

Survey on N-Queen Problem with Genetic Algorithm

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Abstract— The combinatorial optimization problem is a collection of problems which need a sample amount of time and effort to be solved. Vast difficulties have been occurring to solving these types of problem that there is no exact formula to solve the problem. Each feasible solution works on some order and the size of the probability increases algorithmically as the number of the problem also increases dynamically. This paper discusses about N-Queen problem, it is also a type of NP – hard problem. Many researchers have proposed various methods and algorithms for this problem. Henceforth, Genetic Algorithm is one kind of famous algorithm for solving NP hard problems. This paper mainly focuses on the review work of genetic algorithm to solve the N -Queen Problems (NPQ).

Keywords—N-Queen Problem, NP-hard problem, Genetic algorithm, Heuristic algorithm.

I. INTRODUCTION

Most of the researchers and scientists, proposed different types of heuristic algorithm for the best optimistic solution to solve a problem by using a certain model from particular problem, that process may be physically or biological in nature which is frequently performed. Heuristic algorithm differs from the classic algorithms. It performs in various way and pursuit onward with the capacity. Further classic algorithms are difficult for optimization problem it also increases in finite number of times with respect to its scale of the problem. Heuristic algorithms [1] used to find the exact solution in a proper time. Heuristic algorithm finds quickly the solution for a problem than the classic algorithm.NP-hard problem (non-deterministic Polynomial time problem) [2], that is the problem have non-deterministic solutions, these solutions run at a polynomial time. Since due to its large complexity (Eg: $O(N!)$).They cannot be able to solve within a particular amount of times using deterministic approach. The above-mentioned problem, works with an acceptable number of times, which uses heuristic approach necessarily queen is one of the non-deterministic time polynomial problems.

A. N-Queen Problem

The N queen problem [3] is one of the challenging concepts in computer science, the principle of the n-queen problem as follows: N is the number of queens that is placed on the $n*n$

chessboard. The queens cannot be interacting with each other. Each queen has a unique path to travel. All possible solutions can be found for each level. Most of these solutions are based on a particular prescription to allocate queens on a chessboard, the factual conclusion of petite-size problems displayed. The amount of solutions incremented algorithmically number of queens also increases. As a matter of choice search-based algorithm (SBA) [4] evolved. For example, BT search (Backtracking)[5] systematically provide all feasible solution set to a disposed in $n*n$ chessboard. In BT approach generates a limited class in the huge size chessboard. Because it is crucial as BT search for asset solutions, these solutions are significantly differed in the results spaces. Many journalists have developed alternative powerful search technique to run over this problem. These techniques consisting searched heuristic method and divisional search and collision method are identical. Conclusively, the problem has been told in the process of integer programming corresponding to the assignment program. The below figure [6] explains about one of the example for $8*8$ queen problem.

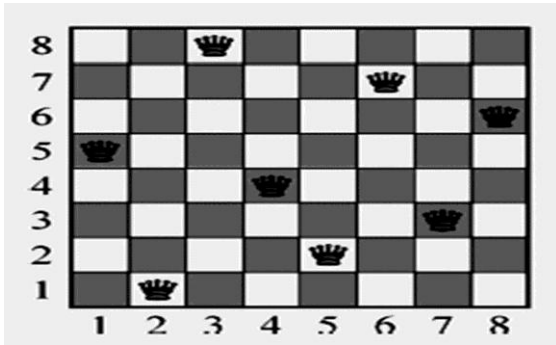


Figure1: solution of 8*8 queen problem

The solutions for n queen value in N*N chessboard are fixed. The solutions for queen value from 1 to 10 are tabulated in table 1 [7].

Table 1: Correct solutions for number of queens

Number of Queens	Solutions
1	1
2	0
3	0
4	2
5	10
6	4
7	40
8	92
9	352
10	724

B. Genetic Algorithm

Genetic Algorithm [8] is one of the best optimization algorithms. It is based on the approach of natural selection and genetics. It is one of the search-based algorithms, established under the concept of evaluation. In GA, each solution is representing as chromosomes in an individual. Each chromosome is estimated using a function that is called a fitness function that denotes the correctness of each chromosome in the individual. The Genetic algorithm is not like classical methods and it suitable for a lot of real life problems. The main objective of genetic algorithm gives high quality solution for hard problem. It is a program which works based on genetic code. It is distinguished from traditional search algorithms. This algorithm searches between a set of points and work along with its coding of parameter within them. The features of genetic algorithm are used as a common optimization procedure. It uses a probability method, whereas the classic algorithm uses deterministic methods. The advantage of GA is very faster and more powerful compared with traditional methods. It gives the better solutions that close to the global optima. It doesn't give any guarantee for all optimal solutions that the reason randomness, but give the nearest optimal values.

Basic terminologies of genetic algorithms are followed

- 1) *Population*: Population means a set of all solution of a problem.

- 2) *Chromosomes*: Chromosomes is referred a single solution from a set of solutions.
- 3) *Gene*: Gene is defined a single element of the single solution.
- 4) *Fitness function*: Fitness function is like a function that takes set of solution as a input and produce solution as a output.
- 5) *Genetic operators*: There are three operators are used in Genetic algorithm.

Genetic operators are followed,

- 1) *Selection*: Selection [9] is one important stage in genetic algorithm. Selection work based on solution and its population using crossover methods.

Selection procedures are,

- a) Fitness function can be evaluated for each individual that providing fitness value, then these are normalized depend on its fitness value.
- b) Populations have been sorted by descending order of fitness values.
- c) Normalized fitness values are calculated.
- d) Random number R has been chosen.
- e) The selected normalized value is smaller than R.

- 2) *Crossover*: Crossover [10] is one type of genetic operator. It used to change the programming of chromosomes from one to the next. The process of crossover is taking more than one from a parent solution and returns one child solution.
- 3) *Mutation*: Mutation [11] is another genetic operator. It used to manage genetic, diversity from one generation of chromosomes from one to the next.

Section I contains the introduction of N-queen Problem & Genetic Algorithm, section II contain the related work of Genetic Algorithm, section III contain the Summary of Genetic Algorithm used to solve N-Queen problem, section IV concludes research work with future directions.

II. LITERATURE SURVEY

Vijayanellappan et al compared two algorithms in [12] for solving n – queen problems, such as genetic algorithm and backtracking algorithm both uses different methods in an entire work solving n queen problem. Time taken for these methods based on a given value of n. The time increases when n value is increased. This algorithm is explained in an efficient way. Since the backtracking algorithm is difficult when n value reached up to 35. The genetic algorithm is

faster than the backtracking algorithm. Backtracking algorithm is very critical to implement in higher values, but it also efficient and simple in lowest value.

Jalal eddinAghazadeh heris et al. [13] proposed a modified genetic algorithm for solving n queen problem. Their paper covered weakness of this algorithm with the help of local search algorithms. A Minimal conflicts algorithm like a local search algorithm contributed the partial view of genetic algorithm. Modified algorithm is the solution of the combinations among GA and minimal conflicts algorithm. The standard GA algorithm and modified GA algorithm are compared to solving n queen problem. The normal GA algorithm is not efficient to solve 8 queen problems with large scale, but their paper solves the problem of GA algorithm by applying minimal conflicts algorithm.

Saadakarbic et al. [14] proposed genetic algorithm for solving the minimum dominating set of queen's problems connected with standardized chessboard positioned puzzles. The paper produced simple, effective and good solutions by using genetic algorithm to solve this problem. Since the optimal solution is also determined by the GA algorithm for different size board form 8*8 to 11*11. This proposed algorithm has been resolved by using MATLAB and 2.6G Hz PC with Intel processor. The proposed GA has found the optimal solution on a chess board.

Ahmed S. Farhan et al. [15] proposed GA for finding 92 solutions of n queen problem. The GA algorithm solved the problem by using genetic code for a good solution to the problem. The probabilities of 92 solutions for 8 queen problems are to be found each genetic represent through one-dimensional array with the same size 8. This representation diminishes the empty cell which wants more time for comparison with representation one array used to store 8 queens for one solution based on GA algorithm and also fitness calculated.

Vishal Jain et al. [16] proposed genetic algorithm for solving various problems from different domains such a word sense disambiguation, tuning the parameters of fuzzy logic 8 queen and image compression. The paper explained the concept GA algorithm and how it's applied in the various problems and finding solutions for vast search space, the paper mainly focused on ample amount of space and optimization problems from different domain large search space 8 queen problems solved by GA algorithm.

Vishal khanna et al. [17] compared various Memetic algorithms for solving NP –hard problem, which has a non-polynomial time problem optimizing the n queen problem using genetic algorithm, SALAMA and HCLSMA algorithms. Memetic algorithm solved n queen problem following two stages. In a first stage generate solutions randomly that are evolved till they become feasible solution and the second stage from these solutions are one more time evolved so violation of soft constraints to be minimized. In a final stage, it produces the best solution in which hard constraints are satisfied. HCLSMA algorithm gives the better

solutions compared with GA for optimal solution. Time and coverage rate also better in HCLSMA than GA.

Soham Mukherjee et al. [18] compared various algorithms to solving n queen problems which provide brief explanation about different algorithms such as Genetic Algorithm, Simulated annealing Algorithm, Brute Force Algorithm, Backtracking and found the best solution to n queen problem and constructs a comparison of these four algorithms. The proposed GA performed very well compared with SA algorithm. BF algorithm and BT algorithm provides the best fitness value than the simulated using by GA. GA gives the best solution that helps to give an optimal solution to the global optima. BF and BT algorithms are only used when the problem size is limited and these are not efficient and effective to solve n queen problem when the n value is high, whereas GA and SA algorithms are given the efficient solution when the n value is high. The proposed GA has the better fitness of the solution than the SA algorithm by GA but execution time of SA by GA is better than proposed GA.

Vikasthada et al. [19] proposed the comparative analysis of n queen problem using Genetic Algorithm and Backtracking algorithm. Both algorithms are used for different methods when solving the n queen problem. The n value of these problems is compared whereas the n value increases. BT algorithm is not good for large size value, it is difficult to solve that problem. The paper consists of whole work carried out in MATLAB using Pentium core 2 and 2.2 GHz processors on windows 8 with 4 GB RAM. The N value taken from 4 to 50 under the population of 1000 and generation is 100 further using these methods execution time is calculated. BT technique using small size n value so less execution time compares to GA technique, but the fact GA are not possible to its random search, that gives only an approximate solution GA is performing much better than the BT algorithm.

Belae Al-khateeb et al. [20] compared two metaheuristic algorithms such as GA and SA for solving 8 queen problems further finding all the 92 feasible solutions for 8*8 chess board. Both algorithms provided a better solution rather than the randomization method and also SA is better than the GA whose are taking less time for finding solutions.

Er.VishalKhanna et al. [21] compared various techniques for solving N-Queen problems used techniques are Genetic Algorithm, Backtracking Algorithm and Tuned Hybrid Technique. This NP problem solved by following its principle that is each queen is not contradict with each other queen vertically, diagonally and horizontally. Performance analysis of n queen problem is increased by removing the threatening cell. These three algorithms are used for solving this NP-Hard problem based on its parameter namely time and space. Time taken by BT and Tuned hybrid techniques to solve the problem is more than the genetic algorithm. The paper explains the complexity analysis is improved using various algorithms. Better solutions are found, but

complexity analysis can be based in the conflict minimization and convergence rate.

S.Pothumani [22] compared various algorithms for solving N-Queen problem. In this paper N queen problem is described and solved using various methods, whereas proposed algorithms are Ant Colony Optimization, Genetic algorithm, DNA Striker algorithm and Particle Swarm Optimization. These all algorithms provide the better result than the traditional algorithms, but the performance differ depending upon the size of the space and number of queens. Some parameters are very useful to make a comparison study for better understand.

Amardeep sing et al. [23] proposed Memetic Algorithm for solving well known NP-hard problem such as N-Queen problem. The paper Memetic Algorithm is used to optimize N-Queen problem, whereas make the complexity of the parameters with respect to the number of iterations. Memetic Algorithm solved N-queen problem consists of being a combination of GA and Local Search. GA steps are followed entire problem. The combination of GA and Local Search to solved the NQP within two phases, in a first stage randomly generated solution are evolved till it become feasible (hard constraints are satisfied) and second stage evolved solutions are minimized the violation of soft constraints.

Ayed M. Turkey [24] proposed genetic algorithm and solved Constraint satisfaction problem that taken the N queen problem. It consumed large N values with time guarantee optimize solved N Queen problem and the results are tabulated. GA produced good results when compared against the other approach. Crossover fraction, mutation fraction, selection mechanism, crossover type, mutation type parameters is used under the principle of GA. The results of this problem successfully solved using GA with repair function. This function is found different solution in different times for a given number of queens, but it is given by best time.

Ivicmartinjak [25] proposed the way in which heuristic algorithm can be used to solve n queen problem. Genetic algorithm, simulated annealing algorithm and Tabu search algorithm are used where test results of these algorithms are calculated and the complexity also determined. These algorithms are successfully compared and their achievements are measured. The reduction of the fitness function complexity $O(1)$ problem occurrences with large magnitude is solved. SA calculated the fitness function equal to its iteration, whereas other algorithms are more complicated and the fitness function is calculated more than once in every step of its procedure. Since fitness calculation time is taken large. GA and SA are contrasted with Tabu search algorithm, but from this algorithm SA is better for solving large dimension N queen problem which also achieved fitness function.

Marco Bozиковic et al. [26] proposed the way, which the genetic algorithm used to solve the NQP. Chromosome representations, genetic operators and evaluation functions

are produced. Furthermore, Global Parallel GA is proved like a possible way of GA. GPGA works simultaneously in the process of selection and crossover, but it is not suitable for large processing at the same time increase the performance for a small number of related processing units.

Milena lazarova [27] produced the efficiency of parallel GA for solving N-queen problem with a multi computer platform. This proposed model of GA is based on al parallel algorithm technique of simultaneous iterations. Chromosomes parameters are used that selected randomly in a bidirectional circular model. This algorithm implemented for both programming models such as flat and hybrid. Performance and scalability made with respect to the board size and parallel system size, but the performance of hybrid parallel programming mode are better than the hardware resource of the destination multicomputer.

III. Summary of Genetic Algorithm used to solve N-Queen problem

Table 2: Summary of Genetic Algorithm used to solve N-Queen problem

Author Name	Merits	Demerits
Vijayanellappan[12]	GA best for large number of values.	Time taken based on given values.
JalaleddinAghazadehheris[13]	Resolve the weakness of GA using Minimal conflicts algorithm	Standard algorithm is not efficient without applying MC algorithm
Saadakarbic[14]	GA produce optimal solution for different size boards	Other computing technique can be improved
Ahmed S. Farhan[15]	Empty cell removed.	One array holds 8 queens for one solution.
Vishal Jain et al [16]	Different domains large space problem solved by GA	Parameters may be used.
Vishal khanna [17]	Constraints are satisfied within 2 stages.	Time and converge rate can be improved.
Soham Mukherjee[18]	GA is efficient and effective than SA by using GA.	Execution time can be improved. That is slow than SA.
Vikasthada [19]	GA better than BT and gives approximation solution.	Random search is not possible.
Belae Al-khateeb [20]	Provide the better solution than randomized method.	Execution time can be improved.
Er.VishalKhanna [21]	Problem solved based on its time and space.	Complexity analysis may be improved.
S.Pothumani [22]	Better than traditional algorithm for finding solution.	Better parameter can be used.

Amardeep sing [23]	Constraints are satisfied.	Long steps may be avoided.
Ayed M. Turkey [24]	Repair function used with GA.	Best time can be need
Ivicamartinjak [25]	Fitness function complexity O (1) is solved.	Fitness function takes large time that can be avoided.

IV. CONCLUSION

This survey aimed to provide a clear understanding, regarding Genetic Algorithm with the influence of N-queen problem. Moreover, the recently proposed various mechanisms were concluded to solve N-queen problem. So, furthermore each mechanism was analyzed and studied and their advantages and improvements were included. Finally, the brief comparison was provided in the preceding which shows merits and demerits of existing works.

REFERENCES

- [1] Kaveh, A.Ghazaan, M Ilchi. "A new meta-heuristic algorithm: Vibrating particles system, *ScientiaIranica. Transaction A, Civil Engineering; Tehran*, Vol. 24, Iss. 2, (2017),pp 551-566.
- [2] Cusack, C., Largent, J., Alfuth, R., & Klask, K. 2010. "Online Games as Social-Computational Systems for Solving NP-complete Problems". *In Proc. of Meaningful Play*'10. 5.
- [3] Er. Vishal Khanna, Er. Sarvesh Chopra, Review on N-Queen Optimization Using Tuned Hybrid Technique, *International Journal of Engineering Sciences & Research Technology (Thomson Reuters)*, Vol.6, Issue.2,2017,pp.62-68.
- [4] https://en.wikipedia.org/wiki/Search-based_software_engineering
- [5] Ji-PyngChiou, Chung-Fu Chang and Chin-Ju Li, "A backtracking evolutionary algorithm for power systems", *MATEC Web of Conferences* Volume,vol. 119, 2017.
- [6] Doug Chatham, "The maximum queens problem with pawn", *Recreational Mathematics Magazine*, vol.3, Issue.6,2018, DOI: <https://doi.org/10.1515/rm-m-2016-0010>.
- [7] B Documentaries, "Full Solution of N-Queens Problem O Reilly", <http://oreillynQueensproblem.blogspot.in>, 3-Sept-2016.
- [8] Song Yan, Yang Guoxing, "A Genetic Algorithm for test paper", *International conference*, 2013.
- [9] ShokouhiM.Chubak P. RaeesyZ "Enhancing focused crawling with genetic algorithms" Vol: 4-6,2005, pp.503- 508.
- [10] B.Klabbankoh, O.Pinngern. "applied genetic algorithms in information retrieval" *Proceeding of IEEE* ,pp.702- 711,Nov 2004.
- [11] V.Thada, V.Jaglan, "Use of Genetic Algorithm in Web Information Retrieval", *International Journal of Emerging Technologies in Computational and Applied Sciences*, vol.7,no.3,pp.278-281, Feb,2014.
- [12] Anuneet Kumar Dubey, VijayanEllappan, Rakesh Paul, Vishal Chopra, "Comparative Analysis of Backtracking And Genetic Algorithm In N Queens's Problem", *International Journal of Pharmacy &Technology*, Vol.8, Issue.4,2016, pp.25618-25623.
- [13] JalaleddinAghazadehheris Faculty of Mathematics and MohammadrezaAsgariOscoe, Modified Genetic Algorithm for Solving n-Queens Problem "Iranian Conference on Intelligent Systems (ICIS), 2014.
- [14] SaadAlharbi and Ibrahim Venkat, "A Genetic Algorithm Based Approach for Solving the Minimum Dominating Set of Queens Problem", *Journal of Optimization*, 2017.
- [15] Ahmed S. Farhan ,Wadhan Z. Tareq and Fouad H. Awad, "Solving N-Queens Problem using Genetic Algorithm ", *International Journal of Computer Applications*, Vol.122, Issue.12, 2015,pp.11-14.
- [16] Vishal Jain, DevendraSaini and K.N Dinesh Babu," A Genetic Approach To Solve Problems From Diverse Domains", *International Journal of Advanced Scientific and Technical Research*, vol.6, Issue -6,2016.
- [17] Er. Vishal Khanna, Er. Sarvesh Chopra and Er.AbhishekBhardwaj," N-Queens Problem Optimization Using Various Memetic Algorithms", *International Journal of Modern Computer Science*, Vol.5, Issue.2, 2017.
- [18] Soham Mukherjee, SantanuDatta, PramitBrataChanda and Pratik Pathak, "Comparative Study of Different Algorithms To Solve N-Queens Problem", *International Journal of Foundations of Computer Science and Technology*, Vol.5, Issue.2, 2015,pp.15-27.
- [19] VikasThada and Shivali Dhaka, "Performance Analysis of N-Queens Problem using Backtracking Algorithm Techniques ", *International Journal of Computer Applications*, Vol.102, Issue.7,2014, pp. 26-29.
- [20] Belal Al-Khateeb, Wadhah Z. Tareq, " Solving 8-Queens Problem by Using Genetic Algorithms, Simulated Annealing and Randomization Method", *2013 Sixth International Conference on Developments in systems engineering*, 2013, pp.187.
- [21] Er. Vishal Khanna, Er. Sarvesh Chopra and Er.AbhishekBhardwaj, "Comparative Analysis Of Backtracking, Tuned Hybrid technique And Genetic Algorithm For Optimization Of N-Queens Problem", *International Journal Of Engineering Sciences & Research Technology*, Vol.6, Issue.3, 2017.
- [22] S.Pothumani, "Solving N-Queens Problem using Various Algorithms-A Survey", *InternationalJournal of Advance Research in Computer Science and Software Engineering*, Vol. 3, Issue. 2, 2013, pp. 247-250.
- [23] Amarbir Singh and Sandeep Singh Dhillon, "A Comparative Study of Algorithms for N-Queens Problem", *International Journal of Advance Foundation and Research in Science and Engineering*, Vol.1, Special Issue, 2015, pp.1-4.
- [24] Ayad M. Turkeyand, MohdSharifuddinAhmad , " Using Genetic Algorithm for Solving N –Queens Problem", *International Symposium on Information Technology*, vol.2, 2010.
- [25] IvicaMartinjak and M. Golub, "comparison of heuristic algorithms for the n-Queen Problem," *International conference on information technology Interfaces*, 2007.
- [26] Marko Bozиковic, Marin Golub and Leo Budin, "Solving N-Queens Problem Using Global Parallel Genetic Algorithm", *European Conference Ljubljana Slovenia*, 2003, pp.11-17.
- [27] Milena Lazarova," Efficiency Of Parallel Genetic Algorithm For Solving N-Queens ProblemOn Multicomputer Platform", *9th WSEAS International Conference On Evolutionary Computing (EC'08)*, Sofia, Bulgaria, May 2-4, 2008.