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Periphery Theory and Its Application to Air Pollution Forecast

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Abstract: — The periphery phenomena and periphery definition as well as periphery theory are introduced; The basic structure of a periphery （jieke） of system is composed of both a wall, which defends system itself, and a gate (or passage), through which the exchange between the system and its environment is carried out. In order to describe the periphery mathematically, perimeter set are presented. On the basis two indicant functions: security degree and subsist ratio are suggested. By using air pollution and meteorological data, a case of air pollution forecast is exemplified in detail.

Keywords: —information, periphery theory, air pollution forecast, environment protect.

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1. Introduction

One can easily find the periphery(*jieke* 界壳 in Chinese) phenomena, for example, a hard shell of a turtle, an airplane (Fig. 1), a castle, a watershed between two rivers, country or region boundary, firewall in the internet etc. But a package of goods, a coffin etc. are not a periphery, as they are out of exchange. A gang syndicate has an almost closed periphery, its members exchange less with other gang-organizations and society. Periphery theory is just to study a kind of periphery phenomena [1,2]; Nowadays periphery theory has been applied to many fields [3,4,5]

At first the periphery phenomena and its definition as well as periphery theory are briefed; herein perimeter set are presented mathematically. By using the air pollution and the meteorological data, a case of air pollution forecast is given as an example.

Fig.1. Airplane

2.Periphery structure and Perimeter set

A periphery of system is undoubtedly a part of the system, which situates on its boundary, and adjacent to environment. So the periphery is an intermediary agent between the system and its environment.

A kind of system boundary that plays a role in

- defending the existence of the system and
- exchanging between the system and its environment

is called as a periphery or *jieke*, There in after both periphery and *jieke* will be used, depending on which is proper. The basic structure of a periphery of system is composed of both a wall, which defends system itself, and a gate (or passage), through which the exchange between the system and its environment is carried out (Fig. 2).

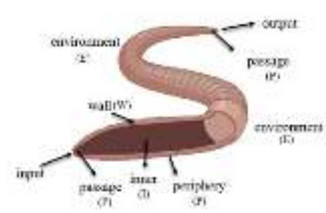

Fig.2. Schematic diagram of periphery

The basic structure of a periphery of system is composed of both a wall, which defends system itself, and a gate (or passage), through which the exchange between the system and its environment is carried out [6].

Suppose an periphery sub-unit in a system boundary (*SB*) is *u*，which is a small part of system boundary, obviously there is

$$SB = \bigcup_i u_i$$

Defense degree $\mu(u)$ and its exchange degree $\nu(u)$ of the sub-unit are given, i.e.

$$\mu(u), \nu(u) \in [0,1], \mu(u) + \nu(u) \le 1 \tag{1}$$

Besides, the state ζ of the sub-unit is surely considered, the state change is related to the states of other parts of the system and affects to defensiveness and exchange rate.

So it needs to define a perimeter set [6]. Let us have a universe of discourse *E*. Let *A* be a subset of *E*. Then construct the set

$$A = \{\langle u, \zeta_A(u), \mu_A(u), \nu_A(u)\rangle \mid u \in E\} \tag{2}$$

where $\zeta_A(u) \in [0,1], \mu_A(u) \in [0,1], \nu_A(u) \in [0,1], \mu_A(u) + \nu_A(u) \le 1.$ We will call the set *A* perimeter set with 3-logos. Suppose perimeter set with n-elements, denote

$$A = (\zeta_1, \mu_1, \nu_1)/u_1 + (\zeta_2, \mu_2, \nu_2)/u_2 + \cdots + (\zeta_n, \mu_n, \nu_n)/u_n \tag{3}$$

"+" expresses another sub-unit following, not algebra addition. Denote system state ζ ∈ [0, 1], then the sub-unit *u* of periphery is expressed as

$$z = (\zeta, \mu, \nu)/u$$

But for the sub-unit *u* of the system inner

$$z = (\zeta, 0, 0)/u$$

Because the sub-unit *u* of the system inner has not functions of both defense and exchange, so $\mu=0$，$\nu=0$.

3. Indicant functions

For simplicity, first of all, ζ(u) is leaved out here. So it reads

$$A = \{\langle u, \mu_A(u), \nu_A(u)\rangle \mid u \in E\} \tag{4}$$

Suppose a perimeter set with n-elements, denote

$$A = (\mu_1, \nu_1)/u_1 + (\mu_2, \nu_2)/u_2 + \cdots + (\mu_n, \nu_n)/u_n \tag{5}$$

"+" expresses another sub-unit following, not algebra addition.

Two indicant functions: security degree and subsist ratio, which belong to presentment function of the periphery. The sum of defense degree is

$$d = \Sigma_i \mu_i, \quad i = 1, 2, \cdots, n$$

The sum of exchange degree is

$$e = \Sigma_i \nu_i, \quad i = 1, 2, \cdots, n$$

Mapping κ: $\{x(\mu,\nu)u \mid u \in E\} \to [0,1]$

Formulates security degree of the periphery

$$\kappa = 1/2 + (d^* - \lambda e^*)/2 \quad \kappa \in [0, 1] \tag{6}$$

where

$$d^* = d/(d+e), e^* = e/(d+e), d^* + e^* = 1, \lambda \in [0,1],$$

where λ is parameter relating to system state, environment and defense degree. Security degree is periphery's defense capability taking account of exchange degree. Just be similar to Chinese medicine theory and Chinese philosophy, the system defense is regarded as pan-positive(*Yang*) but exchange as pan-negative(*yin*). The system holds yin-yang equilibrium, then maintains itself existence. Therefore several periphery methods for forecast and evaluation are based on yin-yang equilibrium principle.

Taking $\lambda=1$

If $d^*=0$, $e^*=1$, then $\kappa=0$;

If $d^*=1$, $e^*=0$, then $\kappa=1$;

If $d^*= e^*$, then $\kappa=1/2$.

Formulate subsist ratio of periphery

$$\varphi = \frac{1}{1 + \left[\frac{d^*}{\lambda e^*}\right]^q}, \quad e^* \ne 0 \tag{7}$$

where q is parameter with positive integer number. Subsist ratio is relative exchange, i.e. proportion of exchange to defense.

Taking $\lambda=1$, $q=2$

If $d^*=0$，$e^*=1$, then $\varphi=1$;

If $d^*=e^*$ then $\varphi=1/2$;

If $d^* \to \infty$ or $e^* \to 0$ $\varphi \to 0$.

If the defense is extra large or exchange is extra small, the subsist ratio tends to zero, namely the system cannot be alive in the case.

4. Air pollution forecast

Air pollutions are relative to a human live and the economic activities as well as military operations. So the air pollution forecast is important issue in the environment protect. Generally, the air pollution forecasts are made by use of statistics and numerical computation[7,8]. Herein a forecast method for the air pollution is suggested based on periphery theory [9,10].

Firstly we selects some variables , which are correlative to the air pollution by means of experience analysis. A concept of departure pair and its calculation are suggested; The departure pair will be developed to make the forecast for the city air pollution. An example was made with the method, from this availability for the city air pollution forecast is verified.

A departure of variables x, e.g. temperature, humanity, pollutant concentration etc. are defined

$$\Delta x = x - xp \tag{8}$$

where xp is the mean or the median value of variable x.

$\Delta x \geq 0$ called positive departure and denoted as $x+$

$\Delta x < 0$ called negative departure and denoted as $x-$.

When the correlation between y and x_i is positive, the standardization is taken as

$$z_i' = \frac{z_i - z_{\min}}{z_{\max} - z_{\min}}$$

TABLE 1 SIGN PROBABILITIES

		x_1		x_2		x_3		x_4		x_5	
		+	-	+	-	+	-	+	-	+	-
y	+	0.7857	0.3846	0.7143	0.4615	0.5294	0.7	0.4286	0.7692	0.8125	0.25
	-	0.2143	0.6154	0.2857	0.5385	0.4706	0.3	0.5714	0.2308	0.1875	0.75

Consider $x+$ as μ , $x-$ as v.

We apply (7) to make the forecast of air pollution, in (7) taking q=2, λ=1; and

$$d^* = d/(d+e), e^* = e/(d+e); d = \Sigma_i x^+, e = \Sigma_j x^-$$

$i = 1, 2,\ldots,I$, $j = 1, 2,\ldots ,J$; I, J are number of the positive departure and negative departure respectively.

Taking air pollution days from December 1999 to February 2002 (samples N=27) as predictand, and 5 atmospheric circulation indexes as predictors, the forecast model has been set up, then the test forecasts were made for March to May 2002, denoted as 28, 29,30 sample.

5. Computing

The predictors are following:

x_1, meridian circulation index over Asia;

x_2, polar vortex index over Asia;

x_3, north latitude degree of western Pacific subtropical high pressure;

x_4, index of Tibetan circulation;

x_5, Southern Oscillation index.

The data of the predictors and predictand can be obtained from the open data in China. The predictand y are correlate with above variables x_i with confidence level α=0.05. The departures were calculated using the median value of variables, as it makes almost the number of $x+$ to be equal to one of $x-$. All data are standardized by use of extreme values difference to [0,1], namely

When negative, take as

$$z_i' = \frac{z_{\min} - z_i}{z_{\max} - z_{\min}}$$

where $z_{\min}$ and $z_{\max}$ are a minimum and a maximum of y or x_i series.

Instead of values of x^+ and x^- we prefer to take the sign probability p as μ, v. p is calculated using

$$p = m/n$$

where m is the number of positive or negative (sign + or -) of y departures, which coincide with that of x_i , namely, in same sample the sign of the y departure have to same sign of the x_i . According to the data the sign probabilities were calculated and listed in Table 1.

As we know, the qualitative forecast is very important in the climate prediction [11,12]. For example, in spring people want to know the following summer will be rainy or dry, hot or cool. This is a qualitative forecast. Besides present forecast technique for climate is not high, an accurate quantitative forecast cannot be made. So it demands to make the qualitative forecast. Therefore it needs to develop the method of qualitative forecast.

Generally, the air pollution forecasts are made by use of both numerical computing and statistics [13]. Up to now the forecast accuracy is not satisfactory. A method based on the periphery theory is described as follows. The method has methodological meaning, it is to say, the periphery theory and the perimeter set will be available to develop the air pollution forecasts.

Make the forecast of 28th case. Divide the + and - of 5 variables according to (8), then find out the corresponding column in table 1, calculate

$d = \Sigma\mu = 0.7857 + 0.7143 + 0.7 + 0.7692 + 0.8125 = 3.7817$

$e = \Sigma\nu = 0.2143 + 0.2857 + 0.3 + 0.2308 + 0.1875 = 1.2183$

$d^* = d/(d + e) = 3.7817/(3.7817 + 1.2183) = 3.7817/5.0 = 0.7563$

$e^* = e/(d + e) = 1.2183/(3.7817 + 1.2183) = 1.2183/5.0 = 0.2437$

$\varphi+ = 1/[1 + (e^*/d^*)^2] = 1/[1 + (0.2437/0.7563)^2] = 0.9060$

$\varphi- =1/[1 + d^*/e^*)^2] = 1/[1 + (0.7563/0.2437)^2] = 0.0941$

Here $\varphi+$, $\varphi-$ represent the positive and negative total contributions of the variables. Calculate the forecast indicator

$F = \varphi+ - \varphi- = 0.906 - 0.0941 = 0.8119$

$F > 0$ show the positive departure will appear, i.e. the pollution days T will positive, namely the pollution days $T \geqslant 14\ d.$, the observed is 25 d.

Similarly, for the 29th case, $F>0$, the pollution days $T\geqslant 14d.$, the observed is 23 d.

Similarly, for the 30th case, $F<0$, the pollution days T<14d., the observed is 11d.

The forecasts for 3 cases are all correct. It demonstrates that above forecast method can be used for qualitative forecast of the air pollution.

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Conflict of Interest

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