# RETINAL IMAGE REGISTRATION BASED ON HYBRID GENETIC ALGORITHM

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**Abstract**: Image registration is process of estimate optimal transform between two or more sets of data. Increasingly importance is situated in medicine diagnosis, and biomedical research. In this paper is introduced software for 2D image registration based on genetic algorithm. After adding iterative gradient method it become of hybrid genetic algorithm. Beside test functions algorithm is examined on real medical images of retina. For this purpose is created graphical user interface with adjustable parameters according to actual requirement.

**Keywords**: Image registration, similarity measures, optimization, genetic algorithm, hybrid algorithm, test function

## 1. INTRODUCTION

The theory of image registration enables to acquire comprehensive information in medical imaging. Commonly it is used in many fields but it can be divided into four main areas. For example multimodal registration enables to achieve information from two different modalities as PET and CT when doctor can find out the location of tumour [1]. Multiview registration is used to create a panoramic, 2D or 3D view representation of the same scene. Utilization of multitemporal registration is effective tool in medicine for notice changes of the same scene during progress of time. The fourth main area is template registration used for finding out a scene in digital anatomical atlas [8].

Nowadays, the ophthalmology is represented in all four area of registration. The main reason is in finding out as many information about health by non-invasive way as possible. For example monitoring of the fundus of retina enables to prevent blindness caused by diabetic retinopathy.

This paper presents a novel combination of genetic algorithm and iterative gradient method for automatic retinal image registration.

## 2. IMAGE REGISTRATION

Image registration is process of searching optimal geometric transform to overlaying two or more images into the one coordinate system. This transformation describes spatial relationship between reference and sensed images, which are represented by M x N array of pixels. Whole process is shown on Figure 1.

In the algorithm is used rigid transformation, which include for 2D images rotation and translation in x-axis and y-axis. Because of operating with digital images transformation could cause loss of pixels information during transfer brightness value to a place outside the sampling. Application of interpolation is essential in case of the rotation outside N*90°, where N notes natural number. Therefore it is necessary to incorporate interpolation technique in order to obtain brightness values in the points of display. In this case bilinear interpolation is used.

A brightness values are used for computing similarity measurements based on intensity of reference and sensed images. Similarity metric can be computed as sum of squared differences (SSD), normalized correlation coefficient (NCC) or mutual information (MI). The application of MI was decided by comparison of these three methods for retinal image registration [6]. The main benefit of MI lays in relative independence intensity values of two images.

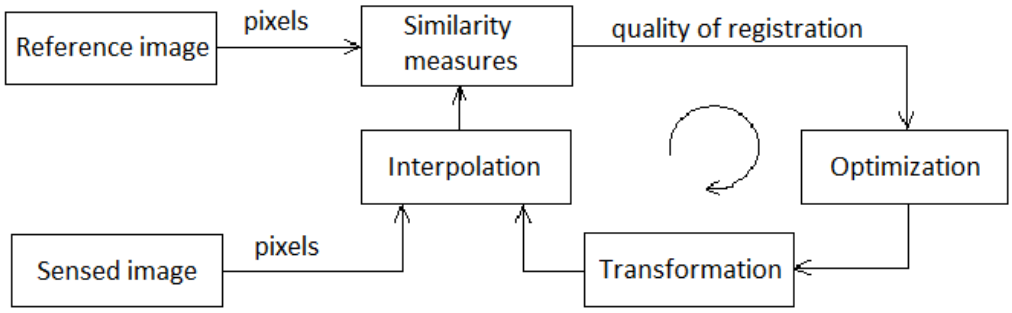


**Figure 1:** Scheme of image registration, adjusted [2].

## 3. OPTIMIZATION

Important consideration for image registration is also selection of suitable optimization technique. Extensive quantity of algorithms makes efforts to find out correct solution by variable effective way. The aim is to achieve the global extreme (maximum or minimum) in minimum time. The focus of the current paper is to propose global optimization technique based on genetic algorithm.

### 3.1. GENETIC ALGORITHM

Genetic algorithms are stochastic optimization methods based on Darwinian principles of natural evolution. Algorithm operates with population, in which every individual represents the encode problem solving. By evaluation of every individual are obtained the values of fitness function, which have the same predictive value as similarity measurements.

Genetic algorithm is blind algorithm because besides of fitness function of individuals in population doesn't use any a priori information about the problem or searching space. Thereby it becomes universal way especially for enormous search space with complicated structure or when isn't required to achieve global extreme but global optimum during optimum time.

In this program every individual is coded and represented by chromosome with three alleles – a shift in x-axes, a shift in y-axes and an angle of rotation. Initial alleles are generated by stochastic process and acquire natural number in engaged limits assigned by user. Thereafter every chromosome is evaluated by fitness function.

Selection decides which individual progress into the next generation. Inspiration is in nature where strong individual can survive. In algorithm is implemented tournament selection because of its minimal time consumptions [3]. In this method two members of population are selected in stochastic process and the member with better fitness function survives to next population. This step is repeated as long as the new population hasn't the equal number of members as the initial population. Tournament selection leads to create population with better fitness functions but preserved diversity because of stochastic process.

Genetic operators as a crossover or mutation are responsible for the potential modification of the population. Crossover operator allows creating better offspring in which are combine alleles of two individuals. Chromosomes of the two offsprings are compound by section of parent and progress to new population instead of their parents. This process usually occurs with 75% - 95 % probability [4].

Mutation operator is allowed to change chromosome with a small mutation probability usually only 0,1 % - 5 % [4]. All alleles of the selected individual are change by stochastic process with uniform distribution. It is random step which leads to larger diversity and thereby searches a new area in the space.

Elitism technique is added at the end of the creating new population process to improvement and acceleration of the convergence. Elitism consists of replacement of the weakest individual of population by the strongest one of the previous population.

Process of improvement is running in cycles until achieved the termination condition. The number of the perform iterations is established as a terminal condition in order to avoid long duration process in case of poorly setting of the initial parameters.

### 3.2. HYBRID GENETIC ALGORITHM

By combining more optimization strategies creates hybrid algorithm which may be able to achieve better results. In this paper iterative gradient method is supplemented as a second method to the genetic algorithm. The result of optimization based on genetic algorithm is input information for finding local maximum by iterative gradient method.

## 4. RESULTS AND DISCUSSIONS

The competitiveness of the hybrid genetic algorithm was compared with three methods accessible from Toolbox of Matlab 2007b: *simulannealbnd*, *fminsearch* and *ga*. All methods were adjusted the same requirement in order to get a relevant evaluation. The quality of method was examined on four test function (Rastrigin, Rosenbrock, Ackley and De Jong's first function [5]) and a real retina image created by fundus camera. Two identity retina images (or one of them blurred image) were used to determine the algorithm accuracy. Therefore the best registration has got zero shifts on the axes x, axes y and zero angle of rotation.

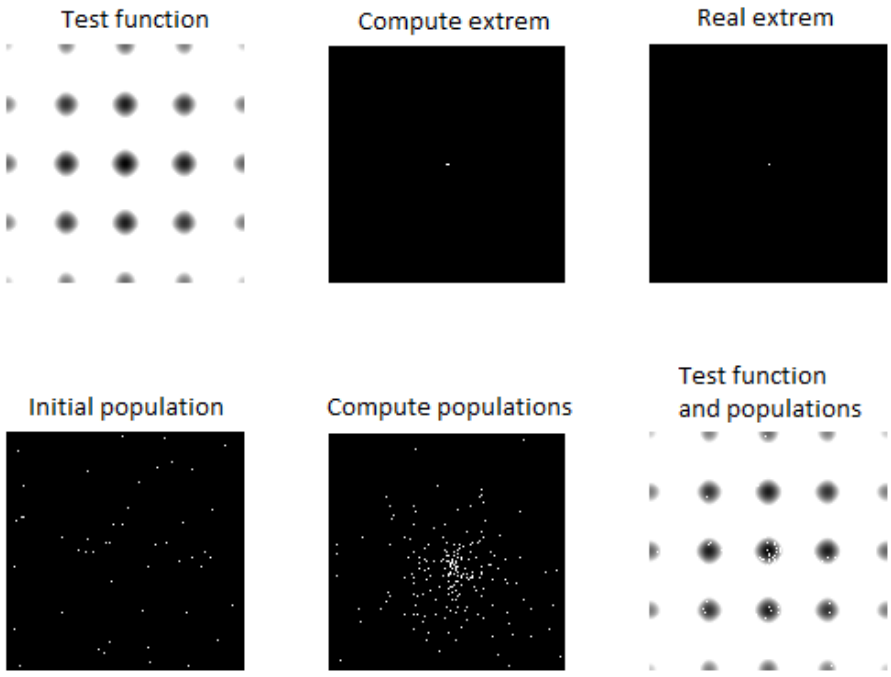


**Figure 2:** Course of the hybrid genetic algorithm which search a global optimum in Rastrigin test function.

It was performed 160 experiments using test functions - four optimization algorithms measured four test functions ten times. Results pointed on dependence of the registration data on fitness function shape. Therefore it can't be consider the best method but about utilization of the method on the data. All methods functioned properly only in case of De Jong's first function. Simulated annealing method achieved similar results as genetic algorithm but collapsed in the invariable function. It became the worst method from the perspective of time consumption. Genetic algorithm was always nearby extreme but could achieve it with the added gradient method. Time consumption was low and almost stable. Despite the added iteration gradient method, created hybrid genetic algorithm required four times less time to get the extreme than genetic algorithm. [7]

Similarity function was created only in the mask area in order to time saving. Therefore mask was needed to create in the invariant area of two images otherwise the global extreme value decrease and it would be problem to distinguished global extreme from local one. Because of the same reason the mask couldn't include similar data as in the demarcated search space.

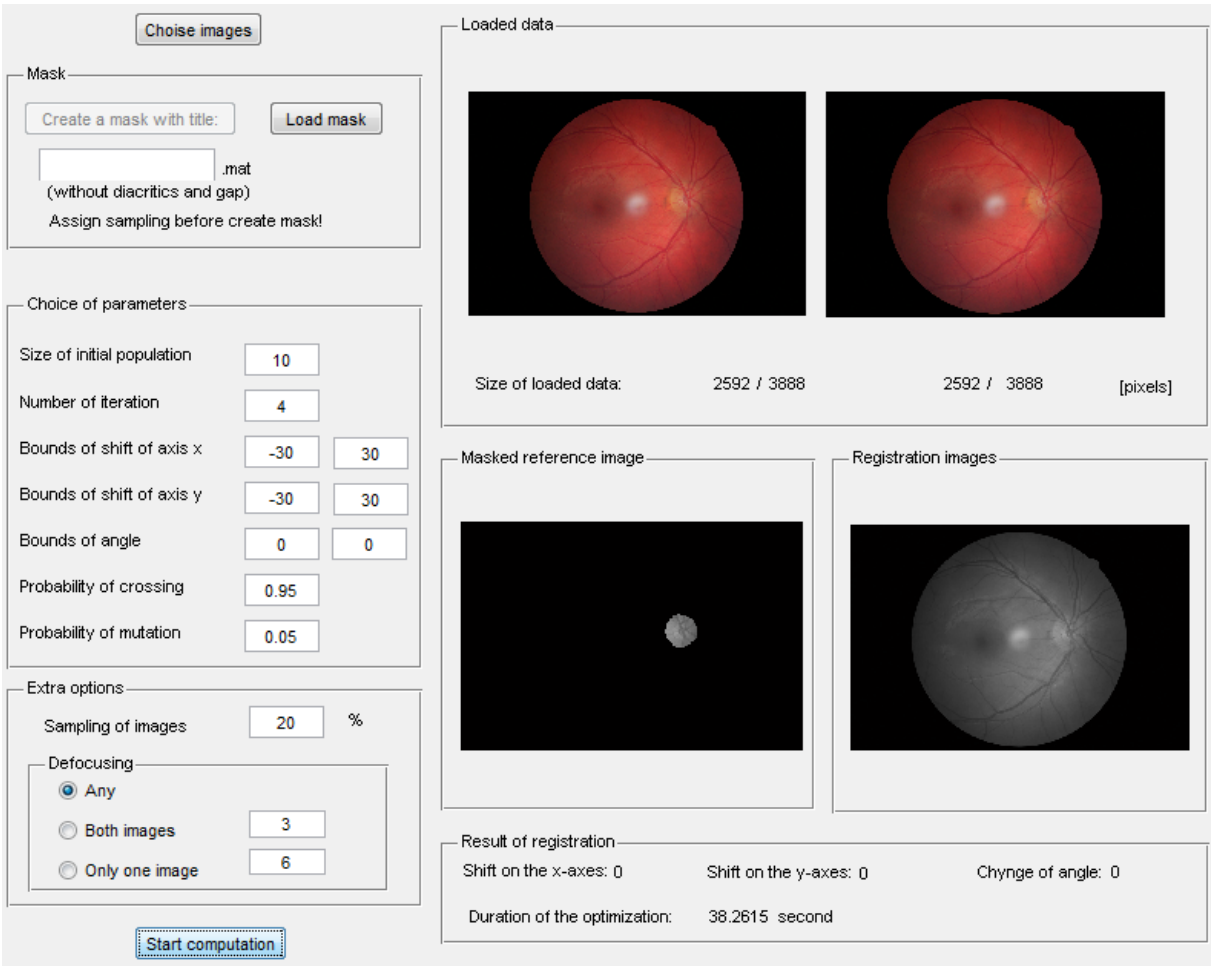


**Figure 3:** User interface of the optimization of two retinal images

For retinal image processing was created graphical user interface with adjustable parameters depending on the current requirements of the user, see Figure 3. The left side is for setting parameters and options. Input and output images are depicted on the right side and results are written below it.

Table 1 contains values for comparison of genetic algorithm (GA) and genetic algorithm with added iteration gradient method (HybGA). Average values were obtained from ten measurements of retina image registration results. Size of used retina images was decrease to 518 x 778 pixels in order to decrease computation time. It is possible to see better results in case of HybGA for shorter

(to zero) distance between acquired extreme and real extreme. Therefore HybGA achieved better results at the expense of six next iteration of gradient method in average. Maximum of evaluation and time consumption relate to a whole process of HybGA. It was required maximum value of similarity function in case of mutual information application. It could achieve value of two for the identical retinal images. Median values show an ideal registration results. It follows that majority of the results leads to the correct solution. Only 10% of the acquired extreme can be considered as outliers [7].

| | Distance HybGA [pixel] | Distance GA [pixel] | Number of iteration of gradient method | Maximum evaluation | Time [s] |
|---|---|---|---|---|---|
| Mean | 5.356 | 10.194 | 6.244 | 1.844 | 58.957 |
| Median | **0.000** | 7.968 | 5.667 | **2.000** | 57.032 |
| SD | 9.626 | 7.929 | 3.480 | 0.264 | 12.243 |

**Table 1:** Average statistic results of the optimization retinal images based on hybrid genetic algorithm and genetic algorithm. [7] Bold numbers shows ideal registration results.

## 5. CONCLUSION

The presented hybrid genetic algorithm for image registration was tested on retinal images and four test function. The measurement interval depended on setting of input parameters, selected area of the mask and output value of genetic algorithm which affected duration of iterative gradient method. The added gradient method obviously improved the results. The best result was obtained from optimization of two retinal images with zero blur and mask on the crossing blood vessels. The created algorithm was comparable with other algorithms.

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