CGH 생성을 위한 유전알고리즘의 최적화 시간단축
A new approach to reduce the computation time of Genetic Algorithm for computer-generated holograms

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A CGH is a hologram generated by computer. It is widely applied to wavefront manipulation, synthesis, optical information processing and interferometer. Some methods have been used to determine the optimum phase pattern to achieve high diffraction efficiency and uniform intensity such as DBS (Direct Binary Search), SA (Simulated Annealing), GA(Genetic Algorithm). These methods require long computation time to generate a hologram. That is the limitation of these methods.

In this paper, we propose a hybrid algorithm for hologram synthesis that employs the good properties and performance of both ANN (Artificial Neural Network) and GA. In this method, the traditional GA is used as teaching signals to train the network. With the trained ANN, approximately desired CGHs can be easily and quickly obtained[1]. Employing those CGHs into the initial process of GA, a hologram of the same diffraction efficiency and uniform intensity as GA but short computation time can be achieved.

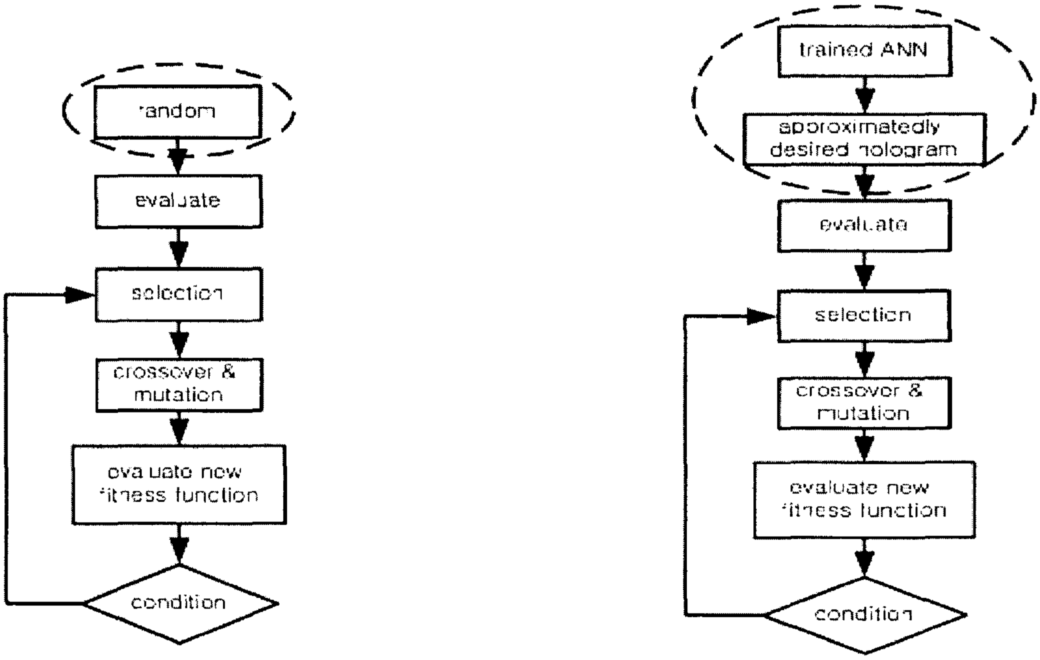
Genetic algorithm, which is invented in the early 1970s, is widely believed to be an effective global optimization algorithm. It is stochastic search procedures modeled on the Darwinian concepts of natural selection and evolution.

To adapt GA for optimizing hologram, chromosome (a trial solution hologram) is coded as a binary integer of length 32x32. The selection with stochastic tournament selection method for decreasing the stochastic sampling error is performed, and a single-point crossover having 18x18 block size is used. Chromosomes are evaluated by using a fitness function including the diffraction efficiency and uniformity between diffraction spots in the output plane. This function can be written as[2]:

$$g(x) = \sum_{m=1}^{M}\sum_{n=1}^{N}(T_{mn} / spots - I_{mn})^2 + W\sum_{m=1}^{M}\sum_{n=1}^{N}(eff / spots - I_{mn})^2$$

where m and n are cell positions of the grating, T_{mn} is a target value, I_{mn} is an intensity of diffraction beams, W is a weight factor, $spots$ is a number of diffraction beams, and eff is a calculated efficiency.

Because of the random initiation of GA, the calculation time of GA is so long. It is better to generate a population of chromosomes which are not random. Here, we would like to describe a hybrid algorithm which is still based on GA but the initial holograms are approximately desired hologram by using ANN. The Figure 1 illustrates the difference between GA and hybrid algorithm:



Genetic Algorithm **Hybrid Algorithm**

Figure 1. The difference between GA and Hybrid Algorithm

In computer simulation, we consider the desired image as a letter "O" showed in the Figure 2. The diffraction efficiency and the time for the design of the hologram using GA are 75.2% and 598 seconds, respectively. With hybrid algorithm, the hologram with 76% high efficiency and 198 seconds computation time is achieved.

This method promises a new way to improve both the efficiency and the computation time of GA as well as other methods. Further investigations are under way to enhance its performance ability.

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0 0 0 1 1 0 0 0 0
0 0 1 0 0 1 0 0 0
0 1 0 0 0 0 1 0 0
0 1 0 0 0 0 1 0 0
0 1 0 0 0 0 1 0 0
0 1 0 0 0 0 1 0 0
0 1 0 0 0 0 1 0 0
0 0 1 0 0 1 0 0 0
0 0 0 1 1 0 0 0 0
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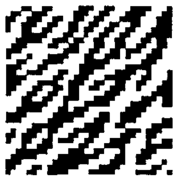
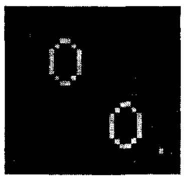
Desired Image



Hybrid Algorithm's Hologram



Reconstructed Image

Figure 2. Simulated result

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References

[1] S. Yamauchi, Y.Chen, and Z. Nakao,*Proc. of the Second Int. Conf. on Knowledge-Based Intelligent Electronic System*, pp. 220-223, Apr. 1998.

[2] Jin Seon Yoon, Nam Kim, *Journal of the Optical Society of Korea*, Vol. 4, pp. 30-36, Apr. 2000.