Optimization of Camera Positions for Taking All Indoor Sceneries by GA

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Abstract

CG images consisting of all indoor sceneries are usually used in movies, virtual reality applications, etc. This paper addresses a GA-base method to find the optimal camara positions to synthesize a complete indoor image from multiple photographs. For this objective, we use a efficiency crossover operation. Our method is evaluted by computer simluations that find the camera positions which can take all walls in the building. The experimental results show that our method can take all walls in the building by the small number of cameras.

Keyword: Genetic Algorithm, CG, Composition of a seamless image

1 Introduction

Recently, Computer Graphics (CG) are used in many fields such as movies, games and so on. Many CG engineers have developed sophisticated techniques to produce photo-realistic CG images. In particular, movies use many CG images to synthesize scenes which are hard to film. This field reruires an easy way to get a complete in image a building. Some CG engineers synthesize the complete indoor image from multiple photographs.

If has two problems to synthesize a complete indoor image from multiple photographs; how to determine the minimum number of cameras to take all indoor scenery, and how to determine the optimal camera positions and view angles. In addition a photograph needs to have appropriate overlap areas between the neighboring photographs to make a seamles image as shown in Figure.1.

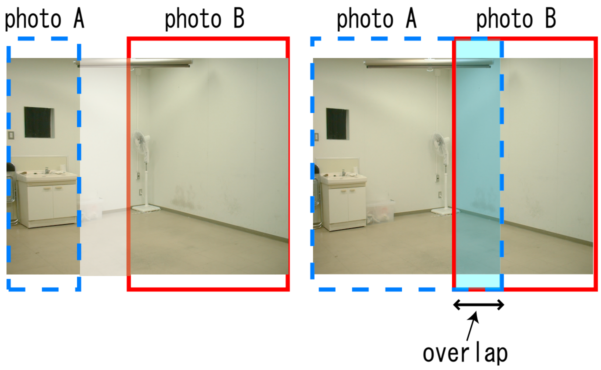

Figure 1: Overlap to compose a seamless image

2 Definition of the problem

The final goal is to compose a seamless image from the minimum number of photographs with suitable overlaps, and the seamless image takes all indoor scene in the building. For this objective we derive the optimal camera positions by GA under the following assumptions and constraints.

2.1 Assumptions

To simplify the problem, we suppose the following four assumptions.

- There is no furniture in the room.
- Building is described as two dimensional floor map.
- Cameras are allowed to put on the descrete position. The interval of positions is given by user.
- The view angle of camera is 48 degree, that is as the same as that of standard lens of 35mm camera. And the focus range is given by user.

2.2 Constrains

To compose a seamless image from multiple photographs, the image has to satisfy the following two constraints.

- The seamless image has to take a complete view in the view building. In other words, the seamless image has to take all walls in the rooms.
- Each photographs has to have suitable overlap areas between neighboring photographs as shown in Figure.1. Since the wall taken by more than two cameras is redundant, it is not used as the overlap.

2.3 Optimal camera position

We define the optimal camera position that satisfies the constraints under the assumptions by the minimum number of cameras. However the minimum number of cameras is not generally decided by the probabilistic search such as GA. Therefore we decide the smallest number of cameras through computer simulations. Concretely, if N cameras put on the appropriate positions can satisfy the constraints, and if $N-1$ cameras can not satisfy them, N is the minimum number of cameras. This N is decided through all computer simulations.

3 Genetic Algorithms

3.1 Genetic Coding

A camera has three parameters; the horizontal position, the vertical position and the angle from the horizontal axis. These three parameters are arranged as an individual. X_i and Y_i denotes the horizontal and vertical coordinates of the camera i, respectively. X_i and Y_i have descrete values as described in the assumption. θ_i denotes the angle of from the horizontal axis. The range of θ_i is ± 180 degree by one degree step.

3.2 Genetic operations

3.2.1 Parents Selection and Crossover

The numbers of cameras in an individual are affected by the crossover operation. To reduce the number of cameras effectively, it is desired that a camera take more area of the walls. For this reason, the selection of parents is operated as follows;

1. "Parent-A" is chosen in order of the fitness value defined by Equation (1) in Section 3.2.2.
2. A temporary individual A' is made from the "Parent-A" . The individual A' is almost the same as the "Parent-A", but some cameras taking a wall that has the smallest area are removed. The wall taking by the removed cameras is called as the "WorstWall-A".
3. "Parent-B" that takes the largest area of the "WorstWall-A" is chosen from the population. Camera is called as the "BestCamera-B".
4. A temporary individual B' is made from the "Parent-B". The individual B' only includes the "BestCamera-B".

The "BestCamera-B"are inserted into Individual A' in one by one as shown in Figure.2 . Finally, new offspring is created.

3.2.2 Fitness Function

The fitness function is defined by Equation (1) where j is ID of walls. N is the number of walls in floor map.

$$f_g = \Sigma_j (P_j + Q_j), \tag{1}$$

$$P_j = \frac{l_{ja} + l_{jb} - \lambda}{L_j} \times 100(\%), \tag{2}$$

$$Q_j = \begin{cases} 100 & P_j\textit{=100(\%)} \quad \textit{and} \\ & \lambda > (1-\alpha)M \\ 0 & \textit{other} \end{cases}, \tag{3}$$

In Equation (2), l_a and l_b denote the length on the wall j taken by the camera A and the camera B, respectively. λ denotes the length of the wall j taken by both of the camera A and the camera B (overlap). L_j is the length of the wall j. These parameters are also illustrated in the Figure 3 . When the wall j is completely taken by the camera A and the camera B, P_j becomes 100.

Q_j becomes 100 if the wall j is completely taken, and the photographs include desirable overlap to compose a complete image. The parameter α $(0 \le \alpha \le 1)$ and M are given by user.

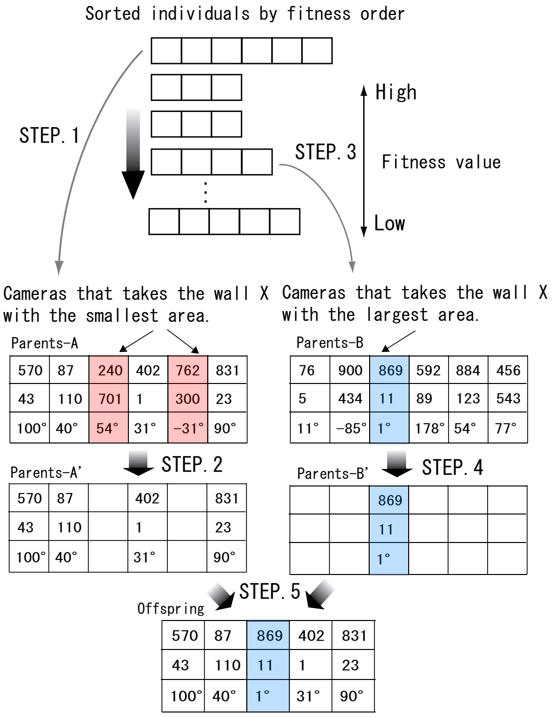

Figure 2: Crossover

Thus the maximum of fitness value for each wall is 200 when all the walls are taken, and it has appropriate overlaps between photographs.

3.2.3 Mutation

In GA, the contents of an individual are randomly changed by the mutation. It means that the direction and the position of the camera are changed by the mutation in this application. However, this mutation causes low fitness value at the last stage of evolutional process. Therefore we use the following two operations as the mutation.

If a camera takes only one wall, this camera is deleted from the individual to reduce the number of cameras. If a photograph taken by camera A is completely included the other photograph, the camera A is deleted from the individual.

3.2.4 Local search

Since GA is a kind of the probabilistic search, it dose not guarantee to find the optimum solution. To improve the quality of solution, local search operation is employed. The local search is operated as follows;

1. Change of the camera direction

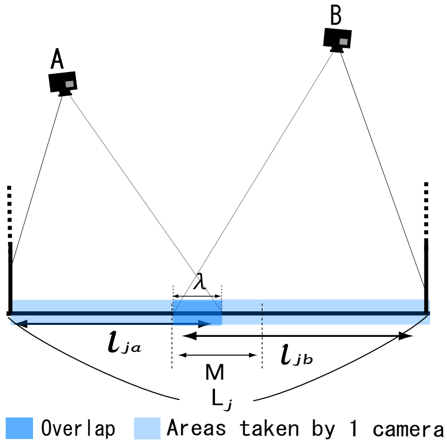

Figure 3: Parameters to calculate fitness

   (a) The angle of all cameras are changed from 0 to 360 degree at random. The angle with the highest fitness value is set to the new angle for each camera.

   (b) After above operation, the individual that have more than 90% of the elite's fitness values are selected. The angle of these cameras is changed within ±10 degree by one degree step, then the angle with the highest fitness value is selected.

2. Change of the camera position

   At first, the camera is provisionally moved to the eight neighbors of the current position. Then the camera is moved to the position with the highest fitness value.

4 Experiments and Discussions

4.1 Experimental conditions

For the experiments, we prepare a floor map based on the actual building in University of Miyazaki.

4.2 The parameter of GA

Parameters of GA for the experiments are described in below. These parameters are derived from the preliminary computer simulations.

- Maximum number of generations: 100
- Number of individuals: 100

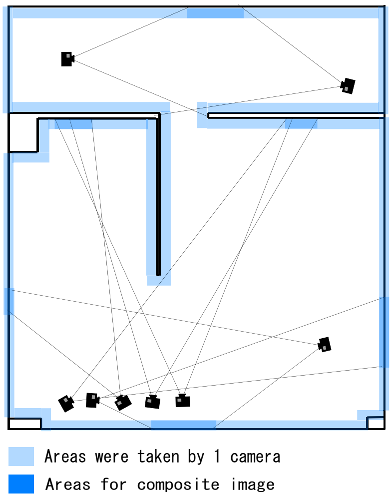

Figure 4: An example of camera layout at 100-th generation

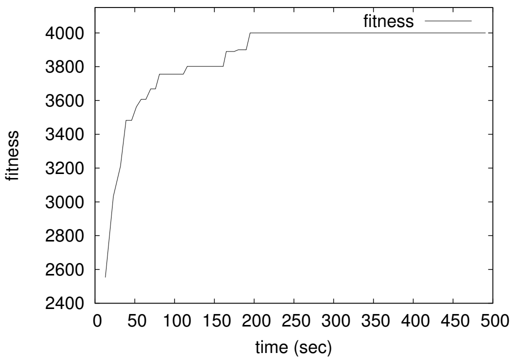

Figure 5: Change of fitness

- Number of offspring generated by Crossover: 100
- Initial number of cameras: 12
- Camera position interval: 0.5 (m)
- Walls in the floor map: 20
- Number of simulations: 30
- Desirable overlap length M: 0.03 (m)
- α :0.3

4.3 Experiments Results

In the 0-th generation, some walls are taken by more than two cameras, and some walls are not taken by any cameras. Figure.4 shows the camera position of an elite individual after 100 generations. As shown in Figure.4, all cameras take more than two walls with suitable overlap. In addition the number of cameras was decreased into 8. In this case, the fitness of the individual was arrived at the maximum value 4000. As a result, it is showed that our method could take multiple photographs including desirable overlap to synthesize a seamless indoor image of the building. Figure.5 shows changes of fitness value. As shown in Figure.5, the fitness reached the maximum value after 200 (sec) execution.

5 Conclusion

Recent progress of image processing technology leads many applications in real world. In particular composition of a seamless image from the multiple photographs taken from many viewpoints attracts attention in the movie fields. We propose a method to composition a seamless image by the minimum number of photographs. For this objective, we employed the genetic algorithm to find an appropriate layout of the cameras. To reduce the computation time we allowed the cameras to place on the discrete positions, and employ a powerful local search method to find the better camera layout. Simulations results showed that our method could derive the suitable camera layout that makes be possible to compose of a seamless image.

Future works remain as the experiments in the floor map containing some funiture, and we try to apply our method to 3-D buildings.

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