service to form the Joint Tele-Critical Care Network. Prior to that assignment, he was the chief of Clinical Trials in Burns and Trauma and the medical director of the U.S. Army Burn Intensive Care Unit at the U.S. Army Institute of Surgical Research. He has served as medical director of the surgical and medical intensive care unit since completing his Critical Care Medicine fellowship at Walter Reed Army Medical Center in 2007. Pamplin has deployed in support of Operation Iraqi Freedom and Operation Enduring Freedom: to Iraq as the chief of Critical Care for the 86th Combat Support Hospital during the former, and to Afghanistan as the deputy deployed medical director for the 33rd Field Hospital and the American contingent's physician leader during the latter. He is the principle investigator of multiple projects exploring the impact of telemedicine and health information technology in austere, operational environments. He remains the medical director for the ADvanced VIrtual Support for OpeRational Forces systems, or ADVISOR, that he helped create to deliver a range of operational virtual health capabilities to deployed forces. He received a Bachelor of Science from the U.S. Military Academy at West Point in 1997 and his medical degree from the Uniformed Services University of the Health Sciences in 2001.

Efthimios Parasidis

Professor of Law and Public Health
The Ohio State University

Efthimios Parasidis, J.D., MBE, is a nationally recognized expert on health law and bioethics. He holds a joint appointment with The Ohio State University Moritz College of Law and the College of Public Health, and is a faculty affiliate with the College of Medicine's Center for Bioethics.

A prolific scholar with over thirty publications, his work has appeared in top journals, including the New England Journal of Medicine, the American Journal of Public Health, and the Boston University Law Review, among others. He is co-author of a leading casebook on the ethics and regulation of research with human subjects, and has a book on military medical ethics under contract with Oxford University Press. Parasidis serves as a law and bioethics consultant to the U.S. Air Force. In 2019 he was appointed to a National Institutes of Health research ethics committee that examines complex and emerging issues in clinical data science and data sharing. The Greenwall Foundation awarded Parasidis a Faculty Scholar in Bioethics fellowship for 2014–2017. As a Fulbright Scholar, Parasidis researched legal and ethical issues related to medical informed-consent policies and practices in Greece. Prior to joining the Ohio State faculty, he was a professor at the Center for Health Law Studies at Saint Louis University. While in Missouri, he was an appointed member of the Law & Policy Workgroup of Missouri Health Connection, the entity responsible for creating Missouri's health information exchange. In addition to his scholarly work and public service, Parasidis served as an Assistant Attorney General for the State of New York, under Eliot Spitzer and Andrew Cuomo, where he handled hundreds of cases in state and federal courts at both the trial and appellate levels. He was an associate in the Litigation Group of Jones Day and a senior associate in the Intellectual Property Group of Dickstein Shapiro. Parasidis counsels start-up companies on corporate and intellectual property matters, co-founded a health informatics start-up company, and is a co-inventor on a patent application related to health information technology.

John Piorkowski

Chief Artificial Intelligence Architect and Applied Information Sciences Branch Head
Asymmetric Operations Sector, Johns Hopkins Applied Physics Laboratory

John Piorkowski, Ph.D., serves as the chief artificial intelligence architect and Applied Information Sciences Branch Head of the Asymmetric Operations Sector at APL. In these roles, he provides technical oversight and technical staff management for a multitude of national security and health care efforts. Under Piorkowski's direction, staff in the Applied Information Science Branch are leading research in the areas of ML, cloud computing, and advanced visualization with government and open-source data. Piorkowski also serves as the chair for the Artificial Intelligence Program and co-chair for the Data Science Program for the Whiting School of Engineering at Johns Hopkins University. Additional research interests include applying system engineering techniques toward the creation of AI systems.

Cynthia Rudin

Professor of Computer Science, Electrical and Computer Engineering, and Statistical Science; Principal Investigator, Prediction Analysis Lab
Duke University

Cynthia Rudin, Ph.D., is a professor of computer science, electrical and computer engineering, and statistical science at Duke University. Previously, Rudin held positions at Massachusetts Institute of Technology (MIT), Columbia University, and New York University. Her degrees are from the University at Buffalo and Princeton University. She is a three-time winner of the INstitute For Operations Research and the Management Sciences (INFORMS) Innovative Applications in Analytics Award, was named as one of the “Top 40 Under 40” by Poets and Quants in 2015, and was named by Businessinsider.com as one of the 12 most impressive professors at MIT in 2015. She has served on committees for INFORMS; the National Academies of Science, Engineering, and Medicine; the American Statistical Association; Defense Advanced Research Projects Agency; the National Institute of Justice; and the Association for the Advancement of Artificial Intelligence. She is a fellow of both the American Statistical Association and the Institute of Mathematical Statistics. She is a Thomas Langford Lecturer at Duke University for 2019–2020.

Fred Streitz

Chief Science Advisor, Artificial Intelligence and Technology Office
U.S. Department of Energy

Fred Streitz, Ph.D., is the chief scientist of the Department of Energy’s Artificial Intelligence and Technology Office. He is also the chief computational scientist at Lawrence Livermore National Laboratory (LLNL) and director of the High Performance Computing Innovation Center. He develops strategies and leads efforts to address the nation’s most critical scientific problems through the application of supercomputing. He also guides LLNL’s efforts to form strategic industrial, academic, and government collaborations that support and expand high performance computing capabilities. Dr. Streitz serves on advisory boards for Argonne National Laboratory and Oak Ridge National Laboratory and as a subject editor for the International Journal of High Performance Computing Applications. He also participates in the Advanced Computing Roundtable at the Council on Competitiveness. He is a fellow of the American Physical Society, a two-time winner of the Gordon Bell Prize, and the recipient of a Special Recognition Award from the U.S. Secretary of Energy. He has a Bachelor of Science in physics from Harvey Mudd College in Claremont, California, and a doctorate in physics from the Johns Hopkins University in Baltimore, Maryland. He is currently an adjunct professor at Georgetown University. Prior to joining LLNL in the Physical and Life Sciences Directorate in 1999, Dr. Streitz held positions as a National Research Council Fellow at the Naval Research Laboratory and an assistant professor at Auburn University.

Mathias Unberath

Assistant Professor, Department of Computer Science
Johns Hopkins University

Mathias Unberath, Ph.D., is an assistant research professor in the Department of Computer Science at Johns Hopkins University, with affiliations to the university's Laboratory for Computational Sensing and Robotics and the Malone Center for Engineering in Healthcare. He created and is currently leading the research group on Advanced Robotics and Computationally AugmenteD Environments (ARCADE), which focuses on computer vision, ML, and augmented reality and their application to medical imaging, surgical robotics, and clinician-centric assistance systems. Previously, Unberath was a postdoctoral fellow in the Laboratory for Computational Sensing and Robotics at Hopkins and completed his Ph.D. in computer science at the Friedrich-Alexander-Universität (FAU) Erlagen-Nürnberg from which he graduated summa cum laude in 2017. While completing a bachelor's degree in physics and a master's degree in optical technologies at FAU Erlangen, he studied at the University of Eastern Finland as an Erasmus Scholar in 2011 and later joined Stanford University as a Deutscher Akademischer Austauschdienst (German Academic Exchange Service) Fellow throughout 2014.

James Weinstein

Senior Vice President
Microsoft Healthcare

James N. Weinstein, D.O., is the Senior Vice President for Microsoft Healthcare. He helps lead strategic partnerships across the health care ecosystem with a particular focus on innovation and health equity. Prior to joining Microsoft, he was the chief executive officer (CEO) and president of Dartmouth-Hitchcock Health. Prior to becoming CEO in 2011, he served as president of Dartmouth-Hitchcock Clinic, and was the director of The Dartmouth Institute for Health Policy and Clinical Practice.

Weinstein is a member of the National Academy of Medicine (NAM) and serves on the organization's Board for Population Health and Public Health Practice. He also serves on two NAM committees related to AI in health care and co-chairs — with NAM president Dr. Victor Dzau — the ongoing inequities in health care "call to action" meetings. He serves on several boards of trustees, including the Max Planck Florida Institute for Neuroscience, the BioFabUSA program (a public-private partnership between the Department of Defense and the Advanced Regenerative Manufacturing Institute), and the Intermountain Health System. He continues to serve as an appointee to the Special Medical Advisory Group of the Department of Veterans Affairs, which advises the Secretary of Veterans Affairs and the Under Secretary for Health on matters relating to the care and treatment of veterans.

In 2015, Weinstein was awarded the Ellis Island Medal of Honor by the National Ethnic Coalition of Organizations (now the Ellis Island Honors Society). In 2017 he was the recipient of the American Hospital Association's Justin Ford Kimball Innovator's Award. He has been named one of The 100 Most Influential People in Healthcare by Modern Healthcare magazine and one of the top 50 Physician Leaders to Know by Becker's Hospital Review. He is the longest standing Editor-in-Chief of a major journal, Spine, and the author of the highly acclaimed *Unraveled: Prescriptions to Repair a Broken Health Care System*, published in February 2016.

M. Brandon Westover

Associate Professor of Neurology
Harvard Medical School, Massachusetts General Hospital

M. Brandon Westover, M.D., Ph.D., obtained his doctorate working in the field of AI (information theory and computer vision), and is a board-certified practicing neurologist and clinical neurophysiologist at Massachusetts General Hospital (MGH). He directs the MGH Critical Care EEG Monitoring Service and the MGH Clinical Data Animation Center. His research uses Big Data and AI to improve medical care for patients with anoxic brain injury, seizures and seizure-like brain states, cerebral ischemia, delirium, and sleep disorders, and to develop closed-loop control technology for precision control of anesthesia in the ICU.

ORGANIZER

ABOUT APL:

For more than 75 years, the Johns Hopkins University Applied Physics Laboratory (APL) has provided critical contributions to critical challenges with systems engineering and integration, technology research and development, and analysis. Our scientists, engineers, and analysts serve as trusted advisors and technical experts to the government, ensuring the reliability of complex technologies that safeguard our nation's security and advance the frontiers of space. We also maintain independent research and development programs that pioneer and explore emerging technologies and concepts to address future national priorities. For more information visit JHUAPL.edu.

ABOUT THE NATIONAL HEALTH MISSION AREA:

The National Health Mission Area aims to revolutionize health through science and engineering. We focus on programs to predict and prevent illness, injury, and disease; rapidly detect and respond to changes in health status; restore and sustain health; and improve overall health and human performance — leveraging expertise from across Johns Hopkins and the Laboratory to develop solutions that advance health and health care for civilian, military, and veteran populations worldwide.

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