A Method for Determining Classroom Seating Arrangements by Using a Genetic Algorithm

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Abstract: This study exploits a method for determining the classroom seating arrangements by using a genetic algorithm. In the genetic algorithm, we propose a procedure named a matrix crossover. Experiments are carried out based on the computational result. It is found from the experiments that satisfaction of each student for our proposed method is higher than the traditional classroom seating arrangement and each student is actually comfortable in the classroom because of the relations between other students.

Keywords: Genetic algorithm, A matrix crossover, Classroom seating arrangement, *Desk rows*, Coaching interview

Introduction

In Japan, classroom seating arrangements are adopted *desk rows* [1] that are placed students' desks like a matrix. In our earlier paper [2], we proposed a method to determine the optimal classroom seating arrangements by using a genetic algorithm. The optimization of two students, however, is not considered in the case where there is an aisle between them and so on. In this study we propose a method for determining the classroom seating arrangements considering relationships between a student and the other students sitting around the student. In order to determine the optimal classroom seating arrangements, a genetic algorithm [3] is applied on the basis of the questionnaire results and the analysis of the observation of behaviors between students.

Based on our proposed classroom seating arrangements, we carried out experiments. We compare our method with a traditional one that is determined by using students' ID numbers or by the homeroom teacher and students' intention. It is found that each student's satisfaction with our method is higher than that with the traditional one. Actually, most students answer in the questionnaire that they feel more comfortable in the classroom in the case of using our method. This proposed method can determine the classroom seating arrangements by a simple process in a short time.

1. A Method for Determining the Classroom Seating Arrangements

1.1 A genetic algorithm to determine classroom seating arrangements

The problem of determining the optimal classroom seating arrangements is a kind of combinatorial optimization problem, and it is well known that it is difficult to solve the problem [4]. Our optimization problem is to determine the combination of classroom seating arrangements in such a way that the minimum of fitness rates of all students is as large as possible. In order to determine the optimal classroom seating arrangements, a genetic algorithm is applied on the basis of the questionnaire results and the analysis of the observation of how the students behave in the classroom.

We have p students $\{i; i = 1, 2, \ldots, p\}$, where p is the number of students. The solution x for the problem is the classroom seating arrangements for the students. The evaluation value W_i, which student i sets on his or her present seat, is described by

$$W_i = \sum_{m=1}^{5} \beta_m a_{im} \tag{1}$$

where a_{im} is one of the results of questions which student i answered, β_m is a weight. The evaluation value W_{ij_k}, which shows behaviors between students i and j_k, is described by

$$W_{ij_k} = \max\{C_i, P_i, S_i, A_i\} + \max\{C_{j_k}, P_{j_k}, S_{j_k}, A_{j_k}\} \tag{2}$$

where C_i, P_i, S_i and A_i show four kinds of personalities student i has and C_{j_k}, P_{j_k}, S_{j_k} and A_{j_k} show four kinds of personalities student j_k has. The evaluation value W, which shows behaviors between student i and the other students sitting around him or her, is described by

$$W = \sum_{k=1}^{n} \alpha_k W_{ij_k} \tag{3}$$

where n is the number of the students sitting around student i, and α_k is a weight. The objective function is defined by

$$\max \quad Z = \min \quad (W + \gamma W_i) \tag{4}$$

where γ is a weight.

The flow of a genetic algorithm for solving our optimization problem is as follows.

1. Generate randomly the initial population which consists of plural candidate solutions. Set g ← 1.
2. Pick up two candidate solutions x_1 and x_2 randomly from the current population, and remove them from the current population.
3. Generate two new candidate solutions x_3 and x_4 from x_1 and x_2 according to a procedure called the matrix crossover, which is proposed by us. In this crossover, these new candidate solutions are generated in such a way that the classroom seating arrangements of x_1 and x_2 are partially inherited.
4. Generate a new candidate solution x_5 by changing a part of x_1. Similarly, generate another new candidate solution x_6 by changing a part of x_2. They are generated by a procedure called the mutation.
5. Select two best candidate solutions from the six candidate solutions $\{x_1, x_2 \ldots x_6\}$ and add them to the population.
6. If $g = G$, terminate this algorithm and output the best candidate solution as the answer. If not, set $g \leftarrow g + 1$ and return to Step 2. The parameter G is given in advance.

1.2 Encoding of chromosomes, crossover and mutation

Encoding of chromosomes is one of the problems in the genetic algorithm. Permutation encoding can be used because student ID numbers are used to encode chromosomes. In the permutation encoding, each chromosome is an m rows and n columns matrix where student ID numbers are used.

In this study, we propose a new crossover named a matrix crossover. Figure 1 shows parents P_1 and P_2. $P_1(p,q)$ is a submatrix of P_1. Figure 2 shows the first child (C_1) that is made by using a procedure shown as follows: First of all, a submatrix is randomly selected in the first parent (P_1) shown by the m by n matrix; Secondly, the chromosome of P_1 except the submatrix is copied to the first child (C_1) ; Finally, when the number which C_1 except

$C_1(p,q)$ does not have is found after P_2 is scanned from the first row and the first column through the m th row and the n th column, it is added to the elements in $C_1(p,q)$. This procedure is repeated until the elements of $C_1(p,q)$ is filled with figures. The second child (C_2) is also made by the same procedure as C_1.

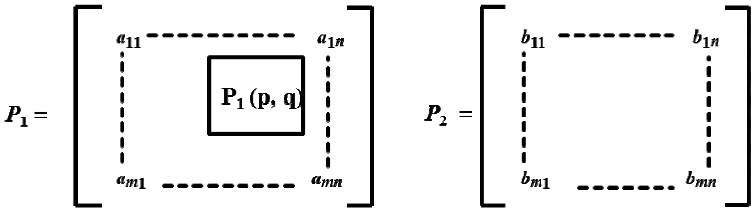

Fig. 1 Parent P_1 and P_2

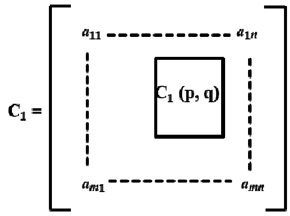

Fig. 2 Child C_1 obtained by the matrix crossover

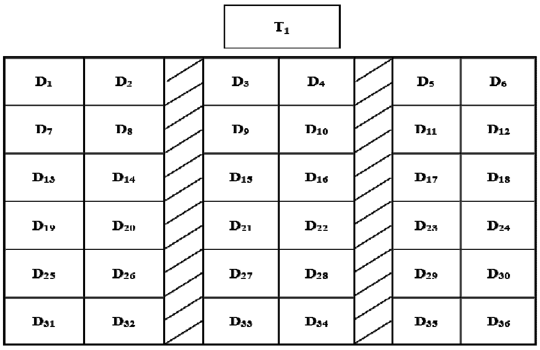

Fig. 3 Desk rows in the classroom

I D	FREQ	HEAR	VIEW	INTE	SEAT
i	a_{i1}	a_{i2}	a_{i3}	a_{i4}	a_{i5}
j_k	$a_{j_{k1}}$	$a_{j_{k2}}$	$a_{j_{k3}}$	$a_{j_{k4}}$	$a_{j_{k5}}$

ID: Student ID number
FREQ: Frequency of conversation
HEAR: Hearing range
VIEW: Viewing distance
INTE: Interest in the class
SEAT: First-choice seat location

Table 1 Fitness values of students i and j for determining classroom seating arrangements

Mutation plays an important part of the genetic search to prevent the population from stagnating at any local optima. In this study, we adopt order changing as a mutation in permutation encoding. Two numbers belonging to one chromosome are selected randomly and exchanged. This order changing is performed in the other chromosomes.

2. Simulations and Experiments

2.1 Problem statement for determining classroom seating arrangements

In higher education, each student takes his or her seat thinking about other students who sit around his or her seat [5]. Figure 3 shows *desk rows*, that is a traditional classroom seating arrangement. In this figure, D_1, D_2, …, D_{35} and D_{36} show desk numbers and slash marks show aisles in the classroom. T_1 shows a teacher's desk and a blackboard is behind the desk. An optimization of the classroom seating arrangements is carried out between a student and the other students who sit around the student.

Table 1 shows fitness values that students i and j_k set on their own seats. In this table, a_{i_1} shows an index as to whether student i often has a non-productive talk. a_{i_2} and a_{i_3} show indexes as to whether the student i can hear the teacher's voice and as to whether student i can see the letters which the teacher writes on the blackboard, respectively. a_{i_4} shows an index of the student i's interest in the class and a_{i_5} shows an index as to which seat student i wants to sit in. $a_{j_{k_1}}$, $a_{j_{k_2}}$, $a_{j_{k_3}}$, $a_{j_{k_4}}$ and $a_{j_{k_5}}$ show the indexes of student j_k.. Each fitness value is translated on a scale of zero to one.

Table 2 Weight values between personalities of students i and j_k obtained from coaching interview

α_k	C_i	P_i	S_i	A_i
C_{j_k}	0.10	0.50	0.75	0.25
P_{j_k}	0.50	0.50	0.75	0.25
S_{j_k}	0.75	0.75	1.00	0.75
A_{j_k}	0.25	0.25	1.00	1.00

C: Controller type
P: Promoter type
S: Supporter type
A: Analyzer type

Table 3 The computational result for the classroom seating arrangements

FG	10,000	100,000
PT	116 (s)	1002 (s)
Z	2.40	2.63
γ	1.0	1.0o

FG: Final generation
PT : Processing time
Z : Values of objective function

Table 2 shows a weight α_k found in equation (3) that is employed to express a chemistry between students i and j_k. In this equation, α_k is a weight of whether they get on well together or not. α_k is determined based on personalities of students i and j_k obtained from coaching interview. Personalities are divided into four types that are a controller type, a promoter type, a supporter type and an analyzer type. A maximum value of C_i, P_i, S_i and A_i determines a personality of student i and a maximum value of Cj_k., Pj_k, Sj_k. and Aj_k determines a personality of student j_k., respectively.

2.2 Computational result

In order to simulate the classroom seating arrangement, thirty six students are selected. First of all, we carry out a questionnaire to investigate the students' feeling on seating arrangements. Secondly, on the basis of the questionnaire, the classroom seating arrangements are calculated by using the genetic algorithm. In our genetic algorithm, there are three parameters: γ shown in equation (4), the population size (*PS*) and the final generation (*FG*). The genetic algorithm is performed ten times with various random seeds.

Table 3 shows theses parameters, processing time and values of objective function obtained from the calculation results. It is confirmed from this table that the genetic algorithm which *FG* is one hundred thousand is better than the other, because the value of objective function is higher than the one in the case where *FG* is ten thousand.

2.3 Experiment based on the computational result

On the basis of computational results, experiments are carried out. First of all, the students take classes sitting the seats which are decided by using only students' IDs shown in Fig. 3. Secondly, students take classes sitting the seats obtained from the computational result. Finally, we compare the results from the first and the second.

Figure 4 shows the classroom seating arrangement obtained from the genetic algorithm. In this figure, each decimal number shows each student's ID number. Students sit in the assigned seats and take a class for approximately one hundred minutes. After the class, they fill in a questionnaire related to the classroom seating arrangement.

Table 4 shows the result of the questionnaire for the classroom seating arrangement in the case where *FG* is one hundred thousand. In this table, the first column shows numbers of the questions and, in the first row, A, B and C show positive alternatives and D and E show negative alternatives of each question. It is found from the first question that 54.0% of the students have some students around them, whom they can talk about their questions. In the second question, 73.0 % of the students are able to sit in and near the seat which they want to. In the third question, since 92.0 % of the students choose the answer A, B or C, it is thought that they are able to hear a teacher's voice more or less. In the fourth question, 88.0 % of students reply that they are able to see the letters which the teacher writes on the blackboard. In the fifth question, 81.0 % of students reply that they prefer their seats obtained from the computational result to their seats which are determined in numerical order?

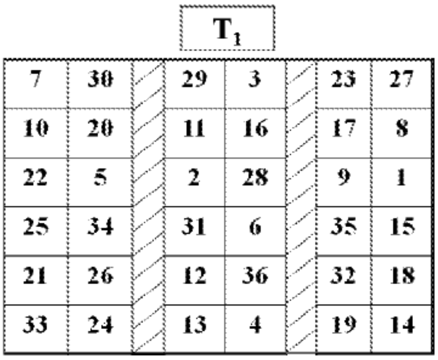

Fig. 4 The classroom seating arrangement based on the proposed genetic algorithm (FG = 100,000)

Table 4 The result of the questionnaire for the classroom seating arrangement (FG = 100,000)

Item	A (%)	B (%)	C (%)	D (%)	E (%)
1	54.0	46.0	0	0	0
2	11.0	62.0	27.0	0	0
3	34.0	27.0	31.0	8.0	0
4	34.0	19.0	35.0	8.0	4.0
5	19.0	27.0	35.0	11.0	8.0

3. Conclusion

In this paper, we propose the classroom seating arrangements to satisfy the requests of students. A genetic algorithm is applied to find the best classroom seating arrangement. Based on the results of the questionnaire, the classroom seating arrangements are calculated by using the genetic algorithm and we carried out experiments at a national college of technology in Japan. Students take classes based on the classroom seating arrangements obtained from the genetic algorithm.

We compare our proposed classroom seating arrangement with the traditional one that is determined by using only students' IDs or by the students and the homeroom teacher's intentions. From the result of the questionnaire filled in after the class, it is found that satisfaction of each student is higher in our method than the traditional one. In addition, this method can determine the classroom seating arrangements by a simple process in a short time. It is confirmed that the proposed method is effective.

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