Pre-segmentation influence on the efficiency of multi-temporal image registration

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***Abstract*—The analysis of the segmentation effect of various background areas in the image on the quality of registration of multi-temporal bridge structure images using stochastic algorithms is carried out. The influence of the parameters of bridge structures image registration, such background structures as cloudiness and ground cover, on the operating range is analyzed under the assumption that the similarity model describes mutual volumetric images.**

Kewwords*—*non-invasive monitoring, stochastic gradient, registration, binding, image processing, cross-correlation

I. INTRODUCTION

Bridge crossings are of great strategic and economic importance. At the same time, one of the main problems of such structures maintenance is monitoring the integrity of their main elements [1, 2]. To solve this problem, the systems based on non-invasive monitoring are promising. The non-invasive monitoring is based on the digital image processing.

Such monitoring involves periodic inspection of structural elements with subsequent detection and comparison of images of the same areas obtained at different times. In this case, an important condition for comparison is a preliminary rough registration of image pairs. This is especially important when working with structures, in which, due to the uniformity of elements, it is difficult to determine which place of the structure corresponds to a particular image. The information that allows to identify the object of interest can be geodata of the shooting location and camera rotation angles [3]. The technique for coarse registration of multi-temporal images obtained from the onboard camera of an unmanned aerial vehicle, based on the usage of stochastic gradient image alignment algorithms and the apparatus of neural networks, was proposed in [4].

II. METHODOLOGY AND CONTENT OF THE STUDY

The scheme in Fig. 1 explaines the process of registering different-time images (photo 1 and photo 2) from the points (x_1, y_1) and (x_2, y_2) . It is obvious that, knowing the coordinates of the studied structure and using relatively simple geometric transformations, it is possible to project images of different times onto a plane corresponding to the observed conditional surface of the bridge. As a result, the images obtained at different times and from different coordinates can be overlaied on one another [4].

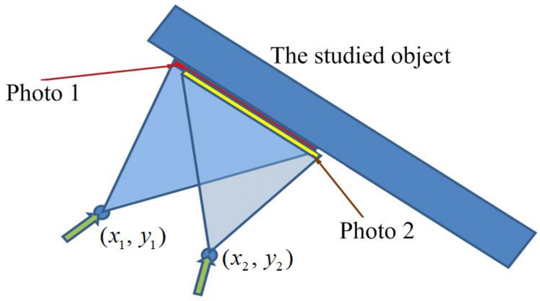

Fig. 1. The scheme of preliminary overlay of multi-temporal photos

Fig. 2 shows an example of georeferenced images of a bridge structure, obtained during research work with the FRPC OJSC «RPA «Mars». The differences that are visible in the images are due to different angles of the optical axis and the distance from the conditional plane of the studied object.

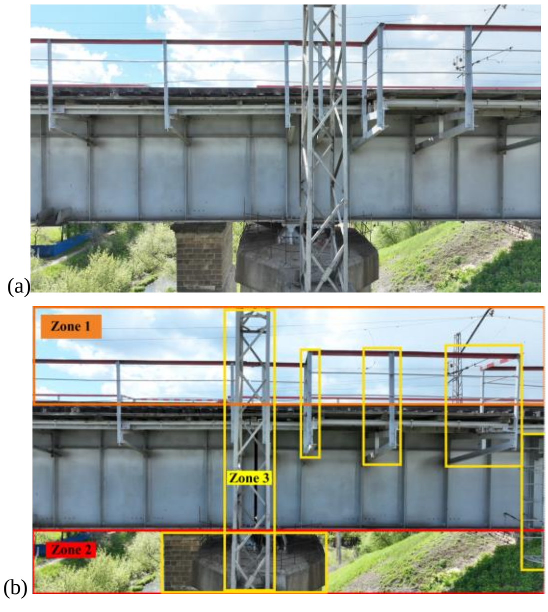

Fig. 2. Example of multi-temporal images of the same structure

The next step for image registration is to highlight the area of interest [3], i.e. bridge structural elements.

An important factor for the application of stochastic gradient algorithms (SGA) for image registration of the object of interest is the preliminary segmentation of the studied object to minimize the influence of the background on which the object is observed, as well as influencing structural elements, for example, significantly receding relative to the conditional plane of the bridge structure. In this work, the influence of background components of the image that interfere with the image registration is investigated.

The image registration process is performed using SGA that provide sub-pixel accuracy in complex changing conditions at acceptable computational costs. The advantages of SGA can also include the absence of the need for a preliminary assessment of the parameters of the studied images and the stability of the generated estimates to the pulse interference [5]. At the same time, SGA can use various models of mutual geometric deformations of combined images, including projective ones. For each specific situation, the choice of the objective function depends on the class of images, the nature of deformations, the requirements and conditions of the problem being solved. For the considered problem, due to the requirement of high processing speed, an effective measure of image similarity is the square of the inter-frame correlation [5, 6]. It is the basis of SGA. The model of spatial deformations is the similarity model.

III. Conducting research

The identification of three «interfering» zones reduces the efficiency of different-time image registration using SGA. They are the sky area (above the bridge structure), the ground area (below the bridge structure) and the area of structural elements that protrude significantly from the plane of the bridge structure (Fig. 2b). It should be noted that the marking of zones using a neural network does not cause difficulties. The problem of the study is a comparative analysis of the operating range of combining multi-temporal image parameters for the same object estimated by SGA in four situations of preliminary segmentation:

A – without preliminary segmentation;

B – with the exception of only one «interfering» zone;

C – with the exception of two «interfering» zones;

D – with the exclusion of all «interfering» zones.

The aim of the study is to identify the dependence of the width of the SGA operating range [5] on the presence/absence of interfering regions. The studies were carried out on the basis of the analysis of 100 real pairs of multi-temporal bridge structure images. In order to improve the accuracy of estimating the width of the SGA operating range, additionally one of the images in each pair was changed in terms of the parameters h_x and h_y within ±10 pixels. Thus, the total sample size was more than 1000 pairs of images.

In the study, the main attention is paid to the effective operating range of the parallel shift parameters, since they are the ones that take large values for the studied multi-temporal images. Other estimated parameters (rotation and scale factor) change insignificantly, so we did not take them into account.

For *situation A* (without preliminary segmentation) due to a large number of interfering factors, such as cloud changes and the influence of different distances of the ground cover and structural elements, the operating range of SGA shift estimates is rather limited and is no more than 8 pixels.

For *situation B* (with the exception of only the cloudy area) the effective operating range for the shift is no more than 22 pixels. In this case, the factor of different remoteness of the elements of the earth cover makes the greatest influence.

For *situation C* (the exclusion of two interfering zones clouds and ground cover) the effective operating range in terms of the shift parameter is no more than 60 pixels. Segmentation of this type is already sufficient to combine most of the multi-temporal pairs of images of the bridge structure, with the exception of such images, where the influence of unequally spaced structural elements is strong (Fig. 2).

For *situation D* the effective operating range for the shift is about 90 pixels. This type of segmentation allows the most significant increase in the efficiency of SGA for the problem of image registration of a bridge structure.

IV. Conclusion

The analysis showed that when using SGA for registration of multi-temporal images of bridge structures, segmentation of the region of interest is an effective technique for increasing the operating range and matching quality. In this case, the greatest distortions in the parameter estimates and, accordingly, in the reduction of their operating range, are introduced by the sky region, as the most variable. Another technique for improving the quality of alignment is to increase the amount of information (number of frames) containing the region of interest, which can be achieved, for example, by reducing the flight speed of the recording complex.

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