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# The Study on Fractal Characteristics of Television Audience Ratings Based on R/S Analysis Method

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## Abstract

According to the nonlinear distribution of Television Audience ratings data, a fractal dimension study on average daily television audience ratings of three TV stations based on *R*/*S* analysis method. Results show that the Hurst index of time series is significantly greater than 0.5 and there is a trend of long-term memory; All the time series is significantly different in the non-periodic cycles length and offer explanation from the perspective of three Television stations' characteristics of development. This method can help television managers realize the viewing situation, master the change rule and help advertisers make a scientific decision.

**Key words:** *R*/*S* analysis method; Television audience rating; Hurst index

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## INTRODUCTION

Television ratings are the dominant indicator of measuring the quality of television programs. Nowadays, the quantitative analysis of television ratings generally focused on the prediction of TV ratings and the analysis to time series of TV ratings. It will help interested parties to make scientific and rational decisions.

According to the influence factors of television ratings and it has a significant nonlinear relationship, the quantitative analysis methods of TV ratings from the initial simple linear regression and the auto-regressive moving-average model, extended to the neural network algorithm. This can better adapt to the distribution characteristics of nonlinear and promote the fitting accuracy of short-term prediction. However, the above method mainly is suitable for short-term forecasts. Neural networks are widely used in the long-term forecast, but its forecast use long time units such as the annual average data only can conduct limited prediction, so it remains to consider the applicability.

Heavy scale range analysis method (*R*/*S*) is a time series analysis based on fractal theory. It is nonparametric analysis algorithm almost do not make any assumption to study objects and it has good robustness make it particularly suitable for analysis of nonlinear time series with long-range correlations. So it fully fits analysis needs of TV ratings. This study established *R*/*S* analysis model and predicts ratings trends over time series of Hunan TV, Zhejiang TV and Guangdong TV. Finally we found that average daily ratings of three television stations have long-term memory and it can help information users to quickly and accurately speculate the future trend through the existing ratings data.

## 1. *R*/*S* ANALYSIS METHOD

### 1.1 *R*/*S* Analysis and Hurst Index

Hurst found that the water flow of the Nile is not a random process in the study of the Nile flood records from 622 ad to 1,469 ad, it seems to have the characteristics of the cycle and its length is non-periodic. Hurst proposed the *R*/*S* analysis method to detect the random nature of Nile water flow inspired by the famous Einstein 1/2 T. Then, he found that many time series in nature are not random flow.

Hurst's method is the first to calculate the cumulative deviation of the time series and then obtain the range of the adjusted time series, next dividing the adjusted range used by the standard deviation of the sample. Basic principles are summarized as follows:

A time series $R(t)$ if its length is N, then the time series is divided into A successive non-overlapping length equal subintervals Ia whose length is $n$ ($2 \le n \le L$, $L$ is the largest sub interval of length), Obviously $n*A=N$. Each element of the Ia is called $ei$, $a$ ($i$=1, 2, …., $n$), we can get the mean value of the time series $Ia$ is as follows,

$$m_a = \frac{1}{n}\sum_1^n e_{i,a} \tag{1}$$

Then calculate the standard deviation , Cumulative mean deviation sequence and Range $RIa$ of each sub interval as follows,

$$S_{Ia}=\sqrt{\frac{1}{n}\sum_1^n \left(e_{i,\ a}-m_a\right)^2} \tag{2}$$

$$X_{i,a}=\sum_1^k (e_{i,a}-m_a) \tag{3}$$

$$R_{Ia}=\max(X_{i,a})-\min(X_{i,a}) \tag{4}$$

Defining the $R/S$ of each sub interval, because of the $R/S$ changed in time increment is based on the scale of power exponent, so its general form is $R/S=(n)H$.

Log on both sides of the general form of $R/S$, Mandelbrot proved that there was a linear relationship between log($R/S$) and log($n$) :

$$\mathrm{Log}(R/S)=\log(a)+\mathrm{H}\cdot\log(n) \tag{5}$$

In the formula, is a constant, $N$ is the length of time series, the log($n$) as the independent variable, log($R/S$) as the dependent variable, so we can get a double logarithmic coordinate scatter diagram, then fitting a straight line estimated by least square. We can get the H value of the linear slope is the Hurst index and also can get the linear fitting degree by curve fitting toolbox CFtool.

The Hurst index is the index of the correlation and the trend of the time series, its range of the values : $0 \le H \le 1$. According to the different values of $H$, you can distinguish the system properties.

If $0 \le H < 0.5$, it is proved that the time sequence is anti-persistent and the sequence of random walks has more average recovery feature. So that past and future information is negatively related.

If $H$=0.5, it is proved that the observation values of the time series are independent and the standard is random. The stronger the randomness of time series when H closer to 0.5.

If $0.5 < H < 1$, it is proved that the time sequence is a partial stochastic process, and it is positive. So that past and future information is positive, and the trend is enhanced.

If $H$=1, it is proved that the original sequence is completely positive correlation and it is a deterministic system. The stronger the randomness of time series when $H$ closer to 1.

According to the $R/S$ principle analysis, it can be used for the study of system characteristics and trends of the time series.

### 1.2 Non-Cyclical Length

Hurst proposed a statistics $Vn = \frac{(R/S)\,n}{\sqrt{n}}$ for the non-cyclical length. Non-cyclical length is a time length that a persistent system is completely lost on dependent of the initial condition. $Vn$ is upward sloping about log($n$)in the non-independent random process, and it is flat about log($n$) in the independent random process. There is a limit to the long range correlation of complex nonlinear systems and the system will appear to uncorrelated random state if it is beyond the limit. So the observation of the scatter diagram that is constituted by statistics $Vn$ and log($n$), we can find a mutation point in which the upward (downward) trend is downward (upward) and the inflection point is obvious. The point is to show that long-term memory is gone and the length of the corresponding time is the length of the non-periodic cycle.

The critical moment (the mutation point) $TC$ is used to describe the time limit for a long range. From the principle of $R/S$, the mutation point of double logarithmic coordinate scatter diagram log($n$)-log($R/S$) is the critical moment T$C$, it is meaning that the long range correlation of the system is changed because of the mutation of the system. According to the formula $T=10TC$ (6), we can infer the timing aperiodic cycle length from $TC$.

## 2. DATA SOURCES

Viewing data from authoritative information released on CCTV Suo Furui, it is including Hunan satellite TV, Zhejiang satellite TV and Guangdong satellite TV. Hunan satellite TV as a leader in the domestic local TV is the focus of the audience research for long occupied the first place in the ratings; Zhejiang satellite TV carried out a brand upgrade in recent years, its development potential and the growth of space is worth a deep analysis;

Guangdong satellite TV as a local brand in Guangdong, the influence of TV is weak and quite inconsistent to the status of the province in economy, so it is quite meaningful to study. Through the analysis of the distribution and variation characteristics of the average daily ratings of three TV stations during 2014.03.15-2015.03.15. We can establish a fast and efficient mechanism for the television ratings prediction, and help advertisers make informed decisions running.

## 3. THE EMPIRICAL RESULTS

We make analysis on the three television ratings by the MATLAB tool, then we can get time sequence diagram of average daily ratings, $H$ value table, double logarithmic scatterplot log($n$)—log($R/S$) and Non-cyclical length analysis chart of average daily ratings.

### 3.1 Time Sequence Diagram of Average Daily Ratings

We arranged the ratings data of the three television stations through time sequence, then we get Figure 1—

time sequence diagram of average daily ratings. The average daily ratings of the television stations have the characteristics of fluctuation and have the feature of Non-linear feature.

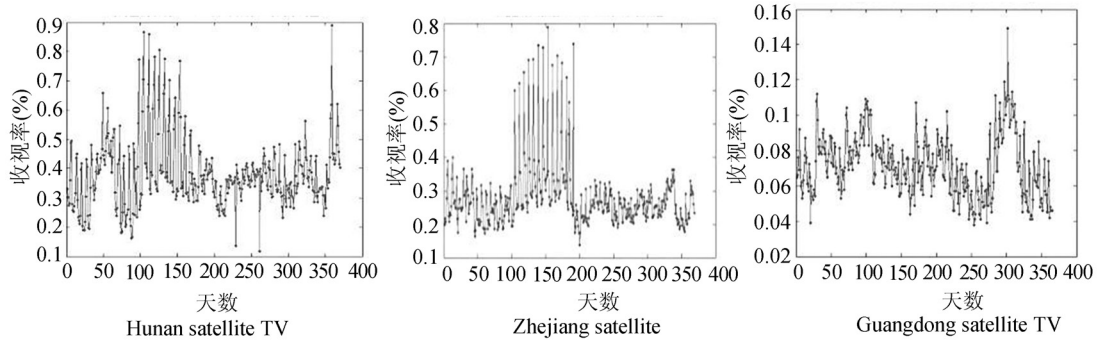


**Figure 1**
**Time Sequence Diagram of Average Daily Ratings**

### 3.2 Hurst Index Value

According to formula (1)-(5), we analyzed the average daily ratings of three TV stations in *R*/*S* analysis. The table 1 showed that the average daily television ratings time series H of Hunan, Zhejiang, Guangdong three TV stations were 0.8089, 0.9537 and 0.8158, and they are all more than 0.5. It represents a positive correlation between future increments and past increments and it has an obvious fractal characteristics. In order to verify the reliability of H value, we carry on the linear fitting of the double logarithmic coordinates of the time series of three TV stations. As shown in Figure 2, the fitting degree was 0.9879, 0.9764 and 0.9817, respectively and the reliability of Hurst index is high.

**Table 1**
**Hurst Index**

| Parameter index | TV station | | |
|---|---|---|---|
| | Hunan | Zhejiang | Guangdong |
| Hurst index | 0.8089 | 0.9357 | 0.8158 |
| Fitting degree *R* | 0.9879 | 0.9764 | 0.9817 |

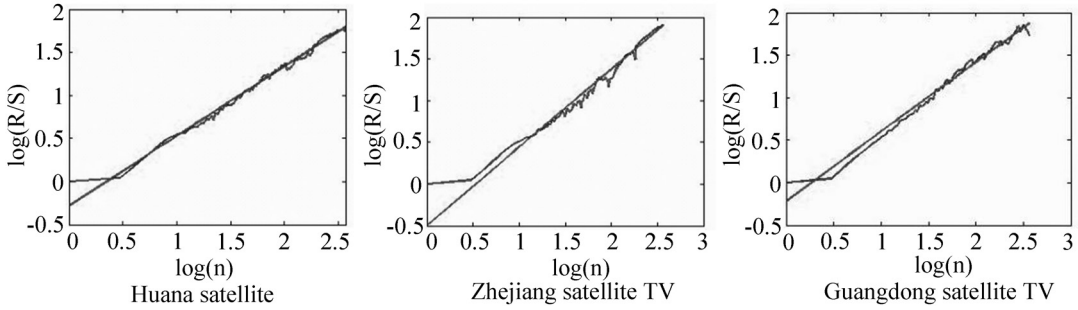


**Figure 2**
**Double Logarithmic Coordinate Scatter Diagram**

### 3.3 Non-Periodic Cycle Length

Figure 3, Figure 4 and Figure 5 are the non-periodic cycle length figure of average daily ratings of three TV stations, it is constituted by double logarithmic coordinate scatter diagram and the changing image between *Vn* and log(*n*). The images *Vn* —log(*n*) of the three TV stations are obviously showing the persistent characteristics of upward tilt. Generally, the higher the upward slope, the more persistent. Zhejiang satellite TV is the highest, followed by Guangdong TV, Hunan satellite TV and this is relative to H value of three satellite TV (*H*zhejiang>*H*Guangdong>*H*Hunan).

In the chart of *Vn* —log(*n*), Zhejiang satellite TV's first inflection point in the position of log(*n*) =1.8438, that is *Tc*=1.8438, according to formula (6) *T* =10*Tc*,we can get that non periodic cycle length is 69.78 days. Similarly, the non-periodic cycle lengths of Hunan and Guangdong satellite TV were 29.42 days and 31.62 days. The non-periodic cycle length of Zhejiang satellite TV is ahead of Guangdong and Hunan satellite TV. This conclusion is consistent with the results of the H analysis of the three stations. The non-periodic cycle length of Zhejiang satellite TV is longest and it has the longest term memory, it will lose the dependence on the past after about 69.78 days. However, the non-periodic cycle length of Hunan satellite TV is only 29.42 days and the impact of the past state is shorter.

It should be noted that the non-periodic cycle length is just indicated the memory intensity of the time series of different satellite TV ratings. There is no relationship with

the absolute value of the ratings itself. For example, the average daily ratings level of Hunan satellite TV is ahead of Zhejiang and Guangdong satellite TVs, but its non-periodic cycle length is the shortest.

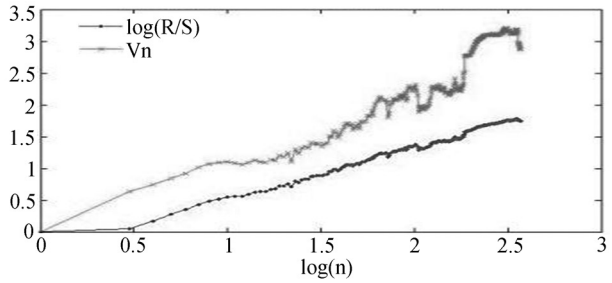


**Figure 3**
**Average Daily Ratings of Non-Periodic Cycle Length, Hunan**

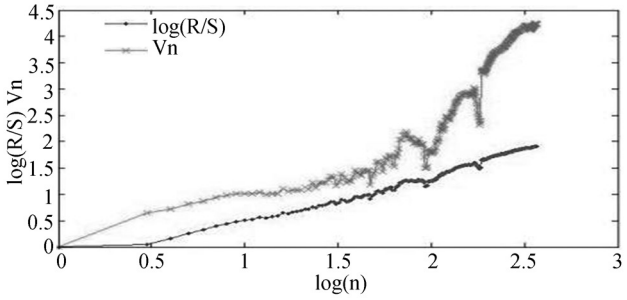


**Figure 4**
**Average Daily Ratings of Non-Periodic Cycle Length, Zhejiang**

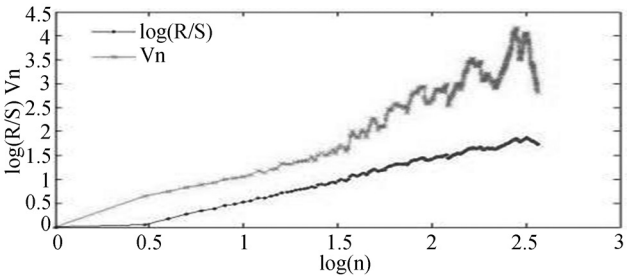


**Figure 5**
**Average Daily Ratings of Non-Periodic Cycle Length, Guangdong**

### 3.4 Numerical Analysis

The value of H of Hunan TV is smallest, and the non-cycle length is shortest. This is largely due to its high and stable ratings, and the fierce competition of the domestic has limited its Market development pace. Although the change of the ratings is encouragable, the growth may not keep pace with Zhejiang TV and Guangdong TV.

Contrary to Hunan TV, the value of H and the non-cycle length are the biggest. It has achieved a big rise in recent years, carried out the series of reforms of "China blue" brand, introduced popular programs, engaged in the win-win cooperation, and achieve a lot. Elaborate branding, combined with the increasingly mature market program operation. Zhejiang TV successfully shortlisted for the domestic TV, comfortably in the first ratings three.

With the lowest average ratings level, the value of Guangdong TV is in the second one. For a long time, ratings levels of Guangdong TV have been not ranked in the first top ten TV of province. There are various reasons lead to its failure, such as the laggard of its programming, the lackness of interactive between online and offline, the rigidness of operation mechanism, also its business positioning is not clear. For solve it, Guangdong TV has decided to invest 1 billion yuan since 2014 in the key cultivation series, variety shows, news programs, to reverse the passive situation. But as the H value shows, its future ratings are strongly positive relate to its past ratings. So it is difficult to obtain the leap because of its low ratings. The investment is necessary, but it is not enough. Learning from Hunan satellite TV, Zhejiang TV to break the rigid management mechanism, and strive to develop innovative, enhances online and offline interaction is more important. After all, the age of the Internet call for more market management idea and operation ways that focus on the user experience, and it only works with the continuous change.

By using MATLAB program to analyze the ratings of time series, we can get the Hurst index, which can directly evaluate the changing trend of each big television, 0.5 as a cut-off point. Once The index of TV between 0-0.5, the future ratings is likely to be a downward trend even if the ratings got growth in the past So the index can help advertisers discriminate the television ratings and make the rational decision, maximum the advertising effect in a security way .

## SUMMARY AND PROSPECT

The change of TV ratings is complex and nonlinear, so we make the *R*/*S* analysis which is replaced the previous linear regression method on the daily average ratings of three TV stations in this paper. It can help grasp the trend of change and non- periodic cycle length quickly. It can help operators to understand the situation and take measures to improve the ratings in time. This method also can be extended to the comparison of multiple TV ratings and it helps to evaluate the strength and potential TV stations. Finally, it can help the advertising operators and other stakeholders to improve the return on investment.

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