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Evaluation of Objects Recognition Efficiency on Mapes by Various Methods

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***Abstract*—The paper analyzes the efficiency of image recognition on terrestrial photographs by SURF, SIFT and ORB methods. It has been shown that for high-quality images, the highest probability of recognition in the application of the SIFT method. In the case of identifying fragments of images on noisy and blurred images, the best results are obtained using the ORB method, which, together with this, has the highest performance among the methods used.**

Keywords —SURF, SIFT, ORB, recognition efficiency.

I. INTRODUCTION

The task of recognizing images in their arbitrary orientation in the image is solved by various methods, the effectiveness of which is evaluated differently for different types of images. When recognizing, it is usually not a problem if the rotation angle of the image is relatively small. Instead, at angles of more than 20 degrees, the recognition efficiency drops sharply. In order to solve the problem of recognition of images with high reliability it is necessary, first of all, to eliminate the dependence of the proposed method or algorithm on affine transformations, namely: parallel transfer, zoom and spatial rotation of the image, which is subject to classification. In addition, in the process of recognition, there are and distorting factors. First and foremost, this is a considerable noising and blurring of investigated images, which are typical distortions during their registration, caused by atmospheric phenomena and imperfect scanning means. The most commonly used methods for solving such problems are SURF (Speeded Up Robust Features), SIFT (Scale-Invariant Feature Transform) and ORB (Oriented Features from Accelerated Segment Test and Rotated Binary robust independent elementary features) [1-7]. In addition, it is known that in order to obtain accurate estimates of the probability of recognition, one can use the approach described in [8-10]. Comparison of the authenticity of recognition and the performance of these methods was carried out by many authors on various objects [3, 11-18]. However, unambiguous conclusions were not drawn, most likely, given the peculiarities of the implementation of methods in specific software solutions.

II. RESULTS AND DISCUSSION

The paper analyzes the efficiency of object recognition on images of the Earth's surface, in particular in city photographs. The quality of recognition is performed for both original high-quality images and for noisy and blurred images. The templates used five fragments of the original image size 256*256 pixels, which were randomly selected on the original image of the map area of 3600*2120 pixels. The recognition program was created using SURF, SIFT and ORB methods implementations in the OpenCV library. The investigated image has a normal histogram. The three methods of specific points detection (SURF, SIFT and ORB) were determined for the range of angles between the orientation of the template and the image from 0 to 90 degrees at different levels of white noise and the size of the blurring matrix at different scaling ratios.

The effectiveness of the methods was determined as the ratio of special point's number on the investigated image that coincided with the corresponding points in the template, to the total number of special points in the template. We denote this value in work as the recognition efficiency a fragment of an image. The dependence of the recognition efficiency on the size of the investigated image was carried out in a manner where the initial image was successively reduced by half until no fragments were identified. The results of this study are shown in Fig. 1, from which we see that all methods give a 100% result for a half-sized image, but for a reduced 4-times only SIFT gives satisfactory results, SURF works well only for parallel and perpendicular patterns of the pattern and image, and the ORB reliably recognizes fragments for orientations close to 45 degrees between the template and the image. In the case of a reduction of the image 8 times, none of the used methods do not recognize changes in any fragment.

The study of the dependence of the recognition efficiency on the noise level was investigated on full-size images by applying a white noise with a sequential increase in the dispersion of the normal distribution. The image of the image at different levels of white noise is shown in Fig. 2, and the recognition results are shown in Fig. 3. The figure shows that for the range of dispersion values from $\sigma = 2$ to $\sigma = 16$, all methods have recognized all fragments. For case $\sigma = 32$, only 100% results were obtained using the ORB method, and the efficiency of recognition by SURF and SIFT is respectively about 90% and 80% respectively. For $\sigma = 64$, none of the methods could identify at least one fragment.

The study of the dependence of the recognition efficiency on the level of image blurring was carried out by using a blurring matrix whose size was $(2n + 1)*(2n + 1)$ pixels for $n = 1..5$. The image of the image at different levels of white noise is shown in Fig. 4, and the recognition results are shown in Fig. 5. From the figure it can be seen that the recognition results for these methods differ markedly from one another. The worst result was obtained by applying the SURF method, which gave the probability of recognition at 70% for a 9*9 pixels blurring matrix and a zero result for a 17*17 pixels matrix. The best results are obtained for the SIFT method, in particular for the 9*9 pixels matrix there is almost 100% recognition, for 17*17 pixels, about 70%, and the lack of recognition for a matrix of 33*33 pixels. Instead, using the ORB method gives 100% for almost all images blurred by matrices up to 17*17 pixels. An exception is the parallel and perpendicular orientation of the image and the pattern for which the probability of recognition is noticeably lower. This behavior of the efficiency dependence of the ORB recognition method from the angle of the mutual orientation of the image and the template correlates with the corresponding dependence when the zoom factor is changed (Fig. 1).

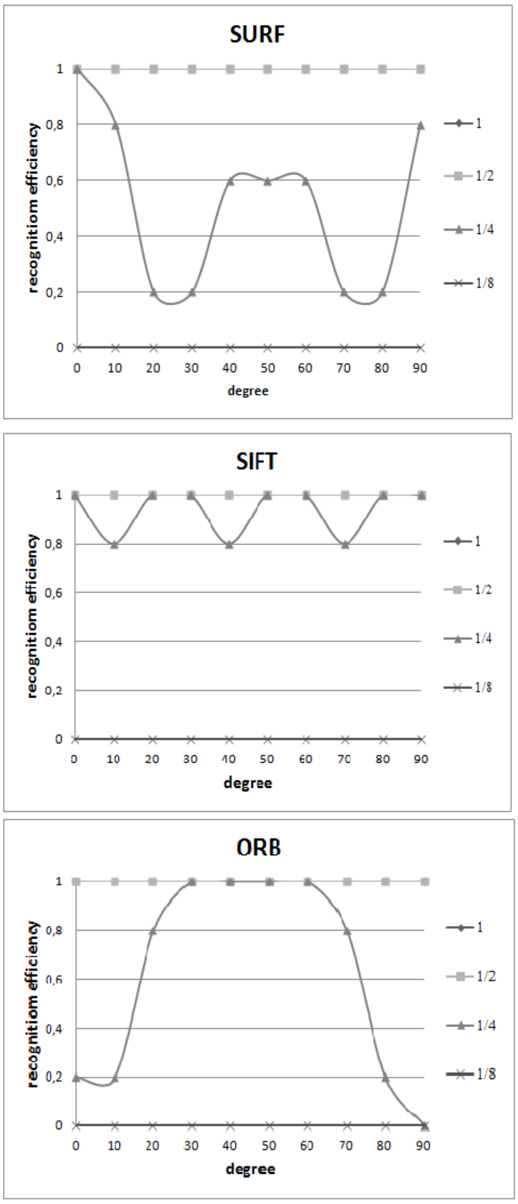

Fig. 1. The dependence of the recognition efficiency on the angle of rotation of the pattern relative to the image for different sizes of the image (1 is the image of the original size, 1/2 - the image is reduced twice, 1/4 - the image is reduced 4 times, 1/8 - the image is reduced 8 times) when used different recognition methods.

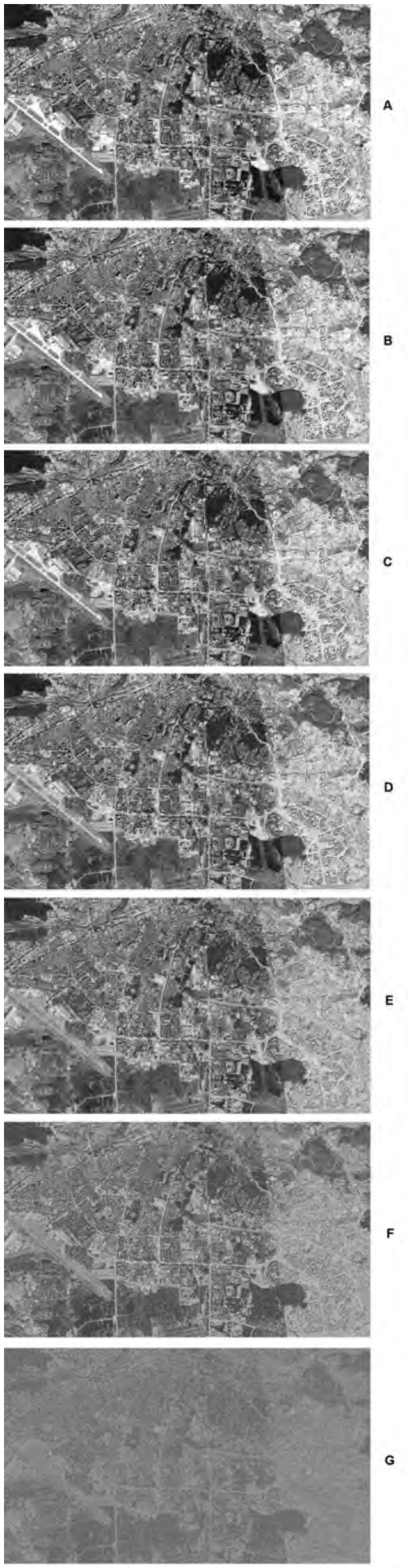

Fig. 2. Photos of terrain with different levels of adiitional noise (A – source, B – σ = 2, C – σ = 4, D – σ = 8, E – σ = 16, F – σ = 32, G – σ = 64).

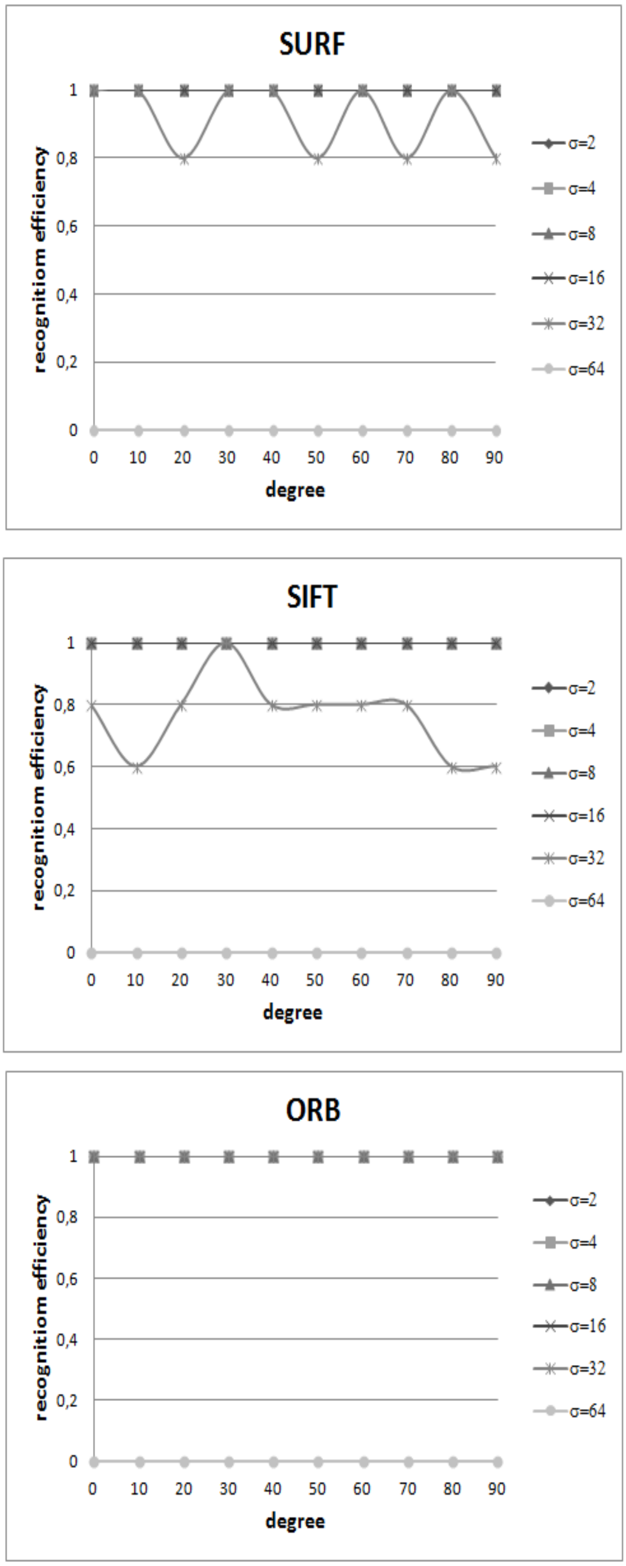

Fig. 3. The dependence of recognition efficiency on the angle of rotation of the pattern relative to the image for different levels of white noise (A – source, B – $\sigma = 2$, C – $\sigma = 4$, D – $\sigma = 8$, E – $\sigma = 16$, F – $\sigma = 32$, G – $\sigma = 64$) using different recognition methods.

Comparing the working times with these three methods indicates a certain advantage of the ORB method, for which the operating times was approximately two times less than the recognition time using the SURF and SIFT methods.

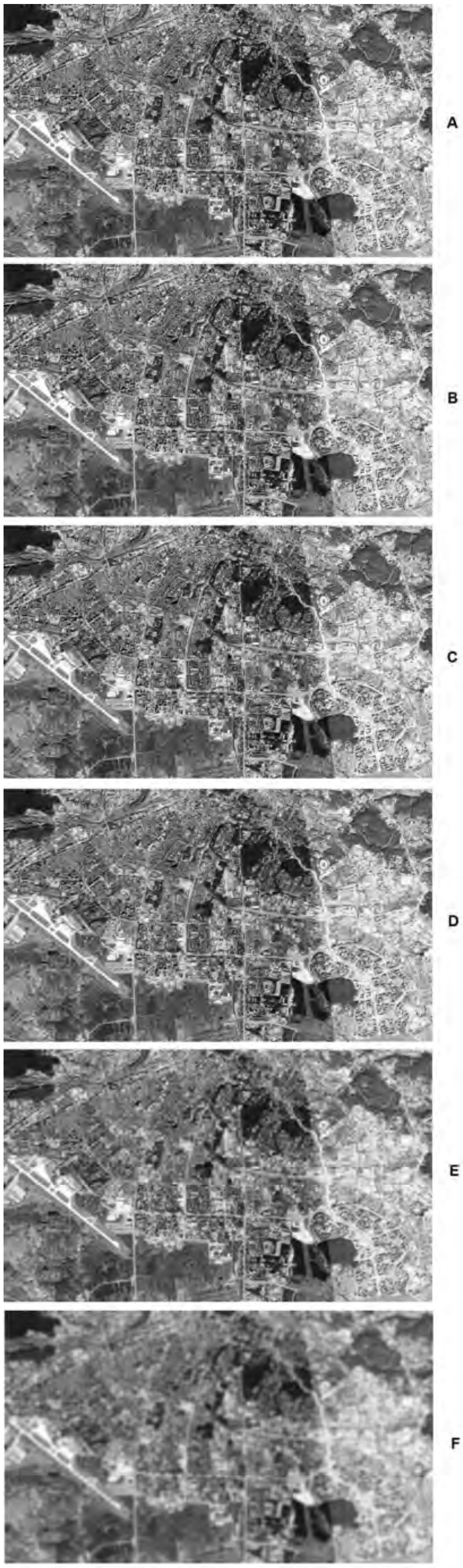

Fig. 4. Photos of terrain with various size blurring mask (A – source, B – 3*3, C – 5*5, D – 9*9, E – 17*17, F – 33*33)

III. CONCLUSIONS

In this work, the dependence of the efficiency of recognition of fragments of the image on the photographs of the area due to the influence of factors that impair the image quality and complicate the obtaining of reliable results is investigated. It is shown that for the ideal conditions for obtaining images, the best result is obtained using the SIFT method. At the same time, the recognition time among the methods used is one of the largest. In the presence of distortion of images such as noise and blur, the best results are given by the ORB method, which works more efficiently at lower image quality. Significantly higher is the efficiency of SURF and ORB recognition at a 45 degrees angle between the original and the investigated image compared to the parallel and perpendicular orientation, and the SIFT method is practically invariant to the angle of rotation of the pattern relative to the image. In general, it can be argued that when recognizing low-quality terrain maps, the best results should be expected when applying the ORB method.

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