iiw2021
ON-LINE ASSEMBLY AND INTERNATIONAL CONFERENCE
JULY 7/21

2021 IIW INTERNATIONAL CONFERENCE

ARTIFICIAL INTELLIGENCE TO INNOVATE WELDING AND JOINING

THURSDAY 8th JULY 2021

13:00-17:00 CEST

INTRODUCTION

Dear Participants of the 74th IIW Annual Assembly International Conference,
Distinguished Guests, Colleagues and Friends,

Honoured to actively chair both the IIW Technical Management Board and its Conference Organising Committee (COC), I shall humble address a few but warm welcoming words to you, the esteemed participants of this first On-line IIW International Conference 2021.

Welding to me personally concisely relates to *intelligence*. Wherever deploying this 'special' manufacturing process I dare asking, who else than the countless experts around the world should better understand this brief statement? Finally, it is they, or, even more precisely *you*, employing your intelligence on a day-to-day basis to make welding and its allied processes yield predictable and thus, reliable results.

The current situation, also causing IIW to arrange for an on-line in-lieu of a face-to-face International Conference, clearly revealed the importance of advanced digitisation. As the members of the COC initially met to discuss and decide on the theme of this IIW International Conference, it actually was 'just' logic to add the variables, finally to derive what obviously belongs together anyway: '*Artificial Intelligence to innovate welding and joining*'. The achievements made in this complementary field are literally breath taking to anyone, passionate about welding and joining. Whom else thus than the IIW, the leading global association concerned with welding and allied technologies, should have been more accredited to take the lead, to reveal insight into this novel and inspiring field?

Consequently, it is my real pleasure to report that we could gain some of the most remarkable individuals and outstanding researchers in this area generously to follow our invitation. Presenting their latest results will take us on a fascinating journey, leading us through different fields of artificial intelligence applied to Machine learning strategies, Non Destructive Examination, Materials and microstructure, Fitness for purpose, and last but very not the least, Production and manufacturing.

I greatly look forward to the corresponding presentations as I especially look forward also to the panel discussion, allowing us to be enlightened by the invited experts. No question though at all, as much as I am excited to listen to the speakers, I am thrilled to warmly welcome all of you to join in for this premiere On-line IIW International Conference 2021. Please enjoy this event, as I personally and my fellow COC members will enjoy to virtually meeting and speaking with you.

All that being said, I am sure that this 74th IIW Annual Assembly International Conference will become as distinguished as you and the invited speakers openly sharing their wisdom with us.

On behalf of the members of the IIW Conference Organising Committee,
Dr Stephan Alfred Egerland (Chairman)

PROGRAM OF THE IIW INTERNATIONAL CONFERENCE

Introduction of the Conference
Dr Stephan Egerland, *Chair of the Technical Management Board of the IIW*

KEYNOTE SPEECH

Theory-Guided Machine Learning - Towards a Synergy between Knowledge and Data
Bernhard Geiger, *Know-Center GmbH, Austria*

INVITED LECTURES

Artificial Intelligence to enhance the NDT of welding: recent study cases
Slah Yaacoubi, *Institute de Soudure, France*

Materials Integration, In-silico linking from process through structure to property and performance
Masahiko Demura, *National Institute for Materials Science, Japan*

Development of Automation and Artificial Intelligence Technology for Welding and Inspection Process in Aircraft
Kawasaki Heavy Industries, Ltd., *Japan*

Adaptive Intelligent Welding Manufacturing – Classical Sensing/Modeling/Control and Modern Machine Learning and Human-Robot Collaborative Approaches Industry
YuMing Zhang, *Institute for Sustainable Manufacturing and Department of Electrical and Computer Engineering, USA*

Three Types of Machine Learning for Fitness for Service Applications
Alex Kitt, *EWI, USA*

THE PROGRAM IN DETAIL

KEYNOTE SPEECH

Theory-Guided Machine Learning - Towards a Synergy between Knowledge and Data

Most engineering domains abound with models that are derived from first principles and that have proven to be effective for decades. These models are not only a valuable source of knowledge, but they also form the basis of simulations using, e.g., the finite-element method. The recent trend of digitization has complemented these models by data in all forms and variants, such as process monitoring time series, measured material characteristics, and stored production parameters. Theory-guided machine learning combines the available models and data, reaping the benefits of both established knowledge and the capabilities of modern, data-driven approaches. The resulting models often are often more accurate, less complex, or allow faster model training or inference. In this talk, we introduce the most prominent approaches to theory-guided machine learning and discuss some of their applications.

Dr Bernhard C. Geiger

Bernhard C. Geiger received the Dipl.-Ing. degree in electrical engineering (with distinction) and the Dr. techn. degree in electrical and information engineering (with distinction) from Graz University of Technology, Austria, in 2009 and 2014. He was a Senior Scientist and Erwin Schrödinger Fellow at the Institute for Communications Engineering, Technical University of Munich (2014-2017) and at the Signal Processing and Speech Communication Laboratory, Graz University of Technology (2017-2018), respectively. He is currently a Senior Researcher at Know-Center GmbH, Graz, Austria, where he also leads the Machine Learning Group within the Knowledge Discovery Area. Dr. Geiger's research interests cover information theory for machine learning, theory-assisted machine learning, and information-theoretic model reduction for Markov chains and hidden Markov models. He is a Senior Member of the IEEE.

INVITED LECTURE

Artificial Intelligence to enhance the NDT of welding: recent study cases

In the field of welding, non-destructive testing (NDT) is essential to guarantee the compliance of welds. NDT can be on-line (during the welding, said also process Monitoring) and off-line (once the weld in achieved). Sometimes making-decision based on NDT results is not straightforward, and recourse to artificial intelligence-based tools becomes somewhat necessary. This allows wining time and costs, pushing the limits of NDT and/or making easier the analyses and so reducing the false alarms rate.

Though the interest on AI is use in the frame of Industry 4.0, it remains complex, and requires interdisciplinary skills that goes from data collection and (multi-) sensoring selection/design to alarms management through models, algorithms, and even tailored hardware. Innovation in machine learning (deep learning, transfer learning, multitasks learning, etc.) as well as Expert Systems (if there are experts in various fields) and MSDF (multi-sensors data fusion) . Virtual, augmented, and/or hybrid realties are also seeded in some problems.

The conference will start by providing a brief summary of technical background (mathematical modelling and algorithms, etc.) that are required to build IA models. Various industrial examples perfomed the frame of European and international projects (EIT Digital, Clean Sky, World AutoSteel, etc.), which developed that provide an added-value to the current state-of-the-art in manufacturing as well as in-service defects detection: hook cracks, corrosion, micro-damages, etc. will be presented.

Dr Slah Yaacoubi

He obtained a PhD in guided waves in which he gained a background in mathematical modelling and algorithms that is necessary for developing AI approaches. He then started working, in the industrial field, on problems that requires multidisciplinary skills. Among the developed products by his team: smart composite vessel (TRL 6/7, won a technology innovation award), TAW The augmented welder™, iTRack (TRL 7) for the health monitoring of rails. In the frame of European and international projects (EIT Digital, Clean Sky, World AutoSteel, etc.), many AI based solutions were developed that provide an added-value to the current state-of-the-art in manufacturing as well as in-service defects detection: hook cracks, corrosion, micro-damages such as HTHA, etc. He co-supervised 3 PhD thesis dealing with AI (ultrasonic guided waves diagnosis based and machine learning, development of a smart system for predictive maintenance using data mining, and automatic diagnosis of welds using ultrasonic phased array data). He is member of the “Intelligence artificielle et CND” working group of COFREND (the French certification body for NDT personnel). He published more than 50 papers in this field; some of them are in international journals. He holds one patent and some others in progress.

INVITED LECTURE

Materials Integration, In-silico linking from process through structure to property and performance

Process, structure, property, and performance are the key elements in materials science and engineering. Materials Integration is a concept to computationally link among the four elements, using any kinds of methods including experiments, theories, empirical rules, databases, and numerical simulations. According to the concept, we have developed a web-based platform called MInt system, on which each link is implemented as a module and a combination of several modules is called a workflow. For example, we have built a workflow to predict the creep rupture time of weld joint from the process conditions, consisting of the four modules such as welding modules, microstructure module, creep property module, and creep damage analysis module. Once the workflow is established, MInt system can execute each module according to it automatically. Furthermore, this automated system can be used to optimize the welding condition in order to maximize the creep rupture time by combining with artificial intelligent (AI) approaches. In this talk, I will introduce the MInt system developed under a national project and detail the AI approaches in Materials Integration.

Dr Masahiko Demura

Dr Masahiko Demura is at present the Director the Research and Services Division of Materials Data and Integrated System (MaDIS) at National Institute for Materials Science (NIMS). His main field of operation is currently "Data-driven Materials Science and Engineering", with a particular focus on Structural Materials.

INVITED LECTURE

Development of Automation and Artificial Intelligence Technology for Welding and Inspection Process in Aircraft Industry

Kawasaki Heavy Industries, Ltd. has established the Kawasaki Production System (KPS) as the basic concept for its innovative manufacturing activities. Particularly in the aircraft industry (airframe and engines), which is positioned as a knowledge-intensive industry, the company is making progress in building a Digital Smart Factory (a smart factory that utilizes a variety of digitalized information infrastructure) through advanced automation and internal and external high-speed networking based on the basic concept of KPS. In this presentation, I will first give a brief overview of KPS. Then, based on this KPS concept, I will describe the intelligent manufacturing system developed by our project team through the development of automation and AI technologies for welding and inspection processes for aero engine parts.
In the process of establishing new welding conditions for the aero engine parts to be TIG welded, we have digitized welding operations, welded part conditions, and welding equipment conditions to standardize and quantify Man, Material, and Machine and to understand production conditions on a time axis. We have created AI program that enables the robot to always perform welding under optimal conditions through statistical machine learning of standardized Man, Material and Machine data. As a result, we established the robot welding system and automated the skilled welding operator technique.
In the process of establishing inspection program for the welded aero engine parts, the camera image of the welded position to be inspected is digitized, and the color tone emphasis is corrected according to the assumed form of surface defects, and special conversion processing is performed on the captured data to improve the data accuracy. Specifically, a calculation process is applied to fit the information of invisible areas. We developed and applied a technology that uses a machine learning method based on a multilayer neural network, the so-called deep learning method, which is currently attracting the most attention among machine learning methods, to judge whether the obtained and conversed image data is pass or fail. As a result, we established the automatic imaging and judgment system and automated the skilled inspection operator technique.
Finally, the stage of the technological strategy and the future Automation and AI technologies for the welding and inspection process of the Digital Smart Factory in the aircraft industry will be summarized.

Dr Ryoichi Tsuzuki
Kawasaki Heavy Industries, Ltd. Aerospace Systems CompanyEngine Manufacturing Group, Japan

INVITED LECTURE

Adaptive Intelligent Welding Manufacturing – Classical Sensing/Modeling/Control and Modern Machine Learning and Human-Robot Collaborative Approaches

This talk analyzes and identifies the challenges in adaptive robotic welding, reviews efforts devoted to solve these challenges, analyzes the principles and natures of the methods behind these efforts, and introduces modern approaches, including machine learning/deep learning, learning from human and human-robot collaboration, to solve these challenges.

Dr YuMing Zhang
Institute for Sustainable Manufacturing and Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40506, USA

INVITED LECTURE

Three Types of Machine Learning for Fitness for Service Applications

Trust is data. Machine learning and artificial intelligence (ML/AI) doesn't change this paradigm, it simply provides tools that can allow more trust with less data. This talk highlights three types of ML/AI that contribute to fitness for service. In the first, process monitoring and ML classification algorithms are used predict whether ultrasonically welded battery tabs have sufficient pull strength. In the second, a Bayesian Network is used to causally relate build parameters and post-process surface finishing to fatigue life of additive manufactured components. In the third use-case we discuss how image recognition can be used to classify NDT data from in-service components. We conclude with how these three use cases can be combined for fitness for service applications.

Dr Alex Kitt
Dr Alex Kitt has ten years of experience performing, leading, and identifying needs for industry-relevant research and development. Over that time, Alex's work has included data science, metal additive manufacturing, X-ray CT and optical metrology, augmented reality, and graphene. Alex was a member of the Buffalo Manufacturing Works start up team, created the EWI metrology and inspection team, initiated EWI's involvement in the ASTM AM CoE, and most recently, is working to leverage EWI process expertise in data science approaches. Alex is the sub-committee chair for ASTM F42.08 on AM data. Before joining EWI, Alex worked as a post-doc at the University of Rochester Insitute of Optics. Alex has a BS in Physics and a BA in mathematics from the University at Buffalo. He received a PhD in physics from Boston University, where he demonstrated proof of concept for graphene-based threshold pressure sensors for remote oil well application