ISSN No. 0976-5697

Volume 5, No. 5, May-June 2014

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Investigating Crossover Techniques for the 8-Queens Problem

Belal Al-Khateeb
College of Computer, Al-Anbar University
Ramadi, Iraq

Ali Jamal
College of Computer, Al-Anbar University
Ramadi, Iraq

Ayman Jalil
College of Computer, Al-Anbar University
Ramadi, Iraq

Abstract: Crossover is one of the main steps of the genetic algorithm. This technique gives the genetic algorithm many advantages in finding better solutions. There are many kinds of crossover techniques, all of them use the same general idea in choosing two randomly parents in order to get two children that can be used in the next generation. This paper aims to investigate crossover techniques, this is done by choosing three techniques of genetic algorithms crossover to be applied in solving the problem of eight-queens. The selected techniques are one point, two point and uniform crossover. The obtained results show that, for the problem of eight-queens, one point crossover is better than the other two selected techniques.

Keywords: Genetic algorithm, Crossover techniques, Evolutionary computation, 8-queens problem.

I. INTRODUCTION

Researchers and scientists offered various heuristic algorithms for optimization by modeling from physical and biological processes in nature, which often operate collectively. Clearly, 8-queens problem was processed with these algorithms; among those algorithms is the genetic algorithm.

This paper aims to investigate which crossover technique is better when using genetic algorithms in solving the problem of 8-queens.

II. 8-QUEENS PROBLEM

The eight queens problem is a classical combinatorial problem. To access to right solution of this problem, we must put all the queens on the 8x8 board so that no queen is attacked with the other queens (No Queen conflicting with other queens). So, the solution must be nonattack (the queen is attaked if it shares the same row, column, or diagonal with another queen) as shown in "Figure 1" [1,2,3]. In the other words, a solution of the eight queens problem must be ensured that each queen can move to the eight neighboring directions (two vertical, two horizontal and four diagonal directions) without attacking with other queens as shown in "Figure 2" [2].

III. BACKGROUN

Josef Hynek[1] presented genetic algorithm for N-Queens problem, but he walked on the main operation of genetic algorithm. The contribution of Josef was using simple mutation operator is greatly faster and capable of generating problem solutions even for a larger n-queens problem.

Kelly Crawford[4] used two techniques of genetic algorithm. The first one was using the simple heuristic to evaluate potential solution. The second was using existing evaluation heuristics by first mapping n-queens problem onto satisfiability which has already been solved using genetic algorithm.

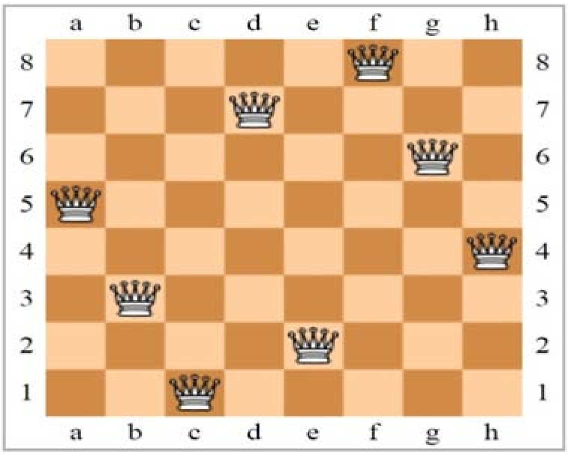

Figure 1. Non-conflict eight queens

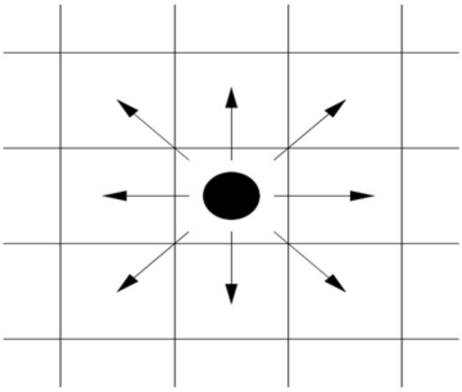

Figure 2. Eight neighboring directions for one queen

Harsh Bhasin and Neha Singla[5] proposed an algorithm which gives a sequential approach in solving the problem of n-queens. Their approach depending on analyzing complexity of the solution proposed in terms of time, by taking the length of chromosome as power of 2, the calculations for complexity become simpler. From result of their proposed technique, unknown constants of regression equation can be easily computed.

Marko Božikovic, Marin Golub, and Leo Budin[6] suggested a global parallel genetic algorithm GPGA for solving n-queens problem. Successfully, they used three-way tournament selection. This way enabled slaves to run simultaneous selections and crossovers, freeing master process from most tasks (population initialization and mutations during the run were still performed by the master thread). GPGA is not suitable for massive parallel processing, but it shows increase in performance for a small number of parallel-processing units.

IV. GENETIC ALGORITHM AND THE 8-QUEENS PROBLEM

Genetic algorithm is a one of the search methods in the artificial intelligence field based on biological principles[4]. It is a general method that can be applied to many problems[7]. It works on two basic fundamentals which are natural selection and natural genetics[8]. In order to solve any problem by a genetic algorithm, two things must be done. The first is a problem representation and the second is the choose of the evaluation function. A problem representation is a way to encode the estimation solution to the problem to be solved. It can be a list of numbers, a string of bits or any things. An evaluation function can be used to compute the fitness of solution to find the best solution[4]. Algorithm 1 is used to find the solution to the search problem[8,9]:

Algorithm 1:

- Initialization: Usually the initial population created randomly.
- Evaluation. This step computes the fitness of the current solution.
- Selection. This step is working on the choice of two parents which are used to generate new generation. The main idea of selection is to select the best solutions to worse ones.
- Crossover: combine two or more parental solution used to generate new possibly better solution. There are many methods of crossover one-point, two-point, uniform, order-based, Partially Matched (PMX) and Cycle Crossover (CX).
- Mutation. While crossover operates on two or more solutions, the mutations operate on local solutions. So it randomly modifies the solution.
- Replacement
- Repeat steps 2–6 until the final condition is achieved.

The main idea of used genetic algorithms to solve complex computational problems. Genetic algorithms used to solve many problems, one of these problems is eight queens problem. The eight queens must be represented in efficient way in oder to be to solved by genetic algorithms. There are many ways to represent eight queens, but the quick and efficient way in storage and speed is the binary representation as shown in figure 4. Algorithm 2 used to solve the problem of eight queens:

Step1: Generate 100 random solutions. This was done by initializing 100 vectors (with length of 64), the values in each vector are either one for the queen or zero for the empty square. Thus each vector will have eight queens distributed randomly. This is the initial population for GA with size equal 100 chromosomes.

Step2: Evaluate the fitness of each chromosome (solution).

Step3: Rank the chromosomes depending on their fitness's values (small fitness values first).

Step4: The 50 solutions that have the best fitness values are selected as parents and retained for the next generation. Those parents are then used to create another 15 offspring using crossover.

Step6: The new solutions are mutated.

Step7: Repeat steps 3-6 until a new solution to the 8-queens problem is found.

0	0	0	0	0	1	0	0
0	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0
0	0	0	0	1	0	0	0
0	0	1	0	0	0	0	0

Figure 3. Binary representation of eight queens

V. CROSSOVER TECHNIQUES

The crossover is one of the most important operation in genetic algorithms. The genetic algorithms choose two chromosomes to generate new offspring. There are many crossover techniques such as one-point, two-point, uniform, order-based, Partially Matched (PMX) and Cycle Crossover (CX) [8]. The most widely and simplest crossover methods that can be used in eight queens problem are one-point, two-point and uniform crossover. Those methods are shown in figure 5. One-point crossover cuts the parent chromosomes at an arbitrarily selected point and swaps the resulting sub-chromosomes. Two-point crossover substitutes intermediate segments of one parent into the middle of the second parent string. Uniform crossover, combines bits sampled uniformly from two parent chromosomes. The uniform crossover shown in figure 5 uses a template (crossover mask) (in this example it is 011010). For the first offspring, a 1 in the crossover mask means sample a bit from first parent at this position, whereas a 0 means sample the bit from the second parent instead. The second offspring is created in the opposite way [8,10].

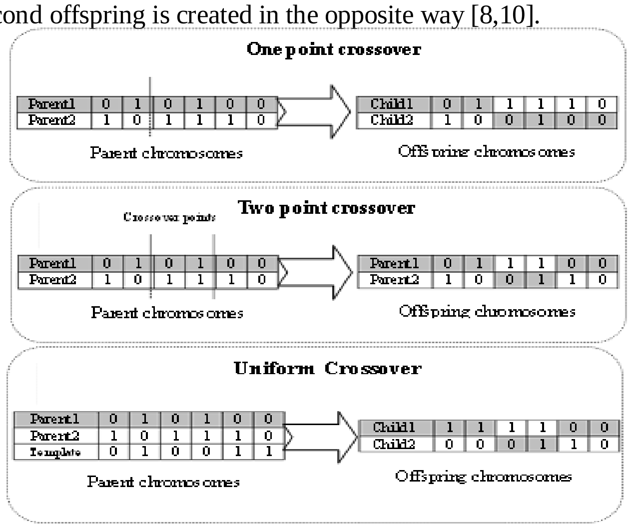

Figure 4. One-point, two-point and uniform crossover

VI. EXPERIMENTAL SETUP AND RESULTS

In this paper, three different experiments were done each one with different crossover techniques (one point, two point and uniform crossover) in order to determine which crossover technique, among the three selected ones, is the best in solving the 8-queens problem using algorithm 2. The only change in algorithm2 is in step 4, when the selected crossover techniques are applied.

"Table 1" shows the results of applying the selected crossover techniques in solving the problem of 8-queens at which the crossover technique that can find a solution to the 8-queens problem in less number of generations will be given three points. Two points will be given to the crossover technique that will come second while the worst crossover technique will be given one point only.

Table I. Results of One-point, two-point and uniform crossover

I.	Number of Generations for One Point Crossover	Number of Generations for Two Point Crossover	Number of Generations for Uniform Crossover	Points for One Point Crossover	Points for Two Point Crossover	Points for Uniform Crossover
1	37	30	38	2	3	1
2	33	36	41	3	2	1
3	29	63	43	3	1	2
4	28	51	38	3	1	2
5	39	28	246	2	3	1
6	53	58	74	3	2	1
7	32	37	74	3	2	1
8	55	54	38	1	2	3
9	34	40	94	3	2	1
10	41	40	62	2	3	1
11	30	36	62	3	2	1
12	61	42	76	2	3	1
13	18	16	109	2	3	1
14	48	73	108	3	2	1
15	45	54	67	3	2	1
16	781	38	60	1	3	2
17	44	66	52	3	1	2
18	71	36	72	2	3	1
19	32	25	37	2	3	1
20	38	61	159	3	2	1
21	49	920	38	2	1	3
22	14	56	39	3	1	2
23	41	14	107	2	3	1
24	29	2	38	2	3	1
25	15	57	58	3	2	1
26	43	36	84	2	3	1
27	21	53	982	3	2	1
28	37	27	34	1	3	2
29	254	40	89	1	3	2
30	42	42	47	3	3	1
31	19	44	64	3	2	1
32	42	67	38	2	1	3
33	22	35	27	3	1	2
34	56	15	182	2	3	1
35	29	27	591	2	3	1
36	56	82	114	3	2	1
37	227	48	91	1	3	2
38	72	32	82	2	3	1
39	24	51	53	3	2	1
40	26	405	117	3	1	2
41	18	49	43	3	1	2
42	61	72	731	3	2	1
43	31	43	489	3	2	1
44	34	54	33	2	1	3
45	20	21	94	3	2	1
46	21	45	57	3	2	1
47	28	48	76	3	2	1
48	48	48	26	1	1	3
49	37	40	39	3	1	2
50	21	21	49	3	3	1
51	48	45	52	2	3	1
52	47	16	102	2	3	1
53	29	48	45	3	1	2
54	21	37	211	3	2	1
55	55	69	80	3	2	1
56	28	25	49	2	3	1
57	24	26	38	3	2	1
58	21	277	44	3	1	2
59	24	83	52	3	1	2
60	49	34	129	2	3	1
61	34	23	66	2	3	1
62	28	35	52	3	2	1
63	25	33	826	3	2	1
64	50	37	27	1	2	3
65	74	41	58	1	3	2
66	20	65	51	3	1	2
67	170	44	66	1	3	2
68	20	55	41	3	1	2
69	63	41	49	1	3	2
70	33	42	54	3	2	1
71	42	32	68	2	3	1
72	31	29	78	2	3	1
73	77	39	49	1	3	2
74	11	41	19	3	1	2
75	60	95	248	3	2	1
76	13	29	59	3	2	1
77	88	22	40	1	3	2
78	25	39	92	3	2	1
79	37	41	39	3	1	2
80	43	64	44	3	1	2
81	37	34	64	2	3	1

82	626	28	56	1	3	2
83	21	61	51	3	1	2
84	81	77	109	2	3	1
85	30	41	42	3	2	1
86	15	52	90	3	2	1
87	45	24	58	2	3	1
88	38	39	51	3	2	1
89	36	21	69	2	3	1
90	38	46	196	3	2	1
91	44	17	831	2	3	1
92	29	42	58	3	2	1
93	19	53	1863	3	2	1
94	83	34	16	1	2	3
95	27	33	41	3	2	1
96	12	52	5013	3	2	1
97	23	43	1004	3	2	1
98	26	19	49	2	3	1
99	22	33	153	3	2	1
100	25	15	64	2	3	1
			Total	**242**	**218**	**141**

VII. CONCLUSIONS AND FUTURE WORKS

This paper aimed to find the best cross over technique that can be used to solve the 8-queens problem using genetic algorithm. Three different experiments were done in order to achieve this aim.

The results showed that one point crossover is better than the other selected techniques as "Table 1" showed that one-point crossover managed to get 242 points out of the possible 300 points, while two-point and uniform crossover managed to score 218 and 141 respectively. Therefore it is recommended to use the one-point crossover in solving the 8-queens problem.

There are two directions for the future works; the first one is to use more crossover techniques for solving the 8-queens problem in order to have a full investigation of which crossover is the best. While the second one is to apply the same proposed techniques to other problems in order to find if the generalization is possible or not.

VIII. REFERENCES

[1] Hynek J., Genetic Algorithms for the N-Queens Problem, In proceeding of: the 2008 International Conference on Genetic and Evolutionary Methods, GEM 2008, Las Vegas, Nevada, USA, July 14-17, 2008.

[2] Sosič R. and Gu J., Efficient Local Search with Conflict Minimization: A Case Study of the n-Queens Problem. IEEE Transactions on Knowledge and Data Engineering. Vol. 6, 5, pp. 661-668, Oct 1994.

[3] Eight queens puzzle. In Wikipedia. Retrieved August 14, 2013, from http://en.wikipedia.org/wiki/Eight_queens_puzzle .

[4] Coley D. A., An Introduction to Genetic Algorithms for Scientists and Engineers, World Scientific, New York,. 1999.

[5] Bhasin H. and Singla N., Genetic based Algorithm for N-Puzzle Problem, International Journal of Computer Applications, Vol. 52, No.21, August 2012.

[6] Božikovic M., Golub M. and Budin L., Solving n-Queen problem using global parallel genetic algorithm, EUROCON 2003, Volume 2, 22-24 Sepetember 2003Ljubljana, Slovenia.

[7] Crawford K.D., Solving the n-Queens Problem Using Genetic Algorithms. In: Proceedings of ACM/SGAPP Symposium on Applied Computing, Kansas City, March 1-3, 1992, pp. 1039-1047.

[8] Sastry K., Goldberg D. and Kendall G., Chapter 4: Genetic Algorithms. In Search Methodologies: Introductory Tutorials in Optimization and Decision Support Techniques, pages 97-125, Springer, 2005.

[9] Kumar M., Husian M., Upreti N. and Gupta D., Genetic Algorithm: Review and Application, International Journal of Information Technology and Knowledge Management, Volume 2, No. 2, pp. 451-454, July-December 2010.

[10] Alabsi F. and Naoum R., Comparison of Selection Methods and Crossover Operations using Steady State Genetic Based Intrusion Detection System, Journal of Emerging Trends in Computing and Information Sciences, VOL. 3, NO.7, July 2012.