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IMPACT OF JPEG COMPRESSION ON TRUSTWORTHINESS OF MULTISPECTRAL IMAGES USED FOR IDENTIFICATION OF AGRICULTURAL BOUNDARIES**

Abstract: *This research has had a goal of testing the influence of lossy compression on effectiveness of detection of agricultural boundaries when using multispectral aerial and satellite images*

The research used two scenes of QuickBird satellite encompassing agricultural areas in central and southern Poland and multi-spectral aerial photograph of scale 1:8000 performed with MSK 4 camera. The research conducted has shown that degrading character of compression is related to the compression level, but the phenomenon is just a tendency that features some random deviations. The results has shown, that low and medium level of compression has only small impact on the effectiveness of boundary detection in multispectral images. Only the high level of compression has significant impact on the degradation of quality for detected boundaries.

Keywords: *JPEG compression, multispectral images, agriculture boundaries*

1. INTRODUCTION

Contemporary aerial and satellite images feature systematically increasing spectral and geometric resolution. This results in ever increasing size of computer files which in spite of improving computing hardware is still bothersome in practice. This in turn results in widespread use of image compression and the only effective compression method for multi-tonal images is a lossy compression [Mikrut et al. 2004]. However, using lossy compression is not always predated by faithful analysis of impact that compression has on quality of results. This

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research has had a goal of testing the influence of lossy compression on effectiveness of detection of agricultural boundaries when using multi-spectral aerial and satellite images.

Detecting edges in the image is a complicated task, mainly because the quality of "boundary" as such is not unambiguous when it comes to image. Formally, the edge is defined as each non-empty set of adjacent pixels of brightness different than their surrounding. The difference of brightness should be higher than brightness change resulting from white noise present in the image, but it should also clearly dominate over the image background. However, classification of image pixels into groups belonging to edge and the ones belonging to background is a peculiar type of fuzzy analysis, since for the aerial and satellite images it is not possible to arbitrarily determine the brightness threshold which defines an edge.

If the spectral reflection of objects located in the image and the inner parts of the object is spectrally homogenous, the probability of effective boundary detection is increased. This, however, is a rare case; most of the time the edges are located in the adjacent areas of objects, as well as within their inner areas. One can define the edges conforming and not conforming in context of the selected goal function; however, when detecting boundaries of agricultural areas, one can rarely find the "good" edges (i.e. the ones conforming to the goal classification) or "bad" edges either (i.e. the ones peculiar for particular area instead of being its boundary). A number of correct as well as incorrect boundaries had to be evaluated in course of the research focused on boundary detection.

2. CHARACTERISTICS OF RESEARCH MATERIAL

2.1. MULTISPECTRAL SATELLITE IMAGES

The research used two scenes of QuickBird satellite encompassing agricultural areas in central and southern Poland and registered in May of 2001 and September 2003. Only the spectral channels of QuickBird system had been the subject of research — blue (B), green (G), red (R) and infrared (NIR), each with geometrical resolution of 2.4 m in nadir.

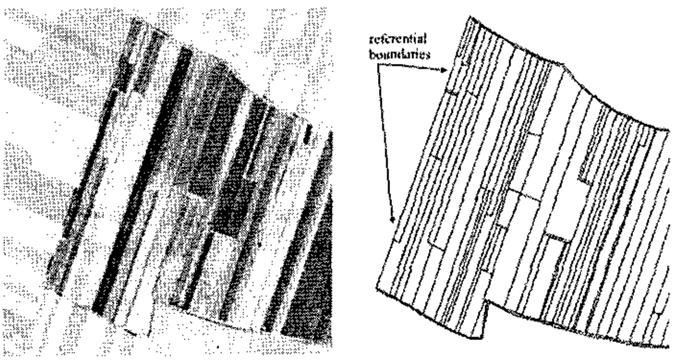

Fig. 1. The test area selected on the first QuickBird image — channel 3 (left) and referential boundaries (right)

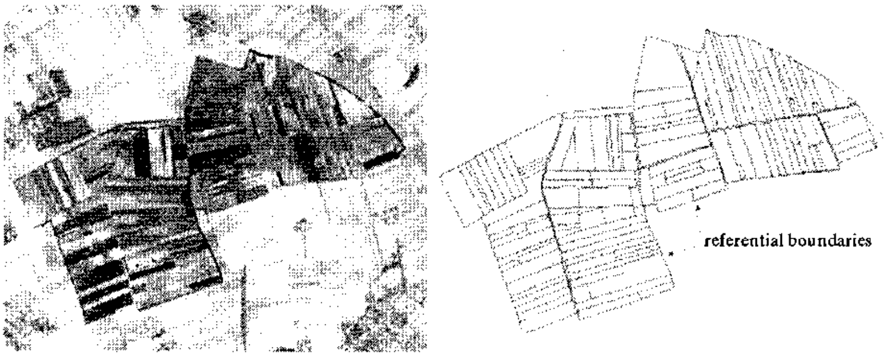

Fig. 2. The test area selected on the second QuickBird image — channel 3 (left) and referential boundaries (right)

One fragment was selected in each scene, using criteria like dominance of agricultural use and minimal built-up areas. The images used this way were recoded from original 11 bits to 8 bits, using power function with exponent smaller than 1, which improved visualization by brightening the shadows (low brightness area) and reducing intensity of lights (high brightness area).

One test field was selected in each QuickBird image in such way so the physical inspection of agricultural area were possible. The following use types were defined: plants of intensive green color, winter crops, spring crops, dry exposed soil, damp exposed soil. Visual interpretation allowed working out vector patterns of agricultural area. The figures 1 and 2 present test areas with boundaries defined as reference.

2.2. AERIAL MULTISPECTRAL IMAGE

Multi-spectral aerial photograph of scale 1 : 8000 performed with MSK 4 camera in 2003 was also used in research. The photograph was taken in four channels: green (G), red (R), close infrared (NIR1), second band of close infrared (NIR2). Particular channels were processed to digital form using PhotoScan TD scanner.

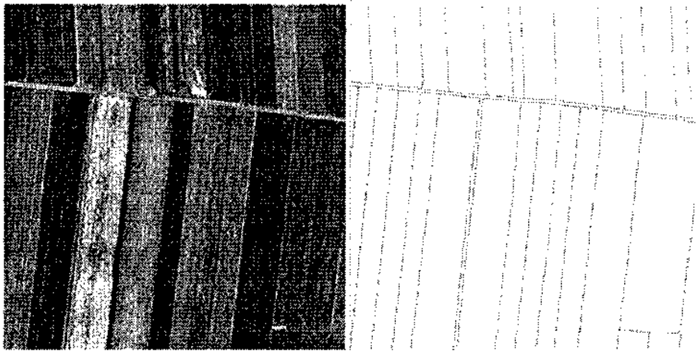

Fig. 3. The test area selected on aerial photo — channel 3 (left) and referential boundaries (right)

A fragment of the photograph was selected that serves agricultural purposes and did not feature buildings. High zoom factor of the photograph allowed to select the rectangular test area. Visual interpretation of area boundaries was performed and saved in the vector representation, which produced referential boundaries. Those are shown on the figure 3 near the photo fragment selected as test field.

2.3. IMAGE COMPRESSION

Spectral channels of satellite images and the aerial photo were compressed using JPEG method using 7 different coefficients: 12, 11, 10, 9, 7, 4, 1, where 12 designates highest quality and 0 the lowest quality. Except the spectral channels the analysis includes an image consisting of linear channel combination in sequence 2, 1, 4, 3 (which corresponds to G, B, NIR, R combination for satellite image and R, G, NIR2, NIR1 for aerial photo), which was called "mix channel". The image was used for visual interpretation and the accuracy of selection was confirmed using results of analysis presented further in the paper. This approach produced 8 test images in total, with separate images for each channel and mix channel of satellite image and aerial photo.

2.4. AUTOMATIC BOUNDARY DETECTION OF AGRICULTURAL AREAS

The methods of detecting boundaries in digital images that are based on brightness differences can be categorized into three groups: gradient, Laplacean and optimization-based. The comparative research conducted by many authors [Heath et al. 1998, Forghani 2000; Czechowicz, Mikrut 2006] indicates optimization-based methods originated by Canny [Canny 1986] as the ones yielding the best results. That is why the solution selected is based on Cannys idea and modified by Deriche [Deriche 1987].

QAedgesDeriche software developed in QGAR (www.qgar.org) project and available under GNU LGPL license was used for boundary extraction. The software requires specifying parameters that are critical for effective boundary identification (so-called thresholding) in order to eliminate boundaries caused by white noise. Parameters were selected for each researched channel separately, but after establishing they were constant for all 8 images that varied in compression only (no compression, 7 levels of compression).

3. STRATEGIES OF COMPRESSION IMPACT ON EFFECTIVENESS OF AGRICULTURAL AREA BOUNDARY DETECTION

The research was based on comparison of conformity of automatically detected boundaries to automatically detected boundaries on images with different levels of compression. The total research set for each test field featured 40 boundary images (5 × 8). All the edges detected in the image except the boundaries defined as correct boundaries were deemed as undesirable data and were classified as incorrect. Two strategies were used independently: raster strategy and vector strategy.

3.1. RASTER STRATEGY

The raster character of strategy was based on comparison of original raster of boundaries in edge images with raster reference image. The edge images were binary, i.e. only {0,1} values were used to represent them. The pattern of area boundaries that originally had vector representation was also converted to binary. The reference and edge images had the same geometrical resolution.

Two criterions were used for comparing the boundaries. The first criterion (A) was based on assumption that only this edge is correct that had its pixels located the same as the reference edges. The second criterion allowed for defined deviation of pixel location in compared images.

The first assumption is very restrictive and it is not always well-founded. The raster representation of boundary lines introduces some distortion of its real location. Mapping lines onto pixel grid makes pixel edge stray away from the vector edge and the difference measured from the middle of the pixel to its mapping can have deviation of 1 pixel (the biggest deviations happen for edges close to 0 and 90° angle).

The second criterion (B) has the edges in the closest vicinity of referential edge defined as correct. The assumption B was implemented by making referential boundaries thicker and replacing them with band three pixels wide.

A special structure of detected edges was defined due to expected geometrical distortion of edges. The boundaries of agricultural areas tend to be close to straight. In such case the edge detection algorithm builds them using single pixels and creates single-pixel edges. Where algorithm detects the change in direction, it creates local thick sections. The higher number of such thick sections, the more probable it is that the edges strayed from straight line. Detection of potential thick sections of edges was implemented using edge thinning and calculating excessive pixels.

3.2. VECTOR STRATEGY

The vector strategy was implemented using image edges as vectors with known start and end pixel coordinates. The next step was calculating the differences between edges in analyzed image and referential boundaries (found by visual interpretation).

The analysis was conducted using following general criteria:

- only the pixels that reference vector goes through belong to the edge,
- only the pixels located in the immediate vicinity of vector belong to the edge.

The calculation included criterion related to the angle of referential vector. Given the above, width of the band was calculated using the following formula:

$$d = \frac{1}{\sqrt{2}} p \cos(\alpha - 45)$$

where:
p — length of pixel edge,
α — angle of referential vector.

The research included four variants of band thickness for:
p = 0,5 if band is 1 pixel thick,
p = 0,75 if band is 1,5 pixel thick,
p = 1,0 if band is 2 pixel thick,
p = 1,5 if band is 3 pixel wide (this value corresponds to the raster analysis, where pixels-to be included lie in distance of $\sqrt{2}$ multiplied by length of pixel edge).

4. RESEARCH RESULTS AND THE DETAILED ANALYSIS

4.1. SATELLITE IMAGES — RASTER STRATEGY

The correctness of boundary detection was summarized as graphs on figure 4. The figure consists of two columns with five graphs each channel (including one "mix" channel). The left column contains results for test area 1, the right column — for test area 2 (both regard the QuickBird satellite scene).

Each graph contains three bar graphs (a), (b), (c) corresponding to three coefficients of detection effectiveness defined as:
coefficient (a) = the number of pixels fulfilling criterion A / number of referential pixels [%],
coefficient (b) = the number of pixels fulfilling criterion B / number of referential pixels [%],
coefficient (c) = number of incorrect pixels / number of referential pixels [%].

Interpretation of coefficient (c) should account for "wrong" edges being defined as located more than a pixel away from reference as well as edges not having anything in common with area boundary (e.g. the line of damp zone).

In general, the comparison for test areas 1 and 2 reveals their common characteristics:
- detection coefficients of A and B edges (two first bars in the graphs) gradually fall and one finds a tendency of the value to decrease slowly at first and then faster reduction in the value (the number of correct edges is falling); the decrease is stronger for compression with level 6 (the coefficient of 4),
- detection coefficients of edges defined as correct according to criterion A are always lower than for criterion B (often more than two times lower),
- detection coefficients of incorrect edges (the third bar in the graph) do not show any stable relation to the compression level; sometimes the number of correct edges is increasing with compression level, sometimes falling.

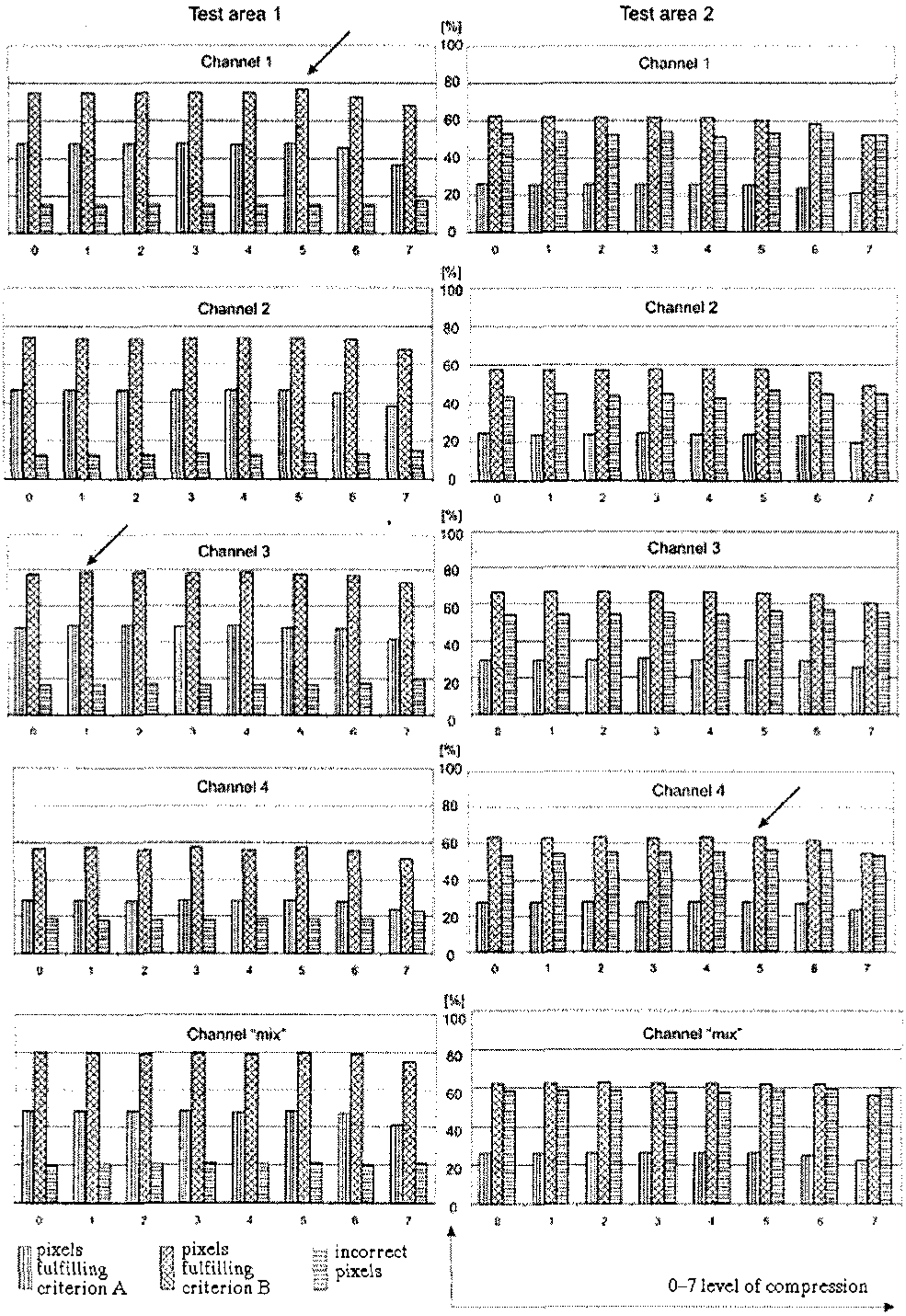

Fig. 4. Summary of boundary detection effectiveness in four spectral channels and in channel combination (satellite images); compression levels 0–7 correspond to JPEG compression coefficients according to PhotoShop v6: 0 — uncompressed, 1 — coef.12, 2 — coef.11, 3 — coef.10, 4 — coef.9, 5 — coef.7, 6 — coef.4, 7 — coef.1

Also, the difference of results for test areas is notable. The test area 1 systematically features lower number of incorrect edges than the number of correct edges, both in A and B variant. For the test area 2, the number of incorrect edges is always lower than the number of correct B edges, and it is systematically higher than the number of correct A edges.

The results found allow for following conclusions:

— the compression level is only weakly destructive for effectiveness of edge detection; only the high level of compression has a significant impact on its correctness,
— the area characteristics influences the incorrect edge numbers: the more brightness changes inside the area (e.g. due to humidity), the more curved edges are there (most of the time those are not area boundaries or property boundaries),
— it is difficult to find the influence of compression on detection of curved edges; the degradation is unnoticeable except for higher number of such edges found at higher levels of compression

Due to similarities found for results of compression in both test areas, the more detailed result interpretation is focused on first test area. The results for test area 2 will be noted only where necessary.

The results are comparable for channels 1, 2 and 3. The number of correct pixels according to criterion A is found to be 47÷48% for uncompressed image, it grows slightly with the level of compression and only the highest level of compression (level 7 on Figure 4) it reduces the level to below 40%. Similar tendency is found for correct B pixels — at low levels of compression the fraction of correct pixels is 74–77% and it decreases significantly by 5÷7% only at the highest level of compression. The numbers of incorrect pixels do not vary significantly either: for compressions level 1 to 5 their number oscillates slightly around the number without compression, the first more significant increase takes place at level 6, *and more significant increase (about 2%) can only be noted at level 7.*

This generic characteristics of channels of 1, 2 and 3 abstracts from astonishing phenomenon of acquiring higher number of correct edges from relatively highly compressed images than the number of correct edges yielded from uncompressed images. This finding is most notable for channel 1 and takes place at compression 5. It is indicated by an arrow on the figure. In that case 1.4% more of correct edges has been found according to criterion B than for the uncompressed channel, while compression 1 to 4 has resulted in small decrease of coefficient in comparison to the results for uncompressed images. Albeit to smaller extent, similar phenomenon took place for channel 3 in areas 1 (compression 2) and for channel 4 (compression 5) in area 2.

The results for channel 4 (area 1) divert significantly from numbers yielded for channels 1, 2 and 3. Significant decrease of almost 20% has been found for coefficient of boundary detecting both for criterions A and for B. Similar fractions of erroneous edges has been found for channels 1, 2 and 3. The unexpected phenomenon of better edge detection for some kinds of compression than for uncompressed images is confirmed; however, its magnitude is significantly lower than for channel 1. In case of area 2, coefficient of boundary detection for channel 4 is not different from the coefficient for other channels.

The artificial image created as linear combination of channels 1, 2, 3 and 4 from test area 1 indicates the best detection capability of edges found: criterion A has almost 50%

of edges detected correctly, while for criterion B almost 80% of reference edges has been detected correctly. However, the number of incorrect edges has grown slightly. This type of "mix" channel dominance has not been found for area 2, while the higher number of incorrect edges has been found (in comparison to channels 1÷4 in that test area).

All the edge images researched have one common characteristics not described above: reduction in edge detecting efficiency is more significant with the increase in level compression. This is not easy to spot on Figure 5, since the detection coefficients for criterion A are two times lower on average than for criterion B. The phenomenon of unexpected increase of "good" edges is weaker than for criterion B, and sometimes it is not present at all (e.g. for channel 4 in area 2).

Second current of research included checking to what degree the detected edges are more than one pixel wide. For this purpose the edge images yielded using Deriche algorithm have been subjected to dimming operation that results in single-pixel edges. The report from thinning process has produced the number of eliminated pixels (i.e. the ones that created local thick sections in edges). The tendency of number of deleted pixels to rise with the compression level is notable. Figure 5 presents the graph containing number of pixels eliminated in comparison to original value; this example is representative for all the images researched (four spectral channels and "mix" channel). In all cases the number of excessive pixels ("thickened sections") was rising slowly until the compression level 4, after which it was increasing more significantly and rose sharply for the highest level of compression.

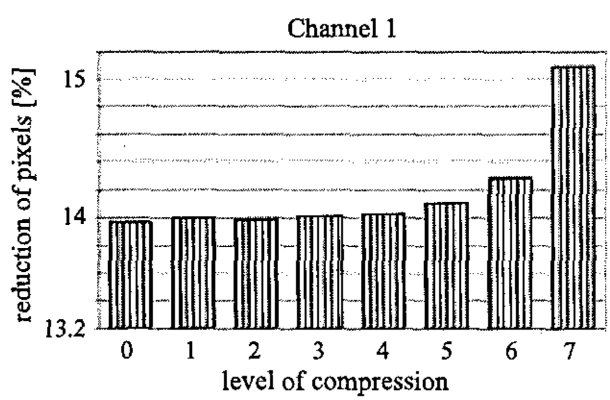

Fig. 5. Reduction of excessive pixels using channel 1 in area 1

The higher number of "thickened sections" accompanying higher compression is another arguments supporting the thesis of compression introducing geometrical distortions by curving the edges. In case of straight lines Deriche algorithm generates single-pixel edges, while thick sections happen where the curve is changing its course. Subsequently, this number is much higher for edges that are erroneous from the viewpoint of boundary detection. Recall that all the edge images in research of edge detection coefficient were reduced to one pixel.

The above conclusion is another data point confirming degrading influence of compression increasing with its level. This conclusion contradicts the phenomenon of sudden improvement boundary effectiveness with the highest coefficient in channel 1 at fifth level of compression. We have to stress that the results presented are statistical and do not indicate what are the locations where edges degrade and whether those are the same edges for the subsequent compression levels. This is the reason of conducting observation of behavior for specific edges detected at various levels of compression. We found edges to be significantly mobile — some of edges detected at low compression is vanishing at higher compression levels an the phenomenon seems to be random. A case of this kind has been presented on Figure 6.

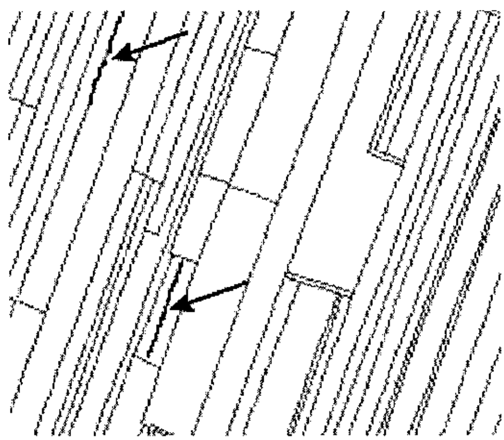

Fig. 6. Edges detected at the fifth level of compression for channel 1 and not detected in other images including uncompressed referential image (edges are indicated by arrows; referential edges are background)

Detecting new edges not found before has resulted in improvement of detection statistics in spite of degradation resulting from compression (curving and breaking the edges). An explanation of conditions for successful detection of boundaries that are invisible for the same algorithm at lower levels of compression is an open question. It would require specifying contrast of local edges and tracking its relation to result of edge detection. This problem was not included in research plan.

4.2. SATELLITE IMAGES — VECTOR STRATEGY

The analysis was conducted for 2 test areas. The results of detection effectiveness were summarized in two tables: test area 1 — Table 1, test area 2 — Table 2. Both tables include rows with subsequent images: uncompressed and increasing levels of compression. The columns are represented by four channels of particular images. Each column that represents a channel was divided into four further subcolumns that contain the width of band: subsequently — 3; 2; 1.5; 1 pixel. The 3-pixels wide band corresponds to raster analysis defined as criterion B.

The numbers define amount of pixels in particular band for each image in 4 channels. Both test areas share common traits revealed in analysis of tables:

— The number of pixels detected that define edges is comparable for channels 1, 2 and 3. Channel 4 introduced reduction of detection effectiveness by about 35% in comparison to other channels.
— In case of area 1 all the channels feature the number of pixels detected in defined band grows slightly in the image of lowest compression level (coefficient 12) in comparison to the uncompressed image. The phenomenon characteristic for area 2 is noticeable only for channels 3 and 4.
— For both of the researched areas the number of pixels detected in the band is decreasing proportionally to the degree of image degradation (from several to a dozen pixels) and subsequently the number of correct pixels is falling sharply for images with level 4 of compression. This facilitates the conclusion that low level of compression has almost no influence on edge detection in comparison to uncompressed image.
— Depending on band width, the number of pixels detected varies in particular channels. In comparison to 1 pixel wide band, the number of detected pixels is rising by 30% for 1.5 pixel wide band; 50% for 2 pixel wide band; and 60% for 3 pixel wide band.

The research confirms results for numbers of correctly detected pixels (i.e. the ones conforming to the referential boundaries) acquired in the raster approach. Both vector and raster analysis have resulted in similar percent ratios of correctly detected edge pixels. Both of the approaches have also confirmed respective falling and rising tendencies of detected pixel quantities for the same channels and levels of compression.

4.3. AERIAL PHOTOGRAPH

The results of correctness of boundary detection are presented in Figure 7. They were produced using the same methods as the ones used for satellite images (section 4.1).

We omitted conducting analysis of incorrect boundaries (defined as edges detected, but not being area boundaries). Large zoom factor (1 : 8000), as well as vegetative period in the day of taking the photograph make enormous number of edges to appear in the photo. The photo researched contains mostly the ploughed areas with furrows present in each of them. The number of incorrect edges exceeds by far the number of correct edges. Trying to draw conclusions about influence of compression on boundary detection in this context is meaningless.

Comparing the graphs for particular channels allows formulating following conclusions:
— the correct A and B boundary detection coefficients generally fall with increasing level of compression, while this fall is significant and it takes place almost always only at the last level of compression (no. 7). However, this decreasing tendency is sometimes distorted, which is visible to the highest degree for channels 3 and 4.
— correct B edge detection coefficients are much higher than the ones for edges of A type: the highest ration of those coefficients takes place in channel 1 and its almost always 4:1, and the smallest ratio of 3:1 is present in channel 2.

The second conclusion can be easily explained. The large zoom factor makes boundaries relatively wide, especially where baulks are present. Defining the reference

Table 1

Summary of pixel numbers located in deviation band for four spectral channels (test area 1)

Level of compression	Coefficient of compression	Channel 1				Channel 2				Channel 3				Channel 4			
		d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1
0	no compr.	5215	3783	2949	2006	5121	3706	3343	1972	5262	3779	2924	2010	3391	2376	1806	1239
1	12	5216	3792	2953	2005	5171	3675	2857	2081	5339	3831	2965	2037	3446	2413	1840	1262
2	11	5213	3808	2946	2001	5062	3667	2850	2086	5366	3858	2981	2048	3358	2358	1785	1223
3	10	5210	3806	2943	2009	5085	3677	2860	1956	5326	3826	2962	2033	3427	2401	1830	1255
4	9	5182	3783	2926	1988	5075	3678	2860	1950	5317	3826	2959	2027	3378	2366	1796	1234
5	7	5238	3792	2946	2005	5048	3652	2846	1956	5229	3758	2903	1989	3484	2443	1857	1274
6	4	5030	3612	2802	1908	5006	3618	2802	1910	5166	3690	2857	1960	3325	2327	1763	1222
7	1	4276	3074	2282	1554	4352	3096	2386	1614	4668	3319	2577	1738	2910	2008	1532	1039

Table 2

Summary of pixel numbers located in deviation band for four spectral channels (test area 1)

Level of compression	Coefficient of compression	Channel 1				Channel 2				Channel 3				Channel 4			
		d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1	d = 3	d = 2	d = 1.5	d = 1
0	no. compr.	5001	3347	2575	1747	4693	3138	2403	1639	5613	3815	2916	1995	5336	3636	2770	1890
1	12	4974	3334	2563	1733	4665	3126	2394	1635	5632	3820	2928	2003	5338	3634	2766	1882
2	11	4969	3331	2563	1734	4669	3130	2398	1636	5631	3822	2926	2000	5331	3630	2759	1879
3	10	4960	3324	2552	1739	4666	3118	2386	1626	5629	3825	2929	2003	5318	3622	2760	1883
4	9	4919	3300	2530	1698	4674	3119	2392	1626	5616	3811	2915	1987	5317	3629	2771	1879
5	7	4843	3246	2488	1698	4660	3122	2394	1624	5521	3741	2865	1944	5280	3585	2729	1863
6	4	4678	3125	2388	1644	4467	2978	2286	1559	5459	3699	2830	1948	5117	3461	2635	1807
7	1	4089	1715	2097	1422	3831	2534	1931	1293	4988	3397	2607	1755	4437	3024	2770	1575

was based on subjective interpretation and probably repeated by many different observers would allow to reduce the difference to a single pixels. Therefore, detecting boundaries automatically in comparison to the thickened three-pixel reference is probably more effective than for the single pixel band.

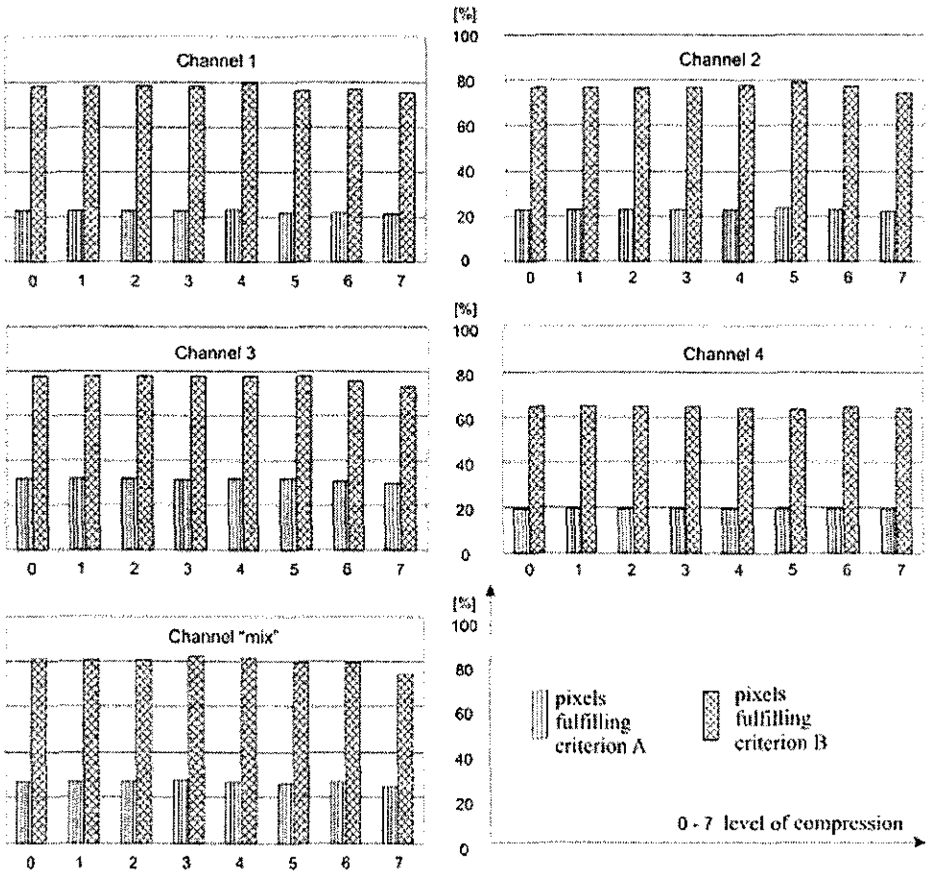

Fig. 7. Summary of boundary detection effectiveness in four spectral channels and in channel combination (satellite images); compression levels 0–7 correspond to JPEG compression coefficients according to PhotoShop v6: 0 — uncompressed, 1 — coef.12, 2 — coef.11, 3 — coef.10, 4 — coef. 9, 5 — coef.7, 6 — coef.4, 7 — coef.1

The first conclusion, however, requires more detailed explanation. Recall that detection of higher number of edges on compressed images in comparison to uncompressed images took place for satellite images before. However, this happens much more frequently for the aerial photos. This is probably caused by curved character of theoretically straight images detected automatically. Figure 8 has images of the same area boundary in three versions: referential, detection taking place on uncompressed image and the one on strongly compressed image. For edges detected on the uncompressed image one can easily spot the deviation from the straight lines. Curving the edges grows with compression; the random artifacts in this case also appear in the form of double edges. The bottom part of image 8 presents discontinued edge on the right hand side in addition to a double edge. In some places the image features excessive edges and in other places it has the deficit of them. If the number of excessive pixels (caused by double edges or curving) is much higher than the missing ones (edge discontinuity), the summary statistics will show better edge detection after strong compression!

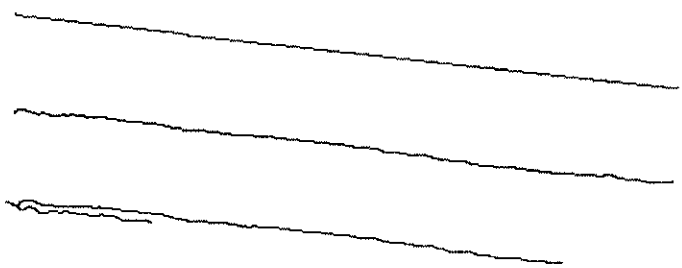

Fig. 8. Comparison of the referential edges (top), automatically detected edges without compression (middle) and edges detected in images of strong compression (bottom)

The above interpretation of results confirms the general conclusion about degrading impact of compression with its increasing level. The results acquired in the statistical analysis sometimes show improvement in the detection of edges in highly compressed images. However, this improvement is illusory; in reality, it results from geometrical edge deformation which makes them longer, or random artifacts making edges appear in images of low compression.

4. SUMMARY

In spite of looking for the new solutions [Mikrut et al. 2004], the JPEG method is still the most popular method of compression for multi-tonal images. The effectiveness of JPEG method is to a large extent yielded due to algorithm accounting for characteristics of human vision. The losses introduced by compression are random to an extent, and they are partly correlated with the image. This complicates analysis trustworthiness of multi-spectral images used for identification of agricultural boundaries.

The research conducted has shown that degrading character of compression is related to the compression level, but the phenomenon is just a tendency that features some random deviations. The problem of boundary identification is additionally complicated by specific qualities of raster representation of images. Still, the research has demonstrated, that low and medium level of compression has only small impact on the effectiveness of boundary detection in multi-spectral images. Only the high level of compression has significant impact on the degradation of quality for detected boundaries: the edges are broken more frequently, there is more curving and more thick sections of edges. The research has concluded that the image that composite image is the most useful one for boundary detection. The boundary detection based on channels corresponding to the close infrared was generally weaker than the one for visible light channels. Infrared band is effective for purpose of identification of damp changes, but not for identification of typical agricultural area boundaries.

We need to stress that research has featured two independent strategies for boundary detection — raster approach and vector approach. The results acquired have produced very similar result: a similar degrading tendency for compression was found, as well as similar random deviations from the general trend. This proves that the research methods selected are correct.

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IMPACT OF JPEG COMPRESSION ON TRUSTWORTHINESS OF MULTISPECTRAL IMAGES USED FOR IDENTIFICATION OF AGRICULTURAL BOUNDARIES

SUMMARY

The article contains description of testing the influence of lossy compression on effectiveness of detection of agricultural boundaries with using multispectral aerial and satellite images. The research used two scenes of QuickBird satellite encompassing agricultural areas in central and southern Poland and multispectral aerial photograph of scale 1 : 8000 recorded with MSK 4 camera. At those images has chosen test area and then tested impact of compression on trustworthiness used for identification of agricultural boundaries.

The images were compressed using JPEG method with different degrees of radiometric quality degradation. We havent analyzed another methods of compression, because the JPEG method is still the most popular method of compression for multi-tonal images. The effectiveness of JPEG method is to a large extent yielded due to algorithm accounting for phychophysical characteristics of human vision. The losses introduced by compression are random to an extent, and they are partly correlated with the image. This complicates the undertaken quantitative analysis of reliability of agricultural boundaries identification on multispectral images.

However, when detecting boundaries of agricultural areas, compliance fact that on every image can find the "good" edges (the ones conforming to the goal classification) or "bad" edges (the ones peculiar for texture of particular area instead of being its boundary). A number of correct as well as incorrect boundaries had to be evaluated in course of the research focused on boundary detection.

The research conducted has shown that degrading character of compression is related to the compression level, but the phenomenon is just a tendency that features some random deviations. The problem of boundary identification is additionally complicated by specific qualities of raster representation of images. Still, the research has demonstrated, that low and medium level of compression has only small impact on the effectiveness of boundary detection in multi-spectral images. Only the high level of compression has significant impact on the degradation of quality for detected boundaries: the boundaries are broken more frequently, there is more curving and more thick sections of edges. The research has concluded that composite image of spectral channels is the most useful one for boundary detection. The boundary detection based on channels corresponding to the close infrared was generally weaker than the one for visible light channels. Infrared band is effective for purpose of identification of wet changes, but not for identification of typical agricultural area boundaries.

We need to stress that research has featured two independent strategies for boundary detection — raster approach and vector approach. The outcome acquired have produced very similar result: a similar degrading tendency for compression was found, as well as similar random deviations from the general trend. This proves that the research methods selected are correct.

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WPŁYW KOMPRESJI JPEG NA WIARYGODNOŚĆ IDENTYFIKACJI GRANIC UŻYTKÓW ROLNYCH NA PODSTAWIE OBRAZÓW WIELOSPEKTRALNYCH

STRESZCZENIE

Praca zawiera opis badań których celem było sprawdzenie, jaki jest wpływ kompresji stratnej na skuteczność *wykrywania granic użytków z wykorzystaniem wielospektralnych obrazów lotniczych i satelitarnych. Badania* przeprowadzono na materiale testowym, który stanowiły dwie sceny satelity QuickBird, obejmujące tereny rolne w Polsce środkowej i południowej, oraz wielospektalne zdjęcie lotnicze w skali 1 : 8000, wykonane kamerą MSK 4. Na tych obrazach wybrano pola testowe, a następnie zbadano wpływ kompresji na wiarygodność identyfikacji granic użytków rolnych .

Obrazy kompresowano metodą JPEG, stosując kompresje o zróżnicowanym stopniu degradacji jakości radiometrycznej. Nie analizowano innych metod kompresji, gdyż JPEG — pomimo poszukiwania nowych rozwiązań — jest dalej najpopularniejszą metodą kompresji obrazów wielotonalnych. Skuteczność metody JPEG jest w dużej mierze efektem uwzględnienia przez algorytm psychofizycznych właściwości systemu wzrokowego człowieka. Straty wnoszone przez kompresję mają w części charakter przypadkowy, a w części są skorelowane z obrazem. Komplikuje to, podjęty w pracy, problem ilościowej oceny wpływu kompresji na wiarygodność identyfikacji granic użytków rolnych na podstawie obrazów wielospektralnych.

Przy wykrywaniu granic użytków rolnych należało uwzględnić fakt, że na każdym obrazie występował przypadek krawędzi „dobrych" — tematycznie zgodnych z celem prowadzonej klasyfikacji treści, jak i „złych" — czyli krawędzi które są charakterystyczne dla tekstury danego użytku a nie stanowią jego granicy. W badaniach skuteczności wykrywania granic należało zatem określać zarówno ilość krawędzi poprawnych z punktu widzenia funkcji celu — których powinno być jak najwięcej, jak i niepoprawnych — których powinno być jak najmniej.

Przeprowadzone badania wykazały, ze degradacyjny charakter kompresji jest związany ze stopniem kompresji ale zjawisko to jest tylko pewną tendencją, której towarzyszą losowe odstępstwa. Problem identyfikacji granic *dodatkowo komplikuje specyfika rastrowej reprezentacji krawędzi. Tym niemniej badania udowodniły, że niski* i średni poziom kompresji w niewielkim stopniu obniżają skuteczność wykrywania granic na obrazach wielospektralnych. Dopiero silna kompresja wyraźnie wpływa na pogorszenie jakości wykrywanych granic — krawędzie są częściej przerwane, mocniej powyginane, więcej jest tzw. „pogrubień" krawędzi. Badania potwierdziły, że najbardziej przydatny do wykrywania granic jest obraz stanowiący wypadkową kanałów spektralnych. Wykrywalność granic na podstawie kanałów odpowiadających podczerwieni bliskiej była z reguły mniejsza niż dla kanałów z zakresu widzialnego. W podczerwieni dobrze odwzorowują się zmiany wilgotnościowe, słabiej natomiast granice klasycznych użytków rolnych.

Na podkreślenie zasługuje fakt, że do badania skuteczności wykrywania granic zastosowano dwie niezależne strategie — rastrową i wektorową. Uzyskane wyniki były bardzo zbieżne — wykryto podobną tendencję degradacyjną kompresji jak i występowanie losowych odstępstw od generalnego trendu. Dowodzi to poprawności zastosowanej metodyki badawczej.

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