Research the textures synthesis method based on the neural network

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Abstract. The article presents the urgency of developing a method for removing clouds. The object of the study are methods of detecting objects on images, in particular, cloud images, to exclude areas containing clouds from subsequent processing and analysis. The algorithm of selection and removal of cloud images is investigated, and its software implementation is developed. On the test example, the quality of the implemented algorithm was evaluated.

1 Introduction

Remote methods of environmental studies - is a highly complex and multifaceted field of science and technology, is experiencing a period of rapid development [1-2]. Modern remote sensing methods of objects, especially space ones, have opened a qualitatively new stage in information support of research and development in the Earth sciences and economic practice. At present, most of the remote sensing data (RS) is obtained from artificial earth satellites [3]. A large survey of the Earth's surface from the altitude of the satellite's flight, high speed of movement of satellite sensors and the ability to register signals in several spectral ranges allow obtaining huge amounts of data [4]. The breadth of coverage of the territory is a characteristic feature of remote methods of Earth exploration. The organization of work on the study of the Earth's surface, based on a combination of aerospace methods with a small amount of ground-based research, which is carried out on a limited number of reference routes and key areas, can significantly shorten the time of production and reduce their cost. Remote sensing data at present are aerospace images that are represented digitally in the form of raster images. Therefore the problems of processing and interpretation of remote sensing data are closely related to digital image processing [3, 4].

Currently, satellite imagery is in most cases produced in clear, cloudless weather, which allows you to get high-quality images of the specified terrain and reduce the amount of work during the pre-treatment phase [2]. But shooting only with cloudless weather significantly reduces the efficiency of obtaining information.

Preprocessing an image, consisting of the allocation of clouds, i.e., the formation of a mask, allows to increase the speed of fast shooting and speed up the process of obtaining an

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image. The quality of image processing with remote clouds increases in comparison with the processing of the image on which the clouds are present [1]. For example, this becomes noticeable in texture processing [1].

Image inpainting or “image completion” is one of the important topics in image processing, which can be applied in many areas, from the automatic restoration of damaged photographs to the removal of unwanted objects in images [5-7]. Reconstruction methods use information from outside of the damaged area for interpolating missing pixels.

Most of image reconstruction methods can be divided into the following three groups: based on the solution of partial differential equations in partial derivatives (PDE) [5]; based on orthogonal transformations [6]; based on texture synthesis [7].

The main disadvantages of the known methods come from the fact that the most of them are unable to recover the curved edges and are more suitable for the removal of scratches and small defects on the structure of images. It should also be noted that these methods often blur textures and structures in the recovery of large areas with corrupted (“empty”) pixels.

The purpose of the work is to develop the textures synthesis method based on the neural network to remove clouds from satellites images.

2 Proposed method

This article presents a two-stage approach, combining algorithms for the cloud detection and reconstruction from satellite images. The first stage is a histogram-based algorithm for the clouds detection. The second stage applies the modified exemplar-based inpainting method using a neural network. The overall framework of the proposed algorithm present in figure 1.

Fig. 1. The overall framework of the proposed algorithm.

The success of most algorithms lies in the choice of thresholds. The simplest method for segmentation of objects is called the threshold value method. Threshold methods are often used to segment images consisting of bright objects against a dark background or vice versa. The global threshold uses one fixed threshold for all pixels in the image and therefore only works if the histogram of the intensity of the input image contains separate peaks corresponding to the desired subject and background. Therefore, it cannot process images containing, for example, a strong light gradient. Also, when the background is uneven as a result of poor or uneven lighting conditions, the global threshold will not segment the image correctly. The way to handle such cases — to use a more complex method — is the method of different thresholds, which is an adaptive threshold. The Fig. 2 shows the histogram of the image with clouds.

In this case, such a histogram corresponds to an image with light objects on a dark background. You can see that all pixels are grouped around several main centers. To select these areas, it is enough to select a certain value T and determine all points that have $f(x,y) \leq T$, as belonging to the object, and otherwise - as belonging to the background. Then the resulting image is determined by the expression:

$$g(x,y) = \begin{cases} 1, & \text{if } f(x,y) > T \\ 0, & \text{if } f(x,y) \leq T \end{cases} \quad (1)$$

where 1 is the value for the pixel corresponding to the object;

0 is the value for the pixel corresponding to the background.
If T depends on the value of $f(x,y)$, then this threshold is called adaptive.

Fig.2. Image of histogram.

In the previous paragraph, it was stated that the method with a global threshold is good as long as we have controlled lighting. As soon as the illumination becomes uneven, a well-divided histogram may turn into a poorly divided histogram, and the method will not work. In this case, the original image should be divided into subregions, in each of which its segmentation is searched for and used for segmentation. The main problem here is the problem of splitting the image into subregions and the choice for each of them has its threshold. As a partitioning criterion, it is convenient to use the notion of light dispersion. I.e., The image is divided into areas whose illumination is approximately the same. The eq. (2) calculates variance:

$$\sigma^2(z) = \sum_{i=0}^{L-1} (z_i - m)^2 p(z_i), \tag{2}$$

where z - the value corresponding to the brightness of the image elements;
 $p(z_i), i = 0, 1, 2, \dots, L-1$ - histogram z , where L denotes the number of different levels of brightness.

Figure 3 shows an example of the clouds detection.

Fig. 3. The clouds detection: a) satellite image, b) masked image.

On reconstruction step, we use the patch-based inpainting algorithm for an image with masked pixels. The algorithm is based on a geometric model for patch synthesis [8]. The lost pixels are recovered by copying pixel values from the source using a similarity criterion. We used a trained neural network to choose the “best similar” patch [9]. The training procedure was repeated on 100 satellite images, and the obtained 100,000 blocks were used as a training sequence for this network. This network contains three layers: the first layer of 20 neurons, the second layer of 20 neurons and the third one of 10 neurons.

The network created ten inputs, 5 of them were fed with only the central pixels found in the blocks, and the other five inputs were fed with the MSE of these blocks. The architecture of the neural network for image inpainting present on figure 4.

Fig. 4. The architecture of the neural network

3 Experimental results

The effectiveness of the presented scheme is verified on the test satellite images with clouds. Figures 5-7 shows the results of image reconstruction (a - image with clouds, b - masked image, c - image reconstructed by the proposed method). The proposed method allows the correct reconstruction of pixel values. It's worth noting that the method does not smear the texture and structure during the restoration of large areas of missing pixels.

Fig. 5. Satellite image processing.

Fig. 6. Satellite image processing.

Fig. 7. Satellite image processing.

Conclusion

The paper presents a two-stage approach, combining algorithms for the cloud detection and reconstruction from satellite images. The first stage is a histogram-based algorithm for the clouds detection. The second stage applies the modified exemplar-based inpainting method using a neural network. Several examples presented in this paper demonstrate the effectiveness of the algorithm in the restoration of different areas of the satellite images for clouds removing.

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