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Research of Forecasting Information Time Delays with Nenural Network in Telecontrol System

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Abstract—**Aiming at the issues of random delay and delay uncertainty in both the before channel and feedback channel for network control system, the root causes of random delay influence closed-loop control system by case is analysis, and the predictive control method based on neural network to solve the feasibility of existence network random delay in control system closed-loop control has provided. Simulation results show that the method can reflect and predict the delay characteristics of between measurement data represents the network path, and can effectively substitute for the actual network in the design of closed-loop control system based on Internet to research; the method used fast and accurate can be used for online learning network model and forecast the network delay value, provides a new way to remote closed-loop control based on Internet.**

Keywords-Model Predictive Control; Network Time-Delay; Simulation; Networked Remote Control System; Closed-Loop Control

I. INTRODUCTION

Network control system based on Internet broke through the many limitations on control system based on field bus and become the new development direction of the network control system, stable, fast, and accurate still the ultimate goal of network control systems pursued [1]. Introduction network easy for the organization and deployment of the control system but the transmission delay and data drops inevitably exist in network communication, these will give control system adverse effects even cause instability. Therefore, in recent years, the network control system design and analysis has aroused widespread concern in both academia and industry. Literature [2] proposed a new method to improve the network latency problem. First, feedback information of the server sends the client is no longer the traditional image information while status information with

the robot movement, contained less byte code. Secondly, on the server side, we set reasonable threshold for the parameters of the dynamic packet to effectively control the time of sending the packet. Only when any one parameter value in the packet exceeds its threshold, the dynamic information was only package and send to the client, data transmission in such networks is greatly reduced. These two aspects, due to reduce the data volume, network congestion reduced and delay and packet loss are greatly improved. Literature [3] describes the network programs and topology of achieve the common CNC machine tools Internet access and remote monitoring by communication controller; given network transmission delay calculation by such a network structure; proposed the method to improve CNC machine tools real-time remote monitoring by establish data buffer in communication controller, use high-speed MCU and zero-copy technology, emergency data processing technology. Literature [4] simplified the block diagram of remote control system based on Internet, the former delay and feedback delay combined total delay so that the system only needs to design a compensator, the system design is simplified and uses the smith compensator to compensate control to improve system quality. To the uncertainty of network delay, use buffering techniques in the site control computer to convert the uncertain time delay into a fixed delay, even without network delay prediction can also to achieve better control effect. Literature [5] uses the hydraulic system as the controlled object; there are challenging researches on the remote control system in the Internet environment. The experimental results show that, when according to the principle of Smith compensator design dynamic compensation and appropriate delay prediction algorithm can make the Stability original system before not join the network latency links to restore stability after joining the network,

so that the remote control of the mechanical movement using the Internet possible. However, due to the uncertainty delay in network transmission links and the data use policies of sampling information processor the control signal distortion after the transmission so that the system steady state error.

See from the current study, analysis and design network controller gradually development by a single variable to multivariate, determine to random, classical control theory to intelligent control theory and advanced control algorithm. But this is only the beginning, so far does not have a systematic approach for analysis, modeling, design whole network control system, and the architecture of the network control system continues to change, the current method is largely concentrated in the condition of network delay is no more than one sampling period, and other cases have yet to be depth.

Self-learning and adaptive capacity of neural network made the neural network model predictive control applications and research gaining increasing attention in the control system, and the prediction control based on neural network has strong robustness can adapt to the changing of system status and network latency links. This paper applied the neural network model predictive control to the network closed-loop system to reduce the impact of random delay to the system, and verified validity of the method by simulation, the method is an effective way to solve the network latency closed-loop control.

II. NETWORK CONTROL RESEARCH BACKGROUND BASED ON INTERNET

In order to study the impact of network latency on the remote closed-loop control system, set up remote motor control system platform based on Internet, a brushless DC motor as charged object,

developed DSP as core and motor drive modules with serial communication functions which directly connected the server serial port in order to facilitate the research on motor network control technology and control network functions embedded in the information networks, for the development of the control network search a more portable way, that is though the method of control functions embedded in the information network to build control information network. Remote motor control based on Internet shown in Fig. 1, this paper used a DSP controller as inner ring, PC server as outer ring dual-loop control structure. The inner ring composed by DSP to complete real-time, general motor closed-loop control; the outer ring of PC server as core to complete the remote closed-loop control. Such a structure ensured more reliable and efficient control effect under the condition of network delay.

This double-loop control system based on improve the performance of the remote controller can achieve safe, reliable and real-time closed-loop control under the conditions of network latency. The inner ring of DSP controller as core complete conventional closed-loop controls of the brushless DC motor, such as complete the speed closed-loop control of brushless DC motor based on DSP. The outer ring constituted by the client-server, DSP controller and brushless DC motor to complete the macroscopic closed-loop control of the client. For example, the client issued the directive forward 2cm and server sent the directive to the DSP controller, the DSP controller on their own to complete the instruction and maintain communication with the client. During the directive implementation, even if it is disconnected from the network, the DSP controller also on their own to complete the control task regardless of the impact of network performance.

III. THE IMPACT OF NETWORK TRANSMISSION DELAY ON THE SYSTEM REAL-TIME

The remote control of such a complex computer network based on Internet, information transmission and processing on the network takes time, the sender and receiver of information can be viewed as a network transmission delay, the transmission delay existence made network real-time restrict, which is response time determined by the inherent properties of the network system and is inevitable. The presence of network delay and its uncertainty is not conducive to achieve closed-loop control based on network, because in such a system, the network transmission delay not only appears in the before control channel the system, but also appear in the information feedback channel shown in Fig. 1. The delay in the feedback channel makes the controller can not found the controlled variable changes; the delay in the before channel makes the control signal unable to work on the controlled object. These factors not only affect the system dynamic quality, but also affect the system stability.
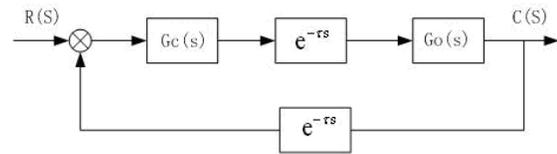

Figure 1.   NetworkRemote Control Systems

The closed loop transfer function of network closed-loop control system can be drawn from Figure. 1:

$$\frac{C(S)}{R(S)} = \frac{Gc(S)Go(S)e^{-2\tau s}}{1 + Gc(S)Go(S)e^{-2\tau s}} \qquad (1)$$

The characteristic equation is:

$$1 + Gc(S)Go(S)e^{-2\tau s} = 0 \qquad (2)$$

Visible, characteristic equation of transfer function of closed-loop control system with the network transmission delay links is a transcendental function of complex variable s, the root of the characteristic equation is no longer finitely but an unlimited number. This is also an important feature of time-delay systems, from the point of information transmission; network delay closed-loop system is a time-delay systems of transmission delay included in the forward channel and feedback channel on the time. Delays caused a negative effect for most of the linear control system and the system changes from stable to unstable. Visible the presence of network delay links not only affect the dynamic quality, but also affect the system stability. Therefore, analysis the time-delay system stability and controller design is a very difficult subject.

IV. THE ROOT CAUSES RESEARCH ON THE IMPACT OF NETWORK TRANSMISSION DELAY LINKS ON THE CLOSED-LOOP CONTROL SYSTEMS

In order to study the impact of network delay on the closed-loop control system, the typical second-order system in a remote control, a simple single-link robot arm as control objects to study the network closed-loop control problems. The system dynamics equation [6]:

$$\frac{d^2\phi}{dt^2} = -10\sin\phi - 2\frac{d\phi}{dt} + \mu \qquad (3)$$

Among them, ϕ represent the angle of robot arm; μ represent the behalf of DC motor torque. The Simulink block diagram of mechanical arm can draw on the type shown in Fig. 2
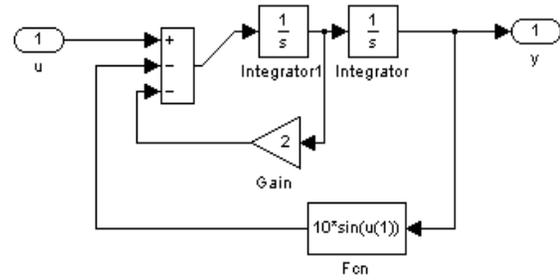
Figure 2.   Simulink Block Diagram of Mechanical Arm

According to actual situation of the network closed-loop control let a delay link connected between the system controller and the controlled object, another delay link connected to the feedback channel. In the network control system, the forward channel and feedback channel is generally the same physical link, and sent in both directions at the same time, that these two values of delay links are the same, so this paper set the two delay value in delay link set to the same to study. First, delay time in the delay links adjust to 0, that is not including delay link, repeatedly adjust the PID parameters to obtain the satisfied response curve. Then, keeping the PID parameters unchanged, increase the network delay value gradually starting from 0.02 seconds obtain the response curve shown in Fig. 3, seen from Fig. 3 with network delay value increasing, the system performance gradually deteriorate, when the delay increased to 0.05 seconds the system become the oscillating system, continue to increase delay to 0.06 seconds system response divergence, that is the system becomes unstable.

Realing the PID parameters of the of increase 0.06 seconds delay link instability control system obtain the response curve shown in Fig. 3 (d). Visible, by adjusting the controller parameters really can make the original unstable closed-loop control systems becomes stable and meet the remote closed-loop control requirements of system which not high request about fast like robot arm.

System control parameter adjustment is a bit trickier, as the delay size and system parameters change constantly adjusted to limit its scope of application, especially not for interstellar adventure, the work environment unknown controlled object, therefore, intelligent control links with adaptive require introduction.
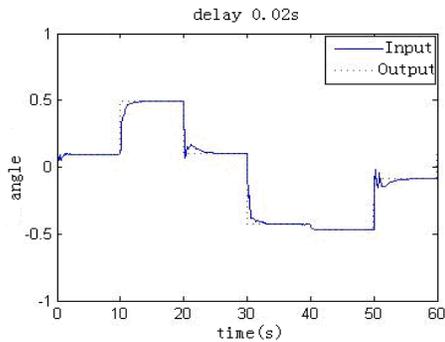
(a) response after adding 0.02 seconds time delay
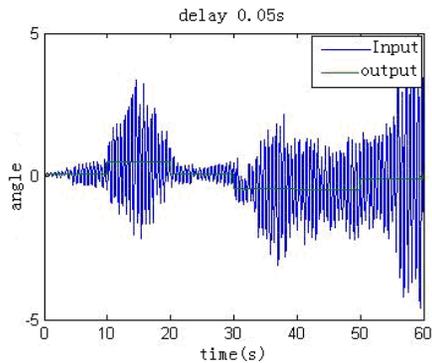
(b) response after adding 0.05 seconds time delay
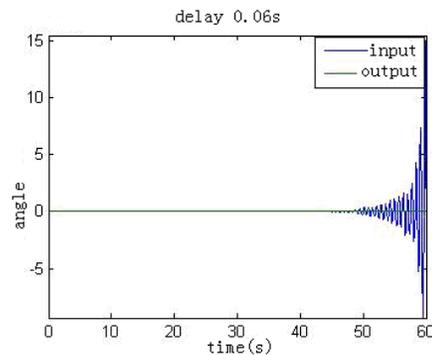
(c) response after adding 0.06 seconds time delay
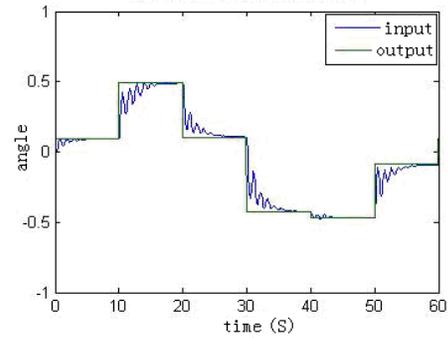
(d) response after regulate PID parameters at 0.06 seconds time delay

Figure 3.   Response after increase network latency

The manipulator control system in Figure 3 as for example analysis, assume that the sampling period of 0.05 seconds in Figure 3, set the delay value to 0.05s, the control information in time k transmitted to the controller after 0.05s, as opposed to the system sampling time 0.05s, the controller receives status information at the moment of k has pass a sampling point, the state of the system has become the state in time k +1, that is state of the k time fed back to the PID controller at time k +1, the PID controller for time k, the state at time k+1 has not yet come, but this time system status values at k-1 after a sample time delay before it is passed controller, therefore, the controller can only decision at time k should be imposed control value u (k) based on the state of the k-1 times, and this control value can be a real work on the system after a time delay, while at the time k +1 and the state of the system has been turned into a time k+1 the state of X(k+1), while u (k) produce at the state time k-1, so u (k-1)grieved and u (k +1) required difference two sampling cycles. In these two sampling cycle, the state of the system state transition, that is x (k-1) transfer to the x (k+1), x (k-1) and x (k+1) often is different lead to u (k-1) and u (k +1) is different. In other word, the system control value produced offset and the greater delay the greater offset, which is the root source of result in deterioration of

the system closed-loop control performance and even instability.

The above analysis shows that the system performance deterioration caused by the remote network delay because of can not correctly calculate the amount of control exerted by the controller to the system ,if the system model is known and the size of delay is known, then forecast the state of system in accordance with the principle of the system predict compensation, and calculate the size of control value need to be added the control system in accordance with the predicted state, that is time k applications to predict the state $\hat{\chi}$ (k+1) at time k+1 yet not the state of x(k-1) at time k-1 calculation to be applied to the system state at time k, then the control value u (k +1) at actual time k +1, the u (k +1) after a delay transmission in the time k +1 transfer to the system just after a sampling period, the state of the system change into x (k +1) ,

So, if the predicted state $\hat{\chi}$ (k+1) is infinitely close to the actual state x (k +1), the performance of control network delay closed-loop control system can be infinitely close the performance of the closed-loop control system without delay links, which is the basic idea of the predictive control model. However, the delay of the control network is time-varying and controlled objects are often immediately confounding factors, it is can not use an inconvenience model to predict the state of system and can not use a specific delay time to do the fixed step predictive control, neural network has the advantages of online learning the state of the system, predictive control based on neural network has strong robustness to be adaptive to the change of system status and network delay aspects ,it is a way to solve the network latency closed-loop control.

V. MODEL PREDICTIVE CONTROL

Model predictive control is according to the running state of the system over the past time and present moment, more accurate forecasting system desired output value in the future moment, calculated control value of the system should be added according to output value desired depending on certain optimization algorithm adaptive computer control of online solving control value [7-10]. Visible, model predictive control algorithm is an adaptive control method based on the future state of controlled object or dynamic predictive value of output and online solving current control [8-13]. Model predictive control is a newer computer control algorithm developed in the late 1970s; the algorithm actually encompasses three steps: prediction model, rolling optimization and feedback correction [9-16].

A. Prediction Model

For a module description of the alleged object behavior in the predictive control based on neural network belong to forward model of system, there use the training methods as shown in Fig.4, where dashed box picture shows the actual controlled object, here is the Simulink block diagram of the robotic arm, at random input signal u to produce output y. Selected BP neural network with one hidden layer as training model of a controlled object , set the number of hidden layer neurons is 10, using the Levenberg-Marquartdt learning rules, with the group [u, y] data training neural network model of the charged object, the results shown in Fig.5, where Fig.5 (a) is the data used for training, Fig. 5 (b) is convergence diagram for training.
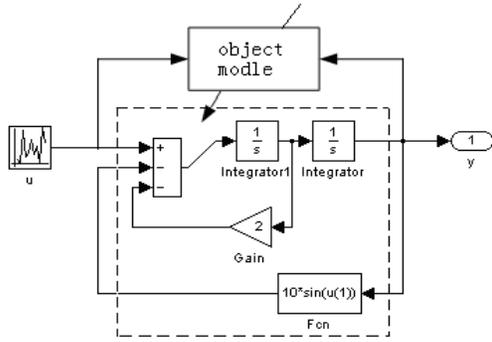
Figure 4.   Neural Network Training Block Diagram of the Manipulator

B. Rolling Optimization

Rolling optimization is an optimal control algorithm, which uses the output of the rolling finite domain optimization that is the goal of optimization over time. Predictive control proposes optimization index based on the moment in every time instead of using global optimization indexes. Rolling optimization index locality through make it can only get the global optimal solution in the ideal case, but when the model mismatch or time-varying and non-linear or confounding factors can take into account this uncertainty in a timely manner compensate, reducing the deviation, keeping the actual optimal control ,and it is also easy to use input/output value of finite difference time domain to identify rapidly the state of controlled object so as to implement the online adjustment to the control law and need for repeated optimization.
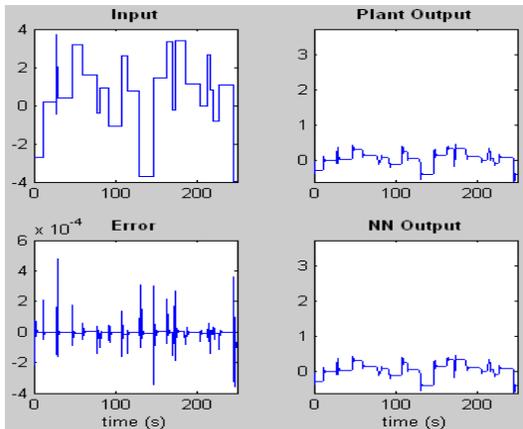
(a)
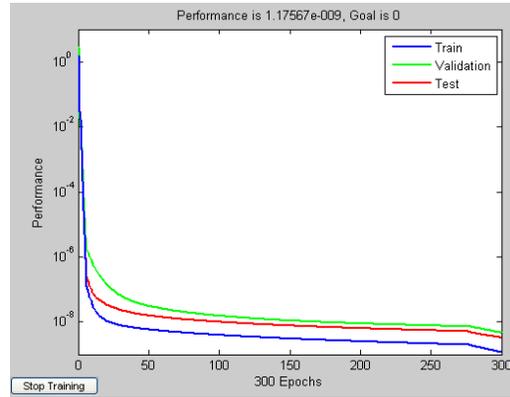
(b)

Figure 5.   Neural Network Model Training Results of Manipulator

Optimization algorithm in this article also uses neural network to achieve, set the time-domain involved in the optimization value of 2, using the BP network neural of hidden layer neuron number 7, the same learning rule Levenberg-Marquartdt do the online training to achieve the control signal to the continuous optimization. Training block diagram is shown in the dashed box in Fig.4. Neural network optimization device in accordance with a given input signal u produce predictable output u1, u1 is imposed to the neural network model of the controlled object to produce predictable output y1, y1 compare with the desired output u of the system, and both the difference to train the neural network optimization. Then, the output u2 of the e2 enough litter as the actual amount of control applied to the actual controlled object. Visible, the optimizer in the regulation system is the inverse model of the charged object. Y1 can also be compared with actual output y2, and the error e1 and the actual input u2 of charged object, output y2 as the data of training charged object neural network model.

C. Feedback Correction

Feedback correction is forecast control to keep the dynamic correction forecasting model to ensure that the prediction model with infinitely close to

7

the actual controlled object, and make optimization algorithm establish on the basis of the correct prediction of the system state then the new optimization. Error e1 is the amendment process of the neural network model of the controlled object. Neural network prediction model is built on the basis of the past run data in system, the new operating environment and the actual system has the nonlinear, time-varying, interference and other factors make prediction model based on neural networks need to constantly learn to modify their weights and even structure to ensure that it can well represent the actual controlled object to a control signal prediction.

VI.   SIMULATION ANALYSES

Build the Simulation block diagram shown in Fig. 6 under robotic arm Simulink environment, network training based on neural network predictive control by the steps in Fig. 4-Fig. 5, and at the role of the same random input signal gradually adjust the value of delay to simulation. The results in Fig.7. Show that the prediction control based on neural network has a good control performance to the fixed delay network. Further used random delay module shown in Fig. 8 (a) instead of fixed delay module in Fig.6 immediately delay module for delay characteristics of input shown in Fig. 8(b), where In. mat file stored random input signal in Fig. 6. There are used random input signal stored in this file in order to compare the simulation results in the simulation. Finally, simulation under the random delay conditions and results shows in Fig.8(c). Whether a fixed delay or random delay neural network predictive controller can satisfy the closed-loop control requirements in the network delay conditions.
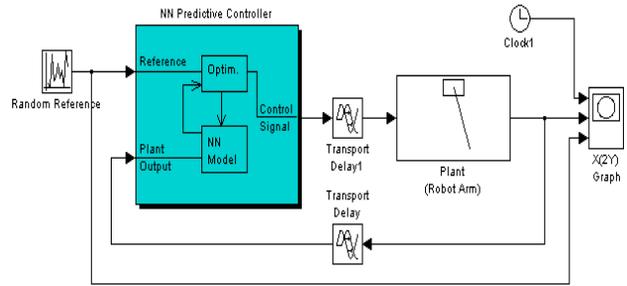
Figure 6.   Simulation of Network Closed-Loop Control System based on Predictive Neural
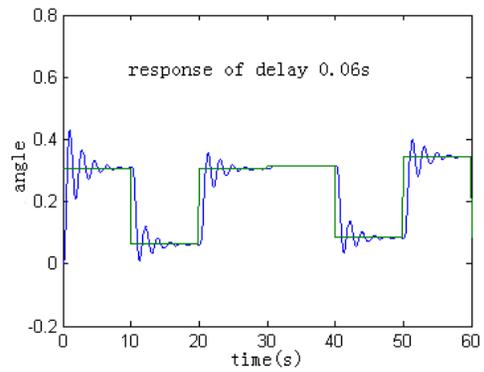
(a) Response of delay 0.06s
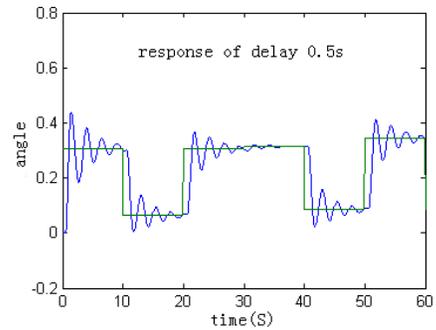
(b) Response of delay 0.5s

Figure 7.   Predictive Control Random Responses Curve based on Neural Network
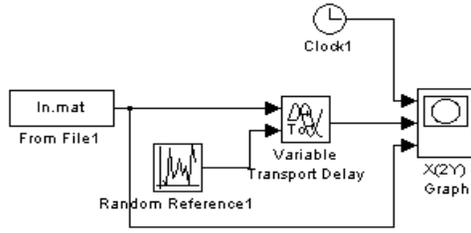
(a) Fixed delay module figure
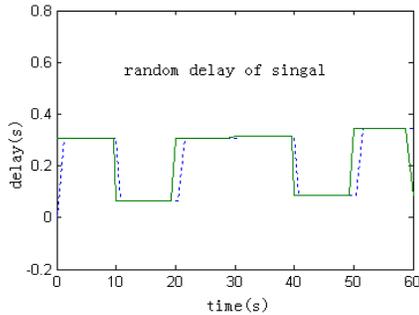
(b) Delay Curve under Random Delay
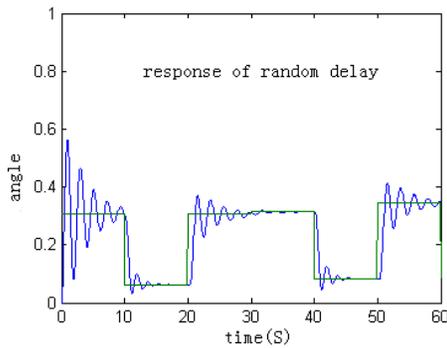
(c) Response Curve under Random Delay

Figure 8.   Responses under Random Delay

VII. CONCLUSION

This article discusses the difficulties of remote closed-loop control, that is the difficulty different from the general control system lies in the uncertain network delay exist in system channel and feedback channel and which greatly reduced the system stability and improved control system design difficulty. This paper described problems on the network closed-loop control from uncertain network delay to includes network delay controller design method, and studied the impact of network transmission delay on the network closed-loop control system, proposed by predictive control based on neural network to solve feasibility of the network control system which existence random delay closed-loop control, and verified the validity of the method by simulation.

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REFERENCES

[1] Xi Yu- geng, Li De-wei, Lin Shu, "Model predictive-status and challenges," Acta Automatica Sinica, vol.39 no.3, pp.713-717, March, 2018.

[2] Edlund K, Bendtsen J D, Jorgensen J B, "Hieratachical model-based predictive control of a power plant portfolio," Control Engineering Practice, vol.19, no.10, pp.1126-1136, 2019.

[3] Zheng Y, Li S Y,   LiN, "Distributed model predictive control over network information exchange for large-scale systems", Control Engineering Practice, vol.19, no.7, pp.757-769, 2017.

[4] Lin S, De Schutter B, Xi Y G, Hellendoorn H, "Fast model predictive control for urban road networks via MILP," IEEE Transactions on Intelligent Transportation Systems, vol.2, no.3, pp.846-856, 2018.

[5] Ghods A H, Fu L P, Rahimi-Kian A, "An efficient optimization approach to real-time coordinated and integrated freeway traffic control," IEEE Transactions on Intelligent Transportation Systems, vol.11, no.4, pp.873-884, 2019.

[6] Zu-de, Z. and C. Ben-yuan, "Research of Networked control system time delay distribution," Control and decision, vol .25, no .4, pp.592-597, 2017.

[7] Shou-ping, G. and Y. Ting, "Network control system predictive control based on pole placement and time delay error compensation," Information and control, vol .38, no .1, pp.37-42, 2019.

[8] Yah, Z., W. Wei and Y. Wei-Ming,. "The research and development of network based robot control technology," Robot, vol .24, no .3, pp.276-282, 2017.

[9] Huang, J.Q., F.L. Lew and K.A. Liu, "Neural predictive control for telerobot swith time delay," Journal of Intelligent and Robotic Systems, vol.29, pp.1- 25, 2019.

[10] Chen, S., C.F.N. Cowan and P.M. Grant, "Orthogonal Least Squares Learning Algorithm for Radial Basis Function Networks," IEEE Transactions on Neural Networks, vol. 2, no.5, pp. 302-309, 2016.

[11] Lian Fengli, "Network design consideration for distributed control systems," Control Systems Technology, vol.10, no.2, pp.297-307 , March 2015.

[12] ZHUANG Yah, WANG Wei, YUN Wei-ming. "The research and development of network based robot control technology," Robot, vol.24, no.3, pp. 276-282, 2016.

[13] Y. Kanayama, N. Miyake, "Trajectov Generation for Mobile Robots,"Robotics Research, the MIT Press, vol.3, no.6, pp.333-340, 2016.

[14] Guoping Zhang, Wentao Gong, "The Research of Access Control Based on UCON inthe Internet of Things," Journal of Software, vol.6, no.4, pp.724-731, 2017.

[15] Jingyang Wang, Min Huang, "Research on Detectable and Indicative Forward Active Network Congestion Control Algorithm," Journal of Software, vol. 7, no.6, pp.1195-1202, 2012.

[16] Yuan Gao, Peng-yu Liu and Ke-bin Jia, "A Fast Motion Estimation Algorithm Based on Motion Vector Distribution Prediction," Journal of Software, vol. 8, no.11, pp.2863-2870, 2013.

Deep Periocular Recognition Method via Multi-Angle Data Augmentation

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Abstract—**Periocular recognition technology is a biometric recognition technology widely used in identity verification. Because of its high precision, high ease of use and high security, Periocular recognition has a broad application prospect and scientific research value. In order to solve the problem of angular rotation of eyes in practical application, this paper proposes a deep learning periocular recognition method based on multi-angle data augmentation. The method is to rotate the original data set from small angle to large angle, so that the amount of data is expanded to 7 times of the original, and the diversity of data is increased at the same time. The InceptionV3 network and MobileNetV2 lightweight network are used for experimental verification respectively, and good results are obtained from multi-angle tests, indicating that the proposed method can improve the generalization ability of the model and has good robustness.**

Keywords-Periocular Recognition; Deep Learning; Convolutional Neural Network; Lightweight Model

I. INTRODUCTION

Identity identification is a basic problem in social life [1], which is not only closely related to the interests of individuals, but also affected national security and social stability. This paper studies the periocular recognition technology based on deep learning, which is to use the image of the eye area to identify the identity of people. Due to the high precision, high ease of use and high security of the eye circumference [2], it is easy to obtain eye images, analyze various information of the eye region, and integrate their respective characteristics to achieve accurate, rapid and robust identification. Periocular recognition has important application value and theoretical value.

Research on periocular recognition started late, and Park [3] initially proposed that eye peripheral area could be used for identity recognition. In the

following studies, they gradually found that the periocular recognition system performed better, but its performance was not stable, due to illumination and blurring, resulting in less texture information. Many researchers had designed different periocular recognition systems for this kind of problem. Kumar [4] had developed various biometric recognition systems using different feature sets and different classifiers to identify subjects by using some reliable segmentation methods, efficient feature extraction methods and various classifiers or classifier integration. In 2017, a hybrid method based on transformation, structure and statistics, namely deep convolutional neural networks (CNNs), was proposed by Proenca and was also used to build periocular recognition systems. At the same time, Canadian professor Hugo. Proenca [5] also proposed to use neural network to process the human eye areas outside the eye, and to take the features extracted from these areas as a mode of identity recognition and attribute recognition.

In order to solve the problem of angular rotation of eyes in practical application, this paper proposes a deep learning periocular recognition method based on multi-angle data augmentation. The method is to rotate the original data set from small angle to large angle, so that the data volume is expanded to 7 times of the original, and the diversity of data is increased. InceptionV3 network and MobileNetV2 lightweight network are used for experimental verification respectively, and good results are obtained, indicating the feasibility of the proposed method.

II.   METHOD

The periocular recognition method based on deep learning in this paper is divided into deep neural network training and testing, as shown in figure 1. The training part of the network including the preparation of training data, data normalization, pre-processing operations, data enhancement, as well as the construction of the network, network parameters setting and adjustment. In the test part, the test image data can be input into the trained network to obtain the classification and recognition results.

The data enhancement method in this paper increases the number of samples, makes the data more diverse, and improves the generalization ability of the model. This method also enhances the robustness of the model and increases the practicability of the system by multi-angle and large-angle rotation of the eye image in the original database. The convolutional network adopts InceptionV3 network and MobileNetV2 lightweight network to carry out convolutional operation to extract features, train them separately, and obtain two recognition models. The recognition results of the two CNN models [6] are obtained through experiments.
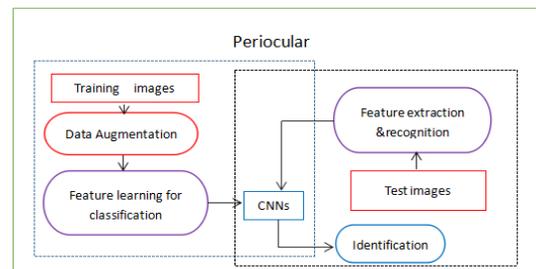
Figure 1.   Data flow chart of the system

A.   InceptionV3 Network Architecture

Inception module is proposed to solve the problem that the difference in image content cannot effectively extract image information. The core is to split the layered network convolution kernel into different size convolution kernels, such as 3×3 convolution kernels split into $\times1,3\times3$ convolution kernel, increases the size of the output network layer, such as 30×30, step size is 1, use 3×3 convolution kernel, without filling, the output image size is 28×28, If 1×1 and 3×3 convolution kernels are used to extract image information, the output depth map size is 30×30 and 28×28, and the acquired image information is richer than a single convolution kernel.

The InceptionV3 network architecture [7] consists of 11 Inception modules with a total of 46 layers. The package contains a total of 96 convolution layers. Table Ⅰ below shows the overall structure of the InceptionV3 network model. Since Google InceptionV3 is relatively complex and the raw approach to building is resource- intensive, using the TensorFlow Slim tool can greatly reduce the amount of code needed

to design InceptionV3. So the TensorFlow Slim tool is used to help build the network.

Type	Size of Convolution Kernel/Step Size
convolution	$3\times3/2$
convolution	$3\times3/1$
convolution	$3\times3/1$
pooling	$3\times3/2$
convolution	$3\times3/1$
convolution	$3\times3/2$
convolution	$3\times3/1$
Inception modules	3 Inception Module
Inception modules	3 Inception Module
Inception modules	3 Inception Module
pooling	8×8
linear	logits
Softmax	Classification of output

B. MobileNetV2 Network Architecture

In recent years, numerous researchers have put forward various lightweight network models successively, such as SqueeZenet, MobileNetV1 [8], ShuffleNetV1 [9], ShuffleNetV2 [10], and MobileNetV2 [11]. In the above network architecture, the test results of MobileNetV2 and ShuffleNetV2 models are relatively good. The MobileNetV2 model uses deep separable convolution, linear bottleneck and reverse residual structure to maintain a certain degree of accuracy while keeping the number of parameters and computational complexity low. MobileNetV2 draws lessons from the RESNET network in the MobileNetV1 model based design. MobileNetV1 is designed according to the conventional convolution neural network chain structure, such as VGGNet model is to pile up in the form of convolution layer to build a network model, therefore, to some extent, improved the accuracy, the innovation points of this model is that the standard separation convolution with depth, reduce the size of the model, to some extent, computational complexity has been reduced. In addition, two compression hyperparameters are used to further shrink the network. However,

because of this, too many convolutional layers will cause the problem of gradient disappearance.

ResNet networks [12] have a great fluidity of information between layers due to the use of residual units. Therefore, MobileNetV2 uses the deep separable convolution base of MobileNetV1 and ResNet's residual unit for reference. MobileNetV2 network introduces a linear bottleneck structure and combines the reverse residual structure to complete improvements in these two aspects.

Table Ⅱ shows the concrete implementation structure of the core building block of MobileNetV2, which is based on the Depth Separable Convolution Block of Reverse Residual, changing the number of input characteristic channels from N to M, where S represents the step size and T represents the expansion rate. A 1×1 convolution layer was added in front of the deep separable convolution layer, and the nonlinear activation function behind the point-by-point convolution layer was deleted to change the nonlinearity into linearity. Finally, in order to realize the subsampling, the scheme adopted is to set the step size parameter in the deep convolution.

Input	Operator	Output
$H\times W\times N$	1×1 conv2d, ReLU6	$H\times W\times t\,N$
$H\times W\times t\,N$	3×3 dwise s=s, ReLU6	$H/s\times W/s\times t\,N$
$H\,s\times W\,s\times t\,N$	linear 1×1 conv2d	$H/s\times W/s\times t\,N$

MobileNetV2 overall network structure as shown in table Ⅲ, every row describes one or more than one layer of the same sequence of loop n times, all sequence of layers have the same output channel number c, the sequence of the first layer step for s, residual layer of step 1, all the size of the space convolution kernels are the specifications of the 3 x 3, expansion ratio t always used the input characteristics described in table Ⅱ. The MobileNetV2 model has an initial full convolutional layer of 32 convolutional cores, and then 17 reverse residual bottleneck modules are connected. The nonlinear activation function adopts ReLu6 with good robustness in the

calculation with low precision, and the size selection of convolutional cores is 3×3[14].

TABLE III.   OVERALL ARCHITECTURE OF MOBILENET V2

Input	Operator	t	c	n	s
224×224×3	Conv2d	-	32	1	2
112×112×32	Bottleneck	1	16	1	1
112×112×16	Bottleneck	6	24	2	2
56×56×24	Bottleneck	6	32	3	2
28×28×32	Bottleneck	6	64	4	2
14×14×64	Bottleneck	6	96	3	1
14×14×96	Bottleneck	6	160	3	2
7×7×160	Bottleneck	6	320	1	1
7×7×320	Conv2d 1×1	-	1280	1	1
7×7×1280	Avg pool 7×7	-		1	-
7×7×1280	Conv2d 1×1	-	1000	-	

C. Data Augmentation

In the process of neural network training, the stability of the model is proportional to the robustness, the number, and diversity of the training set data. However, the quality of the actual eye image acquisition may be poor. Therefore, the eye image in the original database is rotated from multiple angles to make the original database more diverse [15]. At the same time, after the multi-angle rotation expansion, the problem of an insufficient number of eye images in the original data set is also solved, so as to improve the stability of the neural network training process. The schematic diagram of a partial processing of the eye peripheral sample is shown in Figure 2 to 7. The eye peripheral sample is rotated at 30°, 60°, 90°, 120°, 150°, and 180° respectively. Without the above method, in real life, if the user is slightly tilted or the angle of the device changes, the model will not be able to correctly recognize and judge, resulting in wrong recognition results. This will greatly affect the robustness of the model.
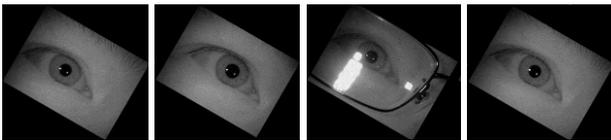
Figure 2.   Treatment diagram of the sample rotated by 30° around the eye
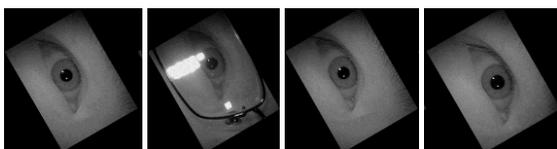
Figure 3.   Treatment diagram of the sample rotated by 60° around the eye
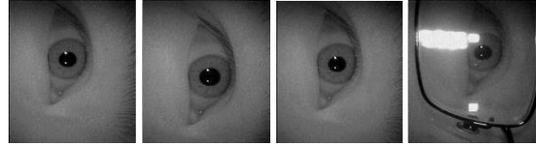
Figure 4.   Treatment diagram of the sample rotated by 90° around the eye
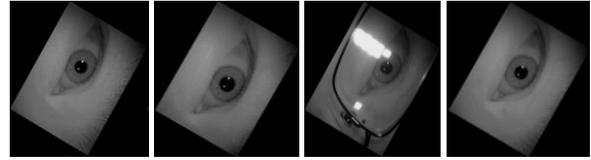
Figure 5.   Treatment diagram of the sample rotated by 120° around the eye
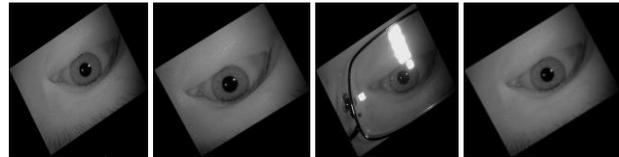
Figure 6.   Treatment diagram of the sample rotated by 150° around the eye
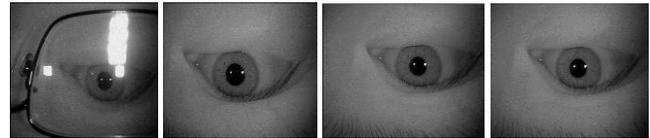
Figure 7.   Treatment diagram of the sample rotated by 180° around the eye

After rotation of 30°, 60°, 90°, 120°, 150° and 180°, the data volume of each group was amplified 6 times. Before the training set, each group had 6 pieces, and after amplification, each group had 42 pieces. Before amplification, the verification set and test set were 2 pieces in each group, and after amplification, 14 pieces in each group. The total number of data sets is 42, 000.

III.   EXPERIMENT AND RESULTS

The experiment in this paper is carried out under Linux Ubuntu 16. 04 system, using NVIDIA GeForce RTX2080Ti ×4 graphics card, Intel Xeon Gold 6254×2 CPU, 128G memory, 960G SSD hard disk +8TB mechanical hard disk. GPU acceleration is used to increase computing efficiency and speed, and CUDA10. 0 is configured. The Python environment is version 3. 6. 5, with TensorFlow as a neural network framework [16].

A. The Data Set

The eye peripheralr data set used in this experiment is the CASIA-IRIS-Thousand periocular image in the IRIS database CASIA-

IRIS 4. 0 of Chinese Academy of Sciences. In this group, there are a total of about 1000 people's eyes and a total of 20, 000 eyes. The eyes of about 500 people were selected. Table Ⅳ shows the sample distribution of the experimental eye peripheral data set. As shown in Figure 8, the partial eye peripheral sample of 000L category in the eye peripheral data set is shown.

Figure 8.   Diagram of 000L partial eye sample

TABLE IV.   SAMPLE EYE PERIPHERAL DATASET

Eye Peripheral Data Set	Original Training Set	Raw Verification Set	Raw Test Set	Total Original Sample	Original Sample Type
CASIA-Iris-Thousand	6000	2000	2000	10000	1000

After the above data augmentation, the sample of the data set changed to the eye peripheral data set amplified by rotation, as shown in Table Ⅴ. 30 °, 60 °, 90 °, 120 °, 150 °and 180 °image datas are added in the training set, verification set and test set. Training, validation and testing experiments are performed on the amplified eye peripheral data set.

TABLE V.   AMPLIFIED SAMPLES OF THE DATA SET AROUND THE EYE

Eye Peripheral Data Set	Training Set	Verification Set	Test Set	Total sample	Sample Type
CASIA-Iris-Thousand	42000	14000	14000	70000	1000

B.   InceptionV3 test results

After the eye peripheralr data set is prepared, specific experimental parameters are set, as shown in Table Ⅵ: The maximum number of steps is set to 20000 rounds, the batch size is set to 24 pieces, the learning rate decay type indicates whether the learning rate drops automatically, which is set to fixed, the learning rat is set to 0. 001, RMSProp is selected by the optimizer and weight decay of all parameters in the model is set to 0. 00004. As shown in figure 9, in the training process of the periocular recognition model based on the InpetionV3 network on the eye peripheralr data training set, its loss function decreased rapidly

from the beginning of training to 5000 rounds, after which the loss function value tended to be flat.

TABLE VI.   PARAMETER SETTINGS

Parameter Types	Parameter Settings
Max number of steps	20000
Batch size	24
Learning rate	0. 001
Learning rate decay type	fixed
optimizer	RMSProp
Weight decay	0. 00004
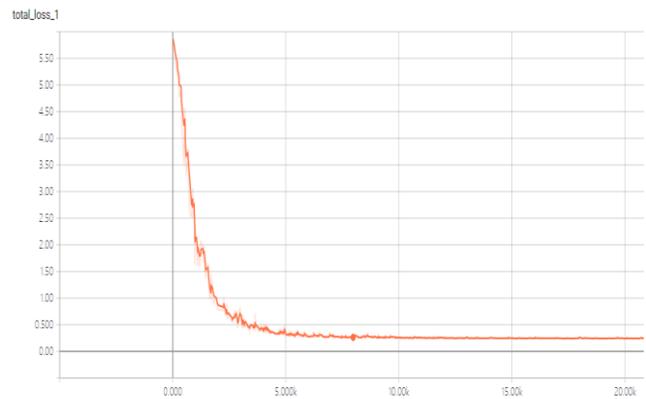
Figure 9.   Loss function diagram of InceptionV3 network model

After model training, validation set is used to verify the model. The verified accuracy rate is 98%. Finally, all the samples around the eyes of the test set are tested and the accuracy rate is 98%. It can be seen that the rotating samples with small and large angles, such as 30 °, 60 °, 90 °, 120 °, 150 ° and 180 °, can be well recognized.

C.   MobileNet V2 test results

MobileNetV2 is used as the recognition method of Convolutional Neural Network and InceptionV3 network. The eye peripheral data sets are all expanded eye peripheral images. A total of 1000 groups of eye peripheral samples, 42 samples for each group, 42, 000 training sets, 14, 000 verification sets and 14, 000 test sets.

The experimental parameters of the MobileNetV2 lightweight network model are set as Table Ⅶ. The maximum number of steps is set to 100000 rounds, the batch size is set to 32, the learning rate decay type indicates whether the bearning rate automatically drops, which is set to

fixed, and the learning rate is set to 0. 001. RMSProp is selected by the optimizer and weight decay is set to 0. 00004 for all parameters in the model. As shown in figure 10, in the periocular recognition model based on the MobileNetV2 lightweight network, in the training process of the training set using the eye peripheralr data, the change of its loss function drops sharply at the beginning, but with the progress of training, when the iteration reaches 20000 rounds, the loss function becomes flat.

TABLE VII. NETWORK MODEL PARAMETER SETTING

Parameter Types	Parameter Settings
Max number of steps	100000
Batch size	32
Learning rate	0. 001
Learning rate decay type	Fixed
optimizer	RMSProp
Weight decay	0. 00004
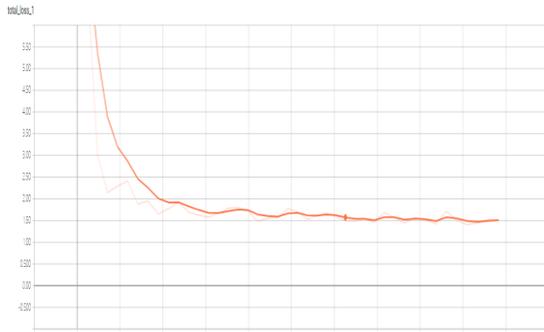
Figure 10. Change diagram of loss function of the MobileNet V2 lightweight network model

The verification accuracy of the MobileNetV2 lightweight network model is 98. 21%. The validation accuracy of the IncpetionV3 network model is 98. 55%. After the training, the model is generated. The file size generated by the IncpetionV3 network model is 93MB, and the MobileNetV2 lightweight network model is 24MB. The MobileNetV2 lightweight network model is 3. 8 times smaller than the incpetionV3 network model when the verification accuracy is only 0. 3% lower. Therefore, the periocular recognition based on lightweight convolutional neural network model is feasible.

The same method is used to test the test set. The test set samples are rotated from multiple angles to test the robustness of the model. After the rotation of the test set, the model is still able to be recognized normally. The accuracy of the IncpetionV3 network model test is 98. 5%, and the MobileNetV2 lightweight model test is 98. 4%.

TABLE VIII. COMPARISON OF INCPETION V3 AND MOBILENET V2 METHODS

Methods	Verification Accuracy	Test Accuracy	Model Size
IncpetionV3	98. 55%	98. 5%	93MB
MobileNetV2	98. 21%	98. 4%	24MB

The eye images of the test set are tested on the two models respectively. As shown in figure 11, when testing the samples belonging to 302R, models with or without glasses can be correctly identified and the category of the tested samples can be correctly output.
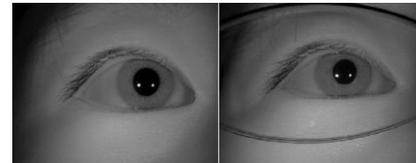
Figure 11. 302R test sample diagram

It can be found from the eye samples that failed in the test, as shown in figure 12, that the feature information of the eye can no longer be accurately extracted due to a large amount of specular reflection interference. In fact, such samples do not meet the conditions of sample collection, which will have a great impact on the recognition accuracy of the model. However, the accuracy of the IncpetionV3 network model test is 98. 5%, and the MobileNetV2 lightweight model test is 98. 4%, even when large specular interference samples are included. Therefore, it can be concluded that the model in this paper still has a good recognition effect under the interference of such factors.

Figure 12. Specular interference around the eye sample

Follow-up, the eye images with specular reflection that has affected the image feature information in the test set are removed. The remaining samples are being tested. The accuracy of the IncpetionV3 network model test is 99. 8%, and the MobileNetV2 test is 99. 4%. It is concluded that the accuracy of both the traditional model and the lightweight model are improved when the image samples with great influence of mirror radiation are removed.

IV. CONCLUSION

This paper mainly studies the periocular recognition technology based on deep learning, and uses the convolutional neural network InceptionV3 model to take the eye circle image as the input of the model, greatly shortening the steps of the entire recognition process. In fact, there are few angular rotation of eyes, so the original data can be more diversified by enhancing the eye image in the original database and carrying out multi-angle rotation. Then, according to the demand of mobile terminal, the application of lightweight model MobileNetV2 is proposed, which is used as the feature extraction classification architecture, and the periocular recognition technology based on lightweight convolutional neural network model is obtained. Experimental results show that both models can achieve satisfactory results after multi-angle data augmentation.

REFERENCES

[1] Miao Di. Multi-modal biometric feature fusion based on feature layer and fractional layer [D]. University of Science and Technology of China, 2017:1-2.

[2] Zhang Xiaobo. Fusion of eye circumference and iris information for identification [D]. Chinese Academy of Sciences, 2012:1-2.

[3] U. Park, A. Ross, A. K. Jain. Periocular biometrics in the Visible spectrum: A feasibility study[C]. In Proceedings of IEEE International Conference on Biometrics:Theory Applications and Systems, 2009:1-6.

[4] Saiyed Umer, Alamgir Sardar, Bibhas Chandra Dhara, Ranjeet Kumar Rout, Hari Mohan Pandey. Person identification using fusion of iris and periocular deep features [J]. Neural Networks, 2020, 122.

[5] He Yong. Research on the preprocessing and recognition method of human eye biometric image [D]. Hunan Industrial Science, 2020:6-7.

[6] Wu Xue, Song Xiaoru, Gao Song, Chen Chaobo. A Survey of Target Detection Algorithms Based on Deep Learning [J]. Sensors and Microsystems, 2021, 40(02):4-7.

[7] Ketan Joshi, Vikas Tripathi, Chitransh Bose, Chaitanya Bhardwaj. Robust Sports Image Classification Using InceptionV3 and Neural Networks [J]. Procedia Computer Science, 2020, 167.

[8] Sun Yan, Ding Xuewen, Lei Yuting, Chen Jing, Kong Xiangxin. Image Recognition of Dogs and Cats Based on SSD_Mobilenet_v1 Network [J]. Journal of Tianjin Polytechnic Normal University, 2020, 30(01):38-44.

[9] Zhang Xiangyu, Zhou Xinyu, Lin Mengxiao ShuffleNet: An Extremely Efficient Convolutional Neural Network for Mobile Devices [J]. 2017:14-15.

[10] Ma Ningning, Zhang Xiangyu, Zheng Haitao. ShuffleNetV2: practical guidelines for efficient CNN architecture design [J]. 2018:33-34.

[11] Lan Tianxiang, Xiang Ziyu, Liu Mingguo. Fast Semantic Segmentation Network Combining U-Net and MobileNet-V2 [J]. Computer Engineering and Applications, 2015:1-8.

[12] He Kaiming, Zhang Xiangyu, Ren Shaoqing. Deep Residual Learning for Image Recognition [J]. 2015:13-15.

[13] Han D, Kim J, Kim J. Deep pyramidal residual networks [J]. 2016:18-19.

[14] Bi Pengcheng, Luo Jianxin, Chen Weiwei. Research on Lightweight Convolutional Neural Network Technology [J]. Computer Engineering and Applications, 2019(16):25-35.

[15] Chen Chen. Research on Hyperspectral Image Classification Based on Convolutional Neural Network Based on Data Enhancement [D]. Beijing University of Chemical Technology, 2020, 45.

[16] Wang Hengtao. Image Recognition Integrated System Based on TensorFlow, Keras and OpenCV [J]. Electronic test, 2020(24):53-54.

Review of Bounding Box Algorithm Based on 3D Point Cloud

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Abstract—**Collision detection is mainly to judge whether there is intersection between virtual models, which means there is collision. Bounding box is one of the important methods of collision detection. It uses regular geometry with simple structure to replace the complex model to be detected. A simple point cloud model usually contains hundreds or thousands of polygons when meshed. When collision tests are performed directly on the geometry of two model objects, the calculation process is relatively complex. In order to reduce the computational cost, the bounding box test of the model was performed before the geometry intersection test. Only when the bounding box has a collision, can further accurate intersection detection be carried out. This paper mainly introduces the content and significance of the bounding box, and compares four kinds of common bounding boxes and their advantages and disadvantages as well as the application scenarios of the bounding box. Firstly, the content and significance of the bounding box are expounded. Secondly, it is analyzed according to different bounding boxes. Finally, the different bounding box algorithms are summarized, and the advantages and disadvantages of different bounding boxes and application scenarios are pointed out.**

Keywords-Virtual Reality; Point Cloud; Collision Detection; Bounding Box

I. INTRODUCTION

Virtual reality technology is closely related to many disciplines, which is widely used in simulation teaching, medical surgery, urban planning, industrial simulation and other fields [1]. In various virtual reality applications, objects in the virtual system often collide with each other due to the interaction between users and objects in the virtual environment. In order to maintain the authenticity of the virtual environment, the system needs to timely judge the occurrence of collisions and make corresponding operations, otherwise it will violate the authenticity of the real world and the user's experience [2]. Collision detection in virtual reality technology is a hot research direction is also one of the most important problems. Collision detection is to determine whether two or more objects in the same space have contact or intersection [3]. If a collision occurs, the collision response will be triggered and the virtual reality system will be guided to the next operation. Collision detection algorithms can be roughly divided into two categories: time domain and space domain [4]. Bounding box is a kind of detection algorithm based on spatial domain. It has the advantages of high detection efficiency and simple detection process [5].

For the complex model to be tested, the thought of bounding box is to surround the model to be tested with simple bounding box whose volume is slightly larger than the model to be tested and whose geometric features are regular [6]. When collision detection is done on two objects, the first detection is to check whether the bounding box intersects. If not, the two objects do not intersect. On the contrary, it is necessary to further accurately detect the two objects. This method can quickly exclude disjoint objects and reduce unnecessary calculation.

II. BOUNDING BOX

Many scholars have studied and explored the bounding box algorithm. The results show that the choice of bounding box algorithm is one of the key factors affecting the result of collision detection. The more compact the virtual model under test is wrapped by a bounding box, the simpler the set features are, indicating that its wrapping effect is better. But at the same time in bounding box algorithm, its simplicity and compactness are usually contradictory [7]. So the researchers came up with a different algorithm. Palmer and Grimsdale et al. [8] proposed a collision detection algorithm based on spherical bounding boxes. Smith et al. [9] proposed an intersection detection algorithm based on AABB axial bounding box. Both the bounding sphere and the AABB bounding box are simple in construction, but poor in tightness. Therefore, Gottschalk et al. [10] proposed the construction of OBB bounding boxes based on the theory of Smith's AABB bounding boxes. Klosowski et al. [11] also proposed a collision detection algorithm using *k*-DOP bounding boxes by studying the characteristics and spatial tightness of AABB bounding boxes. Therefore, the common bounding box algorithms include Bounding Sphere (Sphere), Axis-Aligned Bounding Box (AABB), Oriented Bounding Box (OBB) and discrete oriented polytope (*k*-DOP).

A. Bounding Sphere

Bounding sphere is defined as the smallest volume sphere that can encase the model to be tested [12]. It is a kind of bounding body with good simplicity and flexible structure. To determine the bounding sphere, it first need to determine the center of the bounding sphere, which is composed of the mean value of the vertex coordinates of all elements in the model to be measured. Then determine the radius of the sphere, which is the distance between the center of the ball and the points specified by the three maximum coordinates. The three-dimensional structure of the bounding sphere is shown in Figure 1.
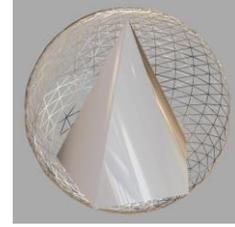
Figure 1.   Three dimensional of the Bounding Sphere.

The radius of the sphere can be expressed as the distance between the farthest vertex and the center of the sphere, and the center of the longest axis is the center surrounding the sphere. The bounding sphere is expressed as formula (1):

$$R = \{(x, y, z) | (x - O_x)^2 + (y - O_y)^2 + (z - O_z)^2 < r^2\} \qquad (1)$$

O_x, O_y, O_z represent the x, y, z coordinates of the spherical center O, and r is the radius.

The principle of intersecting detection between bounding spheres is as follows: judging from the relationship between the sum of the center distance and radius between two spheres, if A and B represent two bounding spheres, the intersection of A and B is only necessary and sufficient if $|d| < (r_1 + r_2)$ is true. This is shown in Figure 2.
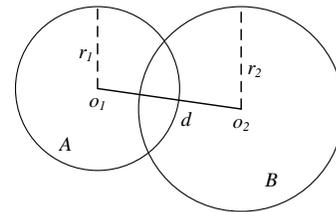
Figure 2.   Intersecting test between spheres.

For update operations, only rotation and translation are needed to satisfy any operation in space. The update operation of the bounding sphere is that no matter the object rotates or moves along any axis or any point, the bounding sphere always wraps the model under test. Therefore, for a translation operation, it just need to do the same transformation of the center of the sphere according to the translation vector, while for a rotation, it don't need to do any update operation, and the position of the center of the sphere doesn't change no matter how rotate it. When compared to other bounding boxes, the advantage of the bounding sphere is obvious. It requires the least

amount of computation compared to other bounding boxes.

By reason of the foregoing, although the calculation of the bounding sphere is small, its tightness is also poor. There are too many redundant calculations for most objects with uneven spatial distribution such as irregular geometric models or elongated objects. Because of its structural characteristics, it is suitable for the movement environment where the detection accuracy is not high. Therefore, when selecting the bounding box, the bounding box that is closer to the model to be tested should be selected, and the best scheme should be selected after comprehensive consideration of the advantages and disadvantages.

B. Axis-Aligned Bounding Box

An Axis-Aligned Bounding Box(AABB) is defined as the smallest hexahedron that wraps the model under test in the same direction as the coordinate axis, so only six scalars are needed to describe an AABB [13]. It was the first bounding box to be used. Determining an AABB requires calculating the maximum and minimum values of the x, y, and z coordinates of the vertices of each element in the set of basic geometric elements that make up the object. The three-dimensional structure of the AABB is shown in Figure 3.
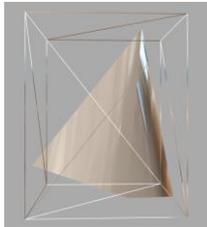
Figure 3.   Three dimensional of the Axis-Aligned Bounding Box.

In the construction of AABB, all bounding boxes have the same direction along the axial direction of the local coordinate system of the model. AABB is expressed as formula (2):

$$R = \{(x, y, z) | x_{min} \le x \le x_{max}, y_{min} \le y \le y_{max}, z_{min} \le z \le z_{max}\} \quad (2)$$

x_{min}, y_{min}, z_{min}, x_{max}, y_{max}, z_{max} represents the minimum and maximum values of the projection of the model on the x, y, and z axes.

The principle of intersection detection between AABB is as follows: if the vertex of the model intersects all the projected intervals on the three coordinate axes, collision may occur between the detection models. If A and B represent two AABB, where l_A and l_B are the projections of A and B bounding boxes on the X-axis respectively, x_A and x_B are A respectively, and the projections of O_A and O_B on the X-axis of the middle points of B bounding boxes. If $|d| < (l_A + l_B)$, then it means that the projection of the bounding box A and B on the X-axis overlaps, otherwise, the projection of the bounding box on the X-axis does not overlap. In the three-dimensional space, the intersection test of AABB bounding box needs at most 6 comparison operations. This is shown in Figure 4.

Both translation and rotation have an impact on the AABB update operation, which is not complicated due to the simplicity of AABB. In the case of translation operation, there is no need to rebuild AABB, but only need to change the vertex coordinates of AABB according to the direction vector and displacement of target model translation. In the case of rotation operation, the coordinates of the rotated vertices need to be calculated by rotation Angle and then re-projected to the x, y and z axes to get the maximum and minimum values, and then rebuild AABB. Similarly, AABB can be used in a wide range of scenarios, including rigid body and soft body.
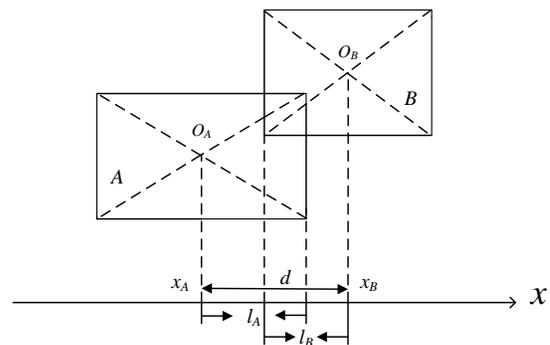

Figure 4.   Intersecting test between AABB.

C. Oriented Bounding Box

Oriented Bounding Box(OBB) is defined as the smallest cuboid that wraps the model to be tested and is in an arbitrary direction relative to the coordinate axis[14]. The most important feature of

OBB is its arbitrary orientation, which makes it possible to surround the model as closely as possible according to the shape characteristics of the surrounded model, but also makes its intersection test complicated. OBB approximates the model more closely than bounding sphere and AABB, which can significantly reduce the number of bounding volumes, thus avoiding the intersection detection of a large number of bounding volumes. The difficulty is to determine the direction to minimize the volume of OBB according to the three-dimensional structure of the model to be tested. The three-dimensional structure of the OBB is shown in Figure 5.
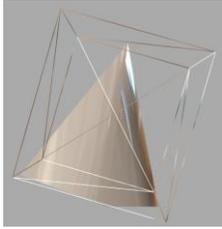
Figure 5.   Three dimensional of the Oriented Bounding Box.

Because of the flexible orientation of the OBB and its ability to wrap the model under test more tightly, it is difficult to create and update the bounding box for collision detection. The OBB region can be expressed as formula (3):

$$R = \{O + ar_1v_1 + br_2v_2 + cr_3v_3 | a,b,c \in (-1,1)\} \qquad (3)$$

O represents the center of OBB. r_1, r_2, r_3 represent the radii of x, y, z coordinate axes respectively. v_1, v_2, v_3 are used to calculate the direction of OBB respectively, which is a vector mutually orthogonal to the direction of coordinate axes.

The principle of OBB's intersecting detection is complicated, and it uses the Separating Axis Theorem (SAT) test. If you can find A straight line so that the bounding box A is exactly on one side of the line and the bounding box B is exactly on the other side, then the two bounding boxes do not overlap. This line is the separation line and must be perpendicular to the separation axis. The two-dimensional schematic diagram of the testing principle is shown in Figure 6. If A and B

represent two OBB bounding volumes, then A and B intersect only if $|T \cdot L| \le l_A + l_B$ is true. T represents the displacement vector between A and B, and L is the unit vector parallel to the separation axis.
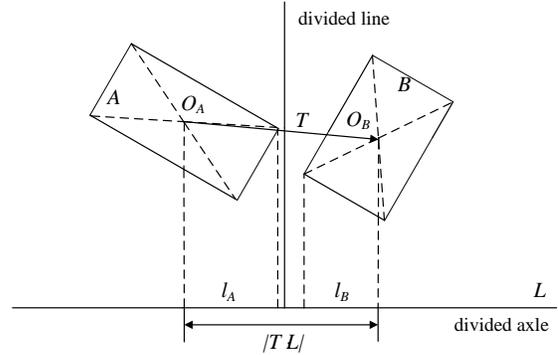
Figure 6.   Intersecting test between OBB.

OBB's update operations for rotation and translation are less computationally intensive. When the model is translated or rotated, the OBB needs to be updated. A new OBB can be obtained by carrying out the same displacement or rotation on all direction vectors of the model.

OBB is used in a narrow range of scenarios, only between rigid bodies. For soft body, OBB is not applicable. When the object is deformed, the update and reconstruction of OBB hierarchy tree is cumbersome and the calculation is very large, so the real-time detection conditions cannot be guaranteed. There is no good solution to the problem of updating the OBB hierarchy tree, and the cost of rebuilding the bounding box hierarchy tree is too high, so OBB is not suitable for collision detection between soft bodies.

D. k-DOP

The discrete oriented polytope (k-DOP) is defined as a convex polyhedron that wraps the model to be tested and the normal vectors of all faces come from a fixed set of orientation (k vectors) [15]. K-DOP can surround the model to be tested more closely than other bounding volumes. The more directional axes it has, the closer it is to the model to be tested. Therefore, its construction difficulty and phase test are more complex. In fact, the AABB bounding box mentioned above is a special case of 6-DOP. When k value is infinite, the k-DOP bounding box

is actually the convex hull of the model, so the tightness of the *k*-DOP bounding box is the best among these kinds of bounding boxes.

The common *k*-DOP generally includes 8-DOP, 14-DOP, 18-DOP and 24-DOP. Since each *k*-DOP of the same category uses the same and fixed directional axis, the test process of intersection between them is similar to that of AABB. The test process can be simply described as finding whether there are separate projection intervals between two *k*-DOP on k/2 directional axes in turn. If there is a separate projection interval, the two *k*-DOP are separated from each other, and vice versa, the two *k*-DOP bounding boxes intersect.

The biggest drawback of *k*-DOP is that even if objects in space rarely collide, it is necessary to perform an update rotation operation on the bounding box to redetermine the maximum and minimum values on the axis. *K*-DOP update operation is that when the model rotates, *k*-DOP update computation is relatively large. In this case, we cannot simply update *k*-DOP by the same rotation, but recalculate *k*-DOP after rotation. However, the cost of recalculating a *k*-DOP vertex is high, so the idea of linear programming is adopted for optimization. For soft body, *k*-DOP

needs to update the deformed leaf node first, and then update the parent node according to the bottom-up method, so *k*-DOP is suitable for both rigid body and soft body environment.

III. SIMULATION AND ANALYSIS

This paper simulates the above three bounding box algorithms. The experiment uses VS2107 compilation environment and VTK visualization library. The 3D point cloud data is the rabbit point cloud data of Stanford in the format of pcd file. Entering point cloud data into it can get the bounding sphere, the bounding box of AABB and OBB that wraps the whole point cloud data. The simulation results are shown in Figure 7.

| (a) Sphere | (b) AABB | (c) OBB |
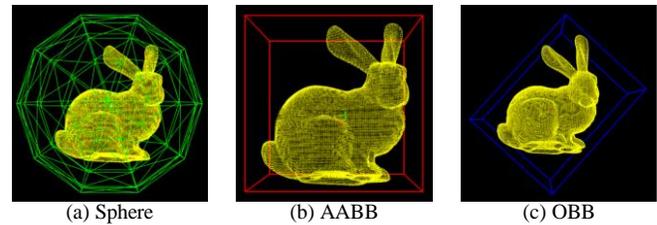
Figure 7. Simulation results of Sphere, AABB and OBB.

Comparison of various bounding box algorithms is shown in Table Ⅰ.

TABLE I.   COMPARISON OF VARIOUS BOUNDING BOX ALGORITHMS

Bounding box type	Simplicity	Tightness	Collision Detection Difficulty	Update the Difficulty	Application Scenarios
Sphere	simpler	worst	easiest	easiest	All
AABB	simplest	worse	easier	more difficult	Both rigid body and soft body are applicable
OBB	most complex	better	most difficult	easier	All
***k*-DOP**	more complex	best	more difficult	most difficult	All

Through the analysis of the table, it is found that the bounding sphere is relatively simple compared with other bounding boxes in terms of construction difficulty, collision detection difficulty and update calculation difficulty, and it has a wide range of applications, including rigid body and soft body. The only drawback is that it has the worst tightness surrounding the model. In the scene where the detection accuracy is not high, the bounding sphere algorithm can be given

priority. AABB is relatively simple in terms of construction difficulty and collision detection difficulty, and has the same disadvantage as the bounding sphere, which has a relatively weak enveloping tightness. It is also relatively difficult to update the calculation. In particular, AABB is not suitable for models with narrow and long shapes and direction deviating from the coordinate axis. OBB has strong bounding compactness and less updating calculation, but its disadvantage is

that compared with other bounding boxes, it is more difficult to construct and collision detection, and its application scope is smaller. The tightness of *k*-DOP is ideal, but its disadvantage is that it is more difficult to construct, detect, and update calculations than other bounding boxes. In the case of no consideration of real-time, *k*-DOP bounding box is the most suitable for the scene with very high precision requirements.

IV. CONCLUSION

Bounding box algorithm is a very important algorithm idea in ray tracing and collision detection. This paper introduces some classical bounding box algorithms and analyzes their advantages and disadvantages as well as their application scenarios and scope. It can be seen from this article that there is no one kind of bounding box is the best choice, but according to different scenes to select the most appropriate bounding box. The bounding sphere is simple but with poor accuracy; AABB is simple but complicated to calculate; OBB has good accuracy and simple update but complicated to construct; *k*-DOP has the best compactness but the most complex update, so it is not suitable for scenes with high real-time performance. This paper provides a theoretical basis for constructing hierarchical tree by selecting appropriate bounding boxes to balance construction difficulty, compaction difficulty, detection difficulty and updating calculation difficulty.

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REFERENCES

[1] Hongjie Chen. The Common Development of Virtual Reality Technology and Computer Technology Application [J]. International Journal of Computational and Engineering, 2020, 5(1).

[2] SUZUKI Masaya, NIWA Takeru, MASUDA Hiroshi. Path Planning in Engineering Plants Using Fast Collision Detection for Large-Scale Point-Clouds. 2016, 2016.26

[3] Gino Van Den Bergen. Collision Detection in Interactive 3D Environments [M]. Morgan Kaufmann Publishers Inc, 2004

[4] Yan S C, Zhou J Z, Zhu H J, et al. Summary of Collision Detection Algorithms in Virtual Maintenance Training System[J]. Machine Building & Automation, 2012.

[5] He Qunqiang, Chunhua Qian. A Collision Detection Algorithm in Virtual Assembly Technology [J]. Applied Mechanics and Materials, 2015, 3744.

[6] Palmer I, Grimsdale R. Collision detection for animation using sphere-trees [J].Computer Graphics Forum 1995; 14(2):105-16.

[7] Rongguo Zhang, Zhifang Wang, Xiaojun Liu, Kun Liu. Objects Collision Detection in Virtual Scene [J]. Advanced Materials Research, 2013, 2109.

[8] Palmer, I.J. and Grimsdale, R.L. Collision Detection for Animation using Sphere Trees. Computer Graphics Forum[C]. Computer Graphics Forum. Blackwell Science Ltd, 14: 105-116.

[9] Smith A, Kitamura Y, Takemura H, et al. A Simple and Efficient Method for Accurate Collision Detection Among Deformable Polyhedral Objects in Arbitrary Motion [C]. Proceedings Virtual Reality Annual International Symposium '95. IEEE, 2002.

[10] Gottschalk, Stefan & Lin, Ming & Manocha, Dinesh. OBBTree: A Hierarchical Structure for Rapid Interference Detection [J]. 171-180.

[11] J. T. Klosowski, M. Held, J. S. B. Mitchell, H. Sowizral and K. Zikan, "Efficient collision detection using bounding volume hierarchies of k-DOPs," in IEEE Transactions on Visualization and Computer Graphics, vol. 4, no. 1, pp. 21-36.

[12] Xue Jing Ding. Research on Collision Detection Algorithm Based on Combined Bounding Box [J]. Advanced Materials Research, 2014, 3137.

[13] Huaiyu Wang, Shugui Liu. A Collision Detection Algorithm Using AABB and Octree Space Division [J]. Advanced Materials Research, 2014, 3326.

[14] Xuejing Ding. Research on Collision Detection Algorithm Based on OBB [J]. Applied Mechanics and Materials, 2013, 2755.

[15] Mingquan Wang, Wei Zhao, Huiyan Qu. An Improved Collision Detection Algorithm Based on GPU [J]. Applied Mechanics and Materials, 2014, 3634.

Performance Analysis of Heat-Based Smart Phone Charger

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Abstract—Smart phone services have become all encompassing in these modern life activities. These phones operate with batteries that provide the necessary electrical power. The batteries' stored energy often got used up; and the conventional electrical power charging sources like public power supply, generating sets, solar devices among others are not only unreliable but most times totally unavailable in some villages and camp settlements. There was then the need to produce simple, inexpensive and easily accessible battery chargers for the phones. This paper therefore studies and analyzes the performance of a locally-made, off-grid and renewable energy power phone charger. The device output voltage, current and hence power has been tested at varying degrees of temperatures. Finally it was tested with different heat sources like, charcoals, Gas- burner, kerosene stove, wood stove, and Camp and Barbecue fires for heat source efficiencies. The results prove that charcoals and gas-burner heat sources are the most efficient heat source for operating the heat-smart- phone charger.

Keywords-Smart Phone; Thermoelectricity; Barbecue; Seebeck Effect; Nano-Technology

I. INTRODUCTION

Ideally, the basic necessities of life are food, clothing and shelter. However, civilization, modern-life style and technological developments have forced some other necessities like Phone services onto mankind. In many rural areas of Africa and other developing countries of the world, peoples try to manage their lives without some amenities like electricity and sanitation, Nuwayhid RY etl (2003). Many of them find it difficult to do without Phones. Phones are fast becomming indispensable companions to both the urban dweller, rural and nomadic group of the entire populace. The simplest of these phones has important features like touch-lights, radio reciever, time piece, mailling facilities apart from the normal making and answering voice calls. These Phones are powered by batteries which need recharging on regular basis for optimum operations. In order to recharge these phones batteries, people do walk for miles to some common cell phone battery charging centers. "The upgrade technology system on cell Phones today makes life easier for everyone in rural areas but our major challenge is when it comes to charging them in the villages we have little or no electrical power supply," says one irritated rural customer. (Susan P. Wyche, 2007). Some people who are tired of searching for opportunities to charge their phones just lose interest completely and eventually they will find out their "SIM" cards are de-activated as well. This is one of the last conditions the telecom industries will allow…… losing a networked customer.

Alternative electrical power sources like car batteries; diesel generators, solar installations and entrepreneurial charging kiosks do exist, but all have peculiar limitations. Most of them are expensive, inconvenience and required maintenance and hence becomes unaffordable or even unavailable. In other cases hunters, hikers, mountain climbers and backpackers in the bush always move with smart phones that are equipped with some other electronics gadgets. These gadgets are powered up by batteries to keep them running and so need electricity to charge up the batteries. Spare batteries and solar chargers often

being used to support are often been used up and the sun rays are very weak or even unvailable for the solar chargers. Other alternatives are either too expensive or impracticable in such rural and outdoor areas. This necessitated the use of heat-based smart phone charging system. This heat-based charging gadget utilizes heat from heat sources like, charcoals, Gas-burner, kerosene stove, wood stove, and camp and barbecue fires.

II. REVIEW OF RELATED LITERATURE

This heat-based charging gadget avails phone users with a local technology for charging phones. It harvests and converts these heats to provide the required electrical energy to charge phone batteries.   This device harvests and directly converts these heats into electrical energy to charge our phones. This device works with the principle of thermoelectricity. Thermoelectricity means the direct conversion of heat into electric energy (Rowe DM, 2006). A thermoelectric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) due to a temperature gradient into electrical energy based on "Seebeck effect". The thermoelectric power cycle, with charge carriers (electrons) serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. The heat collector here is an arrangement designed to collect and transfer heat from the heat source into the system. In order to optimize this heat collection and transfer process, aluminum sheet is used to fabricate the concave heat transfer base. This plate collects as much heat as possible from the cooking stove, wood or gas while the blade can be pushed into the fire flames for better heat collection and transfer. This physical phenomenon where materials develop an electric potential due to temperature difference is known as thermoelectric effect Riffat SB, Ma X, (2003). Here, the thermoelectric modules are positioned in-between the heat harvester. The temperature differences the hot and the cold sides of the heat harvester produce   some   quantity   of   electricity. Thermoelectric modules simply convert a temperature differential across the device, and resulting heat flow through it, into a voltage via

the Seebeck effect. The polarity of the output voltage is dependent on the polarity of the temperature differential across the thermoelectric modules. Reverse the hot and cold sides of the thermoelectric modules and the output voltage changes polarity.

III. METHODOLOGY

In this paper, we are looking at harvesting and directly converting heat into electrical energy enough to charge our smart-phones batteries. Many thermoelectricity developers have produced different kinds of power supply units using this same principle Weiling L etl (2003). An arrangement for the developmental processes of harvesting heat from open fire to electricity is shown below.
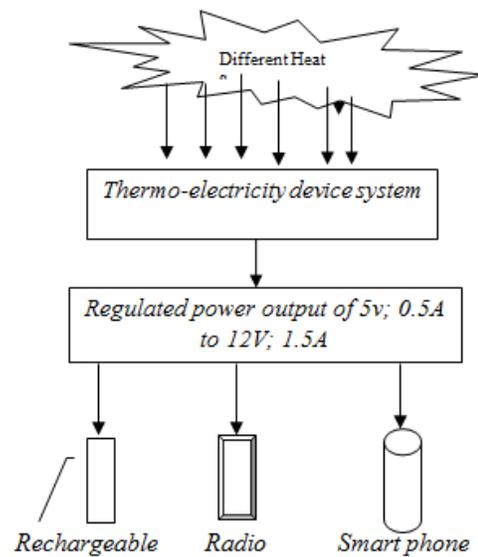
Figure 1.   Operational arrangement of heat-to-electrify charger device.

This one works with the principle of thermoelectricity which appeals to African communities with special reference to off-grid dwellers. The major different is on how heat is harvested: the first one goes directly into the fire while the other is positioned in proximity with fire so as to harvest heat from the fire. In this work, our production was based on the technology that harvests heat by placing it in close proximity with the heat source.

The heat collector here is an arrangement designed to collect and transfer heat from the heat

source into the system. In order to optimize this heat collection and transfer process, aluminum sheet is used to fabricate the concave heat transfer base. This plate collects as much heat as possible from the cooking stove, wood or gas while the blade can be pushed into the fire flames for better heat collection and transfer.

This physical phenomenon where materials develop an electric potential due to temperature difference is known as thermoelectric effect. Here, the thermoelectric modules are positioned in-between the heat harvester. The temperature differences the hot and the cold sides of the heat harvester produce some quantity of electricity.

Thermoelectric modules simply convert a temperature differential across the device, and resulting heat flow through it, into a voltage via the Seebeck effect. The polarity of the output voltage is dependent on the polarity of the temperature differential across the thermoelectric modules. Reverse the hot and cold sides of the thermoelectric modules and the output voltage changes polarity. Thermoelectric modules are made up of pairs or couples of N-doped and P-doped semiconductor pellets connected electrically in series and sandwiched between two thermally conductive ceramic plates.

IV. ANALYSIS AND PRESENTATION OF RESULTS
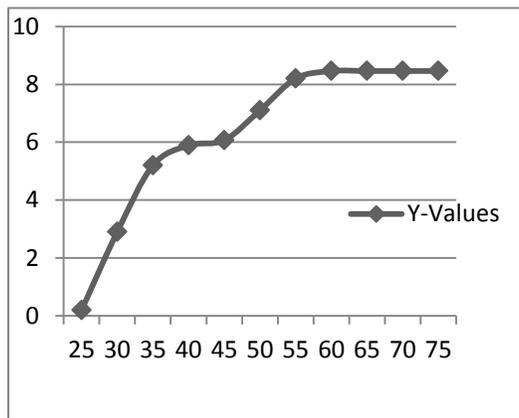
X-axis Temp degrees C	Y-axis Voltage
25	0.20
30	2.90
35	5.20
40	5.89
45	6.07
50	7.10
55	8.20
60	8.46
65	8.46
70	8.46
75	8.46

Figure 2.   Relationship between source temperature and voltage.
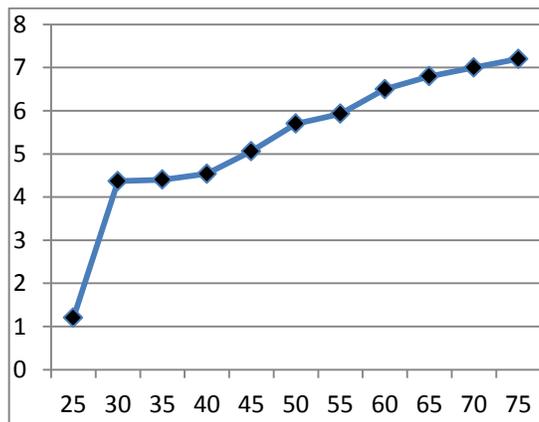
X-axis Temp in degrees C	Y-axis Current in mA
25	1.20
30	4.37
35	4.40
40	4.54
45	5.06
50	5.70
55	5.93
60	6.50
65	6.80
70	7.00
75	7.20

Figure 3.   Relationship between temperature and current output

X-axis Temp degrees C	Y-axis Power in mW
25	0.24
30	12.67
35	24.01
40	26.74
45	30.721
50	40.47
55	49.60
60	55.00
65	57.52
70	59.22
75	60.90
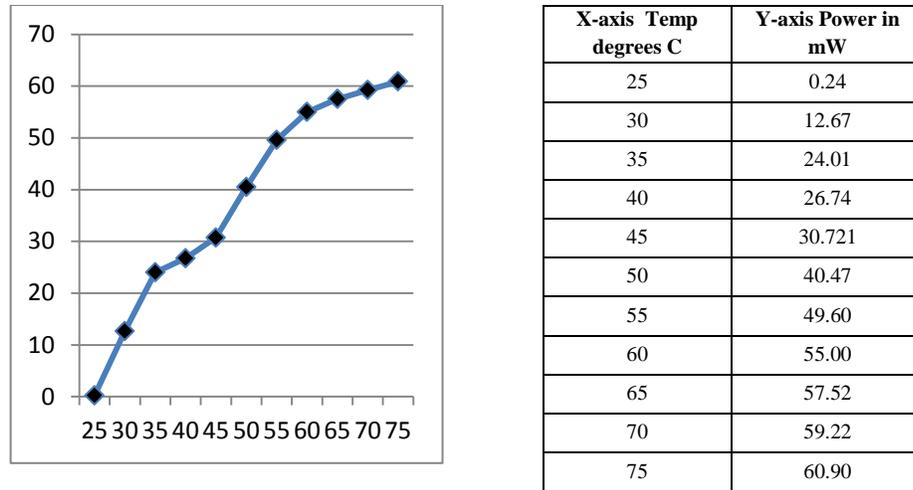
Figure 4.   Relationship between source temperature and power output

V. CONCLUSIONS.

The results of the tests and experiments prove that this heat-to-electricity conversion device authentic. Moreover it is observed that best results come when the intensity of the heat absorptions and disseminations on the thermoelectric device are maximized. It is therefore recommended the elements like heat blowers and sinks be incorporated in the design and construction. The increasing concern of environmental issues of emissions, in particular global warming and the constraints on energy sources has resulted in extensive research into innovative technologies of generating electrical power and thermoelectric power generation have emerged as a promising alternative green technology. There are vast quantities of heat waste discharges into the earth's environment much of it at temperatures that are too low to recover using conventional electrical power generators, Min G, (2004). However, thermoelectric power generation comes with a technology of direct conversion of waste-heat energy, into electrical energy and hence power. This technology is being utilized in a number of useful applications due to their distinct advantages. There are micro- and macro-scale applications depending on the potential amount of heat waste energy available for direct conversion. Micro-scale applications included those involved in powering electronic devices, such as microchips. Since the scale at which these devices can be fabricated from thermoelectric materials and applied depends on the scale of the miniature technology available. Therefore, it is expected that future developments of these applications tend to move towards nano-technology.

REFERENCIES

[1] Rowe DM. Thermoelectric waste heat recovery as a renewable energy source. Int J Innov Energy Syst Power 2006; 1: 13-23.
[2] Rowe DM. Thermoelectrics, an environmentally-friendly source of electrical power. Renewable Energy 1999; 16: 1251-1265.
[3] Riffat SB, Ma X. Thermoelectrics: A review of present and potential applications. Appl Therm Eng 2003; 23: 913-935.
[4] Nuwayhid RY., Rowe DM. Min G. Low cost stove-top thermoelectric generator for regions with unreliable electricity supply. Renewable Energy 2003; 28: 205-222.
[5] Weiling L, Shantung TU. Recent developments of thermoelectric power generation. Chin Sci Bull 2004; 49(12): 1212-1219.
[6] Min G, Rowe DM, Kontostavlakis K. Thermoelectric figure-of-merit under large temperature differences. J Phys D: Appl Phys 2004; 37: 1301-1304.
[7] http://www.customthermoelectric.com.
[8] http://www.ferrotec.com.

Research on User Dynamic Selection Network Technology

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Abstract—**As the world has entered the Internet era, more and more network operators have also developed one after another, which has been widely used in communities, schools, banks and other regions. Due to the uneven distribution of network providers in different regions, a certain network line is not running smoothly. In order to solve this problem, this paper puts forward a method that users can dynamically choose networks according to their preferences, and the problem can be solved by static routing and network address translation. At first, set the internal IP addresses of different users and the external IP addresses provided by internet providers on the ports on both sides of the user LAN router. During network address translation, a fixed one-to-one relationship established by the internal IP and the external IP is loaded into the routing table of the user LAN as a static route. Finally, users can actively and dynamically set the internal IP of the user LAN router in the router list in the user computer and realize the method that the user dynamically selects different interconnection networks.**

Keywords-Dynamically Choose Networks; Network Address Translation; Internal IP

I. USER DYNAMIC SELECTION NETWORK

Regional Internet Service Provider (ISP) provides services for community ISP who is similar to a unified relay station provides directly network support for users. In this way, the packet cannot be transmitted directly, but are transmitted after some preprocessing in the middle [1].

There are three methods for users to choose the Internet.

One is that the network ports provided by the community ISP and a regional ISP only is connected, as shown in Figure 1(a). The main drawback of this method is that once the network fails, the user LAN will be completely paralyzed. And the speed of accessing the network will become very slow when the user visits reach the peak [2].

The other is that the community ISP provides a main line and a standby line port, which are connected with the network port provided by the region as shown in Figure 1(b). The advantage of this method is that when the main line fails, the standby line still keeps running. But that line is extremely low and cannot run smoothly. Obviously, this situation cannot provide users with dynamic choice of internet.

The third is that the network ports provided by community providers are connected with the network ports provided by different regions, as

shown in Figure 1(c). The advantage of this method is that when a line goes wrong, it can be switched to other lines at any time, ensuring the reliability of data transmission [3]. At the same time, it also provides an optimal method for users to dynamically select networks.
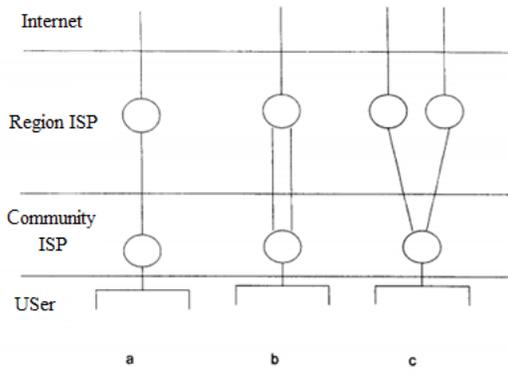
Figure 1.   Connection methods of three modes of computer LAN

accessing internet

By comparison, the third route selection method is adopted. Because users can dynamically select the network provided by different ISP. When a line fails or is not smooth, users can also choose a better route according to their personal preferences.

II.   PRINCIPLE OF METHOD

IP addresses provided by different region ISP are different when the region provides services for a community. If the community switches different network ports, it must return the network ports provided by this region ISP, and then allocate IP addresses provided by another region provider for each computer in the community.

Obviously, this method is inconvenient and greatly affects the timeliness of dynamic network allocation. But Network Address Translation

(NAT) function can be introduced into the community router to solve this problem [4]. NAT allows the whole group to share a public IP address in the Internet. In fact, it is an Internet technology that can convert the private address of the internal network into a public address [5]. It can not only share a public address, but also use the bandwidth provided by the local network service provider to access the Internet safely at high speed [6], hiding and protecting the computers inside the network.

As shown in Fig. 2, IP addresses assigned by ISP1 and ISP2 to router ports of user LAN in community are 200.10.45.253 and 200.33.67.253 respectively, and IP address pools assigned to user local area network in community are 200.10.46.0/24 and 200.33.68.0/24 respectively. All of which are true IP addresses on the internet.

For example, if the user wants to change the ISP1 to the ISP2, the address pool allocated by ISP1 for the community LAN must be returned to it, and then each computer in the community is allocated the IP address 200.33.68.0/24 provided by ISP2. Obviously, this method is inconvenient and also leads to the waste of IP addresses.

If the NAT is introduced into the router in the community, and a LAN is set up in the community to use the internal IP address. Finally, the problem will be solved. For example, the internal IP is 192.168.0.0/8. When the user 192.168.0.5 sends data packets to the 203.120.10.30 on the Internet. The community Router first finds the next hop 200.10.45.253 of the best route in its routing table, so NAT converts 192.168.0.5 into an external address, that is, a true IP address assigned by ISP1.
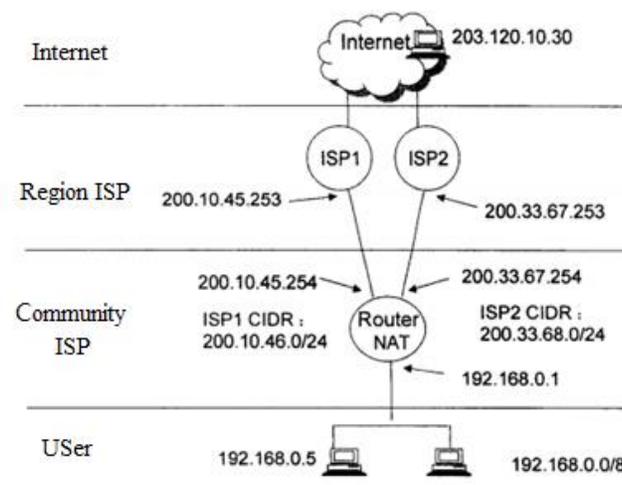
Figure 2.   Connection block diagram for users to dynamically select different regional ISP

In this way, for 203.120.10.30, the data packet is sent from 200.10.46.8. When the packet is returned, it is returned to 200.10.46.8, and then NAT converts the address into 192.168.0.5. In this process, few public IP is reused for private network, which greatly reduces the address usage [7]. The community LAN router can automatically select the best route, but the user can't control this route.

III. DYNAMICALLY SELECTS NETWORKS PROCESS

The purpose of this paper is to provide a method for users to dynamically select region ISPs that users can choose different ISPs to access the Internet at any time according to their preferences through community LAN. And pay fees for such access services according to the prior agreement.

The method for users to dynamically select the internet mainly comprises the following steps:

Step1: Connect the routers of the user LAN with the routers of several regional network providers.

Step2: Set different internal IP addresses at the port of the user LAN router, and set various external IP addresses at the other port of the user LAN router.

Step3: When the network address is translated, a fixed one-to-one relationship established by the internal IP and the external IP of the ports on both sides is loaded into the routing table of the user LAN as a static route.

Step4: The user actively and dynamically sets the internal IP address of the user LAN router in the router list in the user computer according to his preference.

The flow chart of user's dynamic selection of network is shown in Figure 3.
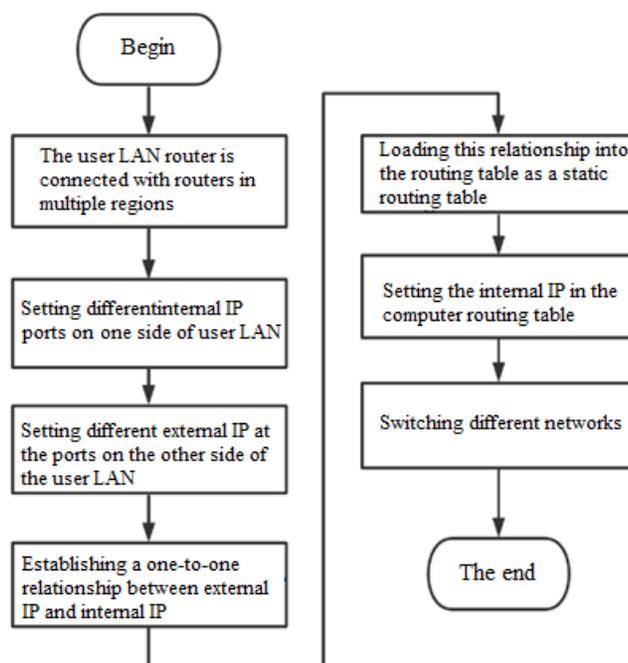
Figure 3.   Flow chart of user 's dynamic selection of network

IV. LOADING THE ROUTER LIST

There are three ways to set the internal IP address of the user LAN router in the router list in the computer: first, only one internal IP address of the router is reserved; Second, keeping all the internal IP addresses of the router, but with different priorities and filtering conditions; Third, keeping all the internal IP of the router, but with the same priority and filtering conditions;

Filtering conditions refer to the stability, price and bandwidth of region ISP.

According to these three router list configurations, routers in community LAN also have three strategies:

First, the user's data packets are sent and received according to the internal IP address and external IP address recorded in the routing table.

The second is to select the internal IP address with higher priority from the list of routers in the user's computer. If the corresponding external IP address reaches the screening index, the user's packet will be forwarded along this route. On the contrary, if it fails to reach the index, the internal IP address with a lower priority is selected to judge whether it reaches the index. Repeat this step until you find a route that meets the filter criteria; If there is no route that meets the filtering criteria, the user's packet is not sent.

Thirdly, an internal IP address is randomly selected from the routing list in the user's computer. If the corresponding external IP address reaches the screening index, the data packet will be sent and received according to this route; On the contrary, if the index is not reached, another internal IP address is taken to judge whether it meets the index; Repeat this step until you find out the route that reaches the screening index; If there is no route reaching the screening index, the packet will not be sent.

The first way to configure the router list is to manually select the network according to the

preference. However, the latter two are that the community LAN automatically selects the internet provided by the regional providers who can meet the screening criteria.

V. DETAILED DESCRIPTION OF THE METHOD

In the technology of user dynamic selection of network, network address translation can be realized by router with NAT function [8] or by a separate device with conversion function. Two routers (RNAT1 and RNAT2) with translation function are connected to the Ethernet switch of the user LAN, and a fixed one-to-one relationship established by the internal IP and the external IP of the ports on both sides through the network address translation device is loaded into the routing table of the user LAN as a static route. In this way, the internet provided by regional providers can be dynamically switched by users.

As shown in Fig. 4. The internal IP addresses set up at the ports connecting RNAT1 and RANT2 to LAN are 192.168.0.1 and 192.168.0.2 respectively, and the external IP addresses 200.10.45.254 and 200.33.67.254 provided by the ISP1 and ISP2 are located on the port where RNAT1 connects to ISP1 and the port RNAT2 connects to ISP2 respectively.

A fixed one-to-one relationship recorded in the routing table of the user LAN as a static route between two routes is established through network address translation. And RNAT1 and RNAT2 ports connected to regional ISP correspond to true IP addresses 200.10.45.254 and 200.33.67.254, respectively. When the user is willing to use ISP1, 192.168.0.1 is uniquely set in the router list on his computer; And vice versa.

At the same time, the user can also record the two internal IP addresses 192.168.0.1 and 192.168.0.2 in the computer, and set different

priorities for them with filtering conditions; Or the priority is the same with filter conditions.
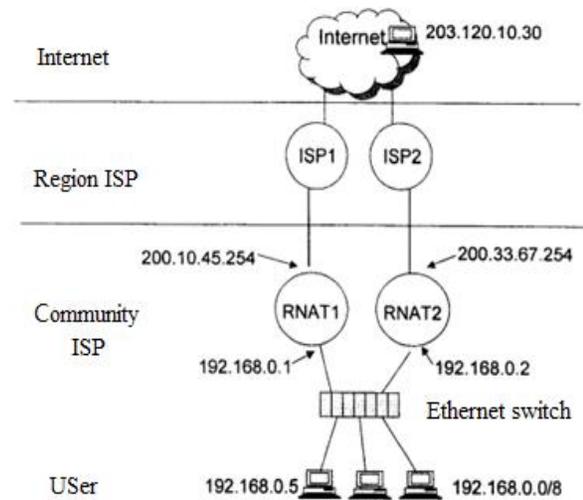
Figure 4.   Application Example of User Dynamic Selection Network Method

VI. METHOD IMPROVEMENT

A. For technical improvements

Figure 5 is an application diagram for further improvement of technology, which is equivalent to merging two routers with NAT function. Router NAT assigns different internal IP addresses to Ethernet interfaces.

For example, the external IP addresses 200.10.45.254 and 200.33.67.254 provided by region ISP1 and ISP2 are respectively located at the port where Router NAT is connected to ISP1 and where Router NAT is connected to ISP2; Then a fixed one-to-one correspondence recorded in the routing table of the user LAN as a static route between the two routes is established through NAT translation. And the next hops of 200.10.45.254 and 200.33.67.254 are fixed to router port 200.10.45.253 of SP1 and router port 200.33.67.253 of ISP2 respectively.
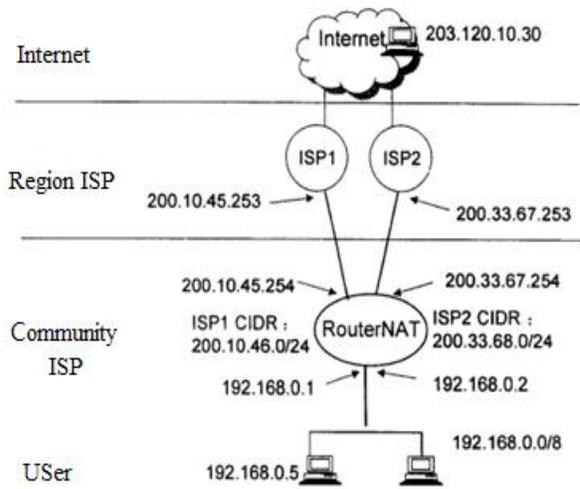
Figure 5.   Application Example of Method Improvement Scheme

Assume the user 192.168.0.5 sends a packet to 203.120.10.30. Because there is no this address in the community LAN, the packet flows to 191.68.0.1, passes through 200.10.45.254 to the port address 200.10.45.253 of ISP1. And Router NAT converts 192.168.0.5 to 200.10.46.8. Therefore, it seems to ISP1 that the data packet is sent from 200.10.46.8. When 203.120.10.30 returns data, the steps are the same as above.

If 192.168.0.5 wants the service of ISP2, it directly changes the unique address in the router list on its computer to 192.168.0.2, and the process is similar to the above.

At the same time, the user can keep two internal IP addresses of the router, and set different priorities for them with filtering conditions or set same priorities with filter conditions.

B. Improvement scheme for a large number of users

When there are a large number of users using the network in the community, the community LAN is divided into several subnets, such as LAN1, LAN2 and LAN3 in Figure 6. Each subnet connected with two NAT devices through different Ethernet switches is connected to the Internet through R1 or R2, and then a one-to-one correspondence between the internal IP and the external IP of the ports on both sides of the router is established.

When 192.168.2.6 in LAN2 wants to access ISP2, 192.168.2.2 is uniquely set in the router list of its computer. When users want to access ISP1, the steps are the same as above.
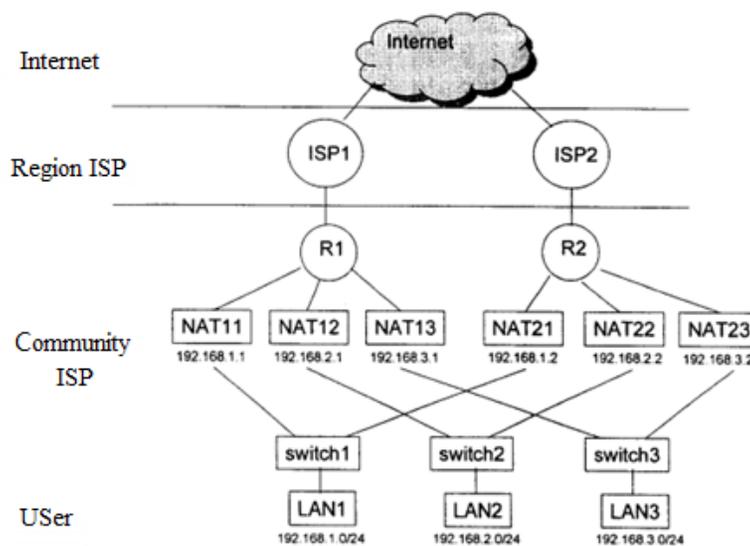
Figure 6.   An application example in complex community

The method can also provide users with a technical scheme of entrusting routers to select on their behalf, that is, allowing users to propose a set of conditions for determining routes, which are called screening conditions. Such as routing stability, price, bandwidth, etc. Routers regularly carry out statistical analysis on routes to providers in various regions, and calculate screening indicators for each route. When the route used by the user changes, the router compares the filtering indexes of each route with the conditions proposed by the user, and then selects a satisfactory route for the user to use.

VII. CONCLUSION

The main purpose of this paper is to improve the user's experience in using the network, and to enable users to dynamically choose the network methods provided by different operators in the user LAN. Because the frequency distribution of users using the network at different times is uneven. Through connecting the routers of the user LAN with the routers provided by the operators, and then the internal IP address of the user LAN is converted into the external IP address provided by the operators through the network address conversion technology. So that users can dynamically select the networks, and the smooth operation of the network can be realized during the peak period of the network. Compared with the traditional network, this method greatly improves the fluency of users in the process of using the network. And this method has been put into use in

YiZhuang, and won the first place in the construction project of "YiZhuang 12 square kilometers triple play demonstration zone".

REFERENCES

[1] SUN Li-ming. The Choice and Application(Implementation) of Multi-access Policy for Campus Network[J]. Journal of Huaibei Coal Industry Teachers College (Natural Science Edition), 2004(04):69-73.

[2] LIU Hai-tao, HUANG Jia-lin. Application of Policy Routing Technology in Multi-export Campus Network [J]. Computer and Information Technology, 2002(04):51-53.

[3] SONG Zi-qiang. Choice and Implementation of Multi-access Policy for Campus Network [J]. J. of Xuzhou Normal Univ.(Natural Science Edition), 2003(04):22-24.

[4] ZHANG Huan-jie, XIAYu-liang. User demanded policy routing for multi-homing campus network [J]. Journal on Communications, 2013, 34(S2):14-16+22.

[5] ZHENG Hai-deng. Research on Configuration of Network Address Translation of Computer Router [J]. Technology Wind, 2015(07):90.

[6] CHEN A-lin, XIAO Dan-Yan, XIAO Wei, MIAO Chun-Ying.Selection and Realization of Route Policy in Campus Network[J]. Telecommunication Engineering, 2002(06):134-137.

[7] Li Xiufeng. Analysis on NAT technology and its application, 2019, 16(19):138-139+146.

[8] HUANG Min, ZHANG Wei-dong. Network Design and Practice Based on Policy Routing [J]. Computer Applications, 2002(05):72-73.

A Review of Segmentation Technology Based on 3D Point Cloud

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Abstract—**Point cloud is an important data format that can completely express scene information. In recent years, with the dramatic increase of polygon complexity of model, the advantage of point model becomes more and more obvious. The point-based computer graphics, which takes point cloud as the research object, has aroused the attention of more and more people, and has been widely used in many fields such as computer vision, automatic driving and robot. In this paper, the point cloud segmentation methods and research status were reviewed in detail, the representative algorithms of each type of methods were analyzed and introduced, and the basic ideas, advantages and disadvantages of each type of methods were summarized. Finally, the problems faced by the segmentation technology and the development direction of the future work are prospected.**

Keywords-Virtual ; Point Cloud; 3D Model; Segment

I. INTRODUCTION

Point cloud is in the same space reference frame to express target spatial distribution and the characteristics of the target surface mass point set, compared with the two-dimensional images, point cloud has its irreplaceable advantages in - depth information, not only avoid the point cloud data encountered in the process of image acquisition of pose, illumination, and itself has abundant spatial information, can effectively express the space objects in size, shape, location and direction [1]. Compared with voxel data, point cloud data has a higher spatial utilization rate, pays more attention to describing the outer surface shape of the object itself, and will not save useless redundant information to describe the occupancy of space. Point cloud segmentation is the essence of point cloud processing, and it is also the embodiment of

the biggest advantage of 3D image compared with 2D image. The purpose of point cloud segmentation is to extract different objects in the point cloud, so as to achieve the purpose of divide and conquer, highlight the key points and deal with them separately [2]. Enhance cloud data processing capabilities.

II. SEGMENTATION

The so-called image segmentation is the use of image gray, color, texture, shape and other features, the image is divided into a non-overlapping area, and make these features in the same area of similarity. There are obviously differences according to the different regions. The unique regions of the segmented image are extracted for different research [3]. Point cloud segmentation refers to the process of dividing points in three-dimensional space into smaller, coherent and connected subsets (This is shown in Figure 1). As shown in Figure 1, the left and right images show the results of segmentation from the tooth point cloud model. As the foreground point cloud (i.e. segmentation target), the white point cloud is completely segmented for further observation and research [4].

After segmentation, points with similar properties are grouped together. A subset of these points should be "meaningful" and split to produce a series of objects of interest to us, such as roofs, trees, streets, and so on. These segments are usually represented as simple geometric primitives[5]. According to the mathematical

methods used, Existing segmentation algorithms can be divided into the following categories [6].
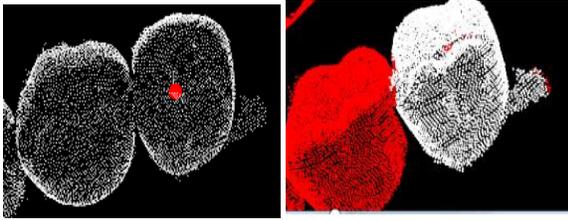

Figure 1.   Diagram of point cloud segmentation.

A.   Point cloud segmentation based on boundary

The boundary-based point cloud segmentation algorithm can obtain segmentation blocks by detecting regional boundaries. The main idea is to obtain the point cloud boundary through the drastic change of the point cloud intensity. The boundary gradient, the change of normal vector direction gradient on the point cloud surface and the 3D line matching were calculated. For the distance image, the scan line segmentation algorithm is not applicable to point cloud data with uneven density. The contour is extracted by binary data to achieve the purpose of fast segmentation[7]. One of the more representative is the famous watershed algorithm. The watershed concept is based on the visualization of the image in three dimensions: two of which are coordinates and one is grayscale. Based on this interpretation of "topographical", we consider three categories:

a)   The point belonging to the local minimum value may also have a minimum plane, in which all the minimum points are

b)   When a drop of water is placed at a certain point, the water must fall to a single minimum point

c)   When water is at a certain point, it will flow to more than one of these minimum points with equal probability
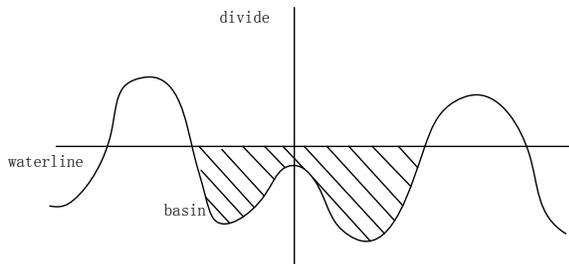
Figure 2.   Diagram of watershed algorithm

Waterway segmentation method is a mathematical morphology segmentation method based on topological theory. At present, it is more famous and more used: bottom-up flood simulation algorithm. For a special region minimum, the set of points satisfying condition (b) is called the watershed of this minimum ". The set of points satisfying the condition (c) constitutes the peak line on the terrain surface, which is called the "watershed line" [8]. This is shown in Figure 2.

Bottom-up flooding simulation is a recursive process. Definitions are as follows(1):

$$g(x,y) = grad(f(x,y)) = \{[f(x,y) - f(x-1,y)]\} \quad (1)$$

Where, f(x,y) represents the original image, and grad{.} represents the gradient operation.

Watershed algorithm responds well to over segmentation through weak edges, image noise and slight changes of object surface gray. However, we must also see that the watershed algorithm is well adapted to the weak edges, which are guaranteed by continuous, closed edges. In addition, the closed basin obtained by the tilt algorithm can be used to analyze the regional features of the image [9].

In order to reduce the excessive segmentation caused by the branching algorithm, two processing methods are commonly used. One is to use prior knowledge to remove irrelevant edge information. Another approach is to modify the gradient function so that the location responds only to the desired target.

B.   Point cloud segmentation based on Region-based growth

Area growth is the process of aggregating pixels or subregions into a larger area according to a predefined standard. Its basic idea is to start from a group of growing points (the growing point can be a single pixel or a small region), and combine the pixels near the growing point or the region with similar properties with the growing point to form a new growing point. Repeat the process until the growing points fail to grow or are completely covered. The similarity criterion between growing point and adjacent area can be

color, texture, gray level and other image information [10].

Steps of the algorithm: Sort the input point cloud according to the curvature value of the point cloud The point cloud with the least curvature among all the point clouds is selected as the initial seed (foreground point cloud), because the region where the point is located is the smoothest region. Starting from the smoothest region can reduce the total number of segmentation fragments and improve the segmentation efficiency [11]. Initialize the seeds of an empty sequence and empty clustering regions, from the sort of point cloud is selected after the initial seed points are added to the seed point sequence, and search for its neighborhood points, comparing each neighborhood point and normal Angle between the seed point, if the result is less than smooth threshold, then add the current point to the current area, if the neighborhood point curvature is less than the curvature threshold (artificial), it is added to the seed point in the sequence, delete the current seed points, loop through the above steps, until the seed sequence is empty is shown in Figure 3.
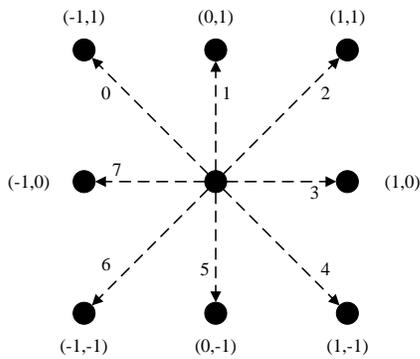
Figure 3.   Regional growth diagram

As shown in Figure 4, the initial point cloud of the cactus point cloud model is red, and with the progress of the region growth algorithm, the white point cloud gradually increases. If the segmentation threshold is not set, the white point cloud will eventually cover the whole model. However, in this process, we choose the appropriate boundary and curvature threshold value, then we can get a reasonable segmentation result.
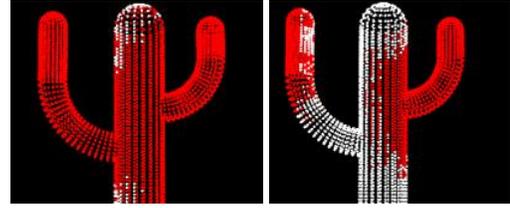
Figure 4.   Diagram of point cloud region growth

C. Image segmentation based on clustering method

Clustering algorithm is a very practical image segmentation algorithm. Firstly, attributes such as pixel gray level are mapped into the feature space, which is divided into many regions according to the response rules. Then according to the attributes of the voxel to determine the pixel belongs to the region, and mark out for segmentation. Clustering generally includes hard clustering, probability clustering, fuzzy clustering and other methods [12].
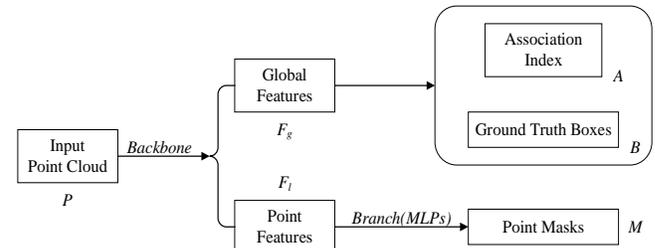
Figure 5.   Clustering algorithm flow diagram

Clustering methods are mainly divided into five categories:

1) Hierarchy-based clustering

Principle: Attempts are made to stratify all the data sets so that they form a tree cluster structure. Partitioning of a dataset can be done using both a "bottom-up" aggregation strategy and a "top down" partitioning strategy.

2) Clustering based on segmentation

Principle: First, a bunch of scattered points should be determined and finally grouped into several classes, then several points should be selected as the initial center points, and then the data points should be iteratively reset according to the heuristic algorithm of pre-set number, the target effect of "intra-class point closer, inter-class point farther" is finally achieved.

3) Density based clustering

Principle: Set a distance radius, the minimum number of points, and then can reach the points are connected, judge for the same kind.

4) Clustering based on grid

Principle: The data space of point cloud number is divided into many grid units, the data object set is mapped into grid units, and the cell density of each grid unit is calculated. According to the preset threshold value to determine whether the area is high density, Grid cells with sufficient density form clusters.

5) Model-based clusterin

Principle: A model is assumed for each cluster, and the best fitting of data to a given model is sought. This kind of methods mainly refer to the methods based on probability model and neural network model, especially the methods based on probability model.

D. Graph - Based Segmentation Method

A graph is composed of vertices and edges, represented as $G(V,E)$. Each pixel represents a vertex $V_i \in E$ of the graph, and two adjacent pixels constitute an edge $(V_i, V_j) \in E$. The difference in pixel color values constitutes the weight $W_{(V_i,V_j)}$ of the edge (V_i, V_j), see Figure 6.
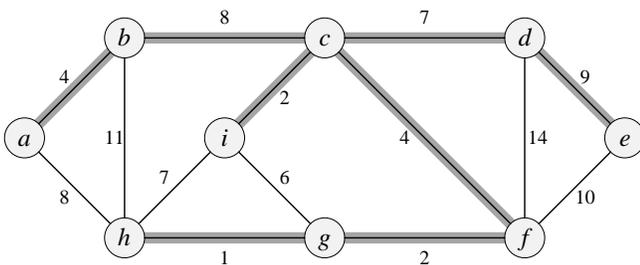
Figure 6.   Undirected graph

The inspiration for this algorithm comes from neighborhood graphs or the construction of neighborhood graphs. The points in the same partition are closer than the points in different interesting connections [13]. Therefore, the boundary of two segmented regions must be the place where the connection is weakest. The adjacent graph is the attribute graph in the point cloud. Each node in the figure corresponds to a point in the point cloud model, and each edge has a weight, which represents the similarity of a pair of points in the point cloud. Through the graph segmentation algorithm to achieve segmentation, the point similarity between different segmented faces as small as possible, the point similarity of the same segmented face as large as possible. Segmentation can be achieved by recursive segmentation or direct multiplexing. In 1999, Kim described the development of an algorithm that could automatically detect buildings from aerial images [14]. In 2001, Fuchs proposed a graph-based approach to city modeling. In 2008, Wang proposed a graph-based segmentation method for airborne radar scan data. In 2009, Aleksey Golovinskiy proposed a point cloud segmentation algorithm based on the minimum cut value. Given the target position, this method constructs the k-nearest neighbor graph, assumes the background in advance, sets constraints on the foreground (optional background), and calculates the forest background segmentation scheme by finding the minimum cut[15].

The energy equation solved by the minimum cut algorithm is usually an energy solution method based on graph structure. Such energy equation can be generally expressed as(2):

$$E(L) = \sum D_p + (L_p) + \sum V_{p,q}(L_p, L_q) \qquad (2)$$

Where L is the result of a label of image P. Set of 3 * 3 P images, P = [3, 8, 9, 4, 9, 8, 2, 9, 7], now want to P pixels can be divided into two kinds, the tag value is 1 or 2, L is one of the all possibility of P can be L = [1, 2, 2; 1, 2, 2; 1, 2, 2] or L = [1, 1, 2; 1, 2, 2, 2, 2, 2] (and many did not enumerated), all the possibilities for 2 ^ 9 L, The energy equation E(L) is to calculate the energy value under the current label result. Usually, we minimize the energy equation, so as to find the label value L that can make the overall energy minimum. The final pixel classification result is used to get the image segmentation and other results.

III.   EVALUATION OF VARIOUS SEGMENTATION ALGORITHMS

With the continuous development of technology, point cloud segmentation technology

is no longer restricted to a single one or two. The data model can be segmented by different methods. But compared with several different segmentation methods, there are still different application scenarios, different segmentation methods also have their own advantages and disadvantages.

a) Edge based methods: In the field of computer vision, the edge detection algorithms of image segmentation are quite mature. Radar data can be converted into depth images (such as digital surface models), making it suitable for image edge detection algorithms. The effect of segmentation depends largely on the edge detector. However, some information is inevitably lost when the 3D point cloud is converted to a 2.5D depth image. Therefore, the boundary-based segmentation method cannot be used for high-precision segmentation scenes, nor can it be used for face recognition, but it also has a place in autonomous driving and other aspects.

b) Region based methods: Region growth stops when there are no pixels or when a region meets the conditions to be added to a growing region. Advantages: the basic idea is relatively simple. Usually, point cloud regions with the same characteristic information can be segmented and good boundary information and segmentation results can be provided. It can achieve the best performance without prior knowledge and can be used for more complex image segmentation, such as natural scenes, coins, medical images, etc. Disadvantages: The segmentation algorithm based on region growth is an iterative method, but it consumes a lot of space and time. When the noise is not uniform, it will lead to voidness and over-

segmentation, and the shadow effect in the image is often not perfect.

c) Cluster based method: Each point is associated with an eigenvector, which in turn contains several geometric or radiative measures. Then, the point cloud data is segmented by clustering in the feature space. Different from other methods, the clustering method is implemented in the feature space, and it can operate on point cloud, mesh and TIN triangular mesh. The performance of clustering algorithm depends on the choice of feature space and clustering method. The clustering algorithm has shown its robustness in the segmentation of airborne or ground-based laser scan point clouds.

d) Graph based methods: In terms of time efficiency, the algorithm basically has a linear relationship with the number of edges represented by the graph of the image, while the edges represented by the graph of the image are proportional to the pixel points, that is to say, the time efficiency of image segmentation has a linear relationship with the number of pixel points of the image. This algorithm has a very important property, it can keep the details of the low variation region, and can ignore the details of the high variation region. This is a very special and very important property, it's a very good segmentation of the image, being able to find areas that are visually consistent, in short, areas of high variability have a very good aggregation, being able to separate them into the same area.

TABLE I.   COMPARISON OF VARIOUS SEGMENTATION ALGORITHMS

Segmentation type	Tightness	To deal with noise	The processing time	Application Scenarios
Edge	worst	difficult	fast	Large scene segmentation with a priori capability
Region	best	perfect	Depends on the number of point	High precision segmentation scene
Cluster	better	suitable for detecting some objects with special shape from the chaotic point cloud	fast	Clustering is the division of a data set into different classes according to a particular criterion
Graph	worst	general	It depends on the number of edges	More for image segmentation

By analyzing the table can be seen In the context of current segmentation technology, region growing segmentation technology and

clustering in noise processing and better segmentation accuracy The segmentation method combined with semiautomatic segmentation

technique is more suitable used in medical, forensic, etc But higher precision means that need more electricity to describe cloud model, has led to the slower speed And figure capable of prior segmentation and semantic segmentation is more suitable big scene, such as automatic driving, etc Need fast real-time data judgment and interaction, the scenario does not require high precision Therefore, we need to make reasonable use of the advantages of different segmentation methods to better serve the purpose of human life.

IV. CONCLUSION

From the point of research and application at home and abroad, point cloud segmentation technology can be described by fewer data points of a model advantages, has been gradually play an important role in all fields Although the point cloud segmentation has been a lot of research of geared to the needs of different applications, but because of the automatic segmentation technology also does not reach the designated position, excessive segmentation, adhesion condition can not completely eliminate, most algorithms are proposed for specific question. But from the point of view of development, with the progress of technology, the simple operation and human-computer interaction of automatic segmentation technology is the trend and trend of development.

REFERENCES

[1] Ji Xiaogang, Zhang Xixi, Hu Haitao. Point cloud segmentation for complex microsurfaces based on feature line fitting [J]. Multimedia Tools and Applications, 2020, 80(3).

[2] V. Barrile, G. Candela, A. Fotia. POINT CLOUD SEGMENTATION USING IMAGE PROCESSING TECHNIQUES FOR STRUCTURAL ANALYSIS [J]. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2019, XLII-2/W11.

[3] Yuan Jiang Huang, Jie Huang. A New Feature Detection Algorithm Based on RANSAC [J]. Advanced Materials Research, 2014, 3255.

[4] Yinghui Wang, Wen Hao, Xiaojuan Ning, Minghua Zhao, Jiulong Zhang, Zhenghao Shi, Xiaopeng Zhang. Automatic Segmentation of Urban Point Clouds Based on the Gaussian Map [J]. The Photogrammetric Record, 2013, 28(144).

[5] Shou Bin Liu, Kun Feng. Point Cloud Segmentation Based on Moving Probability [J]. Applied Mechanics and Materials, 2013, 2617.

[6] Chen Biwu, Shi Shuo, Sun Jia, Gong Wei, Yang Jian, Du Lin, Guo Kuanghui, Wang Binhui, Chen Bowen. Hyperspectral lidar point cloud segmentation based on geometric and spectral information. [J]. Optics express, 2019, 27(17).

[7] Wang Meng, Li Wei, Gao Rong, Wang Sa. Pavement Foreign Body Detection Based on 3D Point Cloud Deep Learning [J]. Application of Computer System, 201, 30(02):165-170.Palmer, I.J. and Grimsdale, R.L. Collision Detection for Animation using Sphere Trees. Computer Graphics Forum[C]. Computer Graphics Forum. Blackwell Science Ltd, 14: 105-116.

[8] Li Jingjing, Sun Xiaoqiang, Cai Yuanbin, Ni Mincheng. Analysis of shape feature recognition algorithm for robot vision based on PCL [J]. Science and Technology Innovation, 2020(33):97-98.

[9] Liu Zhiyuan, Guo Yanning, Liang Weikui, Xu Hang. Initial relative pose acquisition of space non-cooperative target based on point cloud [J]. Journal of Astronautics, 2020, 41(10):1314-1321.

[10] Li Meijia, Yu Zekuan, Liu Xiao, Yan Rongguo, Yu Yuanyuan, Wang Daming, Chen Juan, Lu Lu, Qi Peng, Wang Junjie, Liu Jie. Research progress of point cloud algorithm in medical field [J]. Journal of Image and Graphics, 20, 25(10):2013-2023.

[11] Jie Wei, Zhang Jingjun, Gao Ruizhen. Point cloud segmentation based on regional growth method [J]. Journal of Shandong Agricultural University (Natural Science Edition), 2020, 51(05):899-903.

[12] Liu Fangzhou, Liu Hao, Yun Ting. Journal of Forestry Engineering, 2020, 5(05):109-116. (in Chinese with English abstract)

[13] Gu Junhua, Li Wei, Dong Yongfeng. Review of segmentation methods based on point cloud data [J]. Journal of Yanshan University, 2020, 44(02):125-137.

[14] Ye Yutong, Li Bijun, Fu Liming. Fast detection and tracking of target in intelligent driving midpoint cloud [J]. Geomatics and Information Science of Wuhan University, 2019, 44(01):139-144+152.

[15] Li Yong, Tong Guofeng, Yang Jingchao, Zhang Liqiang, Peng Hao, Gao Huashuai. Progress in Laser & Optoelectronics, 2019, 56(04):21-34.

The Design of Remote Control System Based on the Embedded Web Server

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Abstract—**In order to expedite the development of the control network, according to the newest fruition of the internet, the hardware and software of the system is designed. Since the resource of the sever in embedded remote control system is limited, an approach is presented which use CGI and XML technology to realize remote monitoring computer and embedded Web server for dynamic interaction. Combined with the basic requirements of embedded remote control system, the idea of component design is proposed, the major components of system functions are defined. According to the system functional requirement, the software is designed and realized. The practice prove, the scheme realize the remote control of the transmitter by the small cost. And the system is convenient and safe. The definite reference value is offered to the offspring complex remote control system.**

Keywords-CGI; Remote Control; Web Serve; Embedded Systems

I. INTRODUCTION

With the development of information network and innovation of technology, the remote control is no longer refers to the LAN remote control, but it is based on information network remote control [1-2]. Information network has more advantages than control network. Then the combination of the Information network and control network, using the advantage of the development of information network to develop the remote control system, which has already attracted widespread attention. The rapid development of network technology and embedded technology and their mutual integration has laid a good foundation of technology for On-site inspection and miniaturization and intelligence of control equipment, but also which directly promotes the development of embedded applications toward a deeper level [3-4]. The TCP/IP protocol is embedded in field equipment which makes it possess the embedded Web server functions, and with the help of CGI technology which can achieve real-time dynamic interaction between the field data and embedded Web server, eventually, embedded devices meet needs of networking with Internet directly, the real-time monitoring network has a good foundation to achieve [5].

Embedded WEB server has the advantage of small size, low price, and good platform migration and so on, which the WEB server does not have. In the system, in addition to considering its above advantages, the optional of embedded WEB server

is more important to take into account the embedded WEB server which is more suitable for industrial control field [6-8]. The embedded WEB server which is used in control system not only makes the information collection and dissemination integration into embedded devices to simplify the structure of the control system, but also uses standard interfaces of embedded WEB server and the standard communication protocols, to provide operation and control interface which is unified and browser-based for users who any access to[9]. This way fundamentally changes the operation of equipment and management, reduces maintenance cost of control operation, and improves the efficiency of maintenance of control system. In this study, information network is introduced into the control network to achieve a real-time remote control which is based on information network, and provide a new reference method for the design and implementation of a remote control system [10-11].

II. SYSTEM SCHEME

As is shown in Figure 1, the system mainly consists of client modules, Internet module, embedded WEB server module, PLC programmable controller and the controlled object

modules. Users who are in the client use the browser to access the embedded WEB server, the data is sent to embedded WEB server by the HTTP protocol and the WEB server embedded as a PC automatically encapsulate serial data which is transmitted from the programmable controller PLC as TCP or UDP, then which is transmitted in the network. Similarly network port receives the data which is automatically unwrapped from TCP or UDP packets and sends the it to the serial port, and then the conversion that is between serial and network signal can be completed, the host computer through the serial port transfers data to the lower machine by the communication protocol. According to communication protocol, lower machine receives data which was sent from the host computer, as a result, the communication between embedded WEB server and PLC completes. Embedded WEB server is the core of the whole control system, to archive the interactive information between the remote client and accused objects. The part of Lower machine mainly receives the remote client commands; complete the control of the controlled object, and returns running the information of the controlled object to the remote client.

Figure 1.   System's overall structure

A. Remote Client module

The main function of Remote Client is to complete the communication of embedded WEB server, so as to provide the user with a friendly and intuitive interactive interface; also, it receives

the operating parameters from the PLC to control field devices; and, it displays dynamically the WEB page. Users login the embedded WEB server by a browser, and enter into the Control page, then go to the control operations in the

corresponding form, next click on the submit button, the data is transferred to the embedded WEB server, and then the control command which were obtained by the serial handle of the embedded WEB server is sent to the lower machine, the browser is as a receiver to receive the feedback information from the lower machine. The remote client is to complete the remote client-server communication in main, after adding wireless routing module for multi-client mode, users can control and surveillance the second line device by the PC, mobile phone, PAD, etc. Monitoring which support the HTTP protocol terminals with a browser.

B. Network Module

The system is based on the Internet, and completes the remote control in the Internet. The network module is as a transmission channel of information, and corresponds to a range of LAN, cable and wireless router physical for connecting remote clients and embedded WEB server. The information is transferred from one place to another in internet; in this processing it does nothing, only connecting client and server, keeping the security and the smooth of path. While the network module makes the entire control system and information network combined. Also the remote control system is no longer confined to the local area network, and with the usage of the advantage of information network the remote control can be more convenient. In this module, wireless router uses the function of WIFI, which can make features that smart phones control second line of PLC comes true.

C. Embedded WEB server module

This part is the central part of the whole control system, and completes the function of transfer which happened in information exchange in the object of PLC control and remote users. On the one hand, Embedded WEB server establishes a connection with lower machine, and the serial port data which is transmitted from lower machine is encapsulated as the TCP / IP packets which are transmitted in the Internet, and the lower machine running parameters in real time sent to the remote client. On the other hand, the TCP / IP packets which are sent from the network unpack according to HOST LINK serial communication protocol, as a result, serial data which can be identify by programmable controllers twill be gotten, and the control commands which are from remote client are passed to the lower machine, so as to control lower machine by the programmable controller. Meanwhile it implements the HTTP protocol conversion and encapsulation, when users access the web through a browser, just enters the IP address of embedded WEB server, it can be accessed.

D. Programmable controllers and the controlled object module

The module is charged with the ultimate object of the whole system, controls the controlled object by programmable controller, which is choose, exchanges the data information which is in the upper server host computer by RS232 serial, and implements the control which PC controls the lower machine. Programmable controller works in accordance with the instructions, and the implementation of the current device is sent to the embedded WEB server by the corresponding serial communication protocol, and finally the user's browser obtains them by the Internet. So, even users are away from the industrial site, can also control the controlled object and get the implementation of the object.

III. THE DESIGN OF HARDWARE SYSTEM

Brushless DC motor controller to control the DSP core. Six Road, pulse-width modulation channels for PWM wave output, driving the main power circuit, three-way capture the channel, on

the one hand is used to capture the location of the state brushless DC motor, control motor operation, the other for the speed of calculation, speed the completion of the closed-loop operation. Serial communication port to complete the upper and lower-bit machine information exchange, remote client through the Internet to control information sent to the embedded web server, and then down

through the serial-bit machine to send commands to achieve the control of the motor, while the next crew to motor Real-time operational status through the serial port back to the remote client in order to monitor the motor running. In addition, the control system is also designed to power-surge protection, overvoltage, undervoltage and some basic over-current protection circuit.
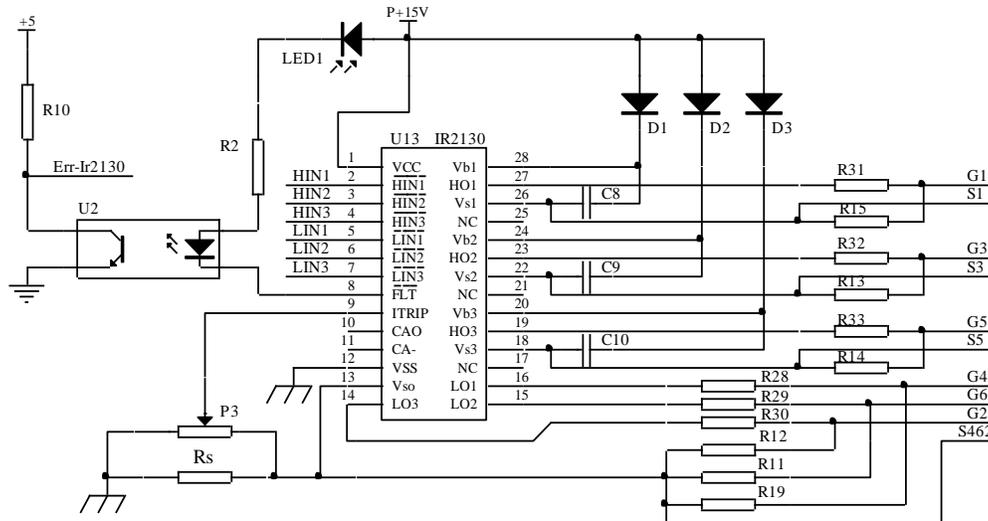
Figure 2.   Driven circuit

A. Drive Circuit Design

After separation from the DSP came out 6-channel PWM wave signal and cannot be directly sent to the main power circuit drive motor, it must be larger. The role of the driver circuit is to output pulse amplification to power a power transistor, or MOSFET. IR2136 is a voltage applied to the mother is not higher than 600V circuit in the power MOS gate devices, which may be the largest positive peak output drive current of 250mA, while the reverse peak drive current of 500mA. IR2136 has the over-current, over voltage, under voltage, logic identification protection, as well as the blockade and instructions such as protection areas, the internal bootstrap technique to make it available for high-pressure system, and the input signal and is compatible with TTL and COMS level. Drive circuit inductance, the general

location of the capacitor as close to the IR2136, the size of bootstrap capacitor 10 times. R20, R25, R28, R19, R24, R29 in order to avoid being driven by the power MOSFET drain-source voltage between electrodes of the oscillation, thus avoiding therefore caused by RF interference and MOSFET subjected to high du / dt caused by the breakdown damage. R21, R26, R30, R22, R27, R31 is the same bridge arm in order to avoid rotation of the two MOSFET turn-on; the instantaneous short-circuit current caused by two MOSFET sets the voltage between the emitter oscillation. EN termination PC817 isolation, when the DSP to a low when, EN-side enable, IRZ136 then be able to work properly. DSP issued by the 6-channel PWM wave through the internal circuitry IR2136 RP, amplified output, driving the main power circuit.

B. Main Power Circuit Design

The system's main power circuit using three-phase full-controlled circuit. In this circuit, the motor for the Y-connected three-phase windings. V1 ~ V6 6 MOSFET, the switch from the role of windings, which are N-channel MOSFET, high conduction time, their methods can be divided into 22 power conduction mode and 33 two kinds of conduction mode, the system conduction mode using 22 intervals of 1 / 6 cycle for phase one, each time a commutation power tube, each power transistor conduction angle of 120 °electrical. In this way, whenever the motor is running 360 ° electrical angle, the stator there are six kinds of magnetic potential state, each difference 60 ° electrical angle, was leaps and bounds, non-continuous state.

IV. THE DESIGN IDEA OF THE SOFTWARE

The design of system software is based on the idea of component, including Web Server component, CGI component, serial communication component, data storage components and so on. The logical relationship is between these components as is shown in Figure 2. Web Server component is the realization of the basic content of TCP / IP protocol, able to response and handle user requests, and achieve independent communication, also is known as a

Web server. Because the TCP / IP -related protocols are achieved, so Web server has the ability to interact with the browser, can handle user requests of client, transmits the network message and returns the result to the browser, in addition, it can work with other applications. CGI component is designed in accordance with the standard of CGI, and is program modules of possessing individual functions, also is a standard interface which implement interaction between the embedded Web server and external expansion application. The data of field devices is transmitted to the embedded Web server by CGI component, which is real time. So, the interaction of dynamic data can be completed between the remote client and the field devices. Serial communication component is independent program modules which can complete the function of serial communication. It realizes that the data is transferred from field devices to CGI components. And it cooperates with the CGI program components, so to make data of the embedded Web server update. Data storage component is a functional module which has the ability to save the data that is collected in the field, and provides methods of reading and writing for the other functional components. The realization of data storage components has two modes. One is file, another is embedded databases.
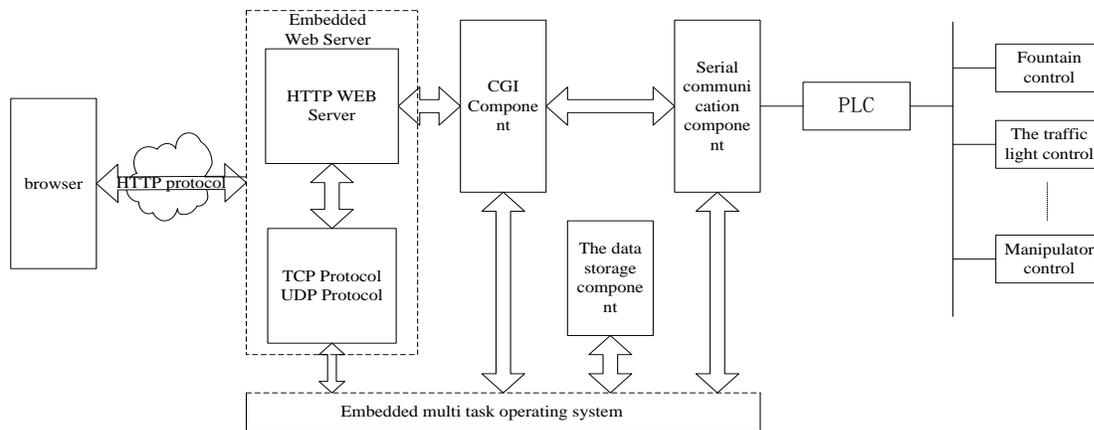

Figure 3.   Structure diagram of software system

In system, users which are located in the remote control terminal enter the IP address of embedded WEB server into the Internet browser, and log in to the appropriate page, then send control commands. The embedded WEB server receives control commands and handles them, next responses to connection requester from the client browser, obtains the control information, and which is sent to the controlled object. After a series of internal operations in the embedded WEB server, the message is converted to the message which the PLC can be identified, so as to complete the processing of communication. Embedded WEB server can also obtain real-time information from the controlled object, by handling, the message is sent to remote clients, while it responds to the connection request from the client browser, the results are in the form of dynamic page and are returned to the client. The embedded WEB server is working on "Serial channel mode ", it means that all serial data are automatically encapsulated as TCP or UDP packets, and which are transmitted in IP network. Similarly, received from the network port to TCP or UDP packets will be automatically unpacking the data, and which is sent to the serial port one by one byte. Embedded server automatically load embedded multi-tasking operating systems and a streamlined WEB server when the system starts up. The web Server listens to the HTTP requests which is sent from client, and delegates HTTP requests to the server process which is CGI program, and which is responsible for receiving data which WEB requests. And serial port communication implements the handling of data, and the results are in the form of dynamic pages and are returned to the client.

V. REALIZATION OF SOFTWARE SYSTEM

A. Building of Boa server

The WEB server of Boa is a very compact Web server, its executable code is about 60KB around. Boa is a Web server of single task, so it only can complete the user's request in turn, and will not fork a new process to handle the concurrent connection requests. But Boa supports CGI, CGI programs can be able to fork out a process to execute.

Download a Boa server under the operating system of Linux from the Internet, and configure the corresponding compiler environment of development board in the development environment of ARM. In this design, the system which the ARM uses is linux-2.6.32.2-1208-nfsandjffs2-w35-ok, the environment of cross compiler is arm-linux-gcc-3.4.1, the Boa server is unzipped through the command of tar, the MAKEFILE which includes in the cabinet needs to be complied crossing, and require a executable Boa file which can run in the ARM environment, then according to the ARM file of boa. conf configure the ARM system.

According to the Boa. conf ,configure the environment of ARM and put the error logs, access logs, executable files of Boa, Webpage of the Web site, and CGI procedures in the corresponding directory. Then, the /etc/init.d/Rcs file is changed, we compile and Boa boot from self-start, eventually Boa server is set up completely.

B. Writing of CGI Programs

The embedded WEB server uses the Linux operating system, CGI program uses function of the language of C to realize, source program of CGI provides assembly format: int NAME(WCT*w, char *file, char*; head) ;NAME is the name of function of corresponding components of CGI, w is the communication structure, the request and response of receiving data are manipulated by w; file is the name of request of the common gateway interface; head

is the header message of request, the length of request packet and Cookie information is obtained by it.

After the CGI is developed, also must be registered with the WEB server, so that when it is invoked, the CGI can connect to the function corresponding, and enable the CGI process to handle.

Registration form which the development of CGI accords to as follows.

Register("POST/GET", NAME, "NAME.cgi");

In the development of CGI , user request have two ways of GET and POST, the way of GET is through submitting the parameter data in the table to the URL which the action attribute refers to, the submitted value is corresponding to the field which is in the form. In GET request mode, data is presented on protocol head of request in HTTP. The way of POST puts every fields and content in the HTML HEADER by HTTP POST mechanism, and then sent to URL which the action attribute points to, the user is not to see the whole process, in POST the submitted data is put in real data. GET is transmitted through the parameter in URL to convey some non-confidential data, so the security of POST is higher than GET. Data that is transmitted in GET is smaller and is not larger than 2KB. But the data that is transmitted in POST is generally larger and is not limit in default. The WEB server which the CGI components register in can work.

C. Design of serial component

In system, the serial communication interface is the bridge that connects the embedded WEB server and the programmable controller. When the data is transmitted from serial port of the embedded WEB server, the number of bytes of data is converted to a serial bit, when the data of lower machine is through the serial port to the host

computer, the data by the serial bit transmission is changed as a number of bytes. in the use of serial communication, serial port must be open, when the communication is over, it is closure.

CGI process complete interaction of user's dynamic web. The information of interaction is from the lower machine through the serial port, in this progress, the appropriate serial communication components need to be designed, so the status of controlled object is extracted and the action of object is controlled. In this system, the serial communication component is a series of functions that are developed for the serial data of lower machine, and gets the serial message to the CGI procedures, and gives CGI program to handle. In the serial port message, according to each of the control commands, the corresponding functions are designed, so commands are sent and data that is returned is received, and the corresponding structure is defined to store the received data. Command to check the state of the object is as an example, its design function follows.

Int set_opt(int fd,int nSpeed, int nBits, char nEvent, int nStop)

//set serial port attribute： fd:file descriptor nSpeed: Baud Rate nBits： Data bits nEvent: Parity nStop: Stop bits

Int open_port(int fd,int comport)

// open S3C2440 Serial device node

int dakai()

//send the command to PLC。

Int jianshi()

//read PLC's the value of the corresponding channel, so to monitor the status of the second line of PLC devices.

In the system, submitting the command data or write data need to obtain information from the

form or the buffer. So relevant functions that can extract data and obtain data requires redesign. These are very convenient to work with CGI serial function which are designed, also package the realization of the complex, so as to improve the efficiency.

Based on the design of the prototype:

cgiFormResultType cgiFormSelectSingle(char *name, char **choicesText, int choicesTotal, int *result, int defaultV)

// extract the data which was submitted in the form, and save the data to the buffer

cgiFormResultType cgiFormSelectMultiple(char   *name,   char **choicesText, int choicesTotal, int *result, int *invalid)

//Get variable value from the buffer according to the variable name

cgiFormResultType cgiFormCheckboxSingle(char *name)

// Get control commands which user input from the buffer according to the button name

D. Several Key Issues in System Design

In embedded remote monitoring system, when it is designed, the minimal overhead must be considered, so as to ensure the system's real-time, safety, practicality and manageability. The methodology of component-based design provides an effective way to solve these problems, but several key issues as follow need to handle.

At any time, the security of system is a very important aspect. For embedded Web -based remote monitoring system that requires the system to be able to protect information security and to prevent vandalism; the users which have no permission cannot allow to observe the important information and carry out the operation. For the

above requirements, you can use the following method: adding firewall between the creation of the internal network and external network to protect the internal LAN from security attacks. Embedded Web server as a node on an internal LAN is also protected by the firewall. In order to prevent unauthorized users to access, when using the Web browser to access the embedded Web server, remote monitoring computer need to authenticate. Username and login password are stored in external memory. When the embedded Web server is powered up or reset, the microprocessor put the username and login password which are read from the external memory to the RAM. After receiving the login connection of RMON host, the login information is validated by byte-by-byte, if the verification is correct, and successful login flag will be set, otherwise the remote monitoring host Web browser sends the Web page which is login fails.

In addition, establishing a reasonable system model and component model is the basis for component design. The function model of the system needs to break down reasonably, and each component which is based on the independent functional modules must have clear boundaries. And, the embedded control systems design and implementation must pay attention to the real-time. So, the redundant TCP/IP protocol implementation should be avoided for keeping the real-time, and the lean Web server is constructed, so as to reduce the occupancy of embedded system resources. Otherwise, if the real-time cannot be guaranteed, the remote monitoring will lose its significance. Standardization is a prerequisite to ensure component compatibility. The interfaces and operations of each component should be defined standardly and possibly. Also the operations and the access of component attributes are required to be standard.

VI. CONCLUSION

Remote control system which is based on Embedded WEB server controls the device of lower machine, and combines the data acquisition with network information technology. It also uses the embedded devices and combines with the WEB technology. In addition, it completes the real-time remote control by the Internet. Lastly, it implements that client browser directly accesses and controls equipment information of the lower machine. In system, the WEB Services is as an intermediate hub. It completes that the message is send to the client PC from the lower machine via Internet. Also, it implements that the control commands of PC are transferred to. The process which the controlled object of lower machine executes commands implements dynamic interaction between the controlled object and browser, so as to achieve remote control functions. Embedded monitoring system becomes the mainstream of development of remote monitoring technology in the future, because of its small size, long continuous working time, stable and reliable of performance and so on.

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REFERENCES

[1] Wu Ying-nian,Zhang Jian-hua,Hou Guo-lian. Network Control System Research (I,II), Modern Power. Volume 5, Oct. 2018 Page(s):41 – 44

[2] Yueru Cai, Xiling LIU. Web Service Tutorial. Tsinghua University Press. 2015. In Chinese

[3] Zhuang Yan.Research and Development Based on the Network-based Robot Control Technology [J].Robot. 2016(3):276 282.

[4] Kunlun Lu, Xudong Li, Huanjing Wu. Web Service programming - using C #. NET Developer Network Services. 2018 In Chinese

[5] ZHuang Yah，Wang Wei，Yun Wei-ming, The research and development of network based robot control technology[J], Robot, 2017, 24(3):276-282.

[6] Aoyama M, Weerawarana S, Maruyama H, Web Services Engineering: Promises and Challenges[C], International Conference on Software Engineering, Orlando, Florida, USA, 2017.

[7] Wang S W, Xie J L. Integrating building management system and facilities management on the Internet[J]. Automation in Construction, 2019, 11(6):707-715.

[8] Rajesh K, Sridharan K, Srinivasan K. The design and development of aweb-based data acquisition system[J]. IEEE Instruction and Measurement, 2017, 51(3):427-432.

[9] Auer C, Klimbacher A P. Embedded Web server technology for remoteon line labs[C]. Dubrovnik:ISIE, 2019.

[10]Ma Ya-na,Qian Huan-yan. The application of Cookie in web authentication[J]. Computer System, 2014, 25(2): 207-210.

[11]Shixu Xu, Shuzhen Gong, Tao Peng. Programmable Controller Application Guide: programming, communications, networking. 2017. In Chinese.

Application Research of Decimal Network Technology

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Abstract—**The current Internet technology is IPv4 Protocol suite, and it is completely developed by the U.S. the IPv4 protocol address space is 232, and it has some shortcoming with the development of the Internet, and IPv6 Protocol suite proposed to expand the address of IPv4, but the two protocols are not compatible, which brings certain difficulties to the final application. The decimal network standard working group of Ministry of Industry Information Technology of China has researched about the future network for more than twenty years since 2001 and developed a whole set of decimal network system, and completed the future network IPV9 series. This paper introduces the basic technology of decimal network and its related applications. The practical application shows that the decimal network has realized the characteristics of "autonomous, controllable, high-speed and compatibility".**

Keywords-IPv4; IPv6; IPV9; Autonomous Network

I. THE GENERATION OF DECIMAL NETWORK

Nowadays, the network is highly valued by all countries in the world. The core of Internet technology is IPv4 and IPv6, and it is developed by the United States. The IPv4 protocol address space is 232, and it has some shortcoming with the development of the Internet, in theory, IPv6 has 2128 addresses, but only one eighth of the addresses can be assigned to end users, so IPv6 also has certain limitations.

Decimal network working group joint Shanghai network information technology company in the field of a new generation of new Internet and the future network for more than 20 years of research since its inception in August 2001, developed a complete set of network framework system, completed the future decimal network with Chinese independent intellectual property rights. This creative new achievement has strong support from China's ministry of industry and built the world's second network system. The technology has been completely tried in Shandong Tai'an City medical ecological domain construction, Jilin Province Political and Legal Committee system, Beijing University of Posts and Telecommunications, Xi'an University of Technology and other units, achieved good results, truly achieve the goal of "autonomy, safety, high speed, compatibility".

In 2001, a number of Internet experts in the United States published an article declaring that IPv6 technology could not solve the old structural problems, but only showed the failure of the incremental improvement route. Instead, they must adhere to the principle of "Clean Slate Design" and Design a new network without

relying on the support of the existing network with a new thinking.

'Future network' is a standardization project in the field of ISO/IEC international standards, it is a technical terms. Its purpose is to use new architecture method to develop a new network system independent of the existing Internet. Achieve safer, more economical, faster, more flexible, and more able to meet the technical goals of the new era.

In April 2007 Xi 'an meeting, the international standards organization ISO/IEC decided to launch the Future Network international standard research plan, determined that the Future Network is the English Future Network, abbreviated as FN, clearly shows that the Future Network is independent of the Internet.

On February 25, 2011. ISO JTC1, SC6 WG7, 6N14848 document response to the United States national member body 6N14510 document. pointed out that the future Internet is a new design of the future network. Future network does not necessarily rely on IP network, but is a hybrid network composed of IP communication and virtual reality circuit mixed communication. Besides, after discussion on the name change of WG7, WG7 changed the working group name to FN Future Network.

On June 1, 2016, the Ministry of Industry and Information Technology of China issued the relevant industry standards for IPV9 implementation in the country: SJ/T11605, SJ/T11604, SJ/T11603, SJ/T11606.This marks after 20 years of research and development, China really has the independent research and development of mature network of decimal mother root, root, from the N Z named 13 root name server system, the core backbone routers and user router product series, built with

independent intellectual property rights, independent and compatible with the Internet computer communication network.

II. DECIMAL NETWORK SYSTEM

Decimal network is also called the future network, referred to as IPV9; the whole system has a perfect network server system. China successively in Shanghai, Beijing, Jilin, Zhejiang, Shandong, Chongqing, Hunan construction completed the future backbone network, through the tunnel technology and the current IPv4 public network connection, complete the testing and commissioning, implements the able fully compatible with IPv4 and IPv6, through a dedicated router and related plug-ins, can be done in mainstream Windows operating system on the network switch and visits, do not need to modify existing hardware and software system, can realize able to IPv4 network access. The national future network structure is shown in Figure 1.

According to the shortcoming of existing TCP/IP protocol, designed the future network IPV9 system. A new transmission theory that uses a three-tier network to transmit telephone and cable data directly, without affecting the existing four-tier network transmission. The link is established and the transmission is completed until the link is removed. Under the research and design of the system framework, the overall design of the system is completed, and the root server system of the system is designed and implemented.

TCP/IP/M solves the high quality real-time media communication problem of three networks (communication network, radio network and Internet) from the network bottom structure, thus providing a smooth network environment for the future network. The new network model can realize the lofty ideal of the future network.
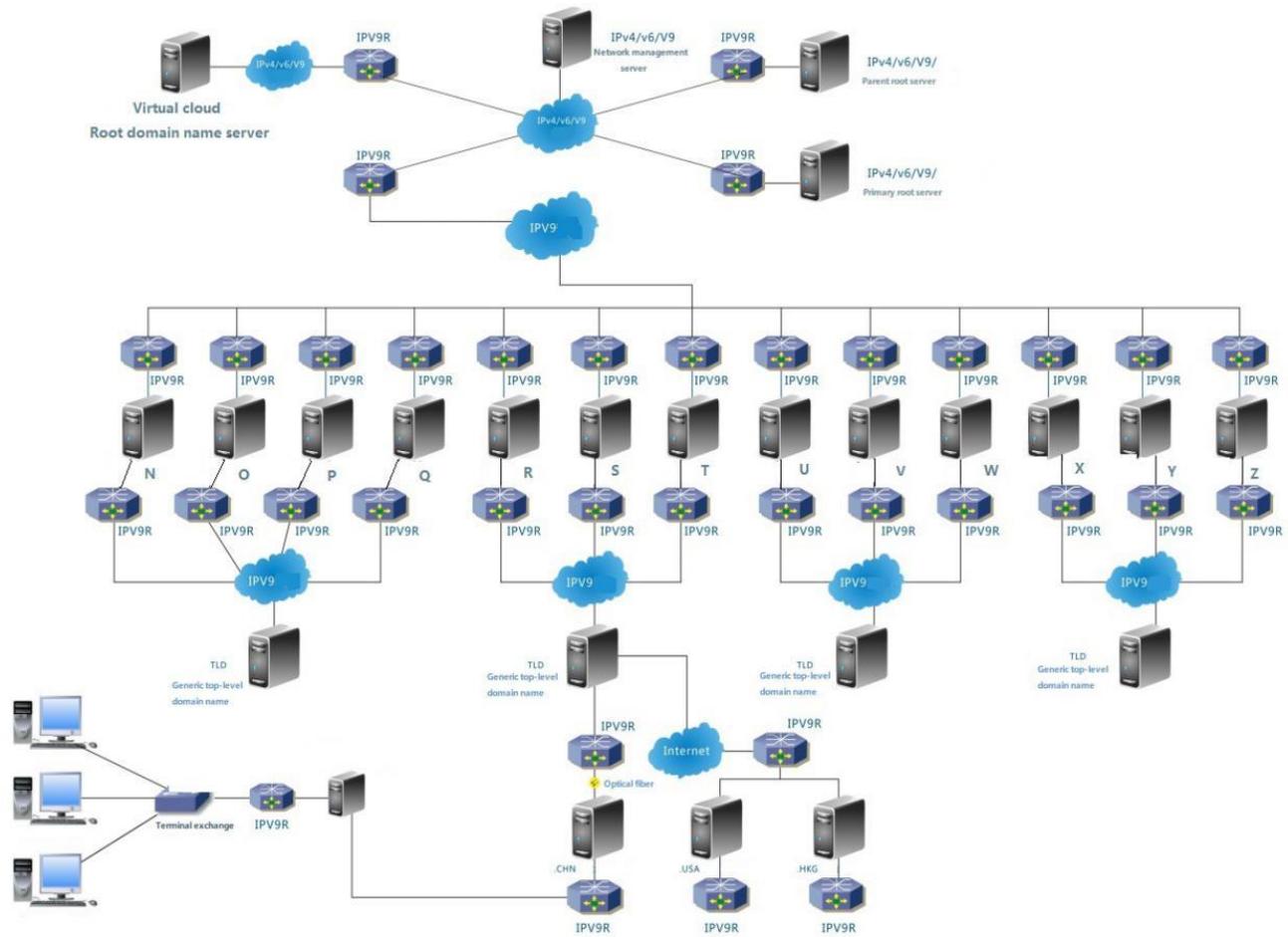
Figure 1.   Decimal network root server system structure

III. FEATURES OF DECIMAL NETWORK

Decimal network is a new generation of network architecture researched and developed by Chinese scholars. It has complete autonomy and control, huge address space, safe and high-speed large-code stream transmission, low distributed resolution delay, and extremely low communication cost. It is compatible with current Internet systems.

A. *Independent root server system*

The intellectual property rights of decimal network and digital domain including based on 'The Networked Computers with full decimal algorithm distribution method of address', 'the able/future network N ~ Z root name server " and "Method for allocation of address among computers acceding to network by using full digital code", which constitutes the IPV9 decimal network address space, 13 root domain name server and 239 countries top-level domain name server.

Decimal network default 256-bit address, can achieve 2048-bit address, can be compressed on both sides, recycling use, can be like the telephone system fixed length not positioning, positioning indefinite length in order to reduce and save unnecessary costs, increase efficiency, fully meet the needs of a long period of network development.

B. *Digital Domain Name System*

In the Digital Domain Name System (DNS), IPv4 and IPv6 are resolved in the United States, while IPV9 is set by each country, which avoids the restriction of IP addresses and makes it cheaper for countries to use domain names. Able decimal network using digital domain technology, reduces the difficulty of network management, the address of the vast space and the increase of security mechanism, solves the existing IPv4 is facing many problems, its automatic configuration, service quality and advantages in aspects of mobility support can meet the needs of the different levels of various equipment in the future.

C. *Routing Technology*

Decimal network routing table is very small, the address assignment follows the principle of geographical spatial clustering, which makes the decimal network router using a record can be said of a country, region, subnets and a specific geographic location. It sharply reducing the length of the router centrally by the table and cleanliness, improves the speed of the routing table to forward data packets.

Such as the address of Shanghai is 86 [21 [5] / 96, then in other router at the same level as long as a point to 86 [21 [5] / 96 addresses routing can be realized to Shanghai municipal IPV9 address routing. According to this logic, between country and country, just need a routing, such as the route to China for 86/64. IPv4 routing table is great and very irregular, IPv6 routing table is smaller than IPv4, but IPv6 routing table does not contain the geographic information.

D. *Security*

The technology of encryption and authentication are significantly improved of IPV9 compared with IPv4, and the encryption technology proposed by IPV9 is difficult to

decipher on the physical level, so the confidentiality performance has been significantly improved. And IPV9 is an Internet protocol with independent intellectual property rights, which bring great guarantee to the national security.

E. *Automatic address configuration*

Decimal network added to the variable length address automatic configuration support, which is the improvement and extension of the IPV9 DHCP protocol and make the network management more convenient. At the same time, IPV9 support multicast and ISO/IEC C6 future network "naming and addressing" TCP/IP/M model. Decimal network address length has a variety of options, which achieve 16, 32, 64, 128, 256, 512, 1024 address length change, according to different use scenarios to choose the most appropriate address length, reduce routing overhead.

Decimal network addresses add geo-location information, personal and industry ID information, achieve the unique binding of IP address and personal information.

IV. DECIMAL NETWORK FEATURES

A. *Add the concept of region and country*

IPV9 is managed by country and region and the information flow is reasonable. Realize the end to end communication according to the needs. Achieve low cost, high efficiency, save the network expenses, achieve green environmental protection.

B. *Realize the unification of electronic tag and bar code*

The huge address capacity of IPV9 realizes the uniqueness of address allocation, and he integration of IP address, digital domain name, electronic tag and barcode coding technology extends the network to every corner that sensor

technology can reach. When the radio channel of RFID electronic tag is interfered, the bar code can also be identified. China's unique bar code and RFID electronic tag technology will greatly reduce the global manufacturing and logistics industry management costs.

C. Realize the unity of multiple codes

IPV9 combines telephone number, mobile phone number, domain name and IP address, IPTV, IP phone into one number, which not only integrates domain name and IP address, but also realizes the integration of global unique identification codes of people or things, is a solution and application platform for the future information society and realizing the future network.

D. Realize the real name system online

IPV9 realize real-name Internet access and protect the privacy rights of customers. A certain number of anonymous addresses can be opened separately for visitors to use. However, in terms of design and technology, anonymous address users are not allowed to enter public networks and credit networks such as banks, governments, social welfare and commodity circulation.

E. Address encryption function

IPV9 design address encryption, which extend the security protection to the network layer, greatly improve the national information security. IPV9 communication protocol is better than IPv4 protocol in address space, quality of service, security and other aspects. IPV9 protocol can replace IPv4 protocol and become the communication protocol of network interconnection.

The address representation and header structure of IPV9 protocol datagram is different from that of IPv4 or IPv6 protocol, so in the future, the datagram header of network protocol will not be recognized by IPv4 or IPv6 system, and will not be propagated directly in these systems. Therefore, the future network protocol communication, the data message will not be directly propagated to other protocols network, so that the data propagation range is controlled, to a certain extent, improve the security of communication.

V. DECIMAL NETWORK APPLICATIONS

At present, China has built lines in Beijing, Shanghai, Shandong, Jiangsu and Zhejiang, with IPV9 address space, root domain name server and IPV9 backbone optical cable system demonstration projects, and is building a national civil-military fusion backbone optical cable. At present, IPV9 network has been tested and applied, and good test data has been obtained.

A. Healthy Tai'an big data ecological domain construction

"Health Tai'an "IPV9 big data platform project relies on the existing backbone optical cable and user transmission access network of Shandong Broadcast Network Co. Ltd. Tai'an Branch, using IPV9 network technology to upgrading and construction, cover the

medical and health institutions of the city, county, township and village levels and the medical insurance bureau, the administrative department and the finance bureau of Tai'an, and further expand to families and individuals. The bandwidth meets the requirements of healthy Tai'an big data business and can be sustainable. The expansion realizes compatible security operation between IPV9 network and IPv4 network (also realizes logical security isolation between IPV9 and IPv4 and IPv6 networks).

B. The application of 5G-future network/IPV9 movie network release application

Now the 5G network of China Unicom Beijing and China Mobile Suzhou have been directly

connected through the IPV9 fiber routing backbone node of Beijing University of Posts and Telecommunications and the IPV9 national backbone optical cable network, and achieved the world's first time End-to-end 500Mbps to 1000Mbps speed on May 21 this year. On the IPV9 national backbone network +5G local access/5G core network, the digital film program network distribution work was successfully carried out, and the national network distribution of Chinese movies was first entered in the new era of "one hour".

C. The System of Jilin Provincial Political and Legal Commission

In 2016, Jilin Provincial Political and Legal Committee used the website www.jlzf.chn to access the IPv4 Internet service, configured the English domain name server in the IP4 environment, and obtained the URL address of the corresponding service. Deploy IPV9 layers, nodes and devices in the computer room of the Political and Legal Affairs Committee of the NPC, join the IPV9 network management system, and serve as the node of the backbone IPV9 network.

Judging from the system operation of Jilin Provincial Committee of Political and Legal Affairs, IPV9 English domain name addressing access speed is fast and accurate, access security is very high, and IPv4 to IPV9 conversion protocol friendly, access is smooth. Protocol configuration has a good interface, simple and easy to understand, easy to operate.

D. Method for accessing IPV9 resources in IPv4 environment

Most of the current network environment that is based on IPv4, the chn domain name network of IPV9 can be accessed through most of the current computer browsers and mobile browsers support access such as Firefox, Google Chrome, Microsoft Edge, 360 Extreme Browser, etc. Safari, Baidu browser. Before using a browser to open the web site, need to network DNS Settings, Point to the IPV9 domain name resolution server with the addresses 202.170.218.93 and 61.244.5.162.

Before visiting, list several typical IPV9 websites, as shown in Table 1 below.

TABLE I.　　　PART OF IPV9 WEBSITE INFORMATION

Website domain name	Web resources	Resource management	Resources address
http://www.v9.chn	.chn portal website	Decimal Network Standards Working Group	Shanghai Municipality
http://em777.chn	Decimal Technology Introduction Site	Shanghai Decimal Network Information Technology Co. Ltd	Shanghai Municipality
http://www.xav9.chn	Xi 'an decimal portal website	Xi 'an Decimal Network Technology Co. Ltd	Xi 'an
http://www.xa.chn	V9Research institute portal website	Xi 'an Weijiu Research Institute Co. Ltd	Xi 'an
http://www.hqq.chn/	Red Flag Canal craftsmen website	Xi 'an Decimal Network Technology Co. Ltd	Xi 'an
http://www.zjsjz.chn	Zhejiang decimal portal website	Zhejiang Decimal Network Co. Ltd	Hangzhou
http://www.zjbdth.chn	Beidou Tianhui	Beidou Tianhui Information Technology Co. Ltd	Hangzhou

Once the DNS setup is complete, the chn website could be browser (recommend Firefox or Google Chrome). Enter http://www.ijanmc.chn to access the IPV9 website, as shown in Figure 2.

Figure 2.   Home Page of ijanmc

Because the future network is still in the experimental operation stage, the application points need to be further expanded, and the experimental data need to be further obtained, so the possible problems and treatment methods of big data concurrency continue to be studied in depth. It is believed that with the continuous improvement of decimal network technology and the introduction of relevant national policies, China's autonomous controllable network will surely benefit thousands of households.

REFERENCE

[1] Zhongsheng Wang. Technology and Application of Future Network[M]. Beijing:Tsinghua University Press, 2021.

[2] XieJianping. A global method of assigning computer addresses to networked computers using a full decimal algorithm:CN00127622.0[P]. 2001-05-02.

[3] XieJianping.A method of assigning computer addresses to networked computers using the full decimal algorithm:ZL00135182.6[P], 2004-06-02.

[4] A Method to Access a Decimal Network (IPV9) Resource, Guangzhou Liu, Fuya Yu, Volume 5, No.3, 2020.

[5] Research and Implementation of Future Network IPV9, Liu Zhang, Wang Yubian ,Volume 5, No.2, 2020.

[6] Research and Implementation of Future Network Router, Sun Huai, Wang Zhongsheng, Volume 5, No.2, 2020.

[7] The Research of Tai'an Big Data Ecological Status Based on IPV9, Gao Yalin, Ma Yihua, Volume 5, No.2, 2020.

[8] A Full Decimal Method of Address Assignment for Networked Computer. Zhan Xin, Xie Jianping, Jin Liming and Lai Jiawen, Volume 4, No.1, 2019.

Motion Blur Image Restoration by Multi-Scale Residual Neural Network

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Abstract—**Blind deblurring is a basic subject of computer vision and image processing. Motion image deblurring is divided into non blind deblurring and blind deblurring by whether to estimate the blur kernel. Blind deblurring is easy to produce motion artifacts because of the inaccurate estimation of the blur kernel. Non blind deblurring is the best choice for the current blurred image processing. The purpose of this paper is to further improve the definition of blurred image, restore the edge information of contour, and strengthen the repair of texture details. Based on the multi-scale convolution neural network, a multi-scale residual network is proposed, which can comprehensively extract image features, enhance image feature fusion, and constrain image generation by combining multi-scale loss function with anti loss function. The performance of the algorithm is evaluated by testing the peak signal to noise ratio (PSNR) structure similarity and restoration time of the generated image relative to the clear image. This algorithm improves the average PSNR on GOPRO testset, and reduces the recovery time accordingly. It can successfully recover the detail information lost due to motion blur. This algorithm has simple network structure, strong robustness and good restoration effect, and is suitable for dealing with various image degradation problems caused by motion blur.**

Keywords-Image Deblur; Motion Deblur; Multi-Scale Residual Network; Deep Learning

I. THE BACKGROUND OF DEBLURRING

Humans rely on the visual system to obtain a large amount of information. Studies have shown that about 70% of the information is obtained through the visual system. Therefore, the acquisition, processing and use of image information is particularly important. From the exploration of space 60 years ago, the importance of image restoration technology can be seen. At that time, the images sent back to the earth from space were affected by the imaging technology at that time, the shooting environment was not ideal, the relative movement between objects and the camera shake [1]. And other problems, resulting in degradation of the returned image, such as low image resolution, blurred image, etc. In order to solve the problem of image degradation caused by various reasons, people began to study image restoration algorithms. The two most typical image degradation phenomena are noise and blur. In the process of acquiring images, many factors can cause poor image quality, such as object movement and solar radiation. Alignment is out of focus, optical deviation, atmospheric flow, etc. In the process of image transmission, the image will also be blurred and noise due to the interference of the transmission channel and the shooting of electronic components. These degraded images bring great difficulties for subsequent image processing, such as image feature extraction, target object tracking and other tasks. With the

widespread use of images in various fields, people are also pursuing higher and higher resolution of images to deblur. Therefore, it is necessary to continuously research on image restoration technology to meet human visual requirements and applications in various fields.

There are three main types of blur, Gaussian blur, defocus blur and motion blur. There are three types of blur: Gaussian blur, defocus blur and motion blur. Gaussian blur is caused by the Gaussian distribution of each pixel in the image, which is formed by the external diffusion and superposition. The center image is more blurred, and the edge image is more loose. Defocus blur is caused by different depth of field in the process of photographing, some or all of the objects are not in the plane of the imaging system, and there will be local or global defocus blur in the image. The defocus blur is mainly caused by the camera focusing inaccuracy, which leads to different degrees of degradation of objects in different depths of the image [2]. Defocus blur is similar to a disk, and the influence gradually decreases from the center to the outside. In the process of motion blur shooting, the relative displacement between the camera and the object is caused by the motion blur, which is called motion blur. Motion blur can be solved by two methods, one is to reduce the noise exposure time, which can reduce the phenomenon of image motion blur, but with the decrease of exposure time, the signal-to-noise ratio of the image will decrease, and the quality of the image will also decline. The second is to simulate the gradient distribution of the image through mathematical modeling, and further study the image deblurring The research object of this paper is motion blur, which is the image blur caused by lens out of focus, object movement, camera shake and other factors dublurring the shooting process[3]. For motion blur, equipment can be avoided by using a sports camera. However, such equipment is generally expensive, ten times or even dozens of times the price of ordinary cameras, and it is difficult to popularize and use it on a large scale. Therefore, using efficient and convenient algorithms designed to restore clear images from motion blurred images is currently the mainstream method to deal with motion blurred. Motion blur is

based on the image blur mechanism to model, solve and restore the corresponding high-quality clear image. When the fuzzy kernel is unknown, deblurring is a typical ill-posed problem. How to obtain the final clear image of the image with few known variables has brought many difficulties to the research. With the continuous improvement of mathematica. theoretical knowledge and the rapid development of computer vision technology, motion deblurring has made great progress and development, and is widely used in astronomical detection, traffic monitoring, industrial detection, target detection and other fields. With the continuous growth of demand and the ever-changing blurring scenes in real applications, this puts forward higher requirements for image deblurring technology, and at the same time brings greater challenges. Image deblurring is an important classification of image restoration technology, and it is also the current research field of computer vision activities [4]. It has important research significance and application value. Image restoration mainly focuses on two aspects. One is to reduce or avoid the blur of the captured image by improving the hardware equipment. The main implementation method is to build the corresponding control system to achieve the purpose of stable shooting, or stable imaging equipment, this method can effectively control the image blur, but it will increase the cost of imaging difficulty. The second is to process the image after imaging, that is, to achieve the purpose of blurred image restoration through the research of image motion blur removal algorithm. Image deblurring is a serious ill posed problem, because in the process of solving, due to the interference of unknown fuzzy kernel and noise and other factors, the difficulty of image motion blur algorithm is also increasing. Therefore, the image motion blur removal algorithm still needs continuous research and improvement [5].

According to the nature of the blur kernel, it is divided into blind deblurring and non-blind deblurring. Non-blind deblurring results in artifacts in the image due to the deviation of the blur kernel estimation, and can only restore limited image blur. Blind deblurring does not rely on the estimation of the blur kernel and achieves

end-to-end deblurring, but due to the illposed nature of blind deblurring, the details of the image are missing, Enhance the color saturation of the image to meet human visual needs. Therefore, this article will focus on restoring the contour edges of the image. A multi-scale residual module is added to the network, and different convolution kernel sizes are used to extract more image features through the information sharing of the shallow network and the deep network. Based on the inspiration of DeblurGAN [6], the method of combining the counter loss function and the multi-scale function is adopted to adjust the network parameters and train a stable network to achieve the research purpose.

II.   RELATED INFORMATION

There are many causes of image blurring. It may be affected by the resolution of the capture device, lighting conditions, atmospheric motion, and the photographer's shooting level, etc., resulting in different degrees and types of blurring in the captured pictures. According to the different types of blur, blurred images can be divided into motion blur, defocus blur, Gaussian blur and so on. This article mainly analyzes the image degradation model of motion blur. Motion blur is the blur produced by the relative displacement between the device and the shooting object during the exposure time of the shooting device. There are many uncontrollable factors that cause image motion blur, such as sun exposure, camera shake, atmospheric movement, and so on. Motion blur image restoration can be widely used in various fields, traffic monitoring, medical imaging, target detection, etc. Therefore, restoring clear images is a hot spot in the field of computer vision today..

The degradation model of motion blur is shown below, b is a blurred image, k is a clear image, and l is a blur kernel, also called a point spread function. The blur kernel is a kind of convolution kernel. This convolution kernel will make the image produce special effects, n is additive noise. The research of this paper does not estimate the fuzzy kernel l, and directly outputs clear images from end to end.

$$b = k * l + n \qquad (1)$$

Through the mathematical modeling and analysis of the motion blur image, the motion blur removal is to establish a corresponding mathematical model, extract information from the contaminated or distorted image signal, and restore a clear image along the inverse process of image degradation. This topic is to restore a clear image on the basis of blind deblurring. Blind defuzzification is the current mainstream technology. The principle is not to rely on fuzzy kernel estimation, and to adjust the weight parameters and loss function by constructing a neural network to achieve the effect of the convergence of the objective function. In the process of non-blind deblurring, false contours will appear due to the inaccurate estimation of the blur kernel, and a large amount of noise will be present in the image, which will bring great difficulties to the restoration of the image.

Fuzzy algorithms can be divided into non-blind deblurring and blind deblurring according to whether the fuzzy kernel is known. Non-blind deblurring is performed under the premise that the blur kernel is known, and a clear image is obtained by deconvolution of the blurred image and the blur kernel. Blind deblurring is performed under the premise that the blur kernel is unknown. The traditional blind deblurring method is generally divided into two steps. First, the blur kernel is estimated, and then the blur kernel is deconvolved on the blurred image to obtain a clear image. Fergus et al. [7] discarded the prior assumptions on the image, based on the characteristics of the heavy-tailed distribution of natural images, proposed a deblurring algorithm based on the gradient distribution model, and constructed the original image and the blur under the condition of the known observation image. The joint posterior probability of the kernel, the posterior probability maximizes the combination of the corresponding original image and the convolution kernel. Shan et al. [8] mainly explored the problem of visible artifacts generated by the blind deconvolution problem, and proposed a unified probability model. Through an efficient iterative optimization scheme, the convolution kernel and the restored image are alternately estimated until convergence. Xu et al.[9] introduced a new second order kernel estimation

algorithm. The article introduced a method based on space prior, which can save the memory of potential image edge information and iterative support detection algorithm, which can strengthen the correct preservation of the space constraint kernel. parameter.In the study of unblind deblurring, Sun et al. [10] is a method based on deep learning to estimate uneven motion blur. First, CNN is used to predict the probability of different motion kernels for each image patch, and then image rotation is used. The technology expands the candidate motion kernel set predicted by CNN, thereby significantly improving the performance of motion kernel estimation; Schuler et al. [11] stack multiple convolutional neural networks to simulate the iterative optimization in traditional deblurring methods, and use the kernel estimation module to partially. The estimated value is collected into a single global estimate of the convolution kernel; Gong et al. [12] made the first universal end-to-end mapping of a fully convolutional deep network from a blurred image to a dense motion stream. Unblind deblurring has great limitations in experiments. Blind deblurring has a huge advantage in image restoration, and it has a wide range of application scenarios and can satisfy actual scene deblurring. We use generative countermeasure network structure. The confrontation training mode of generator and discriminator shows great advantages in generating realistic and natural images. The purpose of generator is to learn the distribution of real data, and the purpose of discriminator is to correctly judge whether the data is real data.

Because of this way of confrontation training, Gan network can generate new data based on the original data set. Gan network has powerful image generation ability. The generator uses multi-scale residual module to fully extract image features. In each scale, it uses convolution advantages of different sizes to output to the next scale, and transfers parameters through jump connection, which makes it easy to share data. The discriminator constructs a nine layer network. The generator network and the discriminator play games with each other to restore a clear image. The specific network structure will be introduced in the next section.

III.   NETWORK STRUCTURE

The following figure 1. Show the overall structure of the multi-scale residual. The generator network. B, L, and S re-present the blurred image. The clear image and the real clear image are output at the initial scale of each layer. Each layer has 17 residuals. The structure consists of two multi-scale residual modules and two convolutional layers. The subscript represents the scale in the Gaussian pyramid, which is sampled at 1/2 scale. The model uses image pyramids as i-nput, and the output of each intermediate scale is trained int-o a clear image [13]. The prediction result of the small picture is combined with the original picture of the middle picture as t-he model input of the middle picture through upsampling, a-nd the prediction of the middle picture is combined with the original picture of the large picture as the model input of the large picture.
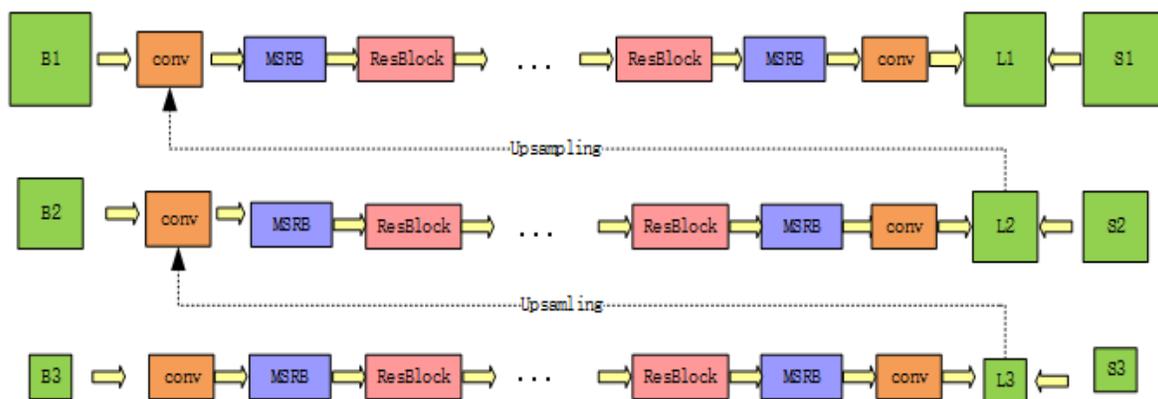

Figure 1.   Generator network structure diagram

A. Residual network

ResNet uses the input of one layer and the output of another layer as the output of a block. Assuming that x is the input of a block and one block is composed of two layers, then he first passes through a convolutional layer and activates relu to obtain F(x), and then the result of F(x) after the convolutional layer is added to the previous input x to obtain a result, and the result is activated by relu as the output of the block. For ordinary convolutional networks, our output is F(x), but in ResNet, our output is H(x) = F(x) + x. This changes the learning goal and turns the original learning into the goal the function is equal to a known constant value and changed to make the residual between the output and the input 0, which is the identity mapping. After the residual is introduced, the mapping is more sensitive to the change of the output. H (x) is regarded as an underlying mapping fitted by partially stacked layers (not necessarily all networks), where x is the input of these layers. Assuming that multiple nonlinear layers can approximate complex functions, this is equivalent to that these layers can approximate complex residual functions, for example, H (x) − x (assuming that the dimensions of input and output are the same). So we explicitly let these layers estimate a residual function: F (x): = H (x) − x instead of H (x). So the original function becomes: F (x) + X. Although these two forms should be able to approximate the required function (as assumed), the learning difficulty is not the same. The motivation of this re expression is caused by the abnormal phenomenon of degradation. If the added layer can be constructed by identity mapping, the training error rate of a deeper model should not be higher than that of its corresponding shallow model. The degeneracy problem shows that it may be difficult for the solver to estimate the identity map through multiple nonlinear layers. With the re expression of residual learning, if the identity map is optimal, the solver drives the weights of multiple nonlinear layers to zero to approximate the identity map. In practice, identity mapping is unlikely to be optimal, but our re expression is helpful for the preprocessing of this problem. If the optimal function is closer to the identity map than to the zero Map, it is much easier for the solver to find the disturbance about the identity map than to learn a new function. Experiments show that the residual function usually has a small response, which shows that identity mapping provides a reasonable preprocessing.

The formula F(x)+x can be realized by the "shortcut connection" of the feedforward neural network. Shortcut connection is to skip one or more layers. In our example, the shortcut connection simply performs identity mapping, and then superimposes their output with the output of the stacked layer. Identical shortcut connection does not increase additional parameters and computational complexity. The complete network can still be trained through end-to-end SGD backpropagation, and can be implemented simply through the public library without modifying the solver.

Show in Figure 2. Residual network, (1) is the original residual structure, (2) is the modified application in the residual structure, removing the batch standardization layer. The main task of this article is to restore the details of the image without generating noise. It is found through experiments, The BN layer is not sensitive to noise, and key image details cannot be found through a large number of image features. When training the modified residual module, it is found that the convergence speed is improved.
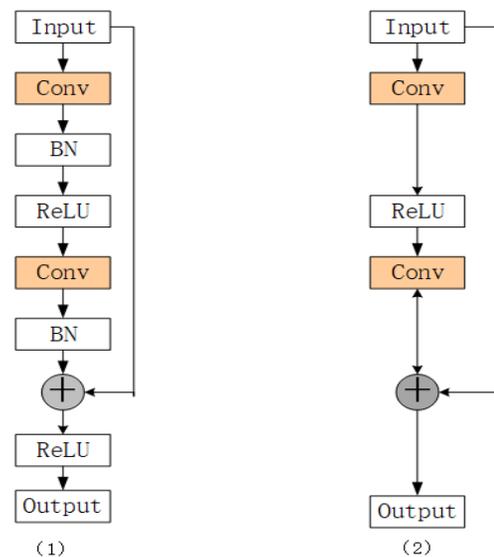

Figure 2. Residual network structure diagram before and after modification

B. *Multi-scale residual block*

The figure 3 below is based on the multi-scale residual module designed by Li et al. [14] MSRB is mainly divided into two parts, multi-scale fusion and residual learning. These two parts will be described in detail below. Use MSRB to acquire image features of different scales and treat them as local multi-scale features. Secondly, the output of each MSRB is combined for global feature fusion. Finally, combining local multi-scale features with global features can maximize the use of low resolution image features and completely solve the problem of features disappearing during transmission. In addition, we introduce a convolutional layer with a 1×1 convolution kernel as the bottleneck layer to obtain global feature fusion. In addition, we used a well-designed reconstruction structure that is simple but efficient and can be easily migrated to any upward scaling factor. At present, many feature extraction blocks have been proposed. The main idea of the inception block is to find out how the optimal local sparse structure in the convolutional network works. However, these different scale features are simply connected together, leading to underutilization of local features. In 2016, Kim et al. proposed a residual learning framework to simplify the training of the network and enable it to obtain more competitive results. Later, Huang et al. introduced dense blocks. The residual block and the dense block use a single size convolution kernel, and the computational complexity of the dense block increases at a higher growth rate [15]. In order to solve these problems, we propose a multi-scale residual block. Based on the residual structure, we introduce convolution kernels of different sizes to adaptively detect the features of images of different scales. At the same time, jump connections are applied between features of different scales to realize the sharing and reuse of feature information. This helps to make full use of the local features of the image. In addition, a 1×1 convolutional layer at the end of the block can be used as a bottleneck layer, which helps feature fusion and reduces computational complexity.

Multi-scale fusion: This part uses different convolution kernels, 1 x 1, 3 x 3, 5 x 5. Through different convolution kernel sizes, different levels of information can be extracted, and different scales of information are transmitted to the next layer of network, feature map. The elephants can share and pass on each other. Each part is combined by jump connections to construct a double bypass network. In this way, the information between these bypasses can be shared with each other, so that image features of different scales can be detected. The operation can be defined as:

$$S_1 = \sigma\left(w^1_{3\times3} * M_{n-1} + b^1\right) \qquad (2)$$

$$P_1 = \sigma\left(w^1_{5\times5} * M_{n-1} + b^1\right) \qquad (3)$$

$$S_2 = \sigma\left(w^1_{2\times3} * [S_1, P_1] + b^2\right) \qquad (4)$$

$$P_2 = \sigma\left(w^2_{5\times5} * [P_1, S_1] + b^2\right) \qquad (5)$$

$$S' = w^3_{1\times1} * [S_2, P_2] + b^3 \qquad (6)$$

Among them, w and b represent the weight and bias terms, the superscript represents the number of layers, and the subscript represents the size of the convolution kernel used in the layer. $\sigma(x) = \max(0, x)$ represents the ReLU activation function, [S1,P1], [P1,S1], [S2,P2] represents the connection operation. Let M denote the number of feature maps sent to the MSRB.
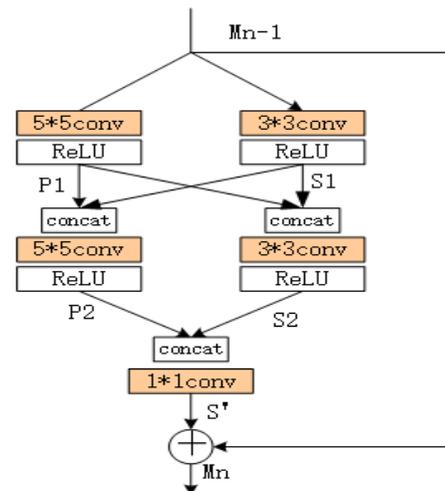

Figure 3.   Multi-scale residual structure diagram

So the input and output of the first convolutional layer have M feature maps. The input or output of the second convolutional layer has 2M feature maps. All these feature maps are connected and sent to a 1×1 convolutional layer. This layer reduces the number of these feature maps to M, so the input and output of the MSRB have the same number of feature maps. The unique architecture allows multiple MSRBs to be used together.

Local residual learning: inspired by residual blocks. Multi-scale residual blocks introduce residual ideas to i-mprove the expressive ability of the network. The expre-ssion of the local residual is as follows:

$$M_n = S + M_{n-1} \qquad (7)$$

Among them, M_n and $M_{(n-1)}$ represent the input and output of MSRB respectively. The operation $S+M_{(n-1)}$ is executed by shortcut connection and adding in order of elements. The use of local residual learning greatly red-uces the computational complexity and improves the pe-rformance of the network.

With the increase of depth, the spatial expression ability of the network gradually decreases, while the semantic expression ability gradually increases [16]. In addition, the output of each MSRB contains different features. Therefore, how to make full use of these hierarchical features will directly affect the quality of the reconstructed image. In this paper, we use a simple hierarchical feature fusion structure. We send all the output of MSRB to the end of the network for reconstruction. On the one hand, these feature maps contain a lot of redundant information. On the other hand, directly using them for refactoring will greatly increase the computational complexity. In order to adaptively extract useful information from these hierarchical features.

TABLE I.   DISCRIMINATOR NETWORK STRUCTURE DIAGRAM

#	Layer	Weight demension	stride
1	conv	32 x 32 x 5 x 5	2
2	conv	64 x 32 x 5 x 5	1
3	conv	64 x 64 x 5 x 5	2
4	conv	128 x 64 x 5 x 5	1
5	conv	128 x 128 x 5 x 5	4
6	conv	256 x 128 x 5 x 5	1
7	conv	256 x 256 x 5 x 5	4
8	conv	512 x 256 x 5 x 5	1
9	conv	512 x 512 x 4 x 4	4
10	fc	512 x 1 x 1 x 1	-
11	sigmoid		-

C. Loss function

Inspired by the loss function of GAN, the loss function used in this paper is a combination of multi-scale loss functions. The multi-scale loss function can be e-xtracted from the features of different scales, and deblurring from coarse to fine; the adversarial loss function uses the idea of generating against each other to generate a clear image that is closest to the real image [17]. The specific definition is as follows:

$$L_{total} = L_{multi} + \lambda \times L_{adv} \qquad (8)$$

1) Multi-scale loss function: This method is coarse to fine method and the output of each intermediate layer *is* a clear image of the corresponding scale. Therefore, the use of a multi-scale loss function can form a clear Gaussian pyramid into each clear image in the middle.

The MSE standard applies to each level of the pyramid. Therefore, the loss function is defined as follows：

$$L_{cont} = \frac{1}{2K} \sum_{k=1}^{k} \frac{1}{c_k w_k h_k} \left\| L_k - S_k \right\|^2 \qquad (9)$$

Among them, L_k and S_k respectively represent the model output and the real image on the scale level k. The loss of each scale is normalized by the number of channels c_k, with w_k and height h_k.

2) Adversarial loss function: The image restoration is constrained by the game between the generator and the discriminator, where G and D represent the generator respectively, that is, the multi-scale deblurring network and discriminator (classifier) in Table Ⅰ log (x) is the probability that the discriminator judges the real data as the real data, and log (1-D (G (B))) is the probability that the discriminator judges the false data generated by the generator as the opposite of the real data, that is, the probability that the false data is still judged as the false data. The total loss of the discriminator is the sum of the two, which should be maximized. As the ability of discriminator to distinguish the true from the false becomes higher and higher with the increase of training times, the generator has to compete with it, and the generator has to improve its technology accordingly. Therefore, the two improve each other or reduce their own losses, in order to constantly confront each other by combining multi-scale content loss and adversarial loss, the generation network and the discrimination network are jointly trained. The expression of the loss function is as follows:

$$L_{adv} = E_{S \sim P_{sharp}(S)} \Big[log D(S) \Big] + \\ E_{S \sim P_{blurry}(S)} \Big[log \big(1 - D \big(G(B) \big) \big) \Big] \qquad (10)$$

Without the generation confrontation network, the generated image will have some improvement compared with the original image, but most of the images are fuzzy, the transition of the object edge will be smooth, and the gap is obvious compared with the real image. After joining the generative countermeasure network, the network can further explore the gap between the generated samples and the real samples, and further improve the visual effect of the generated image. In addition, the network also improves the robustness of the algorithm [18].

IV. EXPEEIMENTS

All experiments adopt Pytorch deep learning architecture, and process training images before each batch of training. Firstly, the blurred image and the clear image are randomly placed in the same position, and the image is cropped to 256×256 pixels. The fuzzy image after cutting is used as the input of the generator, the discriminator is used as the input of the discriminator, and the clear cutting image is used as the output of the generator [19]. It should be noted that only when the discriminating ability of the discriminator is strong enough, can it guarantee the optimal result. The dataset and model are introduced respectively [20].

A. Dataset

Neural network training needs a large number of data sets, and the early blurred image is obtained by convolution of fuzzy kernel and clear image. However, the blurred image produced by this simple method is quite different from the real image collected by the camera. Nah et al. Proposed a new image generation method, which uses a high-speed moving camera to capture video, and extracts the connected short exposure frames for averaging, so as to get the blurred image. For example, GOPRO hero 4 black is used to obtain a long exposure blurred image. This method can simulate complex camera jitter and object motion, and the image is closer to the real image. GOPRO dataset is generated by this method. In this experiment, GOPRO dataset is used to train the network. The dataset contains 3214 pairs of blurred and clear images, 2103 pairs of images are selected for training, and 1111 pairs of images are tested.

B. Model training

This article uses the Pytorch deep learning framework. The neural network requires a large number of datasets to train and test the network, shows in Table Ⅱ. The figure below is a simple discriminator built with 9 layers of convolutional

layers, the activation function uses the sigmoid function, and the volume can all be 5x5 size, as shown in the following table. The weight constant $\lambda = 1\times10^4$. We use ADAM optimizer and mini batch size 4 for training. The learning rate is adjusted adaptively from 5×10^{-5}. After1.5×10^5 iterations, the lea-rning rate is reduced to 1/10 of thr previous one. The overall training requires 4.5×10^5 iterations.

C. Test results

The blurred images in the testset are sent to the generating network for processing, and the deblurring images are obtained. No discriminator is needed in this process. Through the analysis of the original author's data, it can be concluded that PSNR and SSIM have been significantly improved, and the running time has been significantly shortened. In the image shown in the Figure 4. The clarity of the image is significantly improved. The algorithm in this paper can restore the details of the image clearly and meet the basic visual requirements.

TABLE II.　　QUANTITATIVE COMPARISON OF FUZZY PERFORMANCE OF GOPRO DATASET

	PSNR	SSIM	Runtime
Nah et al.	26.64	0.9142	0.93s
ours	27.33	0.9324	0.72s
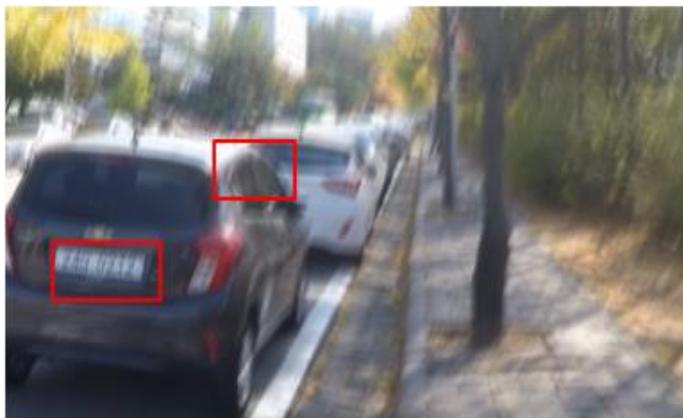
Blurred image

Nah et al.

Ours

Figure 4.   Comparison of GOPRO dataset test results

V.   SUMMARY AND PROSPECT

The main content of this paper is motion image deblurring. In view of the poor effect of motion deblurring, the idea of end-to-end blind deblurring is proposed. Unblinded deblurring is a method that does not depend on the estimation of fuzzy kernel, and it can restore the image directly by constructing neural network. The network structure of this paper Multi-scale fusion is through the use of different convolution kernel, which can extract image features in multiple directions and process the texture details of the image; the function of local residual should be used to fuse the extracted different feature images, and the second function can reduce the load of neural network. The combination of multi-scale loss function and adversarial loss function constrains the generation effect of clear image, making the final image closer to the real image. The whole network structure of this paper is simple, and it is suitable to deal with image degradation caused by motion blur. The future work will focus on the following aspects:

1) The algorithm is still lacking in the restoration of the details of the blurred image, and it is necessary to further modify the network design to improve the clarity of the image.

2) The multi-scale residual network structure extracts feature maps of different scales through convolution kernels of different sizes, and will be considered for application in the field of restoring blurred videos in the future.

REFERENCES

[1] K. Zhang, W. Zuo, and L. Zhang. Learning a single convolutional super-resolution network for multiple degradations. In CVPR, 2018.

[2] Lai W S, Huang J B, Hu Z, et al. A Comparative Study for Single Image Blind Deblurring[C]// IEEE Conference on Computer Vision and Pattern Recognition. IEEE, 2016.

[3] X. Tao, H. Gao, R. Liao, J. Wang, and J. Jia. Detail-revealing deep video super-resolution. In ICCV. IEEE, 2017.

[4] Y.-W. Tai, P. Tan, and M. S. Brown. Richardson-lucy deblurring for scenes under a projective motion path. IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), 2011:1603–1618.

[5] Wang F, Jiang M, Qian C, et al. Residual Attention Network for Image Classification [J]. arXiv: Computer Vision and Pattern Recognition, 2017

[6] Kupyn O,Budzan V,Mykhailych M,Mishkin D and Matas J. DeblurGAN: blind motion deblurring using conditional adversarial networks/ /Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Ｒecognition. Salt Lake City: IEEE, 2018.

[7] Fergus Ｒ, Singh B, Hertzmann A, Ｒoweis S T and Freeman W T. Removing camera shake from a single photograph. ACM Transactions on Graphics, 2006:787-794.

[8] Shan Q, Jia J, Agarwala A. High-quality motion deblurring from a single image[J].Acm transactions on graphics (tog), 2008:73.

[9] Xu L, Ren J S J, Liu C, et al. Deep convolutional neural network for image deconvolution[C]//Advances in neural information processing systems. 2014:1790-1798.

[10] J. Sun, W. Cao, Z. Xu, and J. Ponce. Learning a convolutional neural network for non-uniform motion blur removal. In The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), IEEE, 2015:769–777.

[11] Schuler, H. Christopher Burger, S. Harmeling, and B. Scholkopf. A machine learning approach for non-blind image deconvolution. In The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2013:1067–1074.

[12] Gong D, Yang J, Liu L Q, Zhang Y N, Ｒeid L, Shen C H,Van Den Hengel A and Shi Ｑ F. From motion blur to motion flow: a deep learning solution for removing heterogeneous motion blur/ /Proceedings of the IEEE Conference on Computer Vision and Pattern Ｒecognition(CVPR). Honolulu: IEEE, 2017:3806-3815.

[13] Nah S, Kim T H and Lee K M. Deep multi-scale convolutional neural network for dynamic scene deblurring//Proceedings of theIEEE Conference on Computer Vision and Pattern Ｒecognition. Honolulu: IEEE, 2017:257-265.

[14] Li J, Fang F, Mei K, et al. Multi-scale Residual Network for Image Super-Resolution: 15th European Conference, Munich, Germany, September 8-14, 2018, Proceedings, Part VIII[C]// European Conference on Computer Vision. Springer, Cham, 2018.

[15] Yan Y, Ren W, Guo Y, et al. Image deblurring via extreme channels prior[C]//Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2017:4003-4011.

[16] Xingjian S H I, Chen Z, Wang H, et al. Convolutional LSTM network: A machine learning approach for precipitation nowcasting[C]//Advances in neural information processing systems. 2015:802-810.

[17] Dumoulin V, Visin F. A guide to convolution arithmetic for deep learning [J]. arXiv preprint arXiv:1603.07285, 2016.

[18] Xu X, Pan J, Zhang Y J, et al. Motion blur kernel estimation via deep learning [J]. IEEE Transactions on Image Processing, 2018, 27(1):194-205.

[19] Li Y, Liu S, Yang J, et al.Generative face completion[C]. 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, 2017:5892-5900.

[20] Xingjian S H I, Chen Z, Wang H, et al. Convolutional LSTM network: A machine learning approach for precipitation nowcasting[C]//Advances in neural information processing systems. 2015:802-810.

The Future Network is the System Innovation that Builds on the Future

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I. UNSWERVINGLY BUILDING NETWORK POWERS IN THE NEXT FIFTEEN YEARS

The next 15 years, it is a new period of inspiration to unswervingly build a network power, digital China, and comprehensively strengthening the network security and security system and capabilities; it is a period of tenacious struggle to build and develop a network power with distinct sovereignty, independent control, security and efficiency, and to win a new victory in building a socialist modern country in an all-round way.

The CPC Central Committee's proposal for the formulation of the 14th Five-Year Plan for National Economic and Social Development and the 2015 Vision states that the whole Party should "carry forward the spirit of struggle, set up a bottom-line thinking, accurately recognize change, adapt scientifically, take the initiative to change, be good at raising opportunities in crisis, opening new change situations, seize opportunities, meet challenges, seek advantages and avoid disadvantages, and advance courageously ."

Sovereignty, security and development interests are the whole bottom line thinking of building a socialist modern country in an all-round way, which cannot be decomposed or transferred.

Safeguarding and safeguarding national sovereignty is the basis of the principle of overall development and security; building a solid national security barrier is the fundamental guarantee of sovereignty and development; and achieving higher quality, more efficient, more equitable, more sustainable and safer development is the core will of sovereignty and security.

For a long time, China's public network has been confined to the Internet "American interests first" protocols and standards, restricted by the United States Internet "one Internet dominates the world" constraints and control, shackled in the U.S. military regulation of Cyber Space "the fifth battle area" thinking stereotype, ideological blind pursuit, technical constraints, management Handan toddler, in the field of network information key infrastructure and core technology few innovations, serious lack of international voice and rule-making power. Especially in the absence of scientific practice and argumentation, the blind deployment of the transition (experimental) plan of Internet IPv6 on a scale leads to the deepening, large-scale and diversified serious problems that endanger and threaten the sovereignty, security and development interests of China's important

industries, infrastructure, strategic resources, major science and technology and other key areas.

At present, the resistance, pressure and friction caused by the pro-Americanization and management lag of the existing network information system and mechanism in China are huge, and the tension, tension and centripetal force of independent scientific and technological innovation are obviously insufficient. The bottom-up chaos, confusion, confusion and confusion in the network information industry, and the top-down confusion, uncertainty, interweaving, interlacing, and mutual entanglement, it is difficult to form a powerful driving force and national stability of "coordinating traditional and non-traditional security, and running the development of security through all fields and the whole process of national development.

Some party and government cadres, network letter elite, industry talent, away from the Internet, left the IPv4, IPv6, do not know what to say, what to think, what to do. Emancipating the mind, expanding the vision, opening up the way, learning from the masses is the current management; knowledge level must set up the fashion, ability, and display level. Complicating simple problems, or tugging on the technical links between the US IPv6 and China's five G, is an old set of seemingly authoritative "consistently correct" numbers. We must adhere to the standard of practice to test the truth and carefully comb and clear the audit, and must not allow people and things who "sell their fields without heartache" to continue to mess up and mess up. The Party does not agree, and the people do not.

How to build the future network, what kind of future network, what are the standards, signs and norms to realize the future network power? We must make it clear, we must define and understand, and we must form a highly unified understanding, will, public opinion and action of the whole party, the whole army, ideological and political.

The 14th Five-Year Plan is being refined, deepened and quantified. It is urgent for our country to resolutely adjust the plan and arrangement of the extraordinary scale transition (experiment) falling into the American trap, to encourage independence, self-improvement, and systematic innovation to carry on the past, and the whole country to advance bravely in the new journey of the network power.

II. THE FUTURE HAS COME, COMPARED WITH THE EXISTING PAST, THE FUTURE NETWORK IS A PLAN AND STANDARD INNOVATION

Since the 1980s, the Internet, which was extended and evolved by the American Apache network, has rapidly expanded the world and realized the original intention of "one net world" in the United States. From the beginning of this century, on the one hand, the United States has openly pushed the IPv6 transition (experimental) plan to the world (especially China) to push the Internet; on the other hand, it has organized the domestic dominant scientific and technological forces to secretly develop the "quantum Internet". In July 2020, the United States Government announced that a quantum Internet parallel to the existing Internet would be built within 10 years.

A clear understanding must be made that in the last century, the United States spent more than 20 years basically realizing the "one world" of the Internet, in which China's full access to the IPv4-based Internet in the 1990s accelerated this process. This century, the United States has spent nearly 20 years to realize the basic research and development based on IPv4 Internet under the cover of IPv6 transition (experiment), and has crossed the threshold of quantum Internet systematic innovation of parallel Internet.

China's original Ministry of Information Industry set up the "decimal Network Standards working Group" in September 2001 to explore network protocols and standards to adapt to and promote the modernization of socialism with Chinese characteristics. To explore the systematic innovation of independent and controllable public network based on IPv4 Internet. Despite enormous bottom-up, top-down efforts, the balance between policy implementation and coordination of resources was increasingly skewed to follow IPv6, missed nearly 20 years of innovation exploration and catch-up opportunities. Today, our country is still subject to the United States, behind the United States, more than half a century behind, more than one network era.

The successful experience of the United States should be used for reference. Seeking and maintaining a strong national defense (military) advantage has always been in the first sequence of the "American priority" policy. Military network has always been the core network of the United States Internet, "lighthouse network", "network in the network", in the Internet network of the top, " the top". The network information space composed of "bright net", "deep net" and "dark net", the network information service provided by the Internet, as well as its continuous strengthening and perfect technical support, is not only the outer barrier of the security protection of the American military network, but also the of open source information for the US military and the US government.

The Pentagon's recently released Department of Defense data Strategy 2020 defines the "data weaponization" consciousness and concept of "treating data as a weapon system and managing, protecting and using data to achieve operational and operational results. The U.S. Army Network Warfare Command has also integrated electronic

warfare and information warfare into "information advantage" (Information Advantage) and will gradually replace "information warfare" (Information Warfare) to support "decision advantage "(Decision Advantage). However, China's network information planning has long focused on the application of simple technology, ignoring the comprehensive, multi-angle, deep-seated center of gravity, gravity and emphasis of the integration of the military and the people, ignoring the main contradictions and contradictions in the field of network information, unreasonable structural planning and unsafe technical structure. In the event of an American cyber-attack and defense war against China, the result of serious asymmetry, imbalance and mismatch of attack and defense forces is obvious.

First of all, our country must draw up the independent and controllable network planning and the safe and efficient network standard, and draw the blueprint of our country's self-strengthening and striving network power. China's network planning and standards must be clear-minded in their own decisions, must take a clear-cut stand to ensure the sovereignty, security and development interests of the large circulation in the field of domestic network information, and must actively build and promote the development of a new pattern of domestic and international double circulation in the field of network information under the sufficient and necessary conditions of unswerving construction of network power. This principle of sovereignty, leading thinking, primary and secondary relations must not be reversed, misplaced, counter-control.

China's cyberspace can only be China's sovereign category. The network data and citizen privacy information originated from, originated from and formed in China must be guaranteed and maintained by China's national sovereignty. Any

country, any organization, any individual without our government's approval or violation of our data protection laws and regulations, must be punished by our government according to law, never in vain.

China's cyber-information space should have its country's borders (equivalent to cyber-customs), authentication agencies (equivalent to network immigration), international political, economic, trade and cultural exchange examination and approval agencies (equivalent to network foreign affairs ministry, commerce ministry, culture ministry, etc.), and power agencies (equivalent to network defense ministry of defense, national security, development interests) that defend the country's cyber-information space sovereignty, security, etc. China must step up planning, overall planning, careful planning and implementation of the plan, starting with planning and standards, and build a solid national security barrier.

China's national standards in the field of network communications can refer to the international standards adopted by the members of the ISO/IEC countries, the standards of Europe, Russia and other countries in the world, and cannot follow the standard of pure "American interests first interests first ". It is necessary to have the key infrastructure and core technical standards of China's independent and controllable decision, and must form its own standard system. Frankly speaking, it is necessary to give the United States and its supporting hostile forces the protocols and standards of network letters that potentially endanger China's sovereignty, security and development interests, set up a mirror, read a mantra, sacrifice gold hoops, design, distribute, maintain, route and resolve domain names, addresses, AS autonomous domain codes, and enforce compliance with China's regulations and standards, enforce compliance with China's

jurisdiction and governance, never slacken, and never succumb to threats, clampdowns, blockades and sanctions from any foreign or foreign organization or agency.

China's cyberspace must unswervingly and strictly implement the standards, norms and systems that safeguard and safeguard China's sovereignty, security and development interests. Any data and information must not only accept China's visa, inspection and examination and approval, but also be subject to China's legal and control according to law. Once found, severe punishment, random expulsion.

III. THE FUTURE HAS COME, AND THE FUTURE NETWORK IS THE INNOVATION OF KEY INFRASTRUCTURE AND CORE TECHNOLOGY RELATIVE TO THE PROGRESS OF THE TIMES

The economic, political, cultural, military and social information of the world and other countries, the United States relies on the Internet's coverage, control and surveillance capabilities and scientific and technological advantages, at a glance, in the bag, at its disposal and use. Especially for China, Russia, France, Britain and the long-term allies of the United Nations, Germany, Japan, Canada, Australia, New Zealand and so on, whether dignitaries, giants, soldiers, elites, are in the "prism" of the United States. In recent years, in order to protect the data and personal privacy of member

The Internet has become the bridge and context to communicate the destiny community of global cyberspace. All roads, routes, road signs, road signs (passes) are set up, managed and distributed in the United States, and all pass and road cards of "clear repair trestle, hidden warehouse" are set up and preferential exclusive service for "American interests first ". How easy is it to rebuild the network?

"One size fits all "," one move fresh "," one pot end" idea, people thought many, tried many years. Too many practices prove unrealistic, unfeasible and unreliable. The key is to violate the laws of science.

Some people lose the spirit of "two bombs and one star" patriotic struggle and the soul conscience of scientists, opportunistic, eager to achieve immediate benefits, deceiving the upper and lower, taboo medical care, worthy of fame. In order to solve the so-called "insufficient address" problem, the country and people have spent trillions of huge capital funds since this century alone, and the manpower and material resources and time costs that are difficult to count. At present, we are still forced to go back to the origin of "pure IPv6"" to find a way out, to find a way out, to find a way out. The core U.S. military network still depends IPv4, more than 80% of users IPv4. The world In the face of irreparable cruel lessons and the truth, how can we be calm and insensitive?

The future network is the evolution promotion on the basis of reality, is to draw the foundation for the obvious disadvantages of the existing network, is to inherit critically and critically, is to correct mistakes, change the old, create new, is to turn passivity into initiative, make the old look new, is to create conditions for the realization of the network power, lay the foundation, clear the obstacles, and smooth the road.

Domain name, address and AS autonomous domain code design, planning, allocation (lease), maintenance, analysis (routing command, scheduling and analysis identification system formed according to established protocols, standards and specifications) constitute the "foundation" of all hardware, software and data of the Internet, constitute the physical framework identification system of Internet space, and constitute all sovereign attributes such as the

dominant power and control right of the Internet. More than 96% of the data in China only need to flow in China, but they are forced (mandatory) to accept the guidance of overseas routing to Japan, Taiwan, Singapore and so on. The huge cost of information flow dominated by international routing was eventually passed on to hundreds of millions of Internet users in China.

Can we design, compile and control the domain name, address and AS autonomous domain of our public network? Autonomous control of data information routing, autonomous resolution of domain names address? In theory, there is no can, only possible, since possible, do not try how to know cannot? Americans can, why can't the Chinese? There is nothing difficult in the world, as long as you are willing to climb.

The digital domain name technology of decimal network, as well as the identification network technology, all things wide code technology, graphic code information technology and so on, all show the intelligence of the Chinese nation. Whether it is fair, fair and open to support, for our independent innovation to provide the necessary environment, conditions, scenes and policies for large-scale network experiments and verification, is a clear-cut embodiment of the will of national sovereignty, no one or any unit should have any excuse and criticism of prevarication.

Do not try, dare not try, or no conditions to try, or fear that the United States long arm jurisdiction hegemony not to try? Or scruples about other interests deliberately avoid trying? The future has come, carry on the past, let not try, try not to try, when can try? Urgent need to be clear, urgent need to plan, urgent need to support.

Complex problems should be simplified. In the next 15 years, we should unswervingly build a network power and a digital China, and win a new

victory in building a socialist modern country in an all-round way.

Holding a cow's nose, what cattle do not follow me, do not listen to my words?

IV. THE FUTURE HAS COME, COMPARED WITH THE FUTURE WORLD, THE FUTURE NETWORK HAS ALWAYS BEEN IN THE STATE OF CONTINUOUS INNOVATION REVOLUTION

The future network is the foundation and process of the network power, but also the movement stage of continuous innovation. The future network is always dynamic, developing and progressive. Half a century, a century is subject to certain agreements and standards cannot accurately identify changes, scientific adaptation, active change of the network information space, can only be rigid, lag, do not adapt to the future environmental ecology and the needs of the development of the past tense, old style.

The world's most authoritative standardization organization ISO/IEC officially released TR 29181"Future Network Issues Statement and Requirements", 2014:

1.1 Future Network (FN) [ISO/IEC TR 29181-1]

The FN is the network of the future which is made on clean-slate approach well as incremental design approach. It should provide futuristic capabilities and services beyond the limitations of the current network including the Internet.

Future networks redesigned with clear whiteboards and incremental design methods should provide capabilities and services beyond current network constraints, including the Internet.

From this perspective, the future network will not be restricted by all current and previous electronic computer networks, control networks, embedded networks, etc., and by wired networks, wireless networks, optical communication networks, microwave communication networks, space networks, etc., in the sense of electromagnetic spectrum. It will not be entangled by the physical Internet, telecommunications networks, power networks, industrial control networks, software-defined networks, etc., and will cover the public, private and proprietary cyberspace in all fields of electronics, electromagnetic spectrum, quantum, cosmic gravity, human channels and biological information that mankind already knows, As well as the future development of the new cyberspace domain, constitute a diversified, multi-level, multi-angle coverage of wired, wireless, space, laser, quantum communications and other network domains for the future information society information processing and exchange system.

The future network will eventually have broad and deep space resources, support the interconnection, mutual trust, mutual operation of all network domains, realize the safe space environment of information sharing and exchange of human existence, life and production activities by people, objects and environment, and provide the ability and service of corresponding, interdependent and mutually promoting with the real physical world, and orderly management, security interaction, credibility and control, mutual communication, holographic mapping.

The future network will be an integral part of the cyberspace between the known and unknown universe. And it will not only completely abandon the structural, periodic and epochal defects of today's Internet IPv4, IPv6 technology, create a subversive theoretical and conceptual innovation, and finally complete the evolution and evolution process from computer network to information network, knowledge network and social integrated intelligent network provide the most reasonable,

convenient and advanced information processing ability and service for human information society to adapt to all historical stages.

However, this is not an overnight, wishful thinking, the need for human generation after generation of concerted efforts, continuous innovation and development. Because of this, the future network is a system innovation to carry on the past.

In the next fifteen years, we will start a new journey to build a socialist modern country in an all-round way, march towards the goal of the second century, and unswervingly build a manufacturing power, a quality power, a network power, a digital China, and a patriotic, national and revolutionary soldier in the field of network information in China.

The future has come, the network power, the husband has the responsibility.

Motherland, here we come!

（2020.11.16）