Iterated Local Search with Random Restarts for the Mentorship and Teamwork Problem (Google Hash Code 2022)

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1. Introduction and problem description

In the paper "Iterated Local Search with Random Restarts for the Mentorship and Teamwork Problem (Google Hash Code 2022)," we focus on the Mentorship and Teamwork problem proposed in the Google Hash Code 2022 competition. The Mentorship and Teamwork Problem (MTP) involves creating assignments that are a combination of projects and contributors. We try to do the creation of assignments in the most optimal way. This is done by considering various constraints and objectives to maximize the overall score of the assignments. Hard constraints are: a contributor can work on only one project at a time, once a project starts, contributors work on it for the specified duration and become available for other projects only after its completion, a contributor can be assigned to a project role if they meet the required skill level or have the skill at exactly one level below the required level and are mentored by another contributor on the same project who has the required skill level or higher, each contributor can fill at most one role on a single project, each role in a project can be filled by only one contributor. Soft constraints are: maximize the total score for completed projects, assign contributors to project roles that fit their qualifications and enable opportunities. The complete problem description can be found in the google hash code 2022 web page [1]. To solve this problem we propose an Iterated Local Search (ILS) [2] algorithm with random restarts. The algorithm starts with an initial list of assignments and iteratively refines the solution by exploring the search space, aiming to optimize the given objective function. The ILS algorithm incorporates perturbations and acceptance criteria to escape local optima and enhance search performance.The random restarts are introduced to further improve the algorithm's exploration capabilities. When a certain stopping criterion is met, the algorithm restarts from a new randomly generated solution. This helps the algorithm to explore different regions of the search space and avoid getting trapped in suboptimal solutions.

2. Solution method

The IteratedLocalSearch class presents a utility for iterated local search with random restarts, applied to a mentorship and teamwork problem. The algorithm aims to maximize the score for completed projects while adhering to problem constraints. It accepts an initial solution, maximum runtime, and lists of projects and contributors as inputs.

The search algorithm initializes the search space (S), home base (H), and the best solution found so far (Best). It iterates until the allotted time is reached, applying operators such as Swap, InsertProjects, Inversion, and RemoveProject to tweak the current solution (S). If the tweaked solution (R) is valid and of higher quality, it replaces S. The algorithm updates the best solution (Best) if S is better.

Helper methods include deltaQuality, Copy, Quality, NewHomeBase, Tweak, Swap, InsertProjects, Inversion, RemoveProject, and Perturb. These methods calculate quality differences, create solution copies, compute solution quality, select new home bases, apply random operators, and create new starting points for iterations, respectively.

The algorithm returns the best valid solution found within the given time. If no valid solution is found, it returns the initial solution. The IteratedLocalSearch class offers an efficient approach to solving complex mentorship and teamwork problems using iterated local search techniques.

Table 1. Considered neighborhoods

`Swap(a)`	Swap the order of two assignments in the timetable.
`InsertProjects(a, p, c)`	Insert unassigned projects to the assignments.
`Inversion(a)`	Invert some assignments in the timetable.
`RemoveProject(a)`	Randomly remove a project in assignments.

3. Preliminary experimental results

The table 2 shows the best results of the solution for the MTP. The second row showes the state of the art solutions, they are not from one team but the best among all teams.

Table 2. Preliminary results. Best available solutions are from Hash Code - Problem Archive [3].

Team	a	b	c	d	e	f	Total
The Best Results	33	1,005,020	288,508	674,945	1,650,488	1,194,515	4,813,476
Make love, not war	33	969,087	229,517	674,945	1,640,454	706,200	4,220,236
Rethinkers	33	932,759	274,679	384,328	1,599,952	904,867	4,096,618
Past Glory	33	909,802	223,267	562,814	1,640,172	756,170	4,092,258
Proof by Submission	33	800,991	256,630	173,626	1,587,033	1,194,515	4,015,828
code	33	900,799	259,165	399,105	1,640,492	765,794	3,965,388

In the table 2 we show our results of the solution accros 10 tests, where each test is runing for at least 5 minutes.

Table 3. Experiments with all instances in the test set (with at least 5 minutes)

Minutes	a	b	c	d	e	f	class
Test 1	33	845,631	3,712	76,220	1,245,671	45,627	67
Test 2	33	842,750			1,272,481	39,041	67
Test 3	33	462,614			1,258,633		67
Test 4	33	847,976			1,247,426		74
Test 5	33	427,448			1,243,979		76
Test 6	33	401,454			1,250,225		64
Test 7	33				1,233,796		69
Test 8	33				1,258,242		67
Test 9	33				1,248,196		64
Test 10	33				1,258,035		64

The complete solution for the Mentorship and Teamwork Problem, utilizing the Iterated Local Search with Random Restarts approach, can be found in the GitHub repository provided by Misini et al. [4]. The repository contains the source code, documentation, and relevant resources to better understand and implement the proposed algorithm. Readers are encouraged to visit the repository to explore the solution in detail and experiment with the algorithm for their specific problem instances.

4. Future work

Future Work for the Iterated Local Search with Random Restarts applied to the Mentorship and Teamwork Problem (Google Hash Code 2022) includes the investigation of alternative neighborhoods and the incorporation of domain-specific knowledge into the search process. It is anticipated that the exploration of different neighborhoods could lead to improved performance and a better understanding of the problem's landscape. Additionally, the development and testing of other metaheuristic algorithms, such as Tabu Search, Simulated Annealing, and Genetic Algorithms, may provide insights into their effectiveness when applied to this particular problem domain.

Furthermore, the combination of multiple metaheuristic algorithms or the use of hybrid approaches could potentially result in a more robust and efficient solution strategy. The integration of parallel processing and distributed computing techniques may also enhance the scalability and overall performance of the algorithm. Lastly, the study of adaptive parameter tuning techniques could lead to a more flexible and efficient search process, improving the algorithm's ability to adapt to various problem instances and settings.

References

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