CMPUT-366
Project -Automated Timetable Scheduling System

Introduction

The creation of conflict-free schedules for classes, teachers, and rooms in educational institutions is a complex task that significantly impacts organizational efficiency. This project addresses this challenge by implementing an Automated Timetable Scheduling System using the Constraint Satisfaction Problem (CSP) approach (Chun & Hon, 2020) schedules that accommodate teacher availability, room features, and class capacities is crucial. Manual timetable creation can be time-consuming and error-prone, necessitating the need for automated solutions.

Importance

Efficient timetable scheduling contributes to a conducive learning environment, enhances resource utilization, and aids in effective institution management.

Objective

This project aims to design and implement an Automated Timetable Scheduling System using CSP principles. The system represents classes, teachers, rooms, and timeslots as objects, leveraging the backtracking algorithm with heuristics for efficient scheduling.

Significance

The significance lies in the potential to optimize the timetable creation process, reduce manual errors, and enhance organizational efficiency in educational institutions.

Methods

Data Representation

Classes: Represented by the Course class, including course name, capacity, special requirements, and associated timeslots.
Teachers: Represented by the Teacher class, capturing name, available timeslots, and subjects they can teach.
Rooms: Represented by the `Room` class, describing classrooms with attributes like name, capacity, available timeslots, and features.
Timeslots: Represented by the `Timeslot` class, defining specific time periods for scheduling.

Constraint Satisfaction Problem (CSP) Implementation

Backtracking Algorithm

The backtracking algorithm, the core of the solution, efficiently explores the solution space. It is complemented by:
Variable Selection Heuristic (MRV): Implemented in the select_unassigned_variable function, selecting variables with the fewest remaining values.
Value Ordering Heuristic (LCV): Utilized in the order_domain_values function, prioritizing values with the least impact on neighboring variables.

Constraints

Implementation Details

Instances of classes, teachers, rooms, and timeslots are created and assigned relevant attributes. The CSP representation, denoted by the `csp` dictionary, associates classes with potential teachers and rooms. The system undergoes backtracking search with variable and value ordering heuristics. The implementation is modular, enabling easy extension and adaptation for different scenarios Kumar et al., (2020).

Evaluation

Experimental Setup

Diverse testing scenarios were employed, encompassing different classes, teachers, rooms, and timeslots. Constraints, such as teacher preferences, room features, and class capacities, were introduced. The system was evaluated with and without heuristics to assess their impact on solution quality and execution time .Ahmadian et al., (2021).

Results Presentation

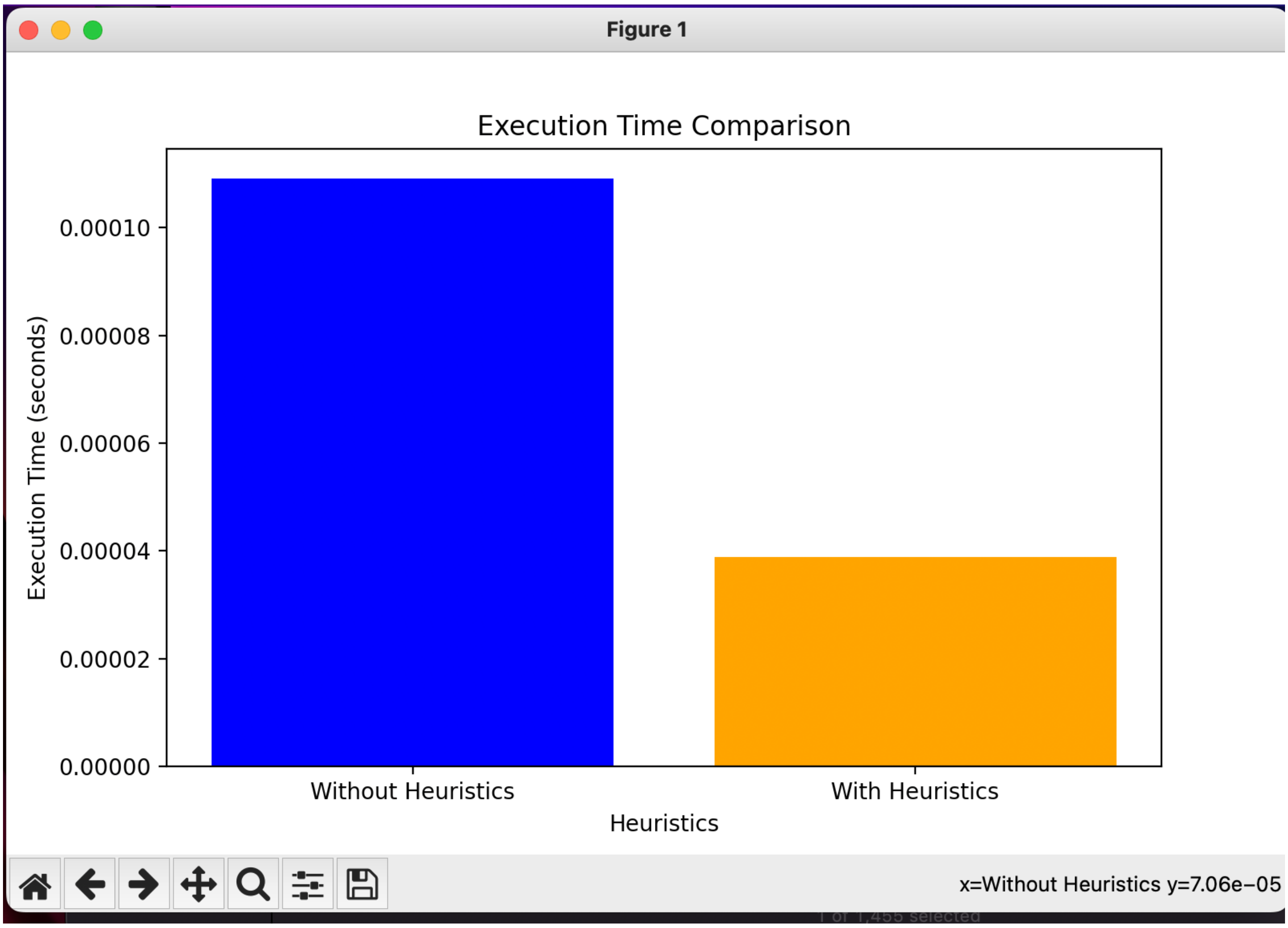
Schedule Visualization

A tabular representation was employed to showcase the assigned classes, teachers, and rooms for each timeslot. This format provides a comprehensive view of the generated timetable.

```
INFO:root:
No conflicts detected in the algorithm.
INFO:root:
No conflicts detected in the algorithm.

Final Schedule Visualization

| Class           | Room            | Teacher         | Day             | Time            |
--------------------------------------------------------------------------------
| Math            | Room1           | MrSmith         | Monday          | 9:00 AM         |
| English         | Room2           | MsJohnson       | Monday          | 10:30 AM        |
| Biology         | Room3           | MrJones         | Monday          | 1:00 PM         |
| Physics         | Room1           | MrSmith         | Wednesday       | 9:00 AM         |
| History         | Room2           | MsBrown         | Wednesday       | 10:30 AM        |
| Chemistry       | Room3           | MrJones         | Wednesday       | 1:00 PM         |
| ComputerScience | Room4           | MsSmith         | Monday          | 2:30 PM         |
| Literature      | Room2           | MsJohnson       | Wednesday       | 2:30 PM         |
| PhysicalEducation | Room5           | MrBrown         | Monday          | 4:00 PM         |
| Art             | Room6           | MsWhite         | Wednesday       | 4:00 PM         |
| Music           | Room7           | MrBlack         | Monday          | 5:30 PM         |
| Geography       | Room8           | MsGreen         | Wednesday       | 5:30 PM         |
| Programming     | Room1           | MrSmith         | Thursday        | 9:00 AM         |
| Algebra         | Room2           | MsJohnson       | Thursday        | 10:30 AM        |
| ChemicalEngineering | Room3           | MrJones         | Thursday        | 1:00 PM         |
| Robotics        | Room4           | MsSmith         | Thursday        | 2:30 PM         |
| WorldHistory    | Room2           | MsBrown         | Thursday        | 4:00 PM         |
| LiteraryAnalysis | Room3           | MrJones         | Thursday        | 5:30 PM         |
| PhysicalTraining | Room5           | MrBrown         | Friday          | 9:00 AM         |
| Painting        | Room6           | MsWhite         | Friday          | 10:30 AM        |
| MusicTheory     | Room7           | MrBlack         | Friday          | 1:00 PM         |
| EnvironmentalScience | Room8           | MsGreen         | Friday          | 2:30 PM         |
| AdvancedMath    | Room1           | MrSmith         | Friday          | 4:00 PM         |
| Economics       | Room2           | MsJohnson       | Friday          | 5:30 PM         |

Schedule Visualization Complete

adityashahi@Adityas-MacBook-Air CMPUT366 %
```

Solution Quality Comparison

Plots were used to compare schedules with and without heuristics. The results highlighted the impact on solution optimality in terms of execution time and quality metrics.



Discussion

Robustness and Efficiency

The system consistently produced conflict-free schedules across diverse scenarios, demonstrating its robustness. The backtracking algorithm effectively navigated the solution space, addressing constraints and optimizing for specified criteria Hassan et al., (2020).

Heuristics Impact

Comparative analysis revealed that schedules with heuristics exhibited improved solution optimality. The graphical representation facilitated a clear understanding of the trade-off between execution time and solution quality.

References

Ahmadian, M. M., Salehipour, A., & Cheng, T. C. E. (2021). A meta-heuristic to solve the just-in-time job-shop scheduling problem. *European Journal of Operational Research*, *288*(1), 14-29.

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Hassan, B. A., & Rashid, T. A. (2020). Operational framework for recent advances in backtracking search optimisation algorithm: A systematic review and performance evaluation. *Applied Mathematics and Computation*, *370*, 124919.

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