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 production line while trying to get whole image of the bigger images can decline due to the distance between camera and detection of faulty products is widespread. The quality of the image taken by camera at the top of production line for

Abstract

As an optimization technique micro genetic algorithm (µGA) 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 µGA known by its high convergence rate and low termination possibility at a local optimum to be used in image stitching process. Using µGA 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 µGA, 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. µGA which refers to GA with small population size is significant one of these studies.

µGA was firstly proposed by Krishnakumar [6]. In Krishnakumar’s µGA it was chosen 5 as the population size, 1 as the crossover rate and zero as the mutation rate. He compared his µGA 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 µGA [6]. Then Coello and Polido had extended the µGA to consider multi-objected optimization problem [7]. After that many methods developed which utilized from µGA to solve numerous problems [8]-[16]. Shin-Yeu Lin and Hsing-Fang Tsai [8] proposed a µGA which consists of spatial crossover and correction schemes to solve the constrained three-dimensional reader network planning. Their purpose of using µGA 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 µGA to solve multi-objective scheduling problem. They aimed to reduce the computational effort by employing the µGA 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 µGA which can be seen in Fig. 1 to improve the computation time of their method. Moreover, they recorded that the use of µGA makes it avoid from local optima and ensures the genetic diversity. There are many more studies which utilized µGA to improve their algorithm performance and correctness for solving various optimization problems in literature [12]-[15]. Furthermore µGA can be combined with other solution techniques. Lahoz, Lacruz and Mateo [16] developed a multi-objective µGA to reduce the number of hidden node and the means square error of extreme learning machine (ELM). In all considered studies shows that µGA 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 µGA 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

µGA 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 µGA are the most significant differences between GA and µGA. µGA emerged from the idea of that 3 individuals are sufficient to convergence to the optimal solution no matter what the chromosome length is.

In the first µGA 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 µGA implementations used mutation rate higher than zero with re-initialization operation [12]-[15]. The basic pseudo code of generalized µGA 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.

![Figure 1. Basic steps of simple µGA [11]](image1)

In µGA small odd numbers such as 3, 5, 7 are used as the population size generally [8]-[15], µGA 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.

![Figure 2. Pseudo code of general µGA, functions are shown by bold.](image2)

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, µGA based a new approach is represented. Our cause for using µGA is that the convergence rate of µGA 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 µGA based image stitching method that is used in this study is given in Fig. 3. We employ µGA for detection of interest points and matching the detected points as can be seen in Fig. 3. The µGA settings used for detection of interest points and matching are as following.
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 \(\mu\) 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.

B. Fitness Function

Finding the interest points means obtaining the same views of two images. So, the purpose of proposed \(\mu\) 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 \(\mu\) GA is given in (1).

\[
\alpha |y_1 - y_2| + \beta \|P_{x_1,y_1} - P_{x_2,y_2}\|
\]

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

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

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

In (1), \(\alpha\) and \(\beta\) 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 \(\mu\)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>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>0.3 MP</td>
</tr>
<tr>
<td>Speed</td>
<td>30 fps</td>
</tr>
<tr>
<td>Connection type</td>
<td>USB 2.0</td>
</tr>
</tbody>
</table>

TABLE I. THE CHARACTERISTICS OF CAMERAS

![Figure 5. Positions of the cameras in camera array at production line.](image)
The gain of our algorithm will be bigger. On the other hand, our method allows for the processing of images in the order of seconds. When the image size increases, the computational time also increases. For instance, when the image size is bigger, the computational time of classical image stitching processes is also significantly increased. In contrast, our proposed method provides a significant computational cost advantage over conventional methods. As a result, the 320x240 sized 4 images taken by the camera in each row were stitched. The stitching process for camera arrays and it is tested by experimental. Consequently, it is possible to get high quality whole product image using low quality cameras thanks to the proposed method. This manner high-performed solutions can be achieved with low cost.

**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 μGA. 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.

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