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Using Scatter Search Algorithm in Implementing Examination Timetabling Problem

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Abstract: University of Anbar like whatever other universities of higher education, faces comparable issue and is utilized as real case in this study. Setting up the examination timetable takes a significant part of the department head's role and it includes all the distinctive tools the errand is overpowering. Timetabling is confounded because of various reasons table such as limited time to create schedule, number of halls usually is specific, number of staff work on create timetable is limited and etc. Attempt to find an optimal result for timetable scheduling of Anbar university by using Scatter Search Algorithm (SSA). To achieve an optimal solution for timetable scheduling of Anbar university with the accompanying targets: to create a tool for final examination time tabling for the colleges in university of Anbar and to investigate the efficiency and the performance of the SSA operators including adaptive mutation and other schemes on the SS. The approach has been presented to improve the efficiency and accuracy of scheduling examination timetables and improve the speed of preparing the schedule. The study investigates the most suitable parameters of Scatter Search algorithm for the population based algorithm. The findings outcome from this study have shown that. The results showed the ability to evaluate the performance of SS between the different operators, hence identifying the best results. The adaptive mutation demonstrated its ability as well to provide variety in the generations and as result the SS was able to explore more variety of solutions and then better solution was found. The optimal settings and configurations found have demonstrated their accurateness and suitability to produce better quality timetable representing very good solution to the problem being addressed. The proposed technique is tested and validated with real case study data and the results are satisfactory. The SS performance is examined in light of the varieties of the chose parameters. The best outcomes are gotten in direct population of 50 tests, 150 generations.

Key words: Examination timetabling, hard and soft constraints, Scatter Search algorithm, adaptive mutation, Iraq, population

INTRODUCTION

Timetable scheduling postures numerous issues over the years to educational organizations. To keep with the demand request for education in the increase of student number, numerous educational establishments now have to suggest two or four last examinations per year. With absence of authoritative staff, constrained time for tabling and different reasons like academic staff late delivery of examination results the university frequently needs to set up the timetable under pressure and in this way heightening the likelihood for errors. The final examination is held at the university level and the examinations generally involve all courses, classes, students and teachers and this is a large amount of work. Most institutions final examination timetable is determined at the college not by the lecturer. Therefore, the examinations are held on a specific scope of dates and a specified time. The examination timetabling issue is an NP real difficult problem and is a hard enhancement issue

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(how to solving this issues without infringement to the college terms) confronted by every educational organization. In this study we discussed the issues in real case study for final examination timetabling and concentrate on how to resolving this issue of preparing and creating the final examination timetable for any institution.

Many studies define the timetabling issue according to Obaid *et al.* (2012) it's an operation of masterminding examinations or halls occasions into particular time periods. Examination tabling limitation maps testing halls accessibility amid examination dates to avoid from clashing availabilities or inconsistent date. The expression "conflict" demonstrates that more than one member gatherings are booked for a similar room in the meantime. Most universities have been examination scheduling was prepared by heads of the departments of the college. Accordingly the method already used to solve the problem obliged using real factors of days and fixed dates. The scheduling issue is represented as an improvement issue for main role to find best or ideal result for space of potential scheduling thus, Scatter Search technique (SS) as an optimization method, work to solve real university problem. there are many features make SS able to solve scheduling issue (Chaudhuri and De, 2010; Laguna and Marti, 2012; Hadjidj and Drias, 2008).

The diversification generation technique concentrate on diversification and not on the goodness of the output solutions. After the diversity solutions are generated by diversification creation technique the fitness of every iteration in P will be rated.

The fitness function can be characterized to evaluate the value or nature of a specific result in this manner recognizing the best timetable from the not good one in variables of the timetabling issue (Obaid *et al.*, 2012; Reis and Oliveira, 2000). Big and multi-modular size of schedules makes the SS an especially perfect method for exploring the results.

Literature review: Automated timetabling incorporates class and examination scheduling has been one of the primary improvement issues in SS utilizations (Bufe *et al.*, 2001). The concept utilizes hybrid techniques by which an evolutionary algorithm plays out a search in the area for competitor answers for optimization. The premier timetable is propped by particular mutation steps to produce a final schedule. SS is fit for delivering examination timetables that satisfy both the hard and delicate limitations. In any case when there is no punishment in a technique with zero result it demonstrates that the result does not exist (Mohammed *et al.*, 2012; Mohammed, 2015a, b; Ueda *et al.*, 2000). Ugray *et al.* (2007) proposed a SS algorithm for solving the course timetabling issue. The algorithm concentrates on two fundamental techniques utilized inside it the reference set update and solution combination strategies. Both techniques give a deterministic search operation by keeping up assorted qualities of the population. This is accomplished by controlling a dynamic population size and performing a probabilistic determination step so as to produce a promising reference set. Experimental outcomes demonstrated that SS algorithm generated great quality solutions and outperforms a few outcomes revealed in the previous studies. Jaradat and Ayob (2011) improved an evolutionary algorithm depend on Scatter Search method for discovering great solutions for exam timetabling. This technique depends on keeping up and advancing a population of solutions. They assess SS proposed algorithm on real case study at college data and contrast the outcomes and the recorder's manual timetable notwithstanding the timetables of other heuristic enhancement approach. The outcomes demonstrate that adjusted SS creates preferred timetables over those created by the administrative staff, manually.

Mansour *et al.* (2009) presented a new explain about algorithm solutions by used two methods are SS and graph heuristics to produce new solutions based on hybrid approach. The execution of the proposed approach shown new solutions before any enhancement process based on quality and the diversity of the new solutions. They validate and compare with the best solutions are generated. A more efficient and productive searching techniques is improved by Mohammed *et al.* (2014) and Obaid *et al.* (2012) Cellular Automata (CA) and GA used to show the rule table and the fitness value is utilized as a part of creating the CA procedure. They investigated that ideal mutation rate to fitness development are available with commonplace examples shown the qualities if the qualities were to advance effectively. Many numerous analysts to utilization various techniques methodologies and give approaches to enhance results used for the entire procedure.

Timetabling issues

Examination timetabling problem: The examination scheduling issue is a table for coordinating students, teachers, rooms; time slots (periods) class subjects and other examination room types (computer labs, halls, studio and etc. Every university timetable has its own special problems. University examination timetable involves more human judgment because of the staff lesser teaching loads and is less constrained than school timetabling. In some institutions where the students are not given choices in their subjects (no electives or co-curriculum subjects).

University of Anbar like whatever other universities of higher education faces comparable issue and is utilized as real case in this study. Setting up the examination timetable takes a significant part of the department head's time and when it includes all the distinctive programs the errand is overpowering (Glover *et al*., 2003; Ugray *et al*., 2007; Ross *et al*., 1994; Birbas *et al*., 2009; Mohammed, 2015a, b). Timetabling is confounded because of many reasons. The following are a portion of the issues that college administrations commonly face while setting up the final examination table (Obaid *et al*., 2012; Burke *et al*., 2004, 2003):

- Limited time to create schedule
- Number of halls or (rooms) usually is fixed
- Number of staff work on prepare timetable is limited
- The changes on the schedule in the last moments
- Number of Inadequate staff not enough to invigilate
- Submission of examination results usually late by lecturers
- Information of timetabling is not exchanged on time because of absence of preparing or deficient time

The most fundamentals of timetable issue an achievable timetable must fulfill the imperative:

- Normally there is no student may have more than exam in a similar date
- The amplitude of rooms for any examination time ought not be override

Some universities and may likewise include different limitations for instance: if a student needs to more than one test in one day there should be no less than one finish time among the more than one test, this issue repeated many times in our university in current situation.

A scheduling must serve and passed various of limitations. Limitations or constraints are generally utilized to manage timetabling issues. In SS the kinds of limitations are soft and hard. Hard constraints or limitation in creating an examination schedule ought not involve any encroachment, e.g., a class impossible to be at various ranges in specific date (Glover *et al*., 2003; Jaradat and Ayob, 2011; Mahdi *et al*., 2012). Hard constraints timetabling problem including: The same student impossible take two exams in same date in other meaning the examinations can't there is only one examination for each course, more than one examination can be held at the same room but there must be enough seats for all the candidate of each examination in the same room and in this issue must be adequate resources such as the rooms and seating amplitude at any given time slot, separately (Obaid *et al*., 2012).

Soft constraints are limitations that could be passed but infringement should be reduced (Mansour *et al*., 2009). For instance, usually in the most universities final examination need a good mode for the students this demand makes to the examinations held in nearest campus. Many numerous soft constraints shown for various specialists and each request of significance differs such as Schedule examination locations that are near to the students, schedule examinations so that, they are apart giving adequate time for students to do revision, very strongly prefer no more than one examination per day for a given student (event spread constraint) and prefer not to allow any student who has two examinations back to back (Obaid *et al*., 2012). Timetabling basically involves two processes, specification and search. The specification process states the basic elements (classes, time slots, classrooms and teachers) of the problem and the constraints upon these elements (schedule preferences and avoiding conflicts). The search process explores search space for a solution with no constraints violation and with higher value of preferences satisfaction (Obaid *et al*., 2012; Burke *et al*., 2004). The timetabling issue is deemed as an enhancement issue since it looks for ideal results in the search size of conceivable timetables and SS as an optimization algorithm can be utilized to solve it.

Problem description: Often examination timetabling issues can be represented by appropriating a group of examinations $E = E_1, E_2, ..., E_e$ into a set number of requested time slots (specific time) $T = T_1, T_2, ..., T_t$ also rooms of particular limit in every time slot $C = C_1, C_2, ..., C_t$, subject to a group of limitations or constraints. The difficulties in solving the algorithms comes from the complexities of the hard and soft constraints that should be contented by the algorithm (Mansour *et al*., 2009; Dammak *et al*., 2009). Examination timetabling problem is a task to schedule all final examinations within a certain time period and in a certain value of classes to fulfill a group of hard and soft constraints. Hard constraints are considerations that should not be passed at all and mostly are due to physical restrictions (Laguna and Marti, 2012). For example, in the case of conflicting examinations, hard constraints may include students enrolled in both examinations, examination room size to fit the examinations scheduled for its use, staff and lecturer invigilating and number of special required rooms like computer labs, scientific labs and technical equipment's. Therefore, if D_{ij} is the number of the students enrolled in both examinations i and j and $x_i \in T$ is the timeslot to which examination i is assigned, then:

$$x_i \neq x_i \forall i, j \in E, i \neq j \text{ and } D_{ij} > 0 \quad (1)$$

Another example of a hard constraint is the number of students taking an examination cannot exceed the total seating capacity of the rooms. In this case, timetable t, S_i is the number of students in examination $i \in E$ then:

$$\sum_{i \in E} s_i \leq C_i, x_i = t, t \in T \quad (2)$$

MATERIALS AND METHODS

Scatter Search: Scatter Search derives its foundations from prior techniques for joining decision rules and surrogate imperatives (issue requirements) with the objective of empowering an answer method depend on the consolidated components to yield preferred results over one construct just in light of the first components (Laguna and Marti, 2012). Generally, the forerunner techniques for joining decision rules were presented with regards to timetabling approaches to get enhanced neighborhood decision rules for employment shop scheduling issues (Laguna and Marti, 2012). The algorithm was propelled by the supposition that data about the relative attractive quality of option decisions is caught in various structures by various rules (here the Scatter Search uses the reference set method: first reference set for quality and second reference set for diversity which are selected depending on special rules) what's more that this data can be exploited all the more viably when incorporated by method for a mix algorithm than when treated by the standard methodology of choosing various rules each one in specific time (here Scatter Search uses combination method for combining the solution using one of combination mechanism) the main advantages of combining decision rules is the technique withdrew from the typical method of halting after achieving a nearby ideal and rather kept on differing the parameter that decided the consolidated principles as a reason for creating extra trial results (Laguna and Marti, 2012; Ross *et al*., 1994). The decision rules by using blend methodologies created preferred experimental results over standard uses of local decision rules, furthermore demonstrated better than a "probabilistic learning approach" that chose diverse principles probabilistically at various crossroads yet without the mix impact gave by producing consolidated rules (Glover *et al*., 2003). The combination mechanism depends on surrogate constraints (problem constraint) to produce new trial solutions. Surrogate constrains are intended to catch helpful information that can't be removed from the parent imperatives individually but I not withstanding a result of their conjunction (Laguna and Marti, 2012). SS is an evolutionary algorithm and metaheuristic method used in many of difficult improvement issues. The essential ideas and basics of SS technique was initially suggested in the 1970s and depended on definitions for joining decision guidelines and issue requirements. Scatter Search doing on the generation of issue results to find best result and to resolved, the solutions will be saved as a group of results called the reference set. The solutions in this group are consolidated with a specific end goal to get new ones, attempting to produce every time better solutions as indicated by high value and assorted qualities criteria (Burke *et al*., 2004; Thomas *et al*., 2008). The primary differences between Scatter Search and other established populace based strategies like Genetic Algorithm (GA) (Au *et al*., 2003) are:

- The size of the developing group of result (solutions)
- Technique of join the current answers for give new ones
- Intensification and diversification instruments that works as adaptive memory, based on basics that connection Scatter Search to tabu search

Unlike a "population" in GA the reference set of results in Scatter Search is generally small. In GA, two solutions generated are randomly selected over the population and a "crossover" or blend component is used to create at least one offspring. A good population size in a GA contains of 100 components which are haphazardly tested to make blends. Conversely, Scatter Search selects at least two components of the reference set in a systematic method with the reason for making new solutions (Obaid *et al*., 2012; Laguna and Marti, 2012; Zhang *et al*., 2007; Sabar *et al*., 2009). Scatter Search is developed and improved by planning and combinational optimization method based on time and satisfying

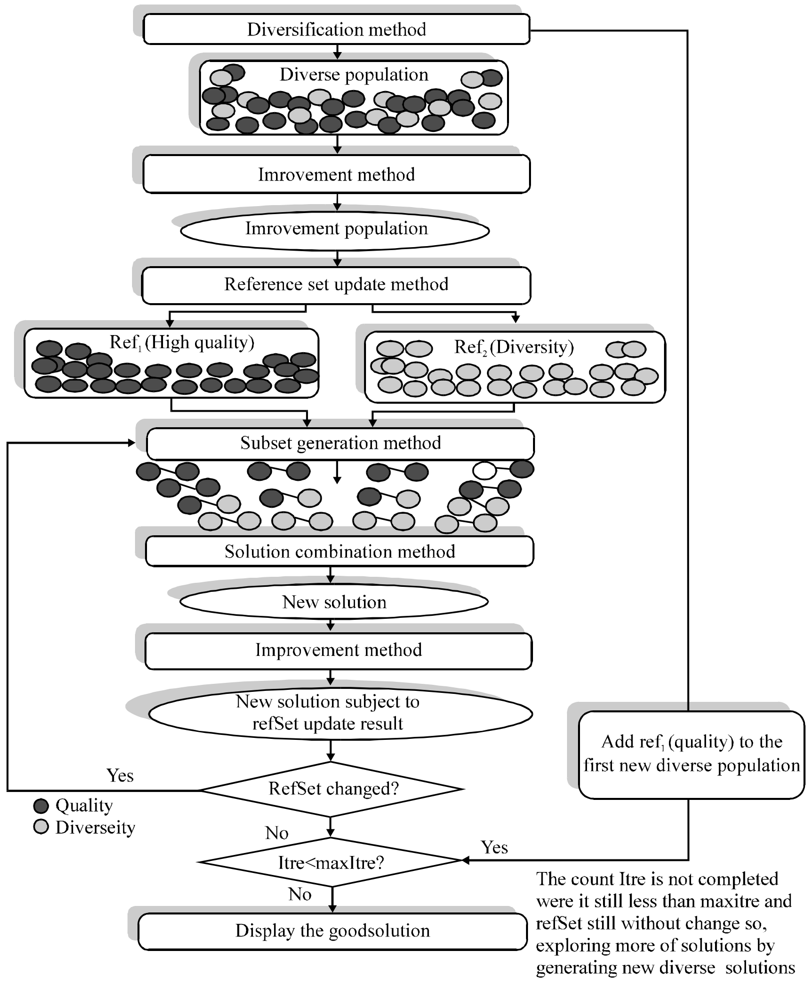

Fig. 1: Scatter Search process

student's and lecturer's desires to obtain the best feasible solutions for examination timetabling problem (Fig. 1).

Approach and implementation: SS is an evolutionary algorithm and metaheuristic method used in many of difficult improvement issues. The essential ideas and basics of SS technique was initially suggested in the 1970s and depended on definitions for joining decision guidelines and issue requirements. Scatter Search doing on the generation of issue results to find best result and to resolved the solutions will be saved as a group of results called the reference set. The solutions in this group are consolidated with a specific end goal to get new ones, attempting to produce every time better solutions as indicated by high value and assorted qualities criteria (Wang *et al*., 2008; Bufe *et al*., 2001; Mahmood *et al*., 2014; Mohammed *et al*., 2014; Mohammed, 2015a, b). According to high quality and differing qualities criteria (Ugray *et al*., 2007; Mansour *et al*., 2009). Figure 2 shows Pseudo code of SS algorithm.

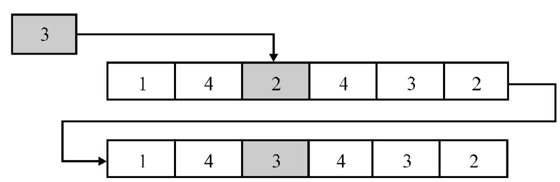

Fig. 2: One mutation (6 exams)

Algorithim 1 (Scatter Search)

```
Input: P = Population, maxitr.
Output: Best solution found.
Initialize the population (p) using a Diversification Generation Methods;
Apply the Improvement Method to the p;
Refrence Set Update Method (Good Solution for RefSet1 and Diversity
solutions for RefSet2);
While (itr<maxitr) do
  Subset generation method;
  While (subset-counter<>0) do
    Solution Combination Method;
    Improvement Method;
    Reference Set Update Method;
End while
End while
```

The proposed algorithm attempts to accommodate a numerical issue of nearly similar properties with real case study though minor differences occur among them. Such as examinations with differing length and hall limit are not deemed in proposed method summarizes the algorithm and the variables that are used in the SS technique.

The assigned parameters:

- The population size (P) = 200
- Number of generation = 100
- The references set size (b) = 20
- The number of quality solutions (b1) = 15
- The number of diverse solutions (b2) = 15
- The size of the subset in the process of tournament selection = 30
- The number of iterations = 4

The main fundamentals of SS method are mostly depending on the accompanying five stages:

Diversification generation method: This method creates a group of differing start solutions. As a rule, greedy strategies are used to diversify the inquiry while choosing best solutions. The create a subset of exams arbitrarily we arrange them concerning some heuristic and after that we allot them one by one into possible timeslots without abusing any hard limitation and with the most minimal punishment. The volume of the subset is given as rate of the full examinations set.

Improvement method: This step changes a trial result into at least one improved trial solutions utilizing any S-metaheuristic. However, a local search algorithm is used and afterward a neighborhood optimum is produced. In the event that the trial solution was not enhanced the “improved” result is thought to be the same as the information solution (Mohammed, 2015a, b).

Reference set update method: In this search part, a reference set is generated and preserve. The goal is to guarantee differences while keeping best solutions. For example, one can choose RefSet 1 solutions with the best target role and after that including RefSet 2 solutions with the best assorted qualities (RefSet = Ref Set 1+RefSet 2).

Subset generation method: This step works on the reference set ref set to generate a subset of results as a foundation for making consolidated results. This method ordinarily chooses every one of the subsets of fixed size.

Solution combination method: A particular subset of results created by the subset production step is recombined. In diversification technique, P of results of subset of exams will be created by utilizing randomized local search technique that based on seed which equal the beginning result that will enter to local find to produce P from it. This process creates random results every result is not the same as another and every solution is represented to as buffer including the subjects of every department or college. The subjects in every result will be encoding to by the form (1-4) where every symbol appear to a subjects in results for example, 1 = AI, 2 = HCI, 3 = ANN and 4 = MSP.

In the wake of producing P by diversification generation technique, rate of the fitness for every result in P will be assessed. The fitness in examination timetabling issue is the summation of subjects whose have a similar department or college. After assessing the fitness of every result, every one of the results in P will be enhanced or stay without modify by improvement technique. The development completed by utilizing SS method which is heuristic changes the present result by a neighbor that enhances the goal work. The neighborhood is finished by mutation operation the result by adding new subjects rather than another Fig. 2 outlines the mutation in solution. The mutation will change the fitness of result in light of the fact that the exams that was with 2 subjects in 3 days.

After local search creates another result, the fitness of this new result will be assessed. In the event that the new solution is superior to present result then present result = new result else the present result will stay without modification. These processes will be used to all results in P to acquire a greater amount of attainable results. Results of P will be requested based on their fitness and reference set update method will select ref set 1 which will take the primary b1 results in P and remove them from P while RefSet 2 will be produced by Euclidean distance to choose differing qualities solutions. Where the euclidean distance processes the divergence of the results in RefSet 1 with results of ref set 1-P and the results of P which are disparate with results of RefSet 1 will be selected as output of RefSet 2.

Results of $RefSet_1$ will enter to SA Algorithm, SA will take each solution in $RefSet_1$ to and generate new one. The new result s* will be assessed if the fitness of the s* is preferable than the result that was generated from it then replace with it else the s* will subject to probability of acceptance. In this case the SA will provide SS with more of investigation for issue search space and this will increase ratio of getting optimal solution. After SA generate the new solutions from $RefSet_1$, all solutions in ref set will be updated using reference set update methods.

After updating the solutions in ref set every result in ref set will make subset with every other output in ref set by subset generation process. Results gathering technique utilizes the subsets produced with the subset generation process to join the results in every subset with the motivation behind making new trial results. The gathering technique can utilize both of these two methods or it can have excited the blend for results by utilizing these two methods. Amid the tests the second method is more suitable for creating new possible results in SS, based on good experiments it will utilize the second method (Glover *et al.*, 2003; Grobner and Wilke, 2002; Mohammed *et al.*, 2012).

The gathering technique will look for subject in result that has neighbors and neighbors have same time slot if they get the gathering will change or enhance these subjects to generate new solution. Subsequent to producing the new result by using result gathering technique to every subset it will be subjected to reference set update rules where the new created result may turn into an individual from the reference set if both of the accompanying conditions is fulfilled:

- The new result (solution) has a best target function value than the result with the worst fitness function in RefSet
- The new result has a best difference amount than the result with the worst difference value in Ref Set

In the all cases to improve the solution their new result exchange the worst then the positioning which is modern to recognize the new worst result regarding either number or assorted qualities. This iteration ends when arrive the mean value without replace and every one of the subsets have as of now been subjected to the results gathering technique. Now, the recreation by diversification generation technique is utilized to build another differences results and the loop will be continuing until get best value. The recreation includes of keeping RefSet 1 in initial of new population and utilizing the diversification generation technique to build new differing solutions.

RESULTS AND DISCUSSION

The experimental results strive investigation to quantitative data decide the factors that produce best solutions between the models with comparative fitness function, the issue which joins speedier and accord many reliable yield through a lot of implementations

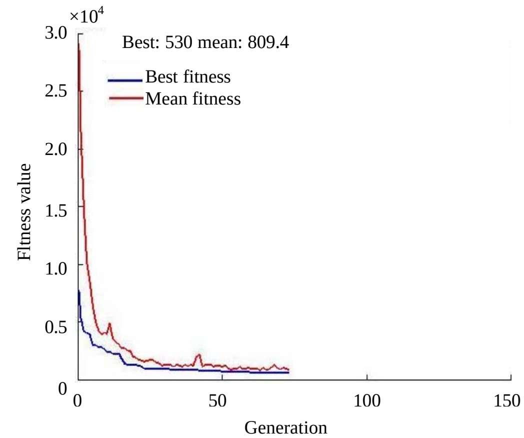

Fig. 3: The experiment actual performance1 ratio

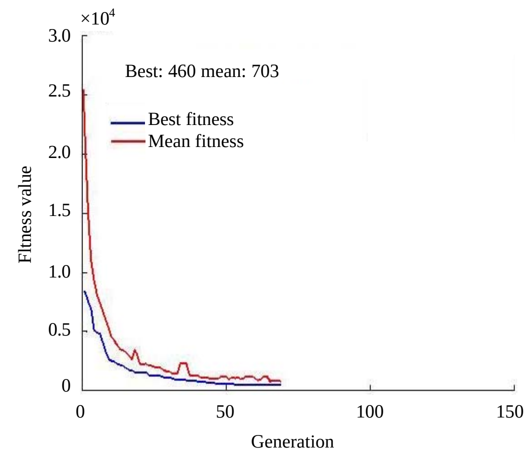

Fig. 4: The actual performance 2 ratio

that could be the best result. Real case study data are utilized in these experiments. The experimental results concentrate the best value acquired with constant population size and obstetrics iterations. To get a good performance SS implement with the experiments is shown by the axes (X, Y). The X axis represents generation iterations and the Y axis represents fitness values.

Experiment 1: First test in solve the problem by using SS technique many parameters are used to implemented SS algorithm in examination timetabling issues: population size = 50, number of generation = 150. Figure 3 presented the execution rate of the SS on experiment one.

Experiment 2: The parameters are used to implemented SS algorithm in examination timetabling issues: population size = 60, number of generation = 200. Figure 4 shows the execution rate of the SS on experiment two.

Experiments evaluation: Each one of the parts (e.g., administrators and variables) are utilized as a part of this study are assessed. The assessment procedure concentrates on every part exclusively as to alternate segments that effect or are influenced by the element through the assessment time.

Best solution: In the investigations of the experimental results the SS operators compete to locate the optimal result. The best likelihood of 80% is allocated and mutation step with fixed rate of 20% is used. The paradigm for terminate reason is the quantity of generation (150). The analyses demonstrate that the generation rate of the posterity decreases on account of the plan contrasted and the fitness value scheme.

CONCLUSION

In this study implemented the usage of SSA to get the optimal result for examination timetabling issue. Moreover, the chose steps effectiveness and proficiency are considered. For some enhancement issues, SS is observed to have the capacity to give satisfactory solutions involving examination timetabling issue. A different method can be arranged and diverse variables can be chosen in SS to accomplish the objective to get the best result. A many of SS methods have been acquainted all together with meet the difficulties and the requests of research study issue. The SS technique is tested and validated with actual case study data and the results are satisfactory and acceptable. The SS performance is examined in light of the varieties of the chose variables. The best outcomes are gotten in direct population of 50 tests, 150 generations.

Consequently, the SS can introduce the number of population in examination timetable results that are achievable (fulfills hard limitations) in every time. It likewise to utilize for more applicable studies into outlined in a way that deigned an assortment of scheduling issue. To get the best solution by using SS the practical solutions created by procedure are thread to improved SS and are assessed independently for fulfill the soft constraints. The findings outcome from this study have shown that. The results showed the ability to evaluate the performance of SS between the different operators, hence identifying the best results. The adaptive mutation demonstrated its ability as well to provide variety in the generations and as result the SS was able to explore more variety of solutions and then better solution was found. The optimal settings and configurations found have demonstrated their accurateness and suitability to produce better quality timetable representing very good solution to the problem being addressed. The proposed technique is tested and validated with real case study data and the results are satisfactory. The SS performance is examined in light of the varieties of the chose parameters. The best outcomes are gotten in direct population of 50 tests, 150 generations.

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