# A Proposal of Distributed Computing Method for Neural Network on Blockchain Network

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Abstract: In this paper, we propose a distributed computing method of neural network on Blockchain network. One of the issues to practice neural network on Blockchain network is that we need large amount of gas cost as commotion fee to execute the smart contract code. Our proposal suppresses the gas cost by introducing distributed computing concept. We implemented the calculation part by using smart contract on Ethereum and estimated the gas cost for the calculation. This paper explains the details of the estimation result.

Keywords: Smart Contract, Distributed Computing, Blockchain, Neural Network

## 1. Introduction

***Fadlullah et al*** and ***N. Kato et al*** explain that, in recent years, deep learning is playing a more and more important role in varies of informatics fields, such as bioinformatics, vision recognition, and so on [1, 2]. As training and using a complete neural network needs huge power of computing, people are making varies attempts to improve their computing ability. One method is to use computers with high computing power to train and use neural network, but this method's cost is very high. People without such computing ability would rather to use another method, which is called distributed computing, such as volunteer computing, to gather computers with limited power and make them becoming network with huge computing power, and use this network to train and use neural network. ***Li H et al*** introduce a method that using edge computing to calculate deep learning in an IoT system [3].

But there are still some problems left. One of the problems that may prevent people from attending the computing system is incentive. System without incentive would be hard to attract people to join into distributed computing network, which make the system lack of computing power. Security is another issue. Because a lot of people will join in the system to train and use the neural network, there is a possibility that malicious nodes will join and attack the system.

Smart contract can solve these problems well. Cryptocurrencies such as Bitcoin [4] are attracting people joining in the computing. People who attend the system can get their financial reward according to their work through smart contract, which can make people more willing to attend the computing. ***Kothapalli A et al*** show that smart contracts play an important role in incentive. The security issue can also be solved well by smart contracts. ***McCorry P et al*** explain that how smart contract solve the security issue [6]. But there will be some issues when we are using neural network on blockchain network. One of the issues to practice neural network on Blockchain network is that we need large amount of gas cost as commission fee to execute the smart contract code. To solve this problem, we will introduce a method that can suppress the gas cost in the following article.

## 2. Backgrounds

### 2.1 Distributed Computing

In computer science, distributed computing is mainly for studying the computing in distributed systems. A distributed system is a

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system which is consist of on different networked computers that communicating with each other [7]. The components interact with one another in order to achieve a common goal. Distributed computing system need to divide the huge computing project into pieces, calculated by computers, summaries the updated results from the computers and get the conclusion. In theory, there are two core problems of distributed computing: how to divide the complex mission into pieces, and how to integrate the results from pieces.

### 2.2 Neural Network

Neural networks, which is the short of artificial neural networks (ANN), are computing systems vaguely inspired by the biological neural networks that constitute animal brains.[8] The neural network is computed by large numbers of neurons. In most cases, neural network can change their structures based on outside information, which is adaptable. Neural network is usually improved by a learning method based on mathematical method. Like other machine learning methods, neural networks have been used to solve problems in varies of fields, such as computer vision, speech recognition, machine translation, social network filtering, playing board and video games, medical diagnosis and even in activities that have traditionally been considered as reserved to humans, like painting [9]. These problems are difficult to solve by traditional rule-based programming.

### 2.3Smart Contract

A smart contract is "a computerized transaction protocol that executes the terms of a contract"[10]. It is designed to digitally facilitate, verify, or enforce the negotiation or performance of a contract. Smart contracts allow the reliable transactions without third parties. These transactions are trackable and irreversible. Many contract terms can be partially or fully self-enforcing, or both. The purpose of smart contracts is to provide better security than traditional contract methods and reduce other transaction costs related with contracts. Various types of cryptocurrencies have implemented smart contract types.

## 3. Conception

### 3.1 Neural Network

First, we will introduce how does a well-trained neural network works. As the neural network (Fig.1) showed below, we will do these definitions:

- The data set is given as:

  $D = \{(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)\}$, $x_i \in R^d$, $y_i \in R^l$, which means the dimension of input data is $d$, and the dimension of output data is $l$.

- As shown in Fig.1, the number of input nodes, output nodes, and hidden nodes are $d$, $l$, $q$. The threshold of the $k$th node in output layer is $\theta_k$, the threshold of the $j$th node in hidden layer is $\gamma_j$. The weight from the $i$th node of input layer to the $j$th node in hidden layer is $v_{ij}$, and the weight from the $j$th node of hidden layer to the $k$th node in output layer is $\omega_{jk}$.
- The activation function is F(x).

The neural network shown in Fig.1 will work like this:

I) The input value of the $j$th node in hidden layer $\alpha_j$, which is:

$$\alpha_j = \sum_{i=1}^{d} v_{ij} x_i$$

II) The output value of the $j$th node in hidden layer $b_j$, which is:

$$b_j = F(\alpha_j - \gamma_j)$$

III) The input value of the $k$th node in output layer $\beta_k$, which is:

$$\beta_k = \sum_{j=1}^{q} \omega_{jk} b_j$$

IV) The output value of the $k$th node in hidden layer $y_k$, which is:

$$y_k = F(\beta_k - \theta_k)$$

That's how a well-trained neural network works.

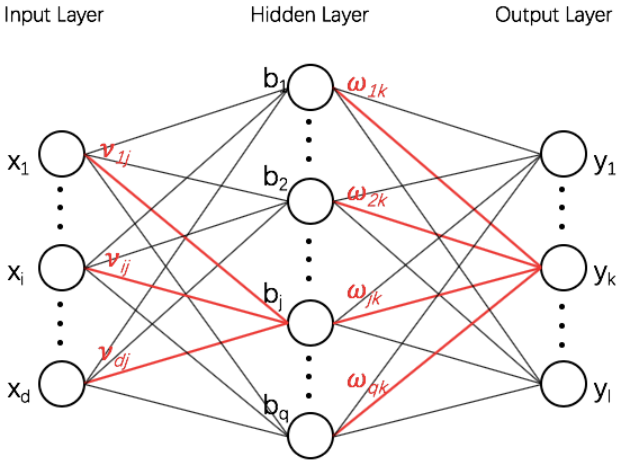


Fig. 1 Neural Network

### 3.2 Construction

As we introduced before, practicing neural network on blockchain network may generate large amount of gas cost, so we will introduce a method that can suppress the gas cost.

Because training a neural network needs much more operating and computing than using it, the gas cost will also be much more expensive, so that only the using part will be set on the blockchain network, the training part will be put outside in advance. After

training the neural network, we will directly use the trained parameter in blockchain network.

For the using part, we can reduce the gas cost by changing the using method of neural network. We consider the neural network as a group, which is consist by single nodes. Each node of the network calculates their assigned task and obtains incentive according to their work. So the nodes of neural network will compute their work according to their position:

a) As shown in Fig.2.a, the *i*th node in input layer will output to all the nodes in hidden layer, the output to the *j*th node in hidden layer $a_{ij}$, which is:

$$a_{ij} = v_{ij} * x_i$$

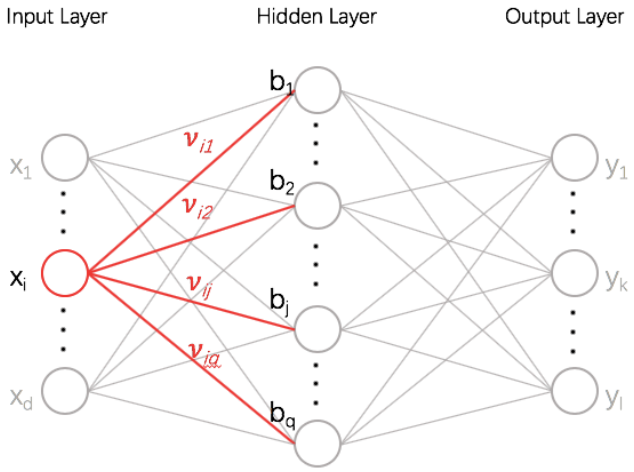


Fig. 2.a Work of nodes in input layer

b) As shown in Fig.2.b, the *j*th node in hidden layer will sum the output from the input layer, which is $\alpha_j$:

$$\alpha_j = \sum_{i=1}^{d} a_{ij}$$

Then output to all the nodes in output layer. The output to the *k*th node in output layer $b_{jk}$, which is:

$$b_{jk} = \omega_{jk} * F(\alpha_j - \gamma_j)$$

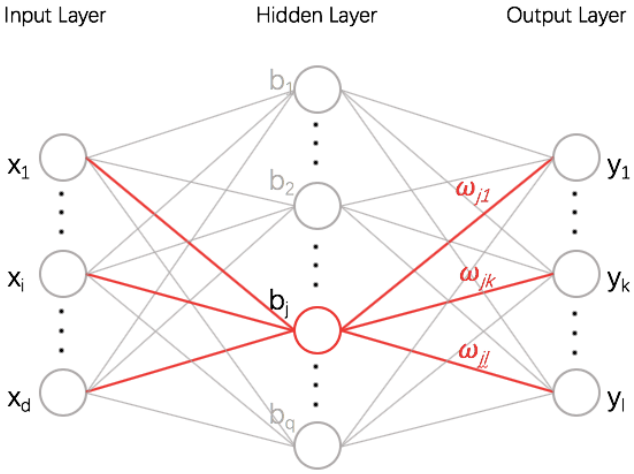


Fig.2.b Work of nodes in hidden layer

c) As shown in Fig.2.c, the *k*th node in output layer will sum the output from the hidden layer, which is $\beta_k$:

$$\beta_k = \sum_{j=1}^{q} \omega_{jk} b_j$$

And the output $y_k$, which is:

$$y_k = F(\beta_k - \theta_k)$$

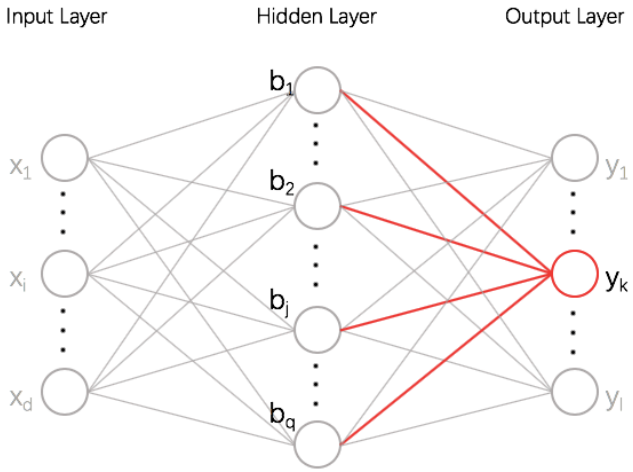


Fig. 2.c Work of nodes in output layer

That's what the nodes in the neural network compute. People only need to do one node's work instead of the whole neural network, the amount of operation and computing will be reduced, and the gas cost will also be suppressed as well.

## 4. Preliminary Simulation

To prove our proposal, we have done some simulation on this.

### 4.1 Environment

The software which we use to write our code is Solidity. Solidity is one of program languages that is used for smart contract. The version of Solidity is 0.6.0. We will use Remix, which is a software of using Solidity, to write our code for experiment.

The Neural Network's construction we use for the experiment is 3-4-3(Input Layer-Middle Layer-Output Layer). The weight and bias will be trained in the cloud in advance. The ReLu function is chosen as the activation function, which is shown as:

$$ReLu(x) = Max(0, x)$$

### 4.2 Simulation Result

We did several experiments to find out if the gas cost is available for users.

First, we test the value of gas cost when we only use a neural

network without training.

As the result shown in Table.1, the gas cost for deploying the code of the neural network and use it one time is $3.24472e^{-13}$(ether) ≈ $6.1127e^{-11}$(USD) (1ether ≈ 188.39USD), which is negligible. But as the structure of the neural network becoming more complex, gas cost may become larger.

Then we will test if our method can reduce the gas cost. As the result shown in Table.1, the gas cost of all three layers is reduced to at most 45.93%. Because deploying code in blockchain network is only once and using neural network will be countless times, the total gas cost of our method will be reduced nearly 50%.

| Compare of Commission Fee (Unit：x10e-18Ether) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | WholeNetWork | InputSingle | | HiddenSingle | | OutSingle | |
| | Geth | Geth | Percent | Geth | Percent | Geth | Percent |
| Deploy | 269672 | 123197 | 45.68% | 213669 | 79.23% | 182283 | 67.59% |
| Use | 54800 | 25710 | 47.15% | 27209 | 49.65% | 24452 | 44.62% |

Table 1

## 5. Conclusion and Further work

In this paper, we introduce a method that can suppress the gas cost when we use neural network in blockchain network. According to our simulation result, the gas cost can be reduced by 50%.

For the further work, firstly we would like to test some neural network with more complex structure to find out how much does the gas cost reduce. Then we would like to improve the whole system, make arrangement part and let it work well. Also we will consider about the training part of neural network and try to make it possible to train a neural network like this.

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