Application of Deep Learning Technology in Computer Go

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Keywords: Deep learning; Computer go; Convolutional neural network; Artificial intelligence.

Abstract: The objective of this study is to analyze the relevant deep learning techniques used by Alpha Go, understand the application of convolutional neural network algorithm in computer Go, and train a value neural network, which can evaluate the chess board of Go and meet the requirements of valuation in computer Go program. In this study, the relationship between deep learning and computer go was analyzed. Based on the convolutional neural network in deep learning, the core network of Alpha Go, that is, value neural network, was elaborated, and the related algorithms of value neural network were optimized to avoid the problem of over-fitting in value network training. It was found that deep learning, as a technology developed by traditional neural network, can perceive the information of computer go board and possess strong understanding and decision-making ability when solving the problem of computer go. In the process of value neural network training, some optimization algorithms were proposed, which can improve the computational efficiency and reduce the storage space at the same time. Therefore, the combination of artificial intelligence based on deep learning technology and computer go can improve the level of professional go players to a certain extent.

1. Introduction

Go is a two-player strategy board game whose purpose is to use the chess pieces to cover more areas on the board than the opponent [1]. Go originated in China and contains rich Chinese cultural connotation. It is the embodiment of Chinese culture, civilization and people's wisdom. During the Sui and Tang Dynasties, Go was introduced to North Korea and Japan by China, and then spread to Europe and the United States [2]. There are 19 horizontal and vertical lines on the chess board, with a total of 361 intersecting points. The two sides of the game use black and white pieces, which are placed at the intersection point alternately, and finally the one who occupies more areas wins [3]. Compared with other board games, go has more space, longer playing time, huge action space and state space, and involves many kinds of human intelligence such as logical reasoning, image thinking and optimal selection. Therefore, go has always been considered as the most complex board game [4].

Artificial intelligence is an important branch of computer science, and it aims to explore the nature of intelligence, so as to create a machine that can react in a way similar to human intelligence [5]. Artificial intelligence includes machine learning, computer vision, computer games and other aspects of technology. With the continuous progress of deep learning technology, people begin to try to use deep learning technology to solve problems about computer go [6]. In 2016, Google's Alpha Go, based on deep learning development, defeated the world's top Go player Li Shishi, which also opened the era of modern computer Go [7]. In 2017, Google's Alpha Go Zero based on reinforcement learning algorithm and deep learning technology was launched. It adopted the zero-based mode, got rid of human knowledge training, defeated the Alpha Go version by 100:0, and achieved great success [8].

Few other organizations can replicate Alpha Go's success. The main reason is that its neural network has a large number of parameters and a large amount of data required for training. Google company's powerful computing force uses a large number of CPUs and TPUs to train self-playing chess and neural network [9]. The research focus of this study was to master the relevant deep

learning techniques adopted by Alpha Go, understand the application of convolutional neural network algorithm in computer Go, and train a value neural network on this basis, which can evaluate the board surface of go and meet the requirement of evaluation in computer go program, so as to help players improve their ability and contribute to the development of computer go.

2. Deep Learning Related Technology

2.1 Deep Learning Technology in Computer Go

Deep learning is an algorithm based on artificial neural network and conduct multi-level abstraction of data by multiple hidden layers, which belongs to the branch of machine learning [10]. Deep learning is a representation learning algorithm for data in the field of machine learning. To solve the problem of the computer, go in deep learning, it is necessary to transform the computer go problem into an environment of reinforcement learning. This specific environment consists of five parts: state space, action space, feasible action, state transition and reward function. In the computer go reinforcement learning system, each game is a series of samples, the chess board information is the state, the position is the action. Every game of chess will have a win or lose, it can directly use the win or loss as a reward function, that is, win +1, negative -1.

Strategy optimization is achieved by strategy iteration method, which aims to achieve the optimal level of strategy convergence by iterative calculation of value function [11]. Strategy iteration method can be divided into two parts: strategy evaluation and strategy improvement. Strategy assessment is to estimate the value of strategies and actions. Strategy improvement is to produce better samples and a better strategy assessment by a greedy strategy based on strategic assessment using, which in turn allows for a more accurate assessment of the value of strategies and actions. In the strategy iteration method, the flow chart of strategy evaluation is shown in figure 1, and the flow chart of strategy improvement is shown in figure 2.

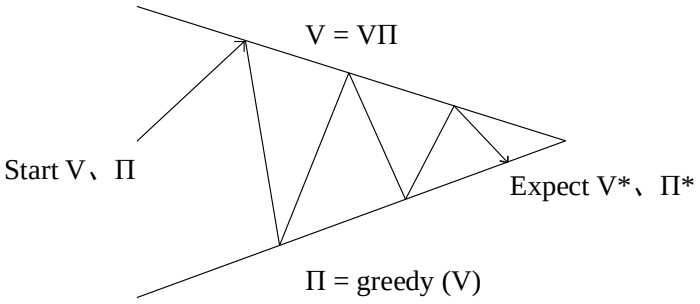

Figure 1. Flow chart of strategy assessment

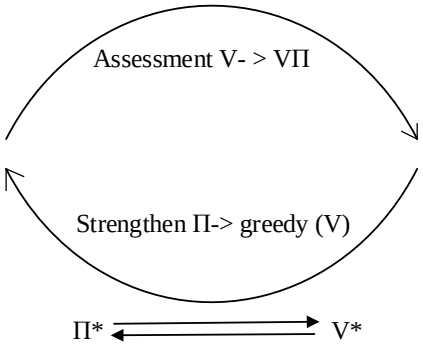

Figure 2. Flow chart for policy improvement

The overall process of computer go deep learning system is to observe the state through deep neural network and evaluate the strategy and value of output action [12]. The input of the deep neural network selects the observed information and extracts the features as the current state through the deep neural network. Then the deep neural network responsible for output is used to obtain the action strategy and value assessment according to the extracted features [13]. According to the output action strategy and value evaluation of the deep neural network, new samples are generated. Finally, through the training of the deep neural network, these samples are used to improve the deep neural network responsible for the output action strategy and value evaluation, so as to achieve the goal of optimizing the strategy.

2.2 Convolutional Neural Network

On the basis of the continuous development of deep learning, people put forward the concept of convolutional neural network. Convolutional neural network consists of two parts: first, convolution layer and pooling layer, second, full connection layer. Among them, the convolution layer and the pooling layer are responsible for extracting complex features of input, the convolution layer is responsible for detecting local connections of features, and the pooling layer is responsible for similar feature merging. The full connection layer is responsible for connecting the complex features extracted from the first part as a whole to obtain the output. Convolutional neural network is characterized by local connection, weight sharing, translation invariance and multi-layer use, so it plays a huge role in the field of computer vision [14].

Convolution kernel is the most core part of convolutional neural network, which can be expressed as equation (1).

$$g(x) = Wx + b \tag{1}$$

Among them, w represents a matrix, w and b will change continuously after initialization according to propagation, and appropriate parameters will be obtained through gradual learning.

The convolution layer of the convolutional neural network works by means of weight sharing, which significantly reduces the size of the weight matrix and improves the convergence speed and training speed of the neural network in training. In addition, at least one convolution layer of convolutional neural network extracts information according to image translation invariance in image recognition field.

3. Realization and Optimization of Value Neural Network

3.1 Value Neural Network Model

Value neural network model is one of the core networks of Alpha Go, which adopts convolutional neural network technology in deep learning [15]. The purpose of the value neural network is to evaluate the probability of winning by white chess or black chess on the current board. The input to the entire network is a 19×19 and 49-channel Go board. Through a 15-layer network, the output is real numbers between -1 and 1. The closer to 1, the closer the black is to victory, the closer to -1, the closer white is to victory, and the part close to zero is about to lose.

In the field of computer vision, the convolutional neural network significantly outperforms the traditional machine learning algorithm in image classification and object detection. In the 19×19 go game, each chess board can be taken as a 19×19 picture with three primary colors, and 49 features can be taken as the channel of the picture, so the input of neural network can choose the chess board features of go. The network model diagram of Alpha Go is shown in figure 3. The first layer to the tenth layer is applied with padding. The first layer is filled with the size of 23×23, and then the convolution kernel with step size of 1 and size of 5×5 is used for convolution. Layer 2-12 is filled to the size of 21×21, and then convolution kernel with step size of 1 and size of 1×1 is used for convolution. In the 13th layer, the convolution kernel with step size of 1 and size of 3×3 is used for convolution. The 14th layer is the full connection layer with output of 256, and the real numbers of

-1~1 are output in the 15th layer. Moreover, the training effect is the best when the convolution kernel is 192.

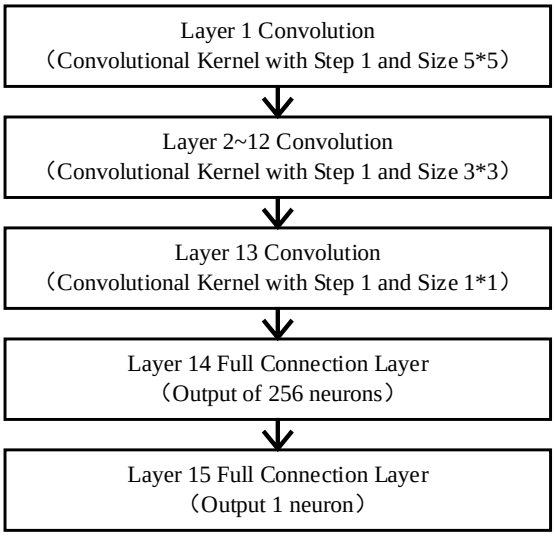

Figure 3. Alpha Go network model diagram

3.2 Optimization Algorithm of Value Neural Network

First, mini-batch gradient descent algorithm: gradient descent algorithm is a classical method in neural networks. However, when executing gradient descent in international training set, a large amount of go data must be processed before gradient descent can be performed, and then iteration can be carried out. Therefore, the operation efficiency is low and the storage space is large [16]. Mini-batch gradient descent can be used to divide a large data set into small parts. Traditional gradient descent algorithm is used to process small data sets for iteration, which results in a small amount of computation and a small amount of storage space.

Second, learning rate attenuation: learning rate attenuation is a method to decrease learning rate with the increase of time in the learning process. The convergence speed of the network will be relatively fast at the early stage, but the error will increase with the passage of time, which indicates that the learning rate is not properly selected. If the learning rate is set to be large at the beginning, it will decline rapidly at the beginning, and the error will increase after reaching a certain degree. If the initial learning rate is small, the overall convergence rate of the network will be slow, which also increases the training cycle of the network. Learning attenuation can run faster at the beginning of network training, and lower learning rate can slow down the rate of decline at the beginning of convergence.

Third, batch normalization methods: the normalization method commonly used in deep learning is batch normalization, which normalizes the input features, reduces differences between different samples, and results in a similar range of values for the input features, thus speeding up the training speed. Batch normalization layers are added after each network layer to accelerate training speed and avoid overfitting. The data is entered as a matrix of 0 or 1, so no normalization is required.

4. Conclusion

The complexity and variety of go make the research on computer go artificial intelligence attract a large number of go enthusiasts. Google's Alpha Go has defeated the world champion in the complex game of Go, marking a huge breakthrough in artificial intelligence. Deep learning is an important technology in the field of artificial intelligence. The network architecture modeling techniques used by Alpha Go can be applied to many areas of strategy and evaluation. Firstly, the strategy neural network is used to select the solution that is easy to be solved, and then the value neural network is used to evaluate the best solution, so that this algorithm model can be extended to a broader field to better serve human beings.

In this research, based on computer Go and starting from computer Go deep learning system, the related technologies of deep learning were studied, and the value neural network used in artificial intelligence computer Go program Alpha Go to evaluate the board surface of Go was analyzed. Through the research, it was found that deep learning, as a technology developed by traditional neural network, can perceive the information of the chess board when solving the problem of computer go, and has strong understanding ability and decision-making ability. In the process of value neural network training, some optimization algorithms were proposed, which can improve the computational efficiency and reduce the storage space at the same time. Therefore, the combination of artificial intelligence based on deep learning technology and computer go can improve the level of professional go players to a certain extent.

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