

Division Newsletter

October 2023

QUALITY CONTROL & RELIABILITY ENGINEERING DIVISION

Newsletter Editors: Shancong Mou, Dr. Mostafa Reisi Gahrooei, and Dr. Dan Li

Message from the Division President

Dear fellow QCRE members,

Welcome to IISE's Quality Control and Reliability Engineering (QCRE) division. It is my great honor to serve as the division president of QCRE. As we look back on the achievements of the past year, I am filled with pride and gratitude for the dedication and enthusiasm from our society members. In particular, the QCRE track at the 2023 IISE Annual Conference was a big success, with record high abstract and paper submissions, well-received special sessions, and an engaging data challenge competition generously sponsored by our industrial partner, ProcessMiner. On behalf of the QCRE Board of Directors, I want to extend congratulations to our members for the remarkable accomplishments we have collectively achieved. Your continued support of the QCRE is truly appreciated. I also wish to express our gratitude to Dr. Ramin Moghaddas, our former President,



the QCRE Board of Directors, and our dedicated volunteers for their invaluable contributions to the division over the past year.

The QCRE Board will continue to organize a variety of activities and events for our members in the coming year. Major activities include coordinating the QCRE track of the 2023 IISE Annual conference, organizing webinars, and editing newsletters. I would also like to bring your attention to some new initiatives we are launching this year.

First, under the leadership of Dr. Xiaowei Yue (<u>yuex@mail.tsinghua.edu.cn</u>), we will introduce a student mentorship program. This program will pair QCRE student members seeking guidance with faculty members who are enthusiastic about mentoring and can offer insights into academic or industrial career paths, research interests, and achieving a healthy work-life balance. We will share updates about this mentorship program as it unfolds.

Second, our news media team, led by Drs. Dan Li (<u>dli4@clemson.edu</u>) and Mostafa Reisi Gahrooei (<u>mreisigahrooei@ufl.edu</u>), has introduced an exciting new monthly member spotlight program. This program will highlight one QCRE member each month. Please let us know if you have any exciting research project and/or research findings you'd like to share with our community.

QCRE is open to any other exciting initiatives that can benefit our division members. If you are interested in contributing to the QCRE division, whether through ideas, collaboration, or service, please don't hesitate to contact me at <u>yxiang4@uh.edu</u> or any of the Board members. We eagerly welcome your engagement and enthusiasm as we work together to enhance the QCRE community.

Sincerely,

Yisha Xiang IISE QCRE Division President, 2023-2024

QCRE Board of Directors (2023-2024)



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Board member: Syed Hasib Akhter Faruqui Sam Houston State University shf006@shsu.edu



Board member: Zimo Wang Binghamton University zimowang@binghamton.edu

2023 IISE Annual Conference & Expo QCRE Award Winners

Winner of the QCRE Best Track Paper Award

"RGI: robust GAN-inversion for mask-free image inpainting and unsupervised pixel-wise anomaly detection"

Shancong Mou, Xiaoyi Gu, Meng Cao, Haoping Bai, Ping Huang, Jiulong Shan, and Jianjun Shi Georgia Institute of Technology, Apple Inc.

Winner of the QCRE Best Student Paper Award

"DETONATE: Nonlinear Dynamic Evolution Modeling of Time-dependent 3-dimensional Point Cloud Profiles" Michael Biehler Advisor: Dr. Jianjun Shi

Georgia Institute of Technology

• Winner of 2023 IISE QCRE Industrial Data Challenge

"Sequence-to-Sequence LSTM for Fungal Spores Concentration (FSC) Prediction"

Raghav Gnanasambandam, Jihoon Chung, Bo Shen, James Kong

Virginia Tech, New Jersey Institute of Technology

Winner of the QCRE Best Student Poster Award

"Physics-constrained Deep Active Learning for Spatiotemporal Modeling of Cardiac Electrodynamics"

Jianxin Xie University of Tennessee, Knoxville

Winner of the QCRE Teaching Award

Dr. Yu Liu University of Electronic Science and Technology of China

Division's Quarterly News

- Michael Biehler, Ph.D. student, Georgia Institute of Technology, was awarded the George Fellowship for academic strength and commitment to health systems, the Mary G. and Joseph Natrella Scholarship from the American Statistical Association (ASA) and was selected to participate in NextProf Nexus, a workshop organized by the University of Michigan (Ann Arbor), UC Berkeley and Georgia Tech as well as the Cornell Operations Research and Information Engineering (ORIE) Young Researchers Workshop.
- Petros Papadopoulos, Ph.D. student graduated from Rutgers University in 2023. PhD Dissertation title: "Data-driven Optimization of Operations and Maintenance in Offshore Wind Farms." Advisor: Dr. Ahmed Aziz Ezzat. Current Position: R&D Engineering at ThermoVault Inc., Belgium.
- Shancong Mou, Ph.D. student, Georgia Institute of Technology, have received the 2023 Best Track Paper Award Winner from Quality Control and Reliability Engineering (QCRE) Division of the Institute of Industrial and Systems Engineering, John S.W. Fargher Jr. Scholarship, Institute of Industrial and Systems Engineering (2023) and Angela P. and Reed J. Baker Research Excellence Award, School of ISyE, Georgia Institute of Technology (2023).
- Ahmed Aziz Ezzat, Assistant Professor, Rutgers University, is the lead PI on a new project entitled: "AI-powered Physics-based Tool for OSW Forecasting and Grid Integration, supported by the National Offshore Wind Research & Development Consortium (Joint DOE/NYSERDA funding). The project will develop, test, and deploy a technology to forecast the wind at key offshore development areas and predict wind plant power output using a physics-based model coupled with Artificial Intelligence (AI) capabilities.
- Ana Maria Estrada Gomez, Assistant Professor, School of Industrial Engineering, Purdue University, Dr. Estrada Gomez has been awarded a grant from the National Science Foundation (NSF) for the project titled "Therapeutic and Diagnostic System for Inflammatory Bowel Diseases: Integrating Data Science, Synthetic Biology, and Additive Manufacturing." The project falls under the Smart and Connected Health program.
- Mostafa Reisi, Assistant Professor, University of Florida, received \$1,188,351 from National Science Foundation (NSF) as the PI for the project entitled, CPS: Medium: Connected Federated Farms: Privacy-Preserving Cyber Infrastructure for Collaborative Smart Farming.

Call for Abstracts: QCRE Track

The QCRE division of IISE is sponsoring the QCRE Track at the IISE Annual Conference & Expo 2024. As Track Chairs of the QCRE Track, we encourage you to contribute to the Conference and Track by submitting a 250-word abstract or presentation summary. Authors of accepted abstracts and presentation summaries will be invited to share their work in a conference session. In addition, there are opportunities to organize and/or participate in Special Sessions (Panels, Workshops, etc.). If you are interested in a special session, please contact us directly by **November 10, 2023**. For more details about submission requirements, please refer to the following CFP: https://tinyurl.com/2w33zp34

- Abstract Submission Deadline: Nov. 17th , 2023 .
- Full Paper Submission Deadline: Feb. 09th , 2024
- Speaker Registration Deadline: March 22nd, 2024

For inquiries and registration, please contact the QCRE Track Chairs: Xiaolei Fang (<u>xfang8@ncsu.edu</u>), Zimo Wang (<u>zimowang@binghamton.edu</u>) and Syed Hasib Akhter Faruqui (<u>shf006@shsu.edu</u>)

Competitions and Awards

The QCRE division of IISE organizes multiple competitions and awards to recognize research and educational excellence. This year, we invite submissions to the competitions and awards listed below. The competition finalists will be invited to present at the IISE Annual Conference & Expo. The winners and awardees will be announced at the QCRE Town Hall meeting and recognized in the upcoming QCRE newsletter. Please keep an eye out for more details about the competitions on our social media. Competition details can be found as follows:

<u>QCRE Best Track Paper Competition</u>

Important dates:

- Abstract submission deadline: Nov. 17th , 2023
- Full paper submission deadline: Feb. 09th , 2024
- Award Presentation: May 18th 21st at the 2024 IISE Annual Conference & Expo Committee chair: Dr. Zimo Wang (<u>zimowang@binghamton.edu</u>)

<u>QCRE Best Student Paper Competition</u>

Important dates:

- Paper submission deadline: Feb. 09th , 2024
- Award Presentation: May 18th 21st at the 2024 IISE Annual Conference & Expo Committee chairs: Dr. Dan Li (dli4@clemson.edu) and Dr. Syed Hasib Akhter Faruqui (shf006@shsu.edu)

QCRE Student Poster Competition

Important dates:

- Student Registration: April 15th , 2024
- Award Presentation: May $18^{th} 21^{st}$ at the 2024 IISE Annual Conference & Expo

Committee chairs: Dr. Mostafa Reisi (mreisigahrooei@ufl.edu); Dr. Chao Wang (chao-wang-2@uiowa.edu)

<u>QCRE Teaching Award</u>

The QCRE division of IISE is inviting submissions to its annual QCRE teaching award. The award recognizes QCRE members for excellence in teaching an undergraduate course in quality, statistics, data science/analytics, and reliability methods or applications. For more details about the application process, eligibility requirements, and evaluation criteria, please visit: <u>https://www.iise.org/Details.aspx?id=52144</u>.

- Teaching Award Nomination Deadline: Feb. 05th , 2024
- Teaching Award Winner Notification: March 05th , 2024
- Award Presentation: May 18th 21st at the 2024 IISE Annual Conference & Expo

Committee chairs: Dr. Zimo Wang (<u>zimowang@binghamton.edu</u>); Dr. Chao Wang (<u>chao-wang-2@uiowa.edu</u>)

Upcoming QCRE Webinar



Speaker: Dr. Hui Yang is a Professor of Industrial and Manufacturing Engineering, Biomedical Engineering at Penn State. (Joint webinar with the DAIS Division)

Title: Digital Twin for Quality Innovations: Manufacturing and Health Applications

Date and Time: Oct 31st, 2023, 12 PM – 1 PM, EDT.

Register at: https://tinyurl.com/2d3cuzw7

Biography: Dr. Hui Yang is a Professor of Industrial and Manufacturing Engineering, Biomedical Engineering at Penn State. He was the president (2017-2018) of IISE Data Analytics and Information Systems Society, the chair (2015-2016) of INFORMS Quality, Statistics and Reliability (QSR) section, and the program chair of 2016 IISE Annual Conference. He is also a Department Editor (DE) for IISE Transactions Healthcare Systems Engineering, as well as an Associate Editor (AE) for IISE Transactions, IEEE Journal of Biomedical and Health Informatics (JBHI). His research focuses on sensor-based monitoring, modeling, and control of complex systems, as well as smart manufacturing and healthcare applications. His research program is supported by National Science Foundation (including the prestigious NSF CAREER award), National Institute of Health (NIH), National Institute of Standards and Technology (NIST), MxD, Fulbright Foundation, industry companies, and private foundations. His research group received several best paper awards and best poster awards from IISE Annual Conference, IEEE EMBC, IEEE CASE, and INFORMS.

Abstract: Modern industry is investing in new digital technologies, such as Internet of Things (IoT), advanced sensing and computing, to propel quality innovations in products and services. Real-time flow of sensing data gives rise to data-rich environments and an unprecedented opportunity to realize a new generation of digital twin (DT) in cyberspace. In a digital twin, physical dynamics are reflected in cyberspace through advanced sensing, information processing, and computer modeling. In the feedback loop, analytics in cyberspace (e.g., artificial intelligence and machine learning) exploits the acquired knowledge and useful information from sensing data for optimal actions to the physical world. This webinar will present our continuous research efforts on the "sensing-modeling-optimization" framework to build new cyber-physical digital twins in disparate disciplines of manufacturing and healthcare. Specifically, I will talk about recent research studies in joint work with my current and former PhD students (Alexander Krall, Hankang Lee and Bing Yao), including

1)	Sensor	DT	for	statistical	quality	control	(IISE	Transactions,
	https://doi.org/10.1080/24725854.2022.2148779),							

- 2) Factory DT for process optimization (ASME Journal of Manufacturing Science and Engineering, https://doi.org/10.1115/1.4063234), and
- 3) Heart DT for smart health (Springer Book on "Sensing, Modeling and Optimization of Cardiac Systems", https://link.springer.com/book/9783031359514).

The next generation of digital twin is strongly promised to innovate quality engineering, manufacturing processes, and healthcare services. At the end of this talk, future research directions will be discussed.

Upcoming QCRE Webinar



Speaker: Dr. Nathan Gaw is an Assistant Professor of Data Science in the Department of Operational Sciences at Air Force Institute of Technology, Wright-Patterson AFB, Ohio, USA. (Joint webinar with the DAIS Division)

Title: Assessing the Calibration and Performance of Attention-based Spatiotemporal Neural Networks for Lightning Prediction

Date and Time: Nov 24th, 2023, 12 PM – 1 PM, EDT.

Register at: https://tinyurl.com/yn2vm6uu

Biography: Dr. Nathan Gaw is an Assistant Professor of Data Science in the Department of Operational Sciences at Air Force Institute of Technology, Wright-Patterson AFB, Ohio, USA. His research develops new statistical machine learning algorithms to optimally fuse high-dimensional, heterogeneous, multi-modality data sources to support decision making in military, healthcare and remote sensing. He received his B.S.E. and M.S. in biomedical engineering and a Ph.D. in industrial engineering from Arizona State University (ASU), Tempe, AZ, USA, in 2013, 2014, and 2019, respectively. Dr. Gaw was a Postdoctoral Research Fellow at the ASU-Mayo Clinic Center for Innovative Imaging (AMCII), Tempe, AZ, USA, from 2019-2020, and a Postdoctoral Research Fellow in the School of Industrial and Systems Engineering (ISyE) at Georgia Institute of Technology, Atlanta, GA, USA, from 2020-2021. He is also chair of the INFORMS Data Mining Society, and a member of IISE and IEEE. For additional information, please visit www.nathanbgaw.com.

Abstract: In the last decade, deep learning models have proven capable of learning complex spatiotemporal relations and producing highly accurate short-term forecasts, known as nowcasts. Various models have been proposed to forecast precipitation associated with storm events hours before they happen. More recently, neural networks have been developed to produce accurate lightning nowcasts, using various types of satellite imagery, past lightning data, and other weather parameters as inputs to their model. Furthermore, the inclusion of attention mechanisms into these spatiotemporal weather prediction models has shown increases in the model's predictive capabilities.

However, the calibration of these models and other spatiotemporal neural networks is rarely discussed. In general, model calibration addresses how reliable model predictions are, and models are typically calibrated after the model training process using scaling and regression techniques. Recent research suggests that neural networks are poorly calibrated despite being highly accurate, which brings into question how accurate the models are.

This research develops attention-based and non-attention-based deep-learning neural networks that uniquely incorporate reliability measures into the model tuning and training process to investigate the performance and calibration of spatiotemporal deep-learning models. All of the models developed in this research prove capable of producing lightning occurrence nowcasts using common remotely sensed weather modalities, such as radar and satellite imagery. Initial results suggest that the inclusion of attention mechanisms into the model architecture improves the model's accuracy and predictive capabilities while improving the model's calibration and reliability.

QCRE Member Spotlight

In each issue of QCRE newsletter, we will feature one outstanding QCRE member who has demonstrated the excellence in the QCRE related fields, and the member can be from academia, industry or our students.



Dr. Jia (Peter) Liu

In this issue of QCRE newsletter, we feature our outstanding member, Dr. Jia (Peter) Liu. Dr. Jia (Peter) Liu is an Assistant Professor, the Ginn Faculty Achievement Fellow, in the Department of Industrial and Systems Engineering at Auburn University. He focuses on interpretable data-driven modeling for complex additive manufacturing (AM) processes with heterogeneous sensor data to achieve online process monitoring, product quality prediction, and control for a variety of AM processes, such as material extrusion, binder jetting, and powder bed fusion. He has been working in this area for seven years, served as PI and Co-PI of multiple government-funded projects, totaling \$2M+ over the past 3 years from NSF, NIST, FAA and DOD, and published 20+ peer-reviewed articles in renowned journals in this area. He is a member of IISE, INFORMS, SME, and has won the 2023 NSF CAREER award and the 2021 Auburn University Early Career Development Grant.

Here is Dr. Jia (Peter) Liu's Story with QCRE:

• Can you share a brief overview of your academic journey so far?

I received a B.S. and an M.S. in Electrical Engineering from Zhejiang University, China. After working in chemical manufacturing for 6 years, I really got into statistical learning and reliability analysis. So, I came to the US to pursue a Ph.D. in Industrial and Systems Engineering and an M.S. in Statistics at Virginia Tech. After graduation, I worked as a data scientist in industry before I joined Auburn as an assistant professor and stayed. I really enjoy working in academia because I can do the research I am passionate about with full flexibility, push the boundaries of science and technology advancement with my own efforts, and educate the future generation of engineers.

• How would you describe your current research focus to a non-expert, and why did you choose this research topic?

Additive manufacturing is a new type of manufacturing technology that can fabricate any complex geometry by adding materials layer by layer without wasting materials and time. I first knew about additive manufacturing through a TED talk in 2012 and was fascinated. However, on the other side, additively manufactured parts usually have less strength and more defects than the parts manufactured by traditional technologies. My research is to understand the new technology and improve the quality of AM parts to promote innovative design, and efficient and sustainable manufacturing.

• What has been the most rewarding project you've worked on so far?

It has to be the project supported by NSF Future Manufacturing Seed Grant: Federated Deep Learning for Future Ubiquitous Distributed Additive Manufacturing, which aims to develop a unified algorithmic and training framework to enable consistent and reliable production in a privacy-preserving, insight-sharing manufacturing network. I am excited about the idea of using collective intelligence to improve data sparsity and solve challenging problems in manufacturing while preserving data privacy for each manufacturer. Also, this is the first project I am the PI, and I have learned a lot from working with an interdisciplinary team and leading the project. We are making steady progress and hoping to share great results with the community later.

• How do you foresee your research area evolving over the next few years?

In the next few years, I will continue my efforts in understanding AM processes and investigating their applications in complex situations. I will integrate fundamental physics knowledge, advanced sensor technologies, and new AI models to improve the understanding of AM processes and the prediction accuracy of quality without compromising interpretability.

What would you do differently if you returned to your graduate student life?

If I were a graduate student again, I would try more proactively to communicate with professors in QCRE and learn more about research and career development from them. In retrospect, I was full of admiration for their achievements. As an eight-year QCRE member, looking back at all the interactions and communications with them, I feel extremely lucky and grateful to get enormous help from them and the great platform QCRE provides for a student like me to grow and flourish.

• Any other suggestions to the QCRE students?

I would encourage the QCRE students to make the most out of the resources provided by the QCRE community to advance their knowledge and skills and prepare for future careers. QCRE is a dynamic community with many distinguished researchers and talented students working on cutting-edge topics in a variety of areas. QCRE hosts many activities for you to present your work, communicate with professors and fellow students from other schools, and build your professional network. These can greatly benefit your growth and your future career, no matter whether you plan to join academia or industry.

Moreover, I would strongly suggest that QCRE students maintain tight connections with the community even after graduation. This will help you keep up with the cutting-edge research and stay in a dynamic professional community for your career development. I have benefited a lot from being a QCRE member since my Ph.D. time. I was and have been inspired by the research in QCRE for my own research and helped by the many professors in my career. Especially when I wanted to join academia after working in the industry for two years, the continued connections I had with the QCRE community definitely helped me to redirect my career and successfully navigate through that challenging time. I am sincerely grateful for that.

Research Story

In each issue of QCRE newsletter, we feature a research story. This could be a novel research work pursued by a group of QCRE researchers, or a topic of relevance to the QCRE community.



Dr. Jing Li

In this issue of the newsletter, we feature Prof. Jing Li to take her fresh perspectives and vision on precision medicine: Weakly Supervised Transfer Learning with Application in Precision Medicine, co-authored with her Ph.D. student Linchao Mao. Professor Jing Li is a Virginia C. and Joseph C. Mello Chair and Professor in the H. Milton Stewart School of Industrial and Systems Engineering and a core faculty in the Center for Machine Learning at Georgia Tech. Prior to joining Georgia Tech in 2020, she was a Professor at Arizona State University and is a co-founder of the ASU-Mayo Clinic Center for Innovative Imaging. Dr. Li's research develops statistical machine learning algorithms for modeling and inference of complex-structured datasets with high dimensionality (e.g., 3D/4D images), multi-modality, and heterogeneity. The objectives of the methodological developments are to provide capacities for monitoring & change detection, diagnosis, and prediction & prognosis. The application domains mainly include health and medicine, focusing on medical image data analytics as well as fusion of images, genomics, and clinical records for personalized and precision medicine.

Her research outcomes support clinical decision making for diagnosis, prognosis, and telemedicine for various conditions affecting the brain, such as brain cancer, post-traumatic headache & migraine, traumatic brain injury, and the Alzheimer's disease. Her research received Best Paper awards from various professional venues such as IISE Transactions, IISE Annual Conferences, INFORMS Data Mining and Decision Analytics, American Academy of Neurology, America Headache Society, etc. Her research has been funded by the NIH, NSF, DOD, and industries. She is an NSF CAREER Awardee.

Dr. Li is a former Chair for the Data Mining Subdivision of INFORMS. She is currently a Senior Editor for IEEE Transactions on Automation Science and Engineering and a Department Editor for IISE Transactions on Healthcare Systems Engineering.



Weakly Supervised Transfer Learning (WS-TL)



Linchao Mao

Traditional approaches to build predictive models for health applications pool data from a cohort of patients to train a model. While this benefit from having more data, one-fits-all models may overlook patient differences originated from sociodemographics, physiological, genetics, and other factors. A notable example is brain cancer. No two patients with the same subtype of tumor behave clinically the same, with or without treatment. What is more, recent studies have shown that heterogeneity exists even within the same tumor, meaning that subregions of the tumor may have different phenotypic and mutational patterns. Ideally, we want diagnosis and treatment optimized for each patient. The practical challenge is that it is often infeasible to collect enough data from each patient to build personalized models. Take brain cancer as an example, the only way to know the amount of tumor cells for a location inside the tumor, known as Tumor Cell Density (TCD), is to take biopsy samples by surgery and then send the specimens for pathological analysis. As one can imagine, this process is extremely costly and only a few labeled samples (biopsies) can be obtained from each patient.

Our work tackles the research question of how learn personalized prediction models under settings with few or even no labeled data from each patient. Transfer Learning (TL) provides a promising approach to build personalized models with limited data. Using the TL paradigm, an 'average-case' model is built using data from other patients with the same disease (known as the source domain), while the data from the patient we are predicting for (known as the target domain) is used to adapt the model for personalization. However, most existing TL algorithms still need a non-trivial number of labeled samples from the target domain to bias the source towards the target, which is not available in some applications. We propose a Weakly-Supervised Transfer-Learning (WS-TL) model to tackle this challenge. The key idea is to leverage domain knowledge to generate weakly labeled samples as additional supervision for the model. Such knowledge can be in the form of ordinal relationships. For example, oncologists can help pinpoint certain areas of the brain are expected to have higher tumor content than others based on Magnetic Resonance Images (MRI), despite their exact TCD is unknown. Using weakly labeled samples is advantageous because they can be easily obtained in large amounts and can integrate domain expertise to train personalized models. We also proposed a theory-supported active sampling strategy to select the most informative weakly labeled samples from a large pool to improve training efficiency.

We applied this model to a real-world case study of precision medicine for brain cancer. Data was collected by our collaborators from the Mayo Clinic from patients with glioblastoma, the most aggressive type of brain cancer. Each patient underwent MRI examination and had on average 4 biopsy samples collected. WS-TL was able to predict accurate spatial map showing the region-to-region variation of TCD across the tumor of each patient. These model outputs can be used to support the design of informed, personalized treatment plans that avoid over-damaging the brain while treatment the high tumor areas more aggressively.

Call for Entries

The division is publishing its quarterly newsletters and hereby soliciting news entries. This is a great opportunity to showcase interesting yet impactful researches, professional practices and educational efforts within the division. The solicited story will go into the following blocks in the newsletter: Research on the News, Practical Applications, and Education and Outreach. It would be great if you could: Please fill in the following Google form: <u>https://forms.gle/GDnQA6kANtVfmdEV6</u> or send an email to Shancong Mou (<u>shancong.mou@gatech.edu</u>). Your entry will appear in the next available division newsletter.

PDF version of our newsletters are available for our members on the IISE Connect (QCRE division Library folder), as well as our LinkedIn Profile and Twitter.

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