

CENG303 DESIGN AND ANALYSIS OF ALGORITHMS

TERM PROJECT

MIDTERM EXAM SCHEDULING WITH CAPACITY CONSTRAINT

WITH SIMULATED ANNEALING ALGORITHM

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REPORT

The project aims to develop an algorithm for scheduling exams while considering both student, professor, and classroom capacity constraints. The proposed solution employs the Simulated Annealing algorithm to iteratively improve the exam schedule until an optimal schedule is achieved.

Implementation Details

Data Structures

The algorithm utilizes pandas DataFrames to manage class lists and classroom capacities efficiently. For the general Schedule, we are using Python dictionary. The structure can be seen below:

```
self.empty_schedule = {day:{hour:{"course": "", "room": "", "end time": ""}}}
```

Simulated Annealing

The algorithm starts with a random initial state and iteratively explores neighboring states using the simulated annealing approach. Successor moves involve swapping courses to find a better arrangement. The cost function evaluates the quality of the schedule based on the defined constraints.

Blocked Hours

We also allow users to specify blocked hours, preventing exams during certain periods.

Algorithm Workflow

- Initialization: Read input files, set up classroom capacities, and create an initial empty schedule.
- Blocked Hours: Optionally, users can specify blocked hours to account for non-exam periods.
- Simulated Annealing: The algorithm iteratively refines the schedule to minimize conflicts.
- Classroom Assignment: Assign classrooms to exams based on student capacities.

RESULTS

The algorithm outputs a final exam schedule considering all constraints. The schedule is presented in a readable tabular format, indicating courses, days, times, assigned classrooms, and blocked hours.

Conclusion

The developed tool successfully addresses the challenges of midterm exam scheduling, providing an efficient and feasible solution. The Simulated Annealing algorithm proves effective in finding near-optimal schedules while considering multiple constraints.

However, here we will talk about the restrictions (brought by the algorithm) and problems we experienced while doing our work. While trying to make the scheduler better and better, the increasing number of constraints was making it longer and longer for the solution to converge. At this point, although we tried to make the successor function more intelligent, these improvements began to break away from the basis of the actual algorithm as they increasingly directed the simulated annealing at some point. At this point, we came to a common decision and decided to adjust the result of the scheduling algorithm to be similar to what our department is currently doing. The point we encountered and could not fully resolve (without going beyond simulated annealing) was that the courses in the same class sometimes accumulated on the same day or did not come consecutively at very close hours. At this point, we think that a solution will be found with an additional control algorithm.

Future Work

- Explore additional optimization techniques to further improve scheduling efficiency.
- Extend the tool to handle additional constraints or specific requirements.
- New control algorithm to prevent consecutive courses from the same class.

EXAMPLE OUTPUTS OF THE PROGRAM:

```
----- WELCOME TO THE EXAM SCHEDULER TOOL -----  
  
Enter blocked hours in the format of  
'course_id Day start_time duration(minutes), course_id Day start_time duration(minutes)...'  
  
Example Usage: TIT101 Monday 09.00 60, TDL101 Wednesday 12.00 90  
  
Type 's' to skip this step: TIT101 Monday 09.00 60, TDL101 Wednesday 12.00 90  
  
Starting simulated annealing scheduler...  
  
Iteration: 50 Fault Score: 4  
Iteration: 100 Fault Score: 2  
Iteration: 150 Fault Score: 1  
Iteration: 200 Fault Score: 1  
Iteration: 250 Fault Score: 1  
Iteration: 300 Fault Score: 1  
Iteration: 350 Fault Score: 1  
Found in 365. iteration  
  
Press Enter to show the schedule...
```

Figure 1 Simulated Annealing Finding a Solution

THE SCHEDULE			
Course Code	Day	Time	Classes
CENG101	Monday	10.30-11.30	B515-C111-C510
CHEM101	Tuesday	09.30-11.00	C503-C403-C510
PHYS101	Tuesday	16.00-18.00	C111-C510-C507
MATH101	Thursday	13.00-15.00	C111-C403-C503
CENG113	Friday	09.30-11.00	C510-C111-B515
CENG207	Monday	18.00-20.00	C503-C111-C403
CENG203	Wednesday	10.00-12.00	C510-B515-C503
CENG209	Wednesday	14.00-15.30	B515-C510-C111
ENGR201	Saturday	10.00-12.00	C510-C503-C507
CENG201	Saturday	14.30-16.00	C111-C503-B515
CENG307	Monday	14.00-16.00	B515-C111-C503
CENG317	Monday	17.00-18.00	C403
CENG327	Wednesday	15.30-17.00	C510
CENG301	Thursday	09.00-10.00	C510-C507
CENG303	Thursday	11.30-13.00	C507-C403
CENG315	Thursday	15.00-16.30	C503
CENG309	Friday	13.30-14.30	C510
CENG325	Friday	16.30-17.30	C510
CENG305	Saturday	12.30-14.00	C403-C507-B515
CENG431	Monday	11.30-13.00	C510
CENG433	Tuesday	13.30-15.00	B515
CENG405	Tuesday	18.00-19.30	C503
CENG460	Thursday	10.30-11.30	C510
CENG463	Thursday	17.00-19.00	C507
CENG465	Friday	11.30-13.30	C403
CENG427	Saturday	17.00-19.00	C507
BLOCKED HOURS			
BLOCKED BY TIT101	Monday	09.00-10.00	
BLOCKED BY TDL101	Wednesday	12.00-13.30	

Figure 2 Final Schedule

```

----- WELCOME TO THE EXAM SCHEDULER TOOL -----

Enter blocked hours in the format of
'course_id Day start_time duration(minutes), course_id Day start_time duration(minutes)...'

Example Usage: TIT101 Monday 09.00 60, TDL101 Wednesday 12.00 90

Type 's' to skip this step: LUNCH Monday 11.30 120, LUNCH Tuesday 11.30 120, LUNCH Wednesday 11.30 120,
LUNCH Thursday 11.30 120, LUNCH Friday 11.30 120

Starting simulated annealing scheduler...

Iteration: 50 Fault Score: 11
Iteration: 100 Fault Score: 5
Iteration: 150 Fault Score: 4
Iteration: 200 Fault Score: 2
Iteration: 250 Fault Score: 2
Iteration: 300 Fault Score: 1
Iteration: 350 Fault Score: 1
Iteration: 400 Fault Score: 1
Iteration: 450 Fault Score: 1
Iteration: 500 Fault Score: 1
Iteration: 550 Fault Score: 1
Iteration: 600 Fault Score: 1
Iteration: 650 Fault Score: 1
Iteration: 700 Fault Score: 1
Iteration: 750 Fault Score: 1
Iteration: 800 Fault Score: 1
Iteration: 850 Fault Score: 1
Iteration: 900 Fault Score: 1
Iteration: 950 Fault Score: 1
Iteration: 1000 Fault Score: 1
Could not find a solution with 6 days after 1000 iterations. Adding an extra day...
Found in 1043. iteration

```

extra day added

Figure 3 Algorithm Didn't Find Any Proper Solution After 1000 Attempts

THE SCHEDULE			
Course Code	Day	Time	Classes
CENG113	Monday	14.30-16.00	C507-C503-B515-C510
PHYS101	Monday	17.30-19.30	B515-C111-C507-C503
MATH101	Thursday	18.00-20.00	C510-B515-C403
CENG101	Friday	10.30-11.30	C403-C507-C503
CHEM101	Sunday	15.30-17.00	C503-C403-C510
ENGR201	Tuesday	18.00-20.00	C507-C510-C503
CENG203	Thursday	09.00-11.00	C510-C503-C403
CENG209	Friday	09.00-10.30	C507-B515-C510
CENG201	Saturday	17.30-19.00	C510-C403-C111
CENG207	Sunday	09.30-11.30	C510-C111-B515
CENG303	Monday	10.00-11.30	C503-B515-C403
CENG317	Monday	13.30-14.30	C403
CENG325	Wednesday	09.30-10.30	C111
CENG301	Wednesday	10.30-11.30	C503-C403-B515
CENG315	Wednesday	18.00-19.30	C111
CENG305	Thursday	16.00-17.30	C503-C510-B515
CENG309	Saturday	09.30-10.30	C111
CENG327	Saturday	11.00-12.30	C503
CENG307	Saturday	14.30-16.30	C503-C403-C510
CENG463	Tuesday	09.30-11.30	B515
CENG433	Tuesday	13.30-15.00	C503
CENG465	Tuesday	16.00-18.00	C403
CENG460	Wednesday	16.30-17.30	C503
CENG431	Thursday	14.30-16.00	C403
CENG405	Saturday	12.30-14.00	C503
CENG427	Sunday	18.00-20.00	C510
BLOCKED HOURS			
BLOCKED BY TIT101	Monday	09.00-10.00	
BLOCKED BY LUNCH	Monday	11.30-13.30	
BLOCKED BY LUNCH	Tuesday	11.30-13.30	
BLOCKED BY LUNCH	Wednesday	11.30-13.30	
BLOCKED BY TDL101	Wednesday	14.00-15.00	
BLOCKED BY LUNCH	Thursday	11.30-13.30	
BLOCKED BY LUNCH	Friday	11.30-13.30	

Figure 4 Extra Day Added to the Final Schedule

```

----- WELCOME TO THE EXAM SCHEDULER TOOL -----

Enter blocked hours in the format of
'course_id Day start_time duration(minutes), course_id Day start_time duration(minutes)...'

Example Usage: TIT101 Monday 09.00 60, TDL101 Wednesday 12.00 90

Type 's' to skip this step: TIT101 Monday 09.00 60, TDL101 Wednesday 12.00 90

Starting simulated annealing scheduler...

Iteration: 50 Fault Score: 4
Iteration: 100 Fault Score: 1
Found in 127. iteration
Not enough classrooms to handle the course capacity. Exiting the program...

```

Figure 5 Not Enough Classrooms