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Informational Characteristics of Some Natural Formations

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The spectrum of the electromagnetic radiation reflected by the natural formations is continuous. In practice, however, a finite number of wavelengths, mainly in the visible range, are chosen for investigation purposes. The set of the reflexion index values for these wavelengths forms a sampled reflective characteristic. Even thus sampled the reflective characteristic contains considerable information which allows the natural formations to be divided in classes of objects with similar reflective characteristics. The degree of the similarity in a given class is conditioned by the extent of the confidence limits of the reflective characteristic. For some wavelengths, however, it is possible to obtain non-empty cross-sections between the confidence intervals of the different classes of objects. In such cases the methods of the pattern recognition theory are applied for the identification of the different classes of objects. It would be of importance to solve the following problem: for which wavelengths the uncertainty obtained from the distribution cross-sections is the greatest and by which classes it is mainly determined. If the answer to these questions is available, more experimental efforts could be concentrated on the respective wavelengths and classes of objects. The solution of these problems will therefore be in the focus of our attention.

1. The Formulation of the Problem

Each natural formation is described by a sampled reflective characteristic $r(\lambda_i)$, r_i — reflection index, λ_i — wavelength, $i=1, \ldots, m$. Formations with similar reflective characteristics $r(\lambda_i)$ form a class of objects. This similarity is expressed by the statistical proximity of $r(\lambda_i)$, i. e. in the presence of $r(\lambda_i)$ distribution around an average reflective characteristic $\overline{r(\lambda_i)}$ (we shall henceforth designate this characteristic by $r(\lambda_i)$ alone). The experience obtained so far furnishes grounds for such an assumption, and even the existence of a normal distribution [1] can be assumed.

Let the set $M=\{r_j(\lambda_i)\}$ from $j=1,\ldots,N$ classes of objects be given. The appearance of an object within the limits of the class $r_j(\lambda_i)$ with a fixed wavelength λ_i will be considered verified if the reflective characteristic obtained is within the confidence limits $r_j(\lambda_i)\pm\Delta r_j(\lambda_i)$ of $r_j(\lambda_i)$. But there exists a certain probability that this object should belong to each one of the other $N-1$ classes of M. In this case, these are the conditional probabilities $p_{ijk}(r_{ik}/r_{ij})$ that at a fixed λ_i and in the presence of indications for r in the confidence interval of the j class, in reality there is an object from the k class. It is obvious that the presence of probabilities $p_{ijk}\neq 0$ for $j\neq k$ leads to uncertainty at the data processing, the total uncertainty of the set being characterized by the matrices $A_i=\|p_{ijk}\|$ of the conditional probabilities p_{ijk}. But the matrices A_i can have different dimensions and, accordingly, a different number of probabilities p_{ijk}. For the purposes of comparative analysis it is necessary to normalize p_{ijk} in such a way that the normalized values should satisfy the condition $\sum_{(k)} p_{ijk}^{(n)}=1$. The substitution

$$p_{ijk}^{(n)}=\frac{p_{ijk}}{\sum_{(k)} p_{ijk}} \tag{1}$$

is suitable for the purpose.

The events of "appearance of a jth class object in the ith wavelength" form a full event system, i. e.

$$\sum_{(j)} p_{ij}^{(n)}=1 \tag{2}$$

if we assume that the set M exhausts all probable classes of objects (or at least those of them which are of interest to the analysis). Further on we shall consider this assumption realized. The problem solved in the course of the work done is the following: an indication for r in the confidential limits of a given class has been obtained. It is necessary at a fixed wavelength to evaluate the average uncertainty which has been introduced by the distributions of the other classes from the set under consideration, if the evidence is accepted as belonging to the class in which it has been obtained. For such an evaluation the quantity of "information" is suitable.

2. Method

The uncertainty contained in matrix A_i when (1) and (2) are fulfilled is evaluated by:

$$I_i=H_i(p_j)-\tilde{H}_{ij}(r_{ik}/r_{ij}), \tag{3}$$

where $H_i(p_j)\ -\sum_{(j)} p_{ij}\log p_{ij}$ is the unconditional entropy of the p_{ij} probabilities for the appearance of the j object in the wavelength,

$\widetilde{H}_i = -\sum_{(j)} p_{ij} \sum_{(k)} p_{ijk}^{(n)} \log p_{ijk}^{(n)}$ is the conditional entropy of the probabilities $p_{ijk}^{(n)} = p(r_{ik}/r_{ij})$.

The coefficient

(3a) $$\delta_i = \frac{I_i}{H_i} = 1 - \frac{\widetilde{H}_i}{H_i}$$

can be used for the comparative analysis as being more convènient.

The magnitude δ_i is suitable because it varies in the interval $0 \leq \delta_i \leq 1$. Equations (3) and (3a) provide a solution to the problem of the uncertainty of evaluation at the identification of the objects from M. An answer to the question what is the contribution of the separate classes from M to the total uncertainty, can be obtained when applying (3) and (3a) for different additional subsets M_l, obtained from M by excluding subsets M_l, $l = 1, \ldots, L$.

3. Conclusions

These two problems: $H_i^{(M)}$ and $\delta_i^{(M)}$ determination for $r_j(\lambda_i) \in M$ and, respectively, $H_i^{(M_l)}$ and $\delta_i^{(M_l)}$ for $r_j(\lambda_i) \in M_l$ can be extended by the introduction of various confidential intervals $\pm \Delta r_j(\lambda_i)$ corresponding to the various distribution dispersions of the objects from M. With a given confidence coefficient of the confidence intervals, the quantity I of information, the part δ it represents from the maximum information $I_{\max} = H_i$ and the subset M_l with the greatest contribution to the reduction of I, or δ_i respectively, can thus be determined.

Table 1

No of object	Name of object	Characteristic of the objects at azimuth 225° and canted shooting angle of 45°	
1	birch	young tree	winter species
2	"	"	young leaf
3	"	"	full leaf
4	"	"	late verdure
5	"	old tree	winter species
6	"	"	full leaf
7	"	"	late verdure
8	"	"	fresh bark
9	elm	old tree	young leaf
10	"	"	full leaf
11	oak	young tree	winter species
12	"	old tree	full leaf
13	"	"	during the autumn
14	lime	"	winter species
15	"	"	full leaf
16	"	"	during the autumn
17	aspen	young tree	winter species
18	"	"	young leaf
19	"	"	full leaf
20	"	old tree	young leaf
21	"	"	full leaf
22	"	"	late verdure
23	"	"	during the autumn

Table 2

Spectral Intensity Coefficients of the Natural Formations Examined

λ (nm) \ Class №	1	2	3	4	5	6	7	8	9	10	11
400	0.058	0.047	0.026	0.059	0.072	0.033	0.084	0.202	0.026	0.033	0.050
410	0.057	0.048	0.027	0.060	0.073	0.034	0.086	0.203	0.027	0.033	0.050
420	0.056	0.049	0.030	0.061	0.074	0.037	0.086	0.204	0.027	0.033	0.050
430	0.054	0.050	0.031	0.062	0.074	0.039	0.091	0.205	0.027	0.035	0.050
440	0.052	0.052	0.034	0.061	0.074	0.044	0.097	0.209	0.030	0.037	0.050
450	0.050	0.056	0.036	0.065	0.073	0.046	0.101	0.210	0.031	0.039	0.050
460	0.049	0.059	0.036	0.073	0.072	0.044	0.109	0.211	0.032	0.040	0.050
470	0.047	0.060	0.037	0.076	0.071	0.042	0.115	0.211	0.034	0.040	0.050
480	0.045	0.060	0.037	0.075	0.070	0.044	0.123	0.212	0.036	0.039	0,050
490	0.045	0.061	0.039	0.087	0.070	0.048	0.131	0.214	0.038	0.037	0.050
500	0.044	0.063	0.040	0.095	0.071	0.045	0.144	0.215	0.043	0.039	0.050
510	0.044	0.071	0.042	0.106	0.073	0.048	0.161	0.215	0.054	0.046	0.051
520	0.044	0.090	0.052	0.120	0.077	0.065	0.185	0.215	0.072	0.058	0.053
530	0.045	0.119	0.070	0.149	0.080	0.087	0.213	0.214	0.092	0.078	0.056
540	0.047	0.138	0.085	0.169	0.082	0.106	0.233	0.213	0.109	0.096	0.059
550	0.050	0.147	0.091	0.176	0.087	0.113	0.245	0.213	0.118	0.108	0.060
560	0.052	0.142	0.088	0.178	0.090	0.110	0.249	0.213	0.117	0.105	0.061
570	0.051	0.130	0.081	0.173	0.091	0.099	0.247	0.216	0.104	0.095	0.063
580	0.050	0.117	0.071	0.168	0.095	0.088	0.241	0.220	0.092	0.084	0.064
590	0.050	0.111	0.071	0.168	0.098	0.090	0.234	0.224	0.083	0.074	0.065
600	0.050	0.103	0.068	0.160	0.100	0.083	0.229	0.231	0.073	0.066	0.066
610	0.049	0.103	0.064	0.152	0.101	0.073	0.224	0.239	0.064	0.058	0.067
620	0.049	0.095	0.060	0.153	0.101	0.068	0.220	0.247	0.060	0.052	0.068
630	0.050	0.092	0.059	0.151	0.102	0.065	0.211	0.254	0.061	0.050	0.067
640	0.051	0.090	0.059	0.143	0.102	0.069	0.205	0.261	0.061	0.050	0.066
650	0.052	0.086	0.059	0.141	0.101	0.070	0.202	0.269	0.060	0.049	0.665

4. Example

The problems formulated above were solved under the following conditions: a set M of deciduous varieties consists of 23 classes of reflective characteristics $r_j(\lambda_i)$, $j=1, \dots, 23$, $i=1, \dots, 26$ (Tables 1,2) of oak, elm, lime, aspen, and birch-trees (Fig. 1). The characteristics are obtained under similar conditions — azimuth 225° and canted shooting angle of 45° [2].

The measurement accuracy of r is 0.01. Experimental data for relation between the confidence intervals $\Delta r_j(\lambda_i)$ and r being unavailable, we took as a first approximation the linear function:

(4) $$\Delta r_{ij} = q r_{ij}.$$

We assumed that the ratio coefficient q varies within the interval $0.01 \div 0.075$ with confidence coefficient $S=0.95$. We selected the following values 0.01, 0.02, 0.04, 0.075 from the interval. The range of q-variations was adopted according to [4].

12	13	14	15	16	17	18	19	20	21	22	23
0.044	0.071	0.068	0.034	0.034	0.056	0.034	0.040	0.041	0.020	0.030	0.047
0.043	0.080	0.066	0.032	0.032	0.057	0.035	0.041	0.040	0.020	0.030	0.046
0.043	0.089	0.062	0.032	0.032	0.059	0.038	0.042	0.041	0.020	0.030	0.048
0.043	0.097	0.060	0.038	0.033	0.061	0.040	0.045	0.042	0.021	0.030	0.049
0.041	0.102	0.064	0.042	0.030	0.062	0.043	0.048	0.043	0.022	0.031	0.050
0.040	0.106	0.066	0.045	0.030	0.063	0.046	0.050	0.043	0.024	0.032	0.051
0.040	0.107	0.064	0.046	0.030	0.065	0.046	0.051	0.042	0.027	0.034	0.054
0.040	0.106	0.063	0.047	0.039	0.068	0.048	0.051	0.041	0.030	0.035	0.061
0.040	0.106	0.066	0.047	0.055	0.070	0.048	0.051	0.042	0.031	0.037	0.068
0.040	0.111	0.070	0.043	0.052	0.071	0.049	0.054	0.047	0.030	0.040	0.074
0,045	0.122	0.072	0.047	0.045	0.072	0.054	0.061	0.052	0.030	0.044	0.081
0.057	0.145	0·074	0.059	0.038	0.074	0.064	0.074	0.063	0.034	0.053	0.091
0.084	0.190	0.077	0.081	0.034	0.076	0.082	0.102	0.080	0.042	0.065	0.112
0.115	0.220	0.078	0.099	0.039	0.079	0.106	0.118	0.107	0.055	0.081	0.142
0.129	0.240	0.080	0.111	0.051	0.081	0.109	0.123	0.117	0.065	0.088	0.161
0.150	0.255	0.081	0.116	0.071	0.082	0.124	0.129	0.125	0.072	0.092	0.177
0.140	0.267	0.081	0.105	0.080	0.084	0.122	0.128	0.128	0.073	0.098	0.188
0.108	0.275	0.082	0.092	0.098	0.085	0.108	0.116	0.125	0.071	0.090	0.200
0.089	0.281	0.082	0.082	0.088	0.087	0.095	0.103	0.117	0.065	0.080	0.210
0.073	0.282	0.084	0.068	0.087	0.089	0.090	0.094	0.104	0.058	0.072	0.220
0.085	0.282	0.086	0.078	0.082	0.090	0.084	0.090	0.095	0.058	0.068	0.220
0.066	0.284	0.087	0.066	0.076	0.090	0.081	0.087	0.087	0.060	0.066	0.214
0.060	0.289	0.088	0.064	0.081	0.090	0.077	0.082	0.080	0.059	0.065	0.208
0.063	0.299	0.089	0.060	0.081	0.090	0.074	0.079	0.071	0.051	0.064	0.199
0.053	0.315	0.089	0.055	0.064	0.091	0.073	0.079	0.060	0.058	0.063	0.191
0.049	0.330	0.089	0.052	0.062	0.091	0.072	0.079	0.055	0.058	0.062	0.186

4.1. Determination of the Sampling Interval

The greatest admissible value of the sampling interval was determined under the following condition: we assume that the reconstruction of the continuous reflective characteristics is performed by Lagrange's polynomial of zero power. The considerations for this assumption are: the $\Delta\lambda$ value by means of which the reflective characteristics have been obtained is at the accuracy limit of the spectrograph we have used, and therefore we do not know anything definite about the r behaviour in the $\Delta\lambda$ interval. That is why we assumed that in this interval $r=\text{const}$ (the zero power of the Lagrange's polynomial). Then, according to [3], the admissible value of $\Delta\lambda$ is equal to

$$\Delta\lambda_{\text{adm}} \leq \varepsilon_0/M_1 \tag{5}$$

where ε_0 is the admissible error for r and M_1 is the maximal value of $dr/d\lambda$.

We assumed that the measurement accuracy of r limits ε_0, i.e. ε_0 0.01 for the examined set of reflective characteristics M. For M we obtained the value $M_1=\frac{0.03}{10}\frac{1}{\text{nm}}$.

Then from equation (5) we obtain $\Delta\lambda_{adm} \leq 3.4$ nm<10 nm.

This result shows that the approximation with a zero polynomial at $\Delta\lambda = 10$ nm is insufficiently precise. Therefore, there are no formal grounds to maintain that the mean information value I between two adjacent values

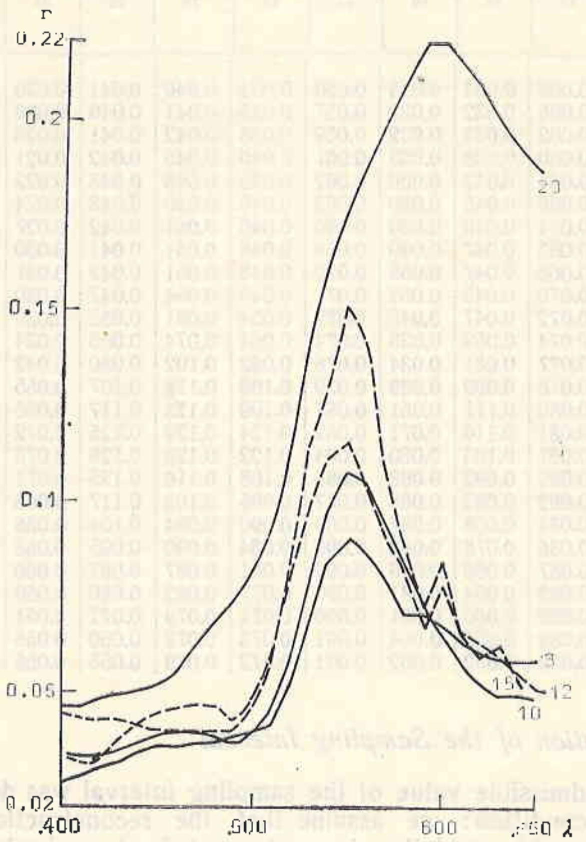

Fig. 1

λ_i and λ_{i+1} would be the arithmetic mean of I_i and I_{i+1}. As the interva $\Delta\lambda = 10$ nm is relatively small, we can assume that there exists a significant correlation in the distributions of r for λ_i and λ_{i+1}. In such a case it is probable that the mean value of I in the interval $\Delta\lambda = \lambda_{i+1} - \lambda_i$ would not differ essentially from $(I_i + I_{i+1})/2$.

4.2. Determination of Information I

The following two problems can be formulated in the study of the structural characteristics of a set of objets.

1. What is the uncertainty in the evaluation of the appurtenance of a single indication (single experiment).

2. What is the uncertainty in the evaluation of the appurtenance of all objects observed (multiple experiment).

In the first problem the appearance of any object from the set is equally probable, inasmuch as we assume that each one of the objects may

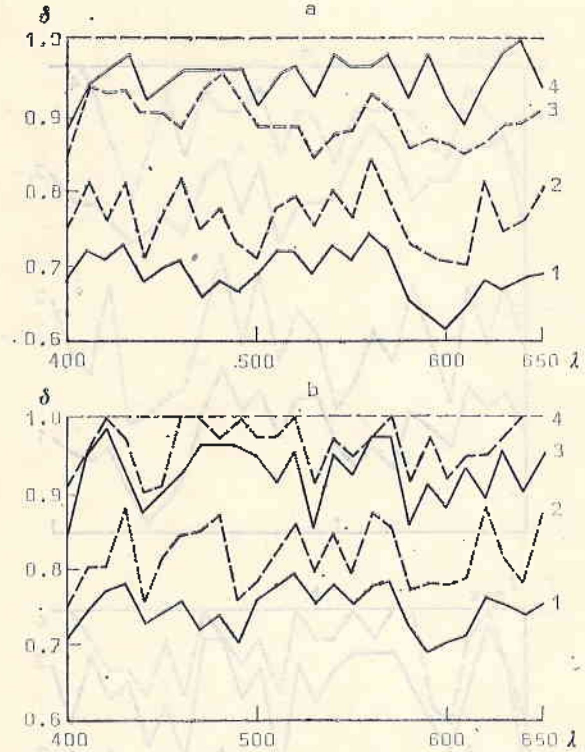

Fig. 2

appear (without being interested in how many times it would appear at a multiple repetition of the experiment), i. e. $p_{ij} = \text{const} = p = 1/N$.

In the second problem it is important that the objects can possess different a priori frequency p_{ij} of appearance under the conditions of the experiment.

In this study our attention was focused on the first problem as it is independent from the determined distribution of the a priori probabilities.

To determine the conditional probabilities $p_{i/k}(r_{ik}/r_{ij})$ it is assumed, according to [1, 4] that the distribution of r for the different objects is normal.

In such a case the conditional probabilities are obtained according to the formula:

(6) $$p_{ijk}(r_{ik}/r_{ij}) = \Phi(z)\Big|_{z_{1ijk}}^{z_{2ijk}}$$

where

(6a) $$z_{1,2\,ijk} = \frac{\pm \Delta r_{ij} - r_{ij} + r_{ik}}{\sigma_{ij}}$$

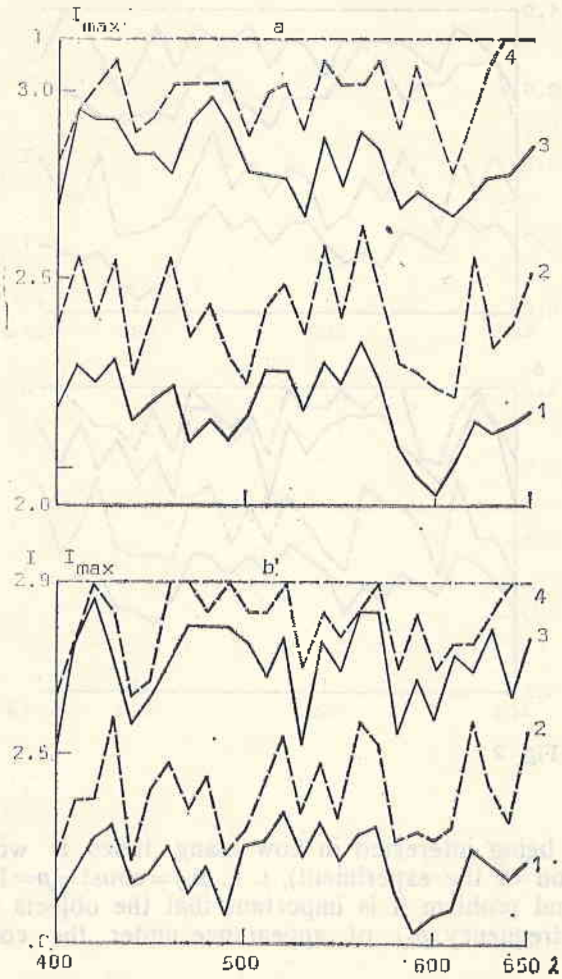

Fig. 3

is the left, the right respectively integration limit of the normalized normal distribution $\Phi(z)$. The confidence intervals Δr_{ij} are determined from equation (4). The standard deviation σ_{ij} is determined from (6a), provided $j=k$. Then $r_{ij}=r_{ik}$ and since $S=0.95$ then $z_{ij\,1,2}=1.96$. From (4) and (6) follows that

Table 3

Dependence of the Information (I) and δ on the Wavelength (λ_i) and the Coefficient (q)

λ (nm)	q=0.075		q=0.05		q=0.02		q=0.01	
	I	$\delta=\frac{I}{I_{max}}$	I	$\delta=\frac{1}{I_{max}}$	I	$\delta=\frac{I}{I_{max}}$	I	$\delta=\frac{I}{I_{max}}$
400	2.1520	0.6864	2.3163	0.7579	2.6937	0.3591	2.8114	0.8966
410	2.2102	0.7240	2.5691	0.8194	2.9547	0.9423	2.9547	0.9423
420	2.2241	0.7093	2.3955	0.7640	2.9285	0.9340	3.0150	0.9616
430	2.2874	0.7295	2.5441	0.8114	2.9243	0.9327	3.0722	0.9808
440	2.1233	0.6772	2.2409	0.7147	2.8358	0.9044	2.8944	0.9231
450	2.1796	0.6951	2.3911	0.7626	2.8393	0.9055	2.9319	0.9351
460	2.2072	0.7039	2.5518	0.8138	2.7834	0.8877	3.0149	0.9616
470	2.0641	0.6583	2.3468	0.7485	2.9284	0.9340	3.0149	0.9616
480	2.1232	0.6771	2,4321	0.7757	2.9869	0.9526	3.0149	0.9616
490	2.0788	0.6630	2.2909	0.7306	2.9053	0.9266	0.0149	0.9616
500	2.1358	0.6812	2.2230	0.7090	2.7897	0.8897	2.8716	0.9159
510	2.2525	0.7184	2.4279	0.7743	2.7793	0.8864	2.0022	0.9543
520	2.2542	0.7189	2.4861	0.7929	2.7685	0.8829	3.0149	0.9616
530	2.1599	0·6889	2.3528	0.7504	2.6647	0.8498	2.8997	0.9248
540	2.2829	0.7281	2.5092	0.8003	2.8884	0.9212	3.0752	0.9808
550	2.2249	0.7096	2.3936	0.7634	2.7497	0.8770	3.0168	0.9621
560	2.3317	0.7436	2.6340	0.8401	2.8957	0.9235	3.0149	0.9617
570	2.2388	0.7140	2.4680	0.7872	2.8477	0.9082	3.0752	0.9808
580	2.0500	0.6538	2.2795	0.7270	2.6802	0.8548	2.8944	0.9231
590	1.9887	0.6343	2.2537	0.7188	2.7207	0.8677	3.0752	0.9808
600	1.9331	0.6165	2.2076	0.7041	2.6919	0.8585	2.8966	0.9238
610	2.0137	0.6422	2.1948	0.7000	2.6644	0.8497	2.7886	0.8894
620	2.1235	0.6772	2.5637	0.8176	2.7180	0.8668	2.9319	0.9351
630	2.0964	0.9686	2.3288	0.7427	2.7720	0.8841	3.0752	0.9808
640	2.1179	0.6755	2.3822	0.7598	0.7890	0.8895	3.1355	1.0000
650	2.1426	0.6833	2.5170	0.8020	2.8496	0.9088	2.9546	0.9423

(7)
$$\sigma_{ij}=\frac{qr_{ij}}{1.96}.$$

As a result of the equation (6a) becomes

(8)
$$z_{1,2_{ijk}}=1.96\,\frac{\pm qr_{ij}-r_{ij}+r_{ik}}{qr_{ij}}.$$

In accordance with equations (3), (3a), (6) and (8) we obtained results for $i=1,\ldots,26$ and $q=0.01$, 0.02, 0.05, 0.075 which are presented in Figs. 2, 3 and Table 3. They show that an increase larger than $q=0.05$ leads to a considerable reduction of the information I, or of δ respectively, and to a resulting increase of the uncertainty of the set identification. This effect is most pronounced at the respective wavelength in the infrared portion.

The elimination of the reflective characteristics Nos. 12, 14, 15, 22 from the M set shows that they contribute considerably to this uncertainty. Figs. 2, 3 and Table 4 show the I- and δ-values obtained after the respective characteristics have been eliminated. These conclusions are valid in ge-

Table 4

Dependence of the Information (I) and the Coefficient $\left(\delta=\frac{I}{I_{max}}\right)$ *on the Wavelength* (λ_i) *and q for* $I_{max}=2.9444$

λ (nm)	Upon elimination of the reflective characteristics Nos.=12, 14, 15, 22							
	$q=0.075$		$q=0.05$		$q=0.02$		$q=0.01$	
	I	$\delta=\frac{I}{I_{max}}$	I	$\delta=\frac{I}{I_{max}}$	I	$\delta=\frac{I}{I_{max}}$	I	$\delta=\frac{I}{I_{max}}$
400	2.0906	0.7100	2.2124	0.7514	2.5101	0.8525	2.6526	0.9009
410	2.1845	0.7419	2.3730	0.8059	2.7985	0.9504	2.7985	0.9504
420	2.2752	0.7727	2.3774	0.8074	2.9108	0.9886	2.9444	1.0000
430	2.3037	0.7824	2.6058	0.8850	2.7456	0.9325	2.8715	0.9752
440	2.1562	0.7323	2.2230	0.7550	2.5816	0.8768	2.6526	0.9009
450	2.1873	0.7428	2.4011	0.8155	2.6574	0.9025	2.6980	0.9163
460	2.2549	0.7658	2.4882	0.8450	2.7355	0.9290	2.9444	1.0000
470	2.1324	0.7242	2.3596	0.8014	2.8297	0.9644	2.9444	1.0000
480	2.2033	0.7483	2.4436	0.8299	2.8376	0.9637	2.8715	0.9752
490	2.0798	0.7063	2.2492	0.7639	2.8389	0.9642	2.9444	1.0000
500	2.2653	0.7693	2.3095	0.7844	2.7995	0.9508	2.8715	0.9752
510	2.2788	0.7739	2.4207	0.8221	2.7008	0.9173	2.8715	0.9752
520	2.3501	0.7981	2.5581	0.8688	2.8034	0.9521	2.9444	1.0000
530	2.2349	0.7590	2.3455	0.7966	2.5262	0.8579	2.7319	0.9278
540	2.3213	0.7884	2.4820	0.8430	2.7991	0.9506	2.8715	0.9752
550	2.2275	0.7565	2.3389	0.7944	2.7266	0.9260	2.8008	0.9512
560	2.2981	0.7805	2.5896	0.8795	2.8715	0.9752	2.8715	0.9752
570	2.3101	0.7846	2.5316	0.8598	2.8717	0.9753	2.9444	1.0000
580	2.1331	0.7245	2.2771	0.7734	2.5542	0.8675	2.7255	0.9257
590	2.0383	0.6922	2.2902	0.7778	2.7017	0.9175	2.8715	0.9752
600	2.0710	0.7034	2.2700	0.7709	2.5956	0.8815	2.7282	0,9266
610	2.0955	0.7117	2.3176	0.7871	2.7645	0.9389	2.7985	0.9504
620	2.2553	0.7660	2.5917	0.8802	2.6286	0.8928	2.7985	0.9504
630	2.2116	0.7511	2.4101	0.8185	2.8328	0.9621	2.8715	0.9752
640	2.1787	0.7400	2.3256	0.7898	2.6538	0.9013	2.9444	1.0000
650	2.2243	0.7554	2.5809	0.8765	2.8172	0.9568	2.9444	1.0000

neral for all examined values of q, which shows that at the specification of the real values of q for these objects special attention should be paid to the planning of the experiment.

References

1. F u, K. S., D. A. L a n d g r e b e, T. L. P h i l l i p s. Informational processing of agricultural data obtained through distance measurements. — TIEP, 1968, No. X.
2. K r i n o v, E. L. The spectral reflective capacity of the natural formations. Moscow, Acad. Sci. USSR, 1947.
3. T e m n i k o v, F. E., V. V. A f o n i n, V. I. D m i t r i e v. Theoretical grounds of the informational technics. Moscow, Energy, 1971.
4 K o n d r a t i e v, K. Ja., A. A. G r i g o r i e v, O. M. P o k r o v s k i y. The informational contents of data from space distance indication parameters of environment and natural resources. Leningrad, 1975.

Информационные характеристики природных образований

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(Резюме)

Рассматривается вопрос о неопределенности при идентификации объектов j-го класса на i-й длине волны ($j=1, \ldots, N$) по отношению к некоторому из остальных $N-1$ классов данного множества объектов $M=\{r_j(\lambda_i)\}$.

Неопределенность рассматриваемого множества выражается матрицей $A=\| p_{ijk} \|$ условных вероятностей p_{ijk}.