Human Machine Systems and Digital Twin Technologies

IEEE SMC Society / SMST, University of Central Florida

Joint Workshop

Date: 16 February 2024

Time: 9:00 - 15:45 (Online & In-person)

SMST Lab Tour: 15:45 - 17:00 (In person only)

Eastern Standard Time

Time zone in Orlando, FL (GMT-5)

Room 233, Partnership III, 3100 Technology Parkway, Orlando, 32826 FL, USA

Overview:

This interactive workshop is a collaboration between IEEE Systems, Man, and Cybernetics Society (SMCS), and the Institute of Simulation and Training, School of Modeling, Simulation, and Training, at the University of Florida. The workshop explores the intersection of Human-Machine Systems (HMS) and Digital Twin Technologies, providing participants with a comprehensive understanding of how these realms converge to shape the future of industries. As digital transformation accelerates, the synergy between human-machine interactions and the creation of digital twins has become a critical aspect of innovation and efficiency across various domains.

The mission of the Systems, Man, and Cybernetics Society is to serve the interests of its members and the community at large by promoting the theory, practice, and interdisciplinary aspects of systems science and engineering, human-machine systems, and cybernetics. It is accomplished through conferences, publications, and other activities that contribute to the professional needs of its members.

This joint workshop aims to nurture a network of universities, research institutions, companies, and organizations from all over the world with educational, and research profiles that match the IEEE Systems, Man, and Cybernetics Society (SMCS) fields of interest: systems science and engineering, human-machine systems, and cybernetics. In addition, the UCF's Digital Twin Strategic Initiative is an opportunity to explore new dimensions and future collaborations in education, training, and research areas.

Human-machine systems cover integrated human/machine systems at multiple scales and include areas such as human/machine interaction; cognitive ergonomics and engineering; assistive/companion technologies; human/machine system modeling, testing, and evaluation; and fundamental issues of measurement and modeling of human-centered phenomena in engineered systems.

Key Takeaways:

- A deep understanding of the principles behind Human-Machine Systems and Digital Twins.
- Practical insights into integrating these technologies for improved system performance.
- Knowledge of real-world applications and case studies showcasing successful implementations.

Workshop Chairs:

Distinguished Professor Saeid Nahavandi

Distinguished Professor Saeid Nahavandi is currently Swinburne University of Technology's inaugural Associate Deputy Vice-Chancellor Research and Chief of Defence Innovation. He previously served as Pro Vice-Chancellor (Defence Technologies) and Founding Director of the Institute for Intelligent Systems Research and Innovation, Deakin University.

Saeid Nahavandi received a Ph.D. from Durham University, U.K. in 1991. His research interests include autonomous systems, modeling of complex systems, robotics and haptics. He has published over 1000 scientific papers in various international journals and conferences. Saeid was the recipient of the Clunies Ross Entrepreneur of the Year Award 2022 from the Australian Academy of Technological Sciences & Engineering, Researcher of the Year for Australian Space Awards 2021, Australian Defence Industry Awards - Winner of Innovator of the year, The Essington Lewis Awards, and Australian Engineering Excellence Awards - Professional Engineer of the Year.

Professor Nahavandi holds six patents, two of which have resulted in two very successful start-ups (Universal Motion Simulator Pty Ltd and FLAIM Systems Pty Ltd).

Professor Nahavandi is the Vice President: Human-Machine Systems, IEEE SMCS, Senior Associate Editor: IEEE Systems Journal, Associate Editor of IEEE Transactions on Cybernetics.

Professor Nahavandi is a Fellow of IEEE (FIEEE), Engineers Australia (FIEAust), the Institution of Engineering and Technology (FIET). Saeid is a Fellow of the Australian Academy of Technology and Engineering (ATSE).

Dr. Soheil Sabri

Dr. Soheil Sabri is an Assistant Professor and Director of Urban Digital Twin Lab, at the School of Modeling Simulation, and Training, University of Central Florida, USA. He holds the titles of Urban Planner and Geospatial Scientist, with a primary focus on Geosimulation and Urban Digital Twin, advancing the field through his research, practical work, and educational pursuits. His core interests revolve around developing Multi-dimensional (3D/4D) Planning Support Systems, and analytical tools tailored to empower planners and decision-makers with evidence-based, data-driven insights for future urban development. He received two Post-Doctorate Fellowships that centered on Urban Analytics Data Infrastructure (UADI), and 3D Geospatial Techniques for Landscape Design from the University of Melbourne, Australia. He is the Ambassador of the Academia and Research within the Digital Twin Consortium, and he has served on the Australian Nation Advisory Committee for PlanTach Working Group at the Planning Institute of Australia. He has significantly contributed to the Digital Twin adoption, including the Spatial Digital Twin Working Group at Geoscience Australia, and the Digital Twin Task Force at the Smart Cities Council in the USA and Australia.

Workshop Program:

8:30 – 9:00 **Arrival and Registration**

9:00 – 9:05 **Opening** **IEEE SMCS President or VP**

9:05 – 9:10 **Welcome Note: Director of IST**

Professor Grace Bochenek

Is the School of Modeling, Simulation, and Training Director at the University of Central Florida. Prior to joining UCF, Dr. Bochenek held a presidential cabinet appointment as Acting U.S. Secretary of Energy and earlier had a career of motivating research, and development in national security and energy, the private sector, and as a member of the federal government Senior Executive Service.

Recognized for her ability to anticipate and inspire technological innovation, Director Bochenek is endlessly fascinated by the potential of next generation technology, and the next generation who will wield it in the workforce.

Her past leadership roles included managing research and overseeing partnerships with universities as Director of the National Energy Technology Laboratory (NETL), serving as the Chief Technology Officer of the U.S. Army Materiel Command, and leading research and development as the Director of the Tank Automotive Research, Development and Engineering Center. She was awarded the Presidential Rank Award as Meritorious Executive, a Silver Medal from the National Defense Industry Association, and Decorations for Exceptional Civilian Service from both Departments of Army and Energy.

9:10 – 9:30 **Opening Speech: Virtual work on Virtual Systems Using Virtual Reality**

Professor Peter Hancock, Provost Distinguished Research Professor, the University of Central Florida (UCF)

Peter A. Hancock, D.Sc., Ph.D. is Provost Distinguished Research Professor in the Department of Psychology and the Institute for Simulation and Training, as well as at the Department of Civil and Environmental Engineering and the Department of Industrial Engineering and Management Systems at the University of Central Florida (UCF). In 2009 he was created the 16th ever UCF University Pegasus Professor (the Institution's highest honor) and in 2012 was named 6th ever University Trustee Chair. He directs the MIT^2 Research Laboratories. Prior to his current position he founded and was the Director of the Human Factors Research Laboratory (HFRL) at the University of Minnesota where he held appointments as Professor in the Departments of Computer Science and Electrical Engineering, Mechanical Engineering, Psychology, and Kinesiology, as well as being a member of the Cognitive Science Center and the Center on Aging Research. He continues to hold an appointment as a Clinical Adjunct Professor in the Department of Psychology at Minnesota. He is also an affiliated Scientist of the Humans and Automation Laboratory at Duke University, a Research Associate of the University of Michigan Transport Research Institute, and a Senior Research Associate at the Institute for Human and Machine Cognition in Pensacola, Florida. He is also a member of the Scientific Advisory Board of the Hawaii Academy.

Professor Hancock is the author of more than 1,000 refereed scientific articles, chapters, and reports as well as writing and editing more than twenty books including: *Human Performance and Ergonomics* in the Handbook of Perception and Cognition series, published by Academic Press in 1999. *Stress, Workload, and Fatigue* published in 2001 by Lawrence Erlbaum and *Performance under Stress* which was published in 2008 by Ashgate Publishing. He is the author of the 1997 book, *Essays on the Future of Human-Machine Systems* and the 2009 text, *Mind, Machine and Morality* also from Ashgate Publishers. His more recent texts include the Cambridge University Press, *Hoax Springs Eternal; The Psychology of Cognitive Deception* and the Springer text: *Transports of Delight: How Technology Materializes Human Imagination*. In addition to his over 1,000 publications Dr. Hancock has also made over 1,000 professional presentations on issues as diverse as human-machine interaction, and psychological deception, to the history of the reign of Richard III. He has been continuously funded by extramural sources for every one of the thirty-eight years of his professional career. This includes support from NASA, NSF, NIH, NIA, FAA, FHWA, NRC, NHTSA, DARPA, NIMH, and all of the branches of US Armed Forces. He has also been supported by numerous State and Industrial agencies. He was the Principal Investigator on a Multi-Disciplinary University Research Initiative (MURI), in which he directed $5 Million of funded research on stress, workload, and performance. It was the first MURI in behavioral science ever awarded by the US Army. He was also the recipient of the first ever research grant (as opposed to contract) given by the Federal Aviation Administration. To date, he has secured over $20 Million in externally funded research during his career. He has presented, or been an author on, over 1,000 scientific presentations. In 1999 he was the Arnold Small Lecturer of the Human Factors and Ergonomics Society and in 2000 he was awarded the Sir Frederic Bartlett Medal by the Ergonomics Society of Great Britain for lifetime scientific achievement. He was the Keynote Speaker for the combined meeting of the International Ergonomics Association and the Human Factors and Ergonomics Society in 2000 in San Diego, the largest-ever professional meeting of the discipline.

9:30 – 9:45 **VAR in Human-Machine Systems**

Professor Carolina Cruz-Neira, Agere Chair Professor, Department of Computer Science, UCF

Dr. Cruz is the Agere Chair in Computer Science at the University of Central Florida. She is a member of the National Academy of Engineering and is a pioneer in virtual reality and interactive visualization, having created and deployed various technologies that have become standard tools in the industry, government, and academia. She is known worldwide for creating the CAVE virtual reality system. She has dedicated a part of her career to transferring research results into daily use by spearheading several open-source initiatives to disseminate and grow VR technologies and by leading entrepreneurial initiatives to commercialize research results. She has over 100 publications, such as scientific articles, book chapters, magazine editorials, and others. She has been awarded over $75 million in grants, contracts, and donations. She is also recognized for having founded and led very successful virtual reality research centers: the Virtual Reality Applications Center at Iowa State University, the Louisiana Immersive Technologies Enterprise, and the Emerging Analytics Center at the University of Arkansas at Little Rock. She serves in many international technology boards, government technology advisory committees, and outside the lab, she enjoys extrapolating her technology research with the arts and the humanities through forward-looking public performances and installations. She has been named one of the top innovators in virtual reality and one of the top three greatest women visionaries in virtual reality. BusinessWeek magazine identified her as a "rising research star" in the next generation of computer science pioneers; she has been inducted as a member of the National Academy of Engineering, a member of the IEEE Virtual Reality Academy, an IEEE Fellow, and an ACM Computer Pioneer; She has received the IEEE Virtual Reality Technical Achievement Award and the Distinguished Career Award from the International Digital Media & Arts Society among other national and international recognitions. She had given numerous keynote addresses and has been the guest of several governments to advise on how virtual

reality technology can help to give industries a competitive edge leading to regional economic growth. She has appeared in numerous national and international TV shows and podcasts as an expert on her discipline and several documentaries have been produced about her life and career.

9:45 - 10:00 **Robot Team Establishment using E-CARGO/RBC**

Professor Haibin Zhu, Department of Computer Science and Mathematics, Nipissing University, Canada

DR. Haibin Zhu is a Full Professor and the Coordinator of the Computer Science Program, the Founding Director of the Collaborative Systems Laboratory, a member of the Senate Research Committee, Arts and Science Executive Committee, Nipissing University, Canada. He is also an affiliate full professor at Concordia Univ. and an adjunct professor of Laurentian Univ., Canada. He has accomplished (published or in press) over 240+ research works, including 40+ IEEE Transactions articles, six books, five book chapters, four journal issues, and four conference proceedings. He is a fellow of I2CICC (International Institute of Cognitive Informatics and Cognitive Computing), a senior member of ACM and IEEE, a full member of Sigma Xi, and a life member of CAST-USA (Chinese Association of Science and Technology, USA).

He is serving as Vice President - Systems Science and Engineering (SSE) (2023-), member-at-large of the Board of Governors (2022-), and a co-chair (2006-) of the technical committee of Distributed Intelligent Systems of IEEE Systems, Man and Cybernetics (SMC) Society (SMCS). Associate Editor (AE) of IEEE Transactions on SMC: Systems (2018-), IEEE Transactions on Computational Social Systems(2018-), Frontiers of Computer Science (2021-), and IEEE Canada Review (2017-). He served as Editor-in-Chief of IEEE SMC Magazine (2022), AE of IEEE SMC Magazine (2015-2021), Associate Vice President (AVP), SSE (2021), IEEE SMCS, Program (Co-)Chair for many international conferences, and PC member for 130+ academic conferences.

He is the founding researcher of Role-Based Collaboration and Adaptive Collaboration and the creator of the E-CARGO model. His research monograph E-CARGO and Role-Based Collaboration can be found at https://www.amazon.com/CARGO-Role-Based-Collaboration-Modeling-Problems/dp/1119693063. The accompanying codes can be downloaded from GitHub: https://github.com/haibinnipissing/E-CARGO-Codes. He has offered 30+ keynote speeches for international conferences and 90+ invited talks internationally. He has received over CAD$1M of grants from SSHRC, NSERC, IBM, DNDC, DRDC, and OPIC.

Abstract:

Hybrid Human/Robot teams are systems that include both humans and highly autonomous robots and they can be used in a wide range of applications, including surveillance, inspection, rescue, automation, and logistics. To establish such a hybrid team, the collaboration between agents in the team can quickly become a challenging problem, particularly when there is a dynamic environment including a variety of well-trained humans with different expertise, and robots with various hardware, software, battery life, size, and functionalities. Hybrid team establishment introduces new requirements, new challenges, and new solutions to real-world problems. When many heterogeneous and autonomous robots and humans are organized as a team to accomplish a mission, evaluating each human/robot for each task and assigning proper tasks to each human/robot before acting is essential. Pertinent and dynamic task assignments can avoid failures in operation and increase operating efficiency while the humans and robots are executing their mission. Role-Based Collaboration (RBC) is a computational methodology that uses role mechanisms to facilitate collaboration activities. RBC and its Environments - Classes, Agents, Roles, Groups, and Objects (E-CARGO) model have been developed into a powerful tool for investigating teamwork. Related research has brought and will bring exciting improvements to the development, evaluation, and management of systems, including collaboration, services, clouds, productions, and administration systems. E-CARGO/RBC has been verified by formalizing and solving significant problems in collaboration and complex systems, e.g.,

Group Role Assignment (GRA). With the help of E-CARGO, the methodology of RBC can be applied to solve various real-world problems. E-CARGO itself can be extended to formalize abstract problems as innovative investigations in research. In this presentation, we examine the requirement of research on robot teams and collaboration, discuss RBC and its model E-CARGO; review the related research achievements on RBC and E-CARGO in the past years, including Group Role Assignment (GRA), GRA with Constraints (GRA+), and Adaptive Collaboration; analyze their connections with hybrid teams, and present initial simulations and experiments. The presenter welcomes queries, reviews, studies, applications, and criticisms.

10:00 – 10:15 **Human-machine symbiosis using multimodal data for the development of human Digital Twins**

Professor Roger Azevedo and Dr. Megan Wiedbusch, School of Modeling Simulation and Training, the University of Central Florida (UCF)

Dr. Azevedo is a Professor in the School of Modeling Simulation and Training at the University of Central Florida. He is also an affiliated faculty in the Departments of Computer Science and Internal Medicine at the University of Central Florida and the lead scientist for the Learning Sciences Faculty Cluster Initiative. His main research area includes examining the role of cognitive, metacognitive, affective, and motivational self-regulatory processes during learning with advanced learning technologies (e.g., intelligent tutoring systems, hypermedia, multimedia, simulations, serious games, immersive virtual learning environments). His overarching research goal is to understand the complex interactions between humans and intelligent learning systems by using interdisciplinary methods to measure cognitive, metacognitive, emotional, motivational, and social processes and their impact on learning, performance, and transfer. To accomplish this goal, he conducts laboratory, classroom, and in-situ (e.g., medical simulator) studies and collects multi-channel data to develop models of human-computer interaction; examines the nature of temporally unfolding self- and other-regulatory processes (e.g., human-human and human-artificial agents); and designs intelligent learning and training systems to detect, track, model, and foster learners, teachers, and trainers' self-regulatory processes.

Dr. Wiedbusch is a postdoctoral researcher at the School of Modeling, Simulation, and Training at the University of Central Florida (UCF) with Dr. Roger Azevedo. Her research is focused on the measurement of the dynamics of metacognition and engagement using traditional (i.e., self-reports) and unobtrusive multimodal (e.g., eye tracking, facial expressions, log files) methodological and analytical approaches across contexts (e.g., health care, K-12 education, teacher training) and learning environments (e.g., VR, simulations, ITS, and GBLEs). She conducts laboratory, classroom, and in-situ studies to model human (meta)cognition and behavior during complex learning to inform the design of human-centered intelligent learning and training technologies.

Abstract:

This presentation explores the paradigm of human-machine symbiosis by leveraging multimodal data (e.g., eye movements, concurrent verbalizations, physiological data) to create human Digital Twins within the context of Human-Machine Systems and Digital Twin Technologies. As technology advances, integrating various data modalities such as physiological, behavioral, psychological, and environmental becomes pivotal in enhancing the fidelity and utility of human Digital Twins. The proposed framework establishes a symbiotic relationship between humans and machines, aiming to replicate and simulate human characteristics and functionalities (e.g., reasoning, problem-solving, learning) in digital environments. This integration involves real-time monitoring and analysis of diverse data sources, including biometric data, motion patterns, cognitive states, metacognitive

monitoring processes, and contextual variables. Machine learning algorithms are crucial in deciphering intricate patterns and fostering a deeper understanding of individual behaviors and responses to external stimuli. The implications of this research extend to applications in healthcare, personalized medicine, military, K-16, and human-centered design. Human Digital Twins can serve as predictive models for learning outcomes and self-regulatory skills development, enabling proactive, intelligent, individualized interventions. Furthermore, in design and engineering, the development of highly responsive and adaptive systems can be realized through the insights gained from human Digital Twins. This talk contributes to the ongoing discourse on Human-Machine Systems and Digital Twin Technologies, presenting a comprehensive framework that advances the concept of symbiotic interaction, pushing the boundaries of technological integration to improve human well-being and system performance.

10:15 – 11:00 **Group Discussion: How integrating Human-Machine Systems and Digital Twin Technologies can improve system performance?**

11:00 – 11:15 **Coffee Break**

11:15 – 11:30 **Synthetic Population as Digital Twin Technology for Real-Scale Social Simulations**

Professor Tadahiko Murata, Cybermedia Center of Osaka University, Japan - IEEE Fellow

Dr. Tadahiko Murata is a Professor at Cybermedia Center of Osaka University, Japan. In Osaka University, he has classes in Division of Electronic and Information Engineering for undergraduate students and Graduate School of Information Science and Technology for graduate students. He was President of Japanese Society for Evolutionary Computation from 2020 to 2022. He is currently Vice President of Organization and Planning in IEEE SMC Society and Vice President in Japan Society for Fuzzy Theory and Intelligent Informatics. He is IEEE Fellow.

Abstract:
In order to realize the digital twin for communities or regions in the cyber space, we need to obtain information on household members in the target area. However, attributes such as age, school, workplace, and income of household members are their privacy, it is difficult to utilize them in a digital twin. Synthetic population method synthesize or generates those personal data only from publicly released statistics. In the pandemic of Covid-19, a lot of researcher synthesize those household information from the statistics and simulate Covid-19 spreading in the target region. In this talk, I show several application examples of synthetic population in Japan.

11:30 – 11:45 **Virtual Learning Environments**

Professor Charlie Hughes, Pegasus Professor, Department of Computer Science, UCF

Dr. Charlie Hughes is a Pegasus Professor of Computer Science at the University of Central Florida (UCF). He is Co-Lead of the Learning Sciences Cluster, Co-Director of the Synthetic Reality Laboratory SREAL), and Co-Director of the Center for Research in Education Simulation Technology (CREST). He has secondary appointments in Electrical and Computer Engineering, the School of Modeling, Simulation & Training, the College of Community Innovation & Education, and the Department of Games & Interactive Media at UCF. Charlie was recently inducted into the National Center for Simulation Hall of Fame. His virtual environment research spans three and a half decades, with the last 15 years focused on virtual learning environments (co-holder of 11 patents in

this area) with an emphasis on preparing teachers for inclusive classrooms and helping students with autism reach their full potentials. He has authored or co-authored 7 books, 68 journal articles, 38 book chapters, and 122 refereed conference papers. He has advised 28 students to completion of their Ph.D.'s in computer science and modeling & simulation, with women being eight of the last 13. He is a Life Senior Member of both the IEEE and the ACM and is an ACM SIGGRAPH Pioneer. He has been PI or co-PI on about $30M in external grants since 2000, of which over $6M in funding is currently active.

Abstract:
Virtual Learning Environments (VLEs) refer to the employment of extended reality (VR, AR, MR) in contexts that are intended to improve the performance of participants in some area of work, education, or job training, especially when these involve human to human interactions. This talk will discuss VLE research in support of the education of youth who have autism, and the efforts of people who interact with those on the spectrum (coaches, teachers, police officers). We will also discuss the use of real-time physiological data to influence the behavior of virtual character, especially virtual companions for children with autism.

11:45 – 12:00 **Real-Time Battlefield Casualty Care Decision Support**
Professor Christopher Nemeth, Principal Scientist, Applied Research Associates

Christopher Nemeth, PhD, CHFP, is a Principal Scientist with Applied Research Associates, a 2000-member national science and engineering consulting firm. His 26-year academic career has included seven years in the Department of Anesthesia and Critical Care at the University of Chicago Medical Center, and adjunct positions with Northwestern University's McCormick College of Engineering and Applied Sciences (Associate Professor), and Illinois Institute of Technology. He is a Fellow of both Applied Research Associates and the Design Research Society, a Life Senior Member of the Institute of Electrical and Electronic Engineers (IEEE), and has served 8 years as a member of the IEEE Systems, Man and Cybernetics Society Board of Governors. He retired from the Navy in 2001 at the rank of Captain after a 30-year active duty and reserve career.

Abstract:
The Trauma Triage Treatment and Training Decision Support (4TDS) system is an operating prototype that provides real-time casualty data and trend indications to medics and clinicians in austere battlefield settings. Using only six vital signs, machine learning models scan vital signs data to detect risk of internal hemorrhage, probability of need for massive transfusion, and likelihood of impending shock. Participatory design from initial development through field evaluation with 00 military medical professionals aligned 4TDS with needs to support Tactical Combat Casualty Cate (TCCC) and Prolonged Field Care (PFC).

12:00 – 12:30 **Lunch Break**

12:30 – 12:45 **Readiness and Medical Solutions**
Dr. Joseph Cohn, SoarTec

Dr. Joseph Cohn is SoarTech's Director for Readiness and Medical Solutions. In this role he focuses on applying SoarTech's human-centric AI to delivering capabilities that support the Joint medical force's ability to provide critical care across a range of threat environments.

A retired Navy Medical Service Corps Captain with a Neuroscience PhD, Joseph embraces high-risk research to deliver technologies that ensure the United States military maintains its technical edge over its adversaries. Throughout his career, he has developed and directed numerous biomedical and human systems-focused Research and Acquisition programs for the Navy, Joint Force and International partnerships. Joseph oversaw a Joint team tasked with combining over $3B in Service medical Research, Development & Acquisition assets into a single Defense Health Agency -led organization. As Deputy Director for Human, Performance and Biosystems, he co-led and managed a $20M cognitive sciences and human performance international research collaboration through the U.S.–India Defense Technology and Trade Initiative. As a Program Officer at the Office of Naval Research, he led a Joint team in developing a capability for selecting Unmanned Aerial System (UAS) Operators, which directly informed the Navy's decision to establish their inaugural UAS Operator Community. As the Office of Naval Research's first Deputy Director for Naval Science, Technology, Engineering and Mathematics (STEM), he coordinated the Secretary of the Navy's $180M STEM program with projects across all 50 states, reaching 200,000 students annually. While a Program Manager at DARPA, Joseph developed AI-based approaches that reduced the time to train and acquire expertise ten-fold, establishing a Navy-approved prototype training pipeline for new recruits based on this capability, with an estimated savings of $50M/year.

Joseph has co-authored over 100 publications, co-edited three textbooks and chaired numerous panels and workshops, focusing on biomedical, human machine interaction and human performance-enhancing technologies. He is a Fellow of the American Psychological Association and the Society of Military Psychologists as well as Associate Fellow, Aerospace Medical Association.

Panel:

12:45 – 13:15 **Discussion for challenges and opportunities and ways forward for Academia, Government, and Industry Collaboration**

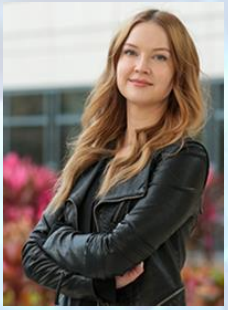
Moderator: Ms. Eileen Smith

Panelists:

UCF IST, Dr. Edward Tunstel, Chief Technology Officer (Motiv Space Systems, Inc. / Motiv Robotics), William Hoffman Chairman and Chief Executive Officer (OMG® Group, Digital Twin Consortium®)

13:15 – 13:30 **Quantifying extended human-plus-tool cognitive systems**

Dr. Mary Jean Amon, Luis H. Favela, School of Modeling Simulation and Training, the University of Central Florida (UCF)



Dr. Mary Jean Amon is an Assistant Professor in the School of Modeling, Simulation, and Training at the University of Central Florida. She holds an M.A. and Ph.D. in Experimental Psychology from the University of Cincinnati, as well as an M.A. in Psychology in Education from Teacher's College, Columbia University. Before joining UCF, she was a Postdoctoral Researcher in the Department of Psychological and Brain Sciences at Indiana University Bloomington, and then a Research Associate in the Institute of Cognitive Science at the University of Colorado Boulder. Her interdisciplinary research is informed by topics in cognitive science, computer science, and data science and centers on user-oriented research aimed toward optimizing decision-making and performance in the context of complex socio-technological systems. This includes augmenting our understanding of teamwork by identifying coordinative patterns and features of socio-technical tasks that enhance performance, as well as how the dynamics of human-computer interaction inform issues associated with online privacy. She has published in venues such as AIED, CHI, Cognitive Science, Communication Monographs, CSCW, ICMI, S&P, LAK, and ACM HEALTH. Her work has also been covered by ACM Tech News, Forbes, Inside Higher Ed, Washington Post, and Yahoo! news, among others.

Dr. Luis H. Favela is an Associate Professor of Philosophy and Cognitive Sciences at the University of Central Florida. He is a Fellow with the Research Corporation for Science Advancement and has held fellowships at University of Pittsburgh's Center for Philosophy of Science, and Duke University's Summer Seminars in Neuroscience and Philosophy. He earned his Ph.D. in Philosophy (Life Sciences Track) at the University of Cincinnati, where he concurrently earned a Master's in Experimental Psychology. Prior to Cincinnati, he earned a Master's in Philosophy at San Diego State University and a Bachelor's in English and Philosophy at the University of San Diego. His research is interdisciplinary, situated at the intersections of the cognitive sciences, experimental psychology, and the philosophies of mind and science.

Abstract:
An empirically supported methodological and theoretical framework is presented for quantifying the dynamics of human-plus-tool cognitive systems. Participants provided perceptual judgments regarding the affordance pass-through-ability of apertures of varying widths while using vision, blindfolded wielding a rod, and blindfolded wielding an Enactive Torch (a vibrotactile sensory-substitution device). Human-plus-tool movement dynamics were assessed via fractal, multifractal, and recurrence quantification analyses. Trials where participants utilized the rod or Enactive Torch demonstrated stable "self-similarity," an indicator of adaptive and healthy single systems, regardless of aperture width, features of the participants' judgments, participant characteristics, and trial order. Trials with the Enactive Torch exhibited slightly greater range of dynamic fluctuations than the rod trials, as well as less movement recurrence, which suggests that the Enactive Torch allowed for more fine-grained exploratory movements. Notably, although participants were more confident with visual judgments, they were significantly more accurate with tool-assisted haptic judgments. Findings provide support for the notion that human-plus-tool systems can be classified as extended cognitive systems and a framework for quantifying system-level properties of these systems.

13: 30 – 13:45 Interaction-Centered Design: Frontier of Human-Autonomy Teaming

Dr. Ming Hou, Senior Defence Scientist with Defence Research and Development, Department of National Defence, Canada

Dr. Hou is an IEEE Fellow, a Senior Scientist, and the Principal Authority Human-Technology Interactions within the Department of National Defence (DND), Canada. He is responsible for delivering cutting-edge technological solutions, science-based advice, and evidence-based policy recommendations on AI and Autonomy science, technology, and innovation strategies to senior decision makers within DND, the Canadian Armed Forces, and their national and international partner organizations including the United Nations. As the Canadian National Leader in human-AI/autonomy teaming, he directs the Canadian innovation ecosystems on defence R&D programs to support Canadian major acquisition projects and large-scale live, virtual, and constructive international joint exercises. As the Co-Chair of an international Human Factors Specialist Committee, he leads the development of international standards for the integration of unmanned aircraft systems into the civilian airspaces. Dr. Hou is the recipient of the most prestigious DND Science and Technology Excellence Award in 2020 and the President's Achievement Award of the Professional Institute of the Public Service of Canada in 2021. He is an Adjunct Professor at the University of Toronto and University of Calgary. Dr. Hou is the General Chair of the 2024 IEEE International Conference on Human-Machine Systems and International Defence Excellence and Security Symposium.

Abstract:

The effective human-machine teaming is challenged by the lack of understanding of human-machine interaction issues and appropriate design methodologies for mission/safety-critical systems. Limitations and strengths of human and artificial intelligence (AI) must be well understood first before designing, developing, and employing AI-enabled human-machine systems. It is not only about the safety of these systems, but more importantly human lives and mission success. A systematic and structured framework for design, develop, verify, validate, and regulate disruptive technologies is critical to the entire life cycle of these emerging systems. This talk reviews the evolution of design strategy of intelligent systems, presents the state-of-the-art design methodologies to address the interaction challenges for developing and deploying responsible AI technologies and thus effective human-AI teaming. A technological solution of trustworthy, collaborative, effective, and responsible human-AI teaming for decision-making in weapon engagement following international laws and rules of engagement provides a best practice example for all stakeholders who are interested in building and using 21st century human-AI symbiosis technologies.

13:45 – 14:00 Automated Collaborative Problem-Solving through Dialogues between Specialized Large Language Models

Dr. Sean Mondesire, School of Modeling Simulation and Training, the University of Central Florida (UCF)

Dr. Sean Mondesire is an Assistant Professor at the University of Central Florida's (UCF) School of Modeling, Simulation, and Training (SMST). He is a part of the Knights Digital Twin Initiative, directs the Human-centered Artificial Intelligence Laboratory (HAIL), and co-directs UCF's Advanced Research Computing Center (ARCC) for high-performance computing. His research specialties are machine learning and big data analytics for real-time recommender systems and autonomous decision-making at scale.

Abstract:

This presentation examines the use of Large Language Models (LLMs) in dialogic self-play for complex problem-solving. By assigning specialized roles to each LLM, we explore their capacity to tackle logic puzzles and improve NPCs in serious gaming. We focus on the efficiency of these AI dialogues in discovering innovative solutions and research questions, highlighting minimal human-in-the-loop approaches. This method demonstrates significant time-saving and creative potential, offering new insights into autonomous AI collaboration and its impact on advancing AI research and applications.

14:00 – 14:15 **Group Discussion: What are the challenges of integrating Human-Machine Systems and Digital Twin Technologies?**

14:15 – 14:30 **AR/VR and Human Comfort Index for Human Robot Collaboration in Industrial Manufacturing**

Dr. Ferat Sahin, Department of Electrical and Microelectronics Engineering, Rochester Institute of Technology

Dr. Ferat Sahin received his M.Sc. and Ph.D. degrees from Virginia Polytechnic Institute and State University. In September 2000, he joined Rochester Institute of Technology, where he is a Professor and Department Head of Electrical and Microelectronics Engineering department. He is also the director of Multi Agent Bio-Robotics Laboratory and Century Mold Collaborative Robotics Laboratory at RIT. His current research interests are Integration of Collaborative Robots in Manufacturing, Human-Robot Collaboration, Deep Learning Approaches for Grasping, Digital Twin, System of Systems Engineering, Machine Learning, Biological Signal Processing, Fault Analysis and Systemic Health Evaluation. Dr. Sahin has over 170 conference and journal publications in these research fields. In addition, he is also the co-author of two books: "Experimental and Practical Robotics" and "Intelligent Control Systems with an Introduction to System of Systems Engineering" by CRC Press. Dr. Sahin has been very actively serving in his scientific community through IEEE. He has served as in several capacities such as technical organizer, reviewer, referee, associate editor and deputy editor for leading journals and conferences in both the IEEE and other organizations. He serves as an Associate Editor for IEEE SMCS: Systems and SMCS Magazine. He is a member of the IEEE Systems, Man, and Cybernetics Society, Robotics and Automation Society, and Computational Intelligence Society. Currently, he is a member of Board of Governors and VP Finance of IEEE SMC Society. He has served as the Student Activities chair for the IEEE SMC Society in 2001, 2002, and 2003. He was the Secretary of the IEEE SMC Society from 2003 to 2006. Dr. Sahin received an "Outstanding Contribution Award" for his service as the SMC Society Secretary in 2007 and 2015. He also served as the Treasurer of the IEEE SMC Society in 2011, 2012, and 2013. Dr. Sahin has been heavily involved with technical conference organization. He has held many committee positions such as publication chair, finance chair, technical committee chair, and general chair of several IEEE sponsored international conferences. He has been mainly involved with two conferences: IEEE SMC International Conference on System of Systems Engineering (SOSE 2007-2023) and IEEE Annual Conference on Systems, Man, and Cybernetics (SMC). Currently, he is the general chair for 2024 International Conference on System of Systems Engineering and was the general co-chair for IEEE SMC 2023.

Abstract:

Collaborative robots are becoming very common in manufacturing industry because of their ability to work with humans safely without a cage around them. In the event of a collision collaborative robots are guaranteed not to jeopardize the safety of the human. However, a collision with a collaborative robot still requires the robot to stop completely and be started by an engineer which can cause significant decrease in throughput of the manufacturing line. Thus, collaborative robots need to avoid collision and maintain the highest throughput. Speed and separation monitoring (SSM) approaches are researched and developed to minimize collision and robot downtimes. There are also dynamic speed and separation monitoring approaches where the robot's and human's speed and positions are factored in for more optimized SSM. However, the SSM approaches only assess the position and speed of the human but does not care about human's physical and mental state while working with a robot. If a person is not comfortable with or scared of a robot, there performance can degrade and resit to collaboration with the robot. We developed approaches where human comfort is assessed and factored into dynamic SSM approach to control the robot's motion to ease human discomfort. We measure human comfortability through physiological signals such as pupil size, heart rate, heart rate variability and galvanic skin response to determine their emotional state based on circumflex model. In addition, we provide the human an AR set (Microsoft HoloLens II) to increase their situational awareness and possibly help with their comfort level. We have run four human subject test with regards to dynamic SSM, comfortability index estimation, human emotion estimation through physiological data and face image, and situational awareness assessment through AR headset. Our experimental results shows that including mental and emotional state (comfort) and situational awareness through AR can improve their performance and the throughput of the manufacturing line.

14:30 – 14:45 Robotic Guide Dog to Aid Visually Impaired Individuals Navigate Unfamiliar Areas

Dr. Crystal Maraj, School of Modeling Simulation and Training, the University of Central Florida (UCF)

Dr. Crystal S. Maraj is a Research Assistant Professor employed by the School of Modeling Simulation and Training (SMST), Institute for Simulation and Training (IST) at the University of Central Florida (UCF). She has attained her Bachelor's degree in Psychology, as well as her M.S. and Ph.D. in Modeling and Simulation (M&S) from UCF. Dr. Maraj has worked for the Simulation & Training Technology Center (STTC) as an experimental psychologist on medical simulation technology projects as well as developing and implementing empirically based research experiments for Simulation-Based Training (SBT) platforms. Most recently, she is leading the Realistic Assessment of Performance in Devices (RAPID) lab that focuses on the evaluations of VR/AR technologies assessing capabilities, deficiencies, specifications, costs, maturity, and risks. She also serves at the Faculty Advisor to the Robotics Club of Central Florida and lead STEM-based initiatives for IST. Dr. Maraj has published research findings to inform the scientific and training communities to improve trainee performance and training system utility.

Abstract:

This research investigates the implementation of a robotic guide dog to aid people with visual impairments. The study specifically focuses on the human participant's subjective attitude towards and opinions about the robotic dog. The feasibility of a robotic guide dog is partially determined by how humans will react to the idea of such technology being implemented in daily activity. The study will require the participants to complete three walks, guided by Tape measure, through set paths of

varying difficulty while blindfolded to simulate visual impairment. Subjective assessment will involve pre- and post-test surveys to gauge human attitudes toward the robot. This effort offers an understanding of human-robot interaction, improving the robotic guide dog framework and proposing a modern alternative for assisting the visually impaired.

14:45 – 15:00 Coffee Break

15:00 – 15:20 Trust and Risk at the Intersection of Human–Machine Systems - (Online – Australia)
Associate Professor Simon Reay Atkinson, Captain in the Royal Australian Navy

Associate Professor Simon Reay Atkinson is a Captain in the Royal Australian Navy with extensive international experience, including in the US, Middle East, South West Asia, and NATO. He is currently serving as the Principal Investigator (PI) RAAF Air Command, Preparedness, Innovation & Improvement. Twice mentioned in despatches, innovative problem solving has been a highlight throughout a wide array of career experiences. A first degree in engineering was combined with a second degree (a research-based Cambridge University MPhil) in International Relations majoring in Law and Economics. This provided the foundation for a PhD (CUED) which examined, through engineering and social science lenses, complex systems and human factors / organisational modelling including with regard to cyber, quantum, risk and resilience. The underlying strength of research has been its applicability and re-use; allowing for re-interpretation and practical application. Including as Chief of Staff of the Defence Response to Covid at Joint Task Force 629 – responsible also for domestic operations, fires and floods.

Abstract:
My talk will first set out the scientific and technological context we face today – described as the Synethical Age, fusing Quantum Computing, with AI (QAIC), with nanotechnology (QAINT). Each scientific age last about 45 years – the juncture between previous and succeeding ages is typified by period of instability and [radical] uncertainty (Keynes, 1921/6). As between the Turbine Age (1885-1929) and the Industrial Age (1930-1974), and the Industrial Age and the Information Age (1975-2020). Hitherto "knowledge could be described as being human and infotechnological" – noting the indivisibility of information and technology, typified by the end of Information Age. The synthesis of QAIC with the infotechnological has the potential of displacing the human. Where knowledge may no longer be existential, but Interstitial – "scripted knowledge forming, or occupying only at the interstices between data and information" (SRA, 2023). Command and Control (Leadership & Management) is at the core of organisational designs – reflecting an organisation's unique culture (knowledge) and ontology (language). Command and Control is intended to enable Decision Making and Taking, or DMT. Where the effective ability to solve complex problems is indicative also of the health of an organisation – with the variety of ideas/views/opinions/skills (exercised through Command and Control) allowing for complex problem solving. This has ethical and moral implications – where morality is inherently human. Command (and leadership) is also related to trust and agility; whereas control (and management) is related to rules and fidelity. Trusts are vested in human values and morality – based upon social (existential) knowledge. Whereas humans might trust robots, or ChatGPT, does the reverse apply? What is the relationship between Risk and Trust, for example. If the robot/machine-system cannot trust the human, does that give rise to infinite risk? This talk will consider organisational agent-based human modelling to consider zero-trust designs. It will consider where a new knowledge may interstist with respect to existential knowledge – raising questions of trust, risk, morality, and ethical applications in organisational designs.

15:20 – 15:40 IEEE Transactions on Human-Machine Systems

Professor Ljiljana Trajkovic, School of Engineering Science, Simon Fraser University, Burnaby, British Columbia, Canada

Ljiljana Trajkovic received the Dipl. Ing. degree from University of Pristina, Yugoslavia, the M.Sc. degrees in electrical engineering and computer engineering from Syracuse University, Syracuse, NY, and the Ph.D. degree in electrical engineering from University of California at Los Angeles. She is currently a professor in the School of Engineering Science, Simon Fraser University, Burnaby, British Columbia, Canada. Her research interests include communication networks and dynamical systems. She served as IEEE Division X Delegate/Director, President of the IEEE Systems, Man, and Cybernetics Society, and President of the IEEE Circuits and Systems Society. Dr. Trajkovic serves as Editor-in-Chief of the IEEE Transactions on Human-Machine Systems and Associate Editor-in-Chief of the IEEE Open Journal of Systems Engineering. She served as a Distinguished Lecturer of the IEEE Circuits and System Society and a Distinguished Lecturer of the IEEE Systems, Man, and Cybernetics Society. She is a Fellow of the IEEE.

15:40 – 15:45 **Concluding Remarks and Workshop Wrap-Up**

Professor Saeid Nahavandi ; Dr. Soheil Sabri

15:45 – 17:00 **Lab Tour – In-Person Only**

1. E2i Creative Studio
2. SENSEable Design Laboratory
3. VAR Lab

17:00 **Assembling of the IEEE SMCS team at the Parking Partnership III**

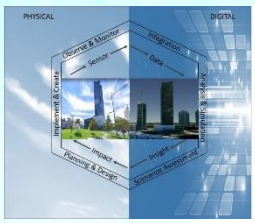
For registration, RSVP before 13 February:

https://ucf.qualtrics.com/jfe/form/SV_42RDbK1xsATlSMm

Workshop Sponsors:

IST, School of Modeling Simulation and Training
UNIVERSITY OF CENTRAL FLORIDA

IEEE SMC Systems, Man, and Cybernetics Society



Urban Digital Twin Lab

Contact:

Soheil Sabri, Ph.D.
Assistant Professor | **Digital Twin Strategic Initiative**
Director | **Urban Digital Twin (UDT) Lab**
3100 Technology Parkway, Suite 329 | Orlando, FL 32826
858.306.2796 | soheil.sabri@UCF.edu

400
200
100