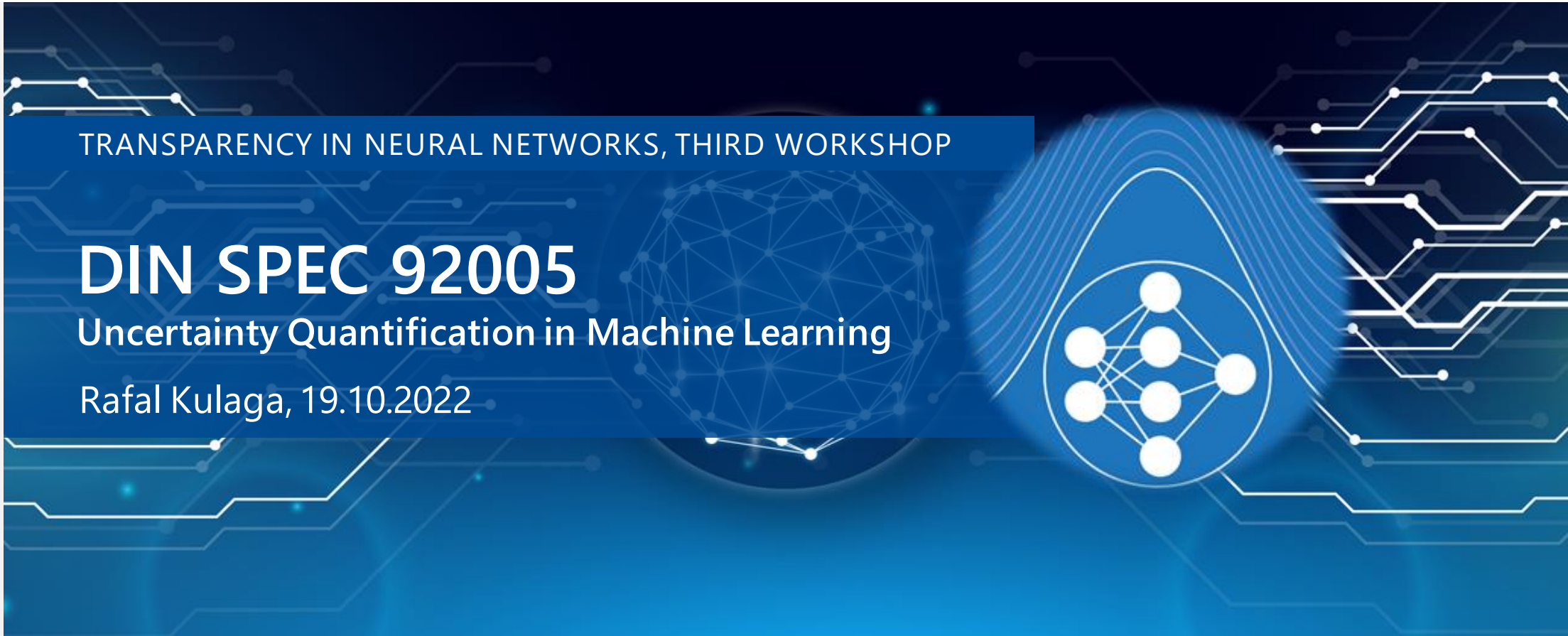
IABG



TRANSPARENCY IN NEURAL NETWORKS, THIRD WORKSHOP

DIN SPEC 92005

Uncertainty Quantification in Machine Learning

Rafal Kulaga, 19.10.2022

Content

Introduction

What is a DIN SPEC?

- "Today's idea. Tomorrow's standard" - DIN SPECs can be used as basis for full standards [1]
- DIN SPECs are developed in a relatively small and agile groups
- DIN SPEC development process is relatively short (usually couple of months)
- DIN orchestrates entire DIN SPEC project
- DIN SPEC process promotes exchange and networking between companies, institutes and research organisations.

Initiators of DIN SPEC 92005:

- IABG
- Fraunhofer IAIS

[1] https://www.din.de/en/innovation-and-research/din-spec-en

Motivation

- Highly relevant for real-world applications of Machine Learning (ML)
- Related to many other Artificial Intelligence (AI) / ML disciplines
  - Robustness
  - Safety
  - Explainability
  - Reinforcement learning
  - Active learning
  - Data fusion
  - …
- Very active research ongoing
- Current AI standardization projects do not cover many uncertainty quantification aspects

Scope

The scope of this DIN SPEC comprises:

- Definition of fundamental terminology for uncertainty quantification in ML considering ISO/IEC 22989 Artificial intelligence concepts and terminology [1]
- Illustration of the purpose, use, and necessity for uncertainty quantification in ML
- Formulation of general guidelines and recommendations for uncertainty quantification in ML
- Provision of an overview of uncertainty quantification methods in ML
- Description of selected applications of uncertainty quantification in ML

[1] ISO/IEC 22989 Information technology - Artificial intelligence - Artificial intelligence concepts and terminology

Terminology

Based on ISO/IEC 22989 Artificial intelligence concepts and terminology [1], clarify terminology related to uncertainty quantification in ML including

- Uncertainty
- Uncertainty types
  - Aleatoric
  - Epistemic
- Confidence (intervals)
- Credible intervals
- Reliability
- Trustworthiness
- Accountability
- Interpretability
- Data shift
- Out-of-distribution
- …

[1] ISO/IEC 22989 Information technology - Artificial intelligence - Artificial intelligence concepts and terminology

Classification & Methods

Various categorization schemes

- (Modelled) Uncertainty types
  - Aleatoric
  - Epistemic
- Uncertainty classification with respect to input data domain [1]
  - In-domain
  - Domain-shift
  - Out of distribution
- Source of uncertainty in ML development pipeline
  - Raw data acquisition
  - ML development and training process
  - Inference
  - Uncertainty quantification itself

Taxonomy of methods

- Example for uncertainty quantification in deep learning [1]
  - Single deterministic methods
    - Internal methods
    - …
  - (Approximate) Bayesian methods
    - Variational inference
      - Monte Carlo dropout [2]
      - …
    - …
  - Ensemble methods
    - …
  - Test-time augmentation methods
    - …
- …

[1] J. Gawlikowski et al., "A survey of uncertainty in deep neural networks,", 2021
[2] Y. Gal and Z. Ghahramani, "Dropout as a Bayesian approximation: Representing model uncertainty in deep learning," Proceedings of the 33rd International Conference on International Conference on Machine Learning - Volume 48, 2016

Guidelines

- Formulation of guidelines that stakeholders should apply while developing and deploying ML systems which quantify uncertainties and utilize them in decision-making.
- Possible aspects:
  - Selection of appropriate uncertainty types to be modelled for a given application
  - Evaluation (assessment of the quality of generated uncertainty measures using ground-truths)
    - Calibration of uncertainty measures
      - Ensuring that the model with uncertainty quantification is neither over- nor under-confident
    - The DIN SPEC will provide an overview of possible metrics for evaluation of uncertainty measures
    - …
  - Guidelines on how to define safety/confidence thresholds
    - Uncertainty thresholds required for an operating/running ML system to decide which predictions are safe/reliable
  - Selection of uncertainty quantification method with respect to:
    - Run time criteria
      - Inference time analysis
      - …
    - Resource criteria
      - Memory consumption analysis
      - …

Applications

- Uncertainty quantification in ML is relevant for many (often safety-critical) applications:
  - Mobility
    - Autonomous/Automated driving
    - Urban air mobility
    - …
  - Robotics
    - Autonomous drones
    - Industrial robots
    - …
  - Medicine
    - Medical image segmentation
    - …
  - Earth observation
    - Fire detection
    - …
  - Natural language processing (NLP)
    - Machine translation
  - …

Join the Consortium!

- DIN SPEC 92005 business plan is now publicly available
  - If you would like to know more (current partners, financing, scope), please visit: [DIN SPEC Business Plan]
- Online Kick-Off meeting is planned for 18.11.2022
- Current time plan of the project:

DIN SPEC-Projekt	2022								2023															
	Sep		Okt		Nov		Dez		Jan		Feb		Mrz		Apr		Mai		Jun		Jul		Aug		Sep	
Initiierung																								
1. Antrag und Prüfung																								
2. Erstellung des Geschäftsplans																								
3. Veröffentlichung des Geschäftsplans																								
Erstellungsphase																								
4. Kick-Off / Konstituierung des Konsortiums																								
5. Erstellung der DIN SPEC																								
6. Verabschiedung DIN SPEC im Konsortium																								
Veröffentlichung																								
7. Prüfung und Freigabe durch DIN																								
8. Veröffentlichung der DIN SPEC																								
Meilensteine						**K**		**W**	**W**		**W**		**W**	**W**		**W**		**W**		**W**	**W**	**W**	**M / V**			

K Kick-Off
M Projektmeeting
W Webkonferenz
V Verabschiedung der DIN SPEC

- If you would like to join the consortium, please contact: Dr. Lukas Höhndorf (hoehndorf@iabg.de) or Lena Krieger (lena.krieger@din.de)

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