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INFLUENCE OF COMPRESSION ON RESULTS OF FARMLAND CLASSIFICATION IN MULTISPECTRAL SATELLITE IMAGES**

Abstract: *The article describes attempts to develop classification on compressed multispectral images. The purpose of this research was to answer a question whether and to what degree may compression influence result of classification. Various methods of classification and various compression ratios were applied, and the results compared to classification performed on non-compressed images. Contrary to expectations, the results of conducted analysis indicate rather low influence of the image compression on classification, provided that the image texture features are not taken into consideration during the classification process. Otherwise, the deterioration of results becomes meaningful, even at a minimum compression.*

Keywords: *JPEG compression, multispectral satellite images, farmland classification*

1. INTRODUCTION

In spite of a dynamic development of computer hardware, an issue pertaining to enormous volumes of image files has not been alleviated in digital photogrammetry. A digital image of aerial or satellite photography recorded without any compression may reach a volume of hundreds of megabytes or even above gigabyte. Therefore, storage of a large number of digitally recorded photographs or images requires gigantic sizes of data carriers. For that reason a search for effective image compression methods has been conducted for a quite a long time. Non-loss compressions do not save a lot of memory. Among lossy compressions, the JPEG method was considered to be the most effective compression method in case of tonal images. This method can provide a high degree of compression

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while maintaining good radiometric and geometric quality of an image. As a result, JPEG compression became increasingly common in photogrammetry, however its application still brings many uncertainties. Although we do not often notice the effect of compression, it could not necessarily mean that it doesn't impact unfavourably the results of various image analyses, such as subject classification, image edging or autocorrelation. Therefore continuous diversified research is conducted pertaining to consequences of application of the lossy compression. The objective of our research was to determine an influence of multispectral image compression on classification of farmlands.

2. PRINCIPLE OF MULTISPECTRAL IMAGE CLASSIFICATION

Multispectral image classification can be done by dividing the image into groups of pixels having some similar features in all component channels. Initially a pixel classification was mainly applied, while recently object classification methods are winning wider appreciation.

2.1. PIXEL CLASSIFICATION

In a traditional method, the image content classification is carried out by grouping the pixels into classes showing statistically similar spectral features. The result of such classification is a creation of a new image where pixel values correspond to class allocations, most often representing categories of land use. We can distinguish two methods of classification: supervised and unsupervised. In unsupervised classification, the proposed algorithm divides spectral area into a determined number of classes automatically. However, in a supervised classification it is required to define class standards, i.e. "training fields". Each "training field" can be described by means of probability distribution in a spectral area. Statistical parameters of each channel spectral value, such as mean value, standard deviation, variance and covariance, are calculated for the mentioned class standards. The task of supervised classification algorithm incorporates assignment of all the image pixels to the classes defined earlier based on determined parameters. A base for such assignment could be measure of distance between a given pixel and centre point of class, or a value of the highest assignment probability in a particular class. In order to obtain credible classification results, it is necessary to define the test regions that are quite uniform and representative for each particular class.

2.2. OBJECT CLASSIFICATION

Object oriented approach to image analysis results from a fresh new look into the issue of obtaining the image data — since there are many tasks waiting for applying the image data to distinguish real land objects. Such expectations cannot be fulfilled by applying a traditional pixel approach method. Units processed in object analysis are no longer single pixels but the objects (segments) of image [eCognition User Guide 3]. The advantage of object oriented analysis of images may be attributed to a multitude of additional data possible to obtain based on the objects. Apart form spectral data, each object has shape, texture, context and also a defined position in relation to the other objects. From a conceptual point of view, the object features could be divided into:

— external — object physical features, such as colour, texture or form
— topological — features describing a geometric relation between objects or a whole scene
— context — features describing semantic relations between objects.

Object classification process comprises of two steps: image segmentation and proper classification.

Segmentation relates to the image division into separate regions (objects). Many algorithms use relatively simple properties — pixel brightness or colour. The texture information may also be used for more difficult objects, in case of more complicated image content [Hu & others, 2005].

Generally speaking, classification denotes allocation of the object to a particular category according to its description or the description of typical properties (or conditions) of such category. If those properties are complied with then the object is allocated to a given category. Traditional classification rules used in remote sensing, such as maximum probability, minimum distance or rule of parallelepiped utilize affiliation parameter 1 or 0 — meaning that the object belongs to some class or not. These are so called "hard" classifiers representing affiliation to a class in binary way only. On the other end there are so called "soft" classifiers, mainly based on fuzzy logic and allowing to describe the affiliation to a class within the range from 1.0 (full affiliation) to 0.0 (no affiliation whatsoever). In effect, degree of affiliation depends on the extent the object meets the properties describing a particular class. The advantage in application of these methods is to make it possible to express a degree of uncertainty in assignment to a class. It also creates a possibility to assign each object to more than one category, but at various degrees of affiliation.

3. RESEARCH TASK

The purpose of this research was to compare classification results of high resolution satellite images (QuickBird) rendered on uncompressed images with those degraded due to the application of JPEG lossy compression. A fragment of scene from QuickBird satellite encompassing farmlands in middle Poland and registered in May of 2001 was used for this research. Seven degrees of compression were applied; from a minimum compression resulting in the highest volume of files (compression ratio of 12 according to Photoshop software), throughout intermediate compression (ratios of 11, 10, 9, 7, 4 according to Photoshop), and up to almost maximum compression (ratio of 1 according to Photoshop software). Dimension of the test field was 300 × 340 pixels, and its contents comprised solely of the farmlands. Four spectral channels were used in the project: blue (channel 1), green (channel 2), red (channel 3) and near infrared (channel 4).

The classification was performed by using two methods: object oriented and pixel oriented. Two extreme situations were selected for comparison; soft object classification in eCognition and hard pixel classification in Idrisi.

3.1. DESCRIPTION OF SOFTWARE APPLIED FOR TRADITIONAL PIXEL CLASSIFICATION

Classification of pixels was performed using Idrisi32 software. Automatic supervised classification was worked out using the highest probability classifier. This classification method makes use of training fields or selected portions of image considered representative for a given application.

Probability of affiliation of each pixel to a particular class is calculated in the mentioned classification by using the highest probability method. A pixel is allocated to the category showing a highest probability for its affiliation. A mean value and variance-covariance matrix is then calculated for each class, thus allowing a pixel to be qualified for particular class. In case an option to classify all image pixels is selected regardless of the existing probability value for affiliation to each particular class, each pixel will be allocated to one category, even if the mentioned probability is significantly low.

3.2. SOFTWARE APPLIED FOR OBJECT CLASSIFICATION

This research was conducted using eCognition software [eCognition User Guide], [www.definiens-imaging.com/ecognition].

Segmentation used in eCognition is based on the process of linking the regions starting from single pixel objects. Smaller objects are combined into the larger ones in subsequent steps. Size of the objects after segmentation determines a scale parameter — and this is an abstract term setting maximum allowed heterogeneity in the resulting objects of the image. Homogeneity of the object coming to existence is defined by three criterions: colour, smoothness and compactness. In majority of cases the colour criterion is the most important one, but in some situations the shape criteria (smoothness and compactness) are quite helpful (since they help to avoid the object fractal forms obtained from radar data).

eCognition classification is based on fuzzy logic. Each class can be described with the fuzzy logic rules based on single-dimensional affiliation functions, or on the nearest neighbour classifier acting within multi-dimensional space of features. Both methods are considered to be supervised. While the affiliation functions are directly edited and let the user learn about the image contents, the nearest neighbour method requires sample objects to determine the properties of given classes. They may be entered manually or automatically based on so called test masks of training fields.

eCognition brings quite a few features which could be used as fuzzy logic to create descriptions of classes.

— **Object features** — values calculated basing on the objects themselves, and also on their position in the object hierarchy, such as: spectral values in various channels, shape, texture, hierarchy
— **Class related features** — mutual relations between classes are also used for classification purpose and that pertains to adjacent objects as well as to superordinate and subordinate objects in the hierarchy.

Apart from the features based on spectral values and object shapes, the eCognition software offers well developed variety of features pertaining to the image texture. In general, these features could be divided to those based on subordinate objects and the ones described in 1973 by Robert Haralick, using co-occurrence matrix (Grey Level Co-occurrence Matrix — GLCM) (also described as neigbourhood or event matrix). Another approach for description of texture may be an application of grey level difference vectors *(GLDV),* calculated as a sum of the event matrix diagonal elements. eCognition software calculates GLCM and GLDV based on object pixels found for each channel and in all directions.

3.3. DESCRIPTION OF CONDUCTED RESEARCH

The test region was selected in the image in such way that it incorporates only the farmlands (Fig. 1). According to a visual interpretation done basing on colour composition taken from channels 1, 2, 3 as well as from colour composition of all four channels in a selected image fragment, there were 5 categories of farmland selected:

1. intensely green vegetation
2. winter grains
3. spring grains
4. uncovered dry soil
5. uncovered moist soil

Apart from the mentioned five categories of farmlands, both balks and field footpaths could be distinguished on the image. The attempt to consider them as a separate category

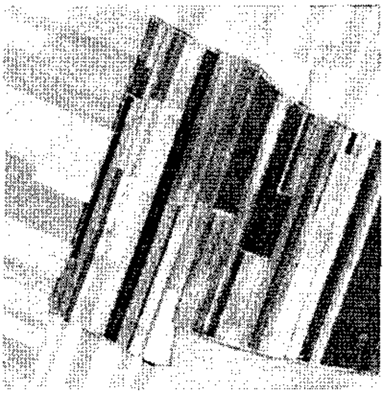


Fig. 1. Test area selected on the image obtained from QuickBird satellite

in Idrisi 32 rendered classification was unsuccessful (the software allocated many pixels dispersed randomly all over the area to this category). This category was detected successfully in the eCognition object classification. However, in order to maintain cohesion between the results rendered by both software programs, this category was excluded. It was allocated to unclassified objects in the results obtained by eCognition software (class 6 on graphs representing comparisons of the classification results).

Unfortunately, there was no possibility to conduct land verification since the image was registered in 2001.

3.3.1. Classification using eCognition software

3.3.1.1. Classification without texture

A requirement to have the boundaries of obtained objects not stepping over farmland boundaries in a given region was considered while selecting image segmentation parameters. Optimal parameters including: scale = 10, colour = 0.8, smoothness = 0.9 and compactness = 0.1, were applied after many trial runs. Unfortunately, this segmentation resulted in division of the existing farmlands into a multitude of small objects.

A few training fields were entered in each category in such way that all the objects located inside the area of a given category were combined into one object.

Following object features were taken into consideration for classification:

- mean values of spectral response in various channels
- standard deviation values of spectral response in various channels
- brightness (mean value of all the object spectral values from all channels
- Max. Diff. (difference between maximum and minimum mean value of channels for a given object, divided by brightness)
- ratio (mean value of the object given channel, divided by the sum of mean values for all channels).

Thus the result obtained after the classification of uncompressed image was found satisfactory (it was confirmed upon comparison of the classification result with a visual image interpretation, as well as based on acquaintance with classification stability values (section 4.3) generated by eCognition for all classified objects).

Then a classification of the compressed images was performed. Since it was found that the changes in classification results are insignificant upon using the minimum compression of the image (ratios 12, 11), then the classification was conducted with compression ratios of 9, 7, 4 and 1 (Photoshop). The same parameters were applied in the process of image segmentation for both uncompressed image and each degree of compression, as well as the same categories and areas of training fields. Obtaining the identical areas of training fields on compressed images was not directly possible since the area boundaries were changed after segmentation. This was achieved by application of the object dividing and linking functions.

Comparison of the results for uncompressed and compressed image classification showed little difference (Fig. 2).

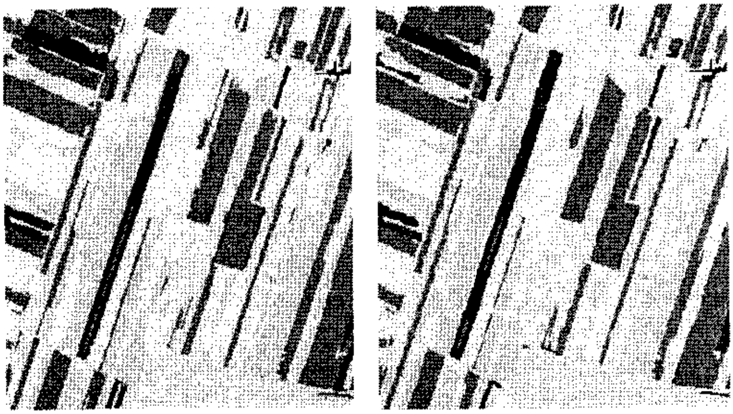


Fig. 2. Result of classification of uncompressed image (on the left) vs. image compressed to a relatively high degree (compression ratio of 4) (see this figure in natural colors in enclosure)

3.3.1.2 Classification using texture features

Classification methods applied earlier used solely spectral values of separate image channels. Subsequent trials were developed by adding the features which describe texture, or spatial distribution of the shades of grey within the image channels.

Trials involving applications of features based on subordinate objects did not bring satisfactory results; it could be explained by the texture of farmlands being a subject of this research (small grain and heterogeneous crops). Upon multiple trials to apply features based on the event matrix, the best results were derived by using all properties calculated from GLDV vector, but only in directions marked 45° and 135° (these directions resulted from a specific pattern of farm fields in the test region). New training fields were applied for texture experiments.

Quite significant changes of results were observed when minimum image compression (ratio of 12) has been applied during initial classification (Fig. 3).

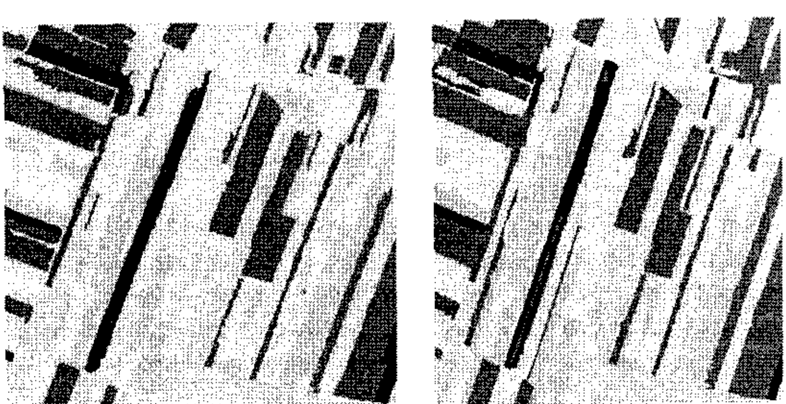


Fig. 3. Results of classification with application of texture in uncompressed image (on the left) and the least compressed image with ratio of 12 (on the right) (see this figure in natural colors in enclosure)

Despite distinct deterioration of the classification results when applying textural features, a decision was made to continue further research using this method. When comparing the classification results obtained with application of textural features with straight classification and with the results derived from manual photo interpretation, one could attempt an conclusion that the application of texture in case of farmland category located within the test region was contributing to a better recognition of the spring grains category. At that time of year those regions were covered with thin vegetation, although uniformly distributed (this couldn't be observed at 2.4 m pixel), but showing various rate of growth throughout regions of fields. This local variation of the degree of growth formed a certain texture, helpful in the classification of farmland.

Since the results of compressed images were deteriorating quickly, the following new images, different from previous ones, were taken for classification: uncompressed image, the least compressed image (ratio of 12), intermediate compressed images (ratios of 11, 10, 9, 7), and finally an image with compression ratio of 4.

3.3.2. Classification using Idrisi32 software

Since it was decided to research those training fields used before with eCognition software for classification without application of texture, a vector file showing boundaries of applied training fields was imported into Idrisi32 software. Based on that the standards of five classes were derived while calculating statistical parameters for each category. Sizes of the training fields were the same for all images taken for analysis (which is easy to do in Idrisi32 software), however, the class standards were individually calculated for each image (original one and those degraded by compression). The images were classified upon proper marking.

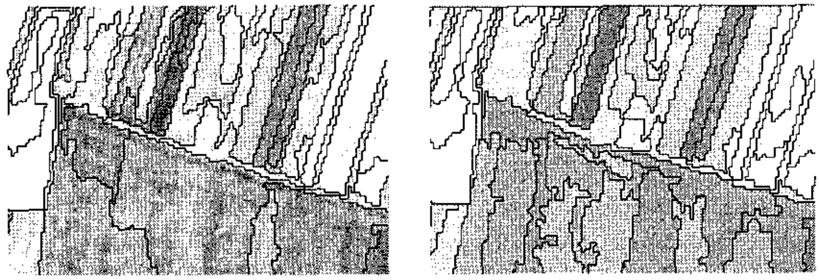
The obtained results were showing that compression does not have an adverse influence on the classification result. Differences between the images obtained after classification were quite small.

4. ANALYSIS OF OBTAINED CLASSIFICATION RESULTS

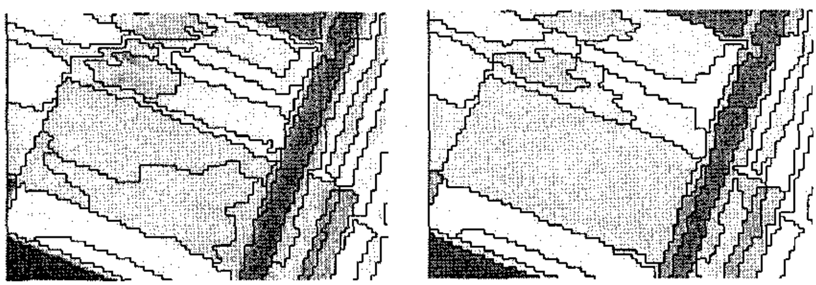
4.1. EFFECT OF COMPRESSION ON SEGMENTATION RESULTS USING ECOGNITION SOFTWARE

The compression of images taken for segmentation process affects greatly not only shape of the obtained objects but also their number. Fig. 4 shows the objects formed within identical segmentation parameters in uncompressed images as well as in images with the least compression (ratio of 12). It is evident that more objects could be formed in compressed images (example a) as well as less objects (example b).

This differentiation is progressing as the compression gets higher. This was shown in Fig. 5 where the segment summed up line lengths (calculated in pixels), derived from



a) image without compression image with compression (12)



b) image without compression image with compression (12)

Fig. 4. Examples of various numbers of objects formed within segmentation process in uncompressed and compressed images

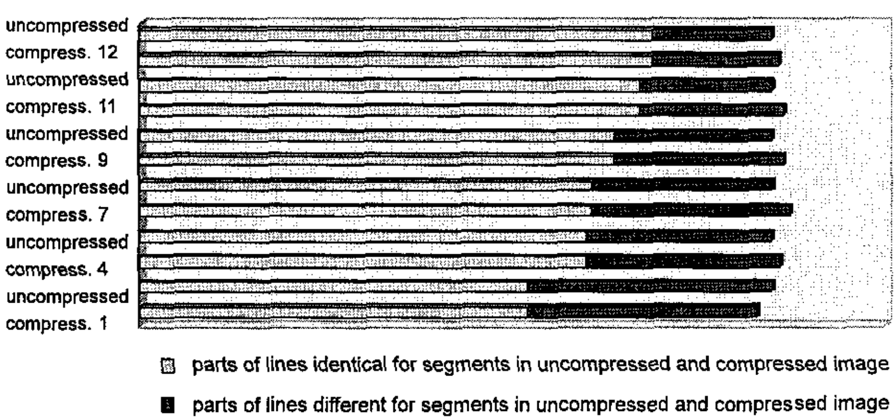


Fig. 5. Comparison of lengths of lines forming the segments in uncompressed images and those with varying degree of compression.

uncompressed images and those with various ratios of compression, were setup in pairs (each showing two subsequent bars).

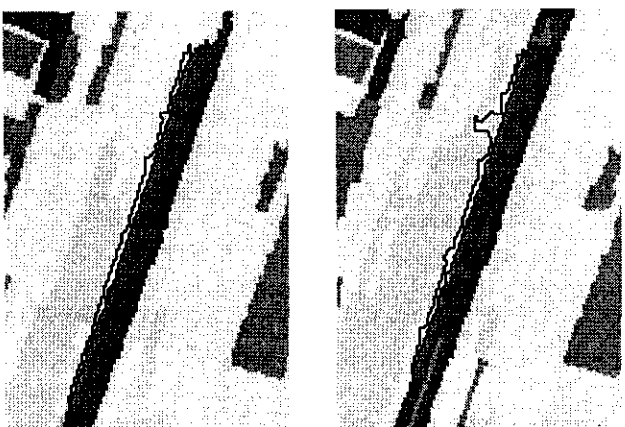
Lets note that identical sections of lines (bright portions of bars), for the images with the least compression (ratio of 12) and those without compression, amount to about 80%

of their total lengths. As the degree of compression increases, this value drops to about 60% for a compression with the ratio of 1 (the highest).

In addition, we could say that in majority of cases the lines forming segments in compressed images are longer than in uncompressed images (with exception of compression of 1).

High degree of compression is also disadvantageous to the shape of objects after segmentation — in case of the highest compression (ratio of 1) the segment lines are clearly matching the 8-pixel portions of the compressed image.

Changed shape and size of objects after the segmentation was performed on compressed pictures may have influence on proper classification of objects. Fig. 6 shows one example. Segmentation done in uncompressed images rendered the shape of balk correctly — upon segmentation this object was long, narrow and over imposed on the balk area, therefore it was classified to the proper category. Upon segmentation of slightly compressed image *(ratio of 12), this object changed its shape, partly combining with the adjacent farmlands,* and as a result, it was allocated to the neighbouring farmland.



balk on uncompressed image **balk on image compressed with ratio of 12, allocated to the neighbouring farmland**

Fig. 6. Change of the object classification after its shape was changed in the segmentation process (see this figure in natural colors in enclosure)

4.2. DESCRIPTION OF APPLIED STATISTICAL METHODS FOR EVALUATION OF CLASSIFICATION RESULTS

Among other things, quality of classification may be assessed in eCognition based on *stability* parameter calculated as a difference between probability of assignment (values from 0 to 1) for a particular object in relation to classified category (the highest assignment), and probability of classifying that object to another category (second in turn assignment). The smaller is the difference (stability), the lower becomes the confidence in the result of classification.

The software allows to visualize stability values for all the objects, rendering high stability in green, and then going through yellow shades (intermediate stability values) to red (thus interpreting classification low confidence objects). By comparing the representations (or their numerical sets) of stability values one could assess the effect of image compression on the classification result.

Another method to determine the effect of image compression on classification results can involve comparison of the obtained arrangement representations of various classes. The images obtained after classification could be analyzed visually, but not only this way. A crosstab function in Idrisi32 software was utilized in order to compare numbers of pixels affiliated with the same classes after uncompressed image classification with the results of classification done for compressed images.

This function allows to compare two images with each other. It calculates a number of pixels belonging to each class, and then categories of one image (farmland class in this case) are compared with the same relevant categories of the other image. The results are shown in table, where number of cells relates to the number of category combinations. The number of pixels belonging to the same class in both images is shown on a diagonal line. The other cells contain numbers of pixels which were transferred from a particular class in the first image to another class in the second image. Results of classification of images compressed to varying degrees with uncompressed images were compared during conducted research.

4.3. EVALUATION OF STABILITY FACTOR

Values of stability factor calculated by the eCognition software are shown in Figure 7. Each graph corresponds to the above described iterations of calculations (with and without consideration of textural features), while particular groups of bars correspond to five selected classes of farmlands.

Analysis of graphs indicates varying behaviours of stability factor for different classes of farmlands. However, one could notice certain trends.

In case of classification without introduction of textural features there are small changes of classification stability in compressed image when compared with the uncompressed one. Those differences do not exceed a few percentage points (sometimes 1% or 2%; and exceptionally around 5%).

In case of classification with consideration of textural features, except for two instances (class 1 with compression ratio of 11 and class 3 with compression ratio of 7), one can distinguish a following rule: stability factor (equivalent to the degree of confidence in classification results) will decrease in steps if we perform classification of the image compressed even with the least compression ratio of 12. It could be observed from graphs that further increase of compression results in rather small changes, therefore a compression of multispectral image certainly lowers a degree of confidence in classification results.

The above observations are well illustrated in Fig. 8 and Fig. 9 showing representations of stability factor. Green colour in these graphs denotes objects showing high stability values, yellow — intermediate stability values, and red marks objects showing low confidence in classification. It could be clearly observed that upon consideration of textural

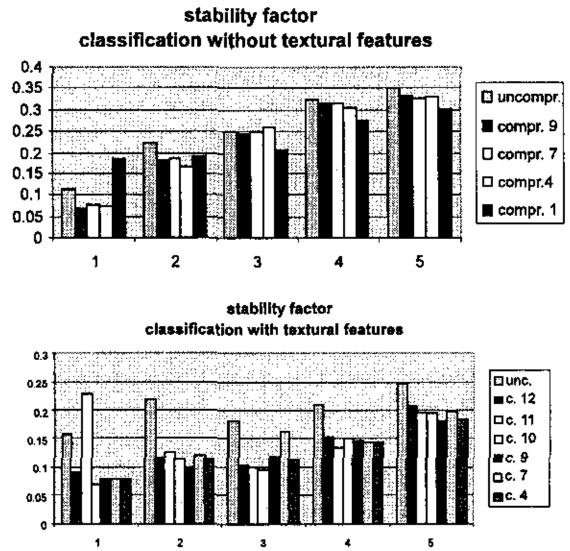


Fig. 7. Stability factor values for various classification methods

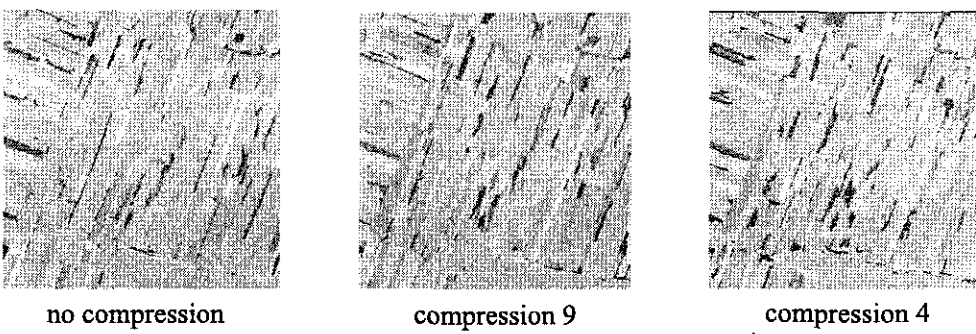


Fig. 8. Representation of stability factor in case textural features of objects were not considered (see this figure in natural colors in enclosure)

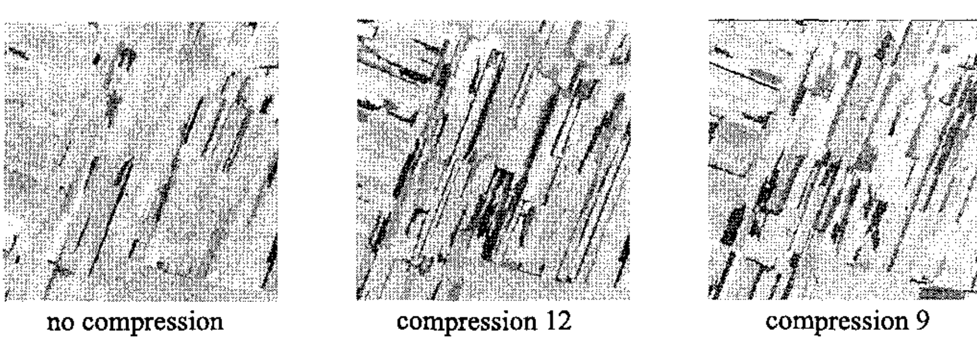


Fig. 9. Representation of stability factor in case textural features of objects were considered (see this figure in natural colors in enclosure)

features, the yellow and red areas are considerably larger in the least compressed images (compression ratio of 12) than in the image with compression ratio of 4, where classification was performed without entering textural properties.

4.4. COMPARISON OF OBTAINED VARIOUS CLASS ARRANGEMENTS

As previously described, an analysis was conducted to show by how much the application of compressed image for classification would change the affiliation of various pixels a particular class. This analysis results were shown on graphs (Figures 10 through 12).

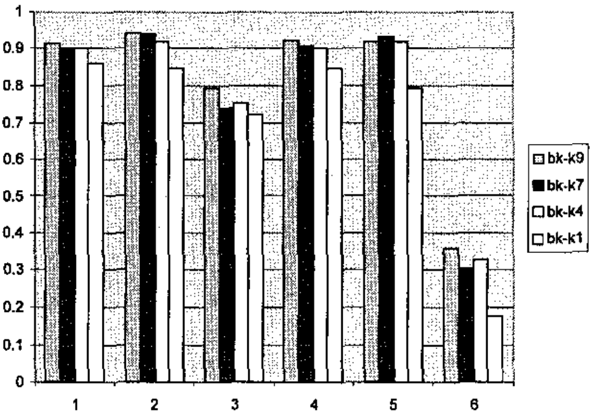


Fig. 10. Numbers of pixels reproduced in the same classes during object classification done with eCognition for various degrees of compression (k1 ... k9) in relation to uncompressed image (ratio of 1), without consideration of texture. Class 6 denotes unclassified objects

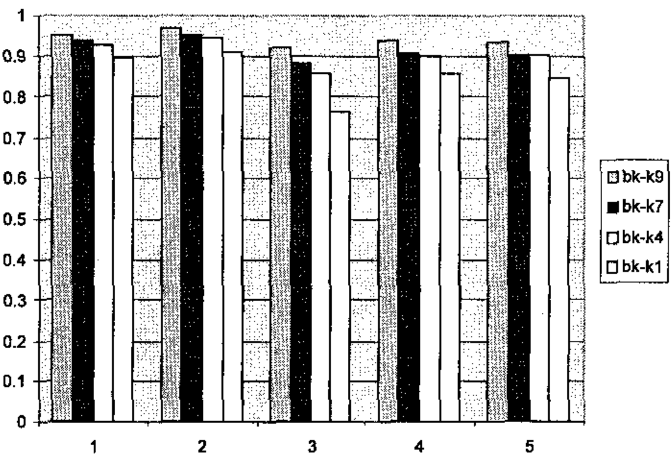


Fig. 11. Numbers of pixels reproduced in the same classes during pixel classification done with Idrisi32 for various degrees of compression (k1 ... k9) in relation to uncompressed image (ratio of 1), without consideration of texture

In case of classification without considering the texture, a slight deterioration of results was confirmed upon application of compressed images in both eCognition and Idrisi32 software programs. However the difference was not significant. Number of pixels affiliated with a different class upon using compression ratio of 9 was a few percentage points (5 to 8%) for four classes in eCognition software (Fig. 10) and all of them in Idrisi32 software (Fig. 11). The number of pixel affiliated differently did not increase by a lot when images with higher compressions were used.

Number of pixels affiliated differently after classification done with consideration of textural features in compressed images (Fig. 12) is higher than in case of classification without addition of texture. At the very minimum compression (ratio of 12) this number equals a few percent for class five, however, for class two it grows to over 10%, for classes one and four approaches to 20%, and in case of class three reaches almost 30%.

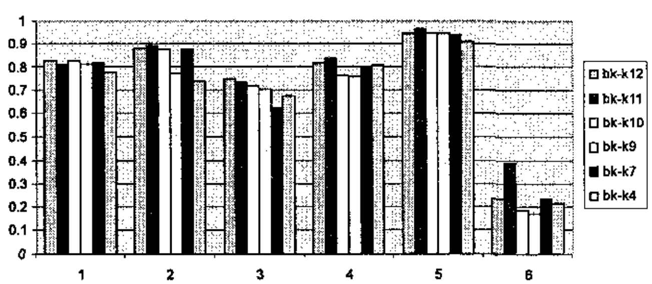


Fig. 12. Numbers of pixels reproduced in the same classes during object classification done with eCognition for various degrees of compression (k1 ... k9) in relation to uncompressed image (ratio of 1), with consideration of texture. Class 6 denotes unclassified objects

Fig. 13 shows comparison of the ratio of pixels affiliated with the same class, upon classification without and with texture. This setting shows the results of classification of images degraded by compression having ratios of 9 and 4.

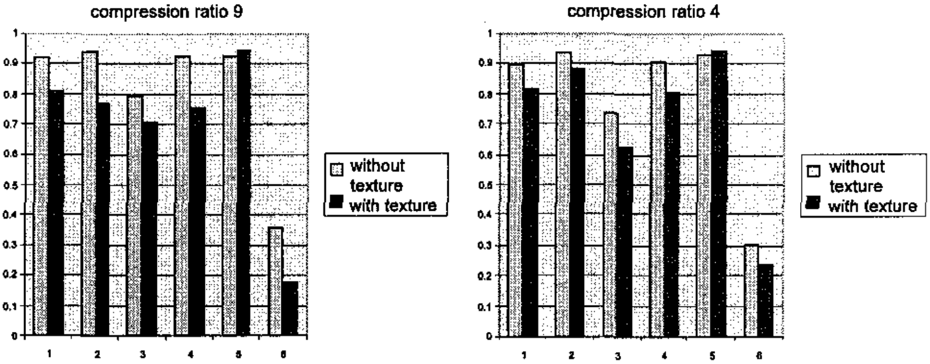


Fig. 13 Comparison of the ratio of pixels affiliated with the same class, upon classification without and with texture as related to uncompressed image (value of 1) for the selected compression ratios (9 and 4)

This comparison leads to conclusion that for the classification using features of texture renders worse results for compressed images (except for class five, or moist soil).

Both stability factor analysis and analysis of pixel assignment to particular classes indicate degradation of image texture even at its very minimum compression.

6. CONCLUSIONS

Classification performed using the pixel method as well as taking advantage of initial segmentation but without consideration of features connected to the image texture, does not vary with compression, even if the compression ratio of 4 is applied (Photoshop). Degree of consistence depends on the type of farmland.

Object classification, performed with the use of textural information is quite sensitive to image compression, since the results are getting worse even at the least compressed images (ratio of 12 — Photoshop).

When considering all types of classifications using object method, one could notice that regardless of application of texture the number of pixels in *unclassified* category drops significantly upon the use of compression (by 20 to 30%) in comparison with the classification without any compression. This means that the other left out pixels are assigned to other categories instead of remaining rather unclassified.

In conclusion of the described research it is recommended to perform classification in uncompressed images, particularly in cases when the application of image textural features is necessary in order to improve the classification results.

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INFLUENCE OF COMPRESSION ON RESULTS OF FARMLAND CLASSIFICATION IN MULTISPECTRAL SATELLITE IMAGES

SUMMARY

The purpose of this research was to get answer to the question whether and to what degree the compression influences results of classification of agricultural uses. The paper includes four parts — the first part reminds theoretical basis concerning image classification, the second part contains description of applied software as well as conducted research. In next part the classification process was described, and the last part concerns analyses and opinions of received results.

Multispectral image classification can be done by dividing the image into groups of pixels having some similar features in all component channels. Initially a pixel classification was mainly applied, while recently object classification methods are winning wider appreciation.

The purpose of this research was to compare classification results of high resolution satellite images (QuickBird) rendered on uncompressed images with those degraded due to the application of JPEG lossy compression. Seven degrees of compression were applied; from a minimum compression resulting in the highest volume of files (compression ratio of 12 according to Photoshop software evaluation), throughout intermediate compression (ratios of 11, 10, 9, 7, 4 according to Photoshop), and up to almost maximum compression (ratio of 1 according to Photoshop software).

A fragment of scene from QuickBird satellite encompassing farmlands was used for this research. The test region was the image fragment (Fig. 1), on which according to a visual interpretation, five categories of farmland were selected. Pixel classification and object classification was conducted using two methods: with and without image texture (spatial distribution of the shades of grey within the image channels) being taken into account. Two software were used: in Idrisi32 was executed pixel classification; object classification was conducted in eCognition software. In both software the same samples of training fields were used, which were characterized selected categories of farmland.

In object oriented approach a region is divided on segments with consideration of parameters defined by user. A few training fields were entered in each category, in such way, that all the objects located inside the area of a given category were combined into one object.

Analysis of classification results begins with observation of compression influence onto result of segmentation. It was noticed, that compression has large influence not only onto the shape of segmented objects, but also onto the number of them (fig. 4 and 5).

The evaluation of classification results was conducted two ways. In first approach parameter "stability accessible in software eCognition was used. This parameter calculated as a difference between probability of assignment (values from 0 to 1) for a particular object in relation to classified category (the highest assignment), and probability of classifying that object to another category (second in turn assignment). In case of classification without introduction of textural features there are small changes of classification stability in compressed image when compared with the uncompressed one (Fig. 7 and 8). Those differences do not exceed a few percentage points. In case of classification with consideration of textural features, stability factor will decrease stepwise already on an image compressed even with the smallest compression factor (Fig. 7 and 8). However at increase of compression factor the changes are rather small, therefore a compression of multispectral image certainly lowers a degree of confidence in classification results.

Another method to determine the effect of image compression on classification results can involve comparison of the obtained arrangement representations of various classes. Results of uncompressed images were compared with results of classification of images with different coefficients of compression. A crosstab function in Idrisi32 software was used in order to compare number of pixels affiliated to selected categories during classification of

noncompressed and compressed in various degree images. This function allows to compare two images with each other. In case of classification without considering the texture, a slight deterioration of results was confirmed upon application of compressed images in both pixel and object method (Fig. 2, 10, 11 and 13). The classification using features of texture renders worse results for compressed images. Both stability factor analysis and analysis of pixel assignment to particular classes indicate degradation of image texture even at its very minimum compression (Fig. 12 and 13).

Based on conducted research it was possible to affirm, that classification performed using the pixel method as well as taking advantage of initial segmentation, but without consideration of features connected to the image texture, does not vary with compression. On the other hand, the object classification, executed using texture information, is very sensitive onto compression of images, which worsens result even at minimum compression.

When considering all types of classifications using object method, one could notice that, regardless of application of texture, the number of pixels in *unclassified* category drops significantly upon the use of compression (by 20 to 30%) in comparison with the classification without any compression. This means that the left out pixels are assigned to other categories instead of remaining rather unclassified.

In conclusion of the described research it is recommended to perform classification in uncompressed images, particularly in cases when the application of image textural features is necessary in order to improve the classification results.

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WPŁYW KOMPRESJI NA WYNIKI KLASYFIKACJI UŻYTKÓW ROLNYCH NA WIELOSPEKTRALNYCH OBRAZACH SATELITARNYCH

STRESZCZENIE

Celem badań była odpowiedź na pytanie czy i w jakim stopniu kompresja wpływa na rezultat klasyfikacji użytków rolnych. W artykule można rozróżnić cztery części. W pierwszej części przypomniano podstawy teoretyczne rodzajów klasyfikacji obrazów. W kolejnej drugiej części scharakteryzowano oprogramowanie oraz materiały wykorzystane do przeprowadzenia klasyfikacji. W następnej części omówiono przebieg badań dotyczących klasyfikacji. Natomiast ostatnia najobszerniejsza czwarta część dotyczy analizy i oceny otrzymanych wyników.

Klasyfikacja obrazu wielospektralnego polega na podzieleniu obrazu na grupy pikseli mające pewne cechy podobne we wszystkich kanałach składowych. Pierwotnie stosowano klasyfikację pikselową, natomiast ostatnio coraz większe uznanie zdobywają metody klasyfikacji obiektowej.

W czasie badań porównywano wyniki klasyfikacji wysokorozdzielczych obrazów satelitarnych (OuickBird) wykonywanej na obrazach nieskompresowanych oraz na obrazach zdegradowanych poprzez zastosowanie kompresji stratnej JPEG. Zastosowano siedem stopni kompresji: od kompresji minimalnej, dającej największą pojemność plików (wg programu Photoshop współczynnik 12) poprzez pośrednie stopnie (wg programu Photoshop: 11, 10, 9, 7, 4) do kompresji prawie maksymalnej (wg. programu Photoshop współczynnik 1).

Obszarem testowym był fragment obrazu zawierający głównie użytki rolne (rys. 1), na którym wizualnie wydzielono pięć kategorii użytków. Przeprowadzono klasyczną klasyfikację pikselową oraz klasyfikację obiektową

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dwiema metodami: z wykorzystaniem i bez wykorzystania tekstury obrazu, czyli przestrzennego rozmieszczenia odcieni szarości na obrazie. Wykorzystano dwa programy: w programie Idrisi32 wykonano klasyfikację pikselową, natomiast klasyfikację obiektową przeprowadzono w eCognition. W obydwu programach wykorzystano te same obszary pól treningowych charakteryzujących wydzielone kategorie użytków.

W podejściu obiektowym obszar początkowo dzielony jest na segmenty z uwzględnieniem określonych przez użytkownika parametrów. Pola treningowe tworzono łącząc segmenty pokrywające wybrane użytki referencyjne.

Analizę klasyfikacji rozpoczęto od określenia wpływu kompresji na wynik segmentacji. Zauważono, że kompresja ma duży wpływ nie tylko na kształt uzyskanych obiektów, ale także na ich ilość (rys. 4 i 5).

Ocenę wyników klasyfikacji przeprowadzono dwoma sposobami. W pierwszym podejściu wykorzystano dostępny w programie eCognition parametr „stabilność". Parametr ten obliczany jest jako różnica pomiędzy prawdopodobieństwem przyporządkowania (wartości w przedziale od 0 do 1) danego obiektu do zaklasyfikowanej kategorii (najwyższe przyporządkowanie), a prawdopodobieństwem zaklasyfikowania tego obiektu do innej kategorii (drugie z kolei przyporządkowanie). Zauważono, że współczynnik stabilności dla poszczególnych klas użytków zachowuje się w sposób zróżnicowany. Dla klasyfikacji nie uwzględniającej cech teksturalnych następują niewielkie zmiany stabilności klasyfikacji wykonanej na obrazach skompresowanych w porównaniu z obrazem nieskompresowanym (rys. 7 i 8). Różnice przeważnie nie przekraczają kilku procent. Dla klasyfikacji uwzględniającej cechy teksturalne, wyraźnie współczynnik stabilności skokowo spada, już na obrazie skompresowanym o minimalnej kompresji (rys. 7 i 9). Natomiast przy zwiększaniu kompresji zmiany są już niewielkie, tak więc sam fakt kompresji obrazu wielospektralnego powoduje obniżenie stopnia zaufania do wyników klasyfikacji.

Do analizy wyników klasyfikacji wykorzystano również porównanie rozmieszczenia poszczególnych klas na uzyskanych obrazach. Porównano wyniki klasyfikacji obrazu nieskompresowanego z wynikami klasyfikacji obrazów o różnych współczynnikach kompresji. Do dokładnego porównania liczby pikseli zaklasyfikowanych do tych samych kategorii wykorzystano funkcję *crosstab* w programie Idrisi32. Funkcja ta porównuje ze sobą dwa obrazy. Dla klasyfikacji nieuwzględniającej tekstury, wykonanej zarówno metodą pikselową i obiektową, stwierdzono niewielkie pogorszenie wyników po zastosowaniu obrazów skompresowanych (rys. 2, 10, 11 i 13). Klasyfikacja wykorzystująca cechy tekstury daje dla obrazów skompresowanych gorsze wyniki, niż bez uwzględniania tekstury. Zarówno analiza współczynnika stabilności jak i analiza przyporządkowania pikseli do poszczególnych klas wskazują, zatem, że nawet minimalna kompresja obrazu często degraduje jego teksturę (rys. 3, 12 i 13).

Na podstawie przeprowadzonych badań można stwierdzić, że klasyfikacja prowadzona zarówno metodą pikselową, jak i z wykorzystaniem wstępnej segmentacji, nie wykorzystująca cech związanych z teksturą obrazu, w niewielkim stopniu reaguje na kompresję. Natomiast klasyfikacja obiektowa, wykonywana z wykorzystaniem informacji tekturowej, jest bardzo czuła na kompresję obrazów, która pogarsza wynik nawet przy minimalnej kompresji.

Odnośnie wszystkich klasyfikacji wykonanych metodą obiektową, niezależnie od stosowania tekstury, można zauważyć, że w porównaniu z klasyfikacją bez kompresji, wybitnie spada (20 do 30%) ilość pikseli w kategorii *niesklasyfikowane* po zastosowaniu kompresji. Oznacza to, że pozostałe piksele zamiast pozostać niesklasyfikowane, zostają włączone do innych kategorii.

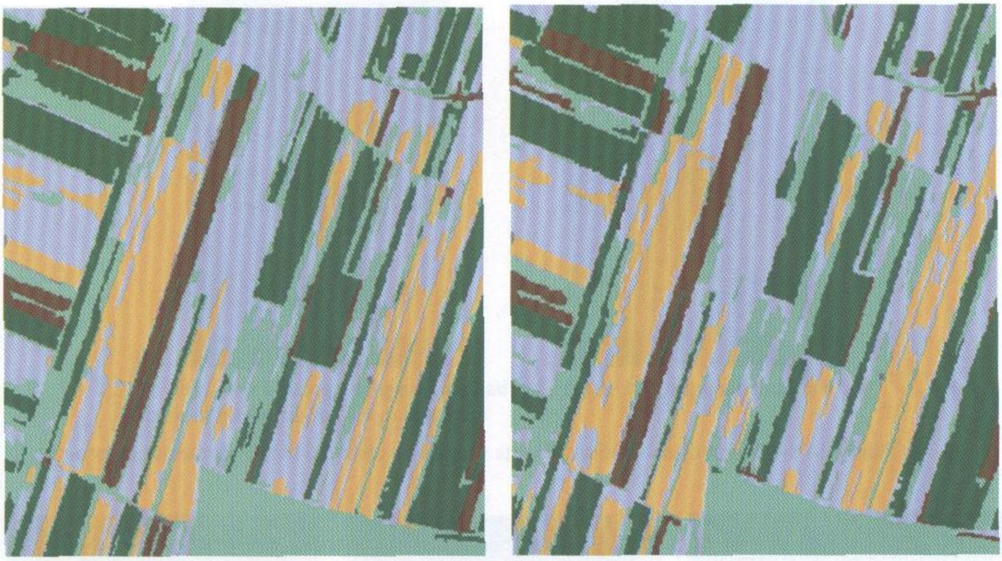


Fig. 2. Result of classification of uncompressed image (on the left) vs. image compressed to a relatively high degree (compression ratio of 4)

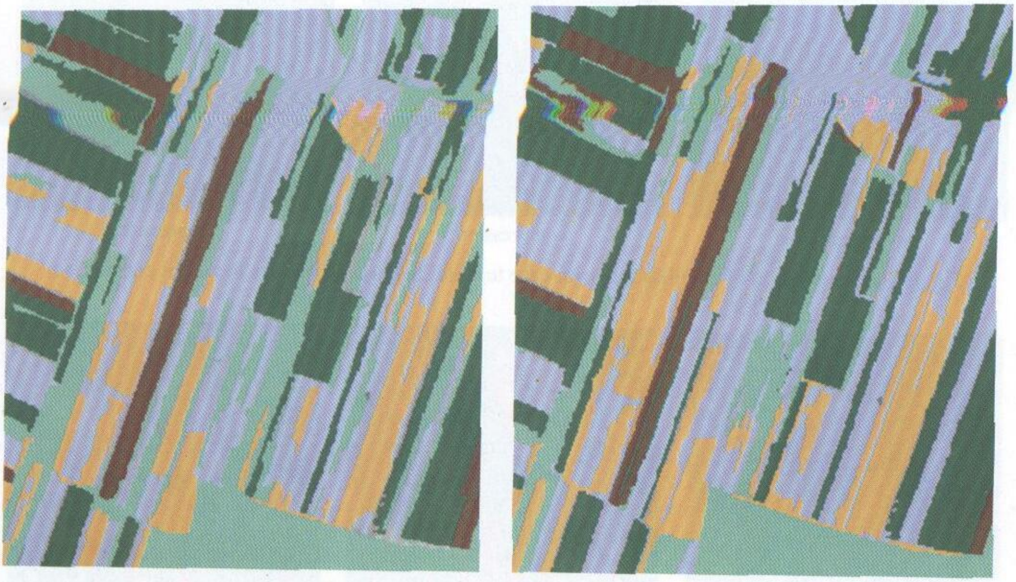
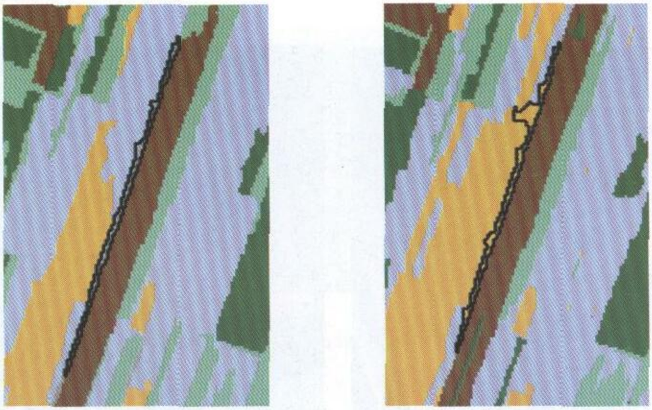
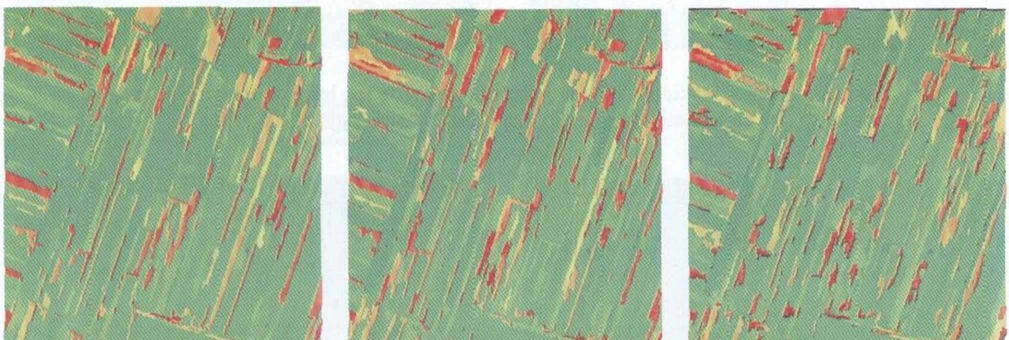


Fig. 3. Results of classification with application of texture in uncompressed image (on the left) and the least compressed image with ratio of 12 (on the right)



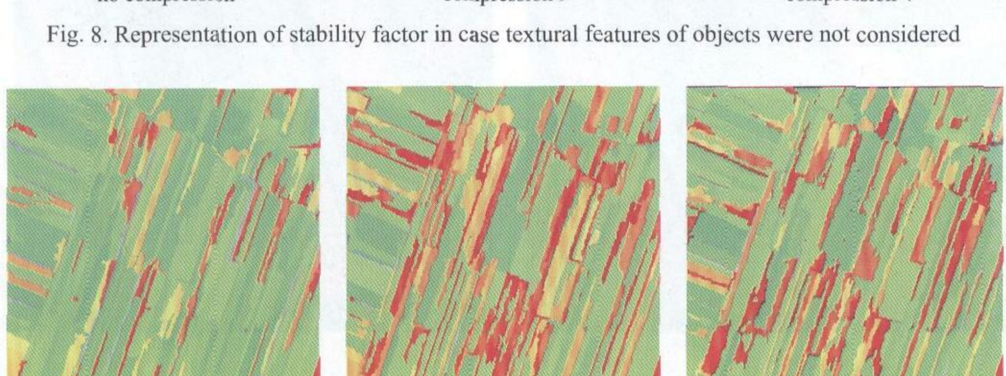
balk on uncompressed image — balk on image compressed with ratio of 12, allocated to the neighbouring farmland

Fig. 6. Change of the object classification after its shape was changed in the segmentation process



no compression — compression 9 — compression 4

Fig. 8. Representation of stability factor in case textural features of objects were not considered



no compression — compression 12 — compression 7

Fig. 9. Representation of stability factor in case textural features of objects were considered