THE PROGRAM FOR IMAGE REGISTRATION

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Abstract: The paper deals with the topic of image registration. Image registration is major step in image processing. Registration accuracy has essential importance for the quality of further processing of images for e.g. in 3D processing. Developed program allows usage of three methods of optimization and four fitness functions. This paper is provides with one new cost function. Experimental results show that this newly proposed function has advantage in low complexity in comparison with present methods. The function has good reliability and fast convergence. The paper presents specific modification of particle swarm optimization for evaluation of the results too.

Keywords: image registration, particle swarm optimization, genetic algorithm, differential evolution, mutually information, normalized correlation coefficient, ratio-image uniformity

1. INTRODUCTION

The term “image registration” is used for finding of corresponding points in two or more images (the same scene) in technical literature about the image processing. Image registration represents fundamental building block of image fusions methods, which are using two or more images of the same scene to gain qualitative better information. Image fusion can be used in many regions of image processing, for e.g.:

- evaluation of the temporal development in the image,
- evaluation of the shape deformation in the image,
- creation of the three-dimensional space in the image,
- merging of images obtained by different modality (biomedical applications).

Discovered correspondence between the images serves as the parameters of geometric transformations [1], which transform one (unregistered) image into spatial coordinates of the second (base) image. These parameters allow us to find exterior orientation of camera. Exterior orientation of camera gives information about spatial position of camera, which is needed for calculation of spatial position of arbitrary pixel.

Correspondence may be searched by two different basic methods. The first is based on the identification of several significant points (features) in one image, to find the corresponding points in a second image and determine the transformation parameters solving the system of equations [2]. The significant points may be detected automatically or specified by the operator. The other possibility is use global optimization methods. Optimization finds optimal solution. Geometrical transformation is repeatedly performed (with certain parameters) and criteria function is calculating measure of similarity of images and evaluates suitability of parameters. Optimization seeks for the best conformity. The paper deals with analysis of the applicability of these methods.

In the paper will be briefly described:

- proposed approaches for image registration,

- implementation of these approaches in MATLAB,
- evaluation of the results.

The conclusion of the paper contains an experiment using different fitness functions and optimization and evaluation of their applicability in terms of results and the time required for calculations. In addition to common cost function (details are describe in [1], [3]) there was developed new cost function. This function is inspired by Woods's Ratio image uniformity [4]. Experimental results confirmed that suggested function reached convenient property.

2. PRESENT USED METHODS

2.1. OPTIMIZATION METHODS

Principles of a simple implementation of image registration are using optimizations that are known and well described in the technical and scientific literature. The basic aim of this work was research in the field of utilization of different optimizations and various cost functions with aim to create a specific new algorithm and criteria (cost function) with respect to a good reliability and fast convergence. Developed program was created to implement known approaches in MATLAB. User interface was created for simple use. There are used three optimization methods in the program: Genetic Algorithm (GA) [5], [6] a Particle Swarm Optimization (PSO) [7] and Differential Evolution (DE) [8]. Finally, the PSO was modified in the developed program (let see section 3.1).

2.2. COST FUNCTION: MEASURE OF THE SIMILARITY

This section is devoted to brief description of similarity ratio that is commonly used. There is also presented newly developed cost function in the next section. Task for cost function in image registration is assessments of similarity of pixels in images which lies after the transformation in both images on the same positions. Similarity may be evaluated in RGB or grayscale. In grayscale is this operation less computationally difficult, but there is lost of some information in scale. In this work there is used grayscale processing as well as in present and known applications. Possibility of application of multi component (RGB) optimization and processing will be tested in the future work.

In this program there are used these ordinary cost functions:

- Mutually Information (MI),
- Normalized Correlation Coefficient (NCC),
- Ratio-Image Uniformity (RIU) by Woods.

Additionally new function was proposed in this paper (let see section 3.2).

3. PROPOSED PSO MODIFICATION AND NEW COST FUNCTION

3.1. MODIFICATION OF PSO

Modifications are used in order to improve reliability of results. Adjustment of algorithm prevents jamming in local minimum of similarity of images. This problem is actually for large range of space parameters. Importance is increased if priory information is not available. Proposed procedure has two parts. Let suppose that at optimal position overlay of images is large and that may occur to achieve false optimum for small overlay. Hence we must affect this situation by using regulating member. This is first part of procedure, which is executed for each particle of swarm. In cost function we determine number of overlapping points. If value exceeds certain threshold output of function is set on high value. Then competent agent is evaluated as insufficient. Subsequent step is searching worst agents in iteration. These agents are replaced by new arbitrary generated particle. Procedure described above may be interpreted as genetic selection used in GA.

Next modification is to prevent jam in local minimum too. Procedure is executed after finished calculation of each generation. At first step algorithm is testing the change in value of error function. If this change is smaller than certain threshold (determinated for each cost function), then constant is increased (by one) and test is performed with actual value of this constant. If value exceeds threshold, then the alignment of agents according their quality is being performed. Consequently worst agents are replaced by randomly generated agents.

3.2. PROPOSED COST FUNCTION

The new criterion was developed as alternative for determining of similarity images. Procedure was inspired by RIU. The following algorithm was designed for calculation of the new criterion. Number of overlapping points is found. The relation (1) expresses individual values of deviation (IndDev) of pixels. The total deviation in whole image is expressed by the formula (2)

$$IndDev(i,j) = \left(\frac{I(i,j) - J(i,j)}{2} \right) - I(i,j) \tag{1}$$

$$Output = \sum_{i,j} IndDev(i,j) \tag{2}$$

where *I*, *J* are matrices of input images. The function works with pixel values in range <0, 255>. Optimal registration is reached at minimum values. Satisfactory result is ensured for values smaller than 15. Proposed function was tested and quality results were reached (see Table 1) for tested set of images. Results were reliable especially in combination with modified PSO algorithm.

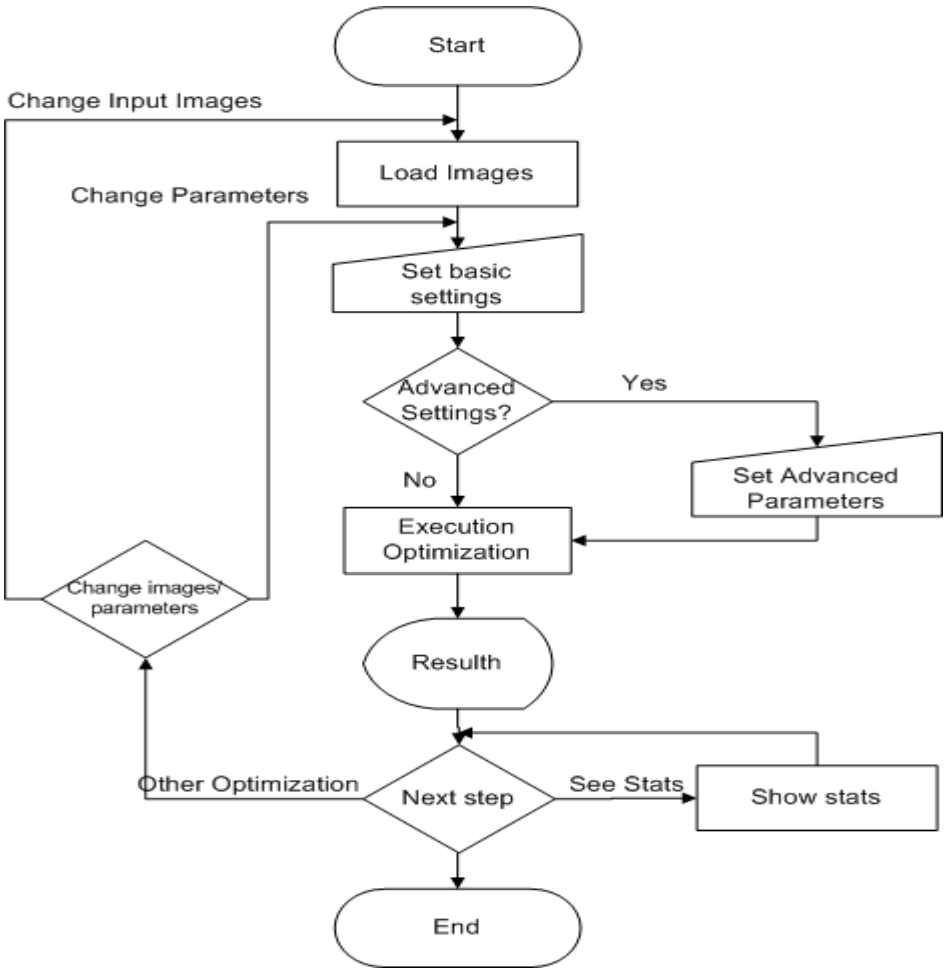

Figure 1: Flowchart of the developed program for image registration

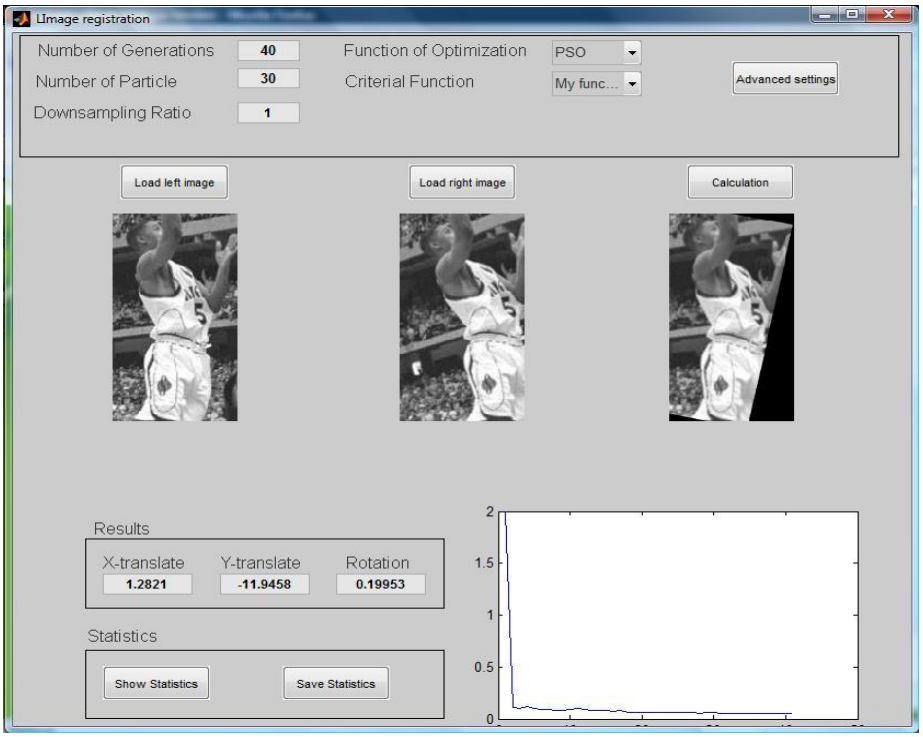

Figure 2: User interface of the developed program for image registration

4. EXPERIMENTAL RESULTS

Object of this work was evaluation of present methods and cost functions and besides this also effort to propose new criterion (mentioned above in section 3.2) and to modify PSO algorithm for optimization (mentioned above in section 3.1).

There were used three procedures of optimization and four criteria functions in the experiment. During the tests there was examined particularly reliability of image registration and as additional aspect assessed execution time. The Table 1 contains some relevant results. Complete results are not shown because it is not possible in limited extend of this paper. It is obvious that computational demands of most approaches are comparable. Only when using MI the execution time is longer in comparison with the other cost functions. Also it can be seen that most procedures reach reliable results despite of change of their parameters and their values. Within this research it has been confirmed that, range of space of parameters have fundamental impact on convergence rate and quality of solution. This influence was decreased by using modification of PSO method, called "Shake the Glass" (described in section 3.1). This procedure is executed in order to prevent the situation of being trapped in local minimum of cost function. Reliable results were achieved when "Shake the Glass" method is combined with new proposed cost function.

Cost function	**RIU**	**Proposed function**	**NCC**	**MI**
Executed time []	47s	50s	43s	70s
Reliability [%]	88	98	80	85

Table 1 Results of test, parameters: Number of generations 30; number of particle 50, Parameters of PSO: c1 = 1, c2 = 3; constraints of parameters: displacements in axes X and Y <-100,100> and angle of rotation<0, 0.5>.

5. CONCLUSION

The main results of research are fast cost criterion (section 3.2) and procedure for prevent jam in local minimum (section 3.1). New cost function was proposed. This function reached satisfactory results and it will be tested in the future work. Algorithm for PSO was modified by adding of loop called "Shake the Glass". Differential evolution was evaluated as most reliable method. Combination of PSO with "Shake the Glass" and new cost function seems to be beneficial. Algorithm will be extended to RGB scales in the future research. The pyramid approach was tested among the others. Image is subsampled during this method. Tests confirmed that this procedure cause faster calculation of the results. But the results were least reliable. Reliability depends on individual image and its parameter. The results introduced in this paper were obtained by the implementation of algorithms in MATLAB. Flowchart of the developed program for image registration is shown in the Figure 1and user interface is shown in the figure 2. Application calculates statistic of optimizations that have been made besides calculation of individual result of one single optimization.

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