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ERGO X SYMPOSIUM Proceedings

OCTOBER 14 - 15, 2022

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October 14-15, 2022

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Exoskeleton Preface

2022 marks the fifth year of ErgoX in the technology focused User-Centered Design (UCD) format and the seventh year overall for the symposium. The overall symposium expanded into four tracks with Extended Reality (XR) joining the ranks of Exoskeletons, Robotics, and Cybersecurity.

Specific to the Exoskeleton Track though, Dr. Christopher Reid (The Boeing Company), 2021-2022 Human Factors & Ergonomics Society (HFES) President, as well as ErgoX Chair opened up the day's welcome with an overview on the 2022 outlook of exoskeletons. Noting the primary growth sectors opportunities in industry (manufacturing, construction, and distribution), healthcare (sharing more than half of the exoskeleton market specific to rehabilitation) and military (logistics and Warfighter mobility/weight bearing), Dr. Reid pointed to the latest tally of over 170 globally accessible commercially available exoskeletons (Exoskeleton Report, 2021). His briefing also touched on what it would take to continuously produce user friendly systems that would help push the exoskeletons through the Hype Cycle's "Trough of Disillusionment" noted from Gartner 2018. This included evaluating exoskeletons for human usage and sustainment by including laboratory testing, short and long duration field trials, and pursuing usable standards for developers and system users. Examples of risks that needed to be solved included safety, ergonomic, and human factors hazards and opportunity to design for these using design readiness levels that included Technology Readiness Levels (TRL), Manufacturing Readiness Levels (MRL), and newly available, Human Readiness Level (HRL). With the growing number of global producers now at 118 according to Exoskeleton Report (2021), Dr. Reid, didn't miss the chance to point out the realistic view that the world was still reeling from the shakeup of COVID-19 that added to producer uncertainties, such as lack of supply chain stability, limited investors, limited consumer demand, limited consensus standards, and lacking government regulations. Until these areas find improvement, the recommendation was to stay the path of continuing to design for the people that would be using and sustaining these devices and learning through annual iteration how to evolve effectively with design.

Keynote Address

This year's Keynote Address was given by Dr. Thomas Karakolis, Defence Scientist from the government organization, Canadian Defence Research & Development Canada. His talk title was "Military Exoskeletons: What Will It Take for Them to Be Adopted". His talk focused on the need for exoskeleton equipment to be developed for Soldier human-systems integration. Any Soldier wearing these devices needed to be able to accomplish their mission objectives without being injured due to wearing the device. Current available military based exoskeletons that were evaluated by Dr. Karakolis' team found that the systems still have not surpassed the human augmentation curve that allowed for them to give a positive contribution to combat Soldiers while not impeding their effectiveness, in this case, for walking performance while loadbearing equipment. The findings from his talk point to the lack of adaptability in the current designs of these exoskeletons to dynamic mission criteria with users, tasks, and/or their environments. His closing argument points to a clear need for further machine intelligence to be developed in order to meet the noted gaps so that their human users can find positive contribution from the system.

Sponsor Talks

This year's program had six sponsor talks of the ten event sponsors. Moderated by Dr. Don Peterson (Northern Illinois University), the Exoskeleton Track was supported by talks from South Carolina Research Authority, German Bionic, HeroWear, LLC, ASTM International's Exo Technology Center of Excellence, Human Solutions of North America, Inc., and ErgoSante.

Research Methods 1 – Human Research Evaluations: Lab & Field Findings

The Exoskeleton Track program consisted of three technical sessions, known as Research Methods 1 through 3. The first of these was the Human Research Evaluations: Lab & Field Findings session. This session heard from speakers whose research was looking at the human testing of exoskeletons in both laboratory and field settings. Dr. Bill Marras from Ohio State University, was the session Moderator and hosted Dr. Jose "Pepe" Contreras-Vidal from the University of House (Brain-Machine Interfaces to Powered Exoskeletons to Improve Quality of Life and Independence in People with Disabilities), Mr. Paul Slaughter from Vanderbilt University (Developing and Field-Testing Back Exosuits with U.S. Army Soldiers), Dr. Sunwook Kim from Virginia Tech University (Field Assessment of an Arm-Support Exoskeleton in Automotive Assembly) and Dr. Jennifer Neugebauer Sperlein from the U.S. Army Combat Capabilities Development Command (DEVCOM) Analysis Center (Human-System Integration and Performance Assessment of Exoskeletons for Military Applications).

Research Methods 2 – Lessons Learned from Industrial Exoskeleton Deployments

Led by Dr. Christopher Reid of Boeing, Research Methods 2 was specific to post deployment knowledge gains from the manufacturing companies that deployed them. The talks included Mr. Ryan Porto from General Motors (Adoption and Implementation of Exoskeletons in the Automotive Industry), Mr. Seth Burt from Toyota Motor Manufacturing Canada (Evaluation and Implementation of Industrial Exoskeletons as an MSD Control) and Mr. Kevin Hansen from The Boeing Company (Deployment and Sustainment Methods of Industrial Exoskeletons in the Workplace).

Research Methods 3 – Standards to Research to Practice

Research Methods 3 was moderated by Dr. Bill Billotte (ASTM International) and spoke to Emerging Topics of interest for exoskeletons. These topics included talks by speakers Dr. Bochen Jia from the University of Michigan (The Application and Precautions of Using Digital Human Modeling Technology in Exoskeleton Design and Evaluation), Dr. Delia Treaster from The Boeing Company (Ergonomics Considerations of Industrial Exoskeletons), Dr. Bob Sugarman from Stavatti Aerospace (Human Factors Practice for Developing Standard Test Methods - All the Things About Testing People Your Professor Never Told You) and Dr. Don Peterson from Northern Illinois University (Development of Safe and Practical Exoskeleton Standards).

Closing Remarks

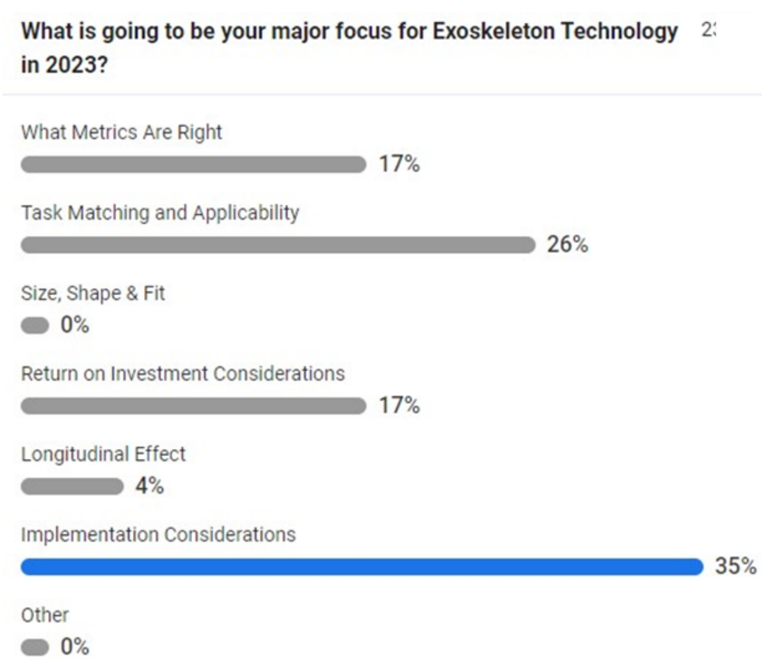
This year, Dr. Don Peterson led the closing discussion with panelists, Bobby Marinov (Exoskeleton Report), and Drs. Bill Billotte and Christopher Reid.

Some thoughts that came out of the discussion include:

- Would government regulation of exoskeletons improve standardizing their designs for people and/or increase consumer confidence for purchasing? Some thought so, while others purported that it could take a long time for those regulators to get in place and it might restrict innovation on the side of the developers. This was of course beyond healthcare/medical exoskeletons that are currently regulated by North American and European governments for patient safety.

- Another area discussed was on industrial exoskeleton sustainability post deployment and the difficulties found by the companies deploying them. Examples of difficulties included a continuously fluctuating user base due to dynamic work environments, lack of continuous user acceptance for utilization, and fluctuating work environment constraints that might inhibit use of exoskeletons. One comment from an attendee proposed that if the system wasn't found to be used for work at 80% or greater in the job, then the value of them might not be perceived by users.

The day's discussion ended with where attendees felt the focus for exoskeletons would be on for 2023. Of the different categories weighed, "Implementation Considerations" was at the top of the list followed by "Task Matching and Applicability" (Figure 1). So this speaks to the continued evolution of focus for those that have attended the event over the last five years. It started in 2018 with "Return on Investment Considerations" being the major focus, to "Task Matching & Applicability" in 2019, to "What Metrics are Right" in 2020, then having "What Metrics are Right" tied with "Implementation Considerations" in 2021. We're sure to continue to see the ecosystem of exoskeleton technologies continue to change as the technologies evolve for a consumer base that is becoming more and more aware of how to implement and use them. On behalf of the ErgoX Exoskeleton Track planning team, we look forward to connecting again at the next event, which will take place at the Washington Hilton Hotel in Washington DC on October 23, 2023.



Christopher R. Reid, Ph.D.
President, Human Factors & Ergonomics Society (2021-2022)
ErgoX Symposium Chair
ErgoX Exoskeleton Track Symposium Chair

Donald R. Peterson, Ph.D., MS, FAIMBE
ErgoX Exoskeleton Track Symposium Co-Chair

William S. Marras, Ph.D., CPE
ErgoX Exoskeleton Track Symposium Co-Chair

Hongwei Hsiao, Ph.D.
ErgoX Exoskeleton Track Symposium Co-Chair
ErgoX Robotics Track Symposium Chair

Reference Section

1. *Updated Directory of Exoskeleton Companies and Industry Statistics,* Exoskeleton Report, 16 December 2021, https://exoskeletonreport.com/2021/12/updated-directory-of-exoskeleton-companies-and-industry-statistics/.

2. *Gartner Identifies Five Emerging Technology Trends That Will Blur the Lines Between Human and Machine,* Gartner, 20 August 2018, https://www.gartner.com/en/newsroom/press-releases/2018-08-20-gartner-identifies-five-emerging-technology-trends-that-will-blur-the-lines-between-human-and-machine.

Exoskeleton Program

October 14-15, 2022

Session	Speakers
Keynote Lecture: Military Exoskeletons: What Will it Take for Them to be Adopted?	Thomas Karakolis, Canadian Department of National Defence
Opening & Research Methods 1 - Human Research Evaluations: Lab & Field Findings	Moderator: Bill Marras, Ohio State University Christopher R. Reid, The Boeing Company Jose 'Pepe' Contreras-Vidal, PhD, University of Houston Paul Slaughter, Vanderbilt University Sunwook Kim, Virginia Tech University Maury A. Nussbaum, Virginia Tech University Marty Smets, Ford Motor Company Jennifer Neugebauer Sperlein, DEVCOM Analysis Center
Exhibitor/Sponsor Session	Moderator: Don Peterson, Northern Illinois University
Research Methods 2 - Lesson Learned from Industrial Exoskeleton Deployments	Moderator: Christopher Reid, The Boeing Company Ryan Porto, General Motors Seth Burt, Toyota Motor Manufacturing Canada Kevin Hansen, The Boeing Company
Research Methods 3 - Standards to Research to Practice	Moderator: Bill Billotte, ASTM International Bochen Jia, University of Michigan Delia Treaster, PhD, CPE, The Boeing Company Robert (Bob) Sugarman, PhD, PE, FHFES, Stavatti Aerospace Donald R. Peterson, Northern Illinois University
Closing Discussion from Track Chairs & Moderators	Moderator: Donald R. Peterson, Northern Illinois University Chris Reid, The Boeing Company Bill Marras, Ohio State University Bill Billotte, ASTM International Borislav Marino, ASTM International

Exoskeleton Sessions

October 14-15, 2022

Keynote Lecture: Military Exoskeletons: What Will it Take for Them to be Adopted?

Thomas Karakolis, Canadian Department of National Defence

Dr. Thomas Karakolis is a Defence Scientist with the Canadian Department of National Defence. He is currently working for Defence Research & Development Canada's (DRDC) Toronto Research Centre. His research interests focus on quantifying the operational performance benefits and drawbacks for both in-service and novel military equipment. For the past seven years, Dr. Karakolis has been the National Lead for Exoskeleton Technologies at DRDC. During this time he has authored a book chapter outlining, "A Roadmap for Biomechanical Testing and Evaluation of Future Human Exoskeletons with Respect to Soldier Performance," as well as authored/co-authored multiple peer-reviewed journal papers and reports in the field of testing and evaluating military exoskeletons. He also continues to work with his national and international partners/collaborators in the area, advocating the need for a paradigm shift in the development of military exoskeletons. Beyond his work specifically on exoskeletons, Dr. Karakolis also has broader interest in the areas of soldier performance, health, and survivability. Specifically, he has recently published on the topic of using an IMU based motion capture system to better characterize soldier movement patterns, and a qualitative systematic review examining the risk factors for musculoskeletal injuries in the military. The later work was a direct result of his role as co-chair for a NATO Research Task Group on Reducing Musculoskeletal Injuries in the Military.

Opening & Research Methods 1 - Human Research Evaluations: Lab & Field Findings

Brain-Machine Interfaces to Powered Exoskeletons to Improve Quality of Life and Independence in People with Disabilities

Jose 'Pepe' Contreras-Vidal, PhD, University of Houston

Noninvasive brain-machine interfaces (BMI) can be designed to engage the user, promote plasticity, and understand human-device interaction. BMI systems can be designed to infer motor intent from brain activity to control upper and lower-limb medical exoskeletons for diagnostic, assistance and rehabilitation purposes. BMI systems may also provide an opportunity to mitigate risks posed by exoskeletons, such as the risk of falls or user's errors; thus, making medical exoskeletons a technology to support the user's independence and learning during cognitive-motor development (in children) or activities of daily living at work, play or home.

Developing and Field-Testing Back Exosuits with U.S. Army Soldiers

Paul Slaughter, Vanderbilt University

Paul will discuss a partnership between Vanderbilt University and the U.S. Army that evaluated the physical demands of field artillery Soldiers, then developed and field-tested military-specific exosuits in collaboration with Soldiers. The talk will address musculoskeletal overuse injuries in the Army, physical limitations and overburdening identified by Soldiers, iterative prototype development, Soldier touch points, and field-testing, including results from Soldiers wearing back exosuits during a combat-realistic live fire exercise.

Field Assessment of an Arm-Support Exoskeleton in Automotive Assembly

Sunwook Kim, Virginia Tech University; Maury A. Nussbaum, Virginia Tech University; Marty Smets, Ford Motor Company
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An increased risk of shoulder musculoskeletal disorders (MSDs) is associated with prolonged or repetitive arm elevation, but reducing exposures to this risk can be challenging. Arm-support exoskeletons (ASEs) are a promising intervention, as they may reduce physical effort and MSD risks. Nearly all reported studies, though, have been completed over brief durations and/or in laboratory settings. The longer-term, real-world consequences of ASE use are largely unknown. We completed an 18-month prospective assessment of one ASE among automobile-assembly workers in several facilities, performing overhead tasks. We found that: 1) usability responses were generally consistent over time; 2) ASE use was perceived effective at reducing physical demands in the upper extremity; 3) perceived job performance and fit/comfort were key drivers of ASE intention-to-use; and 4) ASE use may decrease the likelihood of a medical visit. Several “lessons learned” will be also shared related to the challenges experienced in such a field study.

Human-System Integration and Performance Assessment of Exoskeletons for Military Applications

Jennifer Neugebauer Sperlein, DEVCOM Analysis Center
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Exoskeletons have long been pursued for implementation in military applications; challenges still exist, though, in integrating these systems for effective use in operational environments and to carry out common military tasks. Such challenges with current military-focused exoskeleton designs include but are not limited to control systems, power, load capacities, fit requirements, and the need to integrate with body-borne kit. To better understand these challenges, objective and subjective assessments of military users performing operational tasks with exoskeletons is critical. This often includes moving out of a laboratory into a field environment while maintaining high fidelity sensors and methods. Field based protocols with outcome metrics that quantify operationally relevant performance gains (or impacts) inform both the exoskeleton developer as well as military users and leaders. This brief will discuss military exoskeleton assessments and human-system integration considerations for exoskeletons used for military applications.

Sponsored Sessions

South Carolina Research Authority

German Bionic

HeroWear, LLC

ASTM International Exo Technology Center of Excellence (ET CoE)

Human Solutions of North America, Inc.

ErgoSanté

Research Methods 2 - Lesson Learned from Industrial Exoskeleton Deployments

Adoption and Implementation of Exoskeletons in the Automotive Industry
Ryan Porto, General Motors

This session will cover the implementation and management of a large-scale deployment of Exoskeletons within the automotive manufacturing environment.

Discussion will include an overview of the process and differences between implementing passive and active Exoskeletons in a variety of facilities for different tasks and conditions.

Evaluation and Implementation of Industrial Exoskeletons as an MSD Control
Seth Burt, Toyota Motor Manufacturing Canada

A key principle to a comprehensive MSD Prevention Program is the ability to assess hazards and issue controls. This session will cover the emerging technology that is Industrial Exoskeletons. Topics reviewed will include an applied perspective on Exoskeleton implementation and use, along with underlying research on their utility and potential impact on MSDs.

Deployment and Sustainment Methods of Industrial Exoskeletons in the Workplace
Kevin Hansen, The Boeing Company

Industrial exoskeletons show increased promise to reduce occupational risks, improve task acceptability and have improved over time in design and user acceptability. However, there are still many questions about how to implement and sustain exoskeleton devices from industry users. Boeing is just one of many businesses working to improve the work environment of their industrial workers with exoskeletons. There are several things that know can help. While we do not see that exoskeletons will solve all of our occupational problems, we do see them as a means to help reduce some of the burden in producing and maintaining our products.

Research Methods 3: Emerging Topics

The Application and Precautions of Using Digital Human Modeling Technology in Exoskeleton Design and Evaluation

Bochen Jia, University of Michigan

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Digital Human Modeling (DHM) as an advanced evaluation tool is widely used in the design and evaluation of exoskeleton systems. Incorporating with humans' anthropometric and biomechanical details, the DHM technologies have the capacity to provide detailed and instant understandings of human physical state during human-exoskeleton interaction. However, many factors, such as the proper parameter setting and appropriate data interpretation, could directly affect the correctness of the evaluation results. Further, Applicable scenarios for HDM, such as for return-to-work injured workers, require further clarity as well. Therefore, from basic terminology to primary modeling methods, there is a strong need to establish related standard practice that provides recommended information about the correct and reasonable application of human digital modeling in the design and evaluation of exoskeletons and exosuits.

Ergonomics Considerations of Industrial Exoskeletons

Delia Treaster, PhD, CPE, The Boeing Company

Ergonomics is a primary factor when considering exoskeletons in industry. Many companies are interested in the possibility that exoskeletons can reduce the risk of worker injury from cumulative traumas such as back pain. However, it is important that an exoskeleton does not introduce unacceptable ergonomic risks, either from the exoskeleton itself or the way it is used. The goal of this document is to alert potential exoskeleton users to possible hazards for cumulative trauma associated with using an exoskeleton and to provide general guidelines for mitigating those hazards.

Human Factors Practice for Developing Standard Test Methods (All the Things About Testing People Your Professor Never Told You)

Robert (Bob) Sugarman, PhD, PE, FHFES, Stavatti Aerospace

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Products that include a person as part of its system are especially complex and difficult to evaluate because people are highly variable and differ along a multitude of metrics. This document establishes best practices for the design and execution of experiments that incorporate human behaviors and capabilities as variables and forms the basis of Standard Tests for human-in-the-loop products or systems, in particular exosystems. A standard is only as good as the validity of its assumptions. Criteria for successful compliance must be established for all boundaries of its application and must be validated with respect to the tasks in the real world for which it is a proxy. Because of the variability of humans by virtue of their individual characteristics, prior experiences, physical, physiological, and cognitive impacts of the task, any test results will be probabilistic and dependent on the requirements of the analysis to determine their reliability.

Development of Safe and Practical Exoskeleton Standards

Donald R. Peterson, Northern Illinois University

Exoskeleton technologies aim to provide opportunities to increase human safety and efficiency in industrial, emergency response, medical, military, and consumer applications. As the exoskeleton industry continues to progress, consensus standards are essential to establish minimum performance specifications and testing procedures that ensure durability and reliability and to establish protocols that ensure functionality, compatibility, and user safety. Understanding common specifications and protocols from latest research and practices is a critical step towards the development of safe and practical exoskeleton standards that emphasizes the interoperability of several technologies and systems, including human systems and Human Machine Interfacing (HMI). ASTM International's Committee F48 on Exoskeletons and Exosuits and the Exo Technology Center of Excellence has led the latest efforts to develop international standards for exoskeleton technologies that address safety, quality, performance, ergonomics, etc.

Extended Reality Program

October 14-15, 2022

Session	Speakers
Keynote: Featuring Opening Keynote Address by Amy Peck, Founder and CEO of EndeavorVR	Amy Peck, EndeavorXR
Newlywed Panel: Sharing XR Lessons Learned	Moderator: Emily Mills, Design Interactive, Inc. Elizabeth Baron, Unity Carolina Cruz-Neira, University of Central Florida Amy Peck, EndeavorXR Kay Stanney, Design Interactive, Inc.
XR Storytelling Journey	Moderator: Brian Laughlin, The Boeing Company Elizabeth Baron, Unity Doug House, Porsche
XR Early Adopter Fireside Chat	Moderator: Carolina Cruz-Neira, University of Central Florida Mary Cole, Wayfair Blaire MacIntyre, Georgia Tech
XR Speakers' Quiz	Moderator: Elizabeth Baron, Unity Scott Burkey, Westrock Amy Peck, EndeavorXR Dirk Reiners, University of Central Florida, Computer Science
Speakers' Corner Debate: What's More Important to the Adoption of XR Technology: Digital Twins or Digital Phenotypes?	Moderator: Emily Mills, Design Interactive, Inc. Fabio Terasaka, Hitachi Vantara Brent Winslow, Design Interactive, Inc.

Robotics Preface

The advancement of emerging collaborative robotics during the COVID pandemic over the past three years has accelerated the transformation of hybrid workforces. The transformation includes human-robot workforce composition, teleoperation vs. in-person collaboration with robots, human-robot-systems integration, and the trustworthiness of human-robot interfaces, among others. In responding to the need for discussions on hybrid workforces in robotics, the ErgoX this year focused on the theme of Hybrid Workforces in Robotics in the Workplace to signify the status and advancement of emerging technologies in robotics in occupational settings. Five symposium goals were identified:

- Exploring current hybrid workforces in robotics and the future of work
- Uncovering human-robot communication technologies for safety and efficiency
- Finding insight in robotics methods and its applications
- Discussing challenges and best practices with experts in hybrid robotics with the aim of improving inclusiveness, trustworthiness, safety awareness, and reducing worker stress
- Networking for partnerships on hybrid robotics research for worker health and well-being, such as remote operation, virtual simulation, and mixed work scheduling for workers

The symposium began with a keynote address on Human and Robot – a Collaborative Workforce by Nia Jetter of Amazon Global Robotics. Ms. Jetter brought her 20 years of experience as a Technical Fellow in the Aerospace Industry and her leadership as an Amazon Chief Engineer for autonomous mobile robots with enlightening information on human-robot collaborative workforces.

Following the keynote presentation, Dr. Jesse Jacobs from the Liberty Mutual Insurance delivered a timely and informative presentation on Collaborative Robotics - Knowns and Needs in the Scientific Literature. Jesse is the Product Director of Science and Research for Risk Control Services at Liberty Mutual Insurance. Liberty Mutual Insurance provided a Platinum sponsorship for the symposium.

We then had five Research Sessions within the scope of the main theme “Hybrid Workforces in Robotics in the Workplace.” The first Research Session focused on Trustworthiness of Human-Robot Interfaces. Professor Karen Chen (North Carolina State University), Professor Boyi Hu (University of Florida), and Dr. Marvin Cheng (National Institute for Occupational Safety and Health) presented their works on trustworthiness of human-robot interface in the workplace. Professor Robert Radwin (University of Wisconsin – Madison) chaired the Session. The second Research Session focused on Human-Drone Collaboration. Professor Masoud Gheisari (University of Florida), Professor Julie A. Adams (Oregon State University), and Professor Jose Baca (Texas A&M University – Corpus Christi) presented their works on strategies and solutions for human-drone collaboration. Dr. Craig Schlenoff (National Institute of Standards and Technology) chaired the Session.

The third Research Session covered the subject of human-centered design of robotics. Dr. Sascha Wischniewski (Federal Institute for Occupational Safety and Health, Germany), Dr. Gwen Bryan (Florida Institute for Human and Machine Cognition), and Professor Matthew Gombolay (Georgia Tech University) presented their works on human-centered collaboration robotics in a hybrid human-robot workforce. Dr. Lixiao Huang (Arizona State University) chaired the Session. The fourth Research Session addressed the matter of Human-Robot Interface Simulation. Dr. Joseph Manganelli (Xplr Design), Professor Suman Chowdhury (Texas Tech University), and Dr. Jeremy Marvel (National Institute of Standards and Technology) covered the topics of modeling, simulation, and digital twin in human-robot interface applications. Dr. Menekse Barim (National Institute for Occupational Safety and Health) chaired the Session.

The last Research Session highlighted Mobil Robot Applications. Mr. Fahrudin Alagic, Ms. Mikell Taylor, and Mr. Justin Croyle (Amazon Robotics), Professor Charlie Kemp (Georgia Tech University), and Dr. Vy Nguyen (Hello Robot Inc.) discussed their mobile robot research and applications in warehousing and healthcare settings. Professor Hongwei Hsiao (Texas A&M University – Corpus Christi) chaired the section.

With the number of emerging topics on hybrid workforce in robotics in the workplace and time limitations this year, the symposium had to pass on panel discussion. We had five discussion topics on robotics last year (2021) at the closing panel discussion and had nine to-be-discussed subjects left for 2022 and beyond. We hope to resume panel discussions at future symposia.

The organizing committee members for the symposium are:

- Hongwei Hsiao, Ph.D., ErgoX Robotics Track Symposium Chair, is a Professor & the Rogelio Benavides Memorial Chair with Texas A&M University – Corpus Christi. He is retired Chief of the Protective Technology Branch and Coordinator for Center for Occupational Robotics Research, National Institute for Occupational Safety and Health (NIOSH).
- Robert Radwin Ph.D., ErgoX Robotics Track Symposium Co-Chair, is Duane H. and Dorothy M. Blumke Professor in industrial and systems engineering and biomedical engineering at the University of Wisconsin-Madison. He is a Discovery Fellow at the Wisconsin Institute for Discovery.
- Craig Schlenoff, Ph.D., ErgoX Robotics Track Symposium Co-Chair, is Group Leader of the Cognition and Collaboration Systems Group and Program Manager of the Measurement Science for Manufacturing Robotics Program in the Intelligent Systems Division at the National Institute of Standards and Technology (NIST).
- Christopher R. Reid, Ph.D., ErgoX Robotics Track Symposium Co-Chair, is Human Factors & Ergonomics (HFE) Technical Fellow for Boeing's Environment, Health & Safety (EHS) organization. He is the President, Human Factors & Ergonomics Society 2022.
- Lixiao Huang, Ph.D., ErgoX Robotics Track Symposium Section Chair, is an Associate Research Scientist at the Center for Human, Artificial Intelligence, and Robot Teaming (CHART) within Global Security Initiative (GSI) at Arizona State University.
- Menekse Salar Barim, Ph.D., ErgoX Robotics Track Symposium Section Chair, is a Research Fellow with National Institute for Occupational Safety and Health (NIOSH).

On behalf of the organizing committee, I would like to express our sincere gratitude to participants, speakers, sponsors, and the Human Factors and Ergonomics Society staff for their contributions to this successful symposium.

Hongwei Hsiao, Ph.D.

Robotics Program

October 14-15, 2022

Session	Speakers
Keynote Lecture: Human and Robot, a Collaborative Workforce	Nia Jetter, Amazon
Trustworthiness of Human-Robot Interface	Moderator: Robert Radwin, University of Wisconsin Karen Chen, North Carolina State University Boyi Hu, University of Florida Marvin Cheng, NIOSH
Human-Drone Collaboration	Moderator: Craig Schlenoff, NIST Masoud Gheisari, University of Florida Julie A. Adams, Oregon State University Jose Baca, Texas A&M University
Human-Centered Design	Moderator: Lixiao Huang, Arizona State University Sascha Wischniewski, Federal Institute for Occupational Safety and Health, Germany Gwen Bryan, Florida Institute for Human and Machine Cognition Matthew Gombolay, Georgia Tech University
Human-Robot Interface Simulation	Moderator: Menekse Barim, NIOSH Joseph Manganelli, Xplr Design Suman Chowdhury, Texas Tech University Jeremy Marvel, NIST
Mobile Robot Applications	Moderator: Hongwei Hsiao, Texas A&M University - Corpus Christie Fahrudin Alagic, Amazon Robotics Mikell Taylor, Amazon Robotics Justin Croyle, Amazon Robotics Charlie Kemp, Georgia Tech University Vy Nguyen, Hello Robot Inc.

Robotics Sessions

October 14-15, 2022

Keynote: Human and Robot, a Collaborative Workforce

Nia Jetter, Amazon

Nia Jetter is passionate about changing the world through innovation, technology planning, teaching, mentoring and solving tough problems in Autonomy and AI that can be applied across different platforms. She has a dedicated focus on helping people who may not have easy access to educational materials to understand topics like artificial intelligence. Nia is enthusiastic about working the human-AI interface as artificial intelligence is further integrated into our society.

Nia is an Aerospace Engineer who has 20 years of experience in the Aerospace Industry and has developed key algorithms in supporting a variety of programs across the product-lifecycle from design and development to mission and anomaly resolution and through customer delivery and support. In January 2021, Nia left the Aerospace Industry as a Technical Fellow to join Amazon as a Senior Principal Technologist in Robotics. In this role as a leader in technical development for autonomy as well as strategic planning for robotics and other autonomous applications, Nia has so far led an Autonomous Mobile Robot that will be deployed in an unstructured environment through Preliminary Construction Review for Safety Certification as well as establishing best engineering practices for the product as Chief Engineer.

Nia has a bachelor's degree in Math with Computer Science and a minor in Earth Atmospheric and Planetary Sciences from MIT as well as a Master's Degree in Aeronautical and Astronautical Engineering from Stanford. Nia enjoys reading (especially science fiction), astronomy, baking, travelling and dancing. For more information, please see her website: www.niajetter.com.

Trustworthiness of Human-Robot Interface

Toward A Safer Work Environment: Robot Posture Adaptation in Human-Robot Collaboration

Karen Chen, North Carolina State University

While collaborative robots (cobots) possess various safety features, such as limited end effector speed and torque sensors, the OSHA Severe Injury Reports database has documented a number of robot-related mishaps where one-third of those occurred during normal, uninterrupted automated operations. This research aims to mitigate human-robot collisions through computer vision human activity recognition. A collision avoidance scheme employing a two-level hazard zone was defined around a cobot's end-effector. Upon the detection of a worker, the worker's position and movement speed determined by Videopose3D (computer vision algorithm) activated a series of visible and audible warnings and cobot end-effector retraction. The evaluation of this collision avoidance scheme demonstrated successful end-effector retraction and increased intensity and frequency the visual and auditory warning as a worker continued to approach the cobot. In sum, this collision avoidance is a plausible safety mechanism, but it should be noted that it is primarily designed to be active when interactions between a worker and a cobot was not supposed to take place.

Ergonomics in Robotic-Assisted Manufacturing and Remanufacturing

Boyi Hu, University of Florida

Traditionally, e-waste recycling is labor intensive, and represents multiple safety threat to workers. To reduce safety risk and enhance working efficiency, collaborative robots (cobots) might be a viable option. Therefore, the feasibility of deploying cobots in e-waste disassembly operations needs to be investigated. The major objective of this study is to evaluate the effects of working with a cobot during e-waste disassembly processes on human workload and ergonomics through a lab based human subject experiment. Statistical results revealed that using a cobot to assist a desktop disassembly task reduced the sum of the NASA-TLX scores significantly, compared to disassembling by the human work only condition ($p = 0.001$). A significant reduction was observed in participants' mean L5/S1 flexion angle as well as mean shoulder flexion angle on both sides, when working with the cobot ($p < 0.001$). However, participants took a significantly longer time to accomplish the disassembly task when working with the cobot ($p < 0.001$). Results from this study could advance the knowledge of how human workers wound behave and react during human-robot collaborative e-waste disassembly tasks, and shed light on the design of better HRC for this specific context.

Understanding Safety and Trust of Human-Robot Interaction

Marvin Cheng, NIOSH
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Multi-robot-multi-worker (MRMW) workspaces have become common in manufacturing and transportation industries, which also make safe and effective human-robot interaction in these collaborative environments a critical issue. Unfortunately, safety standards related to industrial robotic applications nowadays still have a huge gap between regulated operations and working efficiency of robotic devices while human workers are present in the same workspace. Human-robot trust can affect the performance in such an environment. To ensure a safe collaborative environment for human workers, safe human-robot interaction (HRI), proactive collision-prevention strategies between robotic devices and human workers, and analysis of robot dynamics of robotic devices in human-robot collaboration are the major research activities in the Robotics Research Lab at NIOSH. By integrating machine vision and deep learning approach of motion recognition, collaborative robotic devices can actively avoid unscheduled contacts to prevent potential injuries. With the assistance of biosensor measurements, quantitative model of human-trust level can be investigated.

Human-Drone Collaboration

Safe Human-Drone Collaboration in Construction

Masoud Gheisari, University of Florida
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We have seen a tremendous increase in the use of drones on construction sites. While beneficial, integrating drones in construction raises novel occupational safety and health issues for construction workers, which are critical to identify, understand, and evaluate. Risks arise from unintended physical contact between drones and human workers or the cognitive interaction between workers and drones that may affect workers' attentional and psychological states. Every interaction, cognitive or physical, creates the potential for an accident. This presentation discusses a series of studies on the safety challenges of human workers working with or near drones. We first envision a future of construction work where human workers constantly interact and collaborate with these aerial robots to do their work on construction jobsites. We then discuss the novel health and safety risks that result from these worker-drone interactions. We will mainly focus on the physical risks, attentional costs, and psychological impacts of such interactions on human workers who work directly or indirectly with or around these robots. Finally, we will provide recommendations and guidelines to ensure the safe integration of these robots in construction.

The Lack of Realistic Workload Models for Single Human Supervising Multiple (Semi)Autonomous Drones

Julie A. Adams, Oregon State University

Models of a single human supervising multiple (semi)autonomous drones were developed in order to provide insight into the factors that impact human performance, identify research gaps, and inform future human-in-the-hardware loop evaluations. A loosely coupled delivery drone task and a tightly coupled wildland fire-fighting task were developed and modeled. Neither the human factors nor the human-robot interaction literature provides concrete evidence of realistic workload models to support model development for multiple drone scenarios, rather the literature focuses on generic enroute scenarios. This presentation will discuss limitations of existing models and some associated gaps to be addressed in order to accurately model realistic applied domains.

Human-Machine Interaction Strategies for Controlling Unmanned Aerial Vehicles

Jose Baca, Texas A&M University
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Through the years, Unmanned Autonomous Systems (UAS) such as ground robots and aerial robots, a.k.a. drones, have gained increasing popularity within the Science and Engineering field. They can be used for exploration and data acquisition over areas that are difficult to access and/or for wide variety of missions. UAS have proven to be useful in terms of human-risk reduction and time consumption. Previous studies have shown the feasibility for one operator to control one robot, as well as one operator to control multiple robots via a joystick or a predefine waypoint navigation. However, when it comes to controlling a multi-robot system, in real-time, by a single operator, several challenges arise, e.g., it is difficult to control the direction of a team of robots or a swarm, the right timing for the execution of tasks, or simply selecting certain robots within the team. In this research project, we propose the development of an intuitive way to control multi-robot system via Human Body Language. We have defined a Human-Machine interaction strategy where body posture and gestures will be used to control the UAS team in a more intuitive manner, this is called semi-autonomous mode. The focus of this research is to broaden the capabilities of UAS and their integration within our everyday lives. The outcome of the project can easily be integrated into other fields such as in search and rescue operations and private companies for monitoring and inspecting large facilities.

Human-Centered Design

Advanced Robotics and its Impact on Safety and Health at Work

Sascha Wischniewski, Federal Institute for Occupational Safety and Health, Germany

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The impact of new technologies and digitalization on occupational safety and health (OSH) has become an increasingly researched topic over the last decades. The introduction of systems to provide physical work assistance like advanced robotics has changed modern workplaces. Innovations in AI-based software has also further increased the breadth of possible applications. Advanced robotic systems can nowadays perform increasingly complex physical tasks, with more autonomy than previous technologies. This also expands the range of OSH dimensions that need to be considered when working with them.

Three major OSH dimensions within a workplace context can be distinguished: physical, psychosocial and organizational. The effects of the technology application can impose chances and challenges. Physical OSH impacts are most commonly observed as a result of physical alterations to the workplace integrated by new technology. These can be the increase of workplace safety and hazard reductions, but also new risks emerging from unexpected malfunctions or collisions. Organizational effects are most often related to and dependent on the technology introduction process, change management and training. Positive effects can be achieved through employee participation and fostering upskilling, while deskilling and misuse can result from a mishandling of these processes. The psychosocial effects on workers can be observed in context of function allocation, task and interaction design and the mode of operation and supervision in relation to technology. Here factors like acceptance, motivation and social support can influence OSH just like fear of job loss, perceived monitoring and automation bias.

The presented results are based on a research project performed by the German Federal Institute of Occupational Safety and Health (BAuA) on behalf of the European Agency for Safety and Health at Work (EU-OSHA), together with the Universities of Leicester and Essex as well as Millieu Consulting. The knowledge base for the project was created through a systematic literature review that included 183 publications, expert interviews and an EU-OSHA focal point consultation.

The Challenges of Collaboration in a Hybrid Human-Robot Workforce

Gwen Bryan, Florida Institute for Human and Machine Cognition

The Challenges of Teamwork in a Hybrid Human-Robot Workforce are the same as those at the heart of Human-Centered Design. It is about designing and building systems that work effectively with people. This involves understanding both the machines and the people they are being designed to work with. Specifically, it requires an understanding of teamwork to guide the design, techniques to build systems that support teamwork, and ways to measure the effectiveness of teamwork to ensure we are achieving our performance goals.

The Present and Future of Collaborative Robotics

Matthew Gombolay, Georgia Tech University

Robot teams are increasingly being deployed into human-robot teaming environments, such as manufacturing and disaster response, to enhance the safety and productivity of human workers. Adaptive decision-making algorithms are essential to satisfy and optimize domain-specific temporospatial constraints and human factors considerations. Unfortunately, exact methods do not scale to real-world problem sizes, and ad hoc heuristics need domain-expert knowledge that is difficult to solicit and codify. In this talk, I will share how we are developing novel architectures and optimization methods for graph neural networks to model and dynamically coordinate human-robot teams. I will show how our techniques can learn rich representations of complex scheduling problems without the need for ad hoc, manual feature and reward engineering. Finally, I will discuss human-factors insights we have gleaned through human-subject experimentation for how robots can explore the latent capabilities of their human teammates to maximize human-robot team fluency.

Human-Robot Interface Simulation

Modeling Computer-Based Agent Behaviors According to Rasmussen's Abstract Decomposition Space in Various Hybrid Work Contexts

Joseph Manganelli, Xplr Design

This presentation summarizes a work in progress modeling framework that shows cognitive work analysis and Rasmussen's Abstract Decomposition Space analytic models mapping cleanly onto and integrating usefully into the Object Management Group's Systems Modeling Language (SysML) as a technical basis for representing HART concerns in a shared representational framework developed from an integration of methods and tools that already exist. Case studies show examples of healthcare and industrial hybrid workflows. Current thoughts being explored for how to represent computer-based agent behaviors according to Rasmussen's Skills, Rules, Knowledge Framework are also shared.

Human Gait and Motor Performance in a Physics-Based Virtual Reality Simulation Testbed

Suman Chowdhury, Texas Tech University

The virtual reality (VR) system has been widely used for sensorimotor training and rehabilitation. The recent advancement in VR research to use VR trackers or VR integrated motion capture systems can assist the researcher in developing a physics-based VR system that can provide both physical and cognitive interactions of the interactive objects. We recently developed a low-cost, physics-based VR testbed that can provide real cutaneous and kinesthetic haptic feedback of the objects instead of computer-generated haptic feedback. This study aimed to evaluate the system by comparing motor control biomechanics of the users (i.e., neuromuscular and visuomotor performance) while they performed three human-robot collaborative (HRC) sequential pick-and-place lifting tasks. We determined the efficacy of the VR testbed usage on the sensorimotor performance of the human participants by comparing their joint movement kinematics and kinetics for the same tasks being performed in virtual and real environments. We hypothesized that the biomechanical parameters, such as joint angles, electromyography-based motor performance, and joint reaction forces, would exhibit limited discrepancies between the tasks performed in virtual and real environments. Results showed minimal discrepancies between tasks performed in virtual and real environments. The innovation of our physics-based VR testbed lies in providing actual haptics of the real object while subjects are immersed in the simulated virtual environment and thereby overcoming the limitations of the computer-generated haptics.

Applications of Digital Twin for Modern Industrial Robotics

Jeremy Marvel, NIST

A marked defining characteristic of modern industrial robotic applications is the increased integration of information to enable more flexible and intelligent applications. From sensor-driven robotic operations at a work cell level, to data-enabled, full-factory workflow optimization, the utility of procedural information has had a dramatic impact on the manufacturing process. As we move toward a fifth industrial revolution in which human involvement and connectivity becomes even more crucial, presenting this information in a meaningful way becomes even more critical. The concept of digital twin thus becomes prominent as a mechanism for providing crucial information about physical systems in a digital world. In this presentation, Dr. Jeremy Marvel will present various mechanisms by which a digital twin can be leveraged in human-robot systems to improve system performance, provide system verification and validation, and present transparent process and health monitoring of robotic systems.

Mobile Robot Applications

Safe and Efficient Human-Robot Collaboration: Enabling Technologies

Fahrudin Alagic, Amazon Robotics; Mikell Taylor, Amazon Robotics; and Justin Croyle, Amazon Robotics

Enabling a hybrid human/robotic workforce requires design for collaboration at a system level, which in turn requires design expertise in many functional areas including proper interpretation and implementation of relevant functional safety and regulatory standards, safety-rated hardware and software development, human-robot interaction, virtual simulation, and sensing technologies. Highest priorities when developing collaborative robots and robotic system are human safety, human perception of those products, efficacy and efficiency. Unsafe products are simply unacceptable. Beyond that, products perceived by users as unsafe – even if they meet safety regulations – will struggle in achieving acceptance, and systems whose safety design leads to inefficient operation result in long ROIs or may be completely infeasible. The balance of safety and solution efficiency is not well addressed in the market today. In this talk, we discuss a different approach for seamless human-robot interaction and, in turn, highly efficient robotic systems.

Mobile Manipulation for Healthcare

Charlie Kemp, Georgia Tech University

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Mobile robots with arms (mobile manipulators) can meaningfully benefit people with disabilities, but versatile mobile manipulators have been too big, heavy and expensive to be practical. Charlie Kemp, director of the Healthcare Robotics Lab at Georgia Tech and co-founder of Hello Robot, will present research that led to Hello Robot's Stretch, a compact and lightweight mobile manipulator that achieves a new level of affordability. He will also show examples of work by the growing community of researchers and developers using Stretch.

Achieving Functional Independence in Daily Activities with the Stretch Mobile Manipulator

Vy Nguyen, Hello Robot Inc.
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For people with and without a disability, participation in everyday activities is essential to health and well-being. Achieving functional independence promotes an individual's ability to engage fully in life situations that are purposeful and meaningful. However, people with severe motor impairments, such as quadriplegia, may experience greater physical, social, and environmental barriers limiting their ability and access to participate in their activities more independently. Furthermore, they frequently rely on their care partners to assist them with everyday activities. Subsequently, the care partners who provide complete assistance to their loved ones may experience significant caregiver strain that impacts their health, well-being, and ability to engage in meaningful activities. As a multidisciplinary team comprised of an occupational therapist, roboticists, and human factors specialists, we believe these challenges can be confronted and relieved by robotic technology designed for assistive use cases in the home, workplace, clinic, or in communities. We present a study that takes place in a home context. It explores how the Stretch mobile manipulator, created by Hello Robot Inc., was used by a non-speaking older adult with quadriplegia to perform his desired daily activities to promote autonomy, independence, and social participation while reducing the level of assistance required from his care partner. We will also present how using Stretch can enrich the personal needs of his care partner and assist with caregiving demands, such as engaging in exercise and meal delivery/clean-up.

Exoskeleton Speakers

Dr. William "Bill" Billotte is the Executive Director of the Exo Technology Center of Excellence and Director of Global Exo Technology Programs at ASTM International. Bill leads a dynamic team that pursues a vision of people of all ages free to pursue high-quality life and participate fully in work and society thanks to safe and reliable exo technologies. He is a member of Committee F48 on Exoskeletons and Exosuits and a board member for the Automotive Exoskeleton Group (AExG). Prior to joining ASTM, Bill spent the past 17 years providing scientific and technical advice to federal agencies, first responders, and international organizations on topics including exoskeletons, critical infrastructure protection, CBRNE detection, and first responder equipment.

Bill holds a Ph.D. in Biology from the University of Dayton, a Master in Science in Engineering from Wright State University, and a Bachelor of Mechanical Engineering from The Georgia Institute of Technology.

Seth Burt has practiced Ergonomics and Safety in various industries such as energy generation/distribution, municipality, and automotive supplier manufacturing. Currently Seth works as a Health and Safety professional and manager at Toyota Motor Manufacturing Canada Inc (TMMC) an organization with 10,000+ employees. Seth manages a team who develops and supports safety/ergonomic tools, standards, and procedures for use at TMMC and other Toyota North America facilities. He more recently lead manufacturing ergonomics practices for new Toyota/Lexus models built in Canada. Seth is a member on the Automotive Exoskeleton Group (AExG) formed and lead by Toyota North America and sponsored via the Wearable Robotics Association. Seth is also a committee member for the F48 Exoskeleton and Exosuit Standard developed by American Standard and Testing Methods (ASTM). Seth holds a Canadian Certified Professional Ergonomist (CCPE) designation and has a BSc in Kinesiology with an Ergonomics Specialization from the University of Waterloo.

Jose 'Pepe' Contreras-Vidal, PhD (Fellow IEEE, Fellow AIMBE) is Cullen Distinguished Professor of Electrical and Computer Engineering and Director of the NSF Research Center for Building Reliable Advances and Innovations in Neurotechnology (IUCRC BRAIN) at the University of Houston. He has pioneered noninvasive brain-machine interfaces and wearable exoskeletons to restore motor function in individuals with disabilities. He is co-chair of the IEEE SA Industry Connections group on standards for neural interfacing. His career development in biomedical engineering was highlighted by the journal Science. Dr. Contreras-Vidal is a member of the National Advisory Board for Medical Rehabilitation Research (NABMRR) at the National Institute of Health. His research has been supported by the National Science Foundation, the National Institutes of Health, DARPA, Industry and Philanthropy. His research has been highlighted in The Economist, Nature, Science, Der Spiegel, and Wall Street Journal, among others.

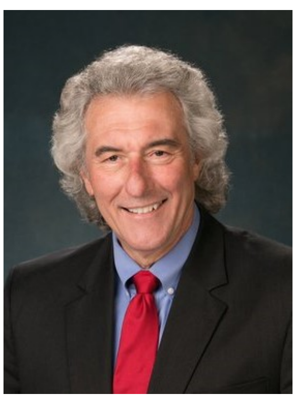
Kevin Hansen currently works as an Environmental Health & Safety Ergonomist for The Boeing Company's 747 & 767 program. Kevin has worked at The Boeing Company for 10 years, initially as physical therapy aide in their P.T. clinic, an Exercise Physiologist in their injury prevention program and most recently as the 747/767 program ergonomist and Everett site exoskeleton SME. Kevin has a B.S. in Exercise Science from California State University, Monterey Bay and has most recently completed the online HF/E program from University of California, Berkeley: Center for Occupational and Environmental Health (COEH). Initially pursuing an advanced degree in physical therapy, Kevin changed course and pursued career fields that prevented injury rather than treating it.

Dr. Bochen Jia is an Associate Professor at the University of Michigan-Dearborn and works on occupational ergonomics issues related to changes in worker abilities due to various risk factors, such as obesity and aging. His recent works focus on modeling and quantifying the impacts of intelligent interventions, i.e., exoskeleton on worker performance and safety, and further apply to develop guidelines for human-robot interaction for future complex work environments. Armed with strong research advantages for the automobile industry in Michigan, his research efforts also extend to ergonomic issues associated with road users (e.g., drivers and pedestrians) performance and safety under complex driving conditions with advanced technologies, such as connected and automated vehicle technologies. He is working on modeling the driver's fatigue development model under prolonged automated driving with the transition between manual and automated control.

Dr. Thomas Karakolis is a Defence Scientist with the Canadian Department of National Defence. He is currently working for Defence Research & Development Canada's (DRDC) Toronto Research Centre. His research interests focus on quantifying the operational performance benefits and drawbacks for both in-service and novel military equipment. For the past seven years, Dr. Karakolis has been the National Lead for Exoskeleton Technologies at DRDC. During this time he has authored a book chapter outlining, "A Roadmap for Biomechanical Testing and Evaluation of Future Human Exoskeletons with Respect to Soldier Performance," as well as authored/co-authored multiple peer-reviewed journal papers and reports in the field of testing and evaluating military exoskeletons. He also continues to work with his national and international partners/collaborators in the area, advocating the need for a paradigm shift in the development of military exoskeletons. Beyond his work specifically on exoskeletons, Dr. Karakolis also has broader interest in the areas of soldier performance, health, and survivability. Specifically, he has recently published on the topic of using an IMU based motion capture system to better characterize soldier movement patterns, and a qualitative systematic review examining the risk factors for musculoskeletal injuries in the military. The later work was a direct result of his role as co-chair for a NATO Research Task Group on Reducing Musculoskeletal Injuries in the Military.

Dr. Sunwook Kim received the M.S. degree in aerospace and ocean engineering and the Ph.D. degree in industrial and systems engineering from Virginia Tech, Blacksburg, VA, USA, in 2004 and 2012, respectively. He is currently a Research Assistant Professor of industrial and systems engineering with Virginia Tech. His research interests include occupational biomechanics, human-exoskeleton interaction, ergonomic intervention, postural balance assessment, and neurodiverse workplace.

Borislav "Bobby" Marinov is the co-founder of the Exoskeleton Report (ExR) news and information website and a founding member of the ASTM International Exo Technology Center of Excellence (ASTM ET CoE).



William S. Marras is the Distinguished University Professor and holds the Honda Chair in Integrated Systems Engineering at the Ohio State University. He serves as the Director of the Spine Research Institute at the Ohio State University where he leads NIH, NSF, DoD and privately funded research efforts. Dr. Marras also holds joint academic appointments in the Department of Orthopaedic Surgery, the Department of Neurosurgery, and the Department of Physical Medicine & Rehabilitation. His research is focused on understanding multidimensional causal pathways for spine disorders through quantitative epidemiologic evaluations, laboratory biomechanical studies, personalized mathematical modeling, and clinical studies of the lumbar and cervical spines. His findings have been published in over 300 peer-reviewed journal articles, hundreds of refereed proceedings, and numerous books and book chapters including a book entitled The Working Back: A Systems View. Professor Marras has been active in the National Research Council (NRC) having served on over a dozen boards and committees and has served as Chair of the Board on Human Systems Integration for multiple terms. He has also served as Editor-in-Chief of Human Factors and is currently Deputy Editor of Spine. Dr. Marras holds Fellow status in six professional societies and is an elected member of the National Academy of Engineering (the National Academy of Science, Engineering and Medicine), recorded a TEDx talk entitled "Back Pain and your Brain" and has been featured on NPR's All Things Considered.

Dr. Jennifer Neugebauer Sperlein is a biomedical engineer in the Weapons Branch of the Human Systems Integration Division of the U.S. Army Combat Capabilities Development Command Analysis Center (DEVCOM DAC), located in Aberdeen Proving Ground, MD. Jen's work is focused on investigating dismounted Soldier performance during operational tasks including marksmanship and exoskeleton technologies. Over the last decade, Jen has been heavily involved assessing exoskeleton technologies specifically for military applications. These assessments included early prototypes to commercial solutions for lower and upper body applications. Jen earned her MS and PhD from the University of California, Davis. She completed a post-doctoral fellowship with the U.S. Army Research Laboratory (ARL) prior to assuming a civilian role with ARL. Most recently, Jen has co-led the formation of biomechanics and human-system integration assessment capabilities within DAC.

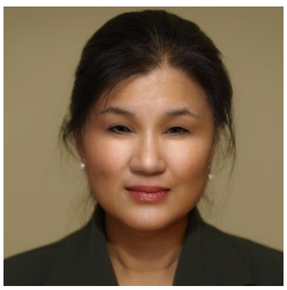
Dr. Donald R. Peterson is a Professor of Mechanical Engineering and serves as the Dean of the College of Engineering and Engineering Technology at Northern Illinois University. He is also an affiliated professor in the Department of Biomedical Engineering at Texas A&M University and a Fellow of the American Institute for Medical and Biological Engineering (AIMBE). Dr. Peterson is a graduate of Worcester Polytechnic Institute, earning degrees in Aerospace Engineering (BS) and Biomechanical Engineering (BS) and a graduate of the University of Connecticut, earning degrees in Mechanical Engineering (MS) and Biomedical Engineering (PhD). Dr. Peterson's experience in biomechanical engineering and medical research has been focused on measuring and modeling injury biomechanics and human, organ, and cell performance, including exposures to various physical stimuli and the subsequent biological or physiological responses. His research has involved the investigation of injury mechanisms and human–device interaction and has led to the generation of new technologies and systems, such as personal protection technologies, occupational exoskeleton systems, robotic exoskeleton assist devices for hemiplegic rehabilitation, long-duration biosensor monitoring and reporting systems, novel surgical and dental devices and instruments, smart medical devices for home patient care, and biotechnology systems. Dr. Peterson currently serves as the Chair of the ASTM International Committee F48 on Exoskeletons and Exosuits and as a US delegate on the International Standards Organization Technical Committee (ISO/TC) 108/SC4 on Human Exposure to Mechanical Vibration and Shock. Dr. Peterson has published over 130 peer-reviewed scholarly works and is the Editor-in-Chief for "The Biomedical Engineering Handbook", published by CRC Press.

Ryan Porto is a Technical Specialist in Ergonomics at General Motors. Mr. Porto received a Bachelor of Human Kinetics and a Masters in Human Performance from the University of Windsor in Canada. Ryan has over 20 years of experience working with design and manufacturing engineering, managing ergonomic requirements, and supporting new program launches in all sectors of the vehicle development including Assembly, Powertrain, and EV. Ryan was also the special assigned Ergonomist on the General Motors-Ventec critical care Ventilator program in 2020. Since his career began at General Motors, Ryan has been the Subject Matter Expert in Digital Human Modelling and has led the advancement of virtual human simulation in Product and Manufacturing for GM's Global Ergonomics program. For the past 6 years, he has led the development and implementation of evolving wearable technologies and manages the Research in Ergonomics at GM. Ryan is a Co-Chair of the Automotive Exoskeleton Group (AExG), sponsored via the Wearable Robotics Association. And a member of the Ergonomic task force at the United States Council for Automotive Research (USCAR).

Dr. Chris Reid is a Human Factors & Ergonomics (HFE) Associate Technical Fellow for Boeing's Environment, Health & Safety (EHS) organization in Charleston, SC. He is the EHS portfolio manager of wearable technology (e.g., exoskeletons, mixed reality, and wearable sensing and computing systems). Prior to Boeing, Dr. Reid worked for Lockheed Martin on astronaut spacesuit assessment as a Human Factors & Ergonomics Discipline Lead at NASA and as a Human Factors Engineer for the US Army assessing Warfighter personal protective equipment. Outside of Boeing, he is a member of the Human Factors & Ergonomics Society Executive Council as the 2020 President-Elect, advises on ergonomics as a Delegates Committee member for the National Safety Council's Board of Directors, sits on the Editorial Boards for the Augmented Human Research and Theoretical Issues in Ergonomics Sciences Journals, is a 2019-2020 Special Issue Editor for the Human Factors Journal, Chair of the Annual ErgoX International Symposium, and Chair of the HFE Subcommittee for ASTM F48 standards on Exoskeletons. He is a recipient of both the 2018 Rising Star Award from the National Safety Council and the 2020 Black Engineer of the Year Award. He graduated from the University of Central Florida, with degrees in Electrical Engineering Technology (BS) and Industrial Engineering (MS and PhD).

Paul Slaughter is a mechanical engineering Ph.D. student in the Center for Rehabilitation Engineering & Assistive Technology at Vanderbilt University where he specializes in the design and evaluation of occupational exoskeletons and exosuits. He has been deeply involved in developing and field-testing exosuits in close collaboration with U.S. Army Soldiers. Paul received his B.S. in Mechanical Engineering from the University of Wisconsin – Madison in 2019, an American Society of Biomechanics Undergraduate Research Award in 2019, and a National Science Foundation Graduate Research Fellowship in 2020.

Dr. Robert (Bob) Sugarman was captivated by a course in human factors (HF) engineering while studying graduate physics at Purdue,. He switched to experimental psychology to study with one of the founders of HF, earned a masters from Purdue and a second from MIT before completing his PhD at SUNY at Buffalo. In 15 years at CALSPAN (formerly Cornell Aeronautical Laboratory) he was Head of Human Factors, led training development programs for major military aircraft, and served on HFES's Nuclear Regulatory Commission project to develop a 5-year research plan. His leadership was rewarded with election as an HFES Fellow. Starting his own company in 1982, Dr. Sugarman did pioneering work in computer-baed instruction for national companies. For the last two decades he has provided expert testimony as a forensic accident analyst. Dr. Sugarman's latest career is Chief Scientist and Director, Human Factors at Stavatti Aerospace. He serves on several ASTM Main Committees, and is technical lead for a "Human Factors Practice for Developing Standard Test Methods".



Dr. Delia Treaster is Ergonomic Team Lead for Boeing in Charleston, SC, with over 25 years in industrial ergonomics. She recommends practical and effective strategies to assist companies in reducing the risk of musculoskeletal injuries. She has implemented ergonomics for many industrial manufacturers, as well as in healthcare, construction, meat-packing, and offices. Dr. Treaster received her BA in psychobiology from Oberlin College, MS in Human Factors and Ph.D. in Occupational Biomechanics from Ohio State University, and is a Certified Professional Ergonomist (CPE). One of the original members of ASTM F48, Dr. Treaster is the technical contact for "WK73074: Application of Ergonomics to Prevent Injury during Exoskeleton Use," currently under development.

Robotics Speakers

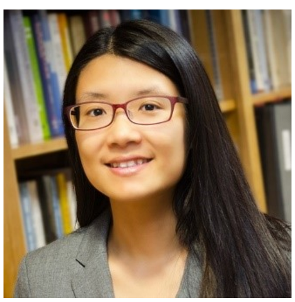
Dr. Julie A. Adams, Oregon State University's College of Engineering's Dean's Professor, was the founder of the Human-Machine Teaming Laboratory at Vanderbilt University, prior to moving the laboratory to OSU. She is also OSU's Collaborative Robotics and Intelligent Systems (CoRIS) Institute's Associate Director of Research. Adams has worked in the area of human-machine teaming for over thirty years. Throughout her career she focused on human interaction with unmanned systems, as well as manned civilian and military aircraft at Honeywell, Inc. and commercial, consumer and industrial systems at the Eastman Kodak Company. Her research, which is grounded in robotics applications for domains such as first response, archaeology, oceanography, the national airspace, and the U.S. military, focuses on distributed artificial intelligence, swarms, and human-machine teaming. Dr. Adams is an NSF CAREER award recipient, an Army Mad Scientist, ANA Avatar XPRIZE judge, and HFES Fellow.

Fahrudin Alagic has over 20 years of experience in new technology development, system architecture and design, hardware design, and new product introduction across multiple industries. Fahrudin is currently a Principal Engineer at Amazon Robotics. He has led multiple product development and early technology development programs across the Amazon Robotics portfolio, including technologies behind Amazon Tech Vest and Proteus AMR. You can actually find information about these on YouTube. Previously, Fahrudin has held positions at Sun Microsystems, Oracle and multiple startups, specializing in signal integrity and high-speed hardware design. He holds a BS degree in Electrical Engineering from Boston University.

Dr. José Baca is an Assistant Professor in the Department of Engineering at Texas A&M University-Corpus Christi (TAMU-CC), USA. He earned his B.S. in Electrical Engineering from Matamoros Institute of Technology, Mexico; his M.Sc. in Mechatronics from University of Applied Sciences in Aachen, Germany; and his Ph.D. in Automation and Robotics, from Technical University of Madrid, Spain. He was a Postdoctoral research fellow in the Computer Science Department at the University of Nebraska at Omaha before joining TAMU-CC. His research interests include the coordination and control strategies for Unmanned Autonomous Systems and the integration of Modular Systems across different domains such as in Robotics, Search and Rescue, Space, Industry, HealthCare, and Education.

Dr. Baca has worked in the Unmanned Autonomous Systems and Modular Robotics fields for over a decade and his work has led to multiple publications in leading conferences and journals. He has organized and co-chaired international conferences and workshops in the field and has been involved in projects funded by Federal agencies including NASA, Office of Naval Research, and National Science Foundation, as well as from the Nebraska and Texas Space Grant Consortiums, the Peter Kiewit Institute, and Texas A&M Engineering Experiment Station. Dr. Baca likes to promote and engage new generations of student in STEM careers with a series of outreach programs developed by his group.

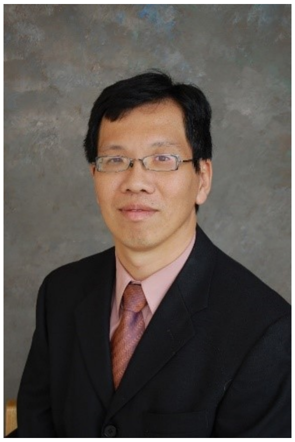
Dr. Gwen Bryan is a research scientist at the Florida Institute for Human and Machine Cognition (IHMC). She leads the exoskeleton team at IHMC which focuses on lower-limb wearable robotic devices aimed at augmenting human performance in clinical, occupational, and military applications. The team intends to maximize exoskeleton benefits through a human-centered research approach. They are currently developing an augmentative exoskeleton for DOE-EM sites and continuing to research a rehabilitative device for people with spinal cord injuries. Gwen received her Ph.D. in Mechanical Engineering with a focus on lower-limb exoskeletons from Stanford University and her B.S. in Mechanical Engineering from the University of New Mexico.



Dr. Karen B. Chen is an Assistant Professor at North Carolina State University in the Edward P. Fitts Department of Industrial and Systems Engineering (NCSU-ISE). She received her Ph.D. in Biomedical Engineering from University of Wisconsin-Madison in 2015 (M.S. 2010 UW-Madison, B.S. 2009 UW-Madison), with an emphasis on human factors, virtual reality, and human-machine interfaces. She was a postdoctoral researcher at Healthcare Systems Engineering Institute at Northeastern University. She joined NCSU-ISE in August 2016, and she currently directs Virtual and Augmented Reality Laboratory at North Carolina State University (go.ncsu.edu/chen).

Chen leverages virtual reality scenarios to study human performances and behaviors. Her current research thrusts include examining the improvements to the understanding of abstract concepts (e.g., size, scale, mechanical forces) using virtual reality, understanding human performances and behaviors while interacting with collaborative robots in virtual environments, and studying the effects of avatar embodiment on perception.

Chen is funded by National Science Foundation (NSF) and by National Institute for Occupational Safety and Health (NIOSH) Education and Research Center (ERC). She also collaborates with The Ergonomics Center of North Carolina for industry projects. Her work on virtual and augmented reality technologies is also disseminated via local media (WRAL5, CW22), outreach for K-12 students underrepresented in STEM, and panels at North Carolina Comicon.



Dr. Marvin Cheng is the Assistant Coordinator of the Center for Occupational Robotics Research with the National Institute for Occupational Safety and Health (NIOSH). His research interests cover studies of workspace safety using collaborative and exoskeleton robots and cyber-physical systems with the concentration in the following areas: worker safety, human-robot interaction in collaborative workspaces, machine vision and motion recognition, and multiaxial control of exoskeleton robotic devices. The goal of his robotic research activities is to create a safer collaborative workspace by avoiding injuries caused by potential collisions between the robotic devices and the human workers in the shared workspace. As the team lead of the Safety Control Team at NIOSH, Dr. Cheng is also actively involved in research projects in the fields of virtual reality simulation, motor vehicle safety, and industrial safety with the consideration of ergonomic engineering. Dr. Cheng is currently a member of the RIA R15.06 and R15.08 committees. He has actively participated in the review and revision of the safety standards on collaborative and mobile robotic devices since 2020.

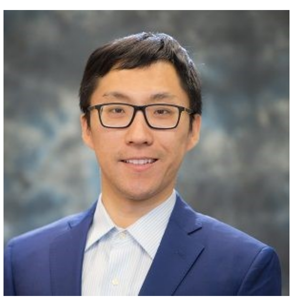
Dr. Suman K. Chowdhury is an Assistant Professor in the Department of Industrial, Manufacturing, and Systems Engineering at Texas Tech University. His research areas include traumatic brain injury, neuro-biomechanics, sensorimotor training and rehabilitation, virtual reality biomechanics, and helmet, exoskeleton, and prosthetic designs. He received his Ph.D. in occupational biomechanics from West Virginia University in 2016. He was a postdoctoral fellow at the University of Pittsburgh from 2016 to 2017 and an Assistant Research Scientist at Texas A&M University from 2017 to 2019. He is currently serving as the Chair-Elect of the Occupational Ergonomics Technical Group of Human Factors and Ergonomics Society, USA. So far, he has secured $1.6 M funding from different federal agencies, including the Department of Homeland Securing and the National Institute of Occupational Safety and Health. Professor Chowdhury's research vision is to discover new scientific knowledge and techniques and instantiate them in product and work design processes in order to augment human capability, performance, and safety.

Justin Croyle has spent over 16 years in industry as a safety engineer. He holds a B.S. in Aerospace Studies and M.S. in Safety Science, both from Embry Riddle Aeronautical University. His safety engineering career has included work on spacecraft, missile systems, autonomous vehicles and robotics. He is currently a Principal Functional Safety engineer at Amazon robotics, with a focus on mobile robots. His work at Amazon has resulted in certified safety systems deployed in over 520,000 robots to date.

Dr. Masoud Gheisari is an Associate Professor in the Rinker School of Construction Management at the University of Florida. He leads the Human-Centered Technology in Construction (HCTC) research lab: https://hctclabs.wixsite.com/hctclab. His research focuses on the theoretical and experimental investigation of human-robot interaction in construction and technology-supported education innovation. He earned his Ph.D. in Building Construction from the Georgia Institute of Technology (2013). To date, he has authored more than 100 peer-reviewed papers in the fields of virtual/augmented/mixed reality (VR/AR/MR) and safe human-drone interaction in construction. His work has received support worth over $1.6m in grants from external funding agencies, including the National Science Foundation (NSF), U.S. Department of Labor, NIOSH's Center for Construction Research and Training (CPWR), and ELECTRI International. Dr. Gheisari is the recipient of Associated Schools of Construction (ASC) International Outstanding Researcher Award (2021), ENR Southeast's Top Young Professional (2020), UF DCP Undergraduate Faculty Teaching Award (2019), BCN Nancy Perry Teaching Award (2019), Russell J. Alessi ELECTRI International Early Career Award (2018), UF DCP Faculty Research Award (2018), ASC Southeast's Excellence in Teaching Award (2018), and ASCE ExCEEd Fellowship (2015). He also serves as an Associate Editor for ASCE's Journal of Computing in Civil Engineering.

Dr. Matthew Gombolay is an Assistant Professor of Interactive Computing at the Georgia Institute of Technology. Dr. Gombolay is the director of the Cognitive Optimization and Relational (CORE) Robotics Lab, which seeks to place the power of robots in the hands of everyone by developing new computational methods and human factors insights that enable robots to learn from interaction with diverse, non-expert end-users to perform assistive tasks and coordinate in human-robot teams in applications from healthcare to manufacturing. In just four years, Dr. Gombolay's lab has produced over 40 peer-reviewed papers, including best paper awards at the ACM/IEEE International Conference on Human-Robot Interaction, a best paper finalist at the 2020 Conference on Robot Learning (CoRL), and a best student paper finalist at the 2020 American Controls Conference (ACC). Dr. Gombolay is a NASA Early Career Fellow and a DARPA Riser and has raised over $4 million in research funding, including support from the government agencies (i.e., NSF, NIH, NASA, ONR, and NRL) and industry partners (i.e., Lockheed Martin, Konica Minolta, and Google) alike. Dr. Gombolay received a chaired assistant professorship form the College of Computing at Georgia Tech. Dr Gombolay is an Associate Editor of Autonomous Robots and the ACM Transactions on Human-Robot Interaction.

Dr. Hongwei Hsiao is a Professor and the Rogelio Benavides Memorial Chair with Texas A&M University – Corpus Christi. His research covers big data and artificial intelligence for protective gear sizing and design for diverse workforces, first responder technology, personal protective equipment 3-dimensional dynamic fitting and performance assessment, hazard investigation and control, and multi-system smart technology integration. He is retired chief of the Protective Technology Branch and coordinator of the Center for Occupational Robotics Research, National Institute for Occupational Safety and Health (NIOSH). He received his degrees from Cornell University and the University of Michigan and has held engineering and management positions in both the manufacturing industry and the U.S. Government. He also has taught human factors engineering for 20 years before joining Texas A&M University system. Dr. Hsiao has headed numerous programs and projects in safety research. He also coordinated development of strategic goals for the NIOSH robotics center and managed center resources and seminars. He managed several laboratories for NIOSH, including the Virtual Reality, Anthropometry Research, High Bay, Vehicle Safety, Digital Modeling, Human Factors, Robotics Research, and Sensor Development Laboratories during 1996-2021. He now directs the Safety Evaluation and Research (SEAR) Laboratory and coordinates a smart technology advancement research (STAR) initiative for industrial innovation for Texas A&M University – Corpus Christi. An editorial board member for eight scientific journals, Dr. Hsiao has written or contributed over 180 publications and patents in human factors and engineering innovation for injury control. He was credentialed as a Silvio O. Conte Senior Biomedical Research Service Fellow by the Government Executive Resources Board in 2003. He is an Emeritus Fellow of the Human Factors and Ergonomics Society (US HFES) and Chartered Institute of Ergonomics and Human Factors (UK CIEHF).



Dr. Boyi Hu serves as an assistant professor of industrial and systems engineering at the University of Florida since 2018 Fall.

His research background includes mechanical engineering, robotics, human-robot interaction (HRI), human factors and ergonomics. He has published numerous papers on human factors and ergonomics, machine learning, and robotics. As a member of the engineering faculty at the University of Florida Department of Industrial and Systems Engineering, he investigated HRI, Human System Safety, and human motion prediction.

The primary outcome of much of his research is the prevention of injuries and promote system productivity. His research study designs are both observational/descriptive and experimental, based in both the laboratory and the real environment.

Dr. Lixiao Huang is an Associate Research Scientist at the Center for Human, Artificial Intelligence, and Robot Teaming (CHART) within Global Security Initiative (GSI) at Arizona State University. She completed her Ph.D. in Human Factors and Applied Cognition from North Carolina State University in 2016 and Postdoc in the Humans and Autonomy Lab (HAL) at Duke University in 2018. She is the founding chair of the Human–AI–Robot Teaming (HART) technical group at Human Factors and Ergonomics Society, advocating cutting-edge HART research, interdisciplinary collaboration, and advanced testbeds and analytics. She has worked on ARL, ONR, and DARPA research projects as a research lead. Dr. Huang's research interests include 1) Human–AI–Robot Teaming effectiveness; 2) Humans' responses (i.e., emotional states, behavioral patterns, and cognitive processes) to robots and technologies, especially emotional attachment, intrinsic motivation, coordination, trust, and metacognition; 3) The design of human-robot systems using Human Factors methods to make AI and robots effective, safe, user-friendly, trustworthy, and engaging.

Nia Jetter is passionate about changing the world through innovation, technology planning, teaching, mentoring and solving tough problems in Autonomy and AI that can be applied across different platforms. She has a dedicated focus on helping people who may not have easy access to educational materials to understand topics like artificial intelligence. Nia is enthusiastic about working the human-AI interface as artificial intelligence is further integrated into our society.

Nia is an Aerospace Engineer who has 20 years of experience in the Aerospace Industry and has developed key algorithms in supporting a variety of programs across the product-lifecycle from design and development to mission and anomaly resolution and through customer delivery and support. In January 2021, Nia left the Aerospace Industry as a Technical Fellow to join Amazon as a Senior Principal Technologist in Robotics. In this role as a leader in technical development for autonomy as well as strategic planning for robotics and other autonomous applications, Nia has so far led an Autonomous Mobile Robot that will be deployed in an unstructured environment through Preliminary Construction Review for Safety Certification as well as establishing best engineering practices for the product as Chief Engineer.

Nia has a bachelor's degree in Math with Computer Science and a minor in Earth Atmospheric and Planetary Sciences from MIT as well as a Master's Degree in Aeronautical and Astronautical Engineering from Stanford. Nia enjoys reading (especially science fiction), astronomy, baking, travelling and dancing. For more information, please see her website: www.niajetter.com.

Dr. Charles C. Kemp (Charlie Kemp) is an Associate Professor at Georgia Tech in the Department of Biomedical Engineering with adjunct appointments in the School of Interactive Computing and the School of Electrical and Computer Engineering. In 2007, he founded the Healthcare Robotics Lab, which focuses on enabling robots to provide intelligent physical assistance in the context of healthcare. He earned a BS, an MEng, and a PhD from the Massachusetts Institute of Technology (MIT) in the areas of computer science and electrical engineering. In 2017, he co-founded Hello Robot Inc. with Dr. Aaron Edsinger to commercialize technology from his lab. Charlie owns equity in Hello Robot, earns royalties from Hello Robot's sales, and works part time at Hello Robot where he is the Chief Technology Officer (CTO). You can learn more at Charlie's personal website: https://charliekemp.com

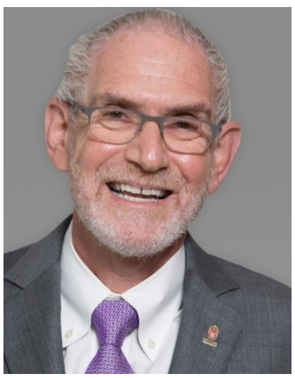
Joe Manganelli is the founder of xplr design, llc, a human factors research and design consultancy focused on human-systems-environment symbiosis. Regarding research activity, he is a co-author of the National Institute of Standards and Technology's, Internet-of-Things-Enabled Smart-City Framework and completed a post-doctoral research fellowship studying distracted driving (phone GUIs) at CU-ICAR. More recently, he is involved in research projects related to human-centered cyber-physical systems, smart infrastructure and smart environment technology and strategy, and human-systems performance modeling.

Joe is a Certified Human Factors Professional (CHFP) with areas of focus on user experience research, requirements development and validation, information architecture, usability, and the cognitive performance and decision making and human-systems integration dimensions of human factors. He is also a licensed architect in the states of Georgia and South Carolina, focused on the design of commercial, institutional, industrial, and biotech/pharma facilities.

In addition to Joe's role developing xplr design, llc, Joe is also Part-Time Faculty teaching graduate UX courses in Kent State University's School of Information, and a Senior Architect with Fluor leading the design of mission-critical biotech/pharma, advanced manufacturing, and laboratory facilities.

Dr. Jeremy A. Marvel is a research scientist and project leader at the U.S. National Institute of Standards and Technology (NIST) in Gaithersburg, MD. Dr. Marvel received the bachelor's degree in computer science from Boston University, Boston, MA, the master's degree in computer science from Brandeis University, Waltham, MA, and the Ph.D. degree in computer engineering from Case Western Reserve University, Cleveland, OH. Prior to NIST, Dr. Marvel was a research scientist at the Institute for Research in Engineering and Applied Physics at the University of Maryland, College Park, MD. He joined the Intelligent Systems Division at NIST in 2012, and has over fifteen years of robotics research experience in industry, academia, and government. His research interests include intelligent and adaptive solutions for robot applications, with particular attention paid to human-robot and robot-robot collaborations, multirobot coordination, industrial robot safety, machine learning, perception, and automated parameter optimization. Dr. Marvel currently leads a team of scientists and engineers in metrology efforts at NIST toward the performance evaluation of human-robot teams, and developing tools to enable small and medium-sized enterprises to effectively deploy robot solutions.

Vy Nguyen is an occupational therapist who strives to have others see greatness in themselves while engaging in lifelong active learning that enriches both her experiences and those she serves. As an OT Clinical Research Lead at Hello Robot Inc., she's promoting ways the Stretch mobile manipulator can support people with and without disabilities to Live in Place and engage in their meaningful daily activities. Her main field of interest is advocating for accessibility in healthcare, community resources, and technology - especially for underserved and rural populations.



Professor Radwin is the Duane H. and Dorothy M. Blumke Professor in industrial and systems engineering and biomedical engineering at the University of Wisconsin-Madison. He specializes in the physiological and biomechanical aspects of work with a view to improving the design of jobs, equipment, products and environments. Professor Radwin frequently works with a range of industry and government organizations. He has received awards as an innovator and researcher, is a fellow of six professional societies, has served on numerous national committees, and is Editor-in- Chief of the journal Human Factors. Professor Radwin is founding chair of the University of Wisconsin-Madison Department of Biomedical Engineering and is a Discovery Fellow at the Wisconsin Institute for Discovery.

Dr. Menekse Salar Barim was born in Monterey, CA in 1988. She earned her doctorate degree in Industrial and Systems Engineering with an emphasis in Occupational Injury Prevention in fall of 2017 from Auburn University. She also earned a MISE with an emphasis in Occupational Safety and Ergonomics in 2013 from Auburn University. She has 2 undergraduate degrees, Industrial Engineering (BS) and Management (BA) from Atilim University in Turkey. As a student, she conducted cutting edge MRI research to better define and estimate biomechanically relevant low back structures to improve ergonomic modelling. She has won numerous academic awards and was the captain of the “Ergo Divas” team that won the international Ergonomic Design Competition for Student Teams besting over 50 teams from more than 35 universities. She is active in professional societies such as American Society of Safety Professionals (ASSP) and the Human Factors and Ergonomics Society (HFES) where she has served as student chapter president. As a doctoral student, she organized and ran an international safety and health workshop that brought 4 Auburn OSE faculty to Turkey where they conducted multiple workshops and exchanged safety and health information with Turkish academics and safety professionals.

In 2018, she joined the National Institute for Occupational Safety and Health (NIOSH) as a research fellow.

Since 2018, she has been with the Human Factors and Ergonomics Team (HFET). Her current research interest includes biomechanics, musculoskeletal disorders, motion analysis, ergonomics, human performance and exoskeletons. She recently works on projects related to ergonomics surveillance, the development of next generation ergonomic assessment tools, the effect of back assist exoskeletons in manual handling in WRT sector and longitudinal effects of shoulder exoskeletons on company injury records in the manufacturing sector.

Dr. Craig Schlenoff is the Group Leader of the Cognition and Collaboration Systems Group, the Program Manager of the Measurement Science for Manufacturing Robotics Program, and the Project Leader of the Agility Performance of Robotic Systems project and the Embodied AI and Data Generation for Manufacturing project in the Intelligent Systems Division at the National Institute of Standards and Technology. His research interests include knowledge representation/ontologies, intention recognition, and performance evaluation of autonomous systems and industrial robotics. He has led multiple million-dollar projects addressing performance evaluation of advanced military technologies and agility performance of manufacturing robotic systems. He has published over 150 journal and conference papers, guest edited three journals, guest edited three books, and written four book chapters. He is the co-chair of the NITRD Artificial Intelligence Interagency Working Group, the Associate Vice President for Standardization in the IEEE Robotics and Automation Society, the co-chair of the IEEE Robot Task Representation Working Group, and was previously the chair of the IEEE Ontology for Robotics and Automation Working Group. He has also served as the Program Manager for the Process Engineering Program at NIST and the Director of Ontologies at VerticalNet. He also teaches two courses at the University of Maryland, College Park: “Calculus” and “Building a Manufacturing Robot Software System.” He received his Bachelor’s degree from the University of Maryland, his Master’s degree from Rensselaer Polytechnic Institute (both in mechanical engineering), and his PhD from the University of Burgundy in computer science.

Mikell Taylor has spent two decades making useful robots - from a robotic senior prom date to autonomous underwater vehicles to cutting-edge industrial robotic systems. She is currently a Principal Technical Program Manager at Amazon Robotics, where she leads the Autonomous Mobility technology and product development program. She is passionate about building robots that are practical, reliable, and good partners for the people that work with and around them. In 2018 Mikell was part of Accomplice VC’s Rev4 class highlighting the top women in the Boston tech community, and recognized as a Woman to Watch by Mass High Tech in 2011. Outside of work she volunteers for various STEM outreach and education initiatives. She holds a BS in

Electrical and Computer Engineering from Olin College, where she was a member of the first class of graduates.

Dr. Sascha Wischniewski is head of the unit "Human Factors, Ergonomics" at the German Federal Institute for Occupational Safety and Health (BAuA). He co-leads the interdepartmental focus programm "Occupational Safety & Health in the Digital World of Work" at BAuA. His fields of expertise are anthropometry and digital human modelling, ergonomics of smart information and communication technologies and human factors in robotics. Sascha is a graduate engineer in mechanical engineering and holds a doctoral degree in industrial engineering. His work focuses on human-technology interaction in the working world with special emphasis on innovative technologies for physical and cognitive work assistance. He is active in standardization and currently chair of the Technical Committee Human Factors in Robotics of the International Ergonomics Association (IEA). Sascha is the general chair for the 2023 IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO).