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THE APPLICATION OF CONDORCET, BORDO, KOPLAND AND SIMPSON RULES TO RATIONAL ORGANIZATION AND CONTROL OF THE GROUND OBSERVATION THE NETWORK OF REMOTE SENSING OF URBAN AIR

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Abstract. The problem of obtaining of the immediate, reasonable and comprehensive information about air pollution in cities is very important. In methods of evaluation of the ecological situation of cities, a great attention is given to optic sounding methods both at regional and inter-regional levels. By its essence, the urban air is smog. When studying this object, the remote sensing methods, which allow getting large volume information about spatial-temporal changeability of air pollution, are used. It is clear that, optic observations give more detailed information about air basin.

The creation of stationary posts of observation of urban air is based on well-defined solution of rational planning and location of these networks. Rational planning of observation posts, in one hand, is characterized by its economical profit, on the other hand, by its high informative character. In order to get representative information on spatial-temporal changeability of air pollution, a number of measurements are executed by mobile devices (pironometer, actinometer, photo-sensor).

The process of receiving any information may be explained as uncertainty changes as a result of transmission of signals. In this case the amount of information is determined as differences of entropy at different situations.

One of the principal problems of modern society is the choice or determination of one of the alternative decisions. Usually, it is accepted that in comparison with individual decisions, collective decisions are more true. For well-defined solution of the problem of rational planning and location of observation posts, the Condercet, Borda, Kopland and Simpson laws are used as collective decision-making laws. The main point of these methods is to determine preference order between the elements of certain characters.

The results of calculations carried out by using the Condercet, Borda, Kopland and Simpson collective decision-making rules, show that by its informative character the time intervals, where measuring data of sun radiation are carried out by means of pironometer tool "Peleng SF-06" in Baku (time interval 10.00-10.30; time interval 10.30-11.00; time interval 11.00-11.30) has the ordered formation.

Keywords: remote sensing, network, informativity, urban air, time series, entropy, Condorset rule.

Introduction

Organization and activity of the monitoring system is connected with its goal and the properties of the solved problems. Creation of observation network of the urban air is based on well-defined solution of rational planning and location of this network. Rational planning of the observation network in one hand is characterized by economical profit and on the other hand by its higher informative character [1].

Rational location of observation network in the given areas are the basic problems to be solved. Determination of organizational structure of observation post of atmospheric pollution in certain extent depends on what purposes the information obtained from the observation

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Table 1. The amount of stationary observation posts

The amount of population, thousand man	< 50	50–100	100–200	200–500	500–1000	1000–2000	> 2000
The amount of posts	1	2	3	3–5	5–10	10–15	15–20

posts is used. There exist a lot of scientific approaches to well defined solution of rational location of an observation post. The group of researchers divide the city territory into the same character zones. This time in choosing the zones the subjectivity is allowed. The method suggested by O. A. Drozdov and A. A. Shepelovski are highly influential among these research works. O. A. Drozdov and A. A. Shepelovski have worked out the method for determining the possible maximum distance between observation posts by substantiation.

1. Methodological aspects of the problem

The urban air in the main is a smog formed by complex anthropology and natural climatic factors. By studying this object, the remote sensing methods enabling to get large volume information on its phase structure and natural changeability are used . Stationary observation post is a specially equipped pavilion, and a device for recording the polluting substances and meteorological parameters according to certain program is located here. As a rule, the place of location of the stationary post is chosen subject to meteorological situation of the level of pollution of atmospheric air. In any city (settlements) the amount of stationary posts is determined by spatial and time change of the number of population, relief, properties of the industry, functional structure (settlement, industrial, green zone), concentration areas of unhealthy matters. For instance, as an example in connection with the amount of population, the amount of posts is determined as follows Table 1.

Taking into account rapid scale up of cities, the structure and working conditions of the existing monitoring systems used in evaluation of ecological situation of cities is argued with special conditions of the area under consideration. That is, the monitoring system is adapted. From this point of view, there arises a necessity to make changes in the structure of adapted monitoring systems and in rational organization of observations.

This is possible on the following technique. To this end, representative information on spatial time air-pollution is obtained by means of travelling devices (travelling laboratory that chooses and analyses air samples) by elementary study of the state of air in certain area. The obtained results make the set of initial statically data. Such a method allows to reveal the boundaries of industrial complexes and their action zones. By processing the received information, the boundaries of atmospheric air pollution, its spectrum and contradiction are determined, the scheme of location of stationary observation posts are worked out.

The process of receiving of any information may be interpreted as the change of uncertainty as a result of transmission of signals. On the transmissing $H(A)$ in a priority entropy, on the receiving $H(B)$ is a post a priori. In order to estimate the amount of information the difference of a priori and a post a priori information is taken [2]. The amount of information in this case is the difference between the entropies

$$I(A,B) = H(A) - H(B). \qquad (1.1)$$

Condorcet first applied mathematical methods to social sciences. In 1785 he published one of his known papers “Arguments on application of analysis to estimation of decisions by the majority of votes”. In this paper “The Condorset method” a voter algorithm that provides decision by real majority of votes was first stated. In the same place, the "Condorcet paradox", the case of nontransitivity of decision in the case of three variants was described. Condorcet determined a rule by which comparison of elected alternative (candidates) is made out with regard to total ordinal information on preference of electorate.

According to the Condorcet law, for determining true will of majority it is necessary that every voter grade all candidates in order of preference. Here upon for each pair of candidates it is determined how many voters prefer one candidate to another one, and a complete matrix of pair-wise preference of electorate is shaped.

Table 2. Entropy values of total radiation (Baku, 2015)

Date	Time interval A 10.00–10.30	Time interval B 10.30–11.00	Time interval C 11.00–11.30
02.03.2015	6.52	11.86	12.39
05.03.2015	0.92	3.41	3.72
12.03.2015	10.84	13.31	16.75
13.03.2015	8.89	7.33	11.14
16.03.2015	4.28	3.45	3.64
17.03.2015	7.05	8.20	7.99
21.07.2015	7.21	8.97	10.57
24.07.2015	5.42	8.36	9.04
27.07.2015	6.03	6.61	6.99
28.07.2015	6.90	8.82	19.45
29.07.2015	8.60	9.90	11.92
30.07.2015	7.60	7.74	8.40
03.08.2015	5.37	5.81	6.16
06.08.2015	5.88	6.45	7.08
07.08.2015	13.52	20.84	18.85

By controlling the monitoring system of urban air it is possible to apply the Condorcet law for solving the following problems.

1. The supporting points to be chosen in rational planning and location of observation posts are taken as “alternative candidate” used in the Condorcet law.

2. The supporting points to be chosen by controlling the density of the existing monitoring system are taken as “alternative candidate” used in the Condorcet law.

3. By controlling the working condition of a supporting observation post, time intervals are taken as an “alternative candidate”.

Serial measurements at supporting observation posts are accepted as electorates. Organization of the relational matrix is based on entropy estimates of serial measurement signals.

In addition to the Condorset rule, we will use the Borda, Kopland and Simpson rules as the decision making methods [3].

According to Borda’s rule every voter orders the preferred m candidate from the best to the worst (indifferent attitude is forbidden). The candidate in the last place doesn’t gain a point. The remaining candidates in comparison with preceding candidate gains one more point. The candidate gaining the highest point becomes a winner.

According to Kopland’s rule, each candidate is compared with other b candidate, and

$$K(a \succ b) = +1, \text{ if for majority of } b \ a \succ b;$$

$$K(a \succ b) = 0, \text{ if for majority } b \succ a;$$

$$K(a \succ b) = 0, \quad \text{if the candidates have equal rights.}$$

For each candidate the following Kopland evolution is carried out:

$$S(a) = \sum_b K(a \succ b).$$

By the Kopland evolution the candidate occupying the highest place is acknowledged a winner.

According to Simpson’s rule every a candidate is compared with other b candidate and we denote the number of candidates with superiority $a \succ b$ by $A(a \succ b)$. For the a candidate

$$S(a) = \sum_b S(a \succ b).$$

Minimum value between the values is called the Simpson evaluation. By the Simpson evaluation, the candidate that occupies the highest place is acknowledged a winner.

Table 3. Informative relations of measurement relations at different days (Baku, 2015)

Date	Uncertainty relations of time intervals A, B, C
02.03.2015	$A \succ B \succ C$
05.03.2015	$A \succ B \succ C$
12.03.2015	$A \succ B \succ C$
13.03.2015	$B \succ A \succ C$
16.03.2015	$B \succ C \succ A$
17.03.2015	$A \succ C \succ B$
21.07.2015	$A \succ B \succ C$
24.07.2015	$A \succ B \succ C$
27.07.2015	$A \succ B \succ C$
28.07.2015	$A \succ B \succ C$
29.07.2015	$A \succ B \succ C$
30.07.2015	$A \succ B \succ C$
03.08.2015	$A \succ B \succ C$
06.08.2015	$A \succ B \succ C$
07.08.2015	$A \succ C \succ B$

2. Results of calculations

As an example we research the problem of control of working conditions of the observation post. Usually, the data enters into the statistical processing blocks of the system in the form of the signal $S(t)$ of experimental data in time series. Experimental data in time series are determined by successive and Δt step of the values of the function $S(t)$

$$S_k(t) = S(t_k), \quad t_k = \Delta t k, \quad k = 0, \ldots, N-1. \tag{2.1}$$

Here Δt is the length of the step, N is the number of the points of the series [4].

We will use the values of total radiation being a Sun radiation component measured on 0.3–24 mkm wave length with the pyrometer Peleng SF-06. The measures were carried out with $\Delta t = 2$ sec interval.

Entropy values of total radiation being a component of Sun radiation measured at different days were calculated by the MATLAB program packet and given in Table 2.

"Shannon" entropy was used in calculations. The Shannon Entropy is defined by the following formula [5]

$$E_1(S) = -\sum S_i^2 \log\left(S_i^2\right). \tag{2.2}$$

Based on the values of Table 2 we construct the uncertainty relations of the following measurement relations. It is shown in Table 3.

According to Borda's rule, the time interval A possesses 27 points, time interval B 14 points, time interval C 3 points. According to Borda's rule and informativity, ordered formation of time intervals is $A \succ B \succ C$.

According to Kopland's rule, the value of the Kopland evaluation for time interval A is equal to 24, for time interval B to zero, for time interval C to 24. According to Kopland's rule and informativity, the ordered formation of time intervals is $A \succ B \succ C$.

According to Simpson's rule, the value of Simpton evaluation for time interval A is equal to 27, for time interval B to 15, for time interval C to 3. According to Simpson rule and informativity, the order formation of time intervals is $A \succ B \succ C$.

Conclusion

According to these three rules, time interval C is uncertain, i.e. is less informative. Therefore, it is not appropriate to make observations in time interval C.

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