Preclassification of Remote Monitoring Data in Change Detection Tasks

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Abstract. Detection of changes occurring on the Earth surface is one of the most important tasks of remote monitoring. It is noted that the traditional methods of detecting changes (basic components, subtraction, division, *etc*.) are not sufficiently effective when they are applied to the problems of remote sensing of the Earth. This is due to the fact that the images obtained by different systems under different conditions of illumination of the Earth surface have significant differences in their characteristics. To reduce the impact of qualitative differences on the result of processing, it is proposed to use a preliminary classification of objects in the images. The proposed algorithm was tested on the detection of deforestation according to the spacecraft data SPOT and Landsat. Recommendations on the choice of parameters of the classification algorithm (frequency channels of images, quantitative and qualitative composition of classes, decision rules, *etc*.) are formulated.

INTRODUCTION

Remote sensing of the Earth from space allows continuous monitoring of processes occurring on the surface of the planet [1-3]. One of the objectives of this monitoring is the timely detection of changes. To solve this problem, various remote sensing systems are involved. The images obtained by these systems may differ significantly in their characteristics [2], which complicates the detection of changes on them by traditional algorithms.

The article discusses the algorithm that allows increasing the detection efficiency by using the object classification procedure at the preliminary stage of processing.

ALGORITHMS FOR CHANGE DETECTION

Images obtained from the Landsat and SPOT spacecrafts were used to analyze the efficiency of the proposed algorithm. The SPOT4 image served as the source image (Fig. 1a, February 21, 2013, resolution 20 m). The Landsat8 image (Fig. 1b) was used as an image with a modified area (September 18, 2014, resolution 30 m). The study area where deforestation occurred in the interval between surveys is marked by a rectangle in the images.

In this research, we used the ScanEx Image Processor software packages for remote sensing data processing [4]. To display changes, this software uses the method of the “Principal components”, “Subtraction”, and “Division” methods.

The images selected for testing the algorithm were obtained by various multichannel optical-electronic remote sensing systems. They have a different number of frequency channels, different spatial and radiometric resolution. The first image was taken in winter, the second in early autumn. In addition, the lighting conditions at the time of shooting were different. Significant differences in image quality led to unsatisfactory results when deforestation was detected. The result of processing these images is shown in Fig. 2. As it is seen from the figure that, in addition to the test deforestation, a lot of false objects were detected.

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(a) (b)

FIGURE 1. Original image (a) and the image with the changed area (b).

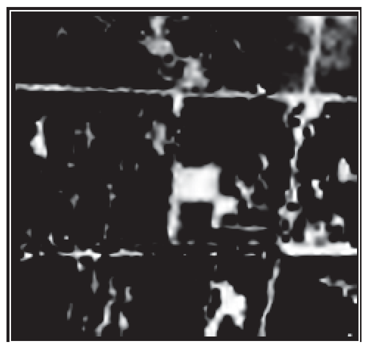

FIGURE 2. Result given by the "Principal components" method.

Slight improving of the processing quality can be achieved by equalizing the quality of images at the preliminary stage of processing. For this purpose, one can use the procedures of reference stretching of the histogram of the brightness distribution of the image, equalization, and local contrast conversion [1, 2]. However, the final quality of processing still remains unsatisfactory.

In this work, to solve the problem, it was proposed to use the preclassification of objects in the images. Given this fact, the algorithm for detecting changes on the surface includes: images synthesis, alignment of their spatial characteristics, preliminary classification of objects in images, detection of changes on classified images by standard methods ("Principal components" method), and compilation of processing results with an electronic topographic map. The last stage is necessary to exclude the false objects outside the area of interest and bind the information to the locality.

Expression for the "Principal components" method can be written as

$$I = \left(PC2X * \left(X - BX\right) + PC2Y * \left(Y_X - BY_X\right)\right), \quad (1)$$

where I is the result of processing, X is the source image, Y_X is the image with changes, $PC2X$ is the multiplier for the second principal component for the X –image, $PC2Y$ is the multiplier for the second principal component for the Y_X –image, BX is the average brightness for X , BY_X is the average brightness for Y_X .

The proposed algorithm, which is based on the preliminary classification of the remote sensing data, can significantly improve the quality of processing. Consider the work of the classifier in detail and assess the impact of its settings on the quality of detection.

In remote sensing, a pixel of an image is the object of classification and brightness is its main information criterion (or brightness-vector, when analyzing a multi-channel image). The Landsat and SPOT spacecrafts receive images in the wavelength range from 0.433 to 2.300 μm. All frequency channels can be used for the classification procedure, but this approach has a large computational cost.

To reduce the amount of calculations, let us define the most informative channels. This parameter depends on the problem to be solved, since the characteristics of the reflections of various natural formations depend primarily on the type of object and the frequency of the received signal. For the forestry tasks, the most informative are "green" and "red" spectrum ranges [2, 3]. Confirmation of this fact can be seen in Fig. 3.

The figure shows the results of detection of deforestation according to the "green", "red", "near infrared", and "middle infrared" channels. As it is seen, the basic information about possible changes in the forest zone is concentrated in the "red" and "green" frequency ranges. Thus, the use of these two most informative channels for classification will significantly reduce the computational cost without decreasing the quality of processing.

Next, one needs to select a classification method and choose a decision rule. Some results of the experiment are shown in Fig. 4. The best results were obtained when using the classification with the teacher and making decisions on the minimum distance of Mahalanobis

$$E = \sqrt{\left(B - K_C\right)^T \left(Cov_C^{-1}\right)\left(B - K_C\right)}, \tag{2}$$

where B is the brightness vector of the candidate pixel, C is the separate class, K_C is the mean vector of the C perfect class, Cov_C^{-1} is the covariance matrix in the C perfect class.

FIGURE 3. Results of change detection made in various channels:
(a) second channel, (b) third channel, (c) fourth channel, (d) fifth channel.

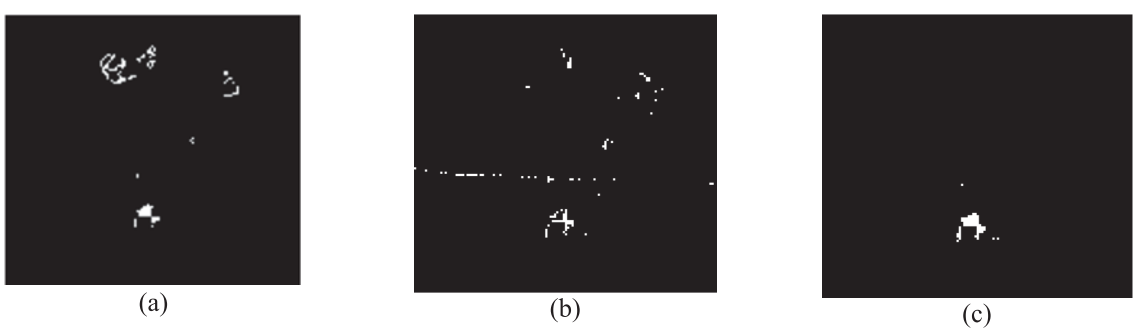

FIGURE 4. Results of change detection by the «subtraction» method with preliminary use of autonomous classification (k-means) (a); classification with the teacher (minimum distance) (b), and with the Mahalanobis distance (c).

Classification with the teacher requires additional work of the operator (selection of the classes and formation of etalons), but interpretation of the processing results becomes considerably simpler, and, also, overall performance of the algorithm increases [5]. The advantage of decision on the basis of the Mahalanobis minimum distance is that this rule takes into account the variability of classes [6].

The study showed that in image the processing, which differs sharply in their characteristics, a significant improvement in quality can be achieved by using the procedure of preliminary classification of objects according to the remote sensing data. The results of forest logging detection using the standard algorithm and the algorithm with the preliminary classification are presented in Fig. 5.

(a) (b)

FIGURE 5. Comparison of the standard (a) and the image preclassification (b) detection methods.

It is seen (Fig. 5b) that the deforestation contours are defined sufficiently accurate, and there are no external objects.

CONCLUSION

Application of traditional methods of detecting changes in the imagery is not always effective because of different conditions (time of year, time of day, weather conditions, *etc*.). It is necessary to supplement the initial algorithm with the procedure of preliminary classification of the remote sensing data. The proposed algorithm includes: the synthesis of images from the space systems, the alignment of spatial characteristics, the preclassification of objects in images, detection of the changes using standard methods, and the compilation of the result of processing with an electronic topographic map.

The algorithm has been tested when deforestation is detected according to the SPOT and Landsat remote sensing systems. The results of the experiments showed that the most influence onto the quality of processing has a stage of preliminary classification.

Recommendations on choice of the classifier parameters are formulated. In particular, it is shown that for the detection of deforestation, the best frequency channels are "green" and "red", and it is necessary to choose the classification procedure with the teacher (with the number of classes 4 – 5) and make a decision on the minimum Maharonobis distance.

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