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AI for Automated Scheduling (College Timetable Generator)

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***Abstract*—Timetable scheduling is a complex problem that involves allocating courses, instructors, classrooms, and more while satisfying multiple constraints. This project implements an AI-based timetable generator using Constraint Satisfaction Problem (CSP) and Genetic Algorithm (GA). The CSP approach ensures feasibility by enforcing hard constraints, while GA optimizes the solution by minimizing conflicts. Our system efficiently generates a weekly schedule while considering faculty preferences, room availability, credit hours, and more. The results demonstrate improved scheduling accuracy with reduced conflicts, making it a practical solution for academic institutions.**

Keywords*— *Timetable Scheduling, Constraint Satisfaction Problem, Genetic Algorithm, Optimization, AI-based Scheduling

I. Introduction

Timetable scheduling is a well-known combinatorial optimization problem that educational institutions face every semester. The implementation addresses the NP-hard timetabling problem by first verifying feasibility through CSP and then optimizing schedules using GA. The system effectively manages multiple constraints including course-instructor assignments, room layouts, and specialized time slots while balancing workload distribution and minimizing scheduling gaps. Manual scheduling is not only time-consuming but also error prone, often leading to conflicts in faculty allocation, room assignments, and course timings. These conflicts result in inefficient resource utilization and dissatisfaction among students and instructors.

The primary challenges in timetable scheduling include:

- Avoiding resource conflicts: Preventing double-booking of instructors or classrooms.
- Ensuring course requirements are met: Assigning the correct number of sessions per course while considering course type (lecture/lab).
- Respecting instructor availability: Ensuring instructors are assigned classes only during their available slots.
- Balancing period distribution: Avoiding excessive gaps between classes for students and distributing instructor workload evenly across the week.

AI-based approaches, particularly Constraint Satisfaction Problems (CSP) and Genetic Algorithms (GA), offer efficient and automated solutions to these problems. This two-phase approach balances the need for constraint satisfaction with optimization quality.

II. Literature Review

Timetable scheduling is still one of the most difficult combinatorial optimization problems in higher education, where limited resources like rooms, teachers, and time slots are to be allocated while satisfying multiple constraints. AI-based methods, including Constraint Satisfaction Programming (CSP) and Genetic Algorithms (GA), have been suggested to solve this problem. This review provides an overview of major studies that investigate these two methods, with an emphasis on their ability to generate optimized timetables.

Zhang and Lau (2005) were the first to apply CSP to university timetable scheduling. The authors formulated the problem as a set of variables (representing resources like rooms, instructors, and time slots), domains (potential values for each variable), and constraints (rules that have to be fulfilled, such as no instructor should be scheduled for more than one class at a time). They used a backtracking search algorithm to identify solutions that satisfy all hard constraints, and thus CSP was a viable method for generating conflict-free timetables. CSP ensures feasibility when generating timetables since it strictly enforces no conflicts to prevent double-booking of instructors or rooms. While CSP-based approaches are dependable, they are computationally intensive, particularly when applied to large-scale timetables with numerous variables and constraints.

The paper "An Automated Timetable Generator for College" (IJREAM) discusses the automation of scheduling through CSP with the aim of creating timetables without conflicts. The method proves that CSP can be used to successfully automate the scheduling process in schools, especially in generating timetables free of conflicts. While CSP guarantees timetables to be conflict-free, Genetic Algorithms (GA) present an option to fine-tune these solutions by enhancing the quality of schedules in general. Genetic Algorithms operate by evolving a population of potential solutions through selection, crossover, and mutation operations. The algorithms can iteratively optimize a list of candidate schedules to reduce soft constraint violations, e.g., instructor workload balancing and room usage maximization.