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**COMPARISON OF PIXEL TO PIXEL AND OBJECT BASED IMAGE ANALYSIS
WITH USING WORLDVIEW-2 SATELLITE IMAGES
OF YANGIOBOD VILLAGE OF SYRDARYA PROVINCE**

ABSTRACT

Currently, more than 300 satellites have been launched into space and providing us with information about the Earth and processes which happens in there. Those information is very useful in all branches. These satellites started to modify and modernize year by year. Especially after 2000, satellites of very high resolution were launched into space. These satellites are sending information with very high resolution. To improve the speed and accuracy of the analysis of these images, scientists have developed a number of methods and programs. As a result, users often find face to difficulties with knowing which method or program is most effective. In this article, analyzed many researches and scientific studies and analyzed WorldView-2 (WV2) images of the Syrdarya Province based on field experiments and outlined the advantages and disadvantages of the method and tool. WV2 images are very important and provide much relevant data for all image analysis. VHR of these images can increase the quality and possibilities of all analysis. But usage of these images globally has not developed because of their costs. Square of satellite image capturing is very little for global analysis. to do global analysis we need 100 s of this image. That is why scientists use this data more often for correlation or creating general methods. That is why it has not been used for regional and global analysis. In our research, we used GEOBIA's eCognition software. The accuracy of this program is 95 %. In arid regions like Uzbekistan, we recommend optimal software, analyse steps and data.

KEYWORDS: remote sensing, Syrdarya, satellite, analyse, eCognition

INTRODUCTION

According to the literatures Remote Sensing (RS) data must be analyzed by a RS analysis program in order to convert it to digital format and obtain the necessary information. RS analysis program analyses use mainly two methods: Pixel to pixel analysis (PPA) and Geographic Object Based Image Analysis (GEOBIA). With the creation of very high resolution (VHR) images, the GEOBIA analysis method of RS analysis program is becoming popular. We will review the advantages of this method with its systematic construction and analysis categories in contrast with PPA in this chapter.

Until 2000, with the launching of VHR commercial satellites, PPA was mainly an analysis method in scientific research. Images of middle and low resolution also help to develop

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this method. Because in these images each pixel contains an object or collection of objects (e.g. MODIS image spectral resolution is 250 m, i.e. 1 pixel covers 250 m²). But spatial resolution of VHR images are very high (WorldView-2 (WV-2) multi 2.5 m, pan 0.5 m) and the group of many pixels gives us one object information and analyzing it by method based on pixels wastes more time and has errors. Scientists have come to the idea “why can we not analyse VHR images by objects?” [Blaschke *et al.*, 2014]. Thus, they started to use GEOBIA for VHR images analysis. This new method shows its advantage in the analysis of VHR images and over time it has become an important analysis method and developed a number of software. And it had been started to be used for high resolution and middle resolution image analysis. Many scientists did analytical research to compare these two methods [Drăguț *et al.*, 2010].

Fig. 1 provides information about the condition of analysis of these methods.

In accordance with the scientists’ conclusion, GEOBIA has big advantages for VHR images analysis [Blaschke, 2010; Drăguț *et al.*, 2010].

Because of pixel heterogeneity, mixed pixels, spectral similarity and object pattern variability of images, the traditional PPA method has errors. GEOBIA found the solution for this problem, with GEOBIA it is possible to analyze according to pixels properties [Peña-Barragán *et al.*, 2011].

The first “Visual image” in fig. 1 represents visual information of the object. The visualization was clearly demonstrated in the boundaries of the object. We did segmentation “Chess Board Segmentation” in the second image, “Image in pixel objects”. Now the visualization of the object disappeared and it is divided into a thousand of pixels. The boundaries of the object are uncertain and the visualization of image is poor. But now this image has partly visual and full pixel information. When we did “Multi Resolution Segmentation” of this image in the third figure, the visual information of the object restored. The pixel information is not separated now, it is formed into a pixel group which is specific to one particular object. As the result we have some homogeneous pixel groups of the object. Moreover, our segment objects acquired geometric textural and many other information like that (for example: geometric information — roads are lines, buildings are squared form, crop fields are in round form).

It should be noted that in eCognition Program it is possible to analyze both objects with images and pixels from top-view photos.

With GEOBIA it is possible to analyze images not only by their pixel features, there are also a number of properties such as texture or geometric properties which one can use for analysis [Navulur, 2006; Platt, 2014]. According to Blaschke’s conclusion, the GEOBIA method has the following advantages: it is fast, it is accurate, it is possible to analyze objects according to the different properties of these objects, it is possible to analyze images without changing the coordinates and it is possible to export the analysed data to GIS. Because of these advantages it becomes an obligatory utilizable method in RS analysis [Blaschke *et al.*, 2014].

Because, together with pixel features, texture and geometric features, VHR images are very important. In fig. 1 one may note the geometric peculiarities of the construction (straight lines, the smallest object, etc.). These features help to point out the lines of the objects and to classify them.

The other advantage of GEOBIA is the possibility to classify different objects into their own classes, in order to classify it into one class by their similarity at the end of the research [Leonhard, Ferrè, 2015]. And it is a cyclic analysing method helping pre-analyse the results.

Xiaohe compared pixel-based analysis and object-based analysis on the basis of extended scientific research and noted that using object-based image analysis is more effective for high-resolution images. He emphasized, “The object-oriented classification is the main method of high spatial resolute remote sensing” [Xiaohe *et al.*, 2014]. So, the number of GEOBIA analysed low and middle resolution images are very low.

Due to the above advantages, GEOBIA was preferred to use in our analysis.

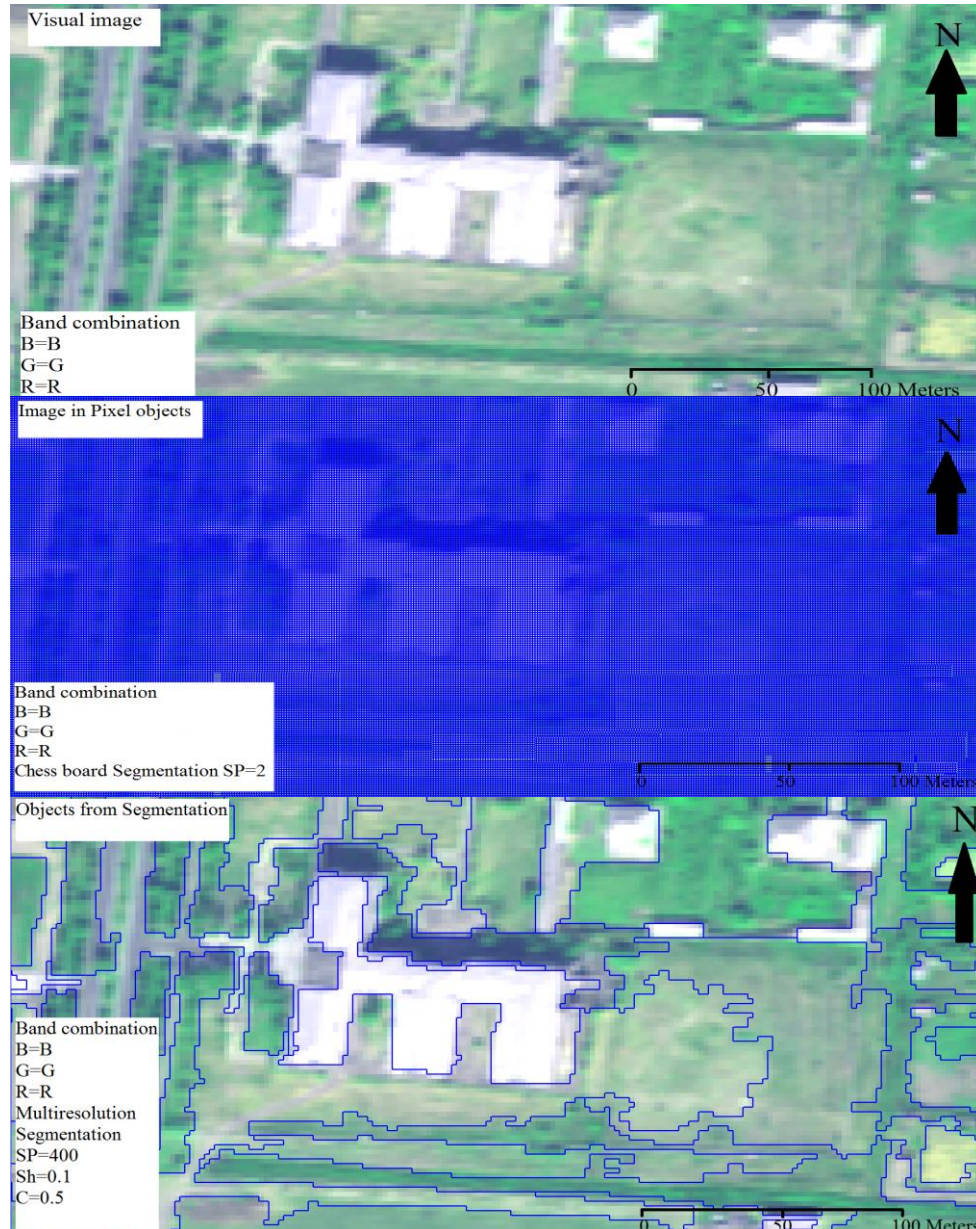


Fig. 1. Difference between pixels and object (WV2 image of Yangiobod college, 2012)

In the analysis object oriented image classification was used. This method of classification was successfully applied to high resolution remote sensing images by scientists [Zhou *et al.*, 2012]. Using spatial and spectral information of the images, and the analysis these images by objects (not by pixels) are the main advantages of this method. An object based hierarchical classification was created by using this method. In this hierarchy an algorithm of classification has been found from water to urban area. This classification was conducted using eCognition 9 software (<http://www.ecognition.com>). This commercial software was developed by Definiens (www.definiens.com) in Munich, Germany [Navulur, 2006]. Advantages of this software in comparison with other software in GEOBIA analysis, have been proven by many scientists. In their scientific research, they compared Erdas Imagine, ENVI and eCognition OBIA analysis programs according to their capabilities and from these programs eCognition software was recommended as a program with minimum errors and high accuracy [Jiaa *et al.*, 2013; Xiaohe *et al.*, 2014]. It is also confirmed in Ozdemir's doctoral work. In his work he

compared eCognition and Erdas Imagine programs, and gave facts about the advantages and disadvantages of this software, as a result of his scientific work he had decided to use eCognition in his analysis [Özdemir, 2013]. The advantage of using this program is an opportunity to apply over thousand properties for analysis. These properties are textural, geometric, areal, etc.

According to Gianinnetto 50 % of RS GEOBIA analysis in the scientific research has been carried out using the eCognition software. This value represents a big number of scientific work within widely used programs [Gianinnetto *et al.*, 2014]. Object based image classification involves three steps: 1) determination of appropriate segmentation parameters; 2) feature selection for the classification based on objects; 3) creation of classification rule sets or the application of a classification algorithm [Zhou *et al.*, 2012]. Those advantages made us use GEOBIA in our analysis.

MATERIALS AND METHODS OF RESEARCHES

All GEOBIA software and eCognition have two steps for analysing: segmentation and classification.

Segmentation

Segmentation is one of the most important stages in GEOBIA [Blaschke, 2010]. Segmentation is the creation of homogeneous objects based on pixel properties or other spatial and spectral criteria [Chen *et al.*, 2012]. This process is carried out by one of the following two ways in eCognition: a) top-down method — cutting big objects into smaller objects; b) bottom-up method is a contrary strategy to the previous method which is merging small objects to get a bigger object [Dao, Liou, 2015].

Top-down segmentation includes the following algorithm (User guide eCognition, 2014):

a) Chessboard Segmentation is the simplest algorithm based on dividing the image into mesh squares. The size of produced squares will be opted by the user. The disadvantage of this algorithm is that here the attention is focused on the equality of square sizes instead of the homogeneity of the object. The advantage is the ability of pixel segmentation of the object.

As it is seen in fig. 2, the object is divided into equal parts in between the white and black objects, but absolute white and black objects are not differentiated. To create these objects of Segment we used “Chess board Segmentation” algorithm and chose “Object size=2”.

b) Quadtree-Based Segmentation is a function similar to chessboard segmentation. But in this segmentation the divided square might be divided again in accordance with different colour. With the change of the scale parameter, the quantity of squares will be managed. The difference of it is in the colour composition. If the large square is green, it will be inserted into big cube. If the image includes numbers of objects of various colours in one point, they will be drawn a segment of the object with several cubes.

In fig. 3 one can see that how the big homogeneous part of the image is divided into big segments, and dense non-homogeneous objects are divided into small and micro segments. This analysis program is mostly used in VHR images, because sometimes in these images the huge homogeneous area and gathered tiny non-homogeneous objects might be seen, e.g., urban area in the middle of wide fields [Navulur, 2006].

c) Contrast Split Segmentation is similar to the multi-threshold approach. The contrast split the scene into dark and bright image objects based on a threshold value that maximizes the contrast between them. The algorithm evaluates the optimal threshold separately for each image object in the domain. Initially, it executes a chessboard segmentation of variable scale and then performs the split on each square, in case the pixel level is selected in the domain. Several basic parameters might be selected, the primary ones being the layer of interest and the classes you want to assign to dark and bright objects. Optimal thresholds for splitting and the contrast can be stored in scene variables. Firstly, the image was segmented into squares, and then were divided into separate non-homogeneous zones which are not related to homogeneous objects.



Fig. 2. Result of Chessboard Segmentation (WV2 image of Yangiobod college, 2012)

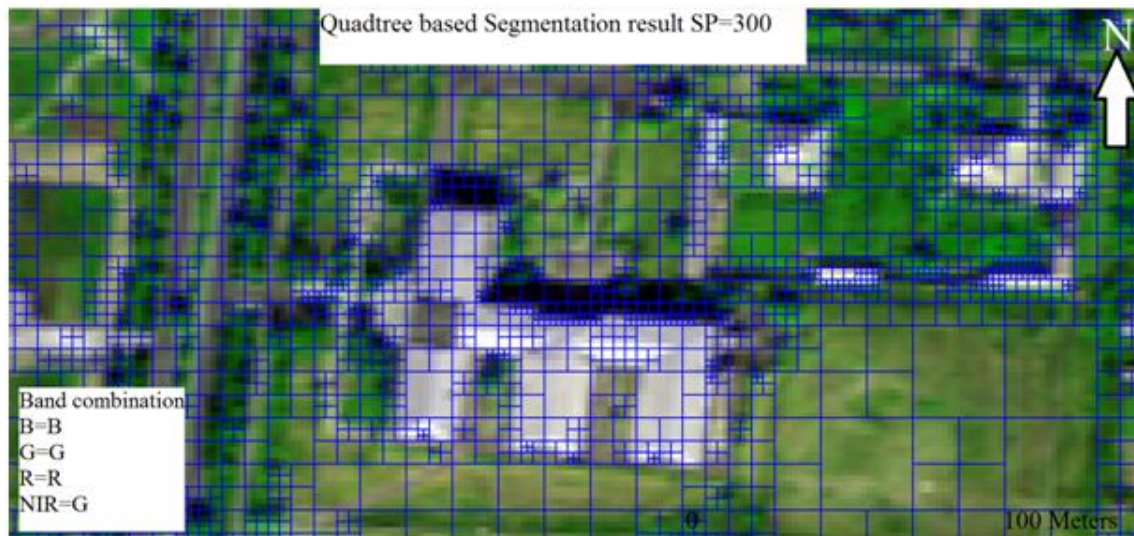


Fig. 3. Result of Quadtree-Based Segmentation (WV-2 image of Yangiobod college, 2012)

Bottom-up Segmentation algorithms are the following [Dao, Liou, 2015]:

a) Multi-Threshold Segmentation and Auto Thresholds algorithms split the image object domain and classify the resulting image objects based on a defined pixel value threshold. This threshold can be user-defined or can be auto-adaptive while used in combination with the Automatic Threshold algorithm. The threshold can be determined for an entire scene or for individual image objects; this determines whether it is stored in a scene variable or an object variable, adding the selected set of pixels in to two subsets so that heterogeneity is increased to a maximum. The algorithm uses a combination of histogram-based methods and the homogeneous measurement of multi-resolution segmentation to calculate a threshold adding the selected set of pixels into two subsets.

b) Spectral Difference Segmentation allows merging neighboring image objects if the difference between their layer mean intensities is below the value given by the maximum spectral difference. It is designed to refine existing segmentation results, by merging spectrally

similar image objects produced by previous segmentations and therefore it is bottom-up segmentation.

c) Multiresolution Segmentation consecutively merges pixels or existing image objects. Essentially, the procedure identifies single image objects of one pixel in size and merges them with their neighbors, based on relative homogeneity criteria. This homogeneity criterion is a combination of spectral and shape criteria.

We can modify this calculation by modifying the scale parameter. Higher values for the scale parameter result in larger image objects, smaller values in smaller ones.

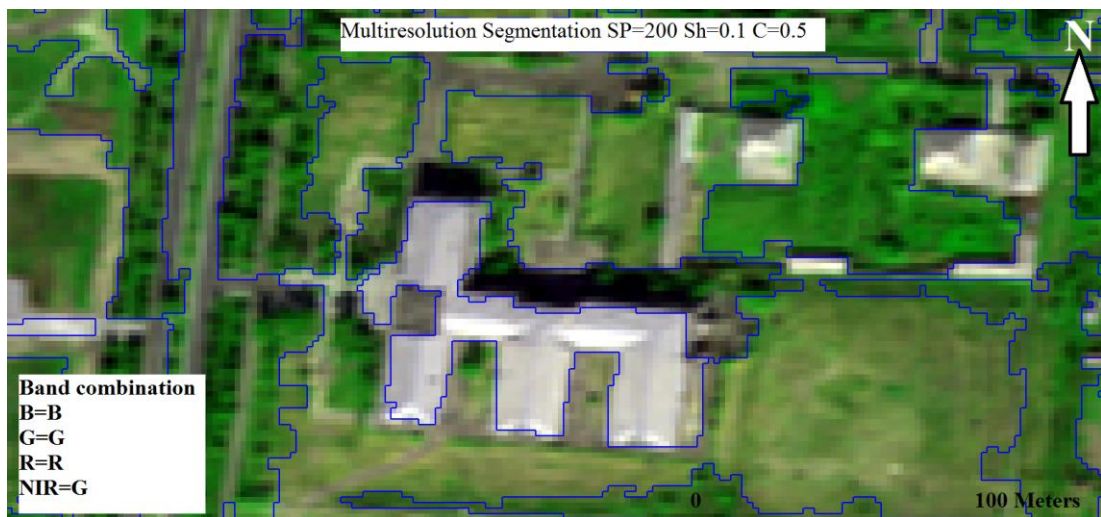


Fig. 4. Results of Multiresolution Segmentation (WV2 image of Yangiobod college, 2012)

As it is seen from fig. 4, absolute black and white objects are segmented into separate objects, by this the homogeneity of the segmentation procedure is provided. In accordance with homogeneity in image, objects might have various shapes.

In segmentation the heterogeneity criterion is controlled by the user. It is provided with changing number's value by four parameters and with visual observation it is possible to get homogeneous images of object segments from any images with different resolutions [Veróné-Wojtaszek, Ronczyk, 2012]. Algorithms of this eCognition software create image segments according to the following four criteria [Navulur, 2006]:

- scale — provides heterogeneity of the pixel;
- colour — provides homogeneity between shape and segments;
- smoothness — provides smoothness of the border of a segment;
- compactness — provides compactness of segment borders.

Regardless which type of Segmentation algorithms is used, it is obligatory to provide high homogeneity, to make it possible to change criteria of segmentation and controlling process by user. Selection of the appropriate segmentation process provides the accuracy of the results. Many scientists recommended multi resolution segmentation algorithms for scientific analysis and they used the same segmentation algorithms in their work and got high accuracy results [Blaschke, 2010; Veróné-Wojtaszek M., Ronczyk, 2012; Zhou et al., 2012; Kokje, Gao, 2013].

As it is known from the reviews above, the multiresolution segmentation algorithm provides high homogeneity in analysis. Furthermore, the user will control the results, the accuracy and direction of the segmentation categories. And we have chosen this segmentation parameter to enable the user's control and the creation of segments in accordance with homogeneity [in the same works]. The image layers of the research area are in different scales, e.g. layer WV2 PAN is 0.5 m, and MS bands are 2.5 m. Besides, the image includes objects of

various shapes and sizes. Because of these limitations the more automated Top-down segmentation algorithm distorts the result. But they might be useful to segment the image at the beginning into pixels and then gather them into one object. Segmentation points out the details that did not receive attention. We get homogeneous objects in all our analyses by changing the segment parameters.

Classification

In eCognition the classification of the algorithm is divided into two groups: Basic Classification Algorithms and Advanced Classification Algorithms. Objects of Basic Classification Algorithms images are divided into various classes in accordance with their features; Advanced Classification Algorithms are intended for the specific assignment of classification and to identify the connections between objects. And we used Basic Classification Algorithms in our classification. These groups content of algorithms: assign class, classification and hierarchical classification. The simplest algorithm among them is assign class algorithm which gives an opportunity to create numbers of other class algorithms.

According to the direction the classification divides into Supervised and Unsupervised classifications. We have chosen supervised classification for our analyses, because unsupervised classification is realized automatically on the basis of given definite algorithm. Supervised algorithm allows controlling the results of each degree, so the accuracy of the results depends on the user's attention. The advantage of this classification is that all the classes are chosen by the user. The process is carried out under the terms and conditions entered by the user. The accuracy of the analysis depends on the knowledge of users about classified objects and according to the quality of knowledge of the class objects analysis accuracy varies. As we have images, GPS and GIS maps of the classified area, we can achieve quite good results by using supervised classification. In addition, numerous scientific articles have been written about the benefits of this method over the unsupervised method for HR image analysis. With an increase of pixel resolution of the images, unsupervised classification leads to a lot of mistakes. Unsupervised classification takes much time in the analysis process. The accuracy of the results ought to be reanalyzed and checked [Gyuris, 2010; Nath, Deb, 2010].

For classification, we have used the "Rule-based Data Classification" method. This method is the most used method in VHR images classification with GEOBIA analysis. The advantages of this method are: the process providing the preliminary created algorithmic stages in a systematic way, step by step and controlling analysis accuracy is available after each process. In some other classifications it is impossible to check results until the end of analysis; and if the result accuracy is unsatisfactory, it is necessary to reanalyze all the data from the beginning on. And this takes much time. Another advantage of this method is the ability to perform this method as well automated as semi-automated. It is possible with the creation of algorithmic stages in GIS or other Geo analysis programs; thus we will create a rule set for analysis and make it semi-automated [Zhou *et al.*, 2012]. This classification has more accurate results in contrast with other methods [Khin *et al.*, 2016]. One more advantage of this method is the opportunity to apply all features step by step [Giannini, Parente, 2014–2015].

In this classification method, the creation of analysis algorithms is provided step-by-step. And it helps to do this analysis easy. At each analysis step, the number of objects decreases. At the end of the analysis, a difficult, non-classified object will be formed and we can add this object into one unclassified area. At the end of classification, there will be formed one class of objects easing our analysis. But one must keep in mind one point while using this method: the accuracy of the final class depends on the accuracy of the first class. Therefore, at the beginning of the classification, great attention should be given to image segmentation and in the end of this segmentation objects must be clearly separated. Three of the rules will be created by the user.

In accordance with method analysis "Rule set based classification" is the most used method, used in much scientific work with Maximum Likelihood algorithms. With the algorithm

of Assign Class, we have set the system of rules. The Assign Class algorithm is most simple among the algorithms of classification. It uses a condition to determine whether an image object belongs to a class or not.

RESULTS OF RESEARCHES AND CONCLUSIONS

From our research, it is seen that modern object-based image analyze method is a highly efficient method for analyzing high-resolution satellite images. The reason is that high-resolution satellite sensors captures images of millions of pixels per object. The pixel-based method is time-consuming and makes some errors during the getting information of objects with using VHR images. Therefore, combining pixels into objects and analyzing images based on objects gives us many other properties of them and enhances the capabilities of analysis.

In this research, used an eCognition Developer program and highlighted the possibilities of an object-based image analyses method in analysis of Worldview-2 satellite image of Yangiabad village of Syrdarya region. According to the analyze results, the accurate tools are the Rule set based classification tool for classification, and for segmentation Multiresolution Segmentation is the.

In addition, in the analyzes gotten resulting parameters of shape, compactness, and scale for segmentation and classification of high-resolution images.

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REFERENCES

1. *Blaschke T.* Object based image analysis for remote sensing. *ISPRS Journal of Photogrammetry and Remote Sensing*, 2010. V. 65. No 1. P. 2–16.
2. *Blaschke T., Hay G. J., Kelly M., Lang S., Hofmann P., Addink E., Feitosa R.Q., van der Meer F., van der Werff H., van Coillie F., Tiede D.* Geographic object-based image analysis — towards a new paradigm. *ISPRS Journal of Photogrammetry and Remote Sensing*, 2014. V. 87. No 1. P. 180–191. DOI: 10.1016/j.isprsjprs. 2013.09.014.
3. *Chen Z., Ning X., Zhang J.* Urban land cover classification based on WorldView-2 image data. 2012 International Symposium on Geomatics for Integrated Water Resources Management (GIWRM), Lanzhou, Gansu, China. IEEE, 2012. DOI: 10.1109/GIWRM.2012.6349578.
4. *Dao P.D., Liou Y.A.* Object-based flood mapping and affected rice field estimation with Landsat 8 OLI and MODIS data. *Remote Sensing*, 2015. V 7. No 5. P. 5077–5097.
5. *Dráguľ L., Tiede D., Levick Sh.R.* ESP: A tool to estimate scale parameter for multiresolution image segmentation of remotely sensed data. *International Journal of Geographical Information Science*, 2010. V. 24. No 6. P. 859–871.
6. *Gianinetto M., Rusmini M., Candiani G., Via D., Frassy F., Maianti P., Marches A., Nodari F.R., Dini L.* Hierarchical classification of complex landscape with VHR pan-sharpened satellite data and OBIA techniques. *European Journal of Remote Sensing*, 2014. V. 47. No 1. P. 229–250.
7. *Giannini M.B., Parente C.* An object based approach for coastline extraction from Quickbird multispectral images. *International Journal of Engineering and Technology (IJET)*, 2014–2015. V. 6. No 6. P. 2698–2704.
8. *Gyuris M.P.* Wp4-satellite remote sensing deliverable D4. Report on the limitations and potentials of satellite Eo data, 2010. DOI: http://www.impactmin.eu/downloads/impactmin_d41.pdf.
9. *Jiaa Y., Lib H.T., Gub H.Y., Hanb Y.S.* Study on the Technology and Method of Land Cover Classification for Geographic National Conditions Surveying. *ISPRS-International Archives of*

- the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2013. V 1. No 1. P. 61–66.
10. *Khin M.M.L., Shaker A., Joksimovic D., Yan W.Y.* The use of WorldView-2 satellite imagery to model urban drainage system with low impact development (LID) Techniques. *Geocarto International*, 2016. V. 31. No 1. P. 92–108.
 11. *Kokje A.A., Gao J.A.* A simplified approach for classifying urban land cover using data fusion. *Proceedings of the SIRC NZ — GIS and Remote Sensing Research Conference, Dunedin, New Zealand, 2013.* 7 p. DOI: <http://hdl.handle.net/10523/4240>.
 12. *Leonhard G., Ferrè N.* Master in space applications for early warning and response to emergencies. Final report. 5 p. Web resource: <https://pdfslide.net/documents/master-in-space-applications-for-early-warning-and-1-master-in-space-applications.html> (accessed 08.06.2015).
 13. *Nath R.K., Deb S.K.* Water-body area extraction from high resolution satellite images — an Introduction, Review, and Comparison. *International Journal of Image Processing (IJIP)*, 2010. V. 3. Iss. 6. P. 353–372.
 14. *Navulur K.* Multispectral image analysis using the object-oriented paradigm. Boca Raton, Florida, USA: CRC Press, 2006. 204 p. DOI: <https://doi.org/10.1201/9781420043075>.
 15. *Navulur K., Pacifici F., Baugh P.* Trends in optical commercial remote sensing industry [industrial profiles]. *IEEE Geoscience and Remote Sensing Magazine*, 2013. V. 1. Iss 4. P. 57–64. DOI: 10.1109/MGRS.2013.2290098.
 16. *Özdemir M.* Uydu görüntülerinden nesne yönelimli yöntemlerle özellik çıkarımı (Feature extraction from satellite images with object oriented methods). Abstract of D diss. Selçuk Üniversitesi Fen Bilimleri Enstitüsü (Selcuk University Institute of Science), 2013. 81 p. (in Turkish).
 17. *Peña-Barragán J.M., Ngugi M.K., Plant R.E., Six J.* “Object-based crop identification using multiple vegetation indices, textural features and crop phenology.” *Remote Sensing of Environment*, 2011. V. 115. No 6. P. 1301–1316. DOI: 10.1016/j.rse.2011.01.009.
 18. *Platt R.V.* Wildfire hazard in the home ignition zone: An object-oriented analysis integrating LiDAR and VHR satellite imagery.” *Applied Geography*, 2014. V. 51. P. 108–117. DOI: <https://doi.org/10.1016/j.apgeog.2014.03.011>.
 19. *Verőné Wojtaszek M., Ronczyk L.* Object-based classification of urban land cover extraction using high spatial resolution imagery. *Proceedings of International Scientific Conference on Sustainable Development & Ecological Footprint, Sopron, Hungary, 2012.* 7 p.
 20. *Xiaohe Z., Liang Z., Jixian Z., Huiyong S.* An object-oriented classification method of high resolution imagery based on improved AdaTree. 35th International Symposium on Remote Sensing of Environment (ISRSE35). *IOP Conference Series: Earth and Environmental Science*, 2014. IOP Publishing. V. 17 (1): 012212. DOI: <http://iopscience.iop.org/1755-1315/17/1/012212>.
 21. *Zhou X., Jancsó T., Chen Ch., Wojtaszek Verőné M.* Urban land cover mapping based on object oriented classification using WorldView2 satellite remote sensing images. *International Scientific Conference on Sustainable Development & Ecological Footprint, Sopron, Hungary, 2012.* 10 p.
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