

Future Trends of AI-Based Smart Systems and Services: Challenges, Opportunities, and Solutions

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Abstract

Smart systems and services aim to facilitate growing urban populations and their prospects of virtual-real social behaviors, gig economies, factory automation, knowledge-based workforce, integrated societies, modern living, among many more. To satisfy these objectives, smart systems and services must comprises of a complex set of features such as security, ease of use and user friendliness, manageability, scalability, adaptivity, intelligent behavior, and personalization. Recently, artificial intelligence (AI) is realized as a data-driven technology to provide an efficient knowledge representation, semantic modeling, and can support a cognitive behavior aspect of the system. In this paper, an integration of AI with the smart systems and services is presented to mitigate the existing challenges. Several novel researches work in terms of frameworks, architectures, paradigms, and algorithms are discussed to provide possible solutions against the existing challenges in the AI-based smart systems and services. Such novel research works involve efficient shape image retrieval, speech signal processing, dynamic thermal rating, advanced persistent threat tactics, user authentication, and so on.

Keywords

Artificial Intelligence, Deep Learning, Sentiment Analysis, Smart Systems and Services

1. Introduction

We are witnessing the rapid growth and evolution of cities using smart services across the world. Artificial intelligence (AI) based systems are an essential component of smart cities where data obtained from sensors is analyzed for efficient decision making. Smart healthcare-based AI systems track a patient's health effectively and identify symptoms that lead to early detections of diseases. Speech recognition and CCTV based image identification systems use AI to detect and authenticate users with minimum human-machine interaction. Numerous applications and services are using AI and building secure and efficient smart services.

Extensive implementation of AI-based solutions in varying smart system applications has multiple challenges and opportunities to overcome them. Solutions are needed to address music noise and filtering problem in speech signal processing, accurate identification of individuals with altering background and lighting conditions, improving ultrasound Doppler blood flow spectrograms to detect diseases, and valid shape identification and classification for automatic plant recognition systems.

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This paper presents various solutions to address existing challenges in smart systems. Solutions include accurate shape image retrieval using included-angular ternary pattern for plant recognition systems and least-mean-square and spectral subtraction based algorithm to eliminate filtering delay problems in speech signal processing. Furthermore, there are challenges in smart systems addressed such as repeat identification of individuals across different cameras using Joint-Bayesian re-identification method and secure authentication of individuals with CCTV based captured images using a multi-factor security framework. Research literature related to the AI-based smart systems and services is included with significant contributions in the fields of multiple smart-city domain applications such as healthcare, security, and energy.

This paper is organized in three sections. Section 2 introduces 18 high quality papers. In particular, these included papers focus on various perspectives: dynamic thermal rating technology, least-mean-square and spectral subtraction algorithm, secure multi-factor security framework using convolutional neural network, physically unclonable functions and Argon2 algorithm, extraction of temporal information, the survey of technologies implemented in smart cities, and so on.

2. AI-Based Smart Systems and Services

In this section, varying solutions such as approaches, algorithms, and frameworks to mitigate the existing challenges in the AI-based smart systems and services are introduced as regular magazine-style papers. Such solutions involve various future track topic, including efficient shape image retrieval, speech signal processing, dynamic thermal rating, advanced persistent threat tactics, user authentication, and so on. In the subsequent paragraphs, this paper describes each topic in a summarized way in terms of existing challenges and their solutions.

Existing dynamic thermal rating (DTR) technology's limited availability in quantity and high cost of hardware facilities requires high investment. Yan et al. [1] proposed a new DTR based on global/regional assimilation and prediction system (GRAPES) and geographic information system (GIS) based on the application of numerical weather forecasts. Thermal load of 750 kV transmission lines in Shaanxi Province is calculated and analyzed using GRAPES and GIS. Results show conservative static thermal ratings constrain the thermal load capacity of overhead transmission lines and DTR effectively utilizes the transmission potential of transmission lines. The proposed DTR technology using Grapes and ArcGIS reduces the requirement of a high amount of investment in hardware, a critical demerit of the existing DTR technology.

Xu et al. [2] proposed a new shape descriptor, included-angular ternary pattern (IATP) for efficient shape image retrieval. IATP shows favorable properties for shape classification and inherently does not modify during rotation, translation, and scaling. Experimental analysis of the proposed descriptor to analyze its essential factors were conducted on MPEG-7 Set B database and Swedish leaf database. Results confirm excellent shape retrieval performance obtained by multi-scale IATP combined with included-angular histogram. Further analysis of IATP shows practical applications which include efficient plant and plant leaf recognition, which is essential for automatic plant recognition systems.

Speech signal processing suffers from the filtering delay problem and to address it, Cao et al. [3] proposed a least-mean-square and spectral subtraction (LMSSS) algorithm. The proposed method is based on the noise reduction principle and is a combination of the least-mean-square (LMS) algorithm

and spectral subtraction algorithm. The proposed LMSSS algorithm post-LMS processing adds spectral subtraction operation to the noisy speech. The addition to the noisy speech helps to avoid the music noise and filtering delay problem by simplifying the parameter adjustment of the filter. Experimental results show the proposed LMSSS achieved the highest accuracy in speech recognition and is appropriate for speech recognition when the signal-to-noise ratio (SNR) is in the range of 0 dB to 15 dB. Speech enhancement based on LMSSS algorithm is better than the existing LMS and spectrum subtraction algorithms.

Jo et al. [4] presented a survey of technologies implemented in smart cities, including edge computing, Blockchain, and AI. These smart technologies help establish a sustainable environment by reducing bandwidth usage, latency, and power consumption in Internet of Things (IoT) based devices operating various smart city-based applications. The survey presents the role of technologies in the growth and sustenance of smart cities and the integration of advanced technologies implemented to help understand new research directions. Different network architectures are discussed from a security perspective to help grow the smart city-based environment. Open research issues, their challenges, and recommendations are provided to help show the direction where future research is needed to build sustainable and secure smart cities.

Re-identification of individuals across different cameras is a challenging task due to the position of the camera, changing backgrounds, lighting conditions, and varying manner of walking manner of individuals. Hou et al. [5] proposed the Joint-Bayesian re-identification (JBR) method to improve the calculation precision in accurately identifying an individual by learning the transition between multiple cameras. The proposed method first obtains a set of Joint-Bayesian matrices by learning with different camera pairs and then combines the properties of multi-camera shooting and character re-identification. Experimental results show an increase in RANK-1 accuracy by 3% and 4% and improvement in maximum a posterior by 1% and 4%. The proposed method can be implemented in the future for multi-scene image retrieval purposes.

Gafurov and Chung [6] presented a survey on IoT based technologies, its technologies, and security perspectives. The study discusses related studies on IoT environment's security, scalability, and state of the art development life cycle. A detailed and layered architecture of IoT with three to seven-layer models, its applications and existing analyses of subsisting technologies implemented with IoT are present. Security issues that arise in IoT applications and environments and their countermeasures in the research literature are included in the study. The proposed survey is a benefit for future research in the field of IoT security using technologies such as edge computing and machine learning. Threat detection using mobile edge computing, mobile cloud computing, and anti-virus and malware software is proposed as areas for future research in IoT security.

Ultrasound Doppler blood flow spectrograms require accurate assessment of blood volume flow, and existing volume flow algorithms are inaccurate and have low stability. Zhang et al. [7] proposed a new ultrasound volume flow estimation method based on multigate (RMG). Detailed information about the local velocity distribution is acquired using the multigate technology. The double iterative algorithm is used to determine the mean velocity (DIV) and experimented in vivo data from carotid. The experimental results show better performance with less than 5% mean error and low sensitivity to SNR. The RMG algorithms show better results than existing volume flow estimation algorithms. The proposed algorithm is useful in monitoring cardiovascular diseases.

Srilakshmi and Sangaiah [8] presented a survey on wireless networks based on various machine

learning algorithms and network parameters, along with their merits and demerits. Machine learning techniques can be used to resolve critical issues in wireless networks such as congestion control, localization, quality of service, selecting a mobile sink path, medium access control protocols, energy harvesting, anomaly detection, and fault detection. A statistical evaluation of the proposed survey is provided detailing the issues resolved using machine learning methods between the years 2014–2018. Limitations in implementing machine learning algorithms are identified, and open research challenges highlighting specific vital problems in wireless networks are discussed.

Xu et al. [9] presented a microblog information dissemination model where analyze the information dissemination mode of microblogging networks (Twitter) with the intervention of an Internet marketer. The relevant data of microblogging networks are used for the simulation of the proposed model and improve the susceptible-infective-removal (SIR) information. Correlation analysis is conducted on the existing information dissemination risk, the rumor dissemination model of the microblog.

Bahrani et al. [10] focused on APT's tactics, techniques, and procedures (TTP), and it facilitates the design of effective defensive strategies. Researcher leveraged the Cyber Kill Chain (CKC) model to decompose any complex attack and identify the relevant characteristics of cyberattacks. The researcher presented a comprehensive CKC-based taxonomy, based on our large-scale analysis of attacks of 40 APT campaigns. The taxonomy captures the TTPs that are most widely utilized by attackers, with the aims of providing up-to-date cyber situational awareness for individuals or organizations to be prepared against cyber-attacks, including those carried out by APT groups.

Ji et al. [11] proposed SC-FDE timing synchronization algorithm for FPGA implementation where the sliding window accumulator, quantization processing, and amplitude reduction techniques are adopted to reduce the complexity in implementation of FPGA. The simulation results of this algorithm show effectively realize the timing synchronization function under the condition of reducing computational complexity and hardware overhead.

Kwon et al. [12] proposed a Multi-factor security framework where used three steps process for authentication of a user and Argon2 technology are used for hashing image features and physically unclonable identification for secure device-server communication. The researcher discussed the methodological workflow of the proposed multi-factor authentication framework and also presented the qualitative analysis of the proposed framework.

Zhang and Song [13] figured out the impact of debt financing on the profits of industrial enterprises. The researcher firstly started with calculating differences between the logarithms of the cost-profit ratios and the debt asset ratios of Chinese industrial enterprises during 179 months from 2002 to 2016. Afterward, the cointegration test and the regression test are used to analyze the obtained first differences, and Simulink software is used for getting the regularity of those changes. It finds out that there is not only a long-term stable relationship between the enterprises' profits and debts but also a steady time series trend within the short term. The profit rate positively correlates to the debt asset ratio, and profit for the current term positively correlates to the profit for the previous term. It indicated that properly raised debts could help increase the profit rate of the industrial enterprises, and a higher previous profit level can help improve the current profit level.

Lim et al. [14] discussed methods of extracting the temporal information and several related issues of existing studies such as task boundary of the temporal information extraction, the history of the annotation languages and shared tasks. This paper provided the approach for a better way of extracting a particular part of the temporal information.

Huang et al. [15] studied a novel approach for natural gait cycles, and it is based on gait recognition via kernel Fisher discriminant analysis (KFDA) in which calculated the features of gait sequences and accelerated the recognition process. In this approach, firstly extracted the gait silhouettes through moving object detection and segmentation from each gait videos. Afterward, GCI-GEIs (gait-cycle-independent-gait energy images) are calculated for each gait videos and used for gait features and the KFDA method is used for extracted gait features for each gait videos. Finally, the nearest neighbor classifier is applied to classify the gait features. The proposed method is evaluated on the CASIA and USF gait databases and shows that our algorithm is better to compare than existing algorithms.

Lee and Seo [16] systematically addressed the bug report processing techniques for improving software management. Several studies were discussed based on the identification of duplicate bug reports and triage bug reports and the studies classified for discussions, such as used techniques, experiment target, and compared target. The results indicated the future research direction of bug report processing techniques. This study further indicates that although all studies in the field of triage are based on machine learning, results of studies on deep learning are still insufficient.

Jia et al. [17] proposed a MUIP clustering method for mobile user interface pattern data analysis and employed supervised kernel fuzzy *c*-means clustering (SSKFCM) method to cluster MUIP data. Clustering parameters are optimized by utilizing global optimization capability of particle swarm optimization (PSO) to improve the performance of clustering. By studying the advantages and drawbacks of SSKFCM clustering, we apply SSKFCM clustering to cluster MUIP data and utilize PSO algorithm to optimize SSKFCM clustering parameters. Finally, evaluate the proposed clustering method and provide the experimental results.

Truong and Kim [18] proposed a tracking-by-detection system for pedestrian tracking, which incorporates a convolutional neural network (CNN) and color information. It has two components: pedestrian detector, tracklets. First component are using R-CNN and ResNet-101 algorithm which is based on CNN. The locations of pedestrians detected by the first component are then fed into the second component, where spatial overlap properties and color information are utilized to associate detected pedestrians with their corresponding tracklets. Finally, the experimental results are evaluated the effectiveness of proposed algorithm for pedestrian tracking.

3. Conclusion

This paper presented the recent challenges, opportunities, and solutions for AI-based smart systems and services. It involved 18 novel and enhanced peer-reviewed papers from different dimensions of the information technology research. The paper mainly contains diverse kinds of mechanisms to subjects, which tackle different types of research fields such as efficient shape image retrieval, speech signal processing, dynamic thermal rating, advanced persistent threat tactics, user authentication, and so on.

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