APPLICATIONS OF EVOLUTIONARY OPTIMIZATION IN STRUCTURAL ENGINEERING

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1. INTRODUCTION

With the recent advanced development of computer technology, it has been widely recognized that optimization can take an important role in accomplishing an economic and efficient process for various engineering problems. It can provide us with useful information for decision-making. From the practical points of view, the optimization should be flexible and intellectual so as to solve real problems with many difficulties such as vague and uncertain objective function and constraints

In this paper, an attempt is made to develop some efficient optimization methods by introducing the concepts of evolutionary computing. Several application examples are presented to demonstrate the applicability of the proposed methods.

2. EVOLUTIONARY COMPUTING

Evolutionary computing has been paid attention as a promising optimization tool in various fields because of its general possibility to reach the optimal solution, simplicity in theory, and easiness of programming. Among many evolutionary computing techniques, Genetic Algorithm (GA), Immune Algorithm (IA), and Particle Swarm Optimization (PSO) have been successfully applied in the field of structural engineering. GA is an evolutionary computing technique, in which candidates of solutions are mapped into GA space by encoding. The following steps are employed to obtain the optimal solutions: a) initialization, b) crossover, c) mutation, d) natural selection and e) reproduction. Individuals, which are solution candidates, are initially generated at random. Then, steps b, c, d, and e are repeatedly implemented until the termination condition is fulfilled. Each individual has a fitness value to the environment. The environment corresponds to the problem space and the fitness value corresponds to the evaluation value of objective function.

Immune Algorithm (IA) is a kind of optimal solution search algorithms and is said to allow the diversity of solutions to be retained and multiple quasi-optimal solutions to be obtained. It is considered that IA is suitable for practical design problems because of these characteristics, which allow two or more different quasi-optimal solutions rather than a single optimal solution to be obtained to a problem which is difficult to evaluate in a standardized manner. Consequently, an engineer can select an appropriate candidate from them based on their subjective judgement and preferences.

3. OPTIMAL RESTORATION SCHEDULE FOR EARTHQUAKE DISASTER

Nowadays, our life is realized based upon the daily use of various lifeline systems. Those lifeline systems form the complicated network whose functions are mutually interrelated. All the lifeline systems have not been designed to protect all natural hazards. Moreover, the newest design theory can not guarantee the absolute safety due to the economic constraints. Therefore, it is necessary to develop a synthetic disaster prevention program based on the recognition that lifeline systems may unavoidably suffer when big earthquakes occur.

The main purpose of this research is the early restoration of lifeline systems after the earthquake disasters. Here, two issues are focused on, the first of which is such an allocation problem that which groups will restore which disaster places, and the second is such a scheduling problem what order is the best for the restoration. In order to solve the three problems simultaneously, Genetic Algorithm (GA) is applied, because it has been proven to be very powerful in solving combinatorial problems. However, road networks after earthquake disaster have an uncertain environment as the secondary disaster by aftershock. Therefore, the restoring works are not progressing on schedule. In this study, an attempt is made to develop an efficient disaster restoration method by using Improved GA. A numerical example is presented to compare the proposed method and the ordinal method.

4. OPTIMAL MAINTENANCE PLANNING OF BRIDGE STRUCTURES

The purpose of this study is to develop a method of optimal maintenance planning for many bridges based on Life-Cycle Cost (LCC) by introducing the technique of GA.

Recently, maintenance work is becoming more and more important, because the number of structures requiring repair or replacement increases in the coming ten years, in Japan. In order to establish a rational and economical maintenance program, the concept of LCC has gained great attention, which minimizes the total cost of whole lives of structures.

In this paper, an attempt is made to minimize LCC for many concrete bridge structures. The concrete bridges are deteriorating due to the corrosion of reinforcing bars and neutralization of concrete. Then, it is necessary to achieve an optimal maintenance plan that can provide appropriate methods and times of repairing or replacement. However, the optimal maintenance problem is very difficult to solve, because it is one of combinatorial problems with discrete design variables and discontinuous objective functions. Furthermore, the problem may become tougher, when it becomes larger and more complex. In this study, an attempt is made to develop an efficient bridge maintenance method by using Improved GA. A numerical example is presented to compare the proposed method and the ordinal method.

5. AESTHETIC DESIGN OF BRIDGE STRUCTURES

In the design of bridge structures, it is becoming important to consider the aesthetic design factors. In this paper, an attempt is made to develop a decision-support system for the aesthetic design of bridge handrails. The colours, upper components, lower components and columns are employed as design items as well as the configuration of bridge, the colours of other bridge components and the harmony with the surrounding environment. The present system consists of the evaluation system using neural network and the optimization system based upon Immune Algorithm (IA). Several numerical examples are presented to demonstrate the efficiency of the proposed system. Computer Graphics (CG) is used for visual examination of each alternative.

6. CONCLUSIONS

n this study, attempts were made to develop some new searching methods for optimization problems of structural engineering. The optimization problems in real life are very difficult to solve, because they have objective function and constraint condition with vagueness and uncertainty. By comparing the proposed methods with the usual method, it was proven that the proposed methods can reduce the computation time and improve the convergence of searching procedure.

REFERENCES

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