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Editorial

Recent Advances in Intelligent Data Analysis and Its Applications

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1. Introduction

In the current rapidly evolving technological landscape, marked by transformative advancements such as cloud computing, the Internet of Things (IoT), and industrial internet, the complexity of data analysis tasks is escalating across the socio-economic spectrum. Within this dynamic environment, the challenges faced by current problem-solving programs when handling big data primarily revolve around the effective management, modeling, and processing of extensive datasets.

This surge in data intricacy necessitates a proactive approach towards researching and developing intelligent models and methods for efficient data analysis and its application. It is crucial to explore innovative solutions that can navigate the intricacies of large datasets while ensuring not only the accuracy of analyses but also the timely extraction of valuable insights. Such research endeavors have become indispensable in addressing the growing demand for robust data processing capabilities in diverse sectors.

Moreover, as the technological landscape continues to evolve, the importance of staying at the forefront of data analysis methodologies becomes evident. This involves not only adapting to existing challenges but also anticipating future complexities. By delving into research on intelligent data models and methods, we pave the way for advancements that are not only responsive to current demands but also resilient in the face of emerging technologies and data-related challenges in our ever-changing socio-economic landscape.

Presently, the domain of intelligent data analysis [1] has experienced a rise in the number of scholars and professionals working within it. Innovative methods have been proposed from diverse perspectives, including data mining, machine learning (ML), natural language processing, granularity computation, social networks, machine vision, cognitive computing, and more. These approaches are intricately woven into the fabric of intelligent data analysis, presenting expansive and profound application scenarios for the field of data mining.

Data mining technology [2] plays a crucial role in dealing with large-scale data by extracting valuable information from massive datasets. It provides essential training data for ML algorithms, enabling the construction of more accurate models. Simultaneously, the development of natural language processing [3] allows machines to better understand and parse human language, imparting more practical meaning to the results of data analysis. Advancements in granularity computing [4] have improved the effectiveness of data analysis by simplifying information into fundamental concepts, facilitating swift and in-depth analysis. Social network analysis [5] uncovers patterns in interpersonal relationships and group behavior, offering substantial groundwork for the development of marketing strategies and policy formulation. The progression of machine vision [6]

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broadens the horizons of data analysis to encompass image and video processing, providing strong support for applications such as intelligent surveillance and autonomous driving. Concurrently, the integration of cognitive computing [7] emulates the functions of the human brain, enhancing the innovation and intelligence of data analysis.

These intelligent data analysis methods have broadened the comprehension of intricate data processing at the theoretical research level, concurrently yielding positive effects on socio-economic development. Especially within the era of big data [8], these methods have shown considerable importance in tackling practical challenges across diverse domains, presenting fresh perspectives and innovative solutions for the complexities posed by intricate data. They not only make data analysis more intelligent and efficient but also drive the development of socio-economics, providing more comprehensive and viable strategies for solving practical issues. The research on these intelligent data analysis methods is becoming a crucial engine for advancing the integration of technology and society.

By conducting in-depth research and widely applying these methods, one can better address the challenges posed by the increasingly vast and diverse data streams, further propelling technological innovation. Not only is this innovation exhilarating, it is also playing an increasingly crucial role in solving practical problems. Further in-depth research and widespread application of newly emerging models and methods in the field of intelligent data analysis are anticipated to drive continuous progress in societal digital transformation and innovation.

To advance research in the field of computer science and engineering, new methods for intelligent data analysis and their applications must be persistently explored. Throughout this explorative process, the focus will be on the practicality, reliability, and effectiveness of innovative technologies and methods, ensuring their maximum impact in real-world applications. By closely integrating theoretical research with practical applications, there is the potential to advance the forefront of the intelligent data analysis field, contributing more beneficial insights to the development of a data-driven society in the future.

Overall, research on intelligent data analysis [9] and its applications holds significant value in the era of big data [10]. Through interdisciplinary approaches and technological innovations, it is possible to better address the challenges posed by complex data in the real world, further advancing the field of computer science and engineering. In the ongoing exploration in this field, attention is directed towards enhancing the practical applicability of intelligent data analysis methods to address real-world challenges. This endeavor aims to provide more reliable and innovative solutions for technological progress and societal development by resolving issues in practical scenarios. Through these efforts, there will be a continual contribution of greater depth and breadth of knowledge to propel the development of the field of data science, continuously pushing the boundaries of technological innovation.

One of the core tasks of intelligent data analysis is to effectively handle vast amounts of data and extract insightful information that informs decision making [11]. The essence of this article is to delve into the latest developments in the field of intelligent data analysis and explore how these technological innovations can be applied to address real-world challenges in the realms of society, economy, and science. By comprehensively understanding the latest developments in this field, one can better grasp the trends in technological advancement. This knowledge enables a more flexible application of these innovative technologies in practical scenarios.

Proactively exploring and implementing forward-looking approaches is pivotal for advancing intelligent and efficient data processing methods across diverse fields. This adaptability is indispensable for navigating the ever-evolving landscape of emerging complex challenges. Immersing oneself in the dynamic realm of intelligent data analysis facilitates not only better adaptation but also leadership in the unfolding trends of data science.

This proactive stance plays a crucial role in fostering innovation and formulating practical solutions that make significant contributions to the sustainable development of society, the economy, and the scientific domain. Delving deeper into the intricacies of intelligent data analysis not only enhances our capacity to address current issues but also positions us at the forefront of anticipating and responding to future challenges.

In this context, keeping abreast of emerging technologies and methodologies is paramount, allowing us to harness the full potential of data-driven insights. Embracing a forward-thinking mindset empowers us to not only meet present demands but also to shape and propel the future of data science. This proactive engagement acts as a catalyst for developing and implementing innovative solutions with far-reaching implications for the betterment of our global community.

Within this Special Issue, twenty-eight papers are published, encompassing diverse aspects of decision making, recommendation systems, intrusion detection, question answering, as well as topics in ML and deep learning (DL).

2. Overview of Contributions

For diverse domain requirements, numerous intelligent granular computing models have been established. The utilization of knowledge distance serves to quantify distinctions between granular spaces, representing an uncertainty metric with robust discriminative capabilities in rough set theory. However, the existing knowledge distance metric falls short when considering the relative disparities between granular spaces within the context of uncertain concepts. To address this gap, Yang et al. (Contribution 1) explored the concept of relative knowledge distance for intuitionistic fuzzy concepts.

Air pollution poses a significant environmental threat that could have potential consequences for human health. The emergence of IoT devices enables instantaneous and ongoing surveillance of atmospheric contaminants in metropolitan regions. However, the presence of uncertainty and inaccuracy in IoT sensor data present challenges in the effective utilization and fusion of these data. Additionally, divergent opinions among decision-makers regarding air quality evaluation (AQE) can impact final decisions. Addressing these issues, Li et al. (Contribution 2) systematically investigated a method utilizing hesitant trapezoidal fuzzy information, examining its application in AQE.

The multigranulation rough set (MGRS) model, extending the Pawlak rough set, describes uncertain concepts using optimistic and pessimistic upper/lower approximate boundaries. However, existing information granules in MGRS lacked sufficient approximate descriptions of uncertain concepts. In response, Yang et al. (Contribution 3) introduced the cost-sensitive multigranulation approximation of rough sets, encompassing optimistic and pessimistic approximations, grounded in approximation set theory. The associated properties of these approximations are scrutinized. Additionally, a cost-sensitive selection algorithm is proposed for optimizing the multigranulation approximation.

A myriad of research endeavors have extensively explored diverse facets within the field. In this context, Liu and his colleagues (Contribution 4) investigated the utilization of contextual information and users' interest preferences within location-based social networks to propose the subsequent point-of-interest for users in the IoT environment. Their study demonstrated that their model, named CGTS-HAN, could more accurately capture the contextual features of users' POI compared to alternative models.

Addressing the tendency of recommender systems to overlook diverse neighbor views in collaborative filtering, Zheng et al. (Contribution 5) proposed a multiscale neighbor-aware attention network. This approach integrates overarching semantics from various neighbor types with significant local embeddings of multiscale neighbors. The collaborative signals for predicting user ratings of items are derived from a range of neighbors, encompassing both attribute views and interaction views.

Modeling users' dynamic preferences is a challenging yet crucial task in recommendation systems. Hu et al. (Contribution 6) systematically addressed this challenge by considering both local fluctuations in user interests and the need for global stability.

Coping with vast amounts of data requires sophisticated methodologies. Variations in procedures and protocols across healthcare services and facilities has resulted in the incomplete and erroneous documentation of medical backgrounds. Rectifying these discrepancies is imperative to establish a singular, accurate record moving forward. A widespread strategy for tackling this concern includes utilizing imputation methods to anticipate absent data values by relying on established information within the dataset. A widespread strategy for tackling this concern is utilizing imputation techniques to forecast missing data values by leveraging known values within the dataset. In this regard, Wilcox et al. (Contribution 7) introduced a neighborhood similarity measure-based imputation technique.

Network clustering held significance in the fields of data mining and bioinformatics. Wang et al. (Contribution 8) introduced a specialized algorithm in this domain, targeting the detection of protein complexes by integrating features of power-law distributions.

A frequency synthesizer serves the fundamental function of generating a desired frequency through the manipulation of a reference frequency signal. Across diverse sectors, including communication, control, surveillance, medical, and commercial applications, the demand for stable and precise frequency generation is critical to ensuring the dependable performance of mechanical equipment. In response to this imperative, Park et al. (Contribution 9) undertook the design and implementation of a highly reliable frequency synthesizer specifically tailored for use in railway track circuit systems. This synthesizer exclusively utilized audio frequency (AF) and was integrated into the logic circuit of a field-programmable gate array, eliminating the need for a microprocessor. The deployment of this exceptionally precise AF-class frequency synthesizer significantly elevated the safety and efficiency of braking and signaling systems in transportation equipment, such as railways and subways.

Data analysis has greatly benefited from the pivotal role played by ML and DL models. For example, mining machinery heavily relies on picks for the automated extraction of coal, and the condition of these picks significantly influences the effectiveness of mining equipment. Facing the task of accurately assessing the overall wear status of cutting tools during coal mining operations, Song and colleagues (Contribution 10) introduced a data-centric model for recognizing the wear condition of these tools. The model employed sophisticated optimization techniques for long short-term memory networks, integrating Bayesian algorithms.

Various devices within the smart home environment experience different levels of susceptibility to attacks. Devices characterized by lower attack frequencies encounter challenges in amassing sufficient attack data, thereby limiting the capacity to train effective intrusion detection models. In response, Chen et al. (Contribution 11) presented an innovative approach termed the improvement technique, which leverages feature enhancement and data augmentation to generate ample training data, particularly for broadening few-shot datasets. The utilization of an expanded dataset in training intrusion detection models significantly enhanced detection performance.

Yet, determining whether the augmented dataset truly enhanced model performance poses a challenge. Relying on the training model for each assessment instance to confirm the data augmentation and dataset quality incurs considerable time and resource costs. To tackle this issue, Cui et al. (Contribution 12) proposed a straightforward and pragmatic method to assess the effectiveness of data augmentation in image classification tasks, making a valuable contribution to the theoretical research on assessing data augmentation quality. Bieliński et al. (Contribution 13) delved into the exploration of how specific ML algorithms tackle the challenge of establishing a virtual mental health index.

Exploring the issue of flight delays, traditional DL algorithms encounter difficulties marked by low accuracy and heightened computational complexity. This poses a practical challenge in directly deploying deep flight delay prediction algorithms to mobile terminals. In response, Qu et al. (Contribution 14) studied the lightweight neural network MobileNetV3 algorithm and the improved ECA-MobileNetV3 algorithm. Their methodology included preprocessing real flight information and weather data.

Zhang et al. (Contribution 15) tackled the underutilization of relationships among words in a question through the introduction of a question-answering methodology for a knowledge base. This approach employed graph convolutional networks, facilitating the effective pooling of information across diverse dependency structures. The result was a heightened efficacy in the representation of sequence vectors.

Amidst efforts to control healthcare expenses and adapt to changing regulations, pharmaceutical laboratories aim to prolong the longevity of crucial equipment, particularly fluid bed dryers crucial for drug manufacturing. Barriga et al. (Contribution 16) proposed a pioneering solution that incorporates exploration data analysis and a Catboost ML model to tackle challenges associated with older dryers lacking real-time temperature optimization sensors. The integration of the Catboost algorithm resulted in a noteworthy decrease in initial heating time, leading to substantial energy conservation. The ongoing surveillance of essential parameters signified a departure from traditional fixed-time models, indicating a paradigm shift in the industry.

Recognizing orphan genes (OGs) can be a labor-intensive process. To address this challenge, Gao et al. (Contribution 17) introduced XGBoost-A2OGs, an automated predictor specifically designed for the identification of OGs in seven angiosperm species. The methodology involves the utilization of hybrid features and XGBoost.

Accurately classifying imbalanced data classes poses a formidable challenge due to the inherent uneven distribution in datasets. To tackle this obstacle, the incorporation of sampling procedures into ML and DL algorithms has underscored its indispensability. In this context, Sadaiyandi et al. (Contribution18) conducted a study that employed sampling-based ML and DL approaches to automate the identification of deteriorating trees within a forest dataset.

In the process of feature learning, conventional models for abnormal state detection frequently neglect the variation in position and orientation system data within the frequency domain. This neglect results in the forfeiture of vital feature details, hindering the possibility for additional improvements in detection capability. To overcome this limitation and with the goal of improving UAV flight safety, Yang et al. (Contribution 19) introduced a technique for detecting abnormal UAV states.

Autonomous underwater vehicles (AUVs) encounter challenges in underwater navigation due to the considerable costs associated with inertial navigation devices and Doppler velocity logs, which impede the acquisition of essential navigation data. In addressing this issue, methodologies such as underwater simultaneous localization and mapping are employed. These approaches, coupled with navigation methods reliant on perceptual sensors like vision and sonar, aim to enhance self-positioning precision. In the field of machine learning (ML), extensive datasets play a crucial role in improving algorithmic performance. Wang et al. (Contribution20) introduced an underwater navigation dataset derived from controllable AUVs.

A network intrusion detection (NID) tool grapples with network data characterized by high feature dimensionality and an imbalanced distribution across categories. Presently, certain detection models exhibit suboptimal accuracy in practical detection scenarios. In response to these challenges, Zhang et al. (Contribution 21) introduced an NID model leveraging multi-head attention and bidirectional long short-term memory.

To address the accuracy limitations of the traditional interacting multiple-model (IMM) algorithm in target tracking, Wang (Contribution 22) proposed an innovative algorithm named VSIMM-CS. This algorithm adopts a variable structure interacting multiple-model approach. The real-time construction of its model ensemble is based on the initial set, considering both the error characteristics of a linear system and the inherent symmetry in the structure of the model set.

Semi-supervised classification stands as a fundamental approach for addressing incomplete tag information without manual intervention. Nevertheless, prevailing algorithms necessitate the storage of all unlabeled instances, leading to iterative processes with potential drawbacks, such as slow execution speed and substantial memory requirements, particularly for large datasets. While previous solutions have primarily concentrated on supervised classification, Song et al. (Contribution 23) presented a novel approach aimed at reducing the size of the unlabeled instance set in the context of semi-supervised classification algorithms.

To enhance scatter quality without a notable reduction in the lateral resolution of the delay multiply and sum (DMAS) beamforming coherence factor, Guo (Contribution 24) introduced an adaptive, spatio-temporally smoothed coherence factor combined with DMAS. In this research, the generalized coherence factor was applied to identify local coherence and dynamically ascertain the subarray length for spatial smoothing. Incorporating this parameter to assess the results improved scatter quality without a substantial compromise in lateral precision, making it particularly advantageous in intricate clinical environments.

In the field of intelligent manufacturing, the proficient use of industrial robots faces a hurdle due to the issue of low absolute positioning accuracy. Tao et al. (Contribution 25) presented an algorithm for precise compensation in the absolute positioning of industrial robots, leveraging deep belief networks through an offline compensation approach. They employed deep belief networks through an offline compensation approach, optimizing these networks using a differential evolution algorithm. Additionally, they introduced a position error mapping model incorporating evidence theory. The aim is to streamline the process of precision compensation, specifically targeting the enhancement of absolute positioning accuracy in industrial robots.

The detection of blind spot obstacles in intelligent wheelchairs holds significance, particularly within semi-enclosed environments of elderly communities. Current solutions relying on LiDAR and 3D point clouds are costly, difficult to implement, and demand substantial computing resources and time. Du et al. (Contribution 26) introduced an optimized lightweight obstacle detection model called GC-YOLO, based on YOLOv5 architecture.

While sentiment analysis has been extensively researched, the majority of studies have concentrated on analyzing individual corpora. Yang et al. (Contribution 27) introduced a pioneering framework, CNEC, tailored for conducting sentiment analysis on bilingual text that includes emojis, commonly found on social media platforms.

Knowledge graph question answering supported users without mandating data structure comprehension, addressing challenges such as semantic understanding, retrieval errors, word abbreviation, object complement, and entity ambiguity. To tackle these issues, Zuo (Contribution 28) presented the innovative Chunked Learning Network method. The model incorporated vector representations of entities and predicates into the question, fully leveraging embeddings derived from the knowledge graph. Adapted for diverse scenarios, the model utilizes a variety of approaches to acquire vector representations for the subject entities and relationships within the question.

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