Machine Learning and Sensors to Enhance Rehabilitation Research

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Restore

Shirley Ryan Abilitylab

Northwestern University

ONLINE, ON DEMAND COURSE

COURSE DESCRIPTION

Over recent years, there has been an explosion of interest in wearable sensors, video, and computer vision for healthcare and patient monitoring. Many commercial and research-grade wearables can now capture continuous, high-resolution measurements about vital signs, activity, sleep, biomechanical metrics, and even physiological signals such as from the muscles or brain. However, translating this complex data into meaningful clinical information poses many substantial challenges. Machine learning is a powerful tool to address some of these challenges. In machine learning, computers themselves are learning from data and create models to make predictions about that data. In this introductory course, we will take a practical approach to understand how machine learning and sensors can be applied in the rehabilitation field, pitfalls to avoid, how to get started, and how these tools can create reliable digital biomarkers.

WHO SHOULD ATTEND

Engineers, Data Scientists, Physical Therapists, Physical Therapist Assistants, Occupational Therapists, Occupational Therapy Assistants, Nurses, Physicians and Speech-Language Pathologists

LEARNER OUTCOMES

Upon completion of this course, participants will be able to:

- List different types of machine learning techniques that have been useful in rehabilitation research and clinical applications
- Identify 5 practical considerations and barriers to using machine learning in real-world rehabilitation problems
- Evaluate open source and publicly available tools and determine which would be a good starting point for a clinical problem

SUCCESSFUL COMPLETION

To successfully complete this course, you will need to view the entire recorded activity and complete an evaluation at its conclusion through the Academy Leaning Portal.

C-STAR & RESTORE

The Center for Smart Use of Technologies to Assess Real World Outcomes (C-STAR), and RESTORE are two of six national resource centers comprising the Medical Rehabilitation Research Resource network (MR3) of the National Institutes of Health.

C-STAR is a joint grant between Northwestern University and Shirley Ryan AbilityLab, conceived out of a need to equip investigators with the skills and know-how to accurately employ technologies to measure and interpret data relevant to sensorimotor and cognitive function in the lab, clinic and real world. Our mission is to connect researchers with the right tools to develop and accurately assess technologies in the field of rehabilitation science. Leveraging the collective experience of clinicians, scientists, engineers and patients, our center provides the expertise, instruction and mentorship to empower researchers on the meaningful use of the vast array of technologies that are readily available but notoriously difficult to implement consistently across diverse patient populations.

The Restore Center (the Center for Reliable Sensor Technology-Based Outcomes for Rehabilitation) is an NIH MR3 Resource Center focused on enabling real-world assessments in rehabilitation. Based at Stanford University, we provide research infrastructure and training to enable rehabilitation scientists to use mobile sensors and video technology to assess movement and factors affecting movement.

Our Center brings together expertise from statistics, computer science, bioengineering, mobile health, and clinical rehabilitation. Together, we are developing software tools and easy-to-use, standardized workflows for real-world monitoring in rehabilitation. These resources, along with programs such as pilot project grants and virtual office hours, will establish a vibrant research community to achieve the potential of mobile technology to improve our knowledge and care of individuals with impaired movement.

COURSE CHAIRS

Arun Jayaraman, PT, Ph.D.
Director, Max Näder Center for Rehabilitation Technologies & Outcomes Research; Director & Business Development Officer, Office of Translational Research, Associate Professor of PM&R, Medical Social Science, PTHMS, Northwestern University

Dr. Arun Jayaraman's work primarily focuses on developing and executing both investigator-initiated and industry-sponsored research in prosthetics, orthotics, rehabilitation robotics, and other assistive and adaptive technologies to treat physical impairments. He conducts all of his outcomes research using advanced wearable patient monitoring wireless sensors and novel machine learning techniques, in addition to the traditional performance-based and patient-reported outcome measures. He collaborates both nationally and internationally with many academic and industrial organizations and is internationally recognized in the field of rehabilitation robotics.

Joy Ku, Ph.D.
Director of Promotions and Didactic Interactions for the NIH-funded Restore Center
Director of Education and Communications for the Mobilize Center
Manager of SimTK

Joy Ku is focused on biocomputation and the advancement of their use through teaching, science communications, community building, and the promotion of research resource sharing efforts, particularly as related to reproducibility and open-source science.She is currently Deputy Director of the Wu Tsai Human Performance Alliance at Stanford (https://humanperformance.stanford.edu) and also leads the education and outreach efforts for the overall Wu Tsai Human Performance Alliance, which consists of institutions across the country, including Boston Children's Hospital, Salk, UC San Diego, the University of Kansas, and the University of Oregon. The Alliance's mission is to discover biological principles to optimize human performance and catalyze innovations in human health.

Dr. Ku is also the Director of Promotions and Didactic Interactions for the NIH-funded Restore Center (https://restore.stanford.edu), as well as the Director of Education and Communications for the Mobilize Center (https://mobilize.stanford.edu), an NIH Biomedical Technology Resource Center. Both Centers provide tools, infrastructure, and training to support the research community. The Mobilize Center's emphasis is on biomechanical modeling and machine learning algorithms to provide new insights into human movement from data sources, such as wearables, video, and medical images. She also manages SimTK (https://simtk.org), a software, model, and data-sharing platform for the biocomputation research community.

Eric Perreault, Ph.D.
Professor of Biomedical Engineering at Northwestern University
Associate Dean for Research in Northwestern's McCormick School of Engineering and Applied Sciences.

Eric Perreault is Professor of Biomedical Engineering at Northwestern University, with joint appointments in the Department of Physical Medicine and Rehabilitation, and at the Shirley Ryan AbilityLab. He is currently the Associate Dean for Research in Northwestern's McCormick School of Engineering and Applied Sciences. His research focuses on understanding the neural and biomechanical factors involved in the control of multi-joint movement and posture

and how these factors are modified following neuromuscular pathologies. His group employs statistical, computational, and machine learning methods to augment their experimental studies. Eric is a fellow of the American Institute for Medical and Biological Engineering, and Chair of the US National Advisory Board on Medical Rehabilitation Research.

Matt Petrucci, Ph.D.
Research Engineer, Bioengineering

Matt obtained a MS in mechanical engineering and PhD in neuroscience from the University of Illinois at Urbana-Champaign, and a BS/BA in mechanical engineering from the University of San Diego. His dissertation research primarily focused on improving gait initiation in people with Parkinson's disease (PD) and freezing of gait (FOG) using a powered ankle foot orthosis. During his graduate career, he also worked on projects that examined the application of a powered ankle foot orthosis for gait assistance in persons with multiple sclerosis and perception vs. action coupling in firefighters wearing protective gear. He was awarded a MnDRIVE Neuromodulation Postdoctoral Fellowship in 2016 to develop quantitative measures of the mechanical and neurophysiological components of rigidity in PD. In 2017, he was awarded the Parkinson's Study Group Mentored Clinical Research Award to evaluate an automated closed-looped algorithm to rapidly optimize deep brain stimulation settings for people with PD.

COURSE FACULTY

Paolo Bonato, Ph.D.,
Director of the Motion Analysis Laboratory at Spaulding Rehabilitation Hospital, Boston
Associate Professor, Department of Physical Medicine and Rehabilitation at Harvard Medical School,

Additionally, Dr Bonato is an Adjunct Professor of Biomedical Engineering at the MGH Institute of Health Professions, an Associate Faculty Member at the Wyss Institute for Biologically Inspired Engineering, and an Adjunct Associate Professor at Boston University College of Health & Rehabilitation Sciences. He has held Adjunct Faculty positions at MIT, the University of Ireland Galway, and the University of Melbourne. His research work is focused on the development of rehabilitation technologies with special emphasis on wearable technology and robotics. Dr. Bonato served as the Founding Editor-in-Chief of Journal on NeuroEngineering and Rehabilitation and currently serves as Founding Editor-in-Chief of the IEEE Open Journal of Engineering in Medicine and Biology. He received the M.S. degree in electrical engineering from Politecnico di Torino, Turin, Italy in 1989 and the Ph.D. degree in biomedical engineering from Universita` di Roma "La Sapienza" in 1995.

Scott Delp, Ph.D.
Director, Human Performance Alliance at Stanford; James H. Clark Professor in the School of Engineering, Stanford University; Professor of Bioengineering, mechanical engineering, and orthopaedic surgery, Stanford University

Dr Delp is the Founding Chairman of the Department of Bioengineering at Stanford and Director of the Wu Tsai Human Performance Alliance, which aims to transform human health through the science of peak performance. Scott is also the Director of the RESTORE Center, a NIH national center focused on measuring real world rehabilitation outcomes and Director of the Mobilize Center, a NIH National Center of Excellence focused on Big Data and Mobile Health. Scott's laboratory develops technologies to advance movement science and human health. Software tools created in his lab, including OpenSim and Simtk.org, have become the basis of an international collaboration involving thousands of scientists who exchange simulations of human movement. He has published over 250 research articles and has recently released a book from MIT Press entitled Biomechanics of Movement: The Science of Sports, Robotics, and Rehabilitation. Professor Delp has co-founded six health technology companies and is a member of the U.S. National Academy of Engineering.

Jennifer Hicks, Ph.D.
Deputy Director, Wu Tsai Human Performance Alliance at Stanford
Director of Research, Mobilize Center
Directory of Research, Restore Center
Research and Development Manager, OpenSim Project

Jen is Deputy Director of the Wu Tsai Human Performance Alliance at Stanford, with a focus on collaborative research projects and programs to advance our understanding of the biological principles underlying human performance. Dr. Hicks also serves as the Director of Research for the Mobilize Center, an NIH Biomedical Technology Resource Center at Stanford University and the Restore Center, an NIH-funded center that brings state-of-the-art engineering tools to rehabilitation scientists. Her research is focused on interfacing biomechanical modeling with statistical and machine learning methods to predict the effects of surgery and other interventions on human movement. She is also using data from mobile phones and other novel sources to understand physical activity and performance. Dr. Hicks helps run the multi-faceted training and outreach programs of the Human Performance Alliance, the Mobilize Center and the Restore Center. In addition, as the Research and Development Manager for the OpenSim software project, she guides the project's development team and serves as the voice of the software user/researcher.

Konrad Kording, PhD
The Nathan Francis Mossell Professor
University of Pennsylvania, Philadelphia PA

Konrad Kording runs his lab at the University of Pennsylvania. Konrad is interested in the question of how the brain solves the credit assignment problem and similarly how we should assign credit in the real world (through causality). In extension of this main thrust he is interested in applications of causality in biomedical research. Konrad has trained as student at ETH Zurich with Peter Konig, as postdoc at UCL London with Daniel Wolpert and at MIT with Josh Tenenbaum. After a decade at Northwestern University he is now PIK professor at UPenn.

Richard L. Lieber, Ph.D.
Senior Vice President
& Chief Scientific Officer,
Shirley Ryan AbilityLab

Dr. Lieber earned his Ph.D. in Biophysics from U.C. Davis developing a theory of light diffraction that was applied to mechanical studies of single muscle cells. He received his M.B.A. from the UCSD Rady School of Business and is currently Chief Scientific Officer and Senior Vice President at the Shirley Ryan AbilityLab and Professor of Physical Medicine & Rehabilitation at Northwestern University in Chicago, IL. Dr. Lieber's work is characterized by its interdisciplinary nature—an approach that is relevant to those who study biomechanics and Orthopaedic Surgery. He has published over 300 articles in journals ranging from the very basic such as *The Biophysical Journal* and *The Journal of Cell Biology* to those more applied such as *The Journal of Hand Surgery* and *Clinical Orthopaedics* and *Related Research*. Dr. Lieber's research focuses on design and plasticity of skeletal muscle.

Megan K. O'Brien, PhD
Research Scientist, Technology and Innovation Hub (tiHUB)
Research Assistant Professor of PM&R, Northwestern University

Dr. O'Brien's research utilizes sensors and other mobile technologies to measure, monitor, and improve rehabilitation outcomes. She applies interdisciplinary techniques in engineering, biomechanics, and machine learning to identify disease-specific biomarkers of health and behavior across the continuum of care, from the clinic to the home. Example projects include: predicting long-term recovery after a stroke, understanding changes in community activity and social interactions for individuals with chronic disease, and early screening of neuromotor delays in infants.

PANELISTS

Aiden Arnold, Ph.D.
Lead Data Scientist | Rune Labs

Aiden is a data-centric scientist with a PhD in cognitive neuroscience. His work is at the intersection of humans and AI, with expertise in digital therapeutics, biometric algorithm development, and interfacing behavioral science with machine learning. He currently leads data science at Rune Labs, a precision neurology company leveraging wearables, brain sensing and machine learning to develop and monitor next generation therapies. Previously, he led AI innovation for Zepp Health and had his research featured in The New York Times, The Atlantic, and The Nature of Things.

Ha Uk Chung PhD
Cofounder, VP of R&D of Sibel Health

Ha Uk Chung PhD, is a an electrical engineer, entrepreneur, and technology innovators. As a cofounder and VP of R&D of Sibel Health, he is leading technology innovations to improve patients care from neonatal to elderly populations. He received his undergraduate and Masters degrees in electrical and computer engineering from University of Illinois at Urbana-Champaign, and a PhD in electrical engineering from Northwestern University. Dr. Chung has authored more than 20 peer-reviewed publications with over 4,500 citations from his publications and he is an inventor of over 10 issued and pending patents. His publications have appeared in Science, Nature Medicine, and other renowned journals garnering press attention from The New York Times, CNN, and The Washington Post. His technologies have garnered more than $50 million dollars in funding and monitored more than 12,000 individuals to date.

Joseph Hitt, Ph.D.
CEO and Co-Founder GoX Labs, Inc.

Dr. Hitt is a highly successful business owner who took his first company from 2 to over 400 employees under contract in 36 months. It was #27 on the INC 500 in 2019. He created the world's first bionic running leg showcased on the DISCOVERY CHANNEL with a Special Forces amputee running at 8 mph four months after losing his limb. Dr. Hitt managed a wide variety of advanced technology programs with a budget in excess of $1 Billion. He was a DARPA Program Manager for exoskeletons, humanoid robotics, guided bullets, and wearable technology. He led, as an Associate

Professor, the United States Military Academy's Aerodynamics and Thermodynamics Group in the #2 US NEWS & WORLD REPORTS nationally ranked Mechanical Engineering Program and started the biomechanics program at the United States Military Academy.

Hulya Emir-Farinas, Ph.D.
Senior Staff Research Scientist, Consumer Health Research Team of Fitbit.

Hulya holds a Ph.D. in Operations Research from the University of Florida. Her team's work is at the intersection of machine learning, behavior science, and healthcare. She and her team explore Fitbit health behavior and signals data, identify behaviors to target, design data driven and behavior science informed interventions, and finally work with cross-disciplinary teams to prototype these interventions, run controlled experiments, and analyze their efficacies.

AGENDA

15 Minutes	**Course Welcome and Expectations** Richard L. Lieber, Ph.D.
1 Hour	**Foundations In Machine Learning and Classes Of Problems That Can Be Solved** Eric Perreault, Ph.D.
1 Hour	**Applications of Sensors and Machine Learning In Rehabilitation** Megan K. O'Brien, Ph.D. & Arun Jayaraman, PT, Ph.D.
45 Minutes	**Challenges and Best Practices For Applying Machine Learning To Real-World, Large-Scale Health Data*** Jennifer Hicks, Ph.D.
45 Minutes	**Most Studies Using Machine Learning Make Elemental Mistakes: How Prevalent Are They and How Can We Avoid Them For Rehabilitation Studies?*** Konrad Kording, Ph.D.
45 Minutes	**Deriving Clinically-Relevant Information From Sensor and Video Data Using Machine Learning-Based Algorithms*** Paolo Bonato, Ph.D
45 Minutes	**Tools For Collecting Large-Scale Movement (or Biomechanics) Data*** Scott Delp, Ph.D.
1 Hour	**Looking Forward: Where Data Analysis Could Push The Field Forward*** Moderator: Joy Ku, Ph.D.

*These presentations are not available for ASHA CEUs.

LOCATION

The program will be held online. All programming will be shared through an online meeting platform, Zoom, and the Academy Learning Portal.

TECHNOLOGY REQUIREMENTS

To participate, you will need access to a computer with an internet connection. High-speed broadband access (LAN, Cable or DSL) is highly recommended.

- Internet connection: broadband wired or wireless (3G or better)
- Web browser:
  - Apple Safari: Latest stable version
  - Google Chrome: Latest stable version
  - Mozilla Firefox: Latest stable version
  - Microsoft Edge: Latest stable version
- JavaScript and Cookies enabled
- Speaker or headset to listen to audio files and participate in Zoom calls
- Do NOT use Internet Explorer, as it is not supported.

ACCESSIBILITY

Please contact the Academy if you require special accommodations for this course.

CONTINUING EDUCATION CREDIT

Physical Therapy

This course has been approved by the Illinois Physical Therapy Board 6.0 Contact Hours. Approval #216-000069

The Shirley Ryan AbilityLab is recognized by the New York State Education Department's State Board for Physical Therapy as an approved provider of physical therapy and physical therapist assistant continuing education. This course has been approved for 6.0 Contact Hours

The following states require continuing education units with no state-specific approval: CT, IA, and WA

Speech-Language Pathology

Rehabilitation Institute of Chicago dba Shirley Ryan AbilityLab

Advanced Level

0.20 ASHA CEUs

FACULTY AND PLANNING COMMITTEE DISCLOSURES:

Course Director's and Planning Committee Members' Disclosure Information:

Rebecca Bagdy, MBA	Has nothing to disclose.
Ronald Cotton, MD, Ph.D.	Has nothing to disclose.
Arun Jayaraman, PT, Ph.D.	Has nothing to disclose.
Melissa Kolski, PT, DPT	Has nothing to disclose.
Joy Ku, Ph.D.	Has nothing to disclose.
Eric Perreault, Ph.D.	Has nothing to disclose.
Matt Petrucci, Ph.D.	Has nothing to disclose.

Speakers, Moderators and Panelists' Disclosure Information:

Aiden Arnold, Ph.D.	Receives a salary from Rune Labs and equity ownership.
Paolo Bonato, Ph.D.	Receive a grant from Barrett Technology (Newton MA), BioSensics (Watertown MA), Veristride (Salt Lake City UT).
Ha Uk Chung, Ph.D.	Receives a salary and IP from Sibel Health.
Scott Delp, Ph.D	Has nothing to disclose.
Hulya Emir-Farinas, Ph.D.	Receives a Salary from Google.
Jennifer Hicks, Ph.D	Has nothing to disclose.
Joseph Hitt, Ph.D	Has nothing to disclose.
Konrad Kording, Ph.D.	Has nothing to disclose.
Richard L. Lieber, Ph.D.	Has nothing to disclose.
Megan K. O'Brien, Ph.D.	Has nothing to disclose.