

# AUTONOMOUS PHOTOGRAMMETRIC NETWORK DESIGN BASING ON CHANGING ENVIRONMENT GENETIC ALGORITHMS

YANG Jian<sup>a</sup>, LU Nai-Guang<sup>b</sup>

<sup>a</sup>Department of Electronic Engineering, Beijing University of Posts and Telecommunications, Beijing 100081, China

<sup>b</sup>Electronic and Information Engineering, Beijing 100081, China

**KEY WORDS:** Photogrammetry, Network Design, CCD Planning, Automation Placing, Precision

## ABSTRACT:

In order to get good precision designer used to consider how to place cameras. Usually, design would refer to multidimensional optimal problem, so people used genetic algorithms to solve it. But genetic algorithms could result in premature or convergent problem. So sometime we get local minimum not global minimum and bring with vibrating phenomenon. Those problems will affect inaccurate design. So we try to solve them using the simulated annealing genetic algorithms. The methods give those species groups difference environment during difference stage to improve the property. Computer simulation result show that the way can accelerate the convergent speed and select good individual. This work would be used in other application.

## 1. INTRODUCTION

Photogrammetric network design is the process of placing cameras in order to perform photogrammetric tasks. An important aspect of any close range photogrammetric system is to achieve an optimal photogrammetric network for special purpose. Network design quality can be expressed through the ability of the photogrammetric measurement operation to satisfy, in an optimal manner, a number of target functions, most notably precision, reliability, economy and testability. This problem can be classified into four interconnected stages in accordance with the classification scheme of Grafarend (1974)<sup>[1]</sup>:

- Zero-order design: the datum problem
- First-order design: the configuration problem
- Second-order design: the weight problem
- Third-order design: the densification problem

The densification problem is not application for close range photogrammetric network design. Moreover, the ZOD and SOD are greatly

simplified in comparison to geodetic networks, for which the four-stage classification was originally developed. Indeed, it will be shown that only FOD, the design of network configuration or the sensor placement task needs to be comprehensively addressed for photogrammetric projects.

In order to design an optimal imaging geometry and the number of sensor, experts provide some methods: the expert system approach<sup>[3]</sup>, trial-and-error fashion or simulation calculation. The expert system approach is based on lots of knowledge of networks that can provide a strong imaging geometry for the class of planar network design problems. But expert system approach is not a full automation of placing sensor. During designing the network, the operators need a lot of knowledge of photogrammetric network design. So this way has rarely been applied by other than experienced photogrammetrists. Trial-and-error fashion need the knowledge of photogrammetric

networks, and can not get the most optimal number and network geometry. In case the object and the task is complex, the way can not solve the problem easily. The question, how to obtain an initial configuration with an optimal imaging geometry, is unsolved and must be faced by the designer. In this case,

Gustavo Olaug<sup>[2]</sup> provided a automation approach to design network using genetic algorithms. Genetic algorithms are stochastic optimization techniques, which have proved useful at solving computationally difficult problems with high combinatorial aspects. Olaug try to get the most optimal value using genetic algorithms.

## 2. PHOTOGRAMMETRIC NETWORK DESIGN PRINCIPLE

Usually network design based on the linear and stochastic models (Markov-Gauss model) for which can be given as

$$V = AX - L$$

$$\text{Stochastic modal: } \begin{cases} E(V) = 0 \\ C_l = \sigma^2 Q = \sigma^2 P^{-1} \end{cases}$$

Where  $L$ ,  $v$  and  $X$  are the vectors of observations, residuals and unknown parameters, respectively;  $A$  is the design or configuration matrix,  $C_l$  the covariance matrix of observation;  $P^{-1}$  the weight matrix;  $Q$  is normalization covariance matrix; and  $\sigma^2$  the variance factor. In situations where  $A$  is of full rank, the parameter estimates  $\hat{X}$  and the corresponding cofactor matrix  $Q$  and  $C_l$  are obtained as

$$\hat{X} = (A^t P A)^{-1} A^t P L$$

**Sponsored by** the National Natural Science Foundation (50675015)  
YANG Jian (1979-), Ph.D., jackeymail@126.com

And

$$C_l = \sigma^2 Q$$

$$Q = (A^T P A)^{-1}$$

These result come from least-square method,

$$V^T P V = \min \text{ and } A^T P A \hat{X} = A^T P L.$$

The result has some excellent nature:

$$E(\hat{X}) = X$$

$$tr(Q) = \min$$

So the value is optimal and without bias. The design optimization goal for precision is to achieve an optimal form of Q.

### 3. CONSTRAINTS ON NETWORK DESIGN

In order to design feasible network we must care about the constraints effects. The work is supported by the national natural science foundation, so in this work discussing the effect of constraint of the project. The project tries to improve the photogrammetric precision of radar antenna. The constraints is

different according your task.

### 4. GENETIC ALGORITHM AND THE PROBLEM

- Firstly, we design the size of population, here set it 15. We set the maximal generation number 60 and generation gap 0.9. The initial random population should satisfy the environment constraints and represented by  $(a_n, b_n)$ . We select binary code.

Where  $a_n$  express the angle of optical axis to Z axis,  $b_n$  express the angle of optical axis to X axis. Genetic algorithm calculation comprise of inheritance, intercross, variation.

- Fitness function:  $tr(Q) = \min$ , when the number of camera is  $N$ . The average fitness value is

$$av(tr) = \sum_1^N tr(Q_n) = \min$$

If the system only has random error, follow is the result of  $N = 3$ .

Test num minimum	individual size	Maximal generation number	Binary variance	Generation size	CCD Angle value gap	covariance matrix number (rad)	trace
1	15	60	20	0.9	3	(1.8405,2.6528)	(1.8263,1.0535)
			0.0748			(1.844,0.918)	
2	15	80	20	0.9	3	(0.599,2.313)	3.2632
						(1.899,1.067)	
3	15	70	20	0.9	3	(2.09,2.83)	0.0496
						(2.10,2.8)	

Figure 1

When using genetic algorithm to design network, we found that sometime the system is unstable. I select one to show.

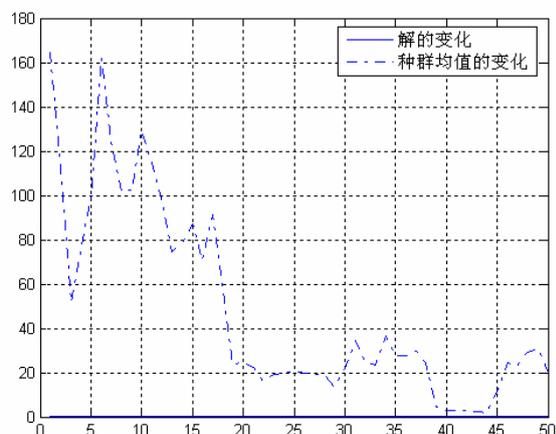


Figure2

### 5. PROBLEM ANALYSIS

When we designed genetic algorithms, the size of genetic group is between dozens and hundreds commonly, and this is deferent for actual natural species size. So it is important to adjusting size of group for genetic algorithms. If there have super Individual in group, it would dominate the whole group and hold back others individual inherit. Namely, this super individual fitness value is greater than average fitness value, and then it must dominate this group. In the case, this genetic algorithm would converge at a local optimal value. The phenomena called premature convergence. In the later stage, though species existence is sufficient in the group, but average group fitness value may approach optimum group fitness value. In the case, the competition dose not exists in this group. Thereby, it is so difficult to improve the optimal value. The phenomena on numerical value are to shake.

### 6. THE CHANGING ENVIRONMENT GRADUALLY GENETIC ALGORITHM AND SIMULATED ANNEALING ALGORITHM

For the genetic algorithm shortcomings, author gives the way that would resolve those problems by changing fitness value. This is to carry out adjustment on value degree. This work bring simulated annealing algorithm to the photogrammetric network design process, meanwhile suggested that new especially simple and convenient environment gradient genetic algorithm comes to solve the problem. It is the mainly thought that providing deferent environment  $T_i$  during deferent stage. In initial stage, suitable living environment was provided for those species in order to decrease the distance of fitness value of deferent individual. This would increase the inherit chance of every individual and resolve the premature convergence problem. The method would increase species diversity to increase the chance of inherit too. As the inherit generation degree increasing, the environment will become more and more poor. This would make the distance of individual fitness value increasing. Only some stronger individuals could live and inherit their effects to next generation. In the case, environment would make outstanding individuals more outstand to overcome net design calculation vibration phenomenon.

- simulated annealing algorithm

$$P_{accept}(s, s_i, T) \begin{cases} 1, f(s_i) < f(s) \\ \exp(\frac{f(s) - f(s_i)}{T}), f(s_i) > f(s) \end{cases} \quad (1)$$

Here, T is the environment temperature. The function  $f(s_i)$  is the fitness value of  $f(s)$  variation.  $s_i$  is the specie.  $P_{accept}(s, s_i, T)$  is the probability of accept the species.

SA algorithm accepted the bad result by  $P_{accept}$  to avoid the local minimum. When we get one fitness value  $f(s_i)$ , if it better than previous value  $f(s)$ , then we accept it. If it worse than previous value, then we accept is by the

$P_{accept}(s, s_i, T)$  probability.

T is the environment temperature. When the temperature value is high, the fitness value is almost same. This would avoid the premature. When the value of temperature down, the deference of individual would be obvious.(figure 2)

Step:

- Initialize the SA function to create the initial result.
- Initialize the SA function parameter, including initial temperature T, the number of variation, end condition.
- Make function for creating next generation value.
- Decide accepting the result or not by formula(1).
- Return the result and next loop.

### 7. SIMULATOR

In order to test the convergence of gradually changing environment genetic algorithms, the work design the simulative test based on Matlab.

Here, I set the size of group is 15, binary variance, max generation 50, gap of generation 0.9, cross variation, and the function is changing environment genetic algorithms.

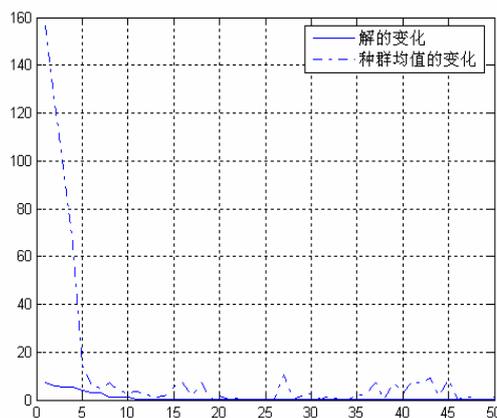


Figure3

The graph show the result and the convergence of algorithms.

Test num	individual size	Maximal generation number	Binary variance	Generation size	CCD Angle value gap	covariance matrix number	trace
1	15	60	20	0.9	3	(1.456,1.671) (1.323,2.9546)	0.0583 (1.3421,1.1044)
2	15	80	20	0.9	3	(1.2175,1.341) (1.5432,2.9541) (1.3212,1.1236)	0.0876
3	15	70	20	0.9	3	(1.775,1.651) (1.3123,2.9089) (1.4314,1.2109)	0.0696

## 8. CONCLUSION

For the genetic algorithm shortcomings, the way would result in error design. Especially the convergence of algorithm affects the result. To resolve the problem, the work provided an approach, simulated annealing algorithm. They have better convergence than genetic algorithm.

Compare the data of two table, we can find that simulated annealing algorithm genetic algorithms get smaller covariance matrix trace, the first table is 0.0748 and the second table is 0.0583.SA algorithm is smaller than genetic algorithms. Meanwhile, it get good convergence.

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