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DIGITAL MEDIA INTERNET MODELING SYSTEM UNDER COMPUTER ARTIFICIAL INTELLIGENCE TECHNOLOGY

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Abstract. With the continuous expansion of network scale, the hierarchical and modular characteristics of network structure are becoming increasingly prominent. The traditional single-layer network research paradigm has certain limitations in characterizing the complex relationships between various network systems. Analyzing and constructing models for multi-layer networks has gradually become an important direction in complex network research. The author proposes a multi-layer network model for the Internet and the significance of constructing multi-layer network models in the field of the Internet, based on the characteristics of the multi-layer network structure presented in the application process of the Internet. By analyzing the characteristics of internet data, a multi-layer network model covering three types of networks, namely the internet infrastructure layer, business application layer, and user account layer, was designed. The experimental results show that the average shortest path lengths of the three networks, namely routing relationship network, web hyperchain network, and email address network, are 3.8, 2.9, and 1.7, respectively. Due to the existence of inter layer edges in multi-layer networks, nodes can reach each other across layers in addition to intra layer edges. Experimental results show that the average shortest path length of the three networks has been shortened to some extent, with values of 3.1, 2.7, and 1.6, respectively. On the basis of the single-layer network generation model, a layer correlation method for multi-layer networks was designed, and the model construction of multi-layer networks was achieved.

Key words: Internet, Digital media, Kernel distribution, Multi layer network, model building

1. Introduction. With the continuous development and application of computer artificial intelligence technology, the field of digital media internet has shown enormous development potential. Digital media internet refers to a form of media that utilizes computer networks and digital technology for information dissemination, content exchange, and user interaction [1]. It has become an important way for people to obtain information, entertainment, and socialize in today's society. However, the rapid development of digital media internet has also brought a series of challenges and problems, such as information overload, uneven content quality, and poor user experience. Firstly, with the popularization of the Internet and the rapid development of digital media, people are facing a huge problem of information overload. In the era of digital media and the internet, people can easily access a large amount of information, but at the same time, they also face difficulties in information filtering and screening. Excessive information may lead people to be unable to quickly and accurately find the content they need, and even fall into the dilemma of information overload. In order to solve this problem, digital media internet platforms need to strengthen the research and development of information classification, recommendation algorithms, and other aspects, provide personalized information services, and help users better obtain the required information. Secondly, the uneven content quality of digital media internet is also an urgent issue that needs to be addressed. With the development of the Internet, anyone can easily publish content on digital media platforms, which leads to uneven quality of content. Some information may be misleading, false, or even illegal, causing confusion and distress to users. In order to improve content quality, digital media internet platforms need to strengthen content review and supervision, establish effective information dissemination mechanisms and content management systems [2]. At the same time, users also need to improve their ability to distinguish information and avoid blindly believing and disseminating unreliable information. In addition, the user experience of digital media internet platforms also needs to be further improved. Although the digital media internet provides users with abundant information resources and communication platforms, sometimes

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users may encounter some problems during the process of using the digital media internet, such as slow page loading speed, excessive advertising, etc. These issues may affect the user experience and even make them lose interest. Digital media internet platforms need to continuously optimize user interface design and improve system performance to provide a smoother, more convenient, and personalized user experience.

In addition, the rapid development of digital media internet has also brought privacy and security issues. In the era of digital media and the internet, the leakage of personal information and network security threats are becoming increasingly serious. In order to protect the personal privacy and information security of users, digital media internet platforms need to strengthen the protection measures of user data, encrypt user data, and establish sound security mechanisms. At the same time, users should also raise their security awareness, strengthen the protection of personal information, and make reasonable use of digital media internet platforms [3].

In short, with the continuous development and application of computer artificial intelligence technology, the field of digital media internet has shown enormous development potential. However, the rapid development of digital media internet has also brought a series of problems and challenges [4,5]. In order to overcome these issues, digital media internet platforms need to strengthen information filtering and filtering, improve content quality, improve user experience, and protect user privacy and information security. Only in this way can digital media and the internet better provide people with high-quality information services, promote social progress and development.

2. Methods.

2.1. Current status of multi-layer network modeling research.

(1) Multi layer network generation model. At present, multi-layer network modeling is still in its early stages, and multi-layer network generation models can be divided into two categories. One type is the growing multi-layer network model, in which the number of nodes gradually increases according to a generalized priority connection rule. These models explain the evolution process of multi-layer networks from simple and basic dynamic laws. The process of constructing this type of model is as follows: 1) Growth, adding a new node in each layer of a multi-layer network at each time step, and connecting the new nodes in each layer to other nodes in the same layer through m links; 2) Generalized priority connection, where new nodes select existing nodes in the network to connect based on the probability of intra layer and inter layer connections [6]. Another type is multi-layer network composite models, which consider multi-layer networks as a collection of single-layer networks that satisfy certain structural constraints between layers. These sets can generate multi-layer networks with degree correlation and controllable overlap. The idea of this type of model is to first consider the generation of each network layer and then consider the connections between layers, where each layer is generated according to the static model of traditional single-layer networks: Given the node degree sequence of each layer, a configuration model is used to obtain a specific network implementation for the given connection set [7]. There are two ways to connect layers: One is to add any inter layer connections, and the other is to specify inter layer edges by giving a joint degree distribution. Although the terms "joint degree sequence", "joint degree matrix", and "joint degree distribution" are commonly used in literature to represent the number of degrees related to the end of link nodes in a simple network, they explicitly refer to the connections between layers. In the process of constructing multi-layer networks, the selection of any network model will impose certain constraints on existing research, and each network model corresponds to a set of networks that satisfy the implicit constraints imposed by the model. The computer internet is a typical complex network system, and multi-source data often has multiple types of correlations, making computer network systems have multi-layer network characteristics. Therefore, it is very important to study the generation model of multi-layer network security that conforms to the actual network characteristics.

(2) Typical network model metrics. The degree k of node i in a complex network is defined as the number of edges connected to that node, and the average of the total degrees of all nodes is called the average degree. P (k) represents the proportion of nodes with degree k in the network to all nodes, used to represent the distribution of node degrees in the network. If there are N nodes in the network and nk nodes with degree k, then:

$$p(k) = \frac{n_k}{N} \tag{2.1}$$

The k-kernel of a complex network is defined as the remaining subgraph after sequentially removing nodes with degree k-1 from the network. If a node is in the k-kernel of the network and not in the graph with degree k-1, then that node is a k-kernel. g (k) represents the proportion of nodes with kernel number k to all nodes in the network, used to represent the distribution of node kernels in the network[8]. If there are N nodes in the network and nk nodes with kernel number k, then:

$$g(k) = \frac{n_k}{N} \tag{2.2}$$

The average path length L of a complex network is defined as the average of the shortest path length d_{ij} between any two points i and j in the network. This indicator is usually used to measure the efficiency of the network. The smaller the average path length of the network, the higher the efficiency of the network. Its specific expression is:

$$L = \frac{2}{N(N-1)} \sum_{i \neq j} d_{ij} \tag{2.3}$$

The diameter D of a complex network is defined as the maximum distance between all nodes in the network.

$$D = \max_{i,j \in N} d_{ij} \tag{2.4}$$

2.2. Analysis of multi-layer network structure of the Internet . With the continuous expansion of network scale, various types of networks have formed in the Internet. In addition to the interconnection of underlying network devices, various business system related networks have formed at the application layer, and various network account related networks have formed at the user layer. The entire Internet exhibits characteristics of diversity, heterogeneity, and layering [9]. Traditional single-layer networks cannot characterize the multidimensional characteristics of internet data, so it is necessary to establish a multi-layer network model in the field of the internet. The author proposes a multi-layer network structure for the Internet from three layers: basic device layer, business application layer, and user role layer.

The infrastructure layer is a physical network established by various network devices interconnected through physical links, with nodes mainly including routers, switches, servers, etc; The business application layer is mainly a logical network formed by various application systems during the communication process of various business applications [10]. Its nodes mainly include, as there are many business systems operating in the Internet, different types of business systems may form their own networks. When these application systems are laid out on the same server device, there may be correlation relationships between different business system networks. Virtual entity composition, such as various sites, application systems, and business software, including various types of websites, email addresses, etc [11]. The nodes in the user role layer mainly include various accounts registered and used by people during the process of using the Internet. The entities and attribute elements of each layer are listed in Table 2.1.

In the application process of the entire Internet, each layer can form different types of networks based on different connections. For example, in the basic equipment layer, nodes form communication networks according to the relationship between optical cables and ground cables; In the business application layer, different business relationship networks are formed based on different types of business, such as email address networks, web hyperlink networks, etc; At the user role level, different types of social networks are formed based on different social relationships, such as friendship networks, Weibo account following networks, etc. From a vertical perspective, the lower level network nodes are the foundation for the existence of the upper level network nodes. For example, each application system operates on servers in the lower level network, and each account is registered on application software. There is a strong dependency relationship between layers [12].

This multi-layered network structure representation for the Internet plays an important supporting role in characterizing network spatial trends, analyzing network vulnerabilities, and conducting network tracing and evidence collection.

From the perspective of network situation display, by constructing a multi-layer network in the Internet field, Internet data can be presented to network users in a multi-level and multi-scale form, in order to understand the structural characteristics of the network and provide model support for subsequent network decision-making

Table 2.1: List of the three-tier network model elements

Network hierarchy	Entity	Attribute
Basic equipment layer	Server, computer, router, access device	City, IP address, autonomous domain number, port, manufacturer
Business application layer	Software, various types of data	System software: Windows, Ubuntu, Centos Application software: WeChat, email, website data: account and password, text, video
User Role Layer	Account	Registration time, registration unit, etc

Table 3.1: Statistics of the actual network characteristic parameters

number	project	Routing network
1	Number of nodes	192244
2	Number of edges	609066
3	Average path length	4.61
4	Average degree	6.34
5	Maximum degree	1071
6	Network diameter	12
7	Number of network cores	31

and deployment[13]. From the perspective of analyzing network vulnerability, the analysis of key nodes based on multi-layer network structure will have a significant impact on the analysis process, which may enable cross layer attack paths that were previously unreachable in single-layer networks to be reachable in multi-layer networks. This provides a new research approach for conducting network vulnerability analysis and evaluation. In terms of network traceability, multi-layer network models can more efficiently achieve this function. For example, if a company receives a phishing email and uses a multi-layer network to analyze and trace criminals, the process is as follows: First, match the email with logs to obtain the sender's email address, locate the email sender upwards, and locate the email sender's IP downwards [14]. If the IP is not the attack source, use the association relationship of the email address to find the address that has email exchanges with the email sender, and further locate the user upwards, downward positioning to achieve multi-path traceability of the target.

3. Experiments and Analysis.

3.1. Single layer network modeling experiment. The author used Python and its NetworkX module for network modeling and related feature parameter statistics experiments. In order to better demonstrate the practicality of the CGN model constructed by the author, actual network topology data was first obtained, and then an equally sized network was generated using the CGN model. The relevant statistical parameters of the CGN model generated network and the actual network were compared and analyzed [15].

The model validation data is sourced from the open-source dataset website CAIDA1. In complex network theory, network topology is generally described using statistical characteristics such as the number of nodes, edges, degree and degree distribution, kernel number and kernel distribution. After calculation, the statistical situation of the relevant characteristic parameters of the actual network is listed in Table 3.1.

The author intends to verify the applicability of the model by comparing the relevant parameters of the actual network and the network constructed by the author's proposed model. In order to ensure the reliability of the experimental results, 10 experiments were conducted using the CGN model to generate networks of the same scale. The average of these 10 statistical results was taken as the comparison parameter for each feature parameter.

Table 3.2: The comparison of static statistical characteristics

number	project	Routing network	CGN network
1	Number of nodes	192244	192244
2	Number of edges	609066	614526
3	Average path length	4.61	4.56
4	Average degree	6.34	6.16
5	Maximum degree	1071	1108
6	Network diameter	12	11
7	Number of network cores	31	31

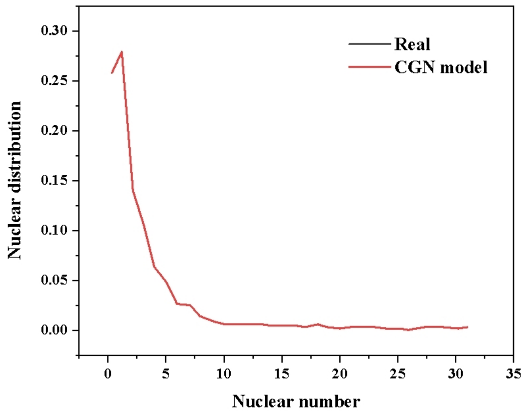


Fig. 3.1: Comparison of Kernel Distribution

From Table 3.2, it can be seen that the actual network and the number of generated network nodes are completely consistent with the number of network cores, the number of node edges is equivalent, the average path length is basically consistent, and the average degree and maximum degree are also similar, indicating that the model has good applicability [16].

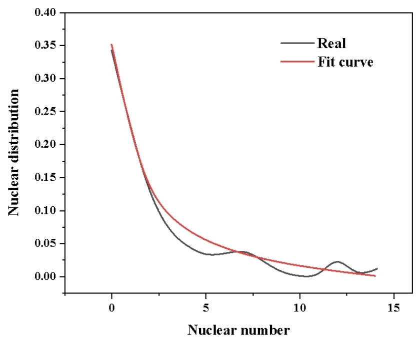
The CGN model can achieve complete controllability of the number of cores of nodes in the network, which is reflected in the fact that the network generated by the model is completely consistent with the actual network in terms of the distribution of cores, as shown in Figure 3.1.

3.2. Internet multi-layer network construction experiment . The three layers of the multi-layer network experiment are routing relationship network, web hyperchain network, and email address network. The data sources for the three layers of the network are all from the NetworkData sets network database website [17].

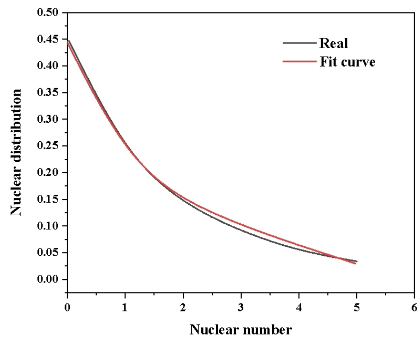
Based on the actual network data obtained, calculate the kernel distribution of the three networks, as shown in Figure 3.2(a-c). The kernel distribution of the three networks follows a power-law distribution, and the function is expressed as:

$$P(K > k) = \alpha \cdot k^{\rho} + \lambda(5) \tag{3.1}$$

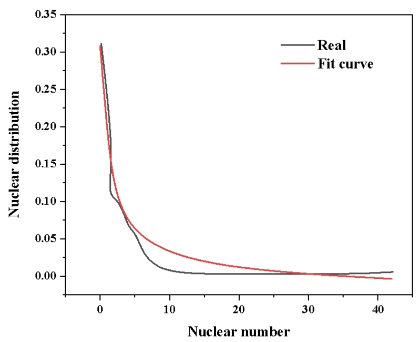
Fit the kernel distributions of three networks using the machine learning library sklearn provided by a third-party in Python, and obtain the corresponding kernel distributions for the three networks α, β, λ, as listed in Table 3.3.



(a) Route network kernel distribution



(b) Core distribution of web page hyperchain network



(c) Core distribution of the email address network

Fig. 3.2: Nuclear distribution fitting

Table 3.3: Network power-law parameters

Network type	α	β	λ
Routing network	0.40	0.79	-0.04
Web hyperlink network	0.64	0.59	-0.19
Email address network	0.32	0.93	-0.01

Based on the obtained kernel distribution functions of the three networks, the sequence of network kernels for a specified network size can be obtained. The node sizes of the three-layer network routing relationship network, webpage hyperlink network, and email address network constructed by the author are $N_1 = 200, N_2 = 50$, and $N_3 = 20$, respectively. Next, let's consider inter layer connectivity. In a routing network, both computers and servers are located at terminal nodes, while other nodes are router nodes. As actual business applications run on computers and servers, nodes in the business application layer will only have connectivity with terminal nodes in the basic device layer, that is, nodes with a moderate degree of 1 between the business application layer and the basic device layer will have connectivity. Therefore, the interlayer edge ratio here 1 corresponds to the proportion of connected edges between the terminal nodes in the routing network layer and the upper layer.

Randomly select interlayer node ratio $\alpha_1 = 25\%, \alpha_{21} = 55\%, \alpha_{23} = 40\%, \alpha_3 = 100\%$, corresponding interlayer edge connection parameters $\beta_{12} = \beta_{23} = 50\%$. Associate the three-layer network according to parameters[18].

(2) Analysis of multi-layer network characteristics. The average shortest path lengths for the routing relationship network, web hyperlink network, and email address network are 3.8, 2.9, and 1.7, respectively. Due to the existence of inter layer edges in multi-layer networks, nodes can reach each other across layers in addition to intra layer edges. Experimental results show that the average shortest path length of the three networks has been shortened to some extent, with values of 3.1, 2.7, and 1.6, respectively. Due to the small scale of the author's experimental data, it is not reflected clearly enough. But overall, there is a decreasing trend, and experiments have shown that compared to single-layer networks, multi-layer networks achieve multi-path reachability of nodes and reduce the average path length between nodes[19].

4. Conclusion. The author designed a three-layer network model for multi-dimensional data of the Internet based on the characteristics of the multi-layer network architecture, defining the elements, attributes, and the meanings of intra layer and inter layer edges of each single-layer network. Based on the idea of k-kernel decomposition, the author proposes a single-layer network model generation algorithm for digital media, designs a multi-layer network generation model on this basis, and finally proposes the significance of constructing multi-layer network models in the field of interconnection networks. As an emerging research direction in recent years, multi-layer networks have been applied in related fields, but there are still many scientific problems worth exploring. There is still a long way to go in establishing its theoretical framework and enriching databases in related fields. Establishing a multi-layer network model in the field of the Internet is of great significance for network security personnel to correctly assess the network security situation, master key network nodes, and make decisions and deployments. This is an important direction for future research.

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