Advances in Artificial Intelligence for Perception Augmentation and Reasoning

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Editorial

Advances in Artificial Intelligence for Perception Augmentation and Reasoning

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1. Introduction

AI has seen great progress in recent decades, with a rapidly increasing computing capacity and the exponentially growing amount and types of processed data. AI has played an important role in technological innovations. Among them, perception enhancement and intelligent reasoning technology are highly valuable and promising directions in the field of artificial intelligence.

The restoration and enhancement of perception can help us better perceive and understand the world in many ways, such as human activity recognition, medical-image-based diagnosis, and remote sensing analysis. Intelligent reasoning makes machines behave more human-like when performing reasoning tasks, and its application to practical problems is conducive to decision-making processes, such as intelligent medical treatment, environmental analysis and prediction, automatic driving, intelligent transportation, text classification, recommendation systems, machine translation, simulated dialogue, etc.

This Special Issue aims to highlight the latest developments in artificial intelligence (AI) applications in key areas such as perception enhancement, activity recognition, natural language processing, and intelligent reasoning, and provide a platform for researchers to present their unique insights and latest achievements.

This Special Issue includes 12 representative papers in the relevant fields. Although not covering all aspects of the topic of "perceptual enhancement and intelligent reasoning", they reflect the latest developments in this domain. These articles can be roughly divided into the following categories.

2. Classification Algorithm Based on Deep Learning

At present, algorithms and models based on machine learning and deep learning are widely used in various classification tasks and have achieved good classification results. However, there are still some problems in current machine learning classification algorithms, such as classification tasks with only a few samples. It is difficult to collect sample label data, i.e., classify it when there is only a small amount of labeled data. This Special Issue contains several articles on the above issues and different classification fields.

Machine olfaction is widely used for the accurate concentration estimation of gas classification and calibration. For example, the purity and quality of food can be assessed by detecting its volatile components, through air quality monitoring, and through disease detection by respiratory gases. However, the collection process of olfactory data is relatively cumbersome, and that of labeled data is even more difficult. A semisupervised learning algorithm can better deal with the classification task with only a small amount of labeled data and a large amount of unlabeled data. Wei Dang et al. [1] researched the semisupervised classification of same-domain data in the field of machine olfaction. Same-domain data refer to the data collected continuously without a drift or slight drift in the sensor. Combining a weighted kernel with a semisupervised learning machine, the authors proposed a semisupervised limit learning machine algorithm based on a weighted kernel (SELMWK) algorithm. This method not only improves the poor operation stability of semisupervised limit learning machinez due to random hidden layers, but also avoids the poor generalization ability of the single-core model. The effectiveness of the algorithm has been verified in the semisupervised gas classification task of the same field data. While extracting the key information of the data, the dimension of the data was also greatly reduced, thus reducing the cost of model training. The work by Siyu Lu et al. [2] mainly concerned semisupervised learning algorithms of data in different fields of machine olfaction, namely the sensor drift compensation algorithm. Combining the domain transformation algorithm with the semisupervised learning algorithm, the authors proposed the domain shift semisupervised weighted kernel limit learning machine (DTSWKELM) algorithm, which transforms the semisupervised classification problem of different domain data into the semisupervised classification problem of the same domain data. Compared with other algorithms, this algorithm can more effectively compensate for the long-term drift of sensors.

In many practical problems, the training sample data for classification tasks are very small. To address this problem, methods of training the model have been proposed by researchers: so-called small-sample learning. In "A Few Shot Classification Methods Based on Multiscale Relational Networks", Wenfeng Zheng et al. [3] focused on the small-sample learning problem in image classification tasks. To make the deep learning model use previous experience and knowledge to learn how to learn, the authors designed a multiscale relational network (MSRN) and realized fast learning and induction from a small number of sample images. This method improved the classification difference of feature extraction, improved the accuracy of the data set with fewer samples, and alleviated the overfitting situation.

In addition, this Special Issue also contains research on the classification of long text. Xi Yue et al. [4] proposed a long-text classification model based on multifeature weighted fusion. This method combines global context features and weighted local features, in which the attention mechanism is combined for obtaining the weighted local features, and, finally, the classification results are obtained using equal-length convolution pooling. In the long-text classification task, the authors proved that this method was superior to the traditional deep learning classification model under the same data set conditions.

3. Medical Image Processing

Medical images can reflect the internal structure of the human body and have become one of the main foundations of modern medical diagnosis. Using image-processing technology to analyze and process images can greatly improve the efficiency, accuracy, and reliability of clinical diagnosis.

The key to image navigation surgery is to find the transformation relationship between the spatial position of the preoperative 3D image and intraoperative 2D image, i.e., 2D/3D image registration. In '2D/3D Multimode Medical Image Registration Based on Normalized Cross-Correlation', Shan Liu et al. [5] proposed an image registration algorithm based on normalized cross-correlation. The improved linearity based on the LoG operator increases the edge information of the image as well as the internal details such as isolated points and lines. The improvement based on the Sobel operator increases the sensitivity of rotation transformation, thus increasing the convergence region while improving the accuracy. Given the computational efficiency problems caused by the normalized cross-correlation algorithm, the multiresolution algorithm was adopted. This method has higher registration accuracy, and the multiresolution strategy can reduce the initial value sensitivity of the registration algorithm and reduce the probability of the algorithm falling into the local optimum. In '2D/3D Multimode Medical Image Alignment Based on Spatial Histograms', Yuxi Ban et al. [6] proposed a feature-based 2D/3D medical image registration algorithm which extracts the statistical features of the image using the gradient direction spatial weighted histogram. This method has a high sensitivity to translation and rotation, and the convergence range of the algorithm is larger. When the structure in the foreground of the image is beyond the vision of the image, it can still achieve successful registration. Based on preserving the sensitivity of the gradient direction weighted histogram to rotation, the authors added the position information of pixel points and weighted the distance measure of the gradient direction weighted histogram with coordinate mean and coordinate variance to achieve the purpose of effectively combining spatial information and gradient information.

4. Application of Deep Learning in Remote Sensing

This Special Issue also contains two novel learning applications in the field of remote sensing. In recent years, deep learning has been widely used to solve major technical problems in the field of remote sensing. Lei He et al. [7] proposed a road extraction learning method D-DenseNet with a new structure. The network combines the extended convolution layer and the previous layer into a building block, so the extended convolution can obtain more global context information through the entire network. The authors' low-level road extraction experiments showed that this method can effectively reduce the model size and improve the segmentation accuracy IoU, in addition to having good extraction performance in complex scenes.

The application of machine learning in the field of river flood disasters is relatively mature. For the monitoring of urban waterlogging disasters, Yongzhi Liu et al. [8] proposed a waterlogging prediction model based on a long short-term memory (LSTM) neural network. The authors selected Jianye District (Nanjing City, in the southeast of China) as the study area. They established a multistep multivariable waterlogging prediction model based on the precipitation and waterlogging monitoring data in the study area and trained three models based on three loss functions. The model prediction results and the measured waterlogging data showed that LSTM made full use of the nonlinear relationship between the rainfall data of each rainfall station and the waterlogging data of a single waterlogging station, as well as having a good multistep prediction effect on the future waterlogging process.

5. AI in Industrial Applications

The following three papers describe the practical application of AI in industrial applications. Dividing the printed circuit board (PCB) circuit into different submodules, the size of the problem to obtain the optimal automatic layout and routing can be effectively reduced. Yali Zheng et al. [9] proposed a heuristic PCB network list partition method based on network attributes and potential patterns. The authors took the network list as the input and the module partition set as the output. This method uses a net attribute to prepartition the module and distributes the scattered resistance, capacitance, and other components caused by prepartition to the initial module through three rules of classification, matching, and enforcement. The network table division method in this paper is significantly superior to the existing technical level in all evaluation indicators and can achieve a division accuracy of 80–96%.

The work of Xi Yue et al. [10] mainly focuses on the detection of fabric defects. The traditional YOLO algorithm struggles to solve the problem of detecting small objects such as fabric defects. Therefore, the authors proposed an improved YOLOv4 target detection algorithm. A new prediction layer is added to the YOLO_head to have a better effect on small target detection. This method integrates the convolution block attention module in the backbone feature extraction network and replaces the CIOU loss function with the CEIOU loss function. The algorithm proposed in this paper can provide enterprises with a more accurate classification and location of minor defects, thus reducing the defective rate of fabric products and improving the economic benefits for enterprises.

Wireless sensor and actuator networks (WSNs) are implemented at the physical layer in the form of the Internet of Things (IoT) and Information Physical Systems (CPS). To solve the problem of cluster-based data collection in the Internet of Things not being able to provide reliable network data security, Prabha Selvaraj et al. [11] proposed an improved data-sharing and cluster head (CH) selection method combined with a firefly swarm optimization (GSO) strategy based on energy, trust value, bandwidth, and memory. This study regards the energy-saving routing challenge between WSN-based Internet of Things (IoT) devices as an optimization problem, uses the hybrid VIKOR-GSO method to select the optimal CH, and aggregates the selected CH. Then, the aggregated data are transmitted to the base station (BS) through the best possible path selected by the cuckoo search algorithm. The results showed that this method has better performance than other methods.

6. Sentence Representation Reasoning Technology

Given the lack of reasoning depth and interpretability of the sentence reasoning model, Wenfeng Zheng et al. [12] designed a deep fusion matching network. The authors improved the matching layer and used a heuristic matching algorithm to replace the bidirectional long and short-term memory neural network to simplify the interactive fusion. The tree convolution network (TBCNN) was used to extract the structure information of sentences based on the convolution layer. This method not only improved the reasoning depth and reduced the complexity of the model, but also improved the interpretability of the reasoning process. The authors also proved that the reasoning effect of this network is better than that of the shallow matching reasoning model.

Our reviewers and authors have gone to great lengths to guarantee the high quality of this Special Issue. As a result, many papers have been extensively revised, which brought a huge workload for everyone, but we believe that such efforts were worthwhile.

We pay special tribute and show appreciation to all 51 authors of the articles, as well as all of the professional and diligent reviewers.

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References

1. Dang, W.; Guo, J.; Liu, M.; Liu, S.; Yang, B.; Yin, L.; Zheng, W. A semi-supervised extreme learning machine algorithm based on the new weighted kernel for machine smell. *Appl. Sci.* **2022**, *12*, 9213. [CrossRef]
2. Lu, S.; Guo, J.; Liu, S.; Yang, B.; Liu, M.; Yin, L.; Zheng, W. An improved algorithm of drift compensation for olfactory sensors. *Appl. Sci.* **2022**, *12*, 9529. [CrossRef]
3. Zheng, W.; Tian, X.; Yang, B.; Liu, S.; Ding, Y.; Tian, J.; Yin, L. A few shot classification methods based on multiscale relational networks. *Appl. Sci.* **2022**, *12*, 4059. [CrossRef]
4. Yue, X.; Zhou, T.; He, L.; Li, Y. Research on Long Text Classification Model Based on Multi-Feature Weighted Fusion. *Appl. Sci.* **2022**, *12*, 6556. [CrossRef]
5. Liu, S.; Yang, B.; Wang, Y.; Tian, J.; Yin, L.; Zheng, W. 2D/3D multimode medical image registration based on normalized cross-correlation. *Appl. Sci.* **2022**, *12*, 2828. [CrossRef]
6. Ban, Y.; Wang, Y.; Liu, S.; Yang, B.; Liu, M.; Yin, L.; Zheng, W. 2D/3D multimode medical image alignment based on spatial histograms. *Appl. Sci.* **2022**, *12*, 8261. [CrossRef]
7. He, L.; Peng, B.; Tang, D.; Li, Y. Road Extraction Based on Improved Convolutional Neural Networks with Satellite Images. *Appl. Sci.* **2022**, *12*, 10800. [CrossRef]
8. Liu, Y.; Zhang, W.; Yan, Y.; Li, Z.; Xia, Y.; Song, S. An Effective Rainfall–Ponding Multi-Step Prediction Model Based on LSTM for Urban Waterlogging Points. *Appl. Sci.* **2022**, *12*, 12334. [CrossRef]
9. Zheng, Y.; Meng, D.; Bai, L. PCB Network Analysis for Circuit Partitioning. *Appl. Sci.* **2022**, *12*, 8200. [CrossRef]
10. Yue, X.; Wang, Q.; He, L.; Li, Y.; Tang, D. Research on tiny target detection technology of fabric defects based on improved Yolo. *Appl. Sci.* **2022**, *12*, 6823. [CrossRef]
11. Selvaraj, P.; Burugari, V.K.; Gopikrishnan, S.; Alourani, A.; Srivastava, G.; Baza, M. An Enhanced and Secure Trust-Aware Improved GSO for Encrypted Data Sharing in the Internet of Things. *Appl. Sci.* **2023**, *13*, 831. [CrossRef]
12. Zheng, W.; Zhou, Y.; Liu, S.; Tian, J.; Yang, B.; Yin, L. A deep fusion matching network semantic reasoning model. *Appl. Sci.* **2022**, *12*, 3416. [CrossRef]