An Overview of the Application of Convolutional Neural Networks in Sentiment Analysis

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Abstract:

The field of natural language processing, or NLP, uses its understanding of human language to find practical solutions to issues. It mainly includes two parts: the core task and the application. The core task represents the common problem that needs to be solved in various natural language application directions. It includes language models, morphology, grammar analysis, semantic analysis, etc. At the same time, the application section focuses on specific natural language processing tasks such as machine translation, information retrieval, question-answering systems, dialogue systems, etc. Natural language processing has made a significant contribution to the development of human society and the economy and provides strong support for all aspects of research work. Opinion mining, or sentiment analysis, is a subfield of natural language processing that develops systems for identifying and extracting ideas from text. Sentiment analysis is a hot topic since it has many practical applications. Many opinion-expressing texts are available on review sites, forums, blogs, and social media as the amount of publicly available information on the Internet grows. This unstructured information can then be automatically transformed into structured data about products, services, brands, politics, or other topics on which people can express their opinions using sentiment analysis systems. This information can be used for marketing analytics, public relations, product reviews, network sponsor ratings, product feedback, and customer service. With the rapid growth of labeled sample data sets and the notable enhancement in graphics processor (GPU) performance, convolutional neural network research has advanced rapidly and achieved remarkable leads to various computer vision tasks. By reviewing the application of CNN, we see that convolutional operations are naturally suitable for some text processing and, thus, naturally suitable for the background of sentiment analysis.

Keywords: Natural Language Processing, Convolutional Neural Networks, Sentiment Analysis, Artificial Intelligence

1. Introduction

1.1 Historical development

CNN is a neural network designed for image processing tasks. After several generations of development, CNN dominated most image tasks after 2012, including image classification, image segmentation, object detection, image retrieval, and the like. The visual system inspired the CNN structure, and in 1962, biologists Torsten Wiesel and David H.Hubel (Nobel Prize in Medicine, 1981) studied the cat visual system, discovering for the first time that hierarchical structures exist in the cat visual system, as well as two important types of cells, simple cells, and complex cells. Different types of cells perform visual perception functions at various levels of abstraction. So they experimented with the visual systems of cats and found:

(1) Neurons have a receptive field or reception field.

(2) Regarding Angle, the cell is selective.

(3) Cells are selective about the direction of movement.

Moreover, here is the takeaway for CNN:

(1) The visual system is handled hierarchically and classificatorily, from low to high-level abstraction to stacking via convolution and pooling.

(2) Neurons do have local receptive areas, particularly. They are locally sensitive→Local neuron

These revelations led the relevant researchers to a large extent at the time, and the first convolutional neural network prototype was created:

In 1980, Japanese scholar Kunihiko Fukushima, drawing on the experimental results of the cat vision system, proposed a hierarchical neural network - the New cognitive machine, stacked using two structures similar to S cells and C cells. S and C cells can be compared to modern CNNS convolution and pooling. However, their disadvantages are significant because they do not update the weights using a backpropagation algorithm, and model performance is limited.

1.2 The first large-scale commercial convolutional neural network - Lenet-5

In 1989, Lecun et al. began researching Lenet. In 1998, Lecun et al. proposed LENET-5, which was successfully applied to handwritten postal code recognition on a large scale in the United States postal system. However, it needed a large amount of data and high-performance computing resources.

1.3 The first excellent convolutional neural network - AlexNet

In 2012, Alex Net won the ILSVRC classification task by 10.9 points in percentage, which started the reign of convolutional neural networks in the image field.

With these preliminary studies of convolutional neural networks, the convolutional neural network model is more widely known, and its application fields are constantly expanding.

2. Methods of sentiment analysis

The method of emotion analysis is divided into two parts: one is the method based on the emotion dictionary. Generally speaking, we process the sentences to be analyzed into words one by one; in general, we process the statements to be analyzed into words and compare them with a "dictionary" (this dictionary contains the emotional attributes of various words, emotional values, and the like), match them one by one, iterate the emotional values, and obtain the emotional score for judgment. This method is "artificial" in some ways. The other method is machine learning. We gather a lot of textual data, train the classifier using SVM, Bayes, and a series of machine learning algorithms, and, after that, feed the judgmental data into the trained classifier to get the associated classification probability. This is a more "intelligent" method.

In detail, for the two methods of sentiment analysis based on dictionaries, the object of sentiment analysis has the smallest granularity of words. However, a sentence is the simplest form of expression for an emotion. While words can convey the essential details of emotions, they are devoid of the object and degree of correlation. Moreover, combining different words can produce different levels of emotion and even opposite emotional tendencies. As a result, it makes sense to consider sentences to be the most fundamental level of detail in an emotion analysis. The emotion of a sentence can calculate the emotion of a text or paragraph. The main steps are as follows: decomposition of paragraphs → decomposition of sentences in paragraphs → decomposition of words in sentences → search for emotion words and mark and count → search for degree words of emotion words and assign different weights according to the magnitude → search for negative words before emotion words and assign inverse weights (-1) → calculate emotion score of sentences → calculate emotion score of paragraphs → calculate emotion score of articles. Considering that the distribution of praise and criticism in sentences is unstable, words with positive and negative emotions are handled differently in the steps above, and the final score is two points, representing the positive and negative emotion values of the text, respectively. Through the above steps, an emotion score will be assigned to each sentence in each paragraph in every article. Then, according to the needs, the score value of the sentence can be statistically calculated, the score value of the paragraph can be statistically calculated, and the final text's positive emotion value and negative emotion value can be obtained. For a machine learning-based approach, we need to collect the text, and the other main tasks are done in the classifier. Therefore, the main difference between the two is whether they are intelligent. So, in some ways, convolutional neural networks can serve for sentiment analysis.

3. Status analysis

With the advancement of convolutional neural networks, there are increasing application fields, including sentiment analysis. The relevant research work is listed below. For example, an improved adaptive weight convolutional neural network algorithm can ensure the accuracy of user emotion prediction. A two-norm linear support vector machine optimization function, different from the classical convolutional neural network model, can solve the gradient dispersion problem in the parameter optimization process. The skip-gram pre-trained word vector model in word2vec is used to express short texts sparsely, and the dynamic pooling function compresses the emotional features. The accuracy of the two-class model and recall rate are greatly improved by quantitative comparison between the actual network review data set and the classical method. The validity of parameter optimization of the two-norm support vector machine is verified by weight updating changes, and the optimal model performance is obtained by adjusting the penalty coefficient. A two-channel convolutional neural network enables the proposed DCCNN algorithm to identify the emotional polarity of text accurately, and its accuracy rate and F1 value are both above 95%, which is significantly improved compared with the logistic regression algorithm, support vector machine (SVM) algorithm and CNN algorithm. A segment-pool strategy in a segment-pool neural network and the Dropout algorithm both help improve the model performance. The proposed method

achieves 91% classification accuracy on the Chinese hotel evaluation dataset and 45.9% accuracy on the Stanford English Emotion Tree dataset five-classification task, significantly improving the baseline model. Compared with the CNN and BiLSTM models, the accuracy of BiGRU combined with the GCN model used in a graph convolutional neural network is about 15% higher in the emotion classification of dialogue text, and the F1 value is also significantly improved, achieving a better emotion classification effect. All in all, applying the convolutional network in sentiment analysis is pervasive.

4. Trend prediction

With the emergence and rapid development of CNN, more and more professionals are beginning to use convolutional neural networks for sentiment analysis because the model of convolutional neural network has a significant improvement in accuracy when compared to the original two methods of sentiment analysis (sentiment analysis based on dictionary and sentiment analysis based on machine learning). It is faster and more widely used. In other words, a single convolutional neural network model can solve all aspects of emotion analysis that previously required multiple models to complete, providing a convenient, efficient, and accurate path for the entire emotion analysis work and encouraging the development of the entire emotion analysis work.

5. Conclusion

Convolutional neural networks are still not flawless and have the following flaws:

(1) Counterpropagating

Due to its high data requirements, the backpropagation algorithm could be more efficient for deep learning.

(2) Translation Invariance

Translation invariance describes the possibility that neurons that recognize an object will not fire when its orientation or position is slightly altered. When a neuron is trained to identify a cat, its parameters will vary in response to its movements and rotations. Although data augmentation has helped somewhat, the problem is still present.

(3) Pooling Layer

When a pooling layer is present, there may be a significant loss of essential data and an oversight of the relationship between the part and the whole. For instance, a face detector requires us to combine the mouth, eyes, nose, and face contours to identify the face. CNN determines that it is a human face if these five features are present simultaneously with a high probability. Layer merging is a lousy idea because essential data is lost. In the case of a face recognizer, the relationship between the parts and the whole will be disregarded. To identify a face, we must combine features (such as the mouth, eyes, oval face, and nose).

Despite its greatness, CNN still has two serious vulnerabilities: the pooling layer and translation invariance. We can use strategies like data amplification to prevent potential flaws. Now, the emergence of new structures, such as capsule networks, is revolutionizing the field of deep learning. More improved things will be born in the future. This will also make significant progress in using convolutional neural networks in sentiment analysis, and the future will be brighter.

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