

A New Micro Genetic Algorithm Based Image Stitching Approach for Camera Arrays at Production Lines

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Abstract—Nowadays, using image processing techniques on the image taken by camera at the top of production line for detection of faulty products is widespread. The quality of images can decline due to the distance between camera and production line while trying to get whole image of the bigger products. Therefore, in this study we employed camera array instead of only one camera and placed it at a nearer position to production line. As the images taken from cameras in camera array contain specific parts of the whole product, it is required to stitch images and obtain single image of the product before analyze it. Production line speed or the product position can be vary so it is required to find the optimal stitching points in order to get single image. As an optimization technique micro genetic algorithm (μ GA) which refers to Genetic Algorithm (GA) with small population size and re-initialization process is popular for its proper and fast solutions. In this paper, we have developed a method using μ GA known by its high convergence rate and low termination possibility at a local optimum to be used in image stitching process. Using μ GA known by its high convergence rate, less need of computational source and rare pre-mature solution provided us optimal and fast solutions. Experimental results show that μ GA, which outperforms conventional GA, gives good results in a reasonable time and it can be used in image stitching process as an alternative.

Index Terms—image stitching, micro genetic algorithm, genetic algorithm, camera arrays, production line

I. INTRODUCTION

GA which searches the optimal or near-optimal solution by converging it when the absolute solution of the problem is hard or impossible has been used for many problem' solution [1]-[5]. But the possibility of terminating at a local optimum, high source consumption when the fitness function is complex and low convergence rate are some weaknesses of GA which doesn't guarantee the exact solution due to its randomness. Various studies have been done in order to minimize the disadvantages of GA. μ GA which refers to GA with small population size is significant one of these studies.

μ GA was firstly proposed by Krishnakumar [6]. In Krishnakumar's μ GA it was chosen 5 as the population size, 1 as the crossover rate and zero as the mutation rate.

He compared his μ GA against a simple GA with a population size of 50, a crossover rate of 0.6 and a mutation rate of 0.001 and reported faster and better results with his μ GA [6]. Then Coello and Polido had extended the μ GA to consider multi-objected optimization problem [7]. After that many methods developed which utilized from μ GA to solve numerous problems [8]-[16]. Shin-Yeu Lin and Hsinng-Fang Tsai [8] proposed a μ GA which consists of spatial crossover and correction schemes to solve the constrained three-dimensional reader network planning. Their purpose of using μ GA was to boost the computing speed and their method with 100% tag coverage succeed to outperform the conventional GA and PSO. Ribas, Yamamoto, Polli, Arruda, and Neves-Jr [9] have developed a hybrid model based on integer linear programming and μ GA to solve multi-objective scheduling problem. They aimed to reduce the computational effort by employing the μ GA rather than GA and succeed to get similar results with the results obtained by multi-objective genetic algorithm in a acceptable computational time. Tsai, Wang, Hu and Chiang [10] developed multiple-search multi-start micro genetic algorithm to balance WLAN load. They reported their method that outperforms GA requires less iteration and works much more effective than the other methods that they considered when the problem is bigger. Yusof, Khalid, Hui, M. Yusof and Othman [11] developed a method to solve job shop scheduling problems using hybrid parallel micro genetic algorithm. They employed μ GA which can be seen in Fig. 1 to improve the computation time of their method. Moreover, they recorded that the use of μ GA makes it avoid from local optima and ensures the genetic diversity. There are many more studies which utilized μ GA to improve their algorithm performance and correctness for solving various optimization problems in literature [12]-[15]. Furthermore μ GA can be combined with other solution techniques. Lahoz, Lacruz and Matco [16] developed a multi-objective μ GA to reduce the number of hidden node and the means square error of extreme learning machine (ELM). In all considered studies shows that μ GA works faster and produces more proper solutions than conventional GA.

On the other hand there are studies to enhance its performance on image processing used in autonomous

systems [17]. Image stitching which is a subject of image processing has also been subjected to studies many times [18], [19]. Zhen, Yewei and Jinjiang developed a stitch algorithm based on scale-invariant feature transform (SIFT) and mean seamless cloning (MSVC) [18]. M. Baygin and M. Karakose developed an approach for resolution enhancement in camera arrays [19].

In this study, we employ μ GA to stitch images taken by cameras in camera array that are placed above production line. In camera array studies, it is aimed to obtain an image which has higher resolution by stitching the images taken by different cameras. Regardless how many camera is used, the images are stitched 2 by 2. We used 2x2 sized of camera array to test our proposed method. The proposed method is tested in MATLAB environment.

II. MICRO GENETIC ALGORITHM

μ GA is a specified type of GA which is a search and optimization technique inspired by the operations of human genetic such as crossover, mutation and natural selection. The population sizes they have and the re-initialization process used in μ GA are the most significant differences between GA and μ GA. μ GA emerged from the idea of that 3 individuals are sufficient to convergence to the optimal solution no matter what the chromosome length is.

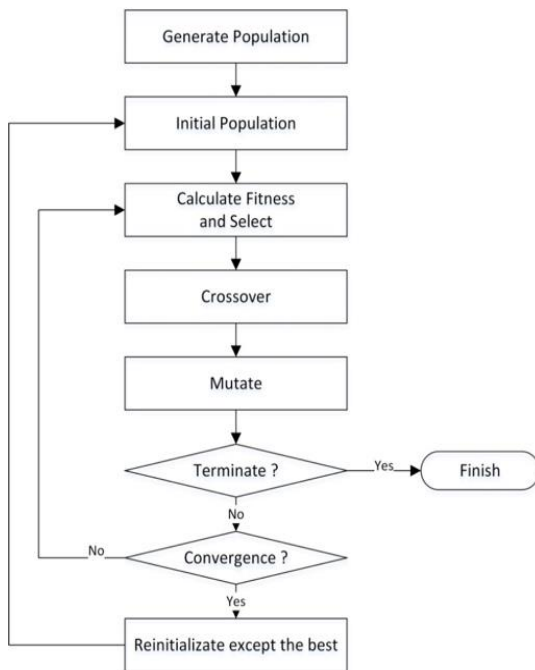


Figure 1. Basic steps of simple μ GA [11]

In μ GA small odd numbers such as 3, 5, 7 are used as the population size generally [8]-[15]. μ GA re-initializes its individuals except the best one to ensure the gene diversity and to prevent terminating at local optimum. The criteria of re-initialization may be the constancy of population for one or a few iterations like in Fig. 2 or the constancy of the best fitness value throughout a few iterations.

In the first μ GA implementation by Krishnakumar [6], 1 is selected as crossover rate and 0 is selected as mutation rate. Thus, the convergence process is made continuous by selecting crossover rate as 1 and gene diversity is maintained with re-initialization instead of mutation operation. But some of the following μ GA implementations used mutation rate higher than zero with re-initialization operation [12]-[15]. The basic pseudo code of generalized μ GA is can be seen in Fig. 2. The stopping condition may be reaching the max iteration number or the stability of the best fitness value for a number of iterations.

```

1  population = createInitialPopulation(N)
2  costs = calculateCosts(population)
3  population = orderByCosts(population)
4
5  while (the stopping condition is not met)
6    pre_population = population
7    if rand < crossOverRate
8      S = select(population) // S is vector of selected individuals
9      crossover(S)
10     update(population)
11   end
12   while (A ∈ population)
13     if rand < mutationRate
14       mutate(A)
15     end
16   end
17   costs = calculateCosts(population)
18   population = orderByCosts(population) // best is first
19   if population = pre_population
20     population(2:N) = createInitialPopulation(N-1)
21   end
22 end

```

Figure 2. Pseudo code of general μ GA, functions are shown by bold.

III. PROPOSED METHOD

The high speed of production line and vibrations caused from production line may cause that the product position is different in images taken by different cameras. Therefore, an optimization process is required to find the optimal points for stitching. In the proposed approach, it is represented micro genetic algorithm based a new method to stitch images taken by camera array at production line. For this reason 2x2 sized a camera array whose cameras have the same properties is set up. The technical properties of cameras are represented in experimental results.

The aim of this study is stitching the images taken from more than one cameras with different position. For this purpose, μ GA based a new approach is represented. Our cause for using μ GA is that the convergence rate of μ GA is high as it is specified in introduction. Operations in image processing are generally about pixel operations. Because of that the pixel count in an image may be big, the computational time of the image processing operations should be low. A block diagram that shows the process of μ GA based image stitching method that is used in this study is given in Fig. 3. We employ μ GA for detection of interest points and matching the detected points as can be seen in Fig. 3. The μ GA settings used for detection of interest points and matching are as following.

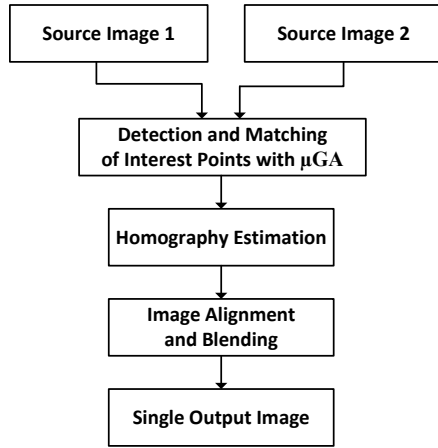


Figure 3. The proposed approach for image stitching process.

A. Population

We aimed to find the pixel coordinates of the interest points for the two images that will be stitched. Therefore, the structure of chromosome is set as $\{x_1, y_1, x_2, y_2\}$, where x_1, y_1 are the coordinates of pixel in image 1 and x_2, y_2 are the coordinates of corresponding pixels in image 2. In order to narrow the search space we used the user defined parameter 'a' that can be seen in Fig. 4. The parameter 'a' depends on speed of the production line, if the production line is fast that means we must use larger value of 'a'. We also divided the candidate interest points area into b heighted n pieces and ran μ GA for each subarea independently. The cause of this is to find more than one corresponding points belonging different parts of images to verify the found interest points.

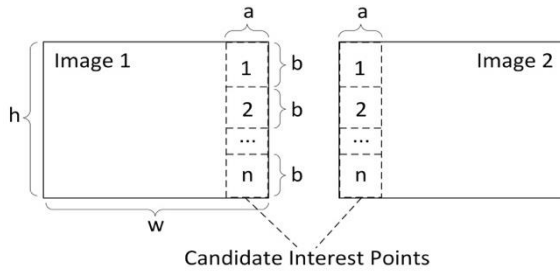


Figure 4. An example for vertical stitching

B. Fitness Function

Finding the interest points means obtaining the same views of two images. So, the purpose of proposed μ GA is minimize the difference between two points to find similar points. In order to find the difference between two pixels, color values and coordinates are compared. The cost function of μ GA is given in (1).

$$\alpha |y_1 - y_2| + \beta \|P_{x_1, y_1} - P_{x_2, y_2}\| \quad (1)$$

$$x_1 \in [w-a, w]$$

$$x_2 \in [0, a]$$

$$y_1, y_2 \in [(i-1)*b, i*b]$$

In (1), α and β are weight parameters, $P_{x,y}$ is the color vector of pixel x, y and i is the sequent of subarea. If the cost equals 0 which is the minimum value of (1), then early stop occurs; otherwise the fitness value equals the inverse of the cost value.

C. Selection

Tournament selection method is not useful in μ GA due to its small population size. We used roulette wheel selection technique that gives the greatest chance of being selected to the fitter individual.

D. Crossing-over and Mutation

The chromosomes used for searching the most similar pixels in image 1 and image 2 are permutation coded. While single point crossover with 0.95 crossover rate is used in this paper, zero is selected as mutation rate.

IV. EXPERIMENTAL RESULTS

In this paper, the image stitching operation is implemented on images taken by the camera array at production line. The diagram of established system given by Fig. 5. The camera array that has 4 cameras with the same characteristics is formed as in Fig. 5. The technical properties of cameras are represented in Table I. A computer with intel i7 6020M CPU, 6 GB ram, and Windows 7 64 bit home premium is used to perform the proposed approach on the images taken by camera array. An example result is shown in Fig. 6.

TABLE I. THE CHARACTERISTICS OF CAMERAS

Feature	Value
Resolution	0.3 MP
Speed	30 fps
Connection type	USB 2.0

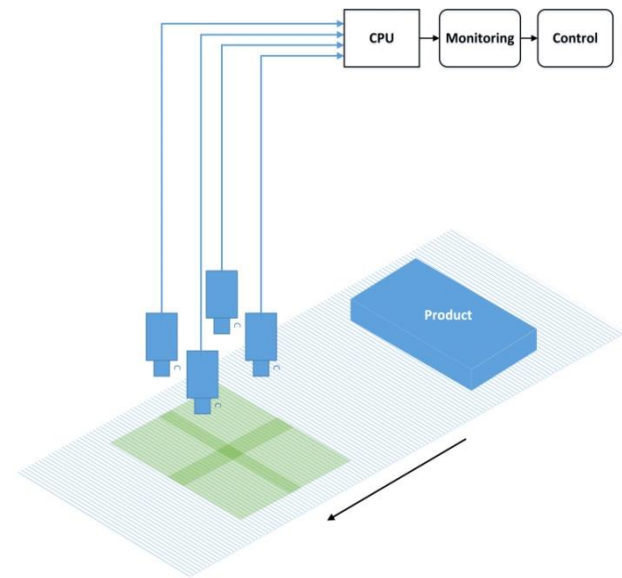


Figure 5. Positions of the cameras in camera array at production line.



Figure 6. An example of 2x2 camera array.

The proposed method is compared with conventional GA with a population size of 50, crossover rate of 0.6, mutation rate of 0.001. The performance of conventional GA and proposed method is represented in Table II. As it can be seen in Table II our proposed method works about 8 times faster than conventional GA.

As a result, the 320x240 sized 4 images taken by camera array are used to generate 623x352 sized single image. The steps of combining images are given in Fig. 6. The stitching process completed in 68 ms. In contrast to classical image stitching process, the computational time doesn't increase directly proportional with the size of the images (interest points), so when the image size is bigger the gain of our algorithm will be bigger.

TABLE II. THE PERFORMANCES OF PROPOSED METHOD AND CONVENTIONAL GA

Process in Fig. 6.	Stitching Performance with Proposed Method		Stitching Performance with Conventional GA	
	Size	Time (ms)	Size	Time (ms)
e	623 x 241	17	622 x 240	136
f	624 x 239	19	625 x 241	156
g	623 x 352	32	625 x 352	253
Total	623 x 352	68	625 x 352	545

V. CONCLUSIONS

In this paper, a new image stitching method is offered for camera arrays and it is tested by experimental. In order to test the method, total 4 cameras are used and 4 different images that belongs the same product taken. The obtained images are linked up with the optimization method based on μ GA. As a result only one image is obtained from the the 4 images. The results are compared with conventional GA's and it is provided the efficiency of proposed method. Furthermore, the little time consumption of proposed method make it possible to be used in image stitching applications.

Consequently, it is possible to get high quality whole product image using low quality cameras thanks to the proposed method. In this manner high-performanced solutions can be achieved with low cost.

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