TITULO DEL LIBRO
A. Editor1 y B. Editor2 (Eds.)

A NEW COLLABORATIVE DESIGN METHOD BASED ON INTERACTIVE GENETIC ALGORITHMS

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Abstract. This paper proposes a new collaborative design method based on interactive genetic algorithms. A network collaboration system is developed to make good design solutions among several person at different locations. We have proposed a parallel distributed interactive genetic algorithm, where the total population is divided into several sub-populations. And the different sub-populations is incorporated to maintain the diversity of the solutions. The proposed method uses an IGA and a distributed GA, which combines several IGA systems. In this method, the design solutions are growing on one user's subjective evaluation, and the migration impedes the premature convergence of the solutions. A new creative design solution or a compromise can be produced among several people with this method. A prototype network collaboration system is developed and it is applied to make good plans for the coloring problem of objects.

Keyword: Collaboration System, Interactive Genetic Algorithms, Parallel Distributed GA

1 Introduction

Recently, corporate activities become global and decision-making involves many people. In such cases, network collaboration systems that enable information exchange and the making of better design solutions in certain problems with many people in remote areas are required. But, it is not easy to make a consensus of opinion with many people in remote areas. So, there is a big demand for network collaboration using a computer.

In the research of network collaboration, there are scientific research and information technology application called "Computer Supported Cooperative Work (CSCW)" .[1] In the research of CSCW, decision-making and making a consensus with cooperative communication activity are supported by computers. However they are not considered to be effective in planning and designing of various systems. This system can be used in many situations such as the making of business plans and the creation of artistic designs.

A prototype network collaboration system is developed and it is applied to make good plans for the coloring problem of objects. The experiment is performed with several people, and the effectiveness of the system is demonstrated.

2 Interactive Genetic Algorithms (IGAs)

A technique called interactive genetic algorithms (IGAs) is introduced to accelerate user's invention and inspiration of new solutions.[2,3] IGA approaches have sought the optimum results related to the process of interaction between human and a computer .[4] Genetic Algorithms (GAs) are stochastic search algorithms based on the mechanics of natural selection and natural genetics.[5] In IGA, the user selects one or more favorite models that survive and reproduce to constitute a new generation.

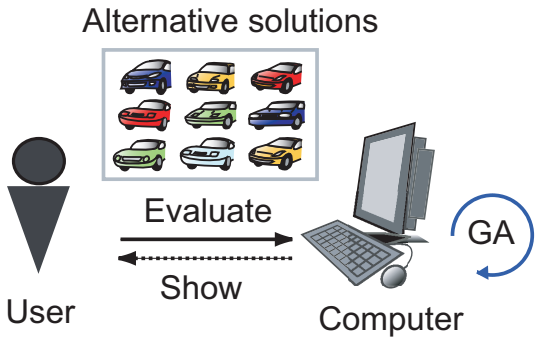

Figure 1: The process of interaction between human and a computer

As shown in Figure 1, an IGA system and its user makes a virtual conversation through the alternative solutions of a problem. The system creates new alternative solutions by evolutional operations, such as crossover and mutation. The user evaluates the alternative solutions. The system performs probabilistic selection based on user's selection. By repeating this process, the better design solutions can be obtained after some generations.

3 Parallel Distributed Interactive Genetic Algorithm (PDIGA)

3.1 Parallel distributed model

The parallel distributed interactive genetic algorithm (PDIGA) is an interactive genetic algorithm (IGA) extended to a parallel distributed model. In PDIGA, many people can perform an IGA simultaneously and their solutions are exchanged. The exchanges of the design solutions enables the joint ownership of the information. A network collaboration system with an IGA and parallel distributed model can provide a creative design solution as well as making of a compromise.

3.2 Implementation

The important point for network collaboration is the transparency of the solutions among multiple users. This proposed system is designed by Java and HORB [1] considering this information transparency. And the architecture of the proposed system is a client-server model. A typical client-server architecture consists of a server application running on one machine, and one or more clients. Each user perfoms IGA in the client-side, and the data management is performed in the server-side.

[1]HORB is the open source distributed object architecture for Java developed by Dr. Hirano, belongs National Institute of Advanced Industrial Science and Technology (AIST)

In the proposed method, the exchange of the design solutions is performed among the users asynchronously after each design solution is evolved at a certain stage. Therefore there is a reservoir of migrated individuals in order to exchange a design solution among the users at an asynchronous interval. Using this reservoir, each user is free from the waiting for the synchronization. Figure 2 shows the model of PDIGA.

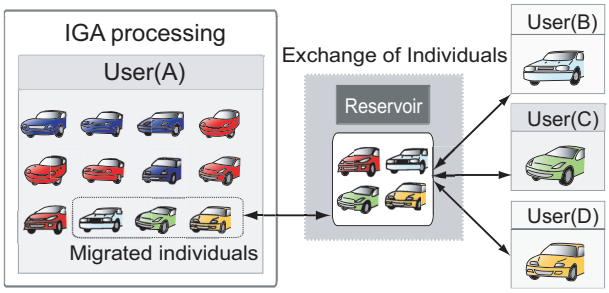

Figure 2: Model of PDIGA

4 The Proposed Method

The effectiveness of the proposed method is investigated by applying PDIGA to the coloring problem of objects. In this system, some people decide the coloring problem of objects by using the PDIGA.

The objects is sofa, carpet, and curtain. And the expression of the color is based on the RGB color model. In the proposed method, the combination of the colors of the objects is based on the real-coded GA[6] which is well suited for the search in a continuous variable space. The crossover method is the Unimodal Normal Distribution Crossover (UNDX).[7]

4.1 Population size and evaluation method

The number of individuals shown on the display is ten native individuals and some migrated individuals. The number of migrated individuals depends on the number of the users. The evaluation of the individuals is performed by the selection of the best three individuals and the worst one individual for each generation.

4.2 Creations of initial individuals

The creation of the initial individuals is based on the user's decision. that is, the user choose his own desirable colors with the RGB color model on a graphical user interface. The initial ten individuals are created based on the initial colors and uniform random numbers.

4.3 Selection and crossover

Two selection methods are used in the network collaboration system, one is a deterministic selection and crossover where the user's preference is realized. The other is a probabilistic selection and crossover that are used in conventional GAs. The reason why the deterministic method is used is to prevent the divergence of the solutions.

4.4 Migration individuals

After five generations, the migrated individuals from the other users are shown on the display. The migrated individuals are the best solutions evaluated by the users. They are not involved in the crossover operation as long as they are not included in the three good selections. If the migration individuals are involved to the crossover operation unconditionally the solutions in each system can be destroyed.

4.5 Terminal Condition

When each user gains a satisfactory solution, the system is terminated.

5 Experiments and Results

The experiments are conducted using ten users of university students. The purpose of the experiment is to examine the effectiveness of the proposed method.

5.1 Effectiveness of IGA

To verify the effectiveness of proposed system, we should carry out an experiment to investigate whether IGA is an effective search method. In this experiment, each user should use the proposed system by oneself.

Table 1: Question: Was the final solution better than the initial solution ?

	Yes	Not Clear	No
IGA	6	3	1

Table 1 shows the result of the question. From the result, it is said that IGA is the effective search method. But, Some users answered that the final solution was worse than the initial solution. The reason this to result is that this system can't return to the previous generation even if the user would like to know the individuals in the previous generation. Thus, there is some possibility of converging of the user's solution in the different area.

5.2 Effectiveness of PDIGA

We carried out the experiment to compare the effectiveness of PDIGA with the effectiveness of IGA. In this experiment, each user should use the proposed system by four users. Thus, the user can know the three migrated individuals in his display. We carried out an experiment to investigate whether the migrated solutions are useful. If each user uses the migrated solutions, it is said that PDIGA is more effective than IGA.

Table 2: Question: Could you use the migrated solutions from other users ?

	Yes	Not Clear	No
PDIGA	0	10	0

Table 2 shows the result of the question. From the result, it is said that PDIGA is more effective than IGA. Because all users answered that they could sometimes use the migrated individuals from the other users. And, the migrated solution provides a new idea and a new creative design solution for users.

5.3 Effectiveness of the ability to make a consensus

We carried out the experiments of making a consensus to compare the effectiveness of the conventional meeting with the effectiveness of the proposed system. To verify the effectiveness of proposed system, three experiments are conducted. The experiments of making a consensus has the purpose of a consensus as follows.

Purpose of a consensus: Please make a design of resting room of the office

5.3.1 Conventional meeting

Each user makes an initial solution. Two users discuss about the initial solutions on the display to make a consensus solution.

5.3.2 Proposed system

Each user design makes an initial solution. Two users discuss about the migrated solution from the other users to make a consensus solution.

Question 1: Was the final solution better than the initial solution ?

Question 2: Could you collaborate with the other users for the final solution ?

Question 3: Was the proposed system better than the conventional meeting with regard to making a consensus?

Table 3: Results of questions

Question 1	Y	NC	N
Conventional meeting	7	3	0
Proposed system	7	3	0
Question 2	Y	NC	N
Conventional meeting	7	3	0
Proposed system	3	7	0
Question 3	Y	NC	N
Proposed system	3	0	7

Y: Yes, NC: Not Clear, N: No

Table 3 shows the result of the questions. From the result, it is said that the proposed system is less effective than the conventional meeting. A proposed system is developed to make good design solutions among several people at different locations. So, we should have carried out the experiments of making a consensus at different locations.

5.4 History of the design solutions

The user A and B used the proposed system and the possibility of the creation of the compromised solution and the creative solution is investigated from the history of the design solutions provided by the users.

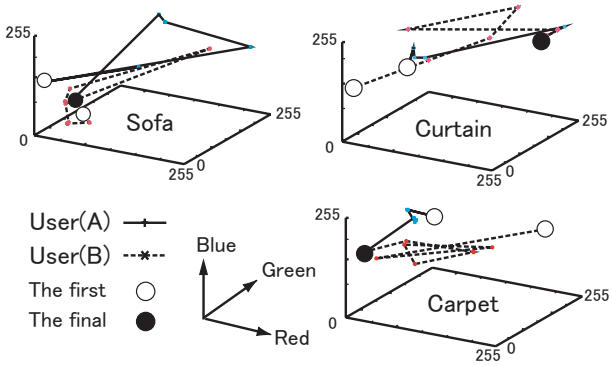

Figure 3: An example of the history of the design solutions produced by users A and B for each furniture

Figure 3 shows an example of the history of the design solutions produced by the user A and B for each object. As shown in Figure 3, two users finally selected the same design solutions. They adopted the other user's design solution occasionally and therefore it can be realized to prevent premature convergence and to maintain the diversity of the solutions. Thus, the compromised solutions for the two users are produced.

6 Conclusions

In this paper, the parallel distributed interactive genetic algorithm (PDIGA) which is the extension of IGA to a parallel distributed model is proposed. The proposed the network collaboration system using PDIGA is able to provide the joint ownership of the sensibleness of the design solutions. We investigate the possibility of the compromised among multiple users. We applied the proposed method to the problem of the determination of the colors of the objects and the experimental result indicates a better design solution or compromise can be produced among several people with the proposed method. The future problem is the investigation of the effectiveness for other decision-making problems with many people.

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