Explore the flow of information and find what qualifies as news

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Abstract. Information spreads quickly in today’s tech-connected communications network. As we all know, the way to spread information changes greatly. The flow of information has never been as easy or wide-ranging as it is today. We are tasked to explore the evolution of the methodology, purpose, and functionality of society’s networks by taking a historical perspective of flow of information relative to inherent value of information.I develop one models to show how the flow of information changes over time. I adopt topology model to show the flow of information. Besides, the discussion about what kinds of information are qualified as news is concerned.

Introduction

With the popularity and interactivity offered by the Internet and World Wide Web, the tech-connected social network is very common to us, which leads to the information spreading quickly than ever before. Every day we are informed of enormous information, including useful, helpful, crucial information and also misinformation. It’s no longer the days when people were almost sealed themselves in the small village.

The mass media went through a dramatic change and development, which not only show up in its mode of transmission, but also change public mode of thinking. The progress of this change can be sketched by the following picture.

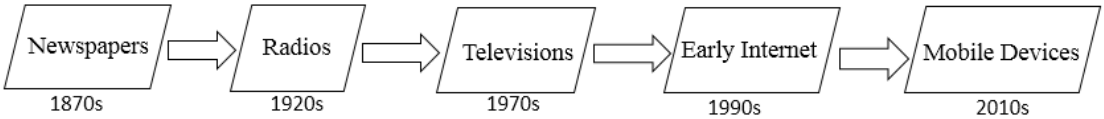

Fig 1. The changes of mass media over time

Theories of mass communication have changed dramatically since the early 1900s, largely as a result of quickly changing technology and more sophisticated academic theories and research methods. A quick overview of the state of the media in the early 1900s and in the early 2000s provides some context for how views of the media changed. In the early 1900s, views of mass communication were formed based on people’s observation of the popularity of media and assumptions that something that grew that quickly and was adopted so readily must be good[1].

In the end of the 1950s, Erdos and Renyi created the famous ER random-network model[2]. In 1998, Watts and Strongatz proposed the WS small world network which improved from completely regular network to completely stochastic network[3]. In 1999, Newman and Watts structure the small world network of randomization[4]. Barabasi and Albert published an article which put forward BA scale-free network model[5].

Assumptions

- I simply the way to spread information into two kinds. The first way to spread is network topology, and another is the spread of social network which is according to whether the receiver can sent the message or not.
- Iconsider the former 3 periods (when information are spread by newspapers, radios and televisions) is in accordance with network topology. Because all the newspapers, radios and televisions can only receive the message, but cannot send message to other places. In 1990s and 2010s, as the computer and mobile phones came into popularity, iconsider the information spread as how virus do. Because both computer and mobile devices can not only receive but also send information to others.
- I assume that information spread almost at the same time with the occurrence of information.

Notations and Definitions

Notations	Definitions
k	the degree of nodes
kN_k	the total number of edges starting from the node whose degree is k.
$p_1(k,t)$	possibility of a susceptible nodes with k nodes connecting to a transmission nodes at time t
$p(k_1 \mid k)$	the contingent probability that the node with degree of k is adjacent to the node with degree of k_1
$p(\mathrm{I}_{k_1} \mid S_k)$	possibility of node with k_1 is in propagating behavior under the condition that the node connects a susceptible nodes with degree of k
p_1.	possibility of susceptible nodes transfers into probability latent node
v_1	speed of latent node transfers into transmission nodes
v_2	speed of latent node transfers into immune nodes
p_2	possibility of transmission nodes that are next to immune nodes transfers into immune nodes
v_3	speed of transmission nodes stops spreading the information

Model :Based on network topology

Network $G=(V,E)$ can be expressed as the simple undirected graph whose vertex set is V, and sets E without the ring and multiple edge. Using notations N and K to represent all the nodes and edges of network G, scilicet $N = |V|$ and $K = |E|$. In recent years, researchers have proposed many methods to depict network topology structure and its statistical characteristic. Define the each element of the adjacent matrix $A = \{a_{ij}\}_{N\times N}$ of unweighted and undirected graph G as

$$a_{ij} = \begin{cases} 1, \text{nodes } \mathrm{v_i} \text{ connected with } \mathrm{v_j}, \\ 0, \text{else.} \end{cases} \tag{1}$$

Average path length: the simple route that the smallest number of edges goes through from node v_i to different node v_j. And the number of edges of the shortest path is called the distance between node v_i to v_j, noted as d_{ij}. And then define the diameter of the network D for the maximum distance between any two nodes, noted as $\mathrm{D} = \max_{1\le i,j\le N} \mathrm{d_{ij}}$.Network of average path length L can be used the following formula,

$$\mathrm{L} = \frac{1}{N^2}\sum_{j=1}^{N}\sum_{i=1}^{N} d_{ij} \tag{2}$$

Since in the simple undirected graph, $d_{ij} = d_{ji}$ and $d_{ii} = 0$,so (1.2) be simplified as,

$$\mathrm{L} = \frac{2}{\mathrm{N(N-1)}}\sum_{i=1}^{N}\sum_{j=i+1}^{N} d_{ij} \tag{3}$$

Degree and degree distribution: degree is a network of single node attributes described in a simple and important concept. The degree k_i of node v_i indicates that the total number of edge and the node in network. The node degree is a measure of the importance of each node in the network of a simple measures. From the visual point of view, the greater the degree of a node, the node in the network becomes more important. Average degree of the network <k> is defined as

$$< k >= \frac{1}{\mathrm{N}} \sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{k_i} \tag{4}$$

Then discuss the relationship between network degree and network adjacency matrix. According to the properties of the adjacency matrix available, the degree of node v_i is the sum of *i* line or *i* column' elements of adjacency matrix A. The number of paths from node v_i to v_j is the value of the element of the *I* line and *j* column in matrix A^k, noted as $a_{ij}^{(k)}$. Therefore, we get $a_{ij}^{(2)}$ expressing the number of the paths from node v_i through two steps to node v_j. Since the simple graph has no self-loop and multi-edges, the paths referred to in the above can be expressed as the path number that node v_i starts along an edge to a node and then from the original road to return, so the degree of node v_i can be written as $k_i = a_{ii}^{(2)}$ .The average degree of network is available, it is the sum of the diagonal element divided by the total number of nodes,

$$< k >= \frac{1}{N} \sum_{i=1}^{N} a_{ii}^{(2)} = \frac{tr(A^2)}{N} \tag{5}$$

where $tr(A^2)$ represent the trace of matrix A^2.

Because each node in the network is likely to be different, but most of the actual network node degree is to obey certain probability distribution, named the degree distribution of the network. *P(k)* is used to represent the possibility to pick a node whose degree is *k* randomly form network, it's equal to the number of nodes whose degree is *k* in proportion to the total number of nodes in network, we have

$$P(k) = \frac{N_k}{N} \tag{6}$$

Despite the degree distribution is an important topological characteristics of the network, but the degree of distribution is not the only sure all a network topology structure, with the same degree of distribution network topology may not be the same. In order to further describe the network topology structure characterization, also need to consider include topological characteristics of more information. For example, the joint degree distribution of undirected network node, the conditional probability between nodes, distribution and degrees - the degree of correlation etc.

For the undirected network, to define the joint distribution *P(k,l)*, it said randomly selected from the undirected network an edge, this side of the two endpoints of the value of the probability of *k* and *l* respectively. In order to express convenient behind, First with *E(k,l)* for *k* and *l* on the number of nodes connected to the side, when $k \neq l$, *E(k,l)* represent the total number of edges connected to the node degrees for k and l; and when $k = l$, *E(k,l)* represent twice of the total edges that connected nodes whose degree is *k* and *l*, and have *E(k,l)= E(l,k).* Then we can launch the joint degree distribution network *P(k,l)*

$$P(k,l) = \frac{\mathrm{E}(k,l)}{2M} = \frac{E(k,l)}{\sum_k kN_k} \tag{7}$$

where $M = \sum_k kN_k / 2$ represent the total number of edges in the network.

Conditional probability distribution *P(l|k)* represent probability from the edge of the degrees of node to the node whose degree is *l*. No matter the degree value *k* and *l* is equal or not, we have the following mathematical expression

$$P(l \mid k) = \frac{E(k,l)}{kN_k} \tag{8}$$

Where kN_k represent the total number of edges starting from the node whose degree is k. According to (1.7) and (1.8) and joint degree distribution and the conditional probability distribution can be launched the following balance relationship between the definition of the nature.

$$kP(k)P(l \mid k) = lP(l)P(k \mid l) = < k > P(k,l) \tag{9}$$

According to (1.7), and can also be further introduced simple undirected network medium, based on the relationship between distribution and degree of joint distribution，

$$P(k) = \frac{kN_k}{kN} = \frac{\sum_l E(k,l)}{kN} = \frac{\sum_l P(k,l)\sum_k kN_k}{kN} = \frac{< k >}{k}\sum_l P(k,l) \tag{10}$$

Put (1.10) into (1.9), we obtain the relationship between conditional probability distribution and degree of joint distribution

$$P(l \mid k) = \frac{P(k,l)}{\sum_l P(k,l)} \tag{11}$$

So it can be seen as containing the topology information from more to less, containing the most is the joint degree distribution of nodes, the time is the degree distribution, the average node degree is a minimum.

Degrees - the degree of correlation with the degree distribution of network nodes and the joint degree distribution, also can't fully describe the topological characteristics of the network. In addition to the random network, most of the network node degree of correlation, therefore degrees - the degree of correlation is also depict an important statistical characteristics of network topology, it describes the network medium large nodes and the degree of correlation between small section points, Newman defines the concept of same with different match degrees - the degree of correlation. If networks tend to be more moderate values of nodes and the degree of value of connected nodes, call it network is - degrees are related, it’s also called assortative. Conversely, if the network tend to moderate values of nodes connected to measure the small section point, call it network is degrees - the degree of negative correlation, it’s also called disassortative.

As for the spread of information, it’s clear that the speed of information flow is not only effected by distance, but other impossible factors should also be taken into consideration, we consider the influence of population and the level of development of science and technology here.

Summary

I consider newspaper, radio and television are the period when media medium can’t send information but receiving. While in 1990s and 2010s, they can both receive and send information through the networks.In topology model, we only consider the information exchange between cities, but we don’t discuss the information communication between inner city.There are huge amount of misinformation flooding in the networks. The misinformation flow may be different from information. But in this paper, we doesn’t discuss this situation.

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