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ANALYSIS of the POSSIBILITY of DISTINGUISHING COLOUR TESTS TAKEN by MULTISPECTRAL CAMERA and USING ERDAS SYSTEM

SUMMARY. The result of analysis of the possibility of distinguishing the colour test fields on the basis of pattern recognition using ERDAS system and multispectral data are presented. The photographs in four spectral bands of 32 NBS colour test fields have been taken by MB-470 NAC multispectral camera on Kodak IR-2424 film. After analog to digital conversion using scanner Howtek, and image to image registration, the four bands of digital data were elaborated. Parametric pattern recognition techniques have been used to classify spectral target classes in multispectral data.

Thirty of the colour fields were recognized with the overall accuracy of 96%. The achieved results shows high performance of MB-470 NAC camera, scanner Howtek and the new 7.4 version of ERDAS software. The minimum Euclidian distance between two classes have been found to be no less then 10.

1. Introduction

The analysis of the possibility of distinguishing the National Bureau of Standards (NBS) 32 colour test fields on the basis of the analog interpretation of multispectral photographs has been already published [1], [2].

From that time development has been done in the field of data analysis methods, software and new hardware.

The same multispectral film in four bands has been used for computer assisted image interpretation using new ERDAS version 7.4 software and scanner Howtek with scanning version 2.0 software elaborated by GIS GRAPHIC in Germany.

2. Materials used

The colour NBS test (Fig.1) has been photographed using multispectral camera MB-470 NAC on Kodak IR-2424 film. Band passes for 4 filters used in the camera are shown in Fig.2 (B - blue, G- green, R - red, IR - infrared).

The colour test consists of eight colors : red, orange, yellow, green, yellow - green, blue, green - blue, grey - black each in four different level of saturation. Spectral reflectance curves for 32 colour test fields have been obtained in laboratory using spectroradiometer. For example four spectral curves for the red/orange colours are shown in Fig.3 . From Fig.3.one can see that test fields 38 and 39 have differences in the bands green and red but not in the Infrared. All these tests would be easily recognized if band red could be used for interpretation. It is imported to have the spectral reflectance curves of different objects taken in the field in the same time when remotely sensed date were taken.

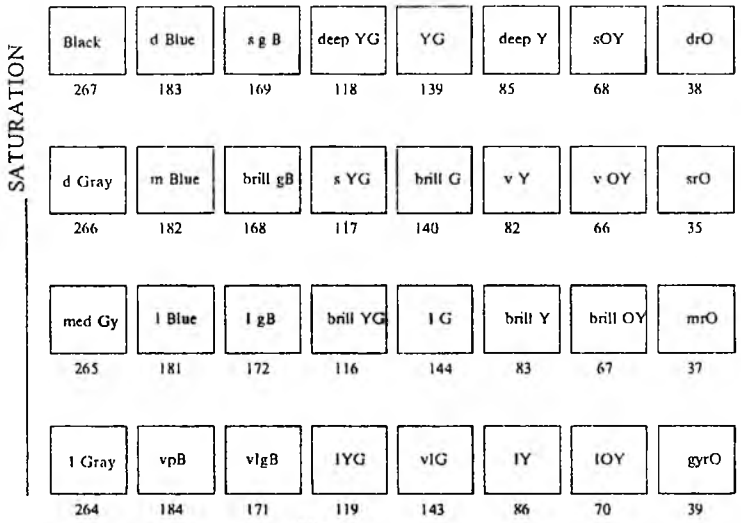

Fig. 1

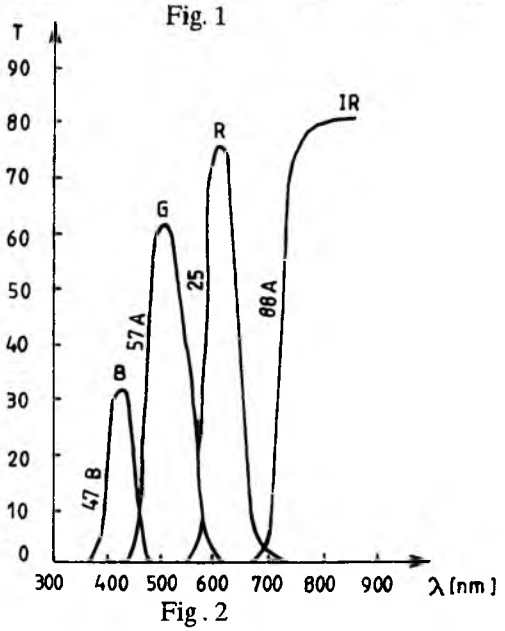

Fig . 2

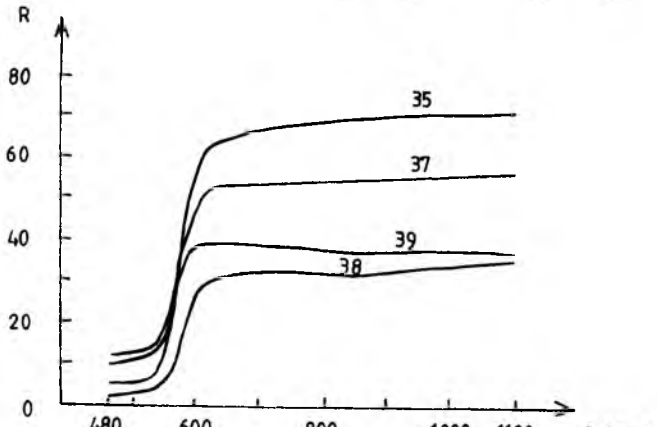

Fig. 3

3. Preprocessing techniques

Four bands of multispectral image have been scanned using Scanmaster Howtek with aperture 200 dpi. Image to image registration has been performed using ERDAS software and neighbor sampling technique. Image file of the size 400 x 400 in 4 bands has been created and used for further elaboration.

4. Analysis techniques

A set of multivariate class statistics for each pixel measurement vector in the image has been created and compared. Then a classification decision rule, the probability of maximum likelihood that the pixel belongs to a class from among the statistics set was calculated and the pixel was assigned to the particular class. In order to develop of the multivariate statistics, supervised classification approach were used. Training areas of the size 6 x 6 pixels with known properties have been used to extract spectral statistics from the image data by identifying the test fields. The signature statistics (Min., Max., Mean value, Standard Deviation) for each of the 32 colour test fields are shown in Table 1. The signature Euclidian distances could be calculated from the Table 1 or directly using SIGDIST programme. For example the signature distances for the similiar classes 183-266 is equel 4; for 183-267 is equel 2, and for 266-267 is equel 6. On the basis of these statistics and signature Euclidian distances, these three tests have been merged. It is found that for classes 66 and 82 Euclidian distance is equal 10.7 which suggests that these classes should be mixed after classification.

SIGMAN programme is used to merge the similar classes before classification. All statistical data of signatures shown unimodal and multivariate normal distribution. In that case MAXCLAS programme with maximum likelihood classifier has been run. As the result GIS file with 30 classes has been created.

5. Results achieved and accuracy assessment

The GIS output had some mixed points. To reduce the "salt and pepper" appearance observed in the output, the GIS file has been screened out using SCAN programme with majority option with 2 x 2 window. This smoothing programme reduces this effect and produces a final map which is then used for accuracy analysis.

To assess accuracy of the output the GIS file has been tested using ERDAS software. Location of check points has been selected randomly by running RANDCAT programme. Each pixel in true test field and classification output has been compared. The number of points to be tested (N) has been determined from the formula for binomial probability theory (as is either TRUE or FALSE, i.e. either pixel belong to the class or not):

$$N > \frac{4pq}{e^2}$$

where p - % expected accuracy
e - allowable error

For p=95% and e=2% we have theoreticaly N>475 points.

Practicaly total 450 randomly selected reference points have been tested using RANDCAT and CLASSERR programmes. As the results of comparision of the classified image with control data, a classification accuracy table was created as a CAT file. From this file the classification error matrix and accuracy report have been produced (shown in Table 2 and Table 3 respectively).

The overall classification accuracy equals 95.6% does not show how confident we can be. The lower limit can be calculated using the formula:

$$p = p' - (1.645\sqrt{\frac{p'q}{N} + \frac{50}{N}})$$

For p'=95.6, q=4.4 and N=450 the lower limit obtained thus has been obtained equel p=94%.

Table 2 shows classification error matrix where on diagonal data are correct pixels, and off-diagonal provide information on error of ommission and commission. Values along given row indicate how misclassified pixels are distributed among the class. For example test 67 have 22 pixels clasified correctly to the class No.22 (name 67) and 3 pixels assigned to incorrect class (class No.42- test 68) out of total 25 pixels. Ommission error for this class is equel 12%. Please note that these two tests fields are different only in saturation and belongs to orange colour (see Fig.1).

Table 3 resides in the CAT file. The table lists of GIS values for the reference points (true maps), which were inputed by operator, and GIS values for the corresponding pixels in the classified GIS file (classification map).

It is not surprising that the class No. 32 (name 66) has smaller accuracy as the other classes as the spectral Euclidian distance between 66 and 82 is the smallest (10.7).

6. Conclusion

Thirty colour test fields out of 32 have been recognized with an overall accuracy of 96% and the lower confident limit 94%. The achieved results shows high performance of multispectral camera MB-470 NAC, scanner Howtek and the new ERDAS version 7.4 software used for digital image processing and accuracy assessment. The minimum spectral Euclidian distance between two classes should be grater then 10, otherwise classes have to be merged.

Bibliography

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Statistical data of the signatures

Field	Band = 1				Band = 1				Band = 2				Band = 4			
=	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD
39	12	25	18.7	2.3	8	16	11.8	1.5	53	78	64	4.6	23	44	27	2.5
37	12	23	15.8	2.4	7	16	11	1.5	92	152	115	8.8	45	72	56	4
35	8	20	12.6	2.5	6	14	9.9	1.3	119	155	137	7.0	70	102	86	5.7
38	6	24	10.7	3.0	4	13	8.3	1.4	39	69	49	4.7	22	37	27.7	3.0
70	48	77	63	5.6	36	57	48	3.9	172	193	183	4.1	109	139	123	5.2
67	14	26	18	2.5	23	44	33	4.9	172	203	188	7.2	96	156	124	13.6
66	6	17	10	1.8	12	26	18	2.4	168	199	187	6.5	123	158	141	6.6
68	4	19	10	2	12	41	17	3.3	151	179	165	5.8	104	129	115	5.1
86	52	97	71	10	50	84	65	7.5	170	199	186	5.7	114	157	136	9.9
83	26	45	32	3	35	57	47	4.2	158	197	185	6	110	152	132	8.9
82	5	15	9	1.4	19	34	26	2.8	158	193	180	7.5	122	160	142	7.5
85	4	14	8	1.5	7	16	12	1.5	48	101	64	9.7	36	65	46	6.9
143	126	164	142	7.6	56	92	67	6.1	47	85	59	8.0	52	92	68	7.8
144	44	80	61	5.9	22	38	29	2.7	17	45	26	4.9	23	100	31	6.5
140	34	65	45	5.6	22	43	31	3.3	14	32	21	3.6	28	64	38	5.7
139	5	15	11	1.8	9	16	12	1.5	8	17	12	1.6	12	24	17	2.5

Statistical data of the signatures

Field	Band = 1				Band = 1				Band = 2				Band = 4			
=	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD	MIN	MAX	MEAN	SD
119	74	109	86	6.5	57	78	65	5	111	144	126	7.5	83	114	97	6.5
116	17	30	23	2.6	35	56	45	3.6	78	114	100	7.6	85	121	101	6.7
117	6	15	10	1.5	10	22	14	1.7	14	31	21	2.8	21	36	27	3.0
118	5	12	8	1.3	5	13	9	1.3	8	15	11	1.5	10	19	13	1.7
171	187	216	206	4.3	77	114	92	6.8	64	107	73	6.5	85	135	98	6.5
172	130	179	147	10	28	54	38	5	15	38	23	4.0	27	55	37	6.3
168	89	159	138	12	15	39	31	3	9	29	17	3.3	41	63	52	3.7
169	49	71	58	4	12	31	16	2	7	16	11	1.5	16	32	21	2.8
184	192	218	210	3	77	101	88	4	87	118	98	5	97	124	109	4.5
181	149	206	184	11	22	47	32	5	18	36	25	3.6	50	104	74	10
182	45	113	70	17	7	16	11	1.8	6	14	9	1.5	13	30	19	3.8
183	6	18	10	1.7	5	11	7	1.3	5	12	8	1	5	12	9	1.2
264	164	190	178	4.4	37	53	43	3	65	92	73	5	50	71	56	3
265	46	66	53	4	9	17	13	1.5	14	33	19	2.3	10	23	15	2
266	9	24	14	2.3	3	11	7	1.3	7	13	9	1.3	6	12	9	1.2
267	4	13	8	1	4	10	7	1	6	11	8	0.9	5	13	8	1.2

CLASSIFICATION ERROR MATRIX TEST - NAC

INTERPRETED CLASSES

Table 2

Class name \ Class No.	11	12	13	14	15	16	17	18	21	22	23	24	25	26	27	28	31	32	33	34	35	36	37	B	41	42	43	44	45	46	Σ	Ommission error %	Commission error %
39	12																								3						15	20	0
70		16	3																												19	16	0
86			13																												13	0	19
143				7										2								1	1								11	36	0
119					20																										20	0	0
171						13																									13	0	0
184							11																								11	0	0
264								10																							10	0	0
37									11																						11	0	9
67										22																3					25	12	0
83											14																				14	0	0
144												16																			16	0	0
116													12																		12	0	0
172														11																	11	0	15
181															16																16	0	0
265																16							1								17	6	0
35									1								7														8	12	0
66																		7													7	0	22
82																		2	18							1					21	14	0
140																				13											13	0	0
117																					15										15	0	0
168																						17									17	0	6
182																							9								9	0	31
Black																								48							48	0	0
38																									10						10	0	23
68																										12					12	0	25
85																											12				12	0	0
139																												17			17	0	0
118																													13		13	0	0
169																							2							12	14	14	0
Σ	12	16	16	7	20	13	11	10	12	22	14	16	12	13	16	16	7	9	18	13	15	18	13	48	13	16	12	17	13	12	450		

Overall classification accuracy = 95.6% Number correct points = 430

Total reference points = 450

CLASSIFICATION ACCURACY REPORT
GIS FILE: TEST - NAC. GIS
CAT FILE: TEST - RAN. CAT

Table 3

Class No.	Class name	Reference points	Classified points	Number of correct points	Producers accuracy %	Users accuracy %
	Back--ground	0	0	0	-	-
11	39	12	15	12	100	80
12	70	16	19	16	100	84
13	86	16	13	13	81	100
14	143	7	11	7	100	64
15	119	20	20	20	100	100
16	171	13	13	13	100	100
17	184	11	11	11	100	100
18	264	10	10	10	100	100
21	37	12	11	11	91	100
22	67	22	25	22	100	88
23	83	14	14	14	100	100
24	144	16	16	16	100	100
25	116	12	12	12	100	100
26	172	13	11	11	85	100
27	181	16	16	16	100	100
28	265	16	17	16	100	94
31	35	7	8	7	100	88
32	66	9	7	7	78	100
33	82	18	21	18	100	86
34	140	13	13	13	100	100
35	117	15	15	15	100	100
36	168	18	17	17	94	100
37	182	13	9	9	69	100
B	Black	48	48	48	100	100
41	38	13	10	10	77	100
42	68	16	12	12	75	100
43	85	12	12	12	100	100
44	139	17	17	17	100	100
45	118	13	13	13	100	100
46	169	12	14	12	100	86
	Totals	450	450	430		

Overall accuracy = 95.6%

Note: B = 266 + 267 + 183

These three classes have been merged.

ROMUALD KACZYŃSKI

ANALIZA MOŻLIWOŚCI ROZRÓŻNIENIA TESTÓW BARWNYCH WYKONANYCH KAMERĄ WIELOSPEKTRALNĄ PRZY UŻYCIU SYSTEMU ERDAS

Streszczenie

W artykule przedstawiono rezultat badań możliwości wyróżnienia testów barwnych z użyciem cyfrowej analizy obrazu zdjęć wielospektralnych.

Zdjęcia spektralne testu składającego się z 32 barwnych pól wykonano w czterech kanałach kamerą wielospektralną MB-470 NAC na filmie Kodak IR-2424. Schemat testu barwnego pokazano na rys. 1. Krzywe transmisji filtrów użytych w kamerze MB-470 NAC pokazano na rys. 2, a krzywe odbicia spektralnego dla wybranych barwnych pól testowych na rys. 3. Wyniki analizy możliwości rozróżnienia 32 barwnych testów metodami analogowymi opublikowano w [1] i [2].

Te same zdjęcia wielospektralne użyto do cyfrowej analizy obrazu z wykorzystaniem systemu ERDAS zainstalowanego w Ethiopian Mapping Authority. Zdjęcia przetworzono na postać cyfrową przy użyciu skanera Howtek, a następnie przeprowadzono wzmocnienie obrazu i cyfrową analizę metodą klasyfikacji nadzorowanej. Dane statystyczne dla 32 barwnych pól testowych zamieszczono w tablicy 1. Na podstawie analizy tych danych, połączono klasy 183, 266 i 267 w jedną klasę używając do tego celu programu SIGMAN. Program MAXCLAS użyty został do klasyfikacji nadzorowanej. W celu określenia dokładności klasyfikacji użyto programu RANCAT i CLASSERR testując 450 losowo wybranych punktów. Rezultat opracowania w postaci matrycy błędów przedstawiono w tablicy 2, a raport dokładności klasyfikacji w tablicy 3.

Trzydzieści testów barwnych rozpoznano z dokładnością 96% i dobrą granicą ufności rzędu 94%. Otrzymany rezultat świadczy o wysokiej jakości kamery MB-470 NAC, skanera Howtek oraz nowej wersji oprogramowania ERDAS w wersji 7.4.

Przeprowadzona analiza wykazała, że minimalna odległość spektralna pomiędzy dwoma klasami powinna być większa od 10 jednostek, w przeciwnym razie klasy należy połączyć w jedną.

РОМУАЛЬД КАЧИНЬСКИ

АНАЛИЗ ВОЗМОЖНОСТИ ВЫДЕЛЕНИЯ ЦВЕТНЫХ ТЕСТОВ, ВЫПОЛНЕННЫХ МНОГОСПЕКТРАЛЬНОЙ КАМЕРОЙ С ИСПОЛЬЗОВАНИЕМ СИСТЕМЫ ERDAS

Резюме

В статье представлен результат исследования возможности выделения цветных тестов с использованием цифрового анализа изображения многоспектральных снимков.

Спектральные снимки теста, состоящего из 32 цветных полей, были выполнены в четырёх каналах многоспектральной камерой MB-470 NAC на пленке Kodak IR-2424. Схема цветного теста показана на рис.1. Кривые трансмиссии фильтров, применённые в камере MB-470 NAC, показаны на рис.2, а кривые спектрального отражения для избранных цветных тестовых полей на рис.3. Результаты анализа возможности выделения 32 цветных тестов аналоговыми методами опубликованы в [1] и [2].

Тот самый многоспектральный снимок был употреблён для цифрового анализа с использованием системы ERDAS, установленной в Ethiopian Mapping Authority. Снимок был преобразован в цифровой вид с помощью сканера Howtek, а затем произведено улучшение изображения и цифровой анализ его методом классификации "с учителем". Статистические данные для 32 цветных тестовых полей представлены в таблице 1. На основе анализа этих данных, соединено классы 183, 266 и 267 в один класс, применяя для этой цели программу SIGMAN. Программа MAXCLAS была использована для классификации "с учителем". С целью определения точности классификации была применена программа RANCAT и CLASSERR, тестируя 450 произвольно избранных пунктов. Матрица ошибок помещена в таблице 2, а рапорт точности классификации в таблице 3.

30 цветных тестов выделено с точностью 96% и с хорошей границей доверия порядка 94%. Полученный результат свидетельствует о высоком качестве камеры MB-470 NAC, сканера Howtek и новой версии програминого обеспечения ERDAS в версии 7.4.

Произведённый анализ показал, что минимальное спектральное расстояние между двумя классами должно быть больше 10 единиц, в противоположном случае классы следует соединить в один класс.

Перевод: Róża Tołstikowa