SI: methodologies for intelligent systems

Gerhard Leitner¹ · Martin Stettinger²

Accepted: 25 November 2021 /

Published online: 7 December 2021

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1 Introduction

This special issue entitled *Methodologies for Intelligent Systems* is a collection of 10 invited papers that represent extended and improved versions of outstanding work presented at the 25th International Symposium on Methods for Intelligent Systems (ISMIS), an international forum for the exchange of scientific, research and technological achievements in building intelligent systems.

Submitted manuscripts underwent thorough single-blind review and revision until they were finally submitted and accepted for publication. The resulting collection of papers represents a broad spectrum of topics ranging from algorithmic foundations over advanced theoretical concepts, to strongly application-oriented approaches. It is fascinating to observe in which variety those representations of Intelligent Systems are applied in different scientific and economic fields. Concretely, the papers address saliency detection problems in hyperspectral image datasets, problems related to k-means clustering, conflict detection in the context of constraint solving, machine learning techniques in constraint solving, the application of neural networks for sentiment analysis, for solving arithmetic problems and for emotion recognition in music, decision making problems in the context of product design, segmentation of free texts in a medical context, action rules applied in artwork pricing models, and, preference construction in recommender systems considering psychological aspects.

We believe that a special issue on the recent advances in Intelligent Systems is of high relevance for an interested audience, because it contains insights to the latest developments in this important area.

✉ Gerhard Leitner
gerhard.leitner@aau.at

Martin Stettinger
martin.stettinger@ist.tugraz.at

¹ Institute for Informatics Systems, University of Klagenfurt, Universitätsstrasse 65-67, Klagenfurt, 9020, Carinthia, Austria

² Institute for Software Technology, Graz University of Technology, Inffeldgasse 16b, Graz, 8010, Styria, Austria

2 Articles included in the special issue

In their article entitled *Leveraging Colour-based Pseudo-labels to Supervise Saliency Detection in Hyperspectral Image Datasets*, Annalisa Appice, Angelo Cannarile, Antonella Falini, Donato Malerba, Francesca Mazzia and Cristiano Tamborrino address problems related to saliency detection, which mimics natural visual attention mechanisms that identify an imagery region to be salient when it attracts visual attention more than the background. Despite of the fact that hundreds of models have been proposed for saliency detection in colour images, there is still a large room for improving saliency detection performances in hyperspectral imaging analysis. In the study described in the paper, an ensemble learning methodology for saliency detection in hyperspectral imagery datasets is presented. It enhances saliency assignments yielded through a robust colour-based technique with new saliency information extracted by taking advantage of the abundance of spectral information on multiple hyperspectral images. The experiments performed with the proposed methodology provide encouraging results, also compared to competitors.

The paper *Interpretable Segmentation of Medical Free-Text Records Based on Word Embeddings* by Adam Gabriel Dobrakowski, Agnieszka Mykowiecka, Małgorzata Marciniak, Wojciech Jaworski and Przemysław Biecek emphasizes that medical free-text records store a lot of useful information that can be exploited in developing computer-supported medicine. However, extracting the knowledge from the unstructured text is difficult and depends on the language. In the paper, the authors apply Natural Language Processing methods to process raw medical texts in Polish and propose a new methodology for clustering of patients' visits. With the applied method, the authors obtain stable and separated segments of visits which are positively validated against final medical diagnoses. They show how algorithms for segmentation of medical freetext records may be used to aid medical doctors.

In their paper *Towards Psychology-Aware Preference Construction in Recommender Systems: Overview and Research Issues* by Müslüm Atas, Alexander Felfernig, Seda Polat-Erdeniz, Andrei Popescu, Thi Ngoc Trang Tran and Mathias Uta the authors point out that user preferences are a crucial input needed by recommender systems to determine relevant items. In their article, the authors provide an overview of preference representations used in different types of recommender systems. They take into account the fact that preferences aren't stable but rather constructed within the scope of a recommendation process. In which way preferences are determined and adapted is influenced by various factors such as personality traits, emotional states, and cognitive biases. The authors summarize preference construction related research and also discuss aspects of counteracting cognitive biases.

Explanations for Over-Constrained Problems Using QuickXPlain with Speculative Executions by Cristian Vidal, Alexander Felfernig, José Galindo, Müslüm Atas and David Benavides addresses conflict detection on the basis of Junker's QuickXPlain, a divide-and-conquer based algorithm for the detection of preferred minimal conflicts. In their article, the authors present a novel approach to the detection of such conflicts which is based on speculative programming. They introduce a parallelization of QuickXPlain and empirically evaluate this approach on the basis of synthesized knowledge bases representing feature models. The results of this evaluation show significant performance improvements in the parallelized QuickXPlain version.

Mieczysław A. Kłopotek and Robert A. Kłopotek in their article *Issues in Clustering Algorithm Consistency in Fixed Dimensional Spaces. Some Solutions for k-means* refer to the work of Kleinberg who introduced an axiomatic system for clustering functions. However, Kleinberg claimed that one of the most popular clustering algorithms, k-means does not

have the property of consistency. In the paper the authors challenge this claim by pointing at invalid assumptions of his proof (infinite dimensionality) and show that in one dimension in Euclidean space the k-means algorithm has the consistency property. They also prove that in higher dimensional space, k-means is, in fact, inconsistent. This result is of practical importance when choosing testbeds for implementation of clustering algorithms while it tells under which circumstances clustering after consistency transformation shall return the same clusters. Two types of remedy are proposed: gravitational consistency property and dataset consistency property which both hold for k-means and hence are suitable when developing the mentioned testbeds.

In his paper *Music emotion recognition using recurrent neural networks and pretrained models* the author *Jacek Grekow* presents experiments based on using recurrent neural networks for emotion detection in musical segments. Trained regression models were used to predict the continuous values of emotions on the axes of Russell's circumplex model. A process of audio feature extraction and creating sequential data for learning networks with long short-term memory (LSTM) units is presented. The usefulness of dividing the data into sequences as well as the point of using recurrent networks to recognize emotions in music, the results of which have even exceeded the SVM algorithm for regression, are demonstrated. The author analyzed the effect of the network structure and the set of used features on the results of the regressors recognizing values on two axes of the emotion model: arousal and valence. Finally, the author presents the use of a pretrained model for processing audio features and training a recurrent network with new sequences of features.

Performing Arithmetic Using a Neural Network Trained on Images of Digit Permutation Pairs written by *Marcus D. Bloice, Peter M. Roth and Andreas Holzinger* is based on the description of a neural network which is trained to perform simple arithmetic using images of concatenated handwritten digit pairs. The network was tested afterwards on permutation pairs that were not present during training in an effort to see if the network could learn the task of addition, as opposed to simply mapping images to labels. The results were encouraging, with the network achieving an accuracy of over 90% on some permutation train/test splits. As far as the authors are aware, no previous work has concentrated on learning a mathematical operation in this way. This paper is an attempt to demonstrate that a network can learn more than a direct mapping from image to label, but is learning to analyse two separate regions of an image and combining what was recognised to produce the final output label.

In their article *Making Design Decisions under Uncertainties: Probabilistic Reasoning and Robust Product Design* by *Paul Christoph Gembarski, Stefan Plappert and Roland Lachmayer*, the authors point out that making design decisions is characterized by a high degree of uncertainty, especially in the early phase of a product development process, when little information is available, while the decisions made have an impact on the entire product life cycle. In their approach they model the uncertainties with probabilistic reasoning in a Bayesian decision network explicitly, as the uncertainties are directly attached to parts of the design artifact's model. The application example of a rotary valve from engineering design shows that the decision network can support the engineer in decision-making under uncertainty. Furthermore, the work constitutes a contribution to knowledge formalization in development projects.

The paper *How to Raise Artwork Prices Using Action Rules, Personalization and Artwork Visual Features* by *Laurel Powell, Anna Gelich, and Zbigniew W. Ras* explores the development of action rules for changing the prices of works of contemporary fine art. The authors used LISp-Miner to generate action rules related to artwork profiles and developed attributes covering artist descriptions and visual features of the artwork. The focus is heavily

on developing a method for partitioning a dataset to produce an increase in the coverage of the rule sets.

Finally, *Leveraging Contextual Embeddings and Self-Attention Neural Networks with Bi-Attention for Sentiment Analysis* by Magdalena Biesialska, Katarzyna Biesialska and Henryk Rybinski emphasises the problem that people express their opinions and views in different and often ambiguous ways, hence the meaning of their words is often not explicitly stated and frequently depends on the context. Therefore, it is difficult for machines to process and understand the information conveyed in human languages. The presented work addresses the problem of sentiment analysis (SA). The authors propose a simple yet comprehensive method which uses contextual embeddings and a self-attention mechanism to detect and classify sentiment. They perform experiments on reviews from different domains, as well as on languages from three different language families, including morphologically rich Polish and German. The authors show that their approach is on a par with state-of-the-art models or even outperforms them in several cases. Their work also demonstrates the superiority of models leveraging contextual embeddings. In sum, the paper constitutes a step towards building universal, multilingual sentiment classifiers.

We would like to thank all authors for their high-quality contributions which made possible such a broad and interesting special issue. We also express our gratitude to all the reviewers for their valuable work, the detailed comments and suggestions. Special thanks to Jude Estrera from Springer for supporting us in the technical processing of special issue. Last but not least we specifically thank Zbigniew W. Ras, the Editor-in-Chief of the Journal of Intelligent Information Systems for his continuous support throughout the whole publication process.

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