Automated School Scheduling System

A Genetic Algorithm Approach to Optimizing Educational Timetables

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December 4, 2024

Automated School Scheduling System: A Genetic Algorithm Approach

Team Scheduling Optimization

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1 Project Overview

1.1 Objective

The primary objective of this project was to develop an automated university timetable scheduling system using a Genetic Algorithm (GA) to efficiently assign teachers to subjects, rooms, and time slots while minimizing scheduling conflicts and optimizing resource utilization.

1.2 Scope

- **Included:** Scheduling for 10 teachers, 7 subjects, 5 rooms, across 15 time slots (5 days, 3 hours per day)
- **Excluded:** Long-term course planning, individual student scheduling, external constraints like teacher preferences

1.3 Key Deliverables

1. Optimized timetable schedule
2. Fitness progress visualization
3. Enhanced timetable heatmap
4. Detailed performance log
5. Comprehensive scheduling algorithm

1.4 Stakeholders

- University administration
- Faculty members
- Scheduling department
- Facility management

2 Methodology

2.1 Overview

The project utilized a Genetic Algorithm to solve the complex timetable scheduling problem through iterative optimization and constraint satisfaction.

2.2 Tools and Technologies

- **Programming Language:** Python
- **Libraries:**
  - DEAP (Distributed Evolutionary Algorithms)
  - NumPy (Numerical computing)
  - Matplotlib (Visualization)
  - Seaborn (Statistical data visualization)
  - Pandas (Data manipulation)

2.3 Solution Representation

- Each individual (chromosome) represents a complete timetable
- Encoded as a list of (teacher, subject, room, time_slot) tuples
- Total of 45 classes to be scheduled

2.4 Fitness Function

- **Hard Constraints:**
  - Teacher qualifications
  - Preventing double bookings (teachers and rooms)
- **Soft Constraints:**
  - Balanced teaching load
  - Subject distribution diversity

3 Results and Analysis

3.1 Performance Metrics

- Fitness value (penalties)
- Minimization of scheduling conflicts
- Teaching load balance
- Subject distribution

3.2 Key Findings

- Reduced fitness penalties from 820 to 201 over 100 generations
- Generated a feasible and optimized timetable
- Visualized fitness progress and timetable distribution
- Created an enhanced heatmap for schedule visualization

4 Challenges and Insights

4.1 Technical Challenges

- Balancing hard and soft constraints
- Preventing scheduling conflicts
- Ensuring teacher specialization is respected
- Managing computational complexity

4.2 Key Insights

- Genetic Algorithms are effective for complex scheduling problems
- Targeted mutation and crossover strategies improve solution quality
- Comprehensive fitness functions are crucial for realistic scheduling

5 Future Work

5.1 Optimization Recommendations

- Implement machine learning techniques for parameter tuning
- Develop more nuanced specialization modeling
- Explore hybrid optimization algorithms

5.2 Potential Expansions

- Extend to more complex scheduling scenarios
- Integrate real-world constraints
- Develop a user-friendly interface
- Create a more dynamic scheduling system

6 Conclusion

The Automated School Scheduling System demonstrates the potential of Genetic Algorithms in solving complex optimization problems. By effectively managing constraints and iteratively improving solutions, we have developed a robust approach to timetable scheduling that can be further refined and adapted to various educational contexts.