International Journal of Computer Science Trends and Technology (IJCST) – Volume 12 Issue 1, Jan - Feb 2024

RESEARCH ARTICLE OPEN ACCESS

A Novel System for Finding Shortest Path in A Network Using Genetic Algorithm

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CHAPTER 1: INTRODUCTION

The travelling salesman problem (TSP) is an algorithmic problem tasked with finding the shortest route between a set of points and locations that must be visited. In the problem statement, the points are the citiesa salesperson might visit [1]. The salesman‘s goal is to keep both the travel costs and the distance travelledas low as possible. Focused on optimization, TSP is often used in computer science to find the most efficientroute for data to travel between various nodes. Applications include identifying network or hardware optimization methods. It was first described by Irish mathematician W.R. Hamilton and British mathematician Thomas Kirk man in the 1800s through the creation of a game that was solvable by finding a Hamilton cycle, which is a non-overlapping path between all nodes [2]. TSP has been studied for decades and several solutions have been theorized. The simplest solution is to try all possibilities, but this is also the most time consuming and expensive method [3]. Many solutions use heuristics, which provides probability outcomes. However, the results are approximate and not always optimal. Other solutions include branch and bound, Monte Carlo and Las Vegas algorithms. Rather than focus on finding the most effective route, TSP isoften concerned with finding the cheapest solution. In TSPs, the large amount of variables creates a challenge when finding the shortest route, which makes approximate, fast and cheap solutions all the more attractive. In the travelling salesman Problem, a salesman must visits n cities [4], [5]. We can say that salesman wishes to make a tour or Hamiltonian cycle, visiting each city exactly once and finishing at thecity he starts from. There is a non-negative cost c (i, j) to travel from the city i to city j. The goal is to find a tour of minimum cost. We assume that every two cities are connected. Such problems are called Travelling- salesman problem (TSP) [6], [7].The TSP has several applications even in its purest formulation, suchas planning, logistics, and the manufacture of microchips. Slightly modified, it appears as a sub-problem in many areas, such as DNA sequencing. In these applications, the concept city represents, for example, customers, soldering points, or DNA fragments, and the concept distance represents travelling times or cost, or a similarity measure between DNA fragments [8]. The TSP also appears in astronomy, as astronomers observing many sources will want to minimize the time spent moving the telescope between the sources; in such problems, the TSP can be embedded inside an optimal control problem. In many applications, additional constraints such as limited resources or time windows may be imposed [9]. In the theory of computational complexity, the decision version of the TSP (where given a length L, the task is to decide whether the graph has a tour of at most L) belongs to the class of NP-complete problems [10], [11]. Thus, it is possible that the worst-case running time for any algorithm for the TSP increases super polynomials (but no more than exponentially) with the number of cities[12].

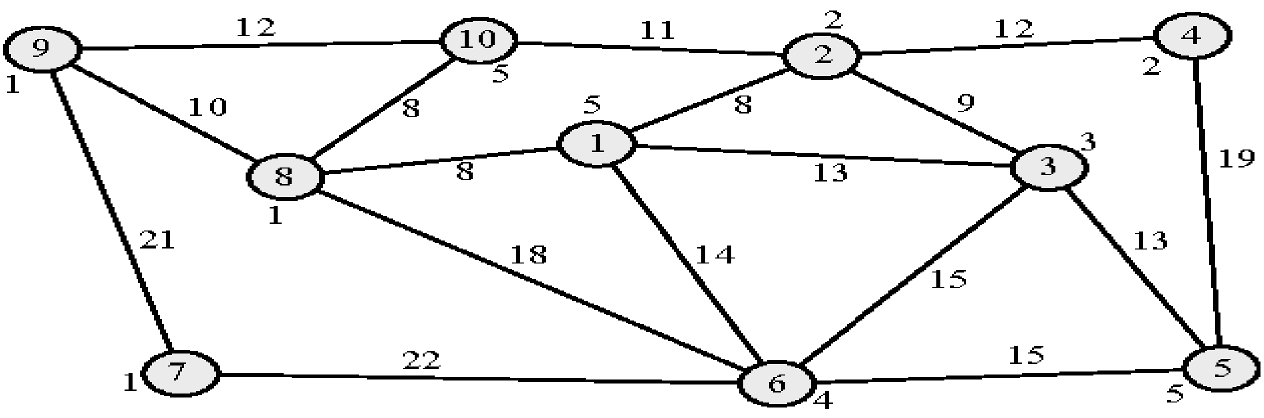

Figure 1: A graph representation of a network of cities; the d_{ij} values are marked on the edges, the f_i values are marked next to the nodes [13]

GENETIC ALGORITHM

Genetic Algorithms (GAs) are adaptive heuristic search algorithms that belong to the larger part of evolutionary algorithms. Genetic algorithms are based on the ideas of natural selection and genetics [14]. These are intelligent exploitation of random search provided with historical data to direct the search intothe region of better performance in solution space [15], [16]. They are commonly used to generate high- quality solutions for optimization problems and search problems. Genetic algorithms simulate the processof natural selection which means those species who can adapt to changes in their environment are able to survive and reproduce and go to next generation [17]. In simple words, they simulate "survival of thefittest" among individual of consecutive generation for solving a problem. Each generation consist of a population of individuals and each individual represents a point in search space and possible solution. Each individual is represented as a string of character/integer/float/bits. This string is analogous to the Chromosome [18].Genetic algorithms are based on an analogy with genetic structure and behavior of chromosomes of the population. Following is the foundation of GAs based on this analogy –

1. Individual in population compete for resources and mate [19]
2. Those individuals who are successful (fittest) then mate to create more offspring than others
3. Genes from "fittest" parent propagate throughout the generation that is sometimes parents createoffspring which is better than either parent [20], [21].
4. Thus each successive generation is more suited for their environment

The process of natural selection starts with the selection of fittest individuals from a population. They produce offspring which inherit the characteristics of the parents and will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance at surviving. This process keeps on iterating and at the end, a generation with the fittest individuals will be found. This notion can be applied for a search problem [22]. We consider a set of solutions for a problem and select the set of best ones out of them. Five phases are considered in a genetic algorithm [23]

1. Initial population [23] ,[24]
2. Fitness function
3. Selection
4. Crossover
5. Mutation [25]

BIG BANG CRUNCH THEORY

The Big Bang is usually considered to be a theory of the birth of the universe, although technically it does notexactly describe the origin of the universe, but rather attempts to explain how the universe developed from a very tiny, dense state into what it is today [26] . It is just a model to convey what happened and not a description of an actual explosion, and the Big Bang was neither Big (in the beginning the universe was incomparably smaller than the size of a single proton), nor a Bang (it was more of a snap or a sudden inflation). In fact, "explosion" is really just an often-used analogy and is slightly misleading in that it conveysthe image that the Big Bang was triggered in some way at some particular centre. In reality, however, the same pattern of expansion would be observed from anywhere in the universe, so there is no particular location in our present universe which could claim to be the origin [27] .The Big Bang model rests on two main theoretical pillars: the General Theory of Relativity (Albert Einstein's generalization of Sir IsaacNewton's original theory of gravity) and the Cosmological Principle (the assumption that the matter in the universe is uniformly distributed on the large scales, that the universe is homogeneous and isotropic).The Big Bang (a phrase coined, incidentally, by the English astronomer Fred Hoyle during a 1949 radio broadcast as a derisive description of a theory he disagreed with) is currently considered by most scientists as by far the most likely scenario for the birth of the universe [28].

CHAPTER 2: REVIEW OF LITERATURE

In this chapter, a literature review has been done to highlight the benefits of the genetic algorithm belongs to the family of evolutionary algorithms, along with genetic programming, evolution strategies, and evolutionary programming. Evolutionary algorithms can be considered as a broad class of stochastic optimization techniques. An evolutionary algorithm maintains a population of candidate solutions for the problem at hand. The population is then evolved by the iterative application of a set of stochastic operators. The set of operators usually consists of mutation, recombination, and selection or something very similar. Let's discuss some of the papers published that is related to the Genetic Algorithm in the past.

2. 1 Comprehensive Review

- Nasr Azadani, et al, (2022) [46] in this paper presents four different versions of computationally efficient genetic algorithms by incorporating several different local directional searches into the GA process. These local searches are based on using the method of steepest descent (SD), the Newton-Ramp son method (NR), a derivative-free directional search method (DFDS), and a method that combines SD with DFDS. Some benchmark functions, such as a low-dimensional function versus a high-dimensional function, and a relatively uneven function versus a very uneven function, are employed to illustrate the improvement of these proposed methods through a Monte Carlo simulation study using a split-plot design. A real problem related to the multi-response optimization problem is also used to illustrate the improvement of these proposed methods over the traditional GA and over the method implemented in the Design-Expert statistical software package. Our results show that the GA can be improved both in accuracy and in computational efficiency in most cases by incorporating a local directional search into the GA process.
- A. N. Singh, J. Mrudula, R. Pandey, et al, (2021)[45] here in this paper compared the results, which come after applying many different crossover and mutation operators devised for the traveling salesman problem and it is concluded that operators that use heuristic information or a matrix representation of the graph give the best results. Genetic algorithms are an evolutionary technique that uses crossover and mutation operators to solve optimization problems using a survival of the fittest idea. They have been used

successfully in a variety of different problems, including the traveling salesman problem. In the traveling salesman problem the aim is to find a tour of all nodes in a weighted graph so that the total weight is minimized. The traveling salesman problem is NP-hard but has many real world applications so a good solution would be useful.

- W. Rahmaniar and A. E. Rakhmania,(2021)[44] in this paper "Evolutionary algorithms" introduced that Evolutionary Algorithms are stochastic optimization techniques based on the principles of natural evolution. An overview of these techniques is provided with the general functioning of EA's, and gives an outline of the main families into which they be divided. Subsequently, it analyzes the different components of an EA, and provides some examples on how these can be instantiated. In the end it finished with a glimpse of the numerous applications of these techniques. Various techniques are Evolutionary Programming, Evolutionary strategies, Genetic programming and Genetic Algorithms. Thebasic differences between these paradigms lie in the nature of the representation schemes, the reproduction operators and selection methods.
- Z. H. Ahmed, (2020) [43] suggested GA for the resolution of real world schedulingproblems, and proposed a coordination mechanism. Because of frequently changing dynamic environments, providing efficient production management and timely delivery areone of the hard to solve problems. Scheduling is to allocate a set of machines to perform a set of jobs within a certain time period, and the goal of scheduling is to find an appropriate allocation schedule which maximizes certain performance measure. For the implementation issues, the solutions are encoded by natural representation, and the order crossover operator is used. They used the inversion mechanism as mutation operator. Finally, Madureia et al. solved dynamic scheduling problem using a set of static schedulingschemes by GA, and they showed the feasibility of GA in Job-Shop scheduling problem.
- B. Kiraz, A. A. Bidgoli, (2020)[42] suggested the GA which is applied for assigning task priorities and offset to guarantees that real time timing constraints. Assigning timingconstraint to task is not trivial problem in real-time system. They showed how timing constraints be mapped to attributes of periodic tasks running on standard preemptive RTOS(Real-Time Operating System). They used GA because of the GA's ability to generate a result that satisfies a subset of the timing constraints in cases where it is impossible tofulfill all constraints. GA, the mechanism of natural selection, gradually improves individuals timing constraints assignment in a population. It's been tested on many test cases and showed good result.
- J. Ma. Y. Liu, and et al. (2020) [38] suggested in this paper on "Test functions for

optimization needs" provides the review of literature benchmarks (test functions) commonly used in order to test optimization procedures dedicated for multidimensional, continuous optimization task. Special attention has been paid to multiple-extreme functions, treated as the quality test for opposing optimization methods (GA, SA, TS etc.). Quality of optimization procedures (those already known and those newly proposed) are frequently evaluated by using common standard literature benchmarks. There are several classes of such test functions, all of them are continuous, which are, first is unmoral, convex, multidimensional, second is multimodal, two- dimensional with a small number of local extremes, third is multimodal, two-dimensional with huge number of local extremes and the last is multimodal, multidimensional with huge number of local extremes. Where, class first contains nice functions as well as malicious cases, causing poor or slow convergence to single global extreme. Class second is intervening between first and third and last is used to test quality of standard optimization procedures in the unfriendlyenvironment, namely that having few local extremes with single global one. Classes third and fourth are recommended to test quality of intelligent resistant optimization methods.

- K. Jungle, J. Hughes, T. G. Thrushel, and F. Iida, (2020) [41] proposed a method ofsolving job- shop scheduling using GA. They generated an initial population randomly including the result obtained by some well known priority rules such as shortest processing time and longest processing time. From there the population will go through the process of reproduction, crossover and mutation to create a new population for the next generation until some stopping criteria defined were reached. In the paper, the numbers of generations are used as stopping criterion. In crossover and mutation, the critical block neighborhood isused and the distance measured to help evaluate the schedules. Result has shown that the implementation of critical block neighborhood and the distance measured can lead to the same result obtain by other methods.
- S. M. B. P. Samarakoon, M. A. V. J. Muthugala, (2020) [40] suggested in his paper on "Genetic Algorithm approach to Operating system process scheduling problem". Scheduling in operating systems has a significant role in overall system performance and throughput. An efficient scheduling is vital for system performance. The scheduling is considered as NP hard problem .The power of genetic algorithm is used to provide the efficient process scheduling. The aim is to obtain an efficient scheduler to allocate and schedule the process to CPU
- M. Takagi, (2020) [39] suggested in his paper on "A Genetic Algorithm on Single MachineScheduling Problem to Minimize Total Weighted Completion Time". In this paper, he

addresses a single machine family scheduling problem where there are multiple jobs. Each job is characterized by a processing time and an associated positive weight, are partitioned into families and setup time is required between these families. For this problem, he propose a genetic algorithm using an optimized crossover operator designed by an undirected bipartite graph to find an optimal schedule which minimizes the total weighted completion time of the jobs in the presence of the sequence independent family setup times.

- V. Singh, L. Ganapathy, and A. K. Pundir, (2019) [36] suggested in his paper on “Efficient CPU Scheduling: A Genetic Algorithm based Approach “that Operating system's performance and throughput are highly affected by CPU Scheduling. The scheduling is considered as an NP problem. An efficient scheduling improves system performance. In her paper she presents and evaluates a method for process scheduling. In this paper, she discussed the use of genetic algorithms to provide efficient process scheduling. And evaluate the performance and efficiency of the proposed algorithm in comparison with other deterministic algorithms and in a way that optimizes some performance by simulation.

Table 1: Comparison of different existing research work

SN	Author Name	Year	Method	Input Variables	Output	Remarks
1.	Nasr Azadani, et al.[46]	2022	Directional search method	low-dimensional function	GA can be improved in accuracy	Local directional search into the GA process
2.	A. N. Singh [45]	2021	Genetic algorithms	Operators	Rank Operators the selected	concluded that operators that use heuristic information

3.	W. Rahmaniar et al. [44]	2021	Evolutionary algorithms	analyzes the different components of an EA	Minimum Shortest Distances	paradigms lie inthe nature of the representation
4.	Z. H. Ahmed et al. [43]	2020	Job-Shop scheduling	They used the inversion mechanism as mutation operator	solved dynamic scheduling problem	Scheduling is to allocate a set of machines to perform a set of jobs within a certain time Period
5.	B. Kiraz, A. A. Bidgoli [42]	2020	Real-Time Operating System	constraint to task is not trivial problem in real- time system	constraints be mapped to attributes of periodic tasks	It's been tested on many test cases and showed good result.
6.	J .Ma. Y. Liu et al. [38]	2022	Review	Not Defined	Not Defined	MSO-ANFIS has the highest classification accuracy, i.e., 99.45 percent.
7.	K. Jungle [41]	2020	job- shop scheduling using GA	They generated an initial population randomly	numbers of generations are used as stopping criterion	implementation of critical block neighborhood
8.	S. M. B. P [40]	2021	"GA approach to OS process scheduling problem	scheduling is considered as NP hard problem	efficient process scheduling	allocate and schedule the process to CPU

9.	M. Takagi [39]	2020	Single Machine Scheduling Problem	scheduling problem where there are multiple jobs	time of the jobs in the presence of the sequence	job is characterized by aprocessing time and an associated positive weight
10.	V. Singh et al. [36].	2019	CPU Scheduling		improves system performance	The scheduling is considered as an NP problem.

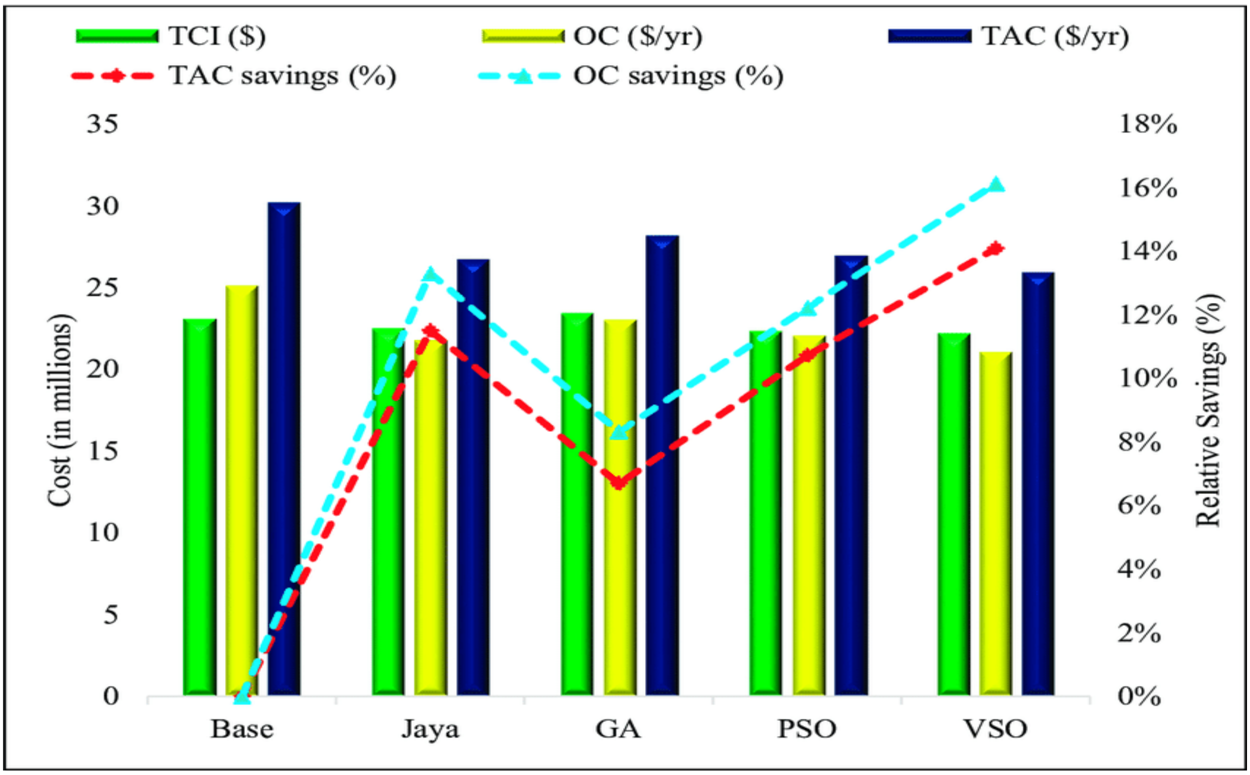

Figure 2: Comparison of Different Algorithm Find Best Solution using a graphical Representation

Considered Journal Comparison

- H. M. Gross, A. Scheidig, S. Müller, B. Schütz, C. Fricke, and S. Meyer,2019], suggested in his paper on "Window Constrained Scheduling of Processes in Real Time CPU Using Multi Objective Genetic Algorithm "a new approach to window constrained scheduling, suitable for weakly-hard real-time systems. The originally developed algorithm, called Virtual Deadline Scheduling (VDS) that attempts to guarantee m out of k deadlines is serviced for real-time jobs such as periodic CPU tasks. VDS is capable of generating a feasible window constrainedschedule that utilizes 100% of resources. However, when VDS either services a job or switches to a new request period, it must update the corresponding virtual deadline. This updating is a bottleneck for the algorithm, which increases the time complexity. Further, when VDS tries to solve the problem of delay the number of context switches increases. Context switching and delay are two conflicting criteria. By using Multi Objective Genetic Algorithm a trade off can beachieved between the context switching and the delay. We design our algorithm in such a way that it also overcomes the problem of updating, which is an additional overhead in the original VDS algorithm.

Advantages of using GA and TSP techniques for the shortest Path Find Out

Genetic algorithm is that it can find solutions to problems that are difficult or impossible to solve using traditional methods. Another advantage is that genetic algorithms can be used to solve problems that have multiple objectives or constraints [43].

Research Methodology

A methodology is referred to a procedure which is utilized by various authors or researchers in order to accomplish an examination by briefly scrutinizing the literature and then proposingenhanced solutions for a particular problem with an appropriate result and decision. Therefore, thisresearch work is done by conducting a systematic and statistical analysis of various evidences from the literature review that shed light on the use of GA and TSP techniques for finding the shortest path.

Literature Search

During the time of a decision about whether a particular research work should be included in theconducted study or not, always consider a factor known as credibility. Moreover, differentdatabases should be explored in order to search for a research work which offers suitable andpertinent data. In this research work, the papers which highlight the development of Shortest Path Algorithm by using TSP and GA and published from 2018 to mid of 2022 are taken user consideration. Also, these papers are searched by using some phrases and keywords such as "GA for Crossover Operators ", "Big Bang for Find out the centre of mass", Review papers for Shortest Path using GA and TSP & Big Bang Theory", and "TSP empowered GA Algorithm for Shortest Problem ", etc. The databases that are explored in the search for perfectly suitable literature related to the chosen topic are Research gate, IEEE, Hinduri and Pub med.

Choosing Eligible Papers and Studies

Before starting any research work, it is necessary to gather the literature which is most suitable andrelevant to the conducted study. Hence, eligibility criteria are made, and all the papers were first evaluated on this criterion. This criterion consists of the year of publication, must be related to shortest path, and development of any Algorithm by using either Big Bang or GA combination of both. Furthermore, while choosing any research study, it was first evaluated on the basis of its abstract and title and then went through the considered eligibility test. If a paper met the entire requirements, only then it was selected for the study.

Results and Findings

Distribution of selected papers on the basis of their year of publication

A total of 15 papers are considered, which have been published in the period 2018 to mid of 2022. Figure 3 shows the distribution of selected papers on the basis of their year of publication. As a result, it is noted that the year 2021 has a maximum number of publications in which GA Algorithm and TSP both approaches are utilized effectively in order to propose an Algorithm which can assist experts in Shortest Path Find out

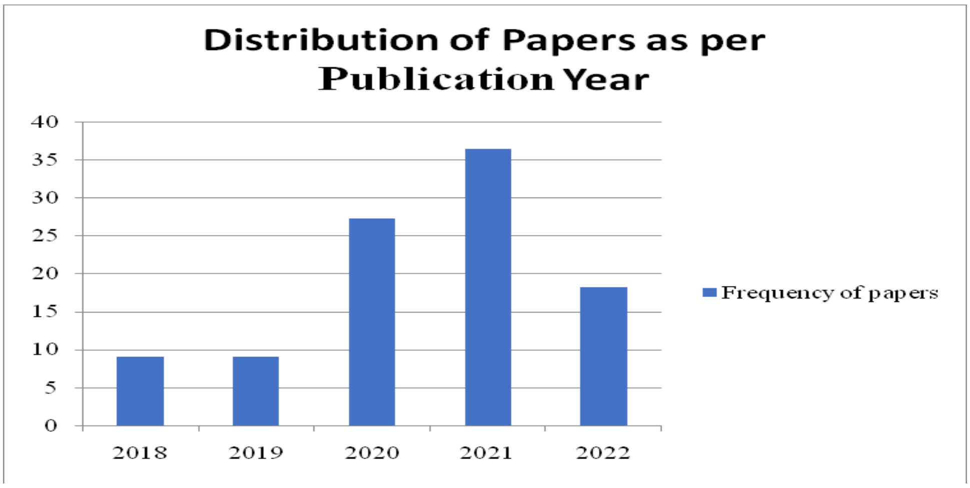

Figure 3: Distribution of selected papers on the basis of their year of publication

Distribution of selected papers on the basis of their database providers

Table 3 shows the different databases that are explored in order to find the most relevant and suitable papers for this study. The database provider who has the maximum participation in the study is IEEE, and in contrast, Elsevier has the least contribution.

Table 3: Distribution of selected papers on the basis of their database providers

Database Providers	**Frequency of papers**	**Percentage**
Elsevier	1	9.02
Pubmed	2	18.15
IEEE	1	9.07
Research gate	3	22.05

Distribution of selected papers on the basis of GA and Big Bang techniques

As the main objective of this review is to analyze the different developed models by utilizing GA and Big Bang Theory techniques, so to complete the prepared aim, the distribution of selected papers has been done on the basis of GA and Big Bang techniques which are displayed in table 4. The most used Big Bang approaches, along with the GA technology, are decision tree and random forest. From this table, it is analyzed that in recent years, the developed models by using a combination of both Big bang and GA approaches are outperforming the models which areimplemented by using either Big Bang approach or TSP technology.

Table 4: Distribution of selected papers on the basis of Big Bang and TSP techniques

Big Bang approaches / GA	**Frequency**	**Percentage**	**References**
Random forest	3	27.27	[44], [45]
Big Bang and GA	2	18.18	[29], [31]
TSP and GA	3	27.27	[28], [33], [34]
Big Bang and GA	1	9.09	[42]

The analysis of various fruitful benefits and significance of using GA incorporated with TSP has been done in this complete study. A number of scholarly articles are read and gone through

Eligibility criteria before selecting them in this conducted work. Moreover, the selected papers are distributed on the basis of the approaches of GA that is used with TSP in the development of models, database providers and year of publications.

CHAPTER3: RESEARCH GAP

- The shortest path problem is defined as finding a minimum length (cost) path between a given pair of nodes. But it has been reported in the literature that existing algorithms are mostly based on Bellman optimization theory which is not suitable for large networks. So there is scope to include genetic algorithm for such problem.
- Overall, the genetic algorithm is a popular and effective met heuristic algorithm for solving TSP, which can handle large-scale scenarios and can be designed to include domain-specific constraints.

CHAPTER4: OBJECTIVES OF THE STUDY

The study will be carried under the following objectives:

1. To study the existing systems for finding shortest path in a network.
2. To proposed a novel system for finding shortest path in a network using Genetic Algorithm.
3. To evaluate the performances of proposed system using few performances matrix

CHAPTER5: PROPOSED METHODOLOGY

The overview of the proposed work is shown in figure 1. The first step in GA is to encode a feasible solution namely chromosome. Then the process of GA starts with a set of generated chromosomes asthe initial population. The performance of each individual within a population would be evaluated through calculation of the fitness function. GA also performs crossover and mutation operators to generate offspring for the next generations in the proposed work we will try to solve the problem with two different.

First Approach is genetic algorithm which is an optimized technique which can be applied to various problems in travelling salesman problem with less time and better results. Second approach, will be big bang theory which is also a better algorithm with travelling salesman solving approach. The research problem is different from the traditional TSP (Traveling Salesman problem) since the latter mention case the resulting tour should contain all the cities with no repetitions while that of the shortest path problem only contains only the cities to be traversed through the shortest possible route. So it is difficult to map the shortest path problem with Traveling salesman problem as problems with similar constraints. At the beginning the TSP is taken to identify and to understand the concepts and constraints of the research goals. Earlier, a simpler version of a genetic algorithm was designed for a map with few towns. Later some modifications were done to achieve the successful results.

Here in a detailed description of the Genetic Algorithm parameters is given.

Initial population: The target/initial population refers to all events for evaluation by a specific performance measure involving patients who share a common set of specified characteristics within a specific measurement set to which a given measure belongs.

Rank Fitness: Rank selection first ranks the population and then every chromosome receives fitness from this ranking.

Crossover operator: in genetic algorithms and evolutionary computation, crossover, also called recombination, is a genetic operator used to combine the genetic information of two parents to generate new offspring

Mutation: Mutation operator in a genetic algorithm (GA) is used primarily as a mechanism for maintaining diversity in the population

Termination Criteria: The termination condition of a Genetic Algorithm is important in determining when a GA run will end.

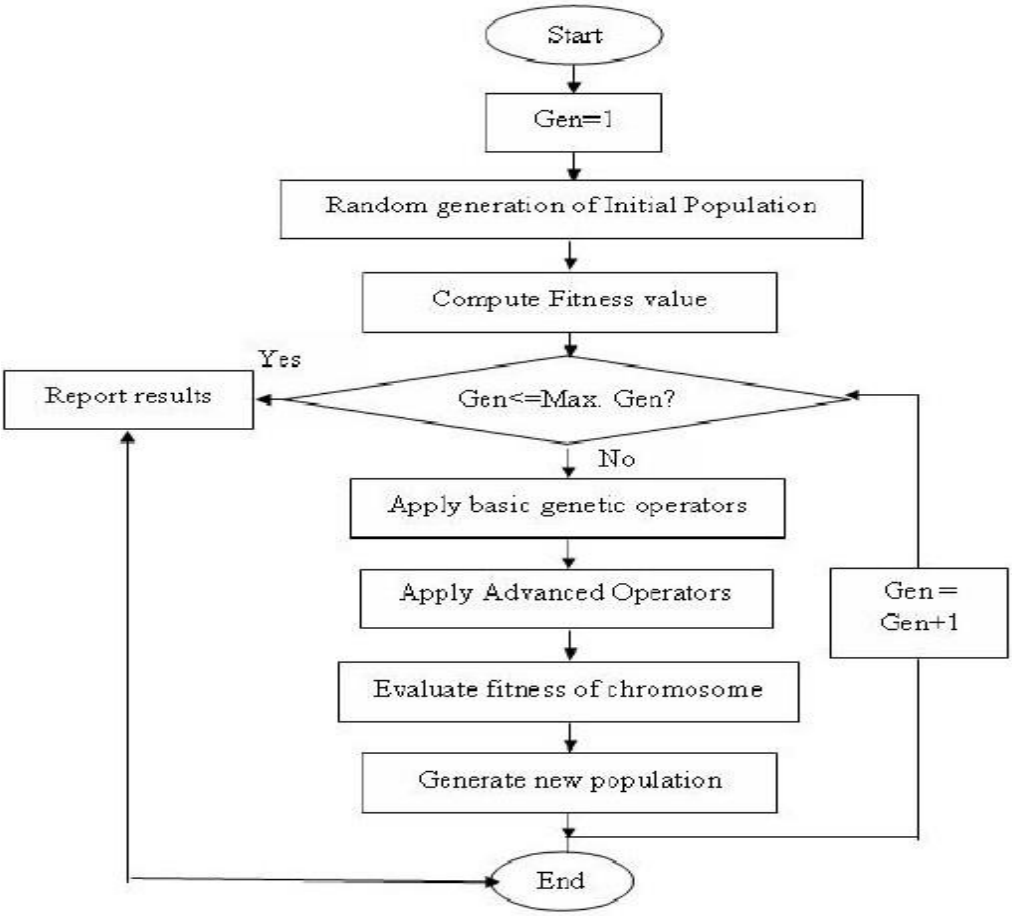

Figure 4: Genetic Algorithm of the proposed model

CHAPTER6: RESULT & DISCUSSION

The results will obtain with the newly designed genetic operators in our algorithm are impressive, on practical random no of cities. Larger targets are to be tested next. This method can be easily adapted to solving the asymmetric TSP. Experiments on comparing those results with other existing solvers for asymmetric TSP also need to be performed. Application of the developed TSPGO-Dijkstra to real life problems like time complexity fragment assembly.

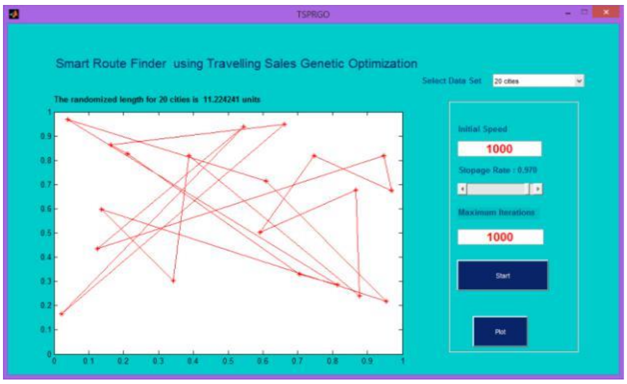

Fig. 6.1 TSP using Genetic optimization for 20 cities with 8.93 unit's efficiency

In above figure 6.1, we take the 20 cities from the dataset for optimize the route, its initial speed is 1000 and maximum optimization is

1000. The experiments show that GOA is the worst approach after all. Since GA can fail in any cases, it is definitely unexpected finding, and the propose method absolutely improves the performance of GA. In the other side, in small amount of data, experiments show that GOA did not just give the same solution as TSPGO, but it also gave better solution. It does not mean that GA will constantly perform better than GOA because small data merely reflects simple problem. That advance method is not effective to be applied for simple problem, it is a common sense.

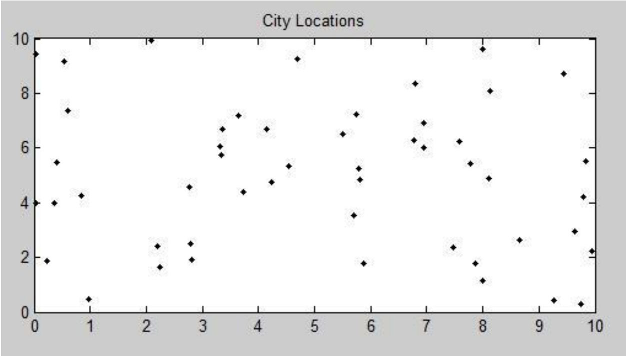

Fig.6.2 TSP City location for Genetic optimization for 20 cities

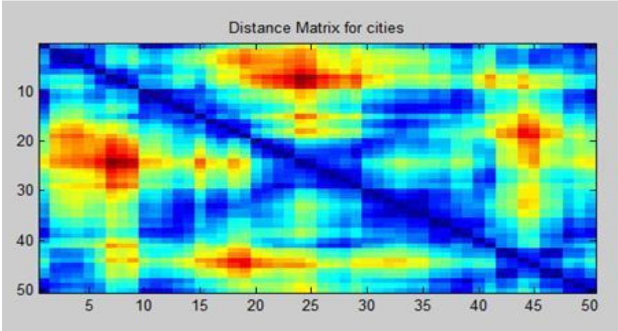

Fig. 6.3 TSP Distance Matrix for Genetic optimization for 20 cities

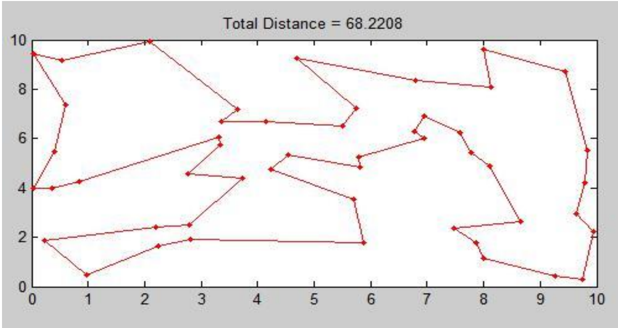

Fig. 6.4 Total distance of TSP for Genetic optimization for 20 cities

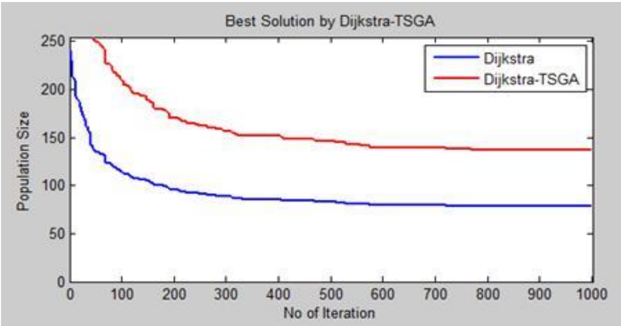

Fig.6.5 Comparison of Dijkstra and Dijkstra-TSGA for best solution

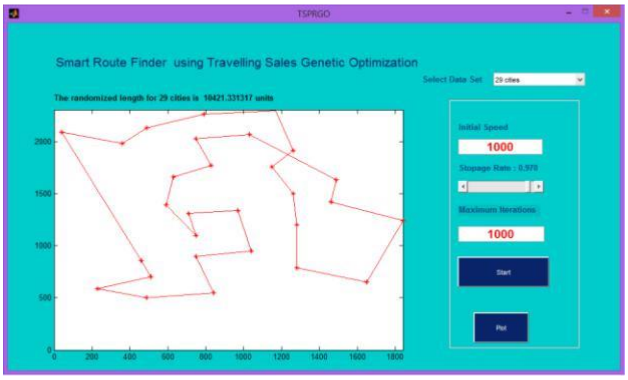

Fig. 6.6 TSP using Genetic optimization for 29 cities with 10525.82 unit's efficiency

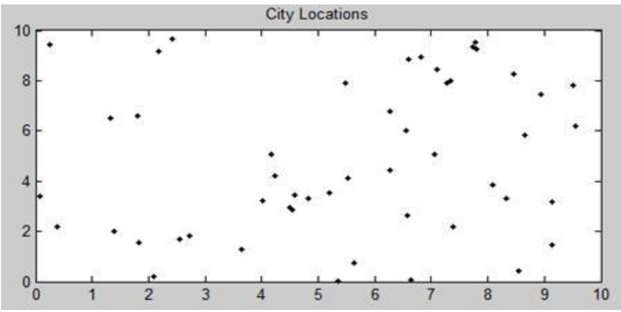

Fig.6.7 TSP City location for Genetic optimization for 29 cities

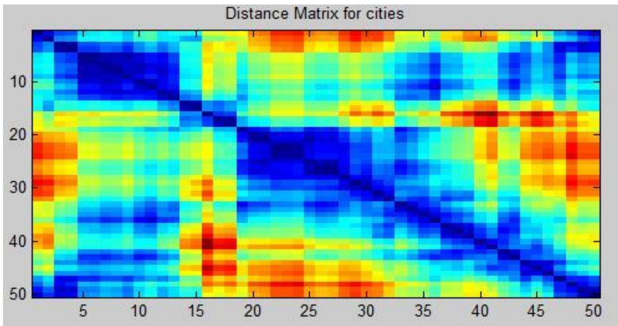

Fig. 6.8 TSP Distance Matrix for Genetic optimization for 29 cities

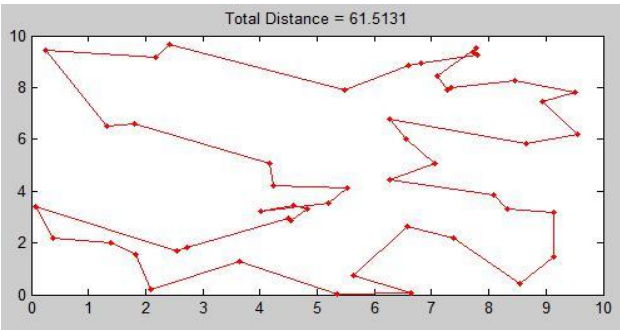

Fig.6.9 Total distance of TSP for Genetic optimization for 29 cities

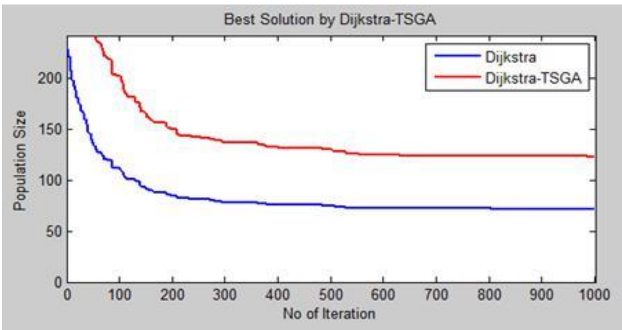

Fig. 6.10 Comparison of Dijkstra and Dijkstra-TSGA for best solution

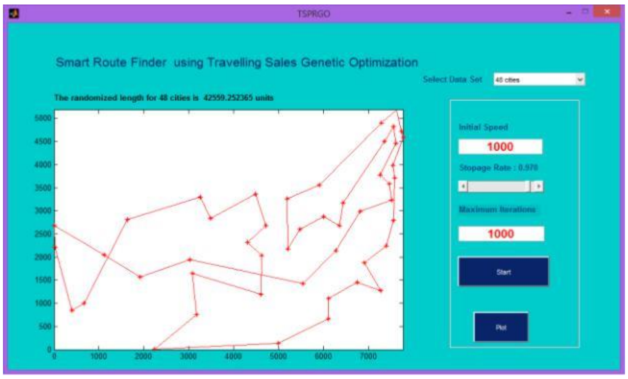

Fig 6.11 TSP using Genetic optimization for 48 cities with 42370.21 unit"s efficiency

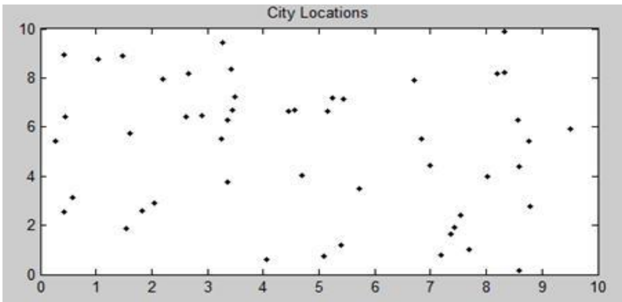

Fig 6.12 Tsp city location for Genetic Optimization for 48 cities

It has been observed from the Figures that the proposed TSPGOA has outperformed genetic algorithm in terms of convergence and optimal solution. The proposed crossover maintains more diversity in population and prevent algorithm to stick in local optima and genetic drift problem. The genetic algorithm usually results in premature convergence due to finite population size. But in proposed crossover, due to the incorporation of local search after normal crossover, the more fit offspring are generated that accelerates the search towards optima.

No of cites	**No. of salesman**	**No. of iteration**	**Total distance**	**Time taken**
50	10	996	74.7897	Elapsed time is 31.486082 seconds.
	15	996	71.8624	Elapsed time is 31.486082 seconds.

	20	989	65.0558	Elapsed time is 27.285622 seconds.

Table 5:
Output of TSP taking as number of Cities 50

CONCLUSION

This Thesis compares the proposed hybrid TSPGO-Dijkstra with pure GO. It was originated that proposed hybrid GA is actual in terms of convergence near the optimal result. The projected variation of crossover and mutation has the advantage of retaining the good solutions by using the value of fitness function.

The assistances to this field cover the growth of a TSPGO-Dijkstra process to solve TSP, the analysis and development of newly proposed algorithm, and the exploration of new applications of the precise sequencing problem. From the analysis and investigational work, the main assistances of the research can be summarized as follows:

1. Developed TSP procedure – developed a clear genetic algorithm procedure for TSP in which route repair based topological sort is inserted in the procedure in order to generate only feasible chromosomes.

2. Developed fitness evaluation procedure for TSP the objective function to evaluate the fitness of each chromosome has been developed.

3. Improved TSPGO-Dijkstra performance – the proposed algorithm has used „earliest position" selection of tasks in order to reduce iteration time, hence improved GA performance.

4. Improved quality of the solution – the proposed algorithm has used simple linear order crossover and inversion mutation to introduce new fitter chromosomes from generations to generations in order to prevent premature convergence.

In future proposed approach can be tested and implemented on different NP Hard problems like vehicle routing problem, Job Shop Scheduling problem and knapsack problem. Study can also be conducted to analyze the performance of algorithm with hill climbing is applied to different percentage of population.

CHAPTER 7: REFERENCES

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