THE CANADIAN SOCIETY FOR MECHANICAL ENGINEERING
LA SOCIÉTÉ CANADIENNE DE GÉNIE MÉCANIQUE

FALL/L'AUTOMNE 2021

BULLETIN

SPECIAL ISSUE ON

Computer-Aided Design and Big Data Analytics

CONTENT

FALL/L'AUTOMNE 2021

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COVER: MECHANICAL ENGINEER DESIGNS 3D ENGINE ON PERSONAL COMPUTER [SHUTTERSTOCK ID: 1335833951 BY GORODENKOFF]

Editor's Letter

WE WELCOME YOU TO ANOTHER ISSUE OF THE CSME *Bulletin* on Computer Aided Design (CAD) and Big Data Analytics.

The *Feature Articles* in this issue are contributed by Dr. **Alison Olechowski** and Dr. **Gary Wang**, focusing on the future of CAD and AI-driven design optimization. The *ME News* pieces by our Technical Editor, Dr. **Ryan Willing**, describe interesting contributions by Canadian researchers to the design of additively manufactured parts. The *New Faculty Spotlight* articles are by Dr. **Xinming (Sherry) Li**, Dr. **Alison Olechowski**, and Dr. **Gobinda Saha**. They describe their research on occupational ergonomics in industrialized construction, new collaborative tools for engineering design, and future of additive manufacturing in an energy-deprived world, respectively. In the *Alumni Q & A* section, we have an interesting interview with **Andrew Brunskill**, the director of Data Science, and a co-founder of Clir Renewables, which we invite you to read.

Updates are provided from the editor of the CSME *Transactions*, the chairs of the *Technical* and *History* committees, and the *CSME Student Affairs and Young Professionals* committee. The impact factor for the CSME *Transactions* has rapidly increased to 1.45; a heartfelt congratulations to the editor Dr. **Marius Paraschivoiu** and his team.

Last year's CSME Congress was held virtually and hosted by the University of Prince Edward Island, co-chaired by Dr. **Ali Ahmadi** and Dr. **Nicholas Krouglicof.** This was a new experience for CSME and hopefully we will take advantage of what we learned about this new method in the future congresses. Dr. **Hossein Rouhani** and Dr. **Andre McDonald** will co-chair the CSME 2022 Congress at the University of Alberta, June 5th – 8th, 2022. Please consider contributing high-quality papers to the upcoming congress.

Finally, we are excited to report that we have made a major change to the CSME *Bulletin* which will further enhance the quality of the future issues. **Starting from the next issue, we will have guest editors who will lead the important sections of the *Bulletin*** such as the selection of *Featured* and *New Faculty Spotlight* articles. To ensure the CSME *Bulletin* continues to cover the full range of topics covered by our society, the guest editors will be the chairs of the CSME Technical Committees, thereby making sure that all CSME research areas are covered. If CSME members would like an issue to cover a specific topic, they are welcome to contact us for being considered as a guest editor. The next CSME *Bulletin* issue will focus on **Climate Change and Sustainability**, and our guest editors will be Dr. **Horia Hangan** and Dr. **Hassan Peerhossaini**, the chair and vice-chair of the Environmental Engineering Technical Committee.

This issue comes out at a time that researchers in Canada, and globally, have experienced many months of limited access to their laboratories and significant challenges in research productivity due to the limitations caused by the pandemic. We hope that the new year brings on health and safety for everyone so we can return to life and business as it was before the pandemic. We hope you enjoy reading this issue. Happy new year in advance.

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PHOTO (REZAI): COURTESY OF THE LASSONDE SCHOOL OF ENGINEERING, YORK UNIVERSITY / PHOTO (GALLART): TABITHA GILLMAN

President's Message

Message de la présidente

Turning the challenges into opportunities...

Dear colleagues and members,

After a long period of working remotely, many of us have been able to attend classes in person, perform activities in research labs in full capacities, have meetings where half of the participants attend virtually and the rest wear masks. The new norm is in fact different but no less exciting. The digital economy has significantly touched our field of engineering and our environment. Considering its impact, we are focusing our next CSME *Bulletin* issue on the topic related to climate change and sustainability.

It is my pleasure to announce that the 2022 CSME International Congress will be held from June 5 to June 8, 2022 at the University of Alberta in person. The congress will have 16 symposia in various fields related to Mechanical Engineering. Please find further information on page 6 of this CSME *Bulletin*.

I would also like to announce that our CSME History Committee has been very active since its inception. Articles in the memory of late professor **Douglas Ruth** (an instrumental member of Engineers Canada and Canadian Engineering Accreditation Board, pg. 16) and (forthcoming) the late Professor **Martha Salcudean** (a former Head of Mechanical Engineering at UBC). The committee is also very active in promoting equity, diversity and inclusion (EDI) by working on an article regarding the history of EDI in Mechanical Engineering.

Finally, I would like to thank our Student Affairs committee for organizing webinars during the COVID-19 pandemic on various engineering topics. There has been a large CSME membership turnout at these webinars. The committees plan to increase student and professional memberships through continued webinars, outreach, and opportunities for getting involved in the organization of events and activities.

Thank you for your continuous support and wish you a healthy and successful year in 2022.

MINA HOORFAR, PhD, P.Eng., FCSME
CSME *President*
Dean of Engineering and Computer Science
Professor, Mechanical Engineering
University of Victoria

Transformer les défis en opportunités....

Chers collègues et membres,

Après une longue période de travail à distance, beaucoup d'entre nous ont pu assister à des cours en personne, effectuer des activités dans des laboratoires de recherche à pleine capacité, avoir des réunions auxquelles la moitié des participants assistent virtuellement et le reste porte des masques. La nouvelle norme est en fait différente mais non moins excitante. L'économie numérique a profondément touché notre domaine de l'ingénierie et notre environnement. Compte tenu de son impact, nous concentrons notre prochain numéro du Bulletin de la SCGM sur le sujet lié au changement climatique et à la durabilité.

J'ai le plaisir d'annoncer que le Congrès international 2022 de la SCGM se tiendra en personne du 5 au 8 juin 2022 à l'Université de l'Alberta. Le congrès comprendra 16 symposiums dans divers domaines liés au génie mécanique. Veuillez trouver plus d'informations à la page 6 de ce Bulletin de la SCGM.

J'aimerais également annoncer que notre comité d'histoire de la SCGM a été très actif depuis sa création. Des articles sont en préparation à la mémoire du regretté professeur Douglas Ruth (membre déterminant d'Ingénieurs Canada et du Bureau canadien d'agrémentation en génie) et de la regrettée professeure Martha Salcudean (ancienne directrice du génie mécanique à l'Université de la Colombie-Britannique). Le comité est également actif dans la promotion de l'équité, de la diversité et de l'inclusion (EDI) en travaillant sur un article concernant l'histoire de l'EDI en génie mécanique.

Enfin, je tiens à remercier notre comité des affaires professionnelles pour l'organisation de webinaires pendant la pandémie du COVID-19 sur divers sujets d'ingénierie. Il y a eu une grande participation à ces webinaires de la part des membres de la SCGM. Les comités prévoient augmenter les adhésions étudiantes et professionnelles par le biais de webinaires réguliers, de sensibilisation et d'occasions de s'impliquer dans l'organisation d'événements et d'activités.

Je vous remercie pour votre soutien continu et vous souhaite une année saine et réussie en 2022.

Mina Hoorfar, PhD, P.Eng., FCSME
Présidente

Welcome New CSME members

1 May 2021 to 30 September 2021

Prof. Arash Arami, *University of Waterloo*
Mr. Abu Bakar Saeed, *GardaWorld*
Mr. Mubesa Beya Fischer, *Canada Stainless Steel Tubing Inc*
Mr. Michael Colby, *Venture Steel*
Dr. Nandini Debnath, *Affinite Instruments*
Mr. Robert Dzirba, *Universal Paper & Plastics, South Africa*
Dr. Ian Frigaard, *University of British Columbia*
Prof. Farbod Khameneifar, *Polytechnique Montréal*
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Prof. Grant McSorley, *University of Prince Edward Island*
Dr. Rezvan Nasiri, *University of Waterloo*
Ms. Meaghan Ormrod, *Powertech Labs Inc*
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Mr. Hassan Shahrukh, *City of Edmonton*
Dr. Benjamin Sponagle, *Dalhousie University*
Prof. Qiao Sun, *University of Calgary*
Mr. Collin Vaness, *MCW*
Dr. Kanglin Xing, *University of Alberta*

PHOTO: SCHOOL OF ENGINEERING AT UBC OKANAGAN

2021 Congress Report

DEAR CSME COMMUNITY,

As many of you are aware, due to the unforeseen circumstances arising from the COVID-19 pandemic, the CSME 2021 Congress hosted by the Faculty of Sustainable Design Engineering at the University of Prince Edward Island (UPEI) was hosted online during June 27th – 30th 2021. We were thrilled to schedule **204** technical, **12** keynote and **4** plenary presentations. We published the presented work in the Progress in Canadian Mechanical Engineering Volume 4. These Proceedings were published by the UPEI library and each paper received a unique DOI number. The papers are available for viewing and downloading at library.upei.ca/csme-2021.

We would like to thank the CSME Community for their continued support. In particular, we thank the CSME Congress Committee and Symposium Chairs for their outstanding help and contributions in organizing twenty technical Symposiums. The Symposium Chairs represented more than twenty Canadian universities and research organizations. We would also like to thank the outstanding support that we received in the past few years from UPEI staff and our volunteers. A team of more than thirty volunteers and staff contributed to the organization of CSME 2021 Congress.

We wish Drs. **Hossein Rouhani** and **Andre McDonald** all the best in organizing the CSME 2022 Congress at the University of Alberta during June 5th – 8th, 2022. On behalf of the organizing committee, we hope that all of you and your loved ones stay safe during these difficult times, and we hope to see you all in Edmonton during the CSME 2022 Congress.

DR. NICK KROUGLICOF, PhD, P.Eng.
Professor, Faculty of Sustainable Design Engineering
University of Prince Edward Island
Co-Chair of CSME 2021 Congress

DR. ALI AHMADI , PhD, P.Eng.
Associate Professor, Faculty of Sustainable Design Engineering, University of Prince Edward Island
Co-Chair of CSME 2021 Congress

Transactions of the Canadian Society for Mechanical Engineering (TCSME)

I want to share with you some fantastic news. The two-year impact factor for *Transactions of the Canadian Society for Mechanical Engineering* (TCSME) is now **1.45**. In 2018, the *TCSME* moved to Canadian Science Publishing and since then the impact factor of our journal has increased from 0.243 (2018) to 0.573 (2019) and, very recently, 1.45 (2020). Note that 2021 also looks very good as the 2019 and 2020 papers in TCSME have already been cited 109 times from January to September.

This year also marks the 50th year since the creation of the TCSME. We can all celebrate!

Please join me in thanking the editorial board that made all this happen:

- Martin Agelin-Chaab, Ontario Tech University
- Ali Ahmadi, University of Prince Edward Island
- Mohsen Akbari, University of Victoria
- Kamran Behdinan, University of Toronto
- Frank Cheng, University of Calgary
- Aleksander Czekanski, York University
- Xili Duan, Memorial University of Newfoundland
- J. Maciej Floryan, University of Western Ontario
- Dominic Groulx, Dalhousie University
- Horia Hangan, University of Western Ontario
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- Rouhani Hossein, University of Alberta
- Farrokh Janabi-Sharifi, Ryerson University
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- Eric Lanteigne, University of Ottawa
- Xianguo Li, University of Waterloo
- Babak Owlam, CSA Group
- Jeff Pieper, University of Calgary
- Ghaus Rizvi, Ontario Tech University
- Kamran Siddiqui, University of Western Ontario
- Li Sunny, University of British Columbia
- Duan Xili, Memorial University of Newfoundland

Please support the journal by downloading and/or submitting articles to the *TCSME*. The journal can be accessed at the link: www.nrcresearchpress.com/journal/tcsme.

MARIUS PARASCHIVOIU, PhD, FCSME, FEIC
Editor-in-Chief, TCSME
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Concordia University

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2022 CSME International Congress

June 5-8, 2022 (www.csmecongress.org)
University of Alberta, Edmonton, Alberta

Symposiums:

Advanced Manufacturing
Biomechanics and Biomedical Systems
Computational Mechanics
EDI in Engineering Education and Research
Future Energy Systems
Machines and Mechanisms
Mechatronics, Robotics and Controls
Microtechnology and Nanotechnology
Advanced Energy Systems
Computational Fluid Dynamics
Engineering Design
Fluid Mechanics
Heat Transfer
Materials Engineering
Solid Mechanics
Transportation Systems

Call for papers: Submissions in the form of 400-word abstracts or 6-page papers*

Call for workshops: Submission in the form of 400-word abstract for workshops on June 5, 2022

Submission deadline: 28 January 2022 (see www.csmecongress.org)

Sponsorship opportunities: www.csmecongress.org/sponsorship

Further information: csme2022@ualberta.ca

** 6-page papers can be considered in the Student Paper Competition and/or Special Issue of Transactions of the Canadian Society for Mechanical Engineering*

THE FUTURE OF COMPUTER-AIDED DESIGN

THE PERVASIVENESS OF COMPUTER-AIDED DESIGN (CAD) technology is immense. Nearly every mass-produced physical product you see was modelled in CAD, and every undergraduate mechanical engineering student in the world is likely to learn CAD. While sketches and hand-drafted engineering drawings were once relied on for representations of designs, since its inception in 1957, CAD has become one of the most prominent tools used by engineers. While CAD has changed in the more than sixty years since its inception, its key capability — to deliver digital, parametric feature-based solid models — long remained stable. For novices and experienced designers alike, digital CAD models have utility not only as a high-fidelity digital representation, but they are also useful for communication with stakeholders, required for computer-aided manufacturing, and enable complex simulation and testing earlier in the design process.

The reliance on CAD proved at times problematic, as traditional CAD has several disadvantages that directly undermine design teams' abilities to work collaboratively. Specifically, CAD was built for individualized work with inflexible product interfaces, leading to issues with accessibility, sharing, coordination and scalability which lead to poor innovation, late re-work, costly mistakes, and unexploited collaboration potential. The unpredictability of human designers further exacerbates the collaboration problem (e.g. the non-standard ways in which we build CAD models, the lack of opportunities to communicate design intent information in models). Basically, CAD enables a design process that is individual, solitary, and personal. Contrast the reality of CAD with cutting-edge design research which points to our need to harness diverse, multidisciplinary, globally distributed teams to unlock higher value.

What I would like to highlight in this feature article is that the CAD industry is currently experiencing a major fundamental transformation, fueled by modern cloud-capability, high-quality connectivity and users' increased need to collaborate on globally distributed teams[1]. Thus, CAD companies now offer CAD packages which are accessible via internet browser (e.g. PTC Onshape, Autodesk Fusion360), have introduced new or expanded collaborative features (e.g. Dassault 3DEXPERIENCE, Siemens NX Cloud Connected Products), or are start-ups dedicated to solving this problem with new approaches (e.g. Canada's own Colab, KittyCAD). In particular, fully-synchronous "cloud-CAD" environments unlock the possibility of novel modes of design, breaking away from the purely solitary nature of traditional CAD and potentially unlocking higher quality outputs, faster design times, more satisfied designers, or more creative products. We can expect these tools to disrupt professional practice and engineering design education. My team in Mechanical & Industrial Engineering at the University of Toronto aims to develop insight to lead CAD designers through this transformation. In the next section, I will present recent findings from my research group that demonstrate how new collaborative features have changed the potential for CAD.

Prof. ALISON OLECHOWSKI, PhD, P.Eng., MCSME
Dr. Olechowski is an Assistant Professor in the Department of Mechanical & Industrial Engineering at the University of Toronto. She completed her PhD at the Massachusetts Institute of Technology (MIT) studying product development decision-making. Dr. Olechowski completed her BSc (Engineering) at Queen's University, where she won the CSME Gold Medal, and her MS at MIT, both in Mechanical Engineering. Her current research focuses on engineering design; in particular, her group conducts studies to understand how new technologies can best be used to improve the process and outputs of engineering design and new product development.

IMAGES COURTESY OF THE RESEARCHER

NEW INSIGHT ON COLLABORATING WITH CAD

Inspired by techniques for software development, my team recently published the results of a study to test the generalizability of findings from the pair programming literature to the same dyadic configuration of work in CAD, which we call pair CAD[2]. We conducted human subject experiments with 60 participants to test three working styles (see *Figure 1*): Individual — individuals working by themselves, Parallel — pairs able to edit the same model simultaneously from two inputs (akin to Google Docs), and, Shared — pairs sharing control of one model instance and input (akin to sitting together at one computer). We compared these working styles on speed and quality, as shown in *Figure 2*. In the dimension of speed, on a per-person basis, individuals were faster than pairs due to coordination and overhead inefficiencies. Further, pair CAD, when done with a single shared input, but not in a parallel mode, leads to higher-quality models. We have since expanded this study and seen similar effects for synchronous collaborative CAD assembly efforts[3].

In a related study[4] we sought to better understand designer emotions in traditional and collaborative CAD environment, since emotion drives established relationships with designer satisfaction, creativity, performance, and other outcomes increasingly valued by engineering designers and managers in virtually collaborative environments. My team developed a new method to link designer emotions with corresponding designer activities while using CAD software. The method employs automated facial emotion detection software and cursor tracking. We applied this method via an experiment

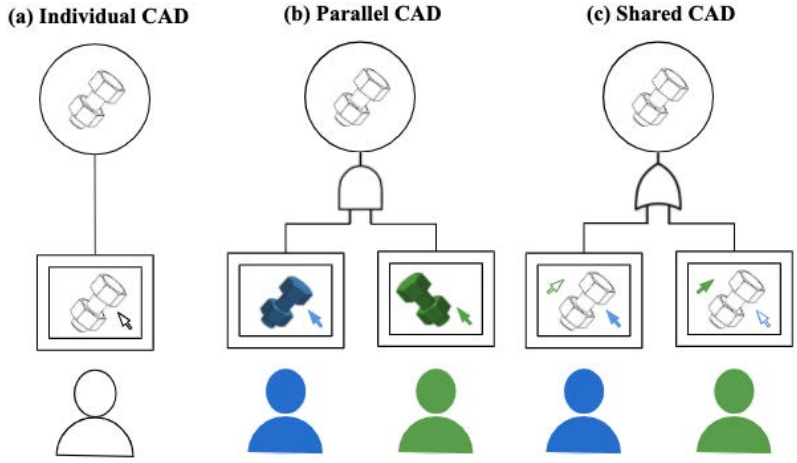

FIG. 1: REPRESENTATION OF VARIOUS CAD WORKING STYLES: (A) INDIVIDUAL CAD USER ACCESSING MODEL VIA A SINGLE WORKSTATION, (B) PARALLEL CAD USERS SHARING A COMMON CAD DATABASE THROUGH INDEPENDENT WORKSTATIONS AND CONTROLS, AND (C) SHARED CAD USERS SHARING ACCESS TO A SINGLE DATABASE, BUT WITH ONE-AT-A-TIME SHARED MOUSE/KEYBOARD CONTROL FROM INDEPENDENT WORKSTATIONS[2].

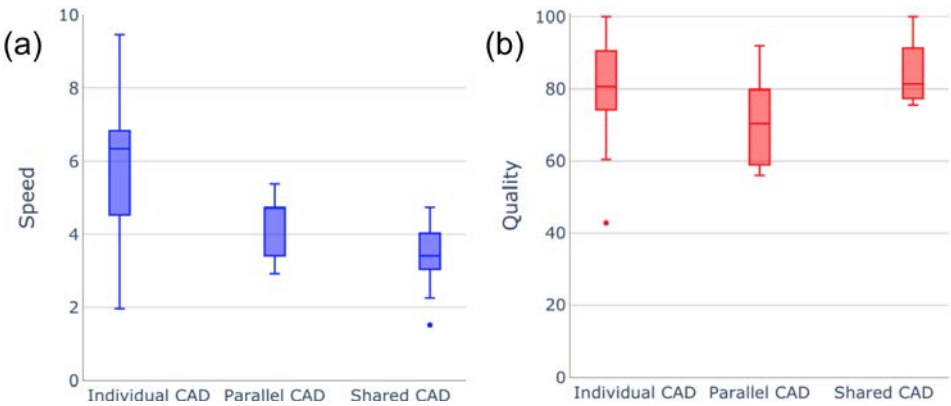

FIG. 2: (A) SPEED AND (B) QUALITY METRICS FOR ALL PARTICIPANTS IN EXPERIMENT PHASE, PER-WORKING STYLE[2].

with nine participants, each working with the same synchronous cloud-CAD platform, and assigned a series of CAD tasks in one of two distinct working styles: single participants working by themselves and paired participants working together. The team then analyzed and compared trends in emotion for these two working styles. Pairs, on average per person, experienced higher levels of emotion (measured as joy, sadness, anger, contempt, fear, and surprise) than individuals.

UNLOCKING INSIGHT FROM USER ANALYTICS

For the engineering design research community, an appealing feature of cloud-CAD is access to the reliable, high-quality back-end user analytics. As an example, in partnership with the CAD provider PTC, my team has begun to decipher patterns of behaviours that are revealed from long-term CAD use. We analyzed the real working data of eight professional designers working on a cloud-CAD platform at the Canadian autonomous cleaning robot company Avidbots[5]. This data corresponds to more than 1,420,000 actions over a span of eight months. We then developed a framework for classifying individual designers by their CAD behaviours. This CAD-type behaviour framework provides a tool for assessment and reflection on the types of roles present or missing on a team of designers – for example, what is your mix of creation, editing, organizing and assembling actions? This can assist CAD educators and trainees in understanding their own CAD learning trajectory. Future extensions of the framework could leverage artificial intelligence techniques to provide real-time feedback on designer roles.

Further expanding on the engineering education and training context, upcoming work seeks to analyze the big data generated from a collaborative CAD learning workshop to identify pathways of CAD learning[6].

CHALLENGES AND OPPORTUNITIES TO ADDRESS

A number of important challenges of cloud-CAD remain to be fully resolved: there are intellectual property and security realities to be managed, questions about the complexity of model and scale of collaboration team that can be accommodated, the ever present resistance to information technology tool change, and the implications of CAD for collaborative conceptual design[7]. Our research will continue to explore the affordances of collaborative CAD with the aim of enabling mechanical engineers to design to their full potential.

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CONTRIBUTE FEATURED AND NEW FACULTY SPOTLIGHT ARTICLES TO THE NEXT CSME BULLETIN

SPECIAL ISSUE ON

CLIMATE CHANGE AND SUSTAINABILITY

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CLIMATE CHANGE IMAGES VIA CANVA

AI-driven design optimization:
How did we get here and where are we going?

ANY RATIONAL HUMAN BEHAVIOR COULD BE MODELLED AS AN OPTIMIZATION PROBLEM, and we do such optimization intentionally or subconsciously almost all the time. Nowadays, we apply optimization to design the best cars, airplanes, cell phones, and so on. We also apply optimization to design the best manufacturing process, the patient treatment process in hospitals, the best logistic process, the best delivery process, and so on.

BRIEF HISTORY OF ENGINEERING OPTIMIZATION

But how did we get here? The earliest optimization approach can be traced back to Pierre De Fermat and Joseph-Louis Lagrange, who first found calculus-based formulae for identifying optima. Issac Newton and Johann C.F. Gauss first proposed iterative methods to search for an optimum. The formal optimization, however, did not start until Leonid Kantorovich published on linear programming in 1939. The first well-known approach, the Simplex Method, was then published in 1947 by George Dantzig. Since then, a large number of optimization approaches have been developed. Among the numerous approaches, the steepest descent method (rooted in the unpublished notes of Riemann in 1863), Newton's method, Quasi-Newton methods, penalty method, feasible direction method, and quadratic programming have become well known and widely accepted. From the 1940s to the 1970s, the classic optimization approaches developed rapidly and peaked in the 1970s. Optimization was also called mathematical programming or mathematical optimization. Optimization has become a large research area with many branches including linear programming, nonlinear programming, unconstrained optimization, constrained optimization, single-objective and multi-objective optimization, goal programming, dynamic programming, and so on. Linear programming has become mature and has found its application in logistics, banking, and economics due to its simplicity. Nonlinear optimization — meaning there is at least one nonlinear objective or constraint function — met more difficulties in application, however. Unfortunately, nearly all problems are nonlinear in engineering design. Thus, the remainder of our discussion will focus on nonlinear optimization problems.

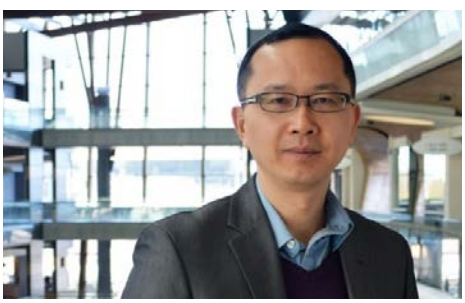
This first wave of optimization approaches is characterized by the following features:

1. Local optimization. Most of these approaches consider a local optimal, i.e., the lowest point of a valley. A global optimal is defined as the lowest point of all valleys and is beyond the capabilities of these methods.
2. Sequential search. The idea of the iterative search is built on the location of the previous search point. Consider an analogy in which a blind man is climbing a hill. This person must know his current position, the direction he is heading in, and how far he should walk, in order to determine the next position. The search iterates itself until the man reaches the top of the hill. This idea encounters difficulties when each step takes a long time, since the total time for optimization equals the time that it takes for each step multiplied by the number of steps.
3. Reliance on gradients or higher-order derivatives. The calculation of gradients or even higher-order derivatives requires extra computing resources and is error-prone. Earlier optimization codes often had problems of non-convergence, float-point error, and other robustness issues.

In application, practitioners complained that these methods could not enable them to explain why the optimum is optimal and could not inform them more about the problems at hand. In case the optimal solution is not usable for any reason, they don't know where to find the next optimum. Also due to limited computing power, these methods did not find wide applications in engineering. Some commercial software tools found success, and numerous free codes were available for download from the Internet. This group of approaches can be considered the first generation of optimization methods.

From the 1980s till now, metaheuristic approaches have attracted the attention of engineers. One of the most popular approaches is the Genetic Algorithm (GA), invented by John Holland in 1960. GA works on the principle of "survival of the fittest." Following this, simulated annealing (SA) was published in 1983 in the journal Science. SA was inspired by the heat treatment process, annealing, and became a global optimization algorithm. Later, algorithms such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Tabu Search, and Artificial Bee Colony were developed, amongst numerous others. This group of approaches was inspired by nature or other heuristics. They are global optimization approaches in essence, they do not require gradients or higher derivatives, and they support parallel computation. Even today, new methods are being developed as new heuristics are being invented. This group represents the second generation of optimization methods.

Despite many benefits, the major problem with metaheuristic approaches is the need for an enormous amount of trial points before reaching the global optimal. For problems with equations, or problems that need little computation to evaluate, these methods work very well. However, in engineering, where computer-aided engineering (CAE) tools are widely adopted and applied, the computation time for evaluating



Prof. GARY WANG, PhD, FASME

Dr. Wang is a professor at Simon Fraser University in the School of Mechatronic Systems Engineering. He received his PhD from the University of Victoria in 1999. He won the 2005 National I. W. Smith Award for creative engineering from CSME, the 2007 Rh Award from the University of Manitoba for outstanding research, and the 2014 SFU Excellence in Teaching Award. He has been serving as the associate editor for Engineering Optimization since 2010, geographically representing North America. He has also served as an associate editor for ASME Transactions, Journal of Mechanical Design, *as well as* CSME Transactions *for many years. His research is in design optimization and advanced manufacturing.*

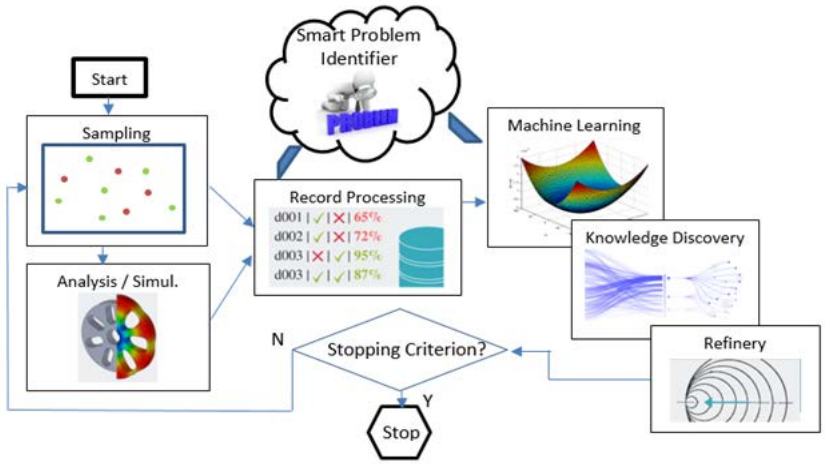


FIG. 1: DATA FLOW OF AI-DRIVEN OPTIMIZATION ALGORITHMS (COURTESY OF EMPOWER OPERATIONS CORP.).

each design could be hours or days. Even with parallel computation, the total time for evaluating thousands of design trials would still be impractical. The question then becomes, how do we find the global optimal with the minimum number of design trials?

To answer this question, surrogate-based optimization emerged in the 1990s as the third generation of engineering optimization methods[1]. The idea was to replace CAE simulation with a cheap-to-compute surrogate model, for instance, a polynomial function or Kriging model. Then traditional optimization is applied using the surrogate models as the optimization functions. The challenge is to use a limited number of design trials (called sample points) to construct a surrogate between the design variables and objectives/constraints. Sample points can be generated following the traditional Design of Experiments (DOE). Soon, the community realized that for computer experiments, DOE methods were no longer applicable, as they tend to go beyond the design space and have little information about the space itself. This is because DOE schemes are developed to reduce the variance caused by random errors in physical experimentation. For computer experiments (simulations), space-filling samples are needed to address the possible system error between the surrogate and the CAE model. Moreover, it is found that simply replacing the original model is insufficient, as the surrogate model may not be accurate, and in fact, it is almost impossible to build a globally accurate surrogate model over a high-dimensional space. For example, in a 10-variable problem, where a quadratic function is modelled by sampling three points along each dimension, the total number of samples would be 59,049 (i.e., 3^10). This is the so-called "Curse of dimensionality," a problem commonly seen in data science.

When the third-generation approach met its bottleneck, the fourth generation of optimization approaches started to emerge around 2010, partially inspired by the advancement of rapid development in machine learning. These AI-driven design optimization approaches iteratively construct a machine-learning model in local spaces, mine the knowledge of the design function and spaces, validate the predictions, revise assumptions, and converge to the optimal[2,3]. Figure 1 shows the typical data flow in an AI-driven optimization algorithm. In contrast to the third generation of approaches, AI-driven approaches 1) do not need DOE or a globally accurate surrogate, 2) do not call conventional optimization routines for optimization, and 3) manifest themselves as an iterative sampling-learning procedure.

These AI-driven approaches are global optimization methods. They support parallel computation, do not need gradients, use fewer design trials than before, solve high-dimensional problems, and offer insight and knowledge about the design problem. For example, a multidisciplinary automobile design optimization problem involving 124 variables with 68 expensive constraints such as crashworthiness, noises, vibration, and durability, is solved by this type of approach with only 2,000 trials. It's worth noting that this problem is based on simulation and does not require a gradient in optimization. In contrast to first spending 59,049 points to build an accurate surrogate, an average AI-driven approach can solve a 10-variable problem with less than 1,000 samples. Most of all, these approaches enable the application of optimization in almost all modern design tasks involving expensive simulation. It is noteworthy that these approaches can only be given a small dataset due to the high computational expense and often tight timeline, whilst machine learning approaches derived from computer science often need a large dataset. Therefore, these approaches may be better categorized as small-data learning (or few-shot learning).

FIG. 2: AN AUTOMOBILE DESIGN PROBLEM WITH 124 VARIABLES AND 68 SIMULATION-BASED CONSTRAINTS CONSIDERING CRASHWORTHINESS, NOISES, VIBRATION, AND DURABILITY.

WHERE ARE WE GOING?

Today, as I look back at the engineering design methodologies of the last 30+ years, I can see two revolutionary waves. These two waves are marked by the invention and wide adoption of CAD and CAE technologies, respectively. I was fortunate to be involved in developing a CAD system in the early 1990s. When I started my academic career in Manitoba in 1999, most of the manufacturers in Winnipeg back then were not familiar with CAD and only a few were using Autodesk products. After teaching university classes on CAD and introducing Pro/Engineer (now Creo) in Manitoba for 8+ years, I saw the wide use of CAD and some CAE tools by local manufacturers. Nowadays, most of the manufacturers in Canada are using CAD, which "liberates" engineers from the drawing board, and many have adopted CAE tools, which reduce the number of lengthy and expensive prototype tests.

The fundamental design task, however, still relies almost completely on engineers. CAD only transfers the design into 3D drawings, and CAE is merely used to check the design. All design revisions are done by trial-and-error — a time-consuming and relatively tedious job. Can we do better than this?

The answer is yes. AI-driven optimization generates many trial designs, checks their performance with CAE, and automatically searches for the best design. This process has been realized and commercialized[4] (see video www.youtube.com/watch?v=-E5Q4LrntHg). It means an engineer can "tell" the tool what they are looking for (objective), what can be changed (variables), what conditions must be satisfied (constraints), and the computer will automatically yield the best design choices. This would free engineers and designers from repetitive trial-and-error, and intelligently find the best solution. This is perhaps the core of the current buzzword "generative design." In this sense, current CAD will be called "Intelligent CAD." In the larger context of additive manufacturing, AI, and new optimization technologies, the third revolutionary wave of design technology is forming, or perhaps has already come.

I envision that in the near future, every CAD or CAE tool will have a button called "Intelligent optimization," "Find the best," or something similar. Engineers can leave the computer alone for a while and use the freed-up time to focus on more creative work. At that point, the benefits of AI-driven optimization such as better-quality products, shorter development time, lower costs, and higher profits, will be widely felt by the industry.

What do we need to do now to get there? Technically, researchers need to come up with better methods to support the formulation for optimization problems, to bridge topology optimization with parametric optimization for the common goal of generative design, and to integrate expert experience with novel AI methods to achieve the "Intelligent Optimization" that goes beyond the narrow notion of traditional optimization. From the application side, software developers need to make the tool as easy to use as a point-and-shoot camera. Investors need to stay alert for new start-up companies who develop these new tools to help them penetrate the CAD/CAE market currently dominated by a few giant companies.

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HIGHLIGHTS

CONSIDERING FUNCTION IN ADDITIVELY-MANUFACTURED PART DESIGN

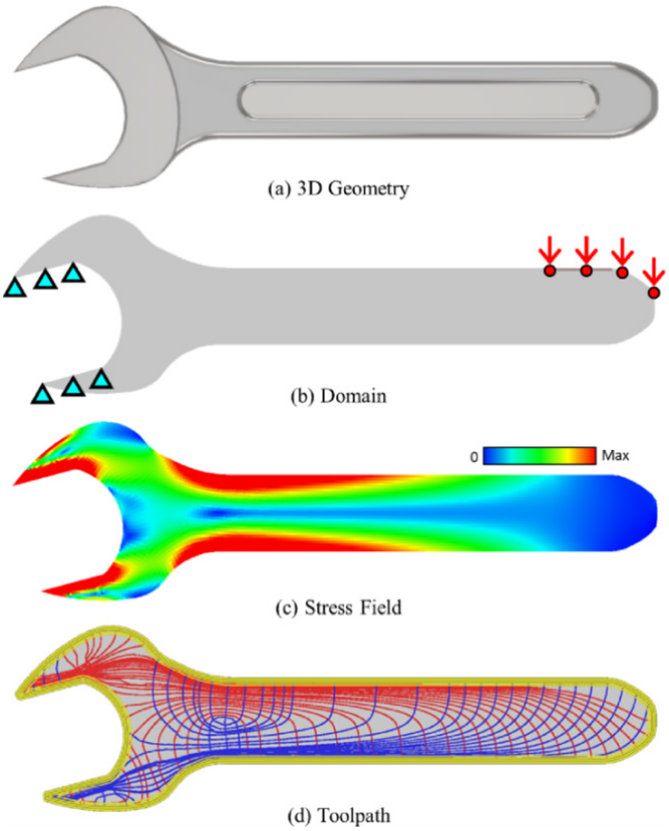

FIG. 1: PSL-BASED TOOLPATH PLANNING FOR A WRENCH. (A) INITIAL 3D GEOMETRY MODEL, USED TO DEFINE (B) THE DESIGN DOMAIN FOR THE INTERNAL STRUCTURE WITH APPLIED LOADS AND BOUNDARY CONDITIONS, (C) THE STRESS FIELD RESULTING FROM APPLIED LOADS AND BOUNDARY CONDITIONS AND (D) THE PSL-BASED TOOLPATH TRAJECTORIES.

The infill structures of 3D additively-manufactured (AM) parts contribute to the overall part strength and stiffness, and the pre-processing software used to prepare part models for 3D AM typically allows the user to select from a variety of infill patterns and densities. These patterns are typically homogeneous; rarely is this infill strategically optimized for the anticipated loading applied to the part. Meanwhile, topology optimization (TO) of parts is increasingly common, and TO capability is built into various CAD/CAE software environments. There is a disconnect, however, between the topologically optimized structures that can be designed, and the toolpaths of the AM machines used to create these parts; this can actually worsen the strength/stiffness of the part. Recent developments by Prof. **Tsz-Ho Kwok's** team at Concordia University addresses this disconnect, by introducing function-aware slicing using principal stress lines (PSLs) for toolpath planning in additive manufacturing[1]. This innovative approach to AM toolpath planning starts by using finite element analysis to determine the anticipated stress/strain tensor field across a part when subjected to its anticipated loading environment. The model results are processed in a layer-by-layer process, following the layer-by-layer building process used in AM. Within each "slice", PSLs are extracted, characterized as compressive or tensile, and AM toolpath motions are created which follow those PSLs. Experimental mechanical testing revealed that prototype parts manufactured using this technique were up to 50% stronger than parts manufactured with typical infill patterns using the same amount of material. Furthermore, the technique is fast – requiring less than 5 seconds to design the PSL-based toolpath plan of the wrench shown in *Fig. 1*. Their results demonstrate the potential benefits of this promising new technique when applied to fused filament fabrication, and their future work will expand this approach to other AM techniques. — *Technical Editor, Prof. Ryan Willing*

ME News continued next page . . .

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OPTIMIZING PART CONSOLIDATION IN ADDITIVE MANUFACTURING

Additive manufacturing enables manufacturing of more complicated parts than many traditional techniques; for instance, the complex organic web-like structures that exist in topology-optimized part designs. As a result, one of the most highly touted benefits of additive manufacturing is the opportunity for part consolidation, replacing many simpler parts in an assembly with a single (albeit more complex) part. While this results in fewer parts with fewer connection points, there can be benefits associated with assemblies of parts even when a single additively manufactured part is technically possible. This may be the case when the consolidated part becomes too large to be constructed in most readily available 3D printers, or inefficient (in terms of printing time and support material usage) to manufacture due to its shape. Previously described part consolidation techniques typically employ a top-down approach, whereby the new parts are similar in shape to the previous assembly, with a limited number of possible part combinations (*Fig. 2*). In the recently published study by **Luke Crispo** and Prof. **Il Yong Kim** at Queen's University[2], they apply a bottom-up approach, unbounded by the original assembly part designs and effectively starting with a clean slate (*Fig. 2*). As a result, there becomes an unlimited number of part combinations. The problem then became how to optimize the topology of individual parts, the number of parts, and the connections between parts, when performing part consolidation. In this study, they explored a multilayered topology optimization approach, in which numerous potential parts of an assembly are simultaneously designed, using a topology optimization approach, in separate but overlapping and interconnected design domains. Their approach employed a multiobjective problem statement that optimizes the complex trade-off between part compliance, additive manufacturing support structure volume, surface area, and number of joints, to minimize the total cost of a final assembly. The trade-offs among various performance measures were studied through three test cases described in the paper. Ultimately, approaches like theirs eliminate bias towards the original assembly design in part consolidation, allowing for novel designs to be created. Their future work will expand this technique to more complicated 3D part consolidation problems, and incorporate additional additive manufacturing factors. — *Technical Editor, Prof. Ryan Willing*

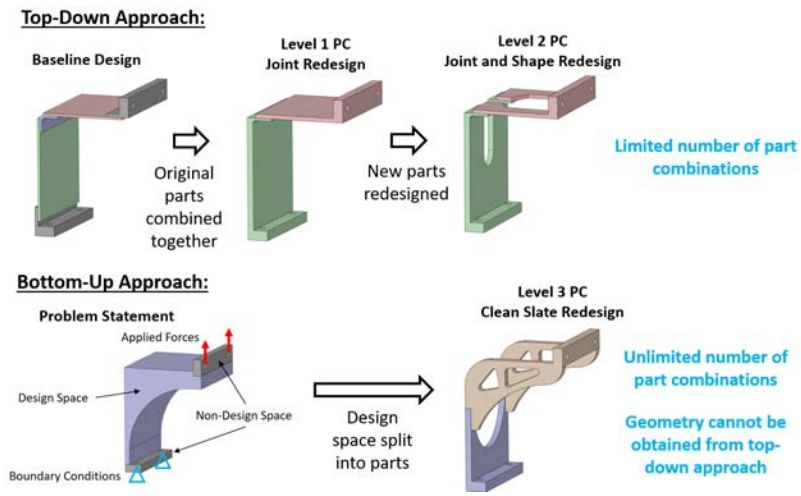
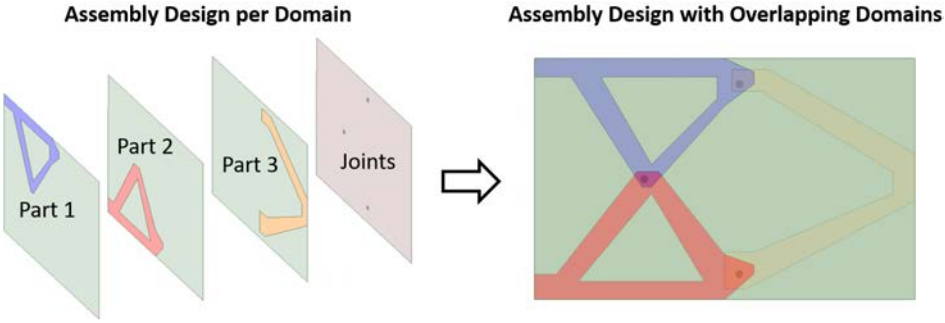


FIG. 2 (ABOVE): (TOP) TYPICAL PART CONSOLIDATION (PC) USING A TOP-DOWN APPROACH, THEREBY LIMITING THE NUMBER OF PART COMBINATIONS. (BOTTOM) A BOTTOM-UP APPROACH TO PC, ESSENTIALLY STARTING FROM A CLEAN SLATE AND POSSIBLY RESULTING IN AN UNLIMITED NUMBER OF PART COMBINATIONS.

FIG. 3 (BELOW): DEPICTION OF DIFFERENT PART DOMAINS, WITHIN WHICH INDIVIDUAL BUT INTERCONNECTED PARTS CAN BE DESIGNED WHILE SIMULTANEOUSLY SATISFYING DESIGN CONSTRAINTS OF THE ENTIRE ASSEMBLY.



RESEARCH IMAGES COURTESY OF CRISPO AND KIM

University of Toronto
Dr. Alison Olechowski

Better mechanical engineering design with new collaborative tools

In the future, we will increasingly see collaborative and remote design, for example a team comprising of a mechanical engineer in Toronto, an industrial designer in Amsterdam and a manufacturing engineer in Shenzhen. New technologies are offering a range of new collaborative configurations for distributed teams. In particular, cloud-based tools and complex modeling packages are rapidly entering the new product development toolbox. Yet much of the best practice knowledge about engineering design tools has not yet been updated to reflect modern features and capabilities, and correspondingly there is latent potential to improve the quality and speed of traditional and remote engineering teams. Addressing this gap, Dr. **Alison Olechowski** and her group aim to help engineers collaborate more efficiently and effectively using modern design tools.

During her PhD at MIT, Dr. Olechowski worked closely with industry partners to understand the challenges of modern professional design practice. Now at the University of Toronto, her lab is among the first in the world to analyze the detailed data from user-studies in multi-tenant Computer-Aided Design (CAD) environments, identifying patterns and recommended practices for improved performance.

Dr. ALISON OLECHOWSKI, PhD, P.Eng., MCSME

Dr. Olechowski is an Assistant Professor in the Department of Mechanical & Industrial Engineering at the University of Toronto. She completed her MS and PhD at the Massachusetts Institute of Technology (MIT) studying product development decision-making. Dr. Olechowski completed her BSc (Engineering) at Queen's University, where she won the CSME Gold Medal. Her current research focuses on engineering design. Her group conducts studies to understand how new technologies can best be used to improve the process and outputs of engineering design and new product development.

IMAGES COURTESY OF THE RESEARCHER

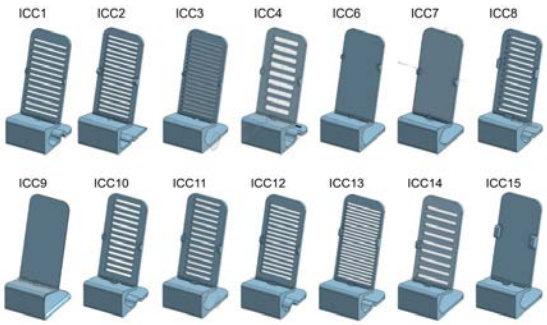


FIG. 1: EXAMPLES OF OUTPUT FILES OF PHONE HOLDER FROM 15 PARTICIPANTS FROM LABORATORY EXPERIMENTS WITH CAD DESIGNERS, IN INDIVIDUAL CAD CONTROL (ICC) STYLE (DOI.ORG/10.1115/1.4050734)

Example's of experimental outputs and anlysis are seen in *Fig. 1* and *Fig. 2*. A recent study from her group published in the ASME *Journal of Mechanical Design*[1] discovered that on average, performing CAD with a real-time partner (as inspired by the pair programming technique for coding) results in higher quality models than when designing by oneself. In a follow-up study[2], the team developed a first prototype of automated detection of CAD styles, the personalized patterns through which one builds and edits a CAD model. This work represents a vital step towards real-time feedback for collaborative CAD teams, and for the future, the foundation for building human-AI collaboration in CAD. The team continues to work with the large-scale data generated from modern CAD packages to identify expert-behaviours, with the aim of improving training and user experience.

From a systems engineering perspective, an award-winning project in the lab focuses on integrating safety analysis earlier in conceptual design using model-based systems engineering (MBSE). MBSE is a methodology for building a single source of truth model, important for coordinating large teams and complex information on systems engineering projects. The integration of MBSE and safety analysis will result in a lower likelihood of late and costly design changes.

Dr. Olechowski and her team conduct research via an interdisciplinary approach that combines engineering design knowledge with concepts from psychology, software engineering, and management science. They apply a range of methods, from qualitative interviews with engineering professionals to statistical analysis of laboratory- or field-collected user data from real engineers. Dr. Olechowski's research space, the Design Observation Studio, features world-class equipment for conducting user studies and analysis. Reflecting the interdisciplinary and industry-driven nature of the research, the lab is funded by both NSERC (Engineering) and SSHRC (Social Science) federal granting agencies, as well as industry partners in the aerospace, manufacturing, and hardware tools industries.

Ultimately, Dr. Olechowski and her team's research improves our understanding of the design process, resulting in recommendations and solutions for industry partners to accelerate their innovation. For more information, visit Dr. Olechowski's group website at readylab.mie.utoronto.ca.

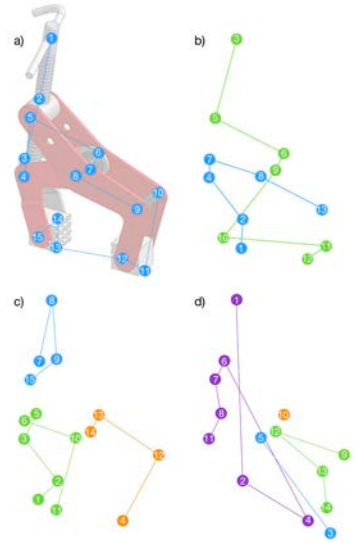


FIG. 2: VISUALIZATION OF INDIVIDUAL AND COLLABORATIVE ATTEMPTS TO ASSEMBLE A MANUAL CLAMP IN CAD. EACH COLOUR REPRESENTS A DIFFERENT INDIVIDUAL, AND ORDER OF ASSEMBLY IS REPRESENTED BY THE NUMBERED LABELS. (CHENG & OLECHOWSKI, PROCEEDINGS OF THE ASME 2021 INTERNATIONAL DESIGN ENGINEERING TECHNICAL CONFERENCES & COMPUTERS AND INFORMATION IN ENGINEERING CONFERENCE; 2021)

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University of Alberta
Dr. Xinming Li

Occupational Ergonomics in Industrialized Construction

Due to the physical demand of labour-intensive tasks, the construction industry in North America has a disproportionately high number of lost-time injuries. Considering workplace ergonomics is therefore essential. Traditional construction methods and techniques are changing with innovative techniques and automation. Industrialized construction manufactures full walls, floors, roofs and even house models in factories and transports these components to the site for assembly resulting in less execution time, less occupational accidents, more sustainable processes and more controllable work environments than traditional construction methods. Although workers work in a controlled factory environment and with the support of a series of machines, due to the improper workplace design, many operational tasks still involve excessive physical exertion. This results in not only reduced productivity and work delays, but also increased work-related musculoskeletal disorders (WMSDs) and non-fatal injuries. To identify worker exposure to ergonomic risk proactively, it is essential to investigate workplace design and the design of operational tasks in industrialized construction facilities.

During her PhD, to conduct preliminary workplace safety assessment, Dr. Li proposed an improved Physical Demand Analysis (PDA) that allows objective risk assessments by using the modified contents in the PDA form, and enables proactive risk identification, risk evaluation, and risk mitigation for operational tasks. To further detail the muscle usage, she later investigated physiological measurements (with sEMG, motion capture, force plate) to identify muscle fatigue, and human body simulation modelling to capture muscle force, joint contact forces, and moments development due to manual repetitive tasks for biomechanical analysis. Cross-comparison and validation were then conducted in order to maximize the advantages of both physiological measurements and human body simulation modelling. The limitation of the experiments can be, thus, eliminated and the accuracy of the human body simulation can be improved. However, physiological assessments are time-consuming and require human subjects to perform the operational tasks. Alternatively, 3D visualization allows users to simulate the task, which is less time-consuming and eliminates the need for costly onsite devices and the detrimental effect of human error during experimentation. Therefore, Dr. Li initiated a comprehensive post-3D visualization based "ErgoSystem" that automates ergonomic risk assessment based on 3D modelling with the development of a user-friendly platform for rapid workplace design. This work enables risk evaluation by detecting awkward body postures and evaluating the handled force/load and frequency that cause ergonomic risks during industrialized construction operations. The developed platform was validated through traditional motion capture devices on human movement detections. The "ErgoSystem" has proved to provide higher accuracy and effectiveness in risk assessment than traditional manual observation because 3D modelling is automated and can reliably analyze continuous motions. By implementing this automated system, the ergonomic risk assessment is efficient and intelligent due to (1) its capability and flexibility to conduct motion data computation, data conversion and data post-processing automatically, and (2) its ability to provide visualization of risk assessment results for the existing workplace or the workplace in design and to help with proposing any changes made to the workplace in the plant.

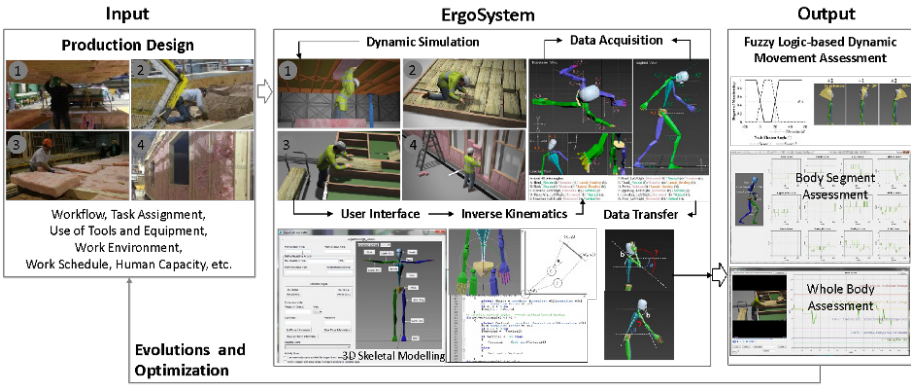

FIG. 1: THE PROCESS OF DEVELOPING POST-3D VISUALIZATION BASED "ERGOSYSTEM"

Dr. Li's team targets improved work performance and workplace design, ensuring a healthy working environment. They are continuing to research the aforementioned topics and are also working on digitalizing physical demand of operational tasks, automating ergonomic risk assessment, and aiming at facilitating a productivity improvement via timely monitoring and rapid evaluations. Multiple rounds of upgrades on post-3D visualization based "ErgoSystem" have improved its accuracy and added more functions (such as fuzzy estimation, standard time estimation, movement detection) in order to estimate productivity proactively. Advanced techniques, such as computer vision, deep learning, data-driven modelling, and virtual reality (VR) are used to obtain real-time human behaviors and working conditions to avoid unsafe behaviors and environmental hazards. Throughout the research activities, Dr. Li's team has worked closely with construction manufacturing enterprises, such as ACQBuilt, All Weather Windows, and their work has yielded results that have benefited industries on Worker's Compensation Board premium rate reduction and productivity improvement via reduced work-related claims and injuries as well as efficient facility designs. As a result, they have not only developed academic contributions, but also provided recommendations that have helped to improve the competitive edge of industry collaborators.

Dr. Li's lab is currently equipped with high performance 3D design workstations, VR immersive devices, wearable inertial sensor-based motion capture devices, and optical markers-based motion capture devices, 3D light field camera, etc. For more information, please visit the group at www.ergoresearchlab.com.

Dr. XINMING (SHERRY) LI, PhD

Dr. Li is an Assistant Professor in the Department of Mechanical Engineering at the University of Alberta. She completed her MSc, PhD and postdoctoral fellowship at the University of Alberta. Dr. Li's research improves industrialized construction operations by evaluating ergonomic risks and investigating corresponding corrective measures to secure the health and safety of workers and enhance workplace productivity. Her areas of focus include physical demand analysis, human body physiological measurement, ergonomic risk assessment, 3D visualization-based modelling, virtual reality, computer vision and lean manufacturing in industrialized construction.

IMAGES COURTESY OF THE RESEARCHER

University of New Brunswick
Dr. Gobinda Saha

Targeting the future of additive manufacturing in an energy-deprived world

UNB NCM LAB GROUP

THE URGENCY

Resource scarcity is, and always has been, a source of innovation. For 2.5 million years, humans used curiosity one of three human qualities, to create new tools and objects to gather wild plants and hunt wild animals. Their way of doing thing was by connecting imagination with nature's bounty. Just as Antoine Van Leeuwenhoek created the first microscope from scrap metals and a candle, human beings have persistently embraced this notion of empowering livelihood by matching curiosity with ingenuity.

Dr. GOBINDA SAHA, PhD, P.Eng.

Dr. Saha is an Associate Professor and Director of the University of New Brunswick's Nanocomposites and Mechanics Laboratory. He led R&D projects in two industrial companies, Hyperion Technologies Inc., and Westpower Equipment Ltd., while serving as an Adjunct Professor at the University of Calgary on composites and nanostructured materials and advanced coating technologies. Dr. Saha is the founding member of the Canadian Alliance in Cold Spray Technology (CACST), and the Joint Canada-U.S.A. Regulatory Cooperation Council on developing strategies for nanomaterials including risk assessment and use of industrial nanomaterials. He is a member of the Board of Directors on the Canadian Association for Composite Structures and Materials (CACSMA) and has served in the ASME Composites and Heterogeneous Materials Technical Committee.

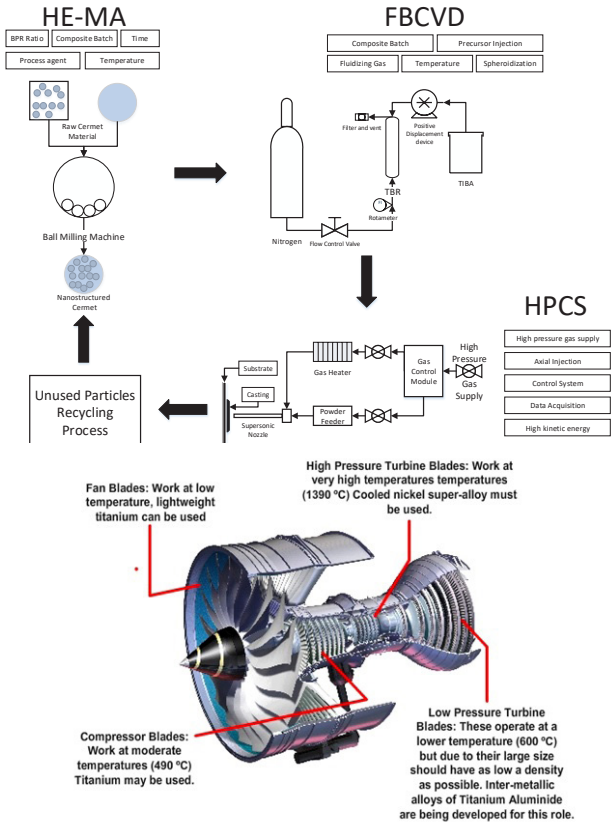

FIG. 2 ROTARY ENGINE FAN BLADE

In engineering science, the simplest way to accommodate ingenuity is through the creation of new possibilities of existing matters: liquid, gas, solid, and plasma. Now, imagine a world where better value is created within these possibilities, yet utilizing less of these quantities. Then the winner is a sustainable future, a phrase echoed at this year's 26th UN Climate Change Conference of the Parties (COP26) in Glasgow, United Kingdom.

HOW DO WE TACKLE A SUSTAINABLE MANUFACTURING FUTURE?

At a grassroot level, the University of New Brunswick (UNB)'s Nanocomposites and Mechanics Laboratory (NCM Lab) is tackling the growing concern of climate change due to high energy usage in manufacturing. Make no mistake, manufacturing is the backbone of a nation whose economic success and democratic stability are directly linked with its national gross domestic product (GDP). Our goal is to discover novelty in fundamental materials and transform them into sustainable products that create value for society. In our approach, material internal energy transformation while keeping the external energy input significantly low is a conundrum that we put into test every day. In other words, without changing the state of matter, we work with manipulation of material crystal structure in their solid state, but atomic scale, throughout the manufacturing process. In doing so, the lab is challenging the current metal-based additive manufacturing approach with nanostructured cermet and biomass-derived composite materials driven mechanically superior and environmentally sustainable solutions. The work activities cover conceptual material design, predictive modelling, nanoscale synthesis, advanced manufacturing, testing and characterization, field trial and recycle of materials using a holistic manufacturing principle. The novel approach integrates three major technologies (see *Fig. 1*) that when successfully aligned has shown the benefit of creating lightweight, high-strength, impact-resistant, 2D/3D/4D material creation with extended operational, safe, and positive environmental lifetimes. The underlying technologies used for particle synthesis are high-energy mechanical alloying (HE-MA), particle spheroidization-functionalization by chemical vapor deposition (FBCVD), and material deposition in the form of 2D coatings/3D freeform objects/4D structures with viscoelastic properties using the high-pressure cold spraying (HPCS).

Using HE-MA, a precursor micron-sized material composition, the suitable nano ceramic grain-reinforced metallic-alloy binder matrix particles with appropriate size distribution are

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Mechatronics Education in Canada

IN MAY 2001, I STARTED A CSME BIENNIAL FORUM on "Mechatronics Education in Canada." The first event took place at the University of Waterloo, looking at the "Past Experience and Future Directions." At Waterloo, we were on the verge of starting our Mechatronics Engineering program and a few other universities in Canada had begun contemplating the teaching of Mechatronics. The goal of the forum was to share some of the growing pains individual programs had experienced, determine what had worked and what had not, and work towards the development of a curriculum that was distinctly Mechatronics. The second forum was held at the University of Calgary and focused more on the research aspects in this area. Finally, the third forum was held at the University of Victoria, revisiting the pedagogical aspects. Unfortunately, these events did not continue due to time constraints, resulting from my moving to SFU to start the Mechatronic Systems Engineering Program.

At that time, Canada appeared to be far ahead of the U.S. in promoting Mechatronics undergraduate teaching. Canadian universities led by UBC and Waterloo and later by Simon Fraser (2007) had started full-fledged Mechatronics degree programs. In addition, other universities such as Victoria, Calgary, Sherbrooke, and the University of Toronto had created options in this area. However, there was no graduate degree or course work focus on Mechatronics in Canada.

According to the 2005 Forum in Victoria, the Mechatronics engineering program at Waterloo started in 2003 following a Mechatronics specialization, introduced in 1999 by the Mechanical, Systems Design, and Electrical & Computing Engineering departments. The UBC Mechatronics program is the evolution of the Electro-Mechanical Design Engineering program, which started in 1994. The SFU program was initially established within the School of Engineering Science and later in 2013 became a stand-alone degree program at the School of Mechatronic Systems Engineering.

At this stage, we continue to see more universities embrace mechatronics. For example, Western and McMaster universities are now offering degree programs in this area, and there are numerous options and courses offered in many Canadian universities. However, it would be great to learn the current level of focus on Mechatronics in our graduate programs. This may be very important since many new graduate students are from abroad without formal training in the Mechatronics field. It is also critical to look at the impact of Mechatronics on the industry.

As the Chair of the CSME History Committee, I would like to continue this effort by documenting the history of Mechatronics Education in Canada, particularly since 2005. I welcome your contributions, comments, or any feedback that you may have on this initiative.
— Farid Golnaraghi, PhD, Chair, CSME History Committee (mfgolnar@sfu.ca)

In Memoriam: Dr. Douglas Warren Ruth (1948-2021)

Dr. **Douglas Warren Ruth** obtained both a BSc degree and an MSc degree from the University of Manitoba and a doctorate from the University of Waterloo. In addition, he held academic appointments at the University of Calgary and the University of Manitoba.

However, Dr. Ruth was a professor in the Faculty of Engineering at Manitoba for more than three decades. During this time, he served selflessly in various leadership capacities, including eleven years as Dean of the Faculty of Engineering. He also served diligently as the Associate Dean of the Faculty, Associate Dean for Design Engineering, Chair of the Mechanical Engineering Department, and founding Director of the Centre for Engineering Professional Practice & Engineering Education. In addition, he was the NSERC Chair in Design Engineering, and finally, Dean Emeritus. Dr. Ruth eventually retired in 2018, leaving behind a huge legacy of contribution to the engineering community. One of these includes fundraising tens of millions of dollars to build the Engineering & Information Technology Complex at the University of Manitoba.

He traveled the country and world to expand engineering education and the profession because he believed strongly that engineers were enablers of civilization. To promote the profile of engineering education in Canada, he advocated for establishing the Canadian Engineering Education Association and housed its secretariat at the University of Manitoba. Furthermore, Dr. Ruth dedicated his time to serving the professional community, including the Board of Directors of the Council of Canadian Academies. He also served as President of the Canadian Academy of Engineering. Additionally, he served as a Chair of the Canadian Engineering Accreditation Board.

Dr. Douglas W. Ruth's contribution to the engineering profession was recognized through his election as a Fellow of the Canadian Academy of Engineering, Engineering Institute of Canada, and Engineers Canada.
— Martin Agelin-Chaab, PhD, Associate Professor, Ontario Tech

news.umanitoba.ca/remembering-dean-emeritus-douglas-ruth

DR. RUTH'S PHOTO COURTESY OF THE PRICE FACULTY OF ENGINEERING / UNIVERSITY OF MANITOBA

Andrew Brunskill is the Director of Data Science and a Cofounder of Clir Renewables

He's currently focused on scaling the delivery of big data analytics and machine learning to increase the value provided by Clir's performance optimization and reporting software. Andrew's role has included leadership across several teams such as Methodologies and Innovation, Customer Success, Data Engineering, and Renewable Analytics. Prior to Clir, Andrew was an engineer at two major technical consultancies. Andrew is an expert in wind and solar energy software and analytics, having worked on teams developing three different software packages now common in the renewables industries. Andrew has been a Professional Engineer since 2012. He lives with his wife and four daughters in Waterloo, Ontario.

You work in the development of software for wind and solar asset management. How do computers help renewable energies improve output power?

Modern wind turbines are large complex machines. Optimal turbine performance and energy production are achieved through the rapid detection and resolution of any issues that arise. Computer hardware and software are critical to wind and solar asset management.

Turbines are equipped with dozens of sensors which continually generate large volumes of data. Information measured by these sensors includes actual power output, energy generation, wind speed, wind direction, nacelle orientation, rotor speed, generator speed, component temperatures, vibrations, reactive power, voltages, currents, oil pressures, and more. These measurements, along with details regarding the turbine's operational status, are recorded by the turbine's supervisory control and data acquisition (SCADA) system. Further, external to the turbines, there are additional data sources relevant to wind farm operation such as meteorological masts, grid operator signals, the substation and the power meter at the point of interconnection with the grid.

Our software extracts data from all these sources and organizes it into an advanced data model. A series of algorithms are run to transform, enrich and label the data, which is then used to identify, describe and quantify any problems at the turbine. For example, the software uses machine learning to flag and explain turbine performance anomalies. Technicians at the wind farm are then able to plan service to address performance issues based on findings from the software. Causes of lost energy can be caught and mitigated or resolved quickly, ultimately improving or maintaining farm performance.

The story for solar plants is very similar, but some of the details are different. Plant data comes from sources such as inverters, transformers, junction boxes, meteorological stations, and trackers. The software monitors temperatures, electrical characteristics, and tracker positions to ensure the plant is operating optimally and that actions are taken when issues arise.

You have experience on turbine placement optimization, what type of computer-aided design are used to achieve this goal? Are detailed computational fluid dynamics simulations including terrain topology used? If not, why?

Wind farm layout design is a complex and iterative process. There are many considerations such as the variation in wind resource across the site, wake effects between turbines, visual impacts, acoustic impacts, wildlife impacts, social factors, geotechnical factors and accessibility. Software packages are available for wind farm design such as WindFarmer, WAsP and windPRO. Geographical information systems (GIS) are also important to ensure that regulations and best practices are followed in terms of setbacks from existing infrastructure, recreational areas, and dwellings.

The most accurate way to determine how the wind resource varies across a site is by measuring the wind with meteorological masts for several years before the farm is built. At sites where a large wind farm is planned, multiple masts are typically erected, spread across the area at locations representative of future turbine locations. However, masts are relatively expensive. It's not economically feasible to measure the wind at every location under consideration for a turbine.

Consider a hypothetical green field site where a developer is planning to build a 200 MW wind farm. They measured the wind for 2 years at three 80 m tall met masts. From these measurements they know the wind resource at three points. Computational fluid dynamics (CFD) simulations would then be used to model the resource across the area, based on the known resource at the three points. CFD is also used to model turbine wake effects. A range of models is used, depending on what's required, from zero equation models to the k-ε turbulence model to large eddy simulation. Topographical data and maps of local vegetation are key inputs into these CFD models.

Which pieces of data are the most important inputs for your analyses, and is there a need for improved data quality or quantity to enhance the utility of these models?

The turbine SCADA system is usually our software's most important data source, although it depends on the purpose of the analysis in question. Our software can carry out over 50 standard wind farm or solar plant analytics, so it really varies. In some cases, the meteorological measurements or power meter measurements from the point of interconnection are most important.

Data quality is a hot topic. We've made a lot of progress in this area by developing reliable data cleaning algorithms. For example, when I started in technical consulting in the wind industry in 2010, I spent many months manually cleaning meteorological data. At Clir we've developed software functionality to automatically and reliably clean data from meteorological masts. Still, data quality can be a limiting factor in some applications. As another example, the data feed from a wind turbine does not always indicate all the information we'd like. Is the turbine offline due to a forced outage or planned maintenance? The SCADA data may indicate something generic like 'Manual Stop'. We've developed ways to automatically label the data but we're also continuously working on making our algorithms better at this. Users of our software can manually categorize and label data, but the more automated this data labeling is, the better, due to the large quantity of new data being regularly processed by our system.

We have an enormous quantity of operational wind farm data, with over 10 GW on our system spanning several years, but we always want more. One application is renewable plant performance benchmarking, which is of major interest to many wind and solar farm owners. Project owners want to know things like "How does my wind farm availability compare to other wind farms with the same turbine type?" The more data we have, the better we can categorize while maintaining a sufficient sample size. Continuing that example, in cases where we have a lot of data, we can benchmark not just by turbine type but by the combination of turbine type and region, which increases the relevance and applicability of the benchmarking results.

Many people are concerned that increasing renewable energy penetration will lead to grid instabilities due to their intermittency, what are your thoughts in this area? Should energy storage be included in the cost of renewable energy?

When I worked in technical consulting we had a Power Markets and Transmission Analysis team. They were very interesting to speak to and this would be a great question for them. I'll answer based on what I've learned over the years.

Power output from wind farms and solar plants is variable. In most markets, if a wind farm is able to produce power but the power is not needed on the grid, then the wind farm will be curtailed, i.e., the wind turbines are intentionally set to not produce power. This supports grid stability. Curtailment occurs when the market price for electricity is too low to support plant operation. Usually, wind farm owners take on the risk of curtailment and are only paid for the electricity actually delivered by the farm when it's needed. Depending on the region and the vintage of the power purchase agreement, wind farm owners may receive some compensation for curtailment. One of the advantages of wind compared to other fuel sources is the ability of wind turbines to quickly ramp power output up and down as needed, with no requirements for long plant cool down or restart periods.

Like wind farm power output, grid power demand is also variable, as is the price of electricity. Further, the market price (and value) of electricity varies depending on where it is on the grid. There are software tools (for example, PROMOD) that model nodal locational marginal prices (LMP) across the grid on a time series basis. This software can be used to estimate how much power from a prospective wind farm will be needed on the grid over time, considering factors such as the transmission capacity where the farm is located. Through this and other tools, the economic impact of a future wind farm on the grid can be quantified based on the farm's characteristics including the specific location.

Your question mentions energy storage. A reliable electricity supply is essential. From my understanding, the cost of energy storage should not be included in the cost of energy from any specific renewable energy facility. Demand and supply are balanced at the system level. It is not necessary to co-develop or co-locate a storage facility with a renewable plant, although the economics may be advantageous depending on the details. It's certainly important to take the variability of renewable power into account when planning the future of the electricity system. If at some point in time it's determined that the grid would benefit from energy storage, then the grid operator, such as Ontario's Independent Electricity System Operator (IESO), can procure storage capacity using a competitive bidding process, as occurred in 2014 in Ontario and occurs regularly now in other markets. Many renewable energy suppliers would be interested in bidding in an energy storage procurement.

Energy arbitrage (purchasing power when market prices are low and selling it when market prices are high) is one role for energy storage facilities, as suggested by your question, but there are other important roles such as frequency response, spinning reserve and voltage support. These services and potential sources of revenue should be considered when evaluating the economic feasibility of an energy storage facility as it's unlikely an energy storage facility would be built for arbitrage alone in current power markets.

Beyond storage, there are various other ways of adapting the grid to increased levels of variable renewable generation including buildout of transmission capacity, demand response, time of use pricing, better siting of renewable power plants, and having a healthy mix of power sources. Another practice that's becoming more common is overbuilding a renewable plant to increase its capacity factor. For example, if a solar plant has a grid export capacity of 100 MW, the plant can be built with 130 MW AC inverter capacity. The plant's overall capacity factor (utilization) will be higher than if it had 100 MW of AC inverter capacity, although some energy will be lost during peak sun hours. Similarly, it would be trivial to design a wind farm with a capacity factor of 90%, but the cost of energy would be higher than that supported by the current market. As the grid and the market evolve, and renewable energy penetration increases, turbine and plant design will adapt towards increasingly economical solutions.

Data analytics and artificial intelligence have received a lot of attention in recent years, however neural network theory has existed for many decades, what improvements have led to the increased utility of data analytics?

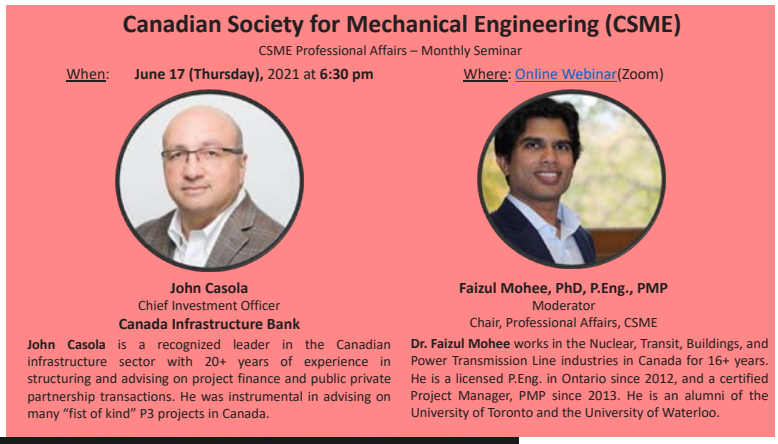
The use of data analytics is growing for a variety of reasons. Many organizations and teams want to be more data driven. When done correctly, analytics can lead to better decisions, providing real and genuine value to a business. For mechanical engineers, increased numbers of sensors, computing power and communication technology make it easier to make measurements, store the data, and then use it for an application. Cloud computing has become much more accessible, facilitating the software as a service business model. Companies like ours can use these new approaches and technologies, combined with machine learning, to provide significant value to industry.

Data analytics and artificial intelligence are becoming increasingly important in many field of engineering; are current University graduates adequately prepared to develop and use these tools, or is greater emphasis required?

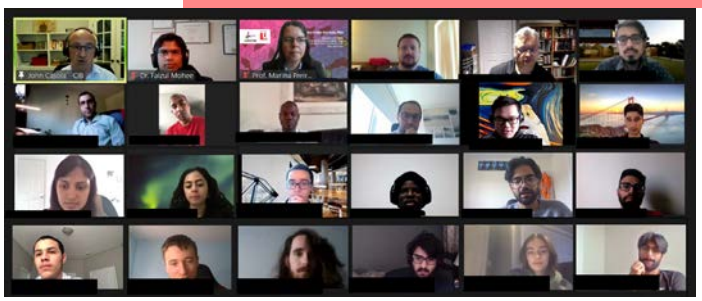
I believe engineering students and many industries would benefit from more options related to programming, analytics, and data science. I could see a university program focused on mechanical engineering and big data being very popular and relevant, especially for industries with large machinery and ubiquitous sensor data. That said, these topics are fairly accessible and much can be learned outside formal education.

To use myself as an example, I've always been very interested in computers and software. When I was young my family had a Commodore 64. I learned to write BASIC programs from a book and continued programming in my own time ever since. I almost went to university for software engineering, but I decided to study mechanical engineering instead, largely because I'm keen on science, physics and machines. As a mechanical engineering student, I took a handful of courses relevant to data science and programming, but they weren't a major focus for me at the time. Much of what I've learned on these topics has been from working with others, self taught or from online sources. These skills have proven extremely useful throughout my career.

CSME STUDENT & PROFESSIONAL AFFAIRS REPORT



POSTER FOR THE CSME WEBINAR ON JUNE 17, 2021



JOHN CASOLA, FAIZUL MOHEE, MARINA FREIRE-GORMALY, AND ATTENDEES AT THE CSME WEBINAR ON JUNE 17TH, 2021

THE CSME STUDENT & PROFESSIONAL AFFAIRS committees facilitate the CSME Student Chapters and new Professional Chapters to organize events, networking and outreach activities. During the past few months, the committee ran a webinar open to all CSME members. We are looking forward to future events that the CSME chapters will host over the next few months, especially as the pandemic wanes!

Dr. Faizul Mohee led the organization and moderation of a joint CSME Professional Affairs and CSME Student Affairs webinar on June 17th, 2021. The keynote lecture was presented by **John Casola**, Chief Investment Officer of the Canada Infrastructure Bank. A total of 21 CSME members participated from across Canada, including Toronto, Waterloo, Windsor, Mississauga, Prince Edward Island, and international attendees from the Philippines.

Attendees learned about the Canada Infrastructure Bank's mission and vision to deliver new infrastructure projects that are revenue-generating and in the public interest across Canada. Mr. Casola provided an overview of several exciting past projects ranging from Public Transportation to Clean Power. He emphasized the Canada Infrastructure Bank's goals to invest in several theme areas including Green Infrastructure, clean power, transportation and broadband.

The attendees were very engaged and there was a lively discussion and Q&A session after the talks. The CSME Student & Professional Affairs committee is looking forward to hosting monthly webinars over the next year to facilitate member learning, collaboration and networking.

Please join as a CSME member, it is FREE for students (csme-scgm.ca/application). The Engineering Careers site (www.engineeringcareers.ca) also provides an opportunity for you to plan for your career. We are also looking forward to facilitating CSME students to learn about the Mechanical Engineering industry in Canada and network with industry professionals.

Thank you to all the professional chapter executives, student chapter executives, volunteers and faculty mentors for your hard work! We are looking forward to featuring your upcoming events at your CSME chapters.

If you are interested in leading and founding a CSME Student Chapter at your campus or a Professional Chapter in your community, let us know. Contact us at the CSME, we will walk you through the process. We are also looking to expand the CSME Student Affairs Committee and the CSME Professional Affairs Committee. If you are interested in helping lead activities locally or at the national level, please reach out!

Do you have a great idea, story or proposal? Feel free to share your ideas with us!

DR. MARINA FREIRE-GORMALY, PhD, EIT, LEED GA
Chair of CSME Student Affairs

Marina is an Assistant Professor at York University in the Department of Mechanical Engineering. She completed her PhD at the University of Toronto in the Department of Mechanical and Industrial Engineering. Marina's research team is investigating how COVID-19 transmits in air, and how to make energy and water systems more reliable and sustainable. Her research and teaching spans energy systems, nuclear, computational modelling, materials, biomedical devices and sustainability.

DR. FAIZUL M. MOHEE, PhD, P.Eng., PMP, MCSME
Chair of CSME Professional Affairs

Faizul is the Director of Research at TMBN Extrados Inc. in Toronto. Faizul teaches at the Royal Military College (RMC) as an Assistant Professor. He completed his PhD at the University of Waterloo on mechanical anchors for composite materials. He also did a master's at the University of Toronto. He has taught a Machine Learning, Artificial Intelligence and Big Data for Manufacturing course at York University. He also taught the Materials Science course at the University of Toronto in the Department of Mechanical and Industrial Engineering. He previously worked at Hatch, WSP and projects for OPG, Bruce Power, Terrestrial Energy, Baffinland, Stornoway, SaskPower and Emera. Faizul works in research and development for the energy, mining and nuclear industries. Faizul is currently is conducting research on COVID-19 transmits in air and HVAC systems. Faizul is passionate about research, teaching and student engagement to build smart and sustainable infrastructure that is resilient and adaptive to climate change.

The Canadian Society for Mechanical Engineering
A constituent society of the Engineering Institute of Canada

La Société Canadienne de génie mécanique
Une société constituante de l'Institut canadien des ingénieurs

NEWS COMMUNIQUÉ

Office of the President — October 2021

The Canadian Society for Mechanical Engineering (CSME), founded in 1970, is pleased to announce the winning recipients of its 2022 technical awards. These awards may be bestowed biannually to members of the society for their outstanding contributions to specific areas of mechanical engineering in Canada.

The following three exceptional engineers will be presented with their medals on 7 June 2022 at the 2022 CSME International Congress to be held from 5-8 June at the Faculty of Engineering, University of Alberta, Edmonton, AB. Each winner will also be presenting a plenary lecture at the Congress.

Please consider attending the 2022 CSME International Congress to congratulate these exceptional winners and attend their lectures: www.csmecongress.org.

Fluid Mechanics Medal
For "exceptional research contributions to the field of fluid mechanics in jet pipes and turbines"

Xiaohua Wu, PhD, MCSME
Professor, MAE Department, Royal Military College of Canada, Kingston, ON

Manufacturing Medal
For "exceptional research and innovation contributions to the field of plastic foam manufacturing"

Chul Park, PhD, FCSME
Distinguished Professor, MIE Department, University of Toronto, ON

Solid Mechanics Medal
For "exceptional research and innovation contributions to the field of nanomechanics"

Tobin Filleter, PhD, MCSME
Professor and Associate Chair of Graduate Studies, MIE Department, University of Toronto, ON

CSME Call for Awards

Nominations by Fellows of the CSME are currently solicited for 2022 Regular Awards of the Canadian Society for Mechanical Engineering (CSME). These aim to recognize deserving mechanical engineering professionals who are members of the CSME. Final decisions regarding award winners are made by CSME's Awards Committee. Please nominate your peers for the 2022 regular awards before **Jan 31, 2022**. Details are available here: csme-scgm.ca/awards

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Dr. Xiaohua Wu

Dr. Xiaohua Wu is a Professor in the Mechanical and Aerospace Engineering Department of the Royal Military College of Canada, and has adjunct appointments at McMaster University, Queen's University and the University of Waterloo. He is a Fellow of the American Physical Society and Associate Fellow of the American Institute of Aeronautics and Astronautics. Dr. Wu was the Tier-2 Canada Research Chair in Aeronautical Fluid Mechanics from 2007 to 2017, and received the Cowan Prize for Research Excellence from the Royal Military College in 2014.

Dr. Wu is known internationally for his pioneering direct numerical simulations of turbine cascade flow, spatially-developing boundary layer and pipe flow. His discovery of turbulent-turbulent spots proved the half-century-old hypothesis of turbulent spots being a basic module of the fully-turbulent boundary layer. Dr. Wu contributed decisively to a high-impact inflow turbulence generation method that is being used world-wide.

Dr. Chul Park

Professor Chul Park, Distinguished Mechanical Engineering Professor at the University of Toronto, is a world leader in the field of plastic foam manufacturing. Based on his research findings, a number of industrially viable foam manufacturing technologies have been developed to improve plastics products and reduce manufacturing costs significantly. Moreover, his research has allowed for ozone-depleting blowing agents to be replaced with inert gases. He has successfully transferred knowledge and technology to both domestic and international industries in manufacturing.

Dr. Park has received numerous honors and awards: 2010 NSERC Strategic Network Grant ($5M), 2010 Julian C Smith Award from the Engineering Institute of Canada, 2012 C.N. Downing Award from the Canadian Society for Mechanical Engineering, and ASME's 2012 M. Eugene Merchant Manufacturing Medal. He is a Fellow of the CSME, the Royal Society of Canada, the American Association for the Advancement of Science, and the Korean Academy of Science of Technology.

Dr. Tobin Filleter

Dr. Tobin Filleter, Professor and Associate Chair of Graduate Studies, MIE Department, University of Toronto, is a world leading expert in solid mechanics, specifically in nanomechanics. He has published in several high impact journals including Nature, Nature Materials, Science Advances, Nature Communications, ACS Nano, and Advanced Materials. Professor Filleter's research has unveiled several novel nanoscale mechanical phenomena including the ultralow friction and ultrahigh fatigue lifetime of graphene, which have proved of critical importance for the application of 2D materials within mechanical engineering application areas in aerospace, automotive and electronics industries. Professor Filleter has also made major contributions to the continued development, and application, of Atomic Force Microscopy-based testing methodologies. These developments have enabled cutting edge mechanistic understand of the solid mechanics of nanostructures and nanostructured materials. Professor Filleter has a strong record of industry collaboration in the areas of aerospace and non-destructive testing.

synthesized and processed enabling good reproducibility and producing nanostructured feedstock on the principle of transferring deformation energy into processed material.

When integrated with fluidized bed reactor (FBR) technology, the standard CVD method (or the FBCVD) has proven to be an effective route to coat/spheroidize individual particles' outer surfaces while functionalizing their surface characteristics, e.g., thermal conductivity, optical refractive index, Bragg index and Bragg index.

The HPCS is used to deposit the functionalized feedstock particles on a substrate. Particles are deposited at a pressure of up to 50 bar (725 psi), with axial injection of feedstock heated up to a temperature of 1100°C in the spray gun housing. The high kinetic energy of the particles and the high degree of deformation during the impact on the substrate allows for the manufacturing of homogeneous and very dense coating, as well as rapid 3D additive manufacturing of components that will lead to fabrication of low residual-stress high-impact fatigue/erosion-resistant components that are not only technologically advanced, but also commercially viable value-added products.

THE BENEFITS

In one specific example, the lab is applying this manufacturing methodology to improve the durability of a rotary engine blade (see *Fig. 2*) that might be damaged due to sand erosion caused by engine runway debris, dust, sand, volcanic ash, calcium magnesium aluminosilicate (CMAS), and other environmental factors. A problem of this nature involving high temperature material degradation at a microstructural level requires a multimaterial design approach. We were able to develop a custom-designed nanostructured alumina-aluminum cermet composite in the revolutionary HPCS process (see *Fig. 3*). As a result, the blade erosion resistance under solid particle dry impingement has been improved by 32%, and the work is ongoing.

THE SUSTAINABILITY AND EDI GO HAND-IN-HAND

As part of UNB's mission, the NCM Lab is poised to create a future where the value of novelty is measured against its creators' diversity and inclusivity (see Figure 4). We are fortunate to work with a team that is as diverse as our country is. With the support of our research/innovation stakeholders this achievement will be kept at its core!

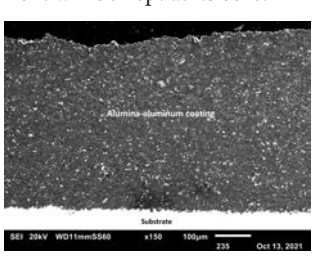

FIG. 3 ALUMINA-ALUMINUM CERMET COATING

TECHNICAL COMMITTEE REPORTS

Advanced Energy Systems

The main activities of the CSME Advanced Energy Systems (AES) Technical Committee over the past 6 months include:

- Supported the CSME International Congress 2021 held at UPEI, by promoting the conference and organizing the Symposium on Advanced Energy Systems.
- Supported the CSME *Transactions* published through the Canadian Science Publishing (CSP) by handling the review of submissions in the field of energy systems.
- Established the CSME Heat Transfer and Energy Systems Seminar Series jointly with the Heat Transfer Technical Committee and successfully organized two seminars in June and October with invited speakers Dr. Kripa Varanasi and Dr. Xiaotao Bi, respectively.

– Dr. Xili Duan

Engineering Design and Analysis

- Associate Editor of the CSME *Transaction*
- Chair/Organized: Advanced Design and Analysis of Multifunctional Materials and Structures - the CSME Congress 2021 (UPEI)
- Organizing a symposium in Design at the CSME Congress 2021 (University of Alberta)
- Member of CNC-IUTAM and representing it at the 2022 IUTAM General Assembly

– Dr. Kamran Behdinan

Fluid Mechanics Engineering

- 2021 CSME Congress: Successfully co-organized the Fluid Mechanics Symposium
- TC Meetings: Held a meeting at the 2021 Congress as planned
- 2022 CSME Congress: Accepted the invitation from the Organizing Committee to co-organize the Fluid Mechanics Symposium

– Dr. Martin Agelin-Chaab

History Committee

The CSME History committee started its mandate in August 2020. The membership includes:

- Professor Farid Golnaraghi, Simon Fraser University (Chair)
- Professor Mélanie Frappier, University of King's College
- Professor Nicholas Krouglicof, University of Prince Edward Island
- Mr. Bruce Fingarson, Automation West Technologies
- Professor Wendy Gentleman, Dalhousie University

Our first key initiative is to assist the Engineering Institute of Canada in preserving engineering achievements through oral history interviews of senior mechanical engineers. Our second major initiative consists of the publication of a series of articles in the CSME *Bulletin*.

Since my last report, the committee has solicited and reviewed two one-page articles for the CSME *Bulletin* publications. The following two articles will be submitted to the *Bulletin*, after revisions, in late April for its June edition.

1. In memory of the late professor Douglas Ruth, from the University of Manitoba. Doug was an instrumental member of Engineers Canada and the CEAB.
2. In memory of the late Martha Salcudean, former Head of Mechanical Engineering at UBC.

The committee also provided seven names for the EIC interviews.

Future plans: the committee has solicited two articles for the CSME *Bulletin*. The following two articles will be submitted to the *Bulletin* in late October for its Fall edition.

Also, we are planning to write two articles for the *Bulletin*:

1. History of Mechatronics in Canada
2. History of EDI in Mechanical Engineering – Canada

– Dr. Farid Golnaraghi

Heat Transfer

- The HTTC continues to support the Transactions of the Canadian Society for Mechanical Engineering.
- HTTC started working with the organization committee of the CSME 2022 to organize the heat transfer symposium.
- HTTC and the Advanced Energy Systems Committee jointly initiated the CSME Heat Transfer and Energy Systems Seminar Series. The first seminar was given in June by Prof. Kripa Varanasi from MIT, and the second seminar was given in October by Prof. Xiaotao Bi from UBC. We have received very positive and supportive feedback about the two seminars.

– Dr. Sunny Li

Microtechnology and Nanotechnology

This year, I recruited two more members for TC, Dr. Derek Roswnweig from McGill University and Houman Savoji from the University of Montreal. Both new members have expertise in advanced manufacturing and 3D printing. I also co-organized a symposium at the 2021 CSME Congress. This year, we had 9 abstracts and one keynote speaker for the event. Recently, I proposed the idea of a journal club specific to this TC to showcase the members' activities in the field of Micro- and nanotechnology and stimulate collaborations among the researchers. The target audience for this event will be graduate and undergraduate students, postdoctoral trainees, principal investigators, and members of the industry. In terms of speakers, priority will be given to the members of the technical committee and their trainees. However, we will accept nominations from outside of the committee as well. The initial plan is to run this program virtually (using Zoom or other platforms) on the last Friday of each month starting from January 2022. The proposal received strong support from the members of the TC and 9 speakers already accepted to give a talk at this event. *– Dr. Mohsen Akbari*

Transportation Systems

- CSME 2021 Congress: Chaired the Symposium of Transportation Systems for orally presented papers on-line.
- CSME 2022 Congress: Discussed with the local organizing committee regarding the organizers for the Symposium of Transportation Systems; discussed with the key members of the committee about the call for papers for the upcoming symposium.
- TCSME: An associate editor

– Dr. Yuping He

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