The Orderly Network Structure of $M \geq 7$ Strong Earthquake Chain and its Prediction in Xinjiang Region of China

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$M \geq 7$ strong earthquakes have had an obvious commensurability and orderliness in Xinjiang, China, and its neighbourhood region since 1800. The main orderly values are 30a $\times k$ ($k = 1,2,3$), 11 $\sim$ 12a, 41 $\sim$ 43a, and 18 $\sim$ 19a. According to the informative forecasting theory of Wen-Bo Weng and complex networks technology, we try to explore the practical methods for strong earthquake prediction with Chinese characteristics, and conceive the informational orderly network structure of $M \geq 7$ strong earthquakes. Based on this, Yutian M7.3 strong earthquake was successful predicted in 2008. Meanwhile, the next strong earthquake with magnitude 7 or so will happen around 2014 – 2015 in this region. The results shows that strong earthquakes could be predicted. This method has an unique effect for mid-and-long term prediction of strong earthquakes.

Key words: Xinjiang and its Neighbourhood; Strong Earthquake Chain; Informational Orderly Network Structure; Complex Networks; Strong Earthquake Prediction.

1. Introduction

According to the determination from China Seismic Network, a magnitude 7.3 earthquake took place in Yutian of Xinjiang on March 21, 2008. It was the first earthquake of $M \geq 7$ in Mainland China since the M8.1 strong earthquake of West of Kunlun Pass in Qinghai occurring on November 14, 2001, and it was also the first earthquake of $M \geq 7$ in Xinjiang and its adjacent region since the M7.9 strong earthquake on the Frontier of Russia, Mongol, and China on September 27, 2003. And a severe M8.0 earthquake struck Wenchuan in Sichuan which is in Western China 52 days after the Yutian earthquake. So the Yutian earthquake has great significance for the study on earthquake tendency in Xinjiang and its adjacent region and even all over Mainland China.

Nowadays, the earthquake prediction has become a challenge all over the world. During the 1980s, Academician Wen-Bo Weng, known as a ‘temporary guru of earthquake prediction’, has created the informative forecasting theory and made outstanding achievements in the forecasting of earthquakes and other natural disasters such as drought and flood, which created a new way for the prediction of major natural disaster [1 – 4]. Informative forecasting theory, which combines the advantages of Chinese and Western cultures, is a major theoretical innovation in contemporary natural disaster prediction studies of Xu et al. [5 – 8] have shown that the major earthquakes in China and Asia have a characteristic of orderliness in both time and space. In 1997, Xu firstly put forward the concept of information orderly series, and then in 2001 and 2007 he proposed the network hypothesis and concept of self-organized network, respectively, which further enriched and developed the informative forecasting theory [9 – 12]. Network hypothesis, which regard the earthquake as a multi-level, multi-factor, multi-dimensional network node, is helpful in the research of the complexity of a major earthquake and the information orderliness of the strong earthquake from total and dynamic perspective. Men [13 – 17] has made a deep analysis on the earthquake network structure in the region of Jiangsu–South Yellow Sea and the northern part of the Tibet-plateau, and then applied it into the practice of strong earthquake prediction. In 1987, Guo [18 – 20] firstly proposed the theory concept and category of disaster chain. As mentioned in his theory [21], geophysical hazard chain is a new innovative and cross-disciplinary subject, which study the relationship between the different hazards within the broad field of geophysics, while the so-called strong earthquake disaster chain is a natural phenomenon in a certain period that an earthquake disaster occurs in the same district or occurs orderly in the joint regional. Since 1972, Geng [22] has achieved a remarkable success in mid-term forecast according to the correlation of drought and earthquake. Chinese expert's research on disaster chain and its prediction have greatly expanded and promoted the development of information prediction theory.

We have been devoted to studying $M \geq 7$ strong earthquake chains of Xinjiang and its orderly network structure since 1992 [23 – 27]. We followed up of the Yutian earthquake from 2007, and gave our opinion to the Nature Disaster Prediction Committee on January 18, 2008 (see the nature disaster prediction statement of 2008). And then we clearly put forward the prediction opinion with 'the explanation about the opinion of nature disaster prediction in 2008' on March 11. The successful prediction for the Yutian $M7.3$ strong earthquake demonstrated that it was an effective method for mid-and-long term leaping prediction of strong earthquake chains combining the informative forecasting theory of Weng with the orderly network structure. This paper will make a summary and supplement based on the previous study of the orderly network structure of $M \geq 7$ strong earthquake chains to offer a dependable opinion of mid-and-long term strong earthquake prediction in Xinjiang and neighbourhood region.

2. The Theory of Information Forecast and Informational Orderly Network

The order denotes an order or regular of nature, which includes periodicity, 'commensurability', rhythm, symmetry, self-simirity, etc. Commensurability serves as a kind of an information system, revealing a certain law of common measure of elements of a system. The word commensurability has an astronomical origin, which was introduced into the scope of prediction science and advanced both in theoretical and practical aspects by the pioneer of natural disaster prediction, Wen-Bo Weng, in the early 1980s. In terms of 'negative random assumption' from which he discarded a poor-information homogeneous distribution, however, he exacted commensurable information on a calamity, thereby bearing out an integer of multiple elements inherent in the time series of the event. The universal applicability of the theory has been demonstrated in the decades of practice for predicting earthquakes, floods, and droughts at home and abroad, thereby contributing greatly to calamity predicting and the branch of science and opening up an utterly new way to natural calamities envisaging [1 – 4].

The commensurable information system has its general expression of the form [2]:

$$X_i = \sum_{j=1}^{h} (I_j X_{ij}) + \varepsilon_0,$$

where $I_j \in \{i\}$, and $I_j \neq i$, suggesting that j denotes an element of the subscript set $\{i\} = \{1, 2, \ldots, n\}$ which differs from i, X_{ij} is an element of $\{X_i\}$ different from X_i, I_j is an integer set to be $+1$ or -1, h the number of commensurable elements, and ε_0 the in-advance fixed feasible critical value (or deviation). X_i is not likely fortuity if there is more than one commensurable expression of X_i, namely

$$X_i = \sum_{j=1}^{h} (I_j X_{ij}, 1) + \varepsilon_1,$$
$$X_i = \sum_{j=1}^{h} (I_j X_{ij}, 2) + \varepsilon_2,$$
$$\vdots$$
$$X_i = \sum_{j=1}^{h} (I_j X_{ij}, m) + \varepsilon_m,$$

where $\max(|\varepsilon_1|, |\varepsilon_2|, \cdots, |\varepsilon_m|) \leq \varepsilon_0$. These expressions denote that it is not an accidental event for a sufficiently large m that is called the frequency of commensurable expressions.

Application of the information prediction theory to construct an orderly network structure lies, first of all, in finding associated order value or commensurability of the time series of severe disaster. Afterwards, the samples and order values typical of vigorous events selected are connected on a 2D or 3D coordinate axis. However, a single net diagram is difficult to cover all information and in this case a few diagrams are needed. And some of the samples are put in a repeated manner to guarantee the time association between surrounding points in the structure [24 – 29].

3. The Orderly Network Structure of $M \geq 7$ Strong Earthquake Chains in Xinjiang

Xinjiang is one of the regions with strong earthquake activity in Western China. In Table 1, there is a total of 30 $M \geq 7$ earthquakes recorded chronologically and in modern instruments from the year of 1800, where 20 earthquakes occurred in China including four $M \geq 8$ strong earthquakes and another

Table 1. Catalogue of $M \geq 7$ strong earthquakes in Xinjiang and its neighbourhood region (1800 – 2008).

No.	Dates	Epicentral location		Magnitude	Locality
	Year-Month-Day	Latitude (°N)	Longitude (°E)	(M)	
1	1812-03-08	43.7	83.5	8	East Nilke
2	1842-06-11	43.5	93.1	7.5	Barkol
3	1883-02-12	43.5	78.0	7.5	Alma- Ata (abroad)
4	1887-06-08	43.1	76.8	7.3	Vilna (abroad)
5	1889-07-11	43.2	78.7	8.3	Qieliekeqi (abroad)
6	1895-07-05	37.7	75.1	7	Taxkorgan
7	1902-08-22	39.9	75.2	8.25	North Atushi
8	1906-12-23	43.5	85.0	7.7	Southwest of Shawan
9	1911-01-03	42.9	76.9	8.2	Alma- Ata (abroad)
10	1911-02-18	40.0	73.0	7.8	Tajik(abroad)
11	1914-08-05	43.5	91.5	7.5	East Barkol
12	1924-07-03	36.8	83.8	7.25	East Minfeng
13	1924-07-12	37.1	83.6	7.2	Minfeng
14	1931-08-11	47.1	89.8	8	Southeast of Fuyun
15	1931-08-18	47.2	90.0	7.5	Northeast of Fuyun
16	1944-03-10	44.0	84.0	7.2	Northeast of Xinyuan
17	1944-09-28	39.1	75.0	7	South Wuqia
18	1946-11-02	41.5	72.5	7.6	Anjiyan (abroad)
19	1949-02-24	42.0	84.0	7.5	West Luntai
20	1955-04-15	39.9	74.6	7	West Wuqia
21	1955-04-15	39.9	74.7	7	West Wuqia
22	1974-07-05	45.7	93.8	7.1	Northeast of Barkol
23	1974-08-11	39.2	73.8	7.3	West Akto
24	1978-03-24	42.8	78.6	7.2	Alma- Ata (abroad)
25	1985-08-23	39.4	75.6	7.4	Wuqia
26	1990-06-14	47.9	84.4	7.3	Zaysanbo (abroad)
27	1992-08-19	42.1	73.9	7.5	Susamer (abroad)
28	1996-11-19	35.2	78.0	7.1	Karakorum
29	2003-09-27	49.9	87.9	7.9	the Frontier of Russia, Mongol, China (abroad)
30	2008-03-21	35.6	81.6	7.3	Yutian

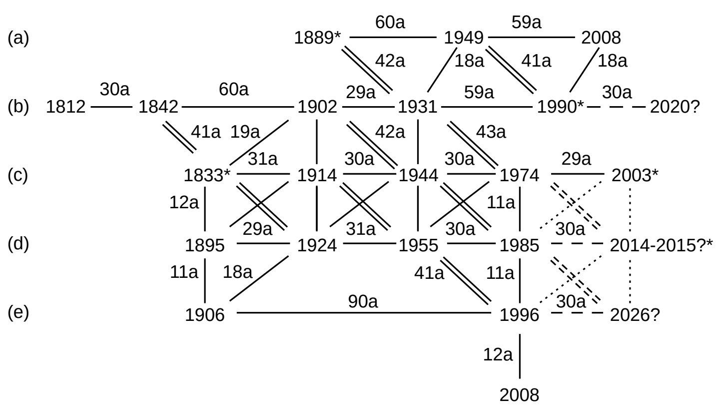

Fig. 1. Orderly network structure of $M \geq 7$ strong earthquake chains in Xinjiang and its neighbourhood region (dashed line denotes prediction, symbol * denotes earthquakes happened abroad).

10 earthquakes occurred in Kyrgyzstan, Kazakhstan, and Russia etc. The results of research for several years showed that the seismic activity of $M \geq 7$ strong earthquakes in Xinjiang and its neighbourhood region assumed good commensurability and orderliness, and the mainly order values (or called order parameters) had 5 types: $\tau_1 = 30\text{a} \times k$ $(k = 1,2,3)$, $\tau_2 = 11 \sim 12\text{a}$, $\tau_3 = 41 \sim 43\text{a}$, $\tau_4 = 18 \sim 19\text{a}$, and $\tau_5 = 5 \sim 6\text{a}$. We studied the relationship between the orderly structure and each interval value of $M \geq 7$ strong earthquakes in detail, and pointed out the special prediction significance of the above-mentioned interval values in references [23 – 29].

The orderly network structure of $M \geq 7$ strong earthquake chains in Xinjiang and its neighbourhood region is given in Figure 1, which was adapted from the original figure suggested in 1998 [26]. In Figure 1, we use the number of years to express the sample of the strong earthquake. Among them, a $M \geq 7$ strong earthquake occurred twice in the year of 1924, 1931, 1944, 1955, and 1974, and we use the same number of year. 24 earthquakes are used in the network structure in Figure 1 occupying 80 % of the total sample number.

In Figure 1, the five horizontal lines, namely, latitude lines (a) $\sim$ (e) are main chains, and they constitute the main frame of strong earthquake activities. They transferred from right to left at intervals of 30a, 60a, or 90a: the strong earthquake sample of chain (a) occurred with the cycle of 60a; the interval is 30a or 60a in chain (b); the interval is 30a in chain (c) and (d); the two earthquakes in chain (e) occurred at an interval of 90a. The vertical lines, namely longitude lines in Figure 1, express the relationship of the strong earthquake sample in the same column of chain (b), (c), (d), and (e) with the intervals of 11 $\sim$ 12a, the double oblique lines express the interval of them is 41 $\sim$ 43a, and the single oblique line shows the interval of 18 $\sim$ 19a. Figure 1 shows the coherent law of interval value τ_1 and the relationship between τ_1 and τ_2, τ_3, τ_4. Consequently, it revealed that the network structure of $M \geq 7$ strong earthquakes in the Xinjiang region was in good order. Structure is the base of function, and function is the reflection of structure. So we can get the time of future earthquakes according to the coherent law of the chains, and give prediction opinion referring to the nearby oblique line. We used to predict the $M7.9$ earthquake on the Frontier of Russia, Mongol, and China in 2003 by Figure 1 [13].

4. The Example of the Prediction for Yutian *M*7.3 Strong Earthquake in 2008

4.1. The Prediction Function of $\tau_1 = 30\text{a} \times k$ *(*$k = 1,2,3$*) and* $\tau_2 = 11 \sim 12\text{a}$

The Heavenly Stems conveys the wisdom of ancient Chinese People, and the traditional Chinese 60 cycle has universally adaptable significance in natural science. The time interval of $M \geq 7$ strong earthquake activities in the Xinjiang region is closely related to it, so we took the interval values 30a, 60a, 90a all in consideration. The five earthquakes occurred in 1931 (twice), 1949, 1990, and 2008 constitute a standard parallelogram in Figure 1, which shows that it is not accidental for Yutian $M7.3$ strong earthquake.

Figures 2 – 4 show the graphs by detailing Figure 1 separately. The interval of the three horizontal lines in

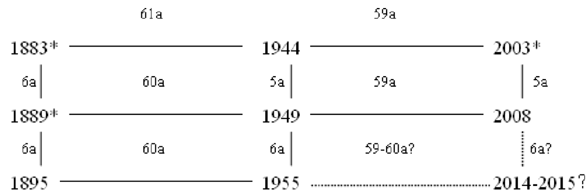

Fig. 2. Orderly network structure of Yutian $M7.3$ earthquake's prediction (dashed line denotes prediction, symbol * denotes earthquakes happened abroad).

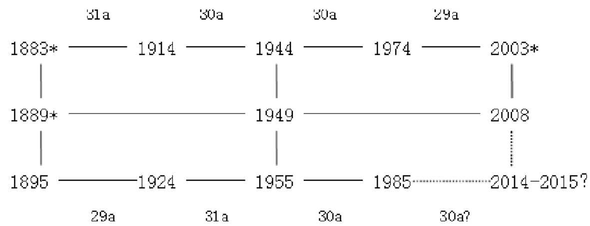

Fig. 3. Orderly network detail structure of Figure 2.

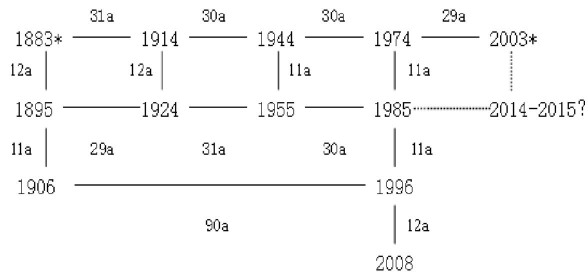

Fig. 4. Orderly network detail structure of Figure 2 and further prediction for Yutian $M7.3$ earthquake.

Figure 2 is 5 $\sim$ 6a, and it is 11 $\sim$ 12a between the first line and the third line, which shows the quite obvious regularity. Figure 3 is the detailed graph of Figure 2, in which the earthquake chains of the first and the third lines transfer greatly regularly to the right with the interval of 30a. We can infer from the middle line both in Figure 2 and Figure 3 that a $M \geq 7$ earthquake would occur possibly in about 2008. In Figure 4, we can get the prediction point of the Yutian $M7.3$ strong earthquake in 2008 by the chain of the right vertical line, videlicet, 1974—1985—1996—2008.

4.2. The Orderliness and Prediction Function of $\tau_3 = 41 \sim 43\text{a}$

The west of Chinese mainland has undergone five recurrences of strong earthquake since the 20th century. Figure 5 reflects the transfer rule on active episodes of τ_3, and the lattice of three lines and nine points is connected by the first, the third, and the fifth active episode in series. In 1994 we predicted

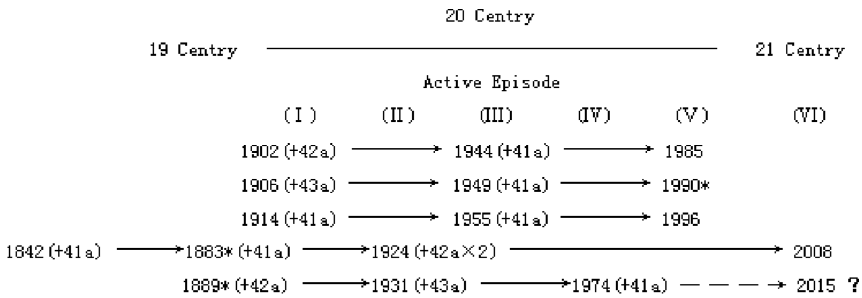

Fig. 5. Transmissible rule of orderly value 41 ∼ 43a and its prediction sketch map.

that the ninth point would be emplaced in 1996 according to the information of the orderliness in Figure 5 [24]. Then the $M6.9$ Atushi earthquake and the $M7.1$ Karakorum earthquake occurred on March 19 and November 19, respectively, both in 1996. The successful prediction showed that the order analysis was a research method of 'less defeat much', and it displayed significant effects on some conditions.

The forth line in Figure 5 elaborates that the second active episode transfers to the sixth with two 42a intervals in the two $M \geq 7$ earthquakes of Minfeng in 1924, and indeed an $M7.3$ strong earthquake happened in Yutian on March 31, 2008. Therefore, we presume that the next $M \geq 7$ earthquake may occur in 2015 according to the fifth line which is connected by the second, the forth, and the sixth active episodes (videlicet, the new active episodes of the 21 century).

In Table 1, we select six samples of strong earthquakes and express them separately as follows:

$$x_1 = 1902, \quad x_2 = 1914, \quad x_3 = 1944,$$
$$x_4 = 1955, \quad x_5 = 1974, \quad x_6 = 1985.$$

Then the five 3-variable commensurable formulas can be obtained as

$$x_6 + x_5 - x_3 = 2015, \quad x_6 + x_3 - x_2 = 2015,$$
$$x_6 + x_6 - x_4 = 2015, \quad x_5 + x_4 - x_2 = 2015,$$
$$x_5 + x_3 - x_1 = 2016.$$

It also shows that the time point of 2015 is not accidental. In another words, it is quite possible that the next $M \geq 7$ earthquake may occur around 2015 in the Xinjiang region.

5. Discussion on the Mechanism of Order Values

5.1. The Orderliness of $\tau_6 = 71 \sim 72$a

The order network diagram could be designed as not only planar structure but also spatial structure (see Fig. 6). τ_6 is a newly discovered order value with important significance, because it can be decomposed into $72 = 42 + 30$ and $71 = 60 + 11$. Therefore, τ_6 includes the periods of 60, 30, 41, and 11a, and the relationship between τ_6 and other values such as τ_1, τ_2, τ_3 etc. can be expressed as the three-dimensional frame of three-layer showed in Figure 6(a). The rectangular of top plane has been completed, and the rectangular of middle plane and the basal plan have not been completed. In Figure 6, the graphs (b) – (f) are decomposed from (a), where (b) is the front side of (a), (c) is the left side, (d) is the diagonal section, (e) is the back side, and

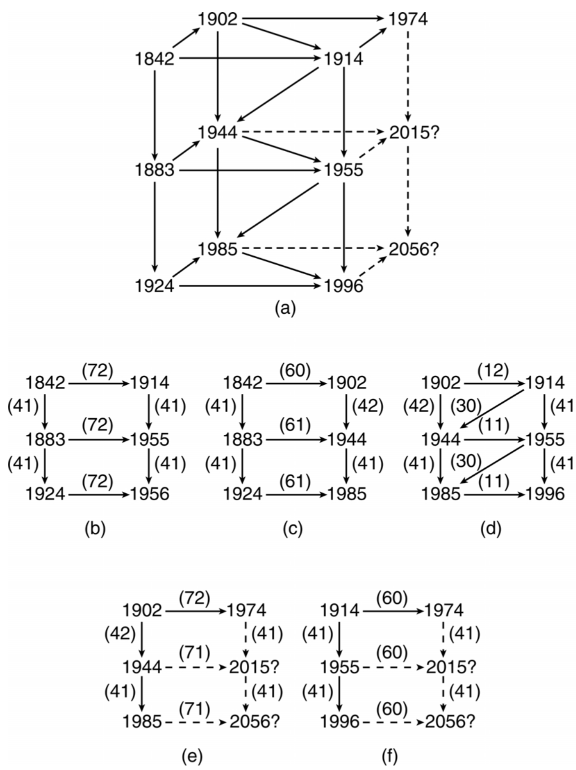

Fig. 6. Orderly network structure of $M \geq 7$ strong earthquake in Xinjiang and its neighbourhood.

(f) is the right side. The three former have been completed, and the last two have not. If the two earthquake samples of 2015 and 2056 will occur in the future, Figure 6 lying before us is a gauge symmetry 'geometric masterpiece'.

5.2. *The Orderliness of* $\tau_2 = 11 \sim 12$a, $\tau_4 = 18 \sim 19$a, *and* $\tau_5 = 5 \sim 6$a

The average period of sunspot activity is 11a, the magnetic period of it is 22a, and the long period is 80 ∼ 90a. So we could consider all the order values 11a, 22a, and 44a. Many scholars both at home and abroad studied the relationship between sunspot activity and earthquake. A. D. Serjinski (1961), a former Soviet Union scholar, pointed out that strong earthquake occurred almost near the peak years or the valley years of solar activity [19]. The $M \geq 7$ earthquakes of Shan-Gan-Ning-Qing area have occurred almost in the peak years of solar activity since the 20th century, and there were 18 $M \geq 7$ earthquakes occurring pre and post the peak years or the valley years, accounting for 62.1 % among them, and 13 earthquakes pre and post the valley years, accounting for 45 %. According to the data from Beijing Observatory of Chinese Academy of Sciences, 1996 was the valley year of the 23rd period since 1755. It is in the year of 1996 that a M6.9 earthquake and a M7.1 earthquake occurred separately in Atushi and Karakorum, followed by the Jiashi strong earthquake swarm in early 1997. These earthquakes provide new evidence for the above conclusion. The precession of the lunar ascending node has a period of 18.6a. The research result of the reference [30] showed that the strong earthquakes of global major seismic belt had the 18.6a seismic cycle, which was related to the period of the precession of the lunar ascending node. In the $M \geq 7$ earthquake activities of this area, τ_4 played an active role. The equation $18 = 12 + 6$ shows that τ_4 is related to τ_2 and τ_5. In addition, $5 \sim 6$a is about 0.55 times of 11a, 11 is about 0.591 times of 18.6, and 18.6 is about 0.62 times of 30. All of the data are in the vicinity of the gold section number 0.618. Guo [19] pointed out that it was likely to cause nature disaster if the two periods pulse is

$$T_b = \frac{T_1 \times T_2}{T_1 - T_2}.$$

The periods pulse of 25 and 18.6 is 72.6 which is close to τ_6, and the periods pulses of 22 and 35, 22 and 18.6, 22 and 25 are 59.2, 120.3, and 183.3, respectively. All of the periods pulses are integral multiple of 60 approximately. Therefore, all of the order values have complex intrinsic connection, and they are interacting one another.

The universe is a unified whole, and the running of the sun, the earth, and the moon has interrelationship and interdependence with the nature disaster such as earthquakes. The earthquake can be considered as the result of nonlinear interaction between the internal factors and external factors of the earth. The external factors are more closely correlated with earthquakes, and the stronger earthquake, the better correlation [19, 30]. In a word, serious disasters such as strong earthquakes could be studied in the systems of astronomy, earth science, and biology because of its uniqueness.

6. Conclusion and Discussion

(i) Strong earthquakes and the prediction of the strong earthquake chains are the forefront but difficult topic in the world and so far no breakthrough has been broken. And by it is an important approach to reduce earthquake disaster and help the development of social economy. But the prediction method based on statistic has no radical breakthrough up to now, because the spatial and temporal distribution of strong earthquakes is inhomogeneous and the geotectonic movement is complicated. Many seismologists have emphasized repeatedly that empirical prediction should take the place of physical prediction since the 1980s. It is a long-term and arduous task to implement the physical prediction by means of seismogenic mechanism of all active block in China, because the continental lithosphere in China has complicated structure and a long evolutionary history.

The information forecast theory proposed by Weng is the wisdom based on a great deal of history data and modern scientific [1 – 2]. The theoretical system contains theoretical exposition and prediction methods, and has successfully solved many scientific problems especially in disaster prediction. So it has been a relatively complete innovative system, and it breaks through the limits and manacles of the western prediction method [4, 10, 31, 32]. Weng emphasized that innovation relied on rethinking. His information forecast theory and method are the results of several recognitions with the existing concepts, and it has been used successfully by applying to many prediction cases. The severe nature disaster belongs to abnormal events, the spatial and temporal distribution of which is different from normal events. Therefore, some scholars abroad take a mournful view on earthquake prediction, and they generally believe that earthquakes could not be predicted. But the information forecast theory of Weng has been very effective on the prediction of severe nature disaster, and facts have proved that strong earthquakes could be predicted. Based on the past three cases which had been predicted successfully (M6.9 Atushi earthquake and M7.1 Karakorum earthquake in 1996, M7.9 earthquake on the Frontier of Russia, Mongol, China in 2003, and the M7.3 Yutian earthquake in 2008), and combined with the orderly network structure in this paper, we can make the prediction that the $M \geq 7$ earthquakes will occur around 2014 – 2015, 2020, 2026, and 2056 in Xinjiang and its neighbourhood.

(ii) In the recent 20 years, complicacy science is gradually being accepted in place of nonlinear science. The British scientist John Holland who was called 'the father of the genetic algorithms' is one of the thinkers with most innovative consciousness, and his work *Hidden Order: How Adaptation Builds Complexity* has an important contribution. The concept of 'Emergence' (from chaos to order) given by him is used to study the interaction with coupling forward backward correlation and the generation process with structure modifiable. The essence of emergence phenomenon is from small to large and from simple to complex. He pointed out that emergence was an interaction with coupling correlation, and both the interaction and the system generated from it are nonlinear. The concept of emergence is so simple that it means the whole is more than the sum of the parts. But it has profound meanings in many fields such as natural sciences and social science, etc. The emergence theory with universality can predict many complex behaviours, and give us many enlightenment of life, wisdom, and tissue [33 – 34].

(iii) Network is the further extension of the system concept [35]. It is open, and it is more suitable for describing some complicated things which exist objectively. It is difficult to delimit a relatively constant system in the comprehensive research of astronomy, earth, biology, and human, because the system border and its relevant factors change in accordance with time, place, and other conditions. Therefore, we should consider it as not a system but a network. In *Physics and Philosophy*, Werner Heisenberg pointed out that the world could be classified not as objects of different categories but as different relations. The world is a complex joint of many events between which it has various relationship, changeable, overlapping, and conjunct. Fritjof Capra thinks that the universe is considered as a dynamic network of the interrelated events. The properties of any parts of the network are not independent, and they are determined by the properties of other parts. The total consistency of interrelationship determined the network structure. System is an abstract concept, but network has strong visibility which can express some important relationships as follows: a) Long range relationship: in the network, the nodes and lines with long distance could be related closer, but the spaces and the nodes with short distance have few relationships. b) The continued and discrete combination: the spaces are discrete, and the nodes and lines are continued. It is very valuable for explaining 'leaping interrelation' [35 – 37]. And it is also proved in the monographs of application of network image and technology which are published in recent years [38 – 44].

So-called self-organization is not the regularity imposed by the human's innate recognition but from the nature. The basic characteristic of self-organized network lies in the lower structural similarity and the large opening degree. In other words, the self-organized network does not have fixed boundary, structure, and initial conditions, and the structure of the next stage is quite different from the last stage [45].

The 21st century is the network times, and the network thought and theory have infiltrated into all aspects of nature science and social science. Many complicated systems in fields of technology, biology, social, economy etc. could be depicted visually by network, for example, transportation network, electric power network, internet, neural network in animals, protein network, and social network etc. The strong earthquakes and earthquake chains are the same with them. The single strong earthquake is like an ant or a neuron, and the strong earthquake chains network which is like ant colony or neural network consist of the single earthquakes by coupling relationship between them. The adaptability showed by the population is well over adaptability of a single unit, and the amount of information contained by the network of strong earthquake chains is much larger than that of single strong earthquakes. Therefore, network technology is also applicable for the study of earthquake prediction.

Dao-yi Xu first proposed that the formation mechanism of strong earthquakes is characterized by network features, and the strong earthquakes are considered as nodes of multi level networks [45]. The network image of $M \geq 7$ earthquakes chains in the Xinjiang area is given in this paper. But the design of prediction function should be perfected, and the earthquake network structure of other areas of Chinese mainland also should be studied further. In addition, nobody has used complex network technology for the study of earthquake prediction until now.

(iv) The active characteristic of $M \geq 7$ earthquake chains in Xinjiang and its neighbourhood is different from the other areas of Chinese mainland, such as the Northern Tibetan Plateau area and the Jiangsu-South Yellow Sea region [15, 16], because it is determined by the network structure of meridian and latitude lines in the area. In this paper, it reveals the activity rhythm of the $M \geq 7$ strong earthquake chains in the Xinjiang region during the past 200 years by the network structure. The regular network structure offered a good example for the network hypothesis. The analysis of network structure is a view image method for medium long term prediction of strong earthquakes, and it avoids the tedious analysis of classic mathematical model. The earthquake prediction study in China should be a few steps ahead of the world, and it should have innovation thought [46, 47]. Combining the informative forecasting theory with complex networks technology, the study is undertaken to explore an effective and creative Chinese method of leaping (especially long time and long distance) prediction of strong earthquakes in order to positively contribute to the modernization construction and disaster prevention and reduction of our country.

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