


Explanatory Data Science in Technology Applications

J.UCS Special Issue


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Data volumes are growing rapidly due to environmental sensor readings, sensor networks, broadband services, and multimodal communication, whereas pervasive and embedded computing is enhancing the capabilities of everyday objects and easing collaboration among people. Problems with the quality of the data, such as incompleteness, inaccuracy, inconsistency, or falsification, make it difficult to analyze, classify, or make comprehensible, accurate, and reliable decisions.

Another general challenge is the low interpretability of various AI approaches and ML models, for which it is important that data scientists design the models, users understand results, and developers debug and improve the tools. The increasing complexity, limited explainability, and interpretability of the complex ML models make it difficult to address the emerging requirements for acceptance of these models and hinder their applications in industrial and mission-critical scenarios.

Therefore, explainability, interpretability, transparency, and accountability of ML models and systems need to be further developed for an effective use of AI technologies. They are a prerequisite for a reliable application of AI within many problem areas, e.g., natural language processing, risk prediction in healthcare, fault/anomaly detection, computer vision, or classification and regression under uncertainty, which are significant ML tasks.

Researchers and practitioners working on theoretical and practical aspects of data science and reliable machine learning, as well as related and fundamental topics of

information-theoretic approaches for smart systems and computer system organization, were invited to contribute to the J.UCS Special Issue on Explanatory Data Science in Technology Applications. This volume presents a conference paper selection from the 4th Workshop on Collaborative Technologies and Data Science in Smart City Applications (CODASSCA 2024): *Data Science and Reliable Machine Learning*, held in Yerevan, Armenia, October 3–6, 2024, <https://codassca2024.aua.am/>.

The workshop continues the cooperation between the University of Duisburg-Essen (UDE) and the American University of Armenia (AUA) funded by DAAD, DFG, and FAST (Foundation for Armenian Science and Technology). This new edition fosters scientific cooperation organized by professors and staff from the Universities of Chile (UCH, Santiago de Chile), UDE and Tsukuba (Japan) at the AUA with young researchers and students in mind. In two rounds of reviewing, 17 of the papers submitted in the three formats of poster, short paper, and full paper to the EasyChair conference management system were selected by the program committees.

The groups of authors were invited to submit a revised version of their contributions for open access and printed publication under the title *Data Science and Reliable Machine Learning* by Logos Verlag Berlin 2024, 167 pages, ISBN 978-3-8325-5855-0, <https://doi.org/10.30819/5855>.

The papers came from four thematic areas:

- Data Science and Information Theoretic Approaches for Smart Systems
- Challenges for Smart Systems and Computer System Organization
- Human-Centered Computing and Reliable Machine Learning
- Interpretability in Learning Models.

The proceeding editors invited five groups of authors from Armenia, Chile, Germany, and the UK to submit enlarged versions of their CODASSCA 2024 papers for a J.UCS special issue on Explanatory Data Science in Technology Applications edited at Graz University of Technology, Austria.

There was also a J.UCS open call so that any author could submit papers on the highlighted subjects. The invitation to review the 16 contributions received was accepted by 16 experts, and, after three rounds, seven articles were finally accepted for publication in the accordingly adapted thematic areas of the special issue.

Data Science and Reliable Machine Learning

Y. Chen: Using Identification Codes in the Two-Party Privacy-Preserving Record Linkage (PPRL) (DE).

Privacy Preserving Record Linkage (PPRL) addresses the problem of linking records that represent the same individuals across multiple datasets without revealing sensitive personal information. In PPRL, the quality of the linkage is usually evaluated experimentally, and there are no universally recognized privacy-preserving measures that allow for an objective evaluation. The presented code identification approach aims to provide an objective assessment of both linkage quality (by reducing the likelihood of misidentification) and privacy (by limiting the relative information gain) based on parameters of the concretely implemented identification codes.

M. Sharma, R. Sandhane, J. R. Katariya: DAI-TIRS: An AI-Powered Threat Intelligence and Response System for Securing the Metaverse (IND). This paper introduces DAI-TIRS, a holistic security framework designed to secure the metaverse

proactively. The experimental results from a simulated metaverse environment demonstrate that DAI-TIRS achieves 93% accuracy in threat detection, 90% precision in classifying the severity, and 45% better response times than traditional security methods. The source code for the DAI-TIRS framework is available on GitHub: <https://github.com/sharmamohini762/DAI-TIRS-Code>

Human-Centered Computing and Interpretable Machine Learning

C. Gutiérrez-Soto, M. A. Palomino, and P. Galdames: An Efficient Workload-balancing Algorithm for a Parallel Environment Using Hybrid Spatio-temporal Indexes (CL, UK). The authors report on the specification, analysis, and evaluation of an algorithm for workload balancing in distributed concurrent environments with spatio-temporal data. The objective is to optimize the time complexity by using and managing hybrid index structures.

S. Peñafiel, E. Ramirez, N. Baloian, I. Saffie, P. Luz, and I. Paredes: Predicting Pathologic Complete Response to Neoadjuvant Treatment in HER2-positive Breast Cancer using Interpretable Classification (CL, PT). In this paper, the authors apply their approach from previous publications to developing an interpretable machine learning model for predicting HER2-positive breast cancer treatment outcomes. By integrating the Dempster-Shafer theory with the gradient descent method (DSGD), the authors develop a robust classifier that not only accurately estimates the likelihood of a favorable response to treatment but also provides explanations for its decisions, thereby offering valuable insights that inform clinical practice. The authors compare their proposed model with four alternative techniques, highlighting the advantages and limitations of each in terms of performance, accuracy, and interpretability. Furthermore, the study demonstrates how the DSGD model's findings either validate or challenge current medical theories regarding key predictors of pathologic complete response to treatment of HER2-positive breast cancer.

Technical Challenges for Smart Environments and Computer System Organization

L. Buron, A. Erbslöh, and G. Schiele: Reducing Memory and Computational Cost for Deep Neural Network Training with Quantized Parameter Updates (DE). The authors present a training scheme for DNNs that reduces memory requirements while speeding up inference in stochastic gradient descent (SGD) optimizers. They use a fixed-point representation and stochastic rounding during weight updates and inference. The new approach was tested on FashionMNIST with competitive validation accuracy compared to the Straight-Through Estimator (STE), achieving 92% validation accuracy while using only 57% of the memory during training.

Interpretability and Efficiency in Classifiers

A. Adamyan, H. Hovanesyan, D. Radrikan, N. Baloian, and A. Harutyunyan: Interpretable Clustering Using Dempster-Shafer Theory (AM, CL). The article presents a novel interpretable clustering method named DSClustering. This method employs an ensemble approach involving two steps: first, traditional clustering is performed using well-known algorithms such as K-Means and DBSCAN to create pseudo-labels for the data. These labels are subsequently used to train the interpretable classifier, DSGD. This

latter component provides rules along with associated levels of certainty and uncertainty regarding membership in each cluster, delivering interpretability. The model achieves performance comparable to traditional clustering methods while offering the distinct advantage of providing these interpretable results.

A. Tarkhanyan and A. Harutyunyan: DSGD++: Reducing Uncertainty and Training Time in the DSGD Classifier through a Mass Assignment Function Initialization Technique (AM).

The Dempster–Shafer theory (DST) has proven valuable for enhancing model interpretability. However, DST-based algorithms often face efficiency challenges. The authors introduce an improved version of the Dempster-Shafer Gradient Descent (DSGD) algorithm, which incorporates a mass assignment function initialization technique. This approach significantly reduces both training time and the uncertainty associated with individual rules while maintaining classification accuracy comparable to other state-of-the-art methods.

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We are very pleased to be able to draw on a pool of more than two dozen experienced reviewers in connection with the proceedings of the CODASSCA workshops published so far by Logos Verlag and the J.UCS Special Issues, who have once again assisted the authors and editors with their professional, transparent, and comprehensible assessments during the multi-stage review process. We are particularly indebted to Dr. Yanling Chen, Prof. Dr. Nelson Baloian, and Prof. Dr. Ashot Harutyunyan for their invaluable help during the preparation of this special issue.

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