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The Evolution of Intangible Cultural Heritage Communication and Its Digital Empowerment under the HDS Network Model

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Abstract: *In this paper, complex network modeling is used as a method to explore the mechanism and law of the influence of digitization on the dissemination of Intangible Cultural Heritage (ICH). The study constructed the complex network model of ICH before and after digitization, calculated and compared its network indicators, such as degree distribution, path length distribution, etc., and carried out the iterative rule modeling of ICH dissemination, and evolved the dissemination process of ICH in the two environments using computer simulation. It is found that digitization increases the speed and growth rate of ICH dissemination and balances the contradiction between "scarcity" and "circulation", which is conducive to the rapid and wide dissemination of ICH. However, it may also lead to the risk of homogenization and outdated of ICH.*

Keywords: *Intangible cultural heritage; complex networks; digitization; communication simulation*

1. Introduction

Digital technology provides new ways and means for the preservation and dissemination of ICH, but it also brings new challenges and problems. This paper reviews the relevant theories and practices from the following three aspects:

The basic theory of digital preservation and transmission of ICH: starting from the scientific problems that need to be solved in the digitization of ICH, Tan Guoxin and Zhang Lilong pointed out and tried to solve the problems such as quantitative analysis and prediction of the cultural space facing ICH [1]. Practical cases of digital preservation and inheritance of ICH: for example, China's "Digital Dunhuang" project [2] and America's first virtual library "America's Memory" [3], which make use of advanced science and technology and concepts of cultural relics preservation. Social Impact Assessment of Digital Preservation and Inheritance of ICH. Jun Huang analyzes and puts forward the living nature of digital preservation from the perspectives of consumer demand and scenarios [2].

Through the review of relevant theories and practices at home and abroad, this paper finds that there are still some deficiencies and gaps in the research on digital preservation and transmission of ICH. For example, the theoretical system of digital preservation and transmission of ICH is still imperfect and lacks unified standards and norms [3]; technical means and tools are still to be innovated [4]; and there is still a lack of effective indicators for social effect assessment. This requires multidisciplinary and multidisciplinary cooperation to study. Therefore, using complex network modeling as a method, this paper tries to explore the digitization of ICH from a new perspective to provide some new ideas and insights for its protection and inheritance.

2. Modeling and Analysis of ICH Communication Network

2.1. Social network construction and modeling assumption

In traditional ICH transmission, inheritance and dissemination are carried out through a limited number of interpersonal relationships and social networks. In this traditional communication model, the connections between people are more limited and the network structure is more regular, similar to the Watts-Strogatz small-world network (hereafter referred to as the WS small-world network), which has a high degree of local clustering and a short average path length [6]. However, with the development of digital communication, ICH heirs can connect with more nodes through digital means such as the Internet, forming a more complex and extensive social network. In this case, the network structure is more inclined to Scale Free scale-free networks (hereafter referred to as SF scale-free networks) [7]. In this study, we used the WS small-world network model as the basis for building traditional social networks, and SF scale-free networks as the basis for building digital social networks.

Since no social relationship network and related dynamics model explicitly suitable for this study has been found, this study independently proposes the HDS model based on the traditional rumor and influenza diffusion model, the RIS model [5], in which the attributes of each node are divided into three categories in the ICH social relationship network: "Heirs", "Disseminator" and "Susceptible", which represents the role played by each node in ICH transmission. The values and meanings of the attributes are shown in Table 1 below.

Table 1: HDS model attribute value-meaning cross-reference.

Number	Value	Meaning
1	H	Heirs
2	D	Disseminator
3	S	Susceptible

Figure 1 shows 2 simple network examples containing only 20 nodes to visualize the social network model under the HDS model. The left figure shows a traditional social network, and the right figure shows a digital social network. Nodes with attribute value H are plotted in red, nodes with attribute value D are plotted in pink, and nodes with attribute value S are plotted in light blue, indicating the distribution of the three types of people in different colors.

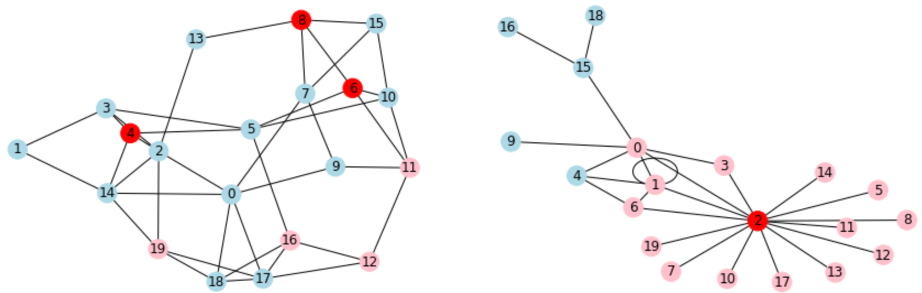

Figure 1: Schematic of a simplified version of the ICH social network.

2.2. Evolutionary Mechanisms of ICH Networks

In terms of the dynamics of the model assumptions, this study sets the rule that each node updates its state in one iteration according to the attribute values of its neighboring nodes, so as to fit the process of the propagation of ICH in the crowd: after one iteration, the S node of the nodes connected to the H node becomes the D node with 70% probability, and the D node has 5% probability of transforming into the H node; the S node connected to the D node has 50% probability of become D nodes. As shown in Table 2:

Table 2: Node conversion rules.

Influencing Node Attributes	Influenced Node Attributes	Expected Conversion Node	Conversion probability
H	S	D	0.7
H	D	H	0.05
D	S	D	0.5

In addition, considering the significance of the H-node "transmitter" itself, there should be a restriction in the evolution of the network, i.e., the principle of "one master, one heir", so that if a transmitter has already selected a disseminator as the heir, the disseminator will not accept any other disciple as the non-genetic heir. If an inheritor has already selected a propagator as the inheritor, then the propagator will not accept other disciples as non-genetic inheritors. In the network nodes, the H node transforms the connected D node into H node, and then no longer transforms other D nodes into H node, in addition to the transformation of the neighboring S node as usual.

A simplified version of the example is shown below for better understanding of this propagation rule. The example still uses a small network with only 20 nodes, and the average degree of the nodes is 4. In the example, the H-attribute nodes, labeled in red, represent the NGPs. Mark the D attribute node in pink to represent the NGN propagator. Mark the S attribute node in light blue to represent the NRM susceptible person.

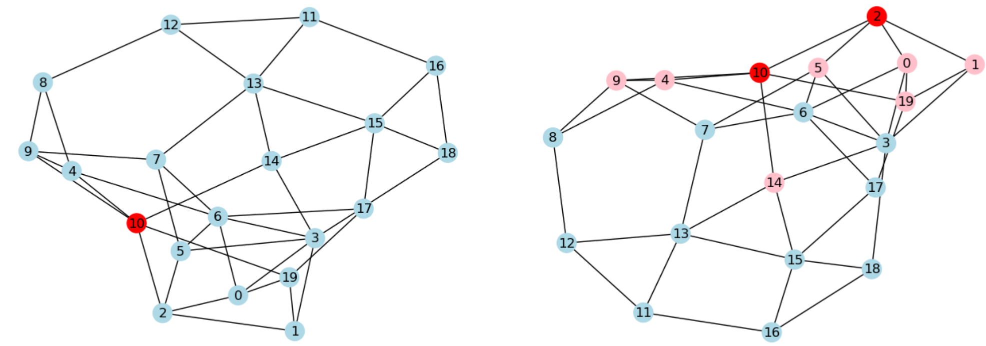

Figure 2: Schematic diagram of HDS evolution rules.

Assume that the attribute of all nodes in the initial state of the network is S, representing some group of only susceptible individuals. As shown in the left half of Figure 2, an H node (node 10 in the figure) is introduced for this network to represent an ICH heir who comes to this social network and establishes similar connections with other nodes in the network. The simulation evolves according to the rules in Table 2, and the network obtained after 10 iterations is shown in the right half of Figure 2. From the figure, it is obvious that ICH spreads out with the network, and over time, node 2 is adopted by node 10 as the heir of the non-legacy and converted into an H node. This basically simulates the spreading process of an ICH in a social network.

Based on the above network construction and modeling assumptions, we will further use networkx tool to specify the simulation function to carry out simulation experiments to study the propagation dynamics of ICH in the network, including the propagation speed, propagation scale, etc., and verify our research assumptions and inferences through the simulation experiment results.

2.3. Statistical Characterization of the Evolutionary Effectiveness of ICH Networks

In the simulation experiment of the evolution of the NRM propagation network model, only the characteristics of the propagation mechanism itself based on the HDS model are considered, and environmental factors such as population birth, death and mobility are ignored. For traditional social networks, this experiment adopts the WS small-world network with network size N=2.0×10^3, network average degree k=4.0, and reconnection probability p=0.5. And for digital social networks, the SF scale-free network with network size N=2.0×10^3 is used in this experiment. Figure 3 and Figure 4 below show the degree distribution and path distribution of these two networks in turn, with the green histogram corresponding to the WS network and the dark blue histogram corresponding to the SF network. These network characteristics shown in the graphs will not change during the evolution of the HDS model since factors such as population births and deaths that cause the number of nodes to change are ignored.

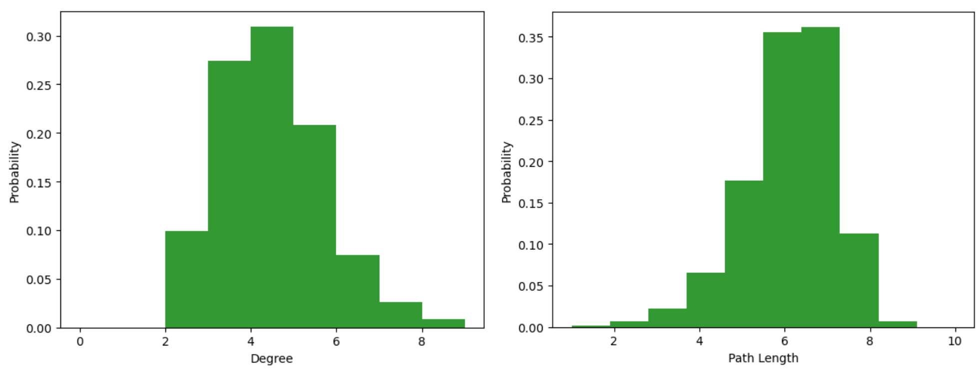

Figure 3: Distributional characteristics of WS networks.

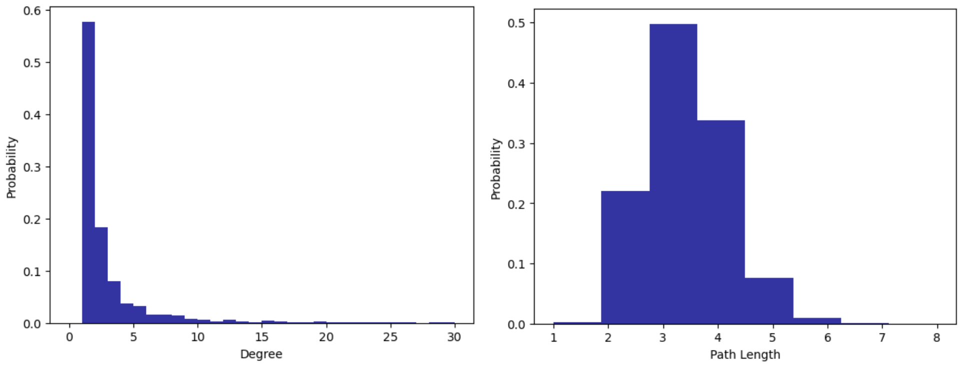

Figure 4: Distributional characteristics of SF networks.

During initialization, each node of these two networks is given the S attribute, and then a node in each of the two networks is randomly selected and re-assigned the H attribute. In this way, it is simulated that an heir of an ICH comes to a new social network and the people in that social network have not heard of this ICH before. 1000 iterations are computed for each of these two networks according to the evolutionary rules of the HDS model in Table 2, and finally the change of the number of each node over time is shown. Figure 5 shows the evolution of the WS network and Figure 6 shows the evolution of the SF network.

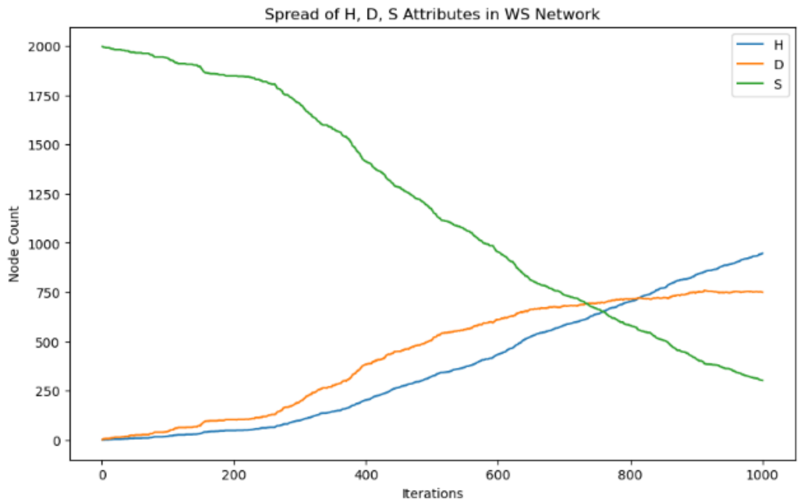

Figure 5: Propagation of ICH in WS network models.

The green line (number of S nodes) can reflect the ICH propagation, i.e., the fewer Susceptibles indicate the wider ICH propagation. Observing the left figure, in the WS network model, ICH spreads slowly and then quickly, and the inflection point occurs roughly at the 300th iteration. The growth of the number of D nodes is also in line with the law of fast and then slow, and in the early stage, the D nodes outnumber the H nodes, both in terms of the growth rate and the number of nodes. However, the growth rate of D nodes gradually slows down, and is surpassed by the steadily rising H nodes towards the end of the iteration. With a little analysis, it is easy to know that in the early stage, ICH propagation mainly relies on a large number of D nodes converted by the initial H nodes and relies on D nodes to expand the influence of ICH. In the late iteration, H nodes will gradually replace D nodes and play the main ICH propagation role. With the passage of time, there will be more and more H nodes.

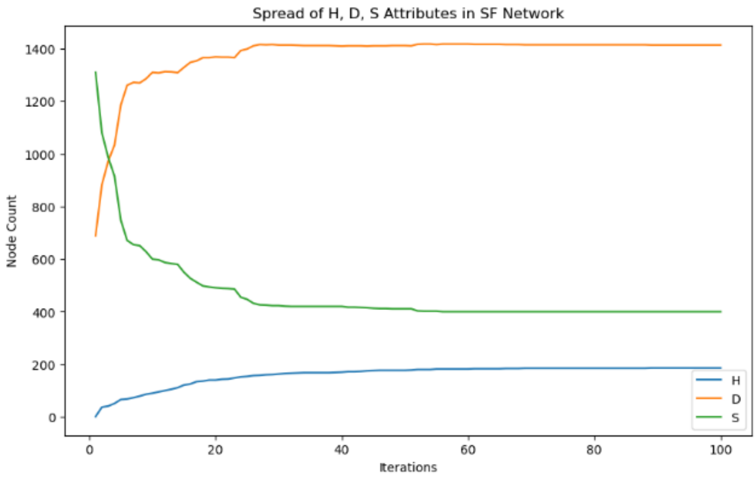

Figure 6: Propagation of ICH in SF network models.

Observing the Figure 6, it is found that ICH spreads very fast at the beginning, and then tends to be leveled off. Specifically, the number of S nodes decreases rapidly in 0-20 iterations, and the D nodes rise rapidly and have a symmetric trend with S nodes, i.e., the ICH propagation objects in the early stage mainly come from the first batch of transformed D nodes of the initial H nodes. Under the constraints of the model rules, H nodes will not transform all the many nodes connected to themselves into H nodes, so the growth of H nodes is not obvious, but the ICH still reaches a stunning propagation speed.

Comparing the evolution in the two graphs, ICH propagates slowly and then quickly in the WS network, while it obviously shows a trend of fast and then slow in the SF network. In addition, the propagation of ICH in the WS network is more dependent on the growth of the number of H nodes; whereas the fast propagation in the SF network does not require numerous H nodes and can rely only on D nodes. From the perspective of steady state, the number of steps required to reach steady state in SF network is much smaller than that in WS network, but the propagation effect at steady state in the former is not as good as that in the latter.

3. Conclusions

The evolutionary computational effects of the WS network model and the SF network model can reflect, to some extent, the characteristics of ICH propagation in traditional and digital social networks. By comparing the propagation effects of ICH under these two different network models, we can draw the following conclusions:

Digitization substantially enhances the speed and growth rate. ICH with digital means of communication can reach a speed more than 50 times faster than traditional communication in a short period of time, thus rapidly achieving a steady state of ICH communication. This suggests that digital means of communication have a significant advantage in quickly spreading ICH to a wider audience.

Digitalization balances the "scarcity" and "circulation" of ICH. The model iteration shows that the dissemination of ICH in traditional social networks relies heavily on the emergence of new ICH successors. In layman's terms, in the past, ICH could only be widely circulated if a certain ICH craft was widely taught and learned by more people. However, when ICH inheritors use digitalization as a medium for dissemination, they no longer need to teach their craft to many people in order to obtain a good social impact. By using digital technology, such as "online performances", the original heirs already have enough influence. This puts an end to the old paradox of "if it is scarce, it will not be widely spread" and "if it is widely spread, it will not be scarce". Protecting the scarcity of the ICH and at the same time making it highly circulated and well known is equivalent to increasing the commercial value of the ICH. To some extent, this will greatly enhance the confidence of the inheritors to promote their ICH.

Digitization brings with it the issue of online buzz benefits; ICH does not spread as widely as it does in traditional social networks when iteration reaches a steady state in digitized social networks. This is a testament to the fact that content on the Internet "goes out of style fast". Therefore, digital ICH may have certain limitations in terms of dissemination effect and needs to be optimized and adjusted in the iterative process in order to maintain a sustainable dissemination effect.

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In summary, in line with our common sense, digital communication means bring obvious advantages to ICH communication, and can achieve faster and more efficient communication effects. However, digital communication means may have certain limitations in the continuity and scope of the communication effect, which need to be improved and perfected in practical application to better promote the development of ICH communication. Future research can further explore the advantages and limitations of digital communication means in ICH communication, and analyze its influencing factors and mechanisms in depth in combination with actual cases, so as to provide more scientific and effective guidance for ICH communication strategies and practices.

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