Research on new fuzzy deep learning model and its construction technology

Xiaofeng Yao

Jiangsu Key Lab of IoT Application Technology,

Wuxi Taihu University, Wuxi 214064, China

E-mail: djyxf@163.com

***Abstract*—The application of deep learning in adaptively extracting corresponding feature expressions from a large number of unbalanced data sets for classification has become a hot topic of research and discussion at home and abroad in recent years. The purpose of this paper is to study the new model of fuzzy deep learning and its construction technology. A vehicle detection algorithm based on fuzzy deep belief network is proposed. Deep belief fuzzy networks can gain the ability to integrate prior knowledge by introducing fuzzy set theory into deep belief networks. It is a deep framework that combines the power of abstract restricted Boltzmann machines with the power of fuzzy set classification. Constrained Boltzmann functions can achieve fast data dimensionality reduction, and fuzzy sets can improve the classification accuracy of deep learning frameworks based on membership functions for each class. The experimental results on the wine dataset show that the detection algorithm based on fuzzy deep belief network proposed in this paper can classify faster and more accurately.**

Keywords-Deep Learning, Model Building, Construction Techniques, Unbalanced Data sets

I. INTRODUCTION

As the core of the Internet, data and content have become more and more critical in all aspects of life than ever before [1-2]. How to accurately and quickly obtain valuable information from these data through technical means has become an important research content. The core of machine learning is classification, which performs model learning on known data, so as to achieve the automatic classification process of data [3-4]. With the continuous research on machine learning, neural networks are getting more and more attention, but this method still needs a lot of label data and experience to set relevant parameters. As one of the most innovative methods of machine learning, deep learning method is an unsupervised learning algorithm that learns data features by simulating the multi-layer perceptual structure of the brain [5-6].

Deep learning has the benefit of recording and making noise, and has shown excellent performance in processing unorganized information such as pictures, text, language, etc. [7] The FDLC provided by Es-Sabery F connects a virtual network (CNN) to an automatic data recovery system and a further virtual network (FFNN) for good or bad scores. Therefore, using the Mamdani Fuzzy System (MFS) as the obfuscation domain, the two deep training solutions (CNN + FFNN) are classified into three categories, namely: unpredictability, apathy, and positivity. The exercise results show that FDLC outperforms other methods in terms of accuracy and complexity, coherence and reliability [8]. Elaskily MA introduces a new in-depth approach based on CMFD. In addition to the long-term memory channel (CovLSTM), this model is also based on the implementation of CNN (network network). A method to extract serial number (CNV) identification numbers, ConvLSTM parts, parts links, and then combine imitation and fake parts. When the number of uses is equal to 100, the given algorithm is about 100% correct for some databases, while some test time datasets (TT) are short, about 1 second [9]. Therefore, it is very important to learn new learning methods and teach their skills.

This paper studies the possible problems of the two types of unbalanced data in the wine data set. First, it introduces the background and significance of the research on the new deep learning model, and introduces the relevant theories and techniques for the construction of the new model of fuzzy deep learning, including fuzzy deep learning. The theoretical basis related to the deep belief network model includes fuzzy clustering algorithm, deep belief network and fuzzy constrained Boltzmann machine. Finally, a classification algorithm based on fuzzy deep belief network is constructed through this model.

II. A NEW MODEL OF FUZZY DEEP LEARNING AND ITS RELATED THEORIES AND TECHNOLOGIES

A. Deep Learning

1) Data-driven

Data-driven technology is an efficient method of processing high-dimensional data, and data-driven technology has obvious advantages in data analysis. The basic idea is to establish a historical data processing model driven by large-scale data, and use the obtained feature data set for conventional method processing [10]. Data-driven is divided into signal processing, machine learning, statistical theory, data mining and other technologies that provide theoretical guidance for the development of data-driven

2473-3636/22/$31.00 ©2022 IEEE
DOI 10.1109/DCABES57229.2022.00064

methods. Therefore, data-driven data support has become an essential element to promote the progress of classification technology [11].

2) Basic idea of deep learning

The simulation implementation process of deep neural network always uses different cortical layers for layer-by-layer abstraction and gradually extracts information, thereby reducing the amount of acquired information and retaining only the useful information structure. Based on this inspiration, researchers constructed a deep neural network. The main idea of this network is that after importing the original data from the input layer, the abstract versions of the original data are collected by each hidden layer, and the final data is extracted from the production layer, and the obtained data is consistent with the original data input [12-13].

3) Deep Belief Network Model

The core of the DBN model pre-training process is the training of each RBM layer [14-15]. RBM is an important Boltzmann device proposed on the Boltzmann platform. RBM is a basic energy base consisting of visible connections and neurons in hidden layers. The biggest difference between RBM and BM is that RBM has only external connections, and there are no connections between hierarchical neurons. Therefore, in the RBM structure, when the state of each neuron node in the visible layer is known, all the neuron nodes in the hidden layer are independent of each other; on the contrary, when the state of each neuron node in the hidden layer is known At the same time, the neuron nodes of all visual layers are also independent of each other [16].

B. Fuzzy Restricted Boltzmann Machine

Fuzzy restricted Boltzmann machine is a deep learning network structure that combines traditional restricted Boltzmann machine and fuzzy set theory [17-18].

We imitate the traditional restricted Boltzmann machine to construct the fuzzy restricted Boltzmann machine, then we need to define a fuzzy energy function model first. Therefore, according to the expansion principle of fuzzy sets, we can obtain the following fuzzy energy function:

$$\tilde{E}(v,h,\tilde{\theta}) = -\tilde{a}^{T} v - \tilde{b}^{T} h - h^{T} \tilde{W} v \quad (1)$$

Among them, $\tilde{E}(v,h,\tilde{\theta})$ represents the fuzzy energy function, and $\tilde{\theta} = \{\tilde{a},\tilde{b},\tilde{W}\}$ is the fuzzy parameter. Then, we can simplify the above equation by marginalizing the hidden layer, and the fuzzy free energy function $\tilde{F}$ can be obtained as follows:

$$\tilde{F}(v,\tilde{\theta}) = -\log \sum_{\tilde{h}} e^{-\tilde{E}(v,\tilde{h},\tilde{\theta})} \quad (2)$$

Assuming that we use the fuzzy energy function to define the probability, the fuzzy probability of the model can be obtained. Therefore, we transform the problem into a fuzzy maximum likelihood problem, which is difficult to express in mathematical language. We need to disambiguate the fuzzy free energy function so that the problem of solving the fuzzy maximum likelihood value becomes a general problem of solving the maximum likelihood estimation. In our algorithm, we deblur the fuzzy free energy function using the centroid method. Then we can get the free energy function obtained after deblurring.

C. Unbalanced Datasets

An unbalanced dataset is a sample set with a large variation in the number of samples between classes. We usually call the class with a small number of samples as the minority class, and some scholars call it the positive class.

With the expansion of application fields, more and more unbalanced datasets appear in real life. In such datasets, whether the minority class in the sample can be correctly classified is usually the focus of attention. When faced with an unbalanced dataset, the classifier ignores the recognition rate of the minority class in order to ensure the overall performance. Therefore, how to improve the existing algorithm without reducing the classification accuracy of the majority class while improving the recognition of the minority class has become a difficult problem that needs to be overcome in the field of machine learning.

III. Investigation and Research on New Model of Fuzzy Deep Learning and Its Construction Technology

A. Dataset

Based on the new fuzzy deep learning model construction method proposed in this paper, the wine samples grown in the same region of Italy are classified, and the samples come from the machine learning wine data set, which is a classic data set. Therefore, the first two categories in the classic wine dataset are selected for classification, and seven groups of the first category of data are randomly selected to form the minority category, and the second category of data is all adopted as the majority category for experiments. Half is divided into training set and half is divided into test set, and finally the classification effect of traditional algorithm and improved algorithm on real-life data sets is compared. There are positive minority classes and negative majority classes in the experimental part of the data categories.

B. Performance Evaluation Indicators

At present, the most commonly used criteria

for evaluating the classification accuracy are the correct rate and the error rate, but the correct rate and the error rate are not suitable for multi-classification problems with correlation. Most of the performance evaluation metrics in use today focus on the correct classification and recognition ability. The classification performance evaluation index adopts the accuracy rate to evaluate, and the omission rate evaluation standard is used to evaluate the risk.

IV. 4.Analysis and Research on New Model of Fuzzy Deep Learning and Its Construction Technology

A. *Fuzzy Deep Belief Network Learning Model*

The structure of the fuzzy deep belief network used in this algorithm is shown in Figure 1.

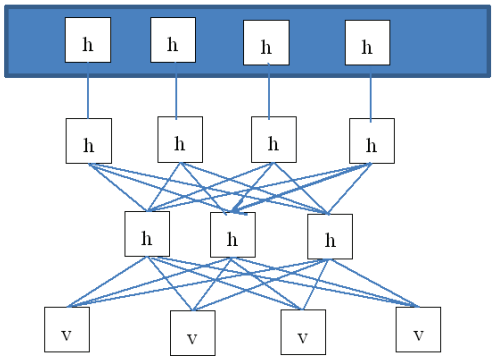

Figure 1. Schematic diagram of fuzzy deep belief network structure

The fuzzy deep belief network training process used in this paper is as follows:

Step 1: Extract the HOG features of the training images and assign corresponding label information.

Step 2: separates HOG features and label information, extracts HOG features for fuzzy c-means clustering, regards the clustering results as features, inputs the visible layer of the first layer of FRBM, and trains the first layer of FRBM.

Step 3: uses the output of the hidden layer of the first layer of FRBM as the input of the second layer of visible layer to train the second layer of FRBM.

Step 4: and so on, train FRBM layer by layer from bottom to top.

Step 5: The output of the hidden layer of the last layer of FRBM is used as the input of the softmax layer, and the output result is compared with the corresponding label information.

Step 6: According to the training results of Step 5, we use the RMSProp algorithm to effectively fine-tune the parameters of the entire fuzzy deep belief network until the fuzzy deep belief network we build is more conducive to the classification operation.

The fuzzy restricted Boltzmann machine used in each layer of the fuzzy deep belief network constructed by this algorithm is added with a function. In order to optimize the classification results obtained by the network and improve the network structure of the network we have constructed, we need to compare the predicted results obtained by the network calculation with the actual real results, so as to optimize the parameters and achieve the optimal classification network. The RMSProp algorithm used in the algorithm of this paper solves the problem of the sharp drop of the Adagrad learning rate, which can make the network parameters converge faster and speed up the fine-tuning of the entire network model.

B. *Experimental Results*

The key to whether the algorithm can correctly detect and identify the target is whether the classification operation of the fuzzy deep belief network is accurate. Therefore, training a robust network is a top priority. The influence of the deep confidence fuzzy network structure on the detection and recognition results is analyzed. 3, 4, and 5 layers of deep belief fuzzy networks are generated respectively, the number of hidden layer nodes is set to 500, 300, 100, 50, 20, and the number of training and optimization iterations is set to 500. The experimental results are shown in Table 1.

Table 1. Performance comparison of fuzzy deep belief networks with different structures

network structure	Accuracy	Missing detection rate
Layer 3 Network	96.5%	0.51%
Layer 4 Network	97.8%	0.31%
Layer 5 Network	99.5%	0.81%

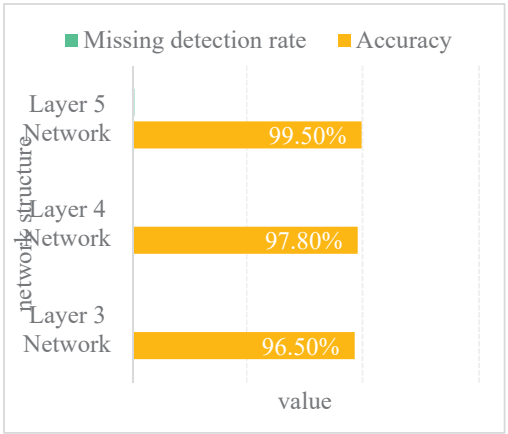

Figure 2. Experimental results

From the experimental results in Figure 2, we can see that the detection performance of networks with different structures is different, and

the 4-layer and 5-layer deep confidence fuzzy networks have the highest accuracy. At the same time, the detection loss rate of the 4-layer network is also the lowest among the three network structures. The reason for this phenomenon is that as the overall structural complexity increases, overfitting may occur, resulting in a decrease in detection and recognition performance. Therefore, considering comprehensively, the fuzzy deep belief network in this algorithm adopts a four-layer network structure, and the number of hidden layer nodes is 500, 300, 100, and 50 respectively.

V. CONCLUSIONS

According to the actual situation, this paper establishes a fuzzy deep belief network learning model with stable and excellent detection performance, and also has better detection performance for a small number of data types. After the model is established, several sets of different experimental data are used to conduct experiments to verify the performance of the fuzzy deep belief network learning model, and the following conclusions can be obtained. For the experimental data of networks with different structures, the average accuracy and detection rate of the four-layer network are as high as 97.8%, respectively, while the false alarm rate is only 0.31%, indicating that the fuzzy deep belief network learning model is an excellent detection performance, reliable and reliable. Efficient intrusion detection model.

REFERENCES

[1] Pham T D , K Wårdell, Eklund A , et al. Classification of short time series in early Parkinson' s disease with deep learning of fuzzy recurrence plots[J]. IEEE/CAA Journal of Automatica Sinica, 2019, 6(6):1306-1317.

[2] Sooraj, S, Manjusha, et al. Deep learning based spell checker for Malayalam language[J]. Journal of intelligent & fuzzy systems: Applications in Engineering and Technology, 2018, 34(3):1427-1434.

[3] Kumar N , Rahman S S , Dhakad N . Fuzzy Inference Enabled Deep Reinforcement Learning-Based Traffic Light Control for Intelligent Transportation System[J]. IEEE Transactions on Intelligent Transportation Systems, 2020, PP(99):1-10.

[4] Sarabakha A , Kayacan E . Online Deep Fuzzy Learning for Control of Nonlinear Systems Using Expert Knowledge[J]. IEEE Transactions on Fuzzy Systems, 2019, PP(99):1-1.

[5] Varghese E , Thampi S M , Berretti S . A Psychologically Inspired Fuzzy Cognitive Deep Learning Framework to Predict Crowd Behavior[J]. IEEE Transactions on Affective Computing, 2020, PP(99):1-1.

[6] Gheisarnejad M , Boudjadar J , Khooban M H . A New Adaptive Type-II Fuzzy-Based Deep Reinforcement Learning Control: Fuel Cell Air-Feed Sensors Control[J]. IEEE Sensors Journal, 2019, PP(99):1-1.

[7] Bodyanskiy Y V , Tyshchenko O K . A Hybrid Cascade Neuro–Fuzzy Network with Pools of Extended Neo–Fuzzy Neurons and its Deep Learning[J]. International Journal of Applied Mathematics and Computer Science, 2019, 29(3):477-488.

[8] Es-Sabery F , Hair A , Qadir J , et al. Sentence-Level Classification Using Parallel Fuzzy Deep Learning Classifier[J]. IEEE Access, 2021, PP(99):1-1.

[9] Elaskily M A , Alkinani M H , Sedik A , et al. Deep learning based algorithm (ConvLSTM) for Copy Move Forgery Detection[J]. Journal of Intelligent and Fuzzy Systems, 2021, 40(3):4385-4405.

[10] Jeyasekar D J , Arulselvi G , Vedanarayanan V , et al. Bone Cancer Identification and Classification Using Hybrid Fuzzy Clustering With Deep Learning Classification[J]. Journal of Advanced Research in Dynamical and Control Systems, 2019, 11(10-SPECIAL ISSUE):88-98.

[11] Ghosh L , Konar A , Rakshit P , et al. Mimicking Short-Term Memory in Shape-Reconstruction Task Using an EEG-Induced Type-2 Fuzzy Deep Brain Learning Network[J]. IEEE Transactions on Emerging Topics in Computational Intelligence, 2019, PP(99):1-18.

[12] Nandhini J U , Prabha D . Novel Fuzzy Pixel Value Stretching and Enhanced Deep Instance Learning for Detection of Diabetic Retinopathy[J]. Journal of Advanced Research in Dynamical and Control Systems, 2019, 11(10-SPECIAL ISSUE):494-505.

[13] Vinayakumar R , Soman K P , Poornachandran P , et al. Evaluating deep learning approaches to characterize and classify malicious URL's[J]. Journal of Intelligent & Fuzzy Systems, 2018, 34(3):1333-1343.

[14] Banerjee S , Singh S K , Chakraborty A , et al. Melanoma Diagnosis Using Deep Learning and Fuzzy Logic[J]. Diagnostics, 2020, 10(8):577-602.

[15] Gegov A , Kaymak U , Sousa J . Guest Editorial: Deep Fuzzy Models[J]. IEEE Transactions on Fuzzy Systems, 2020, 28(7):1191-1194.

[16] Vinayakumar, R, Soman, et al. Evaluating deep learning approaches to characterize and classify malicious URL's[J]. Journal of intelligent & fuzzy systems: Applications in Engineering and Technology, 2018, 34(3):1333-1343.

[17] Munirathinam T , Ganapathy S , Kannan A . Cloud and IoT based privacy preserved e-Healthcare system using secured storage algorithm and deep learning[J]. Journal of Intelligent and Fuzzy Systems, 2020, 39(2):1-13.
[18] Mundra A , Mundra S , Verma V K , et al. A deep learning based hybrid framework for stock price prediction[J]. Journal of Intelligent and Fuzzy Systems, 2020, 38(2):1-8.