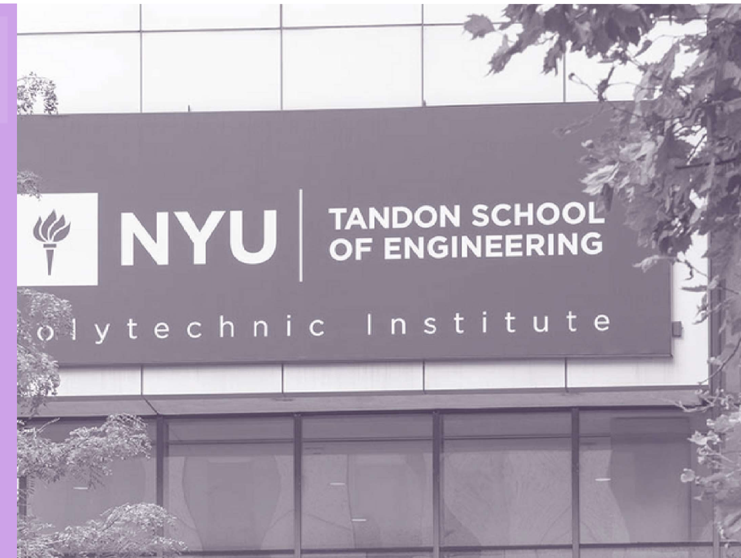
Notes



2ND IEEE WORKSHOP ON RELIABLE AND RESILIENT DIGITAL MANUFACTURING

May 1-2, 2023

Center for Cybersecurity
New York University Tandon School of Engineering
370 Jay Street, Brooklyn, NY 11201

Organizers:

Dr. Nikhil Gupta
Dr. Ramesh Karri
NYU Center for Cybersecurity

Dr. Nektarios Tsoutsos
Center for Cyber security, Assurance and Privacy

WORKSHOP AGENDA

MAY 1, 2023

Time	Topic	Speaker	Institution
8:30-9:00	Breakfast		
9:00-9:10	FMNet Introduction	Nikhil Gupta	NYU
9:10-9:20	Welcome	Kurt Becker	NYU
9:20-10:20	Keynote	Andrew Wells	NSF
10:20-10:40	Invited	Steve Feiner	Columbia
10:40-11:00	Coffee Break		
11:00-11:20	Invited	Mark Yampolskiy	Auburn
11:20-11:40	Invited	Jitesh Panchal	Purdue
11:40-12:00	Invited	Sanha Kim	KAIST
12:00-1:00	Lunch		
1:00-1:40	Keynote	Yan Lu	NIST
1:40-2:00	Invited	Eric MacDonald	UT El Paso
2:00-2:20	Invited	Farokh Atashzar	NYU
2:20-2:40	Invited	Hyunwoong Ko	Arizona State
2:40-3:00	Coffee Break		
3:00-3:20	Invited	Majid Minary	UT Dallas
3:20-3:40	Invited	Nikhil Gupta	NYU
3:40-4:00	Invited	Saman Zonouz	Georgia Tech
4:00-5:00	Panel Discussion	Future Manufacturing	
5:00	Dinner		

Notes

Acknowledgments

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Paule Dubreuze

WORKSHOP AGENDA

MAY 2, 2023

Time	Topic	Speaker	Institution
8:30-9:00	Breakfast		
9:00-9:10			
9:10-9:20	Welcome	Nektarios Tsoutsos	UDelaware
9:20-10:20	Keynote	Ronald Poveda	NavAir
10:20-10:40	Invited	Chinmay Hegde	NYU
10:40-11:00	Coffee Break		
11:00-11:20	Invited	Abhijit Chakraborty	Raytheon
11:20-11:40	Invited	Guha Manogharan	Penn State
11:40-12:00	Invited	Subhashini Ganapathy	Wright State
12:00-1:00	Lunch		
1:00-1:40	Keynote	A. Narasimha Reddy	Texas A&M
1:40-2:00	Invited	Nektarios Tsoutsos	UDelaware
2:00-2:20	Invited	Satish Bukkapatnam	Texas A&M
2:20-2:40	Invited	Mahdi Jamshidinia	ASTM
2:40-3:00	Coffee Break		
3:00-3:20	Invited	Mohamed El Mansori	ENSAM
3:20-3:40	Invited	Ramesh Karri	NYU
3:40-4:00	Invited	Vijay Sanjairaj	NYU Abu Dhabi
4:00-5:00	CCRI Roundtable		
5:00	Adjourn		

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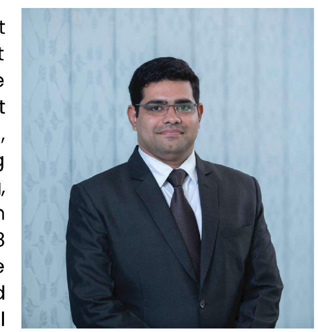
INVITED PRESENTATION

3D (Bio)Printing: The Art of Engineering Tissues

Dr. Vijayavenkataraman Sanjauraj New York University Abu Dhabi

3D Printing and bioprinting are pioneering technologies that enable fabrication of biomimetic, multiscale, multi-cellular tissues with highly complex tissue microenvironment, intricate cytoarchitecture, structure-function hierarchy, and tissue-specific compositional and mechanical heterogeneity. Given the huge demand for organ transplantation, coupled with limited organ donors, these technologies could solve the crisis of organ shortage by fabrication of fully functional whole organs. This talk will briefly introduce the need for these technologies in the field of tissue engineering and its potential applications. Some of the key projects from our lab, namely development of new ecofriendly bioinks for bioprinting of soft tissues, biomimetic bone implant design based on architected meta-materials for better biomimicry and mitigation of stress-shielding, and bioprinting of vascularized human skin tissue will be dealt with. The talk will also highlight some of the challenges associated with bioprinting from a security point of view.



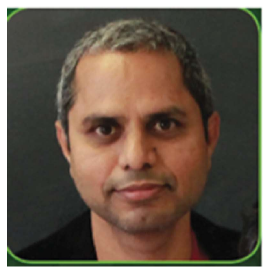
Speaker Bio: Professor Vijay is a tenure-track Assistant Professor of Mechanical Engineering and Bioengineering at New York University Abu Dhabi. He is also affiliated with the Department of Mechanical and Aerospace Engineering at Tandon School of Engineering, New York University, Brooklyn, USA. His research focus includes 3D printing and Bioprinting for tissue engineering, regenerative medicine, drug testing, and medical devices. He has published over 50 articles in peer-reviewed international journals, with a h-index of 28 and citations more than 3000. He was featured on the world's top 2% list of scientists published by Stanford University and Elsevier in 2021 and 2022. He holds editorial positions and serves as editorial board member of several reputed international journals including Bioprinting (Elsevier), Artificial Organs (Wiley), and International Journal of Bioprinting. His works include conductive scaffolds for neural tissue engineering, bioprinting of bi-layer functional human skin constructs, architected meta-materials-based design of bone implants for better biomimicry, and development of novel bio-inks for bioprinting of soft tissues. He was the recipient of several prestigious awards including the President's Graduate Fellowship for his doctoral studies at the National University of Singapore, Raman Memorial Award, The Sachivothama Sir C.P. Ramasamy Aiyar Scholarship, and WISE (Working Internships in Science and Engineering) from DAAD Germany. He was also part of several life sciences and biomedical industry-oriented programs such as Singapore Stanford Biodesign (SSB) Innovation Class, NUS Lean Launch Pad Singapore (modelled after NSF I-Corps program), and P&G Serial Innovator Camp.

INVITED PRESENTATION

NYU Center for Cybersecurity: Introduction and Capabilities

Dr. Ramesh Karri New York University

I will be giving a presentation covering the various research activities conducted at the NYU Center for Cybersecurity. I will focus on three primary areas of interest: general cybersecurity as it relates to the broader industry, cybersecurity specifically within the manufacturing sector, and the growing field of bio-manufacturing cybersecurity. By delving into these topics, I aim to provide a comprehensive overview of the cutting-edge work being carried out at the center, highlighting the significance of cybersecurity across different domains.



Speaker Bio: Ramesh Karri is a Professor at New York University, where he co-directs the Center for Cyber Security and founded the Embedded Systems Challenge. He holds a Ph.D. in Computer Science and Engineering and a B.E. in ECE. His research in hardware cybersecurity covers topics such as trustworthy ICs, processors, cyber-physical systems, computer-aided design, and more. He has published over 300 articles and received several awards and fellowships, including the Humboldt Fellowship and the National Science Foundation CAREER Award. Karri is also an editor and associate editor for multiple journals and has chaired and served on numerous program committees for conferences. He has given keynote speeches, talks, and tutorials on Hardware Security and Trust at various events.

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KEYNOTE PRESENTATION

NSF Support for Digital Manufacturing

Dr. Andrew Wells National Science Foundation

The National Science Foundation (NSF) has supported fundamental research in digital design, analysis, and manufacturing from their earliest versions, with early awards to investigators studying finite element analysis, solid modeling, and 3D printing technologies. NSF continues to underwrite exploration of new techniques to make manufacturing more reliable and resilient, as it invests in research and education to help revitalize the manufacturing sector, increase the resilience of U.S. supply chains, and train Americans for jobs of the future. This presentation will describe some challenges preventing industry from making manufacturing more robust and demonstrate a few recent projects which are advancing the reliability and resilience of manufacturing processes and systems. NSF supports digital and cyber-manufacturing research and education through a number of programs and solicitations, and the presentation will differentiate and describe the relationships between the funding opportunities. Several potentially promising areas of investigation will also be highlighted.

Speaker Bio: Dr. Andy Wells has been a Program Director in the National Science Foundation's Advanced Manufacturing program since 2019, where he supports fundamental research to advance American manufacturing technologies.

He is presently also serving as Acting Deputy Division Director of the Civil, Mechanical, and Manufacturing Innovation Division. He is also the co-leader of the Future Manufacturing solicitation, which supports research and education that will enable new, potentially transformative, manufacturing approaches to overcome scientific technological, educational, economic and social barriers that limit current manufacturing. Dr. Wells has over 25 years of experience developing and building precision equipment that enables manufacturers and researchers to visualize and transform materials at the micro- and nano-scale.

Before joining NSF, he was a technical program manager at Thermo Fisher Scientific and FEI Company, where he led development of scanning electron microscopes and ion-beam machining tools for semiconductor, materials science, and life science customers. Previously, he developed equipment for laser and mechanical micromachining at Electro Scientific Industries and was an adjunct professor at Portland State University. He received his PhD and MS degrees in mechanical engineering from Caltech, and his bachelor's degree from Dartmouth.

INVITED PRESENTATION

TEES-TAMU-ENSAM joint research cluster capabilities

Dr. Mohamed El Mansori Arts et Métiers ParisTech

Speaker Bio: Professor Mohamed EL MANSORI, Arts et Métiers ParisTech, France.

Mohamed EL MANSORI is a Professor at the Department of Mechanical, Material Science and Manufacturing Engineering, Arts et Métiers ParisTech (France) where he leads the Mechanics, Surfaces and Material Processing Laboratory (MSMP-EA-7350)/Engineering. He is appointed as TEES Research Professor at TAMU (USA). He is the Director Program of TEES-TAMU-ENSAM joint research cluster. He served as Deputy General Director in Charge of Research & Innovation at the Arts et Métiers ParisTech, France. He also chaired the Mechanical Engineering and Manufacturing Research Group (LMPF-EA4106) at the Châlons-en-Champagne campus. Mohamed EL Mansori received B.Sc degree in Physics from the University of Hassan II (Casablanca, Morocco:1993), and Ph.D in Mechanical Engineering from the Institut National Polytechnique de Lorraine (Nancy, France:1997) followed by he was employed as a post-doctoral researcher at the Center for Advanced Friction Studies of the Southern Illinois University, USA, and then he joined, before ParisTech, the research group at the ERMES (Nancy, France) for five years to conduct research on "the tribological behavior of engineering materials, especially under the influence of electro-magnetic environment". His current research interests include the interface of thermo-mechanic characteristics of both metallic and composite materials and physics behind their tribological and manufacturing performance. The research activities carried out in the last decade were interdisciplinary by their very nature. They have been engulfed to the issues concerning the tribological characteristics of engineering systems and multiscale advanced and smart manufacturing processes. These activities have led to the formation of a new research team which conceived and developed the concept of multi-scale process signature in conjunction with a new tribo-energetic approach for the fundamental understanding of smart and sustainable manufacturing processes involving lightweight synthetic and/or natural reinforced composite materials, energy-efficient manufacturing processes, advanced tribological studies and new process development for improved product performance and sustainability, etc.

The main interest of this approach was, in its capability, to "bridge the gap" between the traditional approaches of academia and the industrial requirements. These resulted with a strong publication record of more than 160 papers in JCR referenced international journals and more than 200 international and national conference proceedings. He has taught many short courses on tribology in the multiscale manufacturing process. Sevral invitations to technical/scientific meetings and international conferences can assess his strong international exposure.

INVITED PRESENTATION

An Overview of Data Management in Additive Manufacturing

Dr. Mahdi Jamshidinia American Society of Testing and Materials

The advancement of additive manufacturing (AM) over the past few years has led to the increased use of this technology in various industries. However, the lack of standardized guidelines and limited access to high-pedigree data have hindered the further adoption and industrialization of AM. ASTM Additive Manufacturing Center of Excellence (AM CoE) was formed in 2018, with the primary mission of bridging research and standardization for efficient development of standards, while facilitating collaboration among government, industry, and academia. This talk will provide an overview of AM CoE's initiatives on Research to Standardization, and various collaboration mechanisms developed f. In addition, AM CoE's efforts on data management will be reviewed. Data management requirements, data pedigree, quality assessment, automated data acquisition, and potential paths toward standardization are among topics that will be discussed.

Speaker Bio: Mahdi Jamshid, Ph.D. Senior Lead – Data Solutions and Strategy Dr. Mahdi Jamshid is the Senior Lead on Data Solutions and Strategy for ASTM International. In his role, Mahdi oversees AM CoE's Research to Standardization (R2S) and Data Management initiatives. He brings technical expertise to accelerate standardization activities through leading R&D projects, identifying future R&D needs, and forming new collaboration initiatives with technology experts. He has B.Sc. and M.Sc. in Material Science and PhD in Mechanical Engineering; with a focus on electron beam melting (EBM) of Ti-6Al-4V. After his PhD, Mahdi joined EWI and completed several governments, commercial, and R&D projects. Mahdi led the DMLM team in Columbus, OH before leaving EWI to GE Additive. At GE Additive, he was a Staff Engineer in the Materials Technology team and led the Response Surface activities. Mahdi established multiple partnerships with universities and government agencies for using machine learning and data mining in alloy design, process parameter optimization, and in-situ monitoring. He has co-authored 16 peer reviewed publications and has presented more than 25 lectures at various conferences.

KEYNOTE PRESENTATION

Holistic data fusion for additive manufacturing to accelerate AM development and deployment

Dr. Yan Lu National Institute of Standards and Testing

The quality of the final AM parts depends on feedstock material properties, process parameters, and equipment performance. The multitude of factors that affect a build process leads to great challenges in achieving consistent and reliable part quality. To address this challenge, simulations and measurements have been progressively deployed to provide valuable insights into the stability of AM processes and the quality of as-built parts. As a result, massive complex data are generated from AM development. This data not only provides a key role in advancing the understanding of AM processes but also drives engineering decision making through the deployment process of AM parts. At NIST, we are developing a holistic data-fusion framework that includes data obtained beyond a single-part development cycle and results in decision supports for various AM engineering activities, for example, material development, process planning, process control and part qualification. For a single process, data are fused at multiple scales for in-situ monitoring, defect prediction, process control and part qualification. The data from multiple buildings can be used for the establishment of process-structure-property relationship, the identification of process windows and new material development. The effectiveness of the NIST holistic AM data fusion framework is illustrated through three use case scenarios: one that fuses process data from a single build, one that fusses data from a build and simulation, and one that fuses data from multiple builds. The case studies demonstrate that the holistic data fusion framework can be applied to effectively detect over-melting scan strategies, monitor material melting conditions, and predict down-skin surface defects. Overall, an effective data fusion strategy provides a practical solution for enhancing part quality management when individual data sources or models have intrinsic limitations.

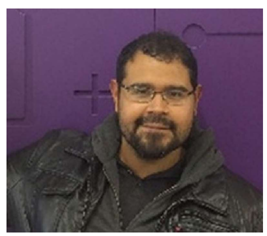
Speaker Bio: Dr. Yan Lu Leads the Information Modeling and Testing Group at the National Institute of Standards and Technology. She is also a project lead for the Data Integration and Management for Additive Manufacturing research. Her research interest includes additive manufacturing data modeling, data management, data registration and data fusion. Her group has developed an open additive manufacturing material database, AMMD, supporting collaborative schema development and AM data sharing. Dr. Yan Lu graduated from Tsinghua University with a BS and MS in automation control theory and from Carnegie Mellon University with a PhD in electrical and computer engineering. She has published more than 100 peer reviewed journal and conference papers and was granted more than 15 patents in industry and building automation technology. Dr. Yan Lu is US expert for IEC TC 65. A member of ASTM, ASME, and IEEE. She is active in developing additive manufacturing and smart manufacturing standards.

KEYNOTE PRESENTATION

Additive Manufacturing in the Navy: A NAWCAD Lakehurst Perspective

Dr. Ronald Poveda Naval Air Systems Command

Naval Aviation, especially within NAWCAD, has benefitted from continuous engineering research and novel, innovative technologies. Additive Manufacturing is one technology that has experienced rapid growth and use within naval aviation through integration of polymer and metallic parts designed for various applications. This includes growth of capabilities involving end-use aircraft parts, tooling and repair of in-service systems, job aids, and fit-form testing/rapid prototyping. Additive Manufacturing in NAWCAD has also allowed for development of novel structures, materials, and fabrication methods. Two examples of this include: 1) fabrication and development of metal matrix nanocomposites, which allow for tailorable materials that may help satisfy strict design requirements and solve fabrication and in-service issues, and 2) utilization of cold spray for repair of aluminum ALRE structures. Given such technological strides, it behooves NAWCAD Lakehurst, as well as the Navy as a whole, to not only continue to refine and push AM technological advancement in collaboration with other government, industrial, and academic partners, but also to consider standardization and qualification of printed parts and systems. Such steps will allow for full integration of AM parts within all sections of the Navy, allowing for consistent part and system performance and availability to benefit and support the warfighter.



Speaker Bio: Dr. Ronald Poveda is a Research Engineer and Subject Matter Expert for the Naval Air Warfare Center Aircraft Division in the Mission Operations and Integration Department in Lakehurst, N.J. He is responsible for multiple research projects and initiatives involving development of novel composite materials and lightweight structures, among other areas, in support of Aircraft Launch and Recovery Equipment and Support Equipment for the Navy. He currently resides as one of the only lead composite structures and materials researchers in all of NAWCAD Lakehurst. Dr. Poveda serves as a liaison between his home branch of Strategic Technologies and the Materials Engineering branch in order to initialize and support research efforts that delve into in-service system support, in addition to use of novel technologies and fabrication methods, to improve Naval system designs and performance to reduce total ownership costs. Dr. Poveda also led an engineering team within the NAWCAD Innovation Challenge program, which aims to fund heavily research-oriented projects under limited funding and timeframes, and as a result earned a NAWCAD Technical Innovation award in 2018. Dr. Poveda earned his Bachelors of Science degree, Summa Cum Laude, and his Masters of Science degree at the Polytechnic Institute of NYU, now NYU-Tandon, in 2009 and 2012, respectively. He has also earned his Doctorate in Mechanical Engineering, with specialization in lightweight, multiscale, polymer composite materials. He is currently a member of the American Society of Composites (ASC) and has published a total of 18 journal and conference publications and is a co-author of a book, titled "Carbon Nanofiber Reinforced Polymer Composites".

INVITED PRESENTATION

Digital twins for cybersecurity assurance in smart manufacturing systems

Dr. Satish Bukkapatnam Texas A&M University

This presentation overviews the ongoing collaboration between Texas A&M and Oakridge National Lab on securing manufacturing controllers. A recent IBM's study suggests that the emerging smart manufacturing systems are the largest target for cybersecurity attacks among all industry sectors. In a manufacturing plant floor, machine tool controllers are considered most vulnerable. Digital twins of controllers are essential for cybersecurity assurance as safety and cost considerations with physical controllers, and their closed architecture prevent an effective study of the vulnerabilities, attack vectors, and their defense innovations under different scenarios. A novel active learning method is presented to reconstruct a digital twin of a controller for cybersecurity applications. The resulting digital twin is a low-dimensional base representation of the closed physical machine tool controller, and it captures the salient structure and dynamic connectivity among the various components of the controller. A case study of developing a digital twin for cybersecurity assurance of a SIEMENS controller is discussed.

Speaker Bio: Satish Bukkapatnam serves as the Rockwell International Professor of Industrial & Systems Engineering at Texas A&M University, and the Director of Texas A&M Engineering Experiment Station Institute of Manufacturing Systems. He received his Ph.D. degree in Industrial and Manufacturing Engineering from Pennsylvania State University (1997). His research interests are broadly in smart manufacturing systems, and ultraprecision manufacturing. Dr. Bukkapatnam is a Fellow of IISE and SME, Associate member of CIRP, and was a Fulbright-Tocqueville Distinguished Chair.

INVITED PRESENTATION

NFTs For 3D Models: Sustaining Ownership in Industry 4.0

Dr. Nektarios Tsoutsos University of Delaware

The fourth industrial revolution, also known as Industry 4.0, is characterized by intelligent interconnected systems that automate production and supply chain management through digital manufacturing (DM), which includes 3D printing. However, the rapid expansion of three-dimensional computer-aided design (CAD) models brings new challenges, particularly in protecting intellectual property (IP) against piracy and counterfeiting. Novel methodologies are necessary to enable trustworthy CAD models to mitigate such attacks. Recent advancements in blockchain technology offer a promising solution to track DM artifacts and record transactions, particularly the use of Non-Fungible Tokens (NFTs), which are unique digital artifacts stored on the blockchain.

Our work offers a new methodology for proving ownership of 3D CAD models based on signal processing, NFTs, and distributed ledger technology. Our approach allows storing 3D design identifiers on a blockchain network to preserve the IP rights of the owner and combines on-chain information with off-chain signal-processing techniques to maintain the IP of the model. Notably, our methodology is resilient to a series of modifications on the CAD model, which protects against existing techniques that defeat file integrity protections. The proposed NFTs are connected to the frequency-domain representation of the shape of a given CAD model, which remains immutable under small modifications of the target file. Earlier techniques for securing manufacturing processes rely mostly on watermarking, which are bound to the model encoding and can be removed by known attacks. To overcome these challenges, we propose a tailored CAD model ownership and supply chain management solution that integrates frequency-domain shape signatures with blockchain tokens to generate unique identifiers for 3D designs. Leveraging NFTs on public distributed ledgers enables both authentication and transfer of ownership via smart contracts. We validate our technique by deploying our solution on Ethereum's proof-of-work Ropsten network and demonstrating the applicability of our methodology. Overall, the proposed method offers a new avenue for ensuring the security of 3D printing in Industry 4.0.

Speaker Bio: Nektarios Tsoutsos is an assistant professor with the Department of Electrical and Computer Engineering at the University of Delaware, with a joint appointment in the Department of Computer and Information Sciences. He is currently serving as the associate director of the Center for Cybersecurity, Assurance, and Privacy at UD. His research interests are in cybersecurity and applied cryptography, with a special focus in trustworthy computing, privacy outsourcing, and digital manufacturing.

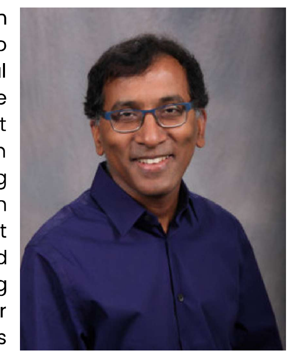
KEYNOTE PRESENTATION

Shifting Sands of Cybersecurity

Dr. A. Narasimha Reddy Texas A&M University

Cybersecurity has received significant attention over the last 25 years. This has resulted in a number of improvements in network and computer security practices. However, the ever-increasing automation has opened new frontiers for hackers, that are less protected. As a result, even as the security of some systems improves, the vulnerability landscape continues to shift requiring constant vigilance. Recently automated systems such as Internet of Things (IoTs), Building automation networks and automobile networks have been sources of many recent security concerns. Could we stay a step ahead as manufacturing becomes digitally automated?

Speaker Bio: Narasimha Reddy received a B.Tech. degree in Electronics and Electrical Communications Engineering from the Indian Institute of Technology, Kharagpur, India in August 1985, and M.S. and Ph.D. degrees in Computer Engineering from the University of Illinois at Urbana-Champaign in May 1987 and August 1990, respectively Reddy's research interests are in Computer Networks, Storage Systems, Multimedia Systems, and Computer Architecture. During 1990-1995, he was a Research Staff Member at IBM Almaden Research Center in San Jose where he worked on projects related to disk arrays, multiprocessor communication, hierarchical storage systems and video servers. Reddy holds five patents and was awarded a technical accomplishment award while at IBM. He received an NSF Career Award in 1996. He was a Faculty Fellow of the College of Engineering at Texas A&M during 1999-2000. His honors include an Outstanding Professor award by the IEEE student branch at Texas A&M during 1997-1998, an Outstanding Faculty award by the Department of Electrical and Computer Engineering during 2003-2004, a Distinguished Achievement award for teaching from the Former Students Association of Texas A&M University, and a citation "for one of the most influential papers from the 1st ACM Multimedia Conference". Reddy is a Fellow of IEEE Computer Society and is a member of ACM.



INVITED PRESENTATION

An AR and VR Testbed for Assigning High-Level Assembly Goals to Remote Robots

Dr. Steven Feiner Columbia University

While some real-world factory tasks can be completely automated using robots, many still rely on human expertise and involvement for robot control. Traditional robot operation is accomplished by workers who undergo extensive and time-consuming robot-specific training to understand how to control each robot. These workers are often required to perform their jobs onsite. We are exploring how a worker might instead remotely assign and monitor assembly tasks in Augmented Reality (AR) or Virtual Reality (VR) through high-level goal-based instruction rather than low-level direct control. To make this possible, we are developing a testbed in which a worker wearing an AR or VR headset manipulates virtual 3D representations of the parts to be assembled at a site. The worker proposes 6DoF poses for the parts, which are passed to a motion-planning component that determines and verifies in simulation trajectories that take into account the robot and scene to realize the proposals. This complements previous work by our team that addressed kitting parts, snapping imprecisely specified object poses to align with kit geometry. We focus here on a user interface that allows the worker to designate destination poses for parts, without assuming that the robot must process the proposals in the same order in which they are defined. To make this understandable, the user interface is designed to communicate the state of a part, indicating whether the worker is trying possible poses for it, the worker has decided on a destination pose, the robot is realizing that pose, the robot has asserted that it has finished, the worker has confirmed that the robot succeeded, or an error had occurred,
Since the robot may take much longer to physically realize a 6DoF pose than the worker takes to virtually specify it, we are investigating timesharing scenarios in which the worker handles multiple sites. They select one site at a time at which to operate, must maintain awareness of the other sites, and switch between sites as needed. To help improve the efficiency with which the worker performs within and between sites, they can be given cues about the current task step, either immediately before or while doing it, and precues about what to do after the current step. We have been studying how precueing multiple steps in advance in AR and VR can influence performance, for better or for worse.

Speaker Bio: Steve Feiner (Ph.D., Brown, '87) is a Professor of Computer Science at Columbia University, where he directs the Computer Graphics and User Interfaces Lab. He has been doing VR and AR research for over 25 years, designing and evaluating novel 3D interaction and visualization techniques, creating the first outdoor AR system using a see-through head-worn display and GPS, and pioneering experimental applications of AR and VR to fields as diverse as tourism, journalism, assembly, maintenance, construction, and medicine. Steve is a Fellow of the ACM and the IEEE, a member of the SIGCHI Academy and the IEEE VR Academy, and the recipient of the ACM SIGCHI 2018 Lifetime Research Award, the IEEE ISMAR 2017 Career Impact Award, and the IEEE VGTC 2014 Virtual Reality Career Award. He and his colleagues have won the IEEE ISMAR 2022 and 2019 Impact Paper Awards, the ISWC 2017 Early Innovator Award, and the ACM UIST 2010 Lasting Impact Award.

INVITED PRESENTATION

Human Centric Design of Digital Manufacturing

Dr. Subhashini Ganapathy Wright State University

As the manufacturing industry moves towards the adoption of Industry 4.0/5.0 principles and tools there is a need to ensure a safe environment for humans and machines to work together. The focus of this topic will be on providing an overview and a path to further the knowledge in the area of integrating human-in-the-loop in digital manufacturing.

Motivation: Interactions between humans and systems is important in smart manufacturing and there is a need to effectively use AI/ML and optimization processes to integrate human-in-the loop to maximize throughput while reducing human fatigue and overload. We aim to provide - a) a responsive and distributed supply chain, b) rapid customization to support foundry services, and c) manufacturing at a scale with better integration of humans and systems.

Speaker Bio: Dr. Subhashini Ganapathy is an educator, entrepreneur, and a leader in the area of Industrial and human factors engineering. Currently, Dr. Ganapathy is a professor and chair in the department of biomedical, industrial, and human factors engineering at Wright State University. After a successful industry stint of 6 years at Intel Corporation, she joined WSU in 2012, where she directs the Interaction, Design and Modeling Lab. Her multi-disciplinary research focus is on understanding human decision making and using these findings to develop applications to enhance human performance in complex systems such as digital manufacturing, incident command systems, emergency management. She has published over 50 articles in premier journals, conferences, and as book chapters. She holds 3 patents in mobile augmented reality. She is a TEDx Dayton speaker, Dayton 40 under 40 recipient, and was recently awarded the DBJ Diversity Champion Award in 2022.

INVITED PRESENTATION

What is all the fuss about Additive Manufacturing (AM) and Hybrid Manufacturing? Challenges and Opportunities for the 21st Century

Dr. Guha Manogharan Penn State University

In this seminar, we will discuss recent advancements in AM and how AM can be seamlessly integrated with other manufacturing methods, i.e., Hybrid AM to address major challenges in two different application domains: (1) Industrial (e.g., aerospace, and defense), and (2) Orthopaedics. (1) Industrial - Over 90% of all manufactured goods and machinery use a cast part. Sand casting accounts for 70% of all cast parts. However, conventional sand casting is regarded as a process of uncertainty due to its tendency to render higher scrap rates even in completely controlled processing environments. Casting defect analysis shows that over 90% of casting defects occur due to improper gating and feeding systems. This talk will first present a novel approach to rethink the design principles for: (a) sand cast parts and (b) gating and feeding systems to reduce defects through 3D sand-printing. Results from numerical analysis, computational melt flow simulations and experimental evaluation show that 3D Sand-Printing can lower melt flow turbulence in castings which reduces casting defects (35% reduction) and improves as-cast mechanical properties (15% increase in as-cast strength)(2) Orthopaedics - Advancements in digitally driven design and manufacturing is driving a new generation of medical implants and meta-biomaterials to address some of the critical clinical challenges, particularly in orthopaedics. This new class of biomimetic design offers multiple advantages, including: (a) greater control over tailoring the mechanical properties, (b) larger pore space that promotes bone ingrowth and vascularization, and (c) greater effective surface area which could be leveraged for bio-functionalization and infection prevention. Bio-mechanical responses of novel designs in AM porous biomaterials that exhibit nature-inspired geometries will be presented. Finally, morphological, and topological responses of these AM biomimetic porous biomaterials are presented to evaluate their structure–function relationships as well as success in mimicking different bio-mechanical properties of human bone.

Speaker Bio: Dr. Guha Manogharan is the Emmert H. Bashore Faculty Development Associate Professor of Mechanical Engineering at The Pennsylvania State University – University Park. He heads the Systems for Hybrid – Additive Processing Engineering - The SHAPE Lab which focuses on additive and hybrid manufacturing with an emphasis on biomedical, defense and aerospace applications. Dr. Manogharan received his Ph.D. (2014) and M.S. (2009) from North Carolina State University. He has received the 2022 ASME ECLIPSE award, 2021 ASTM Emerging Young Professional Award, 2020 NSF CAREER Award, 2018 International Outstanding Young Researcher in Freeform and Additive Manufacturing Award (FAME Jr), 2017 Society of Manufacturing Engineers' Yoram Koren Outstanding Young Manufacturing Engineer Award and the 2016 Outstanding Young Investigator by Manufacturing and Design Division of Institute of Industrial and Systems Engineering. His current work is supported by NSF, DoE, ONR, AFRL and Manufacturing PA.

INVITED PRESENTATION

Myths and Misconceptions in Additive Manufacturing Security

Dr. Mark Yampolskiy Auburn University

As the demand for Additive Manufacturing (AM) Security grows, it is only natural to adopt the well-established approaches from other security domains. However, as Goethe said, "Nothing is more dangerous for a new truth than an old misconception." This literally applies to AM Security, where application of approaches well-suited for other fields can provide a false sense of security for AM.

This talk will point out the common myths and misconceptions that – in the presenter's opinion – have plagued the AM Security field so far. The indicated discrepancies are an appeal to the audience to address the faced challenges clear-eyed.

Speaker Bio: Dr. Mark Yampolskiy is an Associate Professor at Auburn University, department of Computer Science and Software Engineering (CSSE). He is also an Affiliated Faculty with Auburn Cyber Research Center (ACRC) and National Center for Additive Manufacturing Excellence (NCAME). He was among the pioneers and is one of the leading experts in the field of Additive Manufacturing Security. His research interests include the cyber-physical means of attack and defense in AM.

INVITED PRESENTATION

Information Embedding and Retrieval in Additive

Dr. Jitesh Panchal Purdue University

While digitization of manufacturing has accelerated product realization and enabled designers to create products with previously unachievable complexity and precision, it has also opened the door to a range of security concerns, from theft of intellectual property to supply chain attacks and counterfeiting. To address these concerns, information embedding in the form of watermarks and fingerprints has emerged as a promising solution that enhances product security and traceability. Information embedding techniques involve storing unique and secure information within parts, making these parts easier to track and to verify for authenticity. Typical embedded information on components includes serial numbers, watermarks, and other meta-data. The presentation will begin with a discussion of the current state of information embedding in additive manufacturing (AM) and open research challenges. It will then focus on a method for embedding information on the surface of AM parts by controlling the manufacturing process parameters. This information can be retrieved using surface profilometry and optical imaging. Specifically, the information is embedded as geometric features obtained by locally varying printing speed in a Fused Deposition Modeling (FDM) process. Using simple optical cameras, the geometric features are mapped to distinct bits to generate binary strings. The approach is demonstrated with 2D codes printed on a low-cost commercial FDM printer. The results demonstrate that the proposed approach is an efficient and cost-effective method for information embedding in additively manufactured (AM) parts.

Speaker Bio: Dr. Jitesh H. Panchal is a Professor and Assistant Head of Mechanical Engineering at Purdue University. He received his BTech (2000) from Indian Institute of Technology (IIT) Guwahati, and MS (2003) and PhD (2005) in Mechanical Engineering from Georgia Institute of Technology. He is a member of the Systems Engineering Research Center (SERC) Council. Dr. Panchal's research interests are in (1) design at the interface of social and physical phenomena, (2) computational methods and tools for digital engineering, and (3) secure design and manufacturing. He is a recipient of CAREER award from the National Science Foundation (NSF); Young Engineer Award, Guest Associate Editor Award, and three best paper awards from ASME; and was recognized by the B.F.S. Schaefer Outstanding Young Faculty Scholar Award, the Ruth and Joel Spira Award, and as one of the Most Impactful Faculty Inventors at Purdue University. He is a co-author of two books and has co-edited one book on engineering systems design. He has served on the editorial board of international journals including ASME Journal of Mechanical Design, ASME Journal of Computing and Information Science in Engineering. He has served as a program chair of the ASME IDETC/CIE conference, and the Chair of the ASME Computers and Information in Engineering (CIE) division.

INVITED PRESENTATION

Resilient Additive Manufacturing Platform (RAMP)

Dr. Abhijit Chakraborty Raytheon Technologies

The increased connectivity and automation in manufacturing systems promise a huge energy savings potential with relatively quicker tech-to-market transition. Unfortunately, these benefits also come with the cost of increased threat level of potential cyber-attacks.The attacker can operate on two levels: (i) Active Attack: by exploiting machine control, the attacker can actively modify process / machine parameters to introduce defects into parts or assemblies or machines, or (ii) Passive Attack: passively extract proprietary data and steal intellectual properties. This talk focuses on how to utilize process monitoring toolsets to identify cyber-threat. One can argue that making the manufacturing setup more robust is more critical than focusing on cyber-attack. While this is true, the talk will try to convince the listener that existing algorithmic/software tools for in-process monitoring may have the potential to differentiate between faulty and compromised products, and hence providing both robustness and resiliency. Techniques leveraged from traditional fault diagnosis and machine learning for health monitoring can be combined to identify attack vectors and monitor process faults leading to a continuous and automated assessment of complex manufacturing networks.

Speaker Bio: Dr. Abhijit Chakraborty is a Senior Principal Research Scientist at Raytheon Technologies Research Center (RTRC) specializing in developing algorithms for in-situ monitoring and control of both additive and robot assisted manufacturing processes. Dr. Chakraborty is the primary technical lead of process monitoring and control related tasks for variety of internally and externally funded projects. Dr. Chakraborty also performs research on (i) validation & verification of control laws, (ii) optimization-based control algorithm development. Dr. Chakraborty received his PhD in Aerospace Engineering from University of Minnesota in 2012 under the supervision of Dr. Gary Balas and Dr. Peter Seiler. His thesis focused on developing novel validation & verification algorithm for nonlinear flight control applications. Dr. Chakraborty was at Cummins from 2012 -2015 working on vehicle dynamics modeling and engine breathing control algorithm development for heavy duty truck. Dr. Chakraborty joined United Technologies Research Center (now known as RTRC) in 2015 as a senior engineer and initiated manufacturing monitoring and control related activities.

INVITED PRESENTATION

AI for Materials Design and Manufacturing: The Roaring Twenties

Dr. Chinmay Hegde New York University

Recent progress in artificial intelligence (AI) --- including human-level generative models for images, text, and audio --- will transform many aspects of society in this coming decade. However, to achieve AI's true promise in science and engineering applications, several challenges need to be overcome. In this talk, we will discover that two key elements are necessary for AI to succeed in the context of materials design and manufacturing: (i) high-quality, high-resolution datasets that are publicly available, and (ii) new types of generative models that are "physics-aware" and respect the constraints of the system by design. We will show how this approach is particularly useful for designing optimal material microstructures for organic photovoltaics. Finally, we will conclude by highlighting other challenging aspects of AI in materials design: safety, security, and robustness, and pointing towards possible solutions.

Speaker Bio: Chinmay Hegde is an Associate Professor at NYU Tandon, jointly appointed with the CSE and ECE Departments. His research focuses on foundational aspects of machine learning (such as reliability, robustness, efficiency, and privacy). He also works on applications ranging from computational imaging, materials design and manufacturing, and cybersecurity. He is a recipient of the NSF CAREER and CRII awards, the Black and Veatch Faculty Fellowship, multiple teaching awards, and best paper awards at ICML, SPARS, and MMLS.

INVITED PRESENTATION

Multi-Material Additive Manufacturing and Inverse Design Algorithm for Fully Customizable Product Design and Properties

Dr. Sanha Kim Korea Advanced Institute of Science and Technology

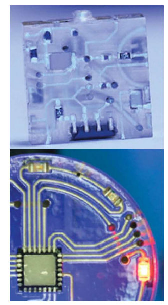
Additive manufacturing (AM) is one of the key production technologies in future digital manufacturing. Its extreme process flexibility is particularly suitable for mass-customization which differentiates with other traditional techniques, yet challenges remain in realization of fully customizable product design and properties. In this talk, I will first introduce an inverse design algorithm accompanied by material-extrusion additive manufacturing which enables personalized production of body- supporting elastomer meshes. 1D tensile behavior of wavy fibers is explored based on mechanics theories, followed by creating an inverse design algorithm based on linear regression and the LASSO method. Experimental validation shows that the inverse designed mesh can suitably duplicate target non-linear mechanical behaviors through an extrusion-printing process. A few examples of body-supporting devices will be shown in the form of a mesh glove and mesh-aided tape by importing several functions in one device. Second, I discuss an additive manufacturing strategy of shell pre-printing and core post-casting (referring as shell-core printing) that effectively enhances the isotropic strength and the production speed of material extrusion additive manufacturing. Shell-core printing involves printing a thin shell of the three-dimensional shape using the conventional material extrusion printing method, followed by the injection and curing of a reinforcement resin inside the core. The degree of isotropy about the strength can be enhanced significantly from 0.4 to nearly 1, while the overall production speed can also be reduced by half that in the conventional MEAM process. Finally, I introduce a new multi-material extrusion printer with an embedded co-axial nozzle which can customize stiffness and toughness in large range and add actuating functionalities.

Speaker Bio: Sanha Kim is an associate professor in the Department of Mechanical Engineering at the Korea Advanced Institute of Science and Technology (KAIST). He earned his Bachelor's and master's degrees in mechanical engineering from Seoul National University, and obtained his PhD degree in Mechanical Engineering from Massachusetts Institute of Technology (MIT). He also worked as a Postdoctoral Associate and a Research Scientist in the Department of Mechanical Engineering and Laboratory for Manufacturing and Productivity at MIT. His focus areas include advanced manufacturing, surface engineering, tribology of mechanical components, semiconductor device polishing & cleaning, 2D and 3D printing technologies, and digital manipulation of micro and nano materials.

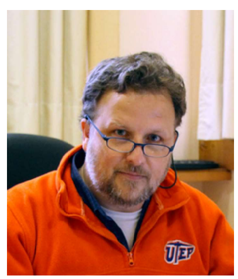
INVITED PRESENTATION

Additive Manufacturing of Elastomer, Ceramic and Metal Multi-functional Structures

Dr. Eric MacDonald University of Texas, El Paso



3D printing has been historically relegated to fabricating conceptual models and prototypes; however, increasingly, research is now focusing on fabricating functional end-use products. As patents for 3D printing expire, new low-cost desktop systems are being adopted more widely and this trend is leading to a diversity of new products, processes and available materials. However, currently the technology is generally confined to fabricating single material static structures. For additively manufactured products to be economically meaningful, additional functionalities are required to be incorporated in terms of electronic, electromechanical, electromagnetic, thermodynamic, chemical and optical content.By interrupting the 3D printing and employing complementary manufacturing processes, additional functional content can be included in mass-customized structures. This presentation will review work in multi-process 3D printing for creating structures with consumer-anatomy-specific wearable electronics, electromechanical actuation, electromagnetics, propulsion, embedded sensors in soft tooling and including metal and ceramic structures. Other projects to be presented include stereovision process monitoring of powder bed fusion, 3D printed smart molds for sand casting, complex ceramic lattices for electromagnetic lenses, elastomeric lattices for the athletic gear, computation geometry and complexity theory for 3D printing



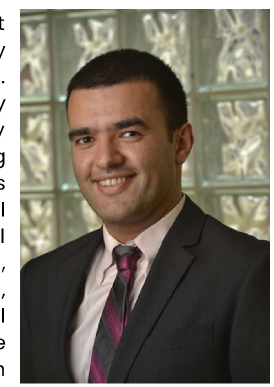
Speaker Bio: Eric MacDonald, Ph.D. is a professor of Aerospace and Mechanical Engineering and Murchison Chair at the UT-El Paso and serves as the Associate Dean of Research and Graduate Studies for the College of Engineering. Dr. MacDonald received his doctoral degree (2002) in Electrical and Computer Engineering from the UT-Austin. He worked in industry for 12 years at IBM and Motorola and subsequently co-founded a start-up specializing in CAD software and the startup was acquired by a firm in Silicon Valley. Dr. MacDonald held faculty fellowships at NASA's Jet Propulsion Laboratory, US Navy Research and was awarded a US State Department Fulbright Fellowship in South America. His research interests include 3D printed multi-functional applications and process monitoring in AM with instrumentation and computer vision for improved quality and yield. As a co-founding editor of the Elsevier journal Additive Manufacturing, MacDonald has helped direct the academic journal to have highest impact factor among all manufacturing journals worldwide. He has recently been involved in the commissioning of a second partner journal, Additive Manufacturing Letters, upon which he serves as the Editor-in-Chief. He has over 100 peer-reviewed publications and dozens of patents. He is a member of ASME, ASEE, senior member of IEEE and a registered Professional Engineer in the USA state of Texas.

INVITED PRESENTATION

Trustworthy Cyber-Physical Additive Manufacturing via Physics-Aware Security

Dr. Saman Zonouz Georgia Institute of Technology

Cyber-physical infrastructures, such as digital manufacturing, integrate networks of computational and physical processes to provide people across the globe with essential functionalities and services. Protecting these infrastructures' security against adversarial parties is a vital necessity because the failure of these systems would have a debilitating impact on economic security. Our research aims at the provision of real-world solutions to facilitate the secure and reliable operation of next-generation cyber-physical infrastructures. This requires interdisciplinary research efforts across adaptive systems and network security, cyber-physical systems, and trustworthy real-time detection and response mechanisms. In this talk, I will focus on real past and potential future threats against cyber-physical infrastructures and embedded controllers, and discuss the challenges in the design, implementation, and analysis of security solutions to protect cyber-physical platforms. I will introduce novel classes of working systems that we have developed to overcome these challenges. In particular, I will present our solutions for security verification of cyber-physical controllers. I will review our results to protect additive manufacturing and 3D printer security against IP theft and to ensure the structural integrity of the ultimate printed objects. Finally, I will briefly talk about our recent efforts in security monitoring of the controller side-channel signals for online attack detection purposes



Speaker Bio: Saman Zonouz is an Associate Professor at Georgia Tech in the Schools of Cybersecurity and Privacy (SCP) and Electrical and Computer Engineering (ECE). Saman directs the Cyber-Physical Security Laboratory (CPSec). His research focuses on security and privacy research problems in cyber-physical systems including attack detection and response capabilities using techniques from systems security, control theory and artificial intelligence. His research has been awarded by Presidential Early Career Awards for Scientists and Engineers (PECASE), the NSF CAREER Award in Cyber-Physical Systems (CPS), Significant Research in Cyber Security by the National Security Agency (NSA), and Faculty Fellowship Award by the Air Force Office of Scientific Research (AFOSR). His research group has disclosed several security vulnerabilities with published CVEs in widely-used industrial controllers such as Siemens, Allen Bradley, and Wago. Saman is currently a Co-PI on President Biden's American Rescue Plan $65M Georgia AI Manufacturing (GA-AIM) project. Saman was invited to co-chair the NSF CPS PI Meeting as well as the NSF CPS Next Big Challenges Workshop. Saman has served as the chair and/or program committee member for several conferences (e.g., IEEE Security and Privacy, CCS, NDSS, DSN, and ICCPS). Saman obtained his Ph.D. in Computer Science from the University of Illinois at Urbana-Champaign.

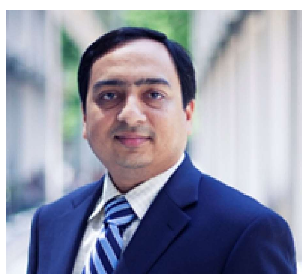
INVITED PRESENTATION

Hack3D: Challenges and Solutions for Cybersecurity in Digital Manufacturing

Dr. Nikhil Gupta New York University

Digital manufacturing (DM) is revolutionizing fields as diverse as aerospace, automobile, medical implants, and archeology. The DM process chain makes extensive use of computers and cloud-based resources from product design stage to final printing of the part using a 3D printer. Such a process chain, integrated with sensors, IoT devices, and network connectivity, is vulnerable to cyberattacks. These possible attacks present numerous challenges for quality assurance, intellectual property protection, and product authentication. Cybersecurity methods such as computer and network security, file encryption and password protection are used for making the DM process chain secure. However, the cyber-physical nature of the DM process chain presents many unique challenges in securing the systems. This work discusses several attack vectors, vulnerabilities and possible solutions that can be deployed for protection of DM processes. These methods include securing designs by embedded design features and authentication codes, design-based encryption and obfuscation methods, and intellectual property protection by file and product authentication methods. These new methods provide a second layer of security rooted in product design and can be applied in addition to cybersecurity methods.

Speaker Bio: Dr. Nikhil Gupta is a Professor in the Mechanical and Aerospace Engineering Department at the New York University Tandon School of Engineering. He is also affiliated with the Center for Cybersecurity. His research interests include developing lightweight materials, additive manufacturing, and materials characterization methods. His research on additive manufacturing security is supported by The National Science Foundation, American Society for Non-Destructive Testing, and industry. He has served as the membership secretary of the American Society for Composites and Chair of the Composite Materials Committee of The Minerals, Metals and Materials Society (TMS). He is an elected fellow of ASM International and the American Society for Composites and senior member of IEEE.



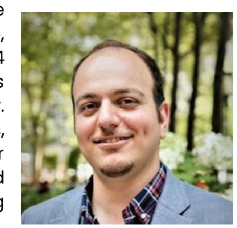
INVITED PRESENTATION

Harnessing Wearable sEMG Sensing for Real-Time Fatigue Monitoring, Gesture Prediction, and Future Exoskeletons in Manufacturing

Dr. Farokh Atashzar New York University

Fatigue significantly affects the U.S. workforce, particularly in manufacturing, causing reduced productivity and injuries. Over half of the workers experience fatigue, contributing to 13% of workplace injuries and costing employers over $136 billion annually. The COVID-19 pandemic has worsened this burden, especially for critical infrastructure workers. Manufacturing industries face constant physical fatigue due to labor-intensive tasks, shift work, and complex team roles. This talk discusses using wearable electromyography (EMG) technology to monitor physical fatigue, analyze muscle network distribution, and predict gestures, enhancing safety and collaboration in manufacturing. It covers interdisciplinary research in neurorobotics, prosthetics, EMG processing, decoding techniques, and applications in fatigue monitoring. Early identification of fatigue helps develop adaptive task distribution strategies, promoting safer and more efficient environments. Exoskeletons can reduce fatigue, but effective control requires a seamless connection to human motor intention and rapid response. Our approach combines biometric sensing, artificial intelligence, and human-centered computing to advance human-machine interactions in advanced manufacturing. By leveraging new modalities, such as high-density EMG, and wearable mechanomyography (MMG) processed by deep learning modules, we predict upcoming gestures that can be integrated into exoskeleton control, preventing added load and fatigue. Our vision is to develop a comprehensive understanding of fatigue in manufacturing through wearable EMG technology, ultimately benefiting both individuals and the industry. By addressing fatigue, we aim to improve efficiency, productivity, worker well-being, and safety, fostering convergence among diverse fields such as neurorobotics, biomedical engineering, computational social science, and human-centered computing. In this talk, we will explore the broader impact of our wearable solutions for decoding fatigue with a vision to enhance the well-being of workers.

Speaker Bio: Dr. S. Farokh Atashzar is an Assistant Professor in the departments of Mechanical and Aerospace Engineering, as well as Electrical and Computer Engineering at New York University (NYU). In addition, he is affiliated with NYU BME, NYU CUSP, and NYU WIRELESS. Before joining NYU, Dr. Atashzar was a Postdoctoral Scientist in the Department of Bioengineering at Imperial College London, UK, sponsored by the Natural Sciences and Engineering Research Council (NSERC) of Canada. At NYU, he leads the Medical Robotics and Interactive Intelligent Technologies Lab, which consists of 9 PhD students, one postdoctoral researcher, 4 master's students, and 6 undergraduate students. The lab's activities are primarily funded by the U.S. National Science Foundation. Dr. Atashzar's research interests encompass human-machine interfaces, robotics, haptics, biosignal processing, deep learning, and nonlinear control. His research has been published in 120 peer-reviewed journal and conference papers. Dr. Atashzar has received numerous awards, including the NSERC PDF award in 2018, ranking among the top 5 in Canada. At NYU, he has secured 5 NSF awards, 1 NIH award, and several industrial awards (including a $2M equipment donation grant from Intuitive Foundation). He has served as the Associate Editor for IEEE Transactions on Robotics, IEEE Robotics and Automation Letters, IEEE IROS, IEEE ISMR, IEEE ICORR, IEEE BioRob, and IEEE ICRA. In 2021 he was named as Outstanding Associate Editor for IEEE Robotics and Automation Letters.



INVITED PRESENTATION

A Framework Driven by Physics-guided Machine Learning for Process-structure-property Causal Analytics in Digital Additive Manufacturing

Dr. Hyunwoong Ko Arizona State University

Data analytics with Machine Learning (ML) using physics knowledge and big data offers high potential to continuously transform raw data to newfound knowledge of Process-Structure-Property (PSP) causal relationships. In Additive Manufacturing (AM), however, realizing the potential is still limited mainly due to the lack of a systematic way to learn the PSP relationships for various AM processes. Focusing on addressing the limitation, this talk will introduce a novel framework driven by physics-guided ML, which consists of three tiers: (1) knowledge of predictive PSP models and physics, (2) PSP features of interest, and (3) raw AM data, as shown in Figure 1. The framework defines a PSP-learning process with two sub-processes.

The first uses a knowledge-graph-guided top-down approach to generate the requirements for predictive analytics and data acquisition. The second uses a data-driven bottom-up approach to construct and model new PSP knowledge. Together, these processes connect the proposed framework to decision-making and control activities and cyber-physical AM systems. The framework enables a systematic physics-guided data-driven approach for the PSP analytics in AM that can couple physics knowledge with the versatility of data-driven ML models. Using the approach, the framework continuously updates the models (1) to improve the understanding of dynamically generated AM data and (2) to link sub-models into coupled PSP models. The framework also facilitates proactive decision-making and control activities and enhances the development of digital twins at multiple spatial-temporal scales for AM.

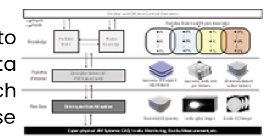
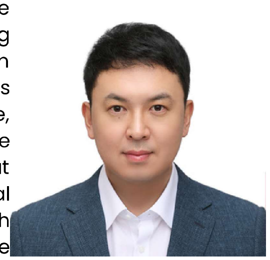


Figure 1A Framework Driven by Physics-guided Machine Learning for Process-structure-property Causal Analytics in

Speaker Bio: Dr. Hyunwoong Ko is an assistant professor in the School of Manufacturing Systems and Networks of the Ira A. Fulton Schools of Engineering and the principal investigator of the Digital Manufacturing and Design Group at Arizona State University. He completed his Ph.D. studies at Nanyang Technological University in Sep. 2019. He worked as a research associate at the NIST during his Ph.D. and postdoctoral studies until Sep. 2021. His research is focused on data science, manufacturing science, and design science, as well as the intersections between these three areas. His research aims at building foundations of Artificial Intelligence (AI) and Digital Transformation for Advanced Manufacturing and Design. Such foundations help facilitate the integration between the disciplines of AI and Machine Learning, Cyber-physical Systems, and Digital Twins at multiple scales in the context of advanced manufacturing, such as Digital Additive Manufacturing.



INVITED PRESENTATION

Emerging Manufacturing Processes for Ceramics and Thin Metallic Films

Dr. Majid Minary University of Texas at Dallas

In this presentation, I will present recent work from our group on room environment printing of high conductivity, crystalline metal films and microstructures for electronics and sensors applications using localized electrodeposition process. This work started as a basic research in our lab, and was subsequently attracted industrial interest and several follow up Phase II SBIR grants from DOE and NASA. Currently, we are working with a company (funded by NASA) to test this technology in zero-gravity conditions. In the second part of the presentation, I will present on 3D printing of ceramic materials by photopolymerization and embedded printing methods, and challenges and opportunities in ceramic 3D printing.

Speaker Bio: Majid Minary is currently an Associate Professor of Mechanical Engineering at the University of Texas at Dallas. Research in his lab is focused on Materials Processing and Advanced Manufacturing. He received his PhD from University of Illinois at Urbana-Champaign (UIUC), followed by a Postdoctoral training at Northwestern University. Currently, Minary serves as the chair of the materials processing technical committee of ASME, and an Associate Editor of the Journal of the American Ceramic Society, and a committee member of ASTM International on Additive Manufacturing. He is recipient of two DoD Young Investigator awards, ONR-YIP and AFOSR-YIP.