Visualization Study on the Structure of Visual Communication by Network Technology

Li Zhoujun
Wuhan Huaxia Institute of Technology
Wuhan, China
5761515@qq.com

Abstract—Structural visualization in visual communication was explored from a social network perspective to understand the role of visual elements in information transfer and communication. Through the introduction of related techniques and literature, the importance of structural visualization in social networks was found. An approach based on network analysis and visualization techniques was then proposed based on the result. Effective structural visualization facilitates information dissemination and understanding, which helps communication and cooperation in social networks.

Keywords—social networks, visual communication, structural visualization, network analysis, information dissemination

I. INTRODUCTION

With the development of social media and network technology, social networks have become an important platform for people's information transfer and communication [1]. In the network environment, how to effectively communicate information becomes important. Visual communication, as an important way of communication, plays a crucial role in information dissemination in social networks [2] as it is one of the important means to present the complex network structure in an intuitive form. Therefore, it is essential to explore structural visualization from the perspective of social networks to improve the efficiency and quality of information communication [3,4].

II. SOCIAL NETWORK ANALYSIS

A social network analysis algorithm is used to explore and understand the relationships, structure, and features in social networks. The algorithm reveals important information about key nodes, groups, and information dissemination patterns in social networks [5].

In the node centrality algorithm, where Degree Centrality is calculated using (1).

$$C_D(v) = \frac{k_v}{n-1} \tag{1}$$

Where $C_D(v)$ is the degree centrality of the node V, k_v is the degree of the node (i.e., the number of edges connected to it), and n is the number of nodes in the network.

Betweenness centrality is calculated using (2).

$$C_B(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}} \tag{2}$$

where $C_B(v)$ is the meso-centrality of node v, σ_{st} is the number of shortest paths from node s to node t, and $\sigma_{st}(v)$ is the number of shortest paths through node v.

Closeness Centrality is calculated using (3).

$$C_c(v) = \frac{1}{\sum_{u \neq v} d(u,v)} \tag{3}$$

where $C_c(v)$ is the proximity centrality of node v and $d(u,v)$ is the shortest path length from node u to node v.

Modularity Optimization is calculated using (4).

$$Q = \frac{1}{2m} \sum_{ij} (A_{ij} - \frac{k_i k_j}{2m}) \delta(c_i c_j) \tag{4}$$

where Q is the module degree, A_{ij} is the weight of the connection between node i and node j in the network, $k_i k_j$ is the degree of node i and node j respectively, m is the total weight of all the connections in the network, c_i and c_j are the communities to which node i and node j belong to, and $\delta(c_i,c_j)$ is the indicator function which is 1 when c_i and c_j are 0.

III. STRUCTURE AND MODELING

A. Design of Visual Communication

Visual communication structure was designed from the perspective of the social network using an interdisciplinary discipline. Social network theory and visual communication principles are combined in the design to present complex structures in social networks for the dissemination, communication, and understanding of information. Related research involves a variety of aspects, including social network analysis, information design, and user experience [6]. The design of a visual communication structure requires an understanding of the characteristics and laws of social networks. The social network is a complex network composed of nodes and edges, where nodes represent individuals or entities and edges represent relationships between them [7].

Using social network analysis algorithms, important information such as key nodes, group structure, and information dissemination paths in the network are obtained for designing the visualization structure. Designers need to consider how to present the structure of the social network intuitively so that users can quickly understand and analyze it [8]. This involves graphical layout algorithms, visualization techniques, and user interaction design. By choosing appropriate layout algorithms, the structure of the network can be clearer. Through information visualization techniques, the attribute of the information of the nodes and the connection relationship is presented for more analysis. At the same time, the interactive design enables users to explore and manipulate the visualization results freely. Thus, they can understand the characteristics and inherent laws of the network. The design also needs to focus on the user

experience and the effect of information communication [9]. Designers need to consider the needs and cognitive characteristics of users and choose the appropriate visual language and design styles so that users can easily understand and utilize the visualization results (Fig. 1, Table I).
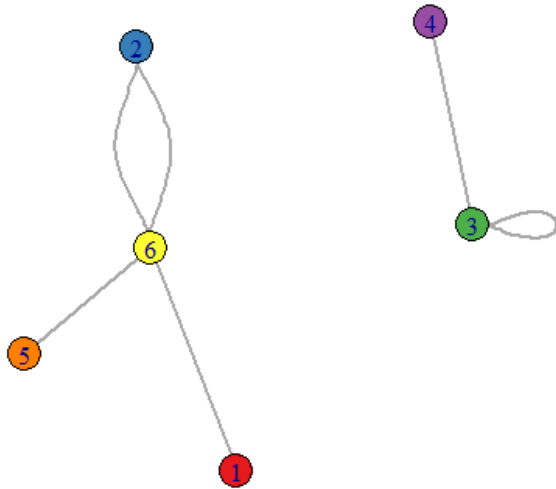

Fig. 1. Simple model diagram of structural communication for visual communication from a social network perspective.

TABLE I.   RELEVANT EDGE DATASETS FOR SIMPLE STRUCTURED GRAPHS OF VISUAL COMMUNICATION FROM SOCIAL NETWORK PERSPECTIVE

	1	2
1	3	3
2	6	5
3	3	4
4	2	6
5	2	6
6	6	1

B. Characterization and Acquisition of Visual Communication

Feature extraction for visual communication is a key to extracting meaningful information from complex social network structures. It provides a basis for designing effective visual presentations. Node attributes are extracted to analyze user profiles or apply machine learning techniques. Network topology analysis is used to extract characteristics such as node degree, aggregation coefficient, and meson number centrality to understand the structure and key nodes. Community detection is used to identify the structure of densely connected communities and their features are extracted to understand group relationships. Information propagation pattern analysis is conducted to understand the path and speed of information propagation in the network as well as user behavior analysis. Features are extracted from the frequency of posting, commenting, re-tweeting, and other behaviors to understand the user's interest and activity and understand the structure and function of social networks. Then, the design and realization of visual communication are achieved [10] (Table II).

TABLE II.   CHARACTERISTICS OF VISUAL COMMUNICATION FROM PERSPECTIVE OF SOCIAL NETWORKS

	Feature type	Relevant features
1	Node Attribute Characterization	Age, gender, geographic location, user type, interests
2	Network Topology Characterization	Nodal degree, clustering coefficient, centrality, network density, diameter, and average path length
3	Community structural characteristics	Number of communities, number of community members, density of connections within communities, strength of connections between communities
4	Characteristics of the information dissemination model	Length of information dissemination path, speed of information dissemination, reach of information dissemination, pattern of influence dissemination
5	User Behavioral Characteristics	Frequency of posting, number of comments, number of retweets, level of interaction, time period of user activity

The common types of features and their associated characteristics in visual communication are presented in Table II. Node attribute features include basic attribute information describing individuals or entities in a social network, such as age, gender, and geographic location. Network topology features reflect the overall structural characteristics of a social network, including the degree of connectivity and clustering of nodes, as well as the density and diameter of the network. Community structure features refer to the community structure existing in the network and its internal characteristics, such as the number of communities, the number of members, and the strength of connections between communities. Information dissemination pattern features focus on the way and pattern of information dissemination in social networks, including the length of the dissemination path, the speed of dissemination, the scope of information dissemination, and the influence dissemination pattern. User behavior features describe the behavioral characteristics of users in social networks, such as the frequency of posting, the number of comments, the number of retweets, and the user's active time. The analysis results of these characteristics help to understand the structure and characteristics of social networks and provide an important reference basis for designing effective visual communication [11].

C. Strategies for Dissemination of Information

In response to the characteristics and important communication nodes in the social network, a series of programs are used to promote information dissemination and enhance the efficiency of dissemination. It is necessary to identify and focus on important communication nodes with high influence in the network, which may have high connectivity or centrality of active users who frequently participate in information dissemination. For these nodes, personalized communication strategies can be formulated, such as establishing close contact with them, providing high-quality content and incentives to motivate them to actively participate in information dissemination, and expanding the dissemination impact. Active users are highly engaged and frequently interactive in social networks [12]. They actively participate in information dissemination by posting content, commenting, and retweeting. They have a certain influence and social status in the network [13]. These users may be opinion leaders in social networks, industry experts, or well-known personalities with many fans and followers, and their behaviors and remarks can often trigger the attention and

response of other users, thus playing a key role in information dissemination [14] (Table III and Fig. 2)

TABLE III.   CHARACTERISTICS OF ACTIVE USERS OF SOCIAL NETWORKS ORGANIZED TABLE

| Hallmark	Descriptive
Frequent participation	Active on social networks, posting more than 5 pieces of content per day and interacting more than 30 times per week.
Punch	Have more than 1,000 fans or followers and retweet or share content that has been retweeted or shared more than 50 times on average.
Expertise	Possess professional qualifications or experience in a relevant field and have participated and presented in professional discussions or activities related to the field.
Social status	Has over 500 fans or followers in social networks and is often mentioned or quoted by other users.
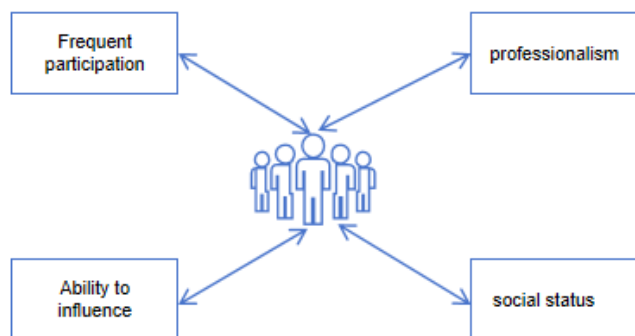
Fig. 2. Schematic diagram of characteristics of active users of social networks.

In addition, social network analysis and data mining technology are used to explore the communication paths and modes of communication in the network. By analyzing the network structure and user behavior, effective information dissemination paths and dissemination nodes are determined. When implementing the communication program, it is necessary to design attractive visual communication programs in combination with the user's behavior and preferences. Vivid charts, engaging content, and other ways can be used to design attractive forms of information presentation and enhance the user's reading experience and the attractiveness of the information. Efficient information dissemination promotes the user's acceptance and sharing of information, further expanding the scope and influence of information dissemination [15].

IV.   EXPERIMENT

Important features in the social network were tested by using the visual communication analysis method, especially focusing on the dissemination of users with high influence (active users of cross-network). Focusing on the observation of the connection density between the nodes, the correlation graphs with the data were drawn. Sections connected to more than 4 nodes were in red circles ("active users"), while sections connected to more than 6 nodes were in green circles ("super active users"). These represent the most active and influential areas of the network and may contain core users or key content that plays an important role in the propagation of the entire network (Figs. 3 and 4).
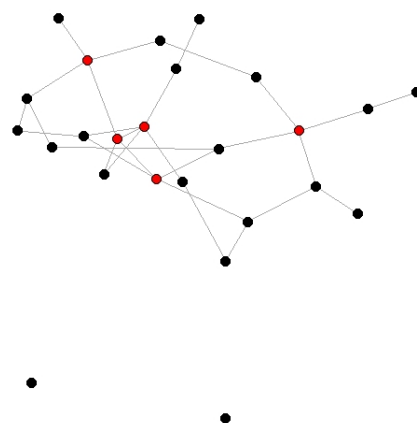

Fig. 3. Map of information dissemination network and active users of social network with 25 nodes.
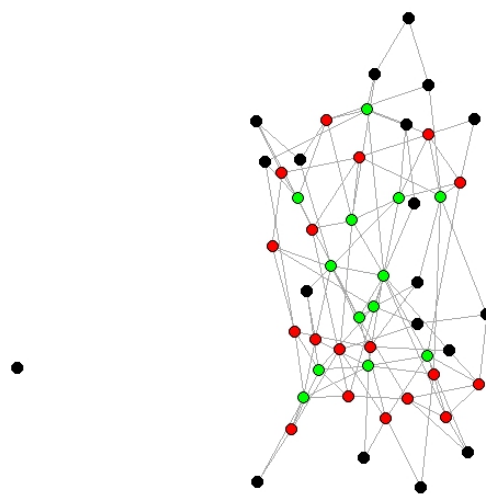

Fig. 4. Map of information dissemination network and active users of social network with 50 nodes.

As the number of nodes in the social network increases, the number of green nodes increases, too. Red and green nodes present an improved dissemination efficiency whereas red nodes represent nodes or content with higher popularity, usually with greater influence and connectivity. These represent opinion leaders or active users on social media, and their content has higher dissemination power. Green nodes are more prominent, representing core nodes or content in the network, whose connection to more nodes implies a wider reach and spread. By focusing on influencing people in red and green nodes, the efficiency of information dissemination in social networks can be improved.

V. CONCLUSION

The structural visualization of visual communication was analyzed from a social network perspective to propose an approach based on network analysis and visualization techniques. Through empirical analyses, the important role of effective structural visualization was determined in facilitating information dissemination and understanding. This provides new ideas and methods for communication and cooperation in social networks. Future research is necessary to explore the application of structural visualization in different types of social networks and delve into its impact on information dissemination and decision-making.

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