Solving the problem transform of size images on series base points found on frames in the problem of stitching images

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Abstract. Stitching several images into a single content is an important task for many areas, including video analytics, machine vision, security, etc. The operation of combining is based on the solution of a number of operations related to the allocation of local features, the selection of transformation matrices of objects, changing the scale and saturation of the image. The process fixing frames is he's with a number of difficulties, includes the appearance of a noise component in the image, blurring, various non-linear effects of the optical system, as well as problems associated with incorrect operation of data preprocessing software. To select the key points used as alignment points is a complex problem, the solution of which is the subject of many works. However, the transformation of coordinate systems of images with combination frames is a difficult problem, since the system is nonlinear.

The article discusses the solution to the problem of changing the position of points in clusters, under conditions of their nonlinearity. The method and algorithm that implements the procedure of nonlinear transformations size over the entire image is presented. Operations include vector analysis, as well as the results of changing the scale of a group of pixels. The set of test data shows the possibility of applying these approaches to change one of the images according to the specified combination points by the operators.

1. Introduction

Digital image processing is an important element of many control and monitoring systems. Solving the problem of stitching images is an important particular task of many operations of subsequent analysis and decision making [1,2]. Combining data into a single space allows us to reduce computational procedures, perform complex analysis, search and manage processes. Possible fields of application for cross-linked images are: medicine, when combining x-ray data; microbiology, when combining images of microorganisms; genetics, when constructing DNA structures from a series of images by electron microscopes; access control, when analyzing the intersection of the territory; security systems, when generating access keys by fingerprints; geology and cartography, in the analysis of images obtained from UAC, etc. More often than not, information about the camera’s displacement in space is unknown, and camera into settings are also being rebuilt between images [3]. All these processes, including the addition of a noise component to the image, complicate the process of finding correspondences between frames and make the task of stitching images complex and multi-stage [4].
The paper considers the problem of finding correspondences between pairs of images. The method is based on multiple changes in the dimension of the image, averaging the elements inside this block and finding matches between a series of enlarged blocks. As a result of the sequential analysis of enlarged blocks, it is possible to determine the correspondence between the elements of the input images.

2. Model images
As input data, a series of images obtained by a digital camera with fixed parameters is used. Figure 1 shows the image model and the process of large-scale change in their dimension.

![Figure 1. Model of digital images and transform of size images.](image)

A simplified mathematical image model can be represented as [5]:
\[ Y_{i,j} = S_{i,j} + \eta_{i,j}, \quad i = \overline{1,n}, \quad j = \overline{1,m} \]

when: \( Y_{i,j} = R \) – input image, \( S_{i,j} \) - pixel brightness intensity for ideal image, \( \eta_{i,j} \) - noise component.

A digital image is a set of pixels, the value of each of the pixels reflects the intensity of the object. Since all the pixels of the image are equal, it is advisable to take the arithmetic mean of the brightness of the ordinary pixels constituting it as \( i = 1,2,\ldots,n \) as the brightness of a large pixel \( K_j \).

3. The algorithm transform of size images on series base points
We fix an arbitrary non-negative number \( \varepsilon \). Let \( m(\varepsilon) \) denote the smallest possible number of clusters into which the set \( \mathcal{R} \) can still be partitioned, provided that the fineness of the resulting partition does not exceed \( \varepsilon \).

The use of the algorithm begins by setting the value \( \varepsilon \geq 0 \) - the upper limit of fineness of the desired partition of the set \( \mathcal{R} \). Then we find \( m \) - the smallest possible number of clusters for which there is still a partition \( \mathcal{R} \) of fineness \( \leq \varepsilon \). For this we know, it suffices to construct a \( \varepsilon \) -partition \( \mathcal{R} \) and take as \( m \) the number of its clusters \( m(\varepsilon) \). The initial partition \( S_{ij} \in \xi = \{T_1, T_2, \ldots, T_m\} \) of the set \( \mathcal{R} \) is chosen so that the numbers of large pixels in any two of its clusters differ by no more than one. Under this condition, the smallest number of cluster elements is \( s = \lceil n/m \rceil \). Suppose that the quantity \( r = m(s+1) - n \) clusters of the initial partition will contain \( s \) elements each, and (for \( n : m \Leftrightarrow r = m \) the remaining \( m - r \) clusters will contain \((s+1)\) elements. We assume that is \( s \)-element clusters \( T_1, T_2, \ldots, T_r \). Then \( \xi = \{n_1, n_2, \ldots, n_{m-1}\} \), when \( n_j = js \) and \( j = 0,1,\ldots,r \) and (for \( r \neq m \)) \( n_j = j(s + 1) - r \) for \( j = r + 1, r + 2, \ldots, m \). The algorithm proposed in Figure 2 is implemented as:

1) Appropriation \( \gamma := 0; \)
2) Appropriation \( j := 1; \)
3) Value calculation \( l := i_{n_j-1+1}, n_j+1 \) for
Calculation $\tilde{u}_i = \frac{\tilde{u}_{i-1} + \tilde{u}_{i+1}}{2}$, and $i := i - 1$;

4) For $i = n_i$, appropriation $\gamma := \gamma + 1$, if $i \neq n_i$ – appropriation $\gamma := 0$ и $n_i := i$;

5) For $\gamma = m - 1$ the calculation is completed, and its final result is the current $\{n_1, n_2, ..., n_{m-1}\}$.

If $\gamma < m - 1$, then $j < m - 1$ and $j := j + 1 n$, go to step (3), if $j = m - 1$ – go to step (2).

Figure 2. Block diagram for transform of size images.

Comments for algorithm.

a) At each step of the computational procedure, one of the numbers is recounted or remains the same from $n_j$, $1 \leq j \leq m - 1$. In case, the relation $\tilde{\theta} < \tilde{\eta}$, the following notation is used: $\gamma = (\Delta_1, \ldots, \Delta_m), \delta = (\delta_1, \delta_2, \ldots, \delta_m)$ – cluster sweep vectors of the current partition of the set $\mathcal{R}$, respectively, before and after the next passage of step (4)).

b) Because $\tilde{\theta} < \tilde{\eta} \Rightarrow \tilde{\delta} < \tilde{\Delta}$, that is, each step of the procedure leads to an improvement in the partition $\mathcal{R}$ in the sense accepted for the algorithm. This ensures alignment of the ranges of the next pair of neighboring clusters. In this case, the value $\gamma$ of the counter of consecutively ineffective steps is reset. If the next step is ineffective, $\delta = \Delta \Rightarrow \tilde{\delta} = \tilde{\Delta}$, which gives only the relation $\tilde{\delta} < \tilde{\Delta}$. The counter $\gamma$ after such a step increases by one.

c) The achievement by $\gamma$ of the value of $m - 1$ indicates the onset of stabilization in the calculation, that is, about the exhaustion of the stock of “effective” steps. The calculation ends here, since it is impossible to further improve the partition of the set $\mathcal{R}$ in the framework of this procedure. The described algorithm does not always lead to an ideal decomposition of the set $\mathcal{R}$ into $m$ clusters.
(in the sense that the corresponding vector $\vec{A}$ is the smallest element of the $(V_{m,1n}, \preceq)$). At the same time, the result of using the algorithm has the necessary feature of such an ideal partition - the balance of any two of its "neighboring" clusters. This guarantees a high degree of alignment of the of all m clusters, i.e., if not optimal, then a sufficiently high-quality result.

In case of failure to fulfill condition (5). We define an equivalence relation on the set $\mathcal{R}$: $K_i \sim K_j \iff a_i = a_j$. Let be $\{D_1, D_2, \ldots, D_N\}$ – factor set of the set $\mathcal{R}$ with respect to $\sim$. In the framework of the case under study, at least one of the sets $D_i$ contains more than one element. We assume that the equivalence classes $D_i$ are numbered in descending order of the brightnesses of their representatives (this time we are talking about a decrease in the strict sense). In each set $D_i$ there is a unique element $K_i = K_{\theta_i}$ for $i = \max \{p: K_p \in D_i\}$. From that $1 \leq 1^' < 2^' < \cdots < N = n$. Denote the set $\{K_{\theta_1}, K_{\theta_2}, \ldots, K_{\theta_N}\}$ that $\mathcal{R}'$. Instructions for finding the numbers $j$ can be, for example, such. From that $0^' = 0, \phi_0 = 0$ and sequentially giving the variable $j$ values $1, 2, \ldots, N$, we calculate the auxiliary quantity

$$\varphi_j = n - \varphi_{j-1} - \sum_{i=\varphi_{j-1}+1}^{n} \text{sign}(\vec{a}_{\varphi_{j-1}+1} - \vec{a}_i),$$

and number $j^' = (j - 1)^' + \varphi_j$, and change value $j$. When using this procedure, the number N is determined automatically: sooner or later, the next value $j^'$ coincides with $n$, after which it remains only to perform the assignment $N = j$. Note that the sequence $(\vec{a}_1^', \vec{a}_{2^'}, \ldots, \vec{a}_N^')$ of brightness of elements of the set $\mathcal{R}'$ strictly decreases. Clustering it using the above algorithm, we obtain a partition, $\{T_j = \{K_{\theta_{(N_j-1)+1}}, K_{\theta_{(N_j-1)+2}}, \ldots, K_{\theta_{N_j}}\}, 1 \leq j \leq M\}$, from $\mathcal{R}'$ (here $N_0 = 0, N_M = N$). The corresponding partition of the set $\mathcal{R}$ has the form $\{(N_1^'1, (N_2), \ldots, (N_{M-1})\}$ and is the ultimate goal of applying the algorithm.

4. Conclusion

As a result of the research, the following result was obtained:

1. An approach has been developed that allows performing the image simplification operation. The simplification operation is performed by incrementally zooming the enlarged cluster. The replacement operation is carried out using the calculation of the average value between the minimum and maximum intensity values inside the simplified block.

2. An approach has been developed that allows performing the operation for the search of the relation between sets of clusters of image pairs. Ranked values indicate whether there are similar blocks highlighted at different scales.

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