A Constraint-Driven Algorithm for Automated Examination Seating Allocation in Academic Institutions

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***Abstract*—Examination management is a critical activity in academic institutions, especially when a large number of students from different departments participate in examinations simultaneously. Preparing seating arrangements manually is often time-consuming and may result in errors such as improper seat allocation or inefficient utilization of examination halls. To address these challenges, this paper presents an automated examination seating allocation system based on constraint-driven algorithms. The proposed system accepts student records in CSV format and processes them to generate optimized seating arrangements according to predefined rules such as hall capacity, subject distribution, and adjacency restrictions. The allocation algorithm systematically distributes students across available examination halls to maintain fairness and reduce opportunities for academic malpractice. The generated seating layout is automatically converted into a structured PDF format that can be easily shared with invigilators and examination authorities. Experimental results indicate that the system significantly reduces administrative effort while producing accurate seating plans within a short time.**

***Index Terms*—Examination Management, Seating Allocation, Constraint-Based Algorithm, Web Application, CSV Processing, PDF Generation, Academic Automation.**

I. INTRODUCTION

Conducting examinations in educational institutions requires careful planning and coordination. One of the most important tasks during examination management is the preparation of seating arrangements for students. When the number of students is large and multiple departments are involved, manual preparation of seating plans becomes difficult and prone to errors. Issues such as uneven distribution of students, duplicate seat assignments, and inefficient utilization of available examination halls may arise when the process is handled manually.

With the increasing adoption of digital technologies in academic administration, automated systems can simplify many examination-related processes. Automated seating allocation systems are capable of processing student information quickly and generating organized seating layouts while following predefined rules. Such systems help reduce administrative workload and ensure a fair distribution of students across examination halls.

This paper presents an automated examination seating allocation system designed to generate seating plans using a constraint-driven algorithm. The system processes student information stored in CSV files, applies allocation rules based on hall capacity and subject distribution, and produces hall-wise seating layouts. The final seating plans are generated in PDF format to enable easy printing and distribution. The proposed approach improves efficiency, minimizes human errors, and supports effective examination management.

II. LITERATURE REVIEW

Several studies have explored the use of automated systems to simplify examination management tasks in educational institutions. Traditional examination management systems mainly focus on functions such as student registration, examination scheduling, and result processing. However, seating arrangement is

still frequently handled manually using spreadsheets or paper-based methods in many institutions. This manual approach often increases administrative workload and may lead to errors in seat allocation.

Researchers have proposed different automated methods for allocating seats during examinations. Many of these systems assign seats based on roll numbers or available room capacity. While these methods help reduce manual effort, they often rely on simple sequential allocation techniques and do not fully address constraints such as preventing students from the same subject or department from sitting close to each other.

Recent research has introduced constraint-based and rule-driven allocation methods for improving seating distribution. These approaches attempt to balance student placement across examination halls while considering factors such as hall capacity, subject grouping, and adjacency restrictions. Constraint-based techniques provide better control over seating distribution and help maintain fairness during examinations.

The system proposed in this paper builds upon these approaches by implementing a constraint-driven seating allocation algorithm. The system processes student data in CSV format, groups students according to subject information, and distributes them across available halls while ensuring efficient utilization of seating capacity. The final seating layout is automatically generated as a structured PDF document for easy use by examination administrators.

III. METHODOLOGY

The proposed Intelligent Exam Seating Planner is designed to automate the process of generating seating arrangements for examinations in educational institutions. The system follows a structured methodology that involves data collection, preprocessing, seat allocation, and final seating plan generation. The objective of the system is to distribute students efficiently across available examination halls while minimizing the chances of academic malpractice.

A. Data Collection

The first step in the methodology is collecting necessary data required for the seating allocation process. The system receives input in the form of student information and examination hall details. Student data typically includes roll number, department, and subject code, while hall information contains the hall number and seating capacity. These inputs are stored in structured formats such as CSV files or databases, which are then processed by the system.

B. Data Preprocessing

Before generating the seating arrangement, the collected data is organized and validated. Students are grouped based on their subjects to ensure that candidates writing the same examination are properly distributed. Sorting and grouping operations are performed to create a balanced dataset that can be efficiently used by the seating allocation algorithm.

This stage also removes duplicate entries and verifies that the number of students does not exceed the available seating capacity of examination halls.

C. Seating Allocation Algorithm

The core component of the system is the seating allocation algorithm. The algorithm iteratively assigns students to available seats in examination halls while considering predefined constraints. One of the primary constraints is ensuring that students from the same subject are not seated next to each other whenever possible.

The system first reads the hall capacity and divides seats into rows and columns. Students are then allocated in a systematic order across halls. If the current hall reaches its maximum capacity, the system automatically moves to the next available hall.

The algorithm ensures efficient seat utilization and balanced student distribution across multiple halls.

D. Constraint Verification

After the initial seat allocation, the system performs constraint checking to ensure that all rules are satisfied. These rules include verifying hall capacity limits, avoiding duplicate seat assignments, and maintaining proper subject distribution among neighbouring seats.

If any conflicts are detected, the system reassigns the affected students to suitable seats until all constraints are satisfied.

E. Seating Plan Generation

Once the allocation process is completed, the system generates the final seating plan. The output includes

hall-wise seating charts showing the roll numbers assigned to each seat. These charts can be exported in formats such as tables or printable reports, making it easier for examination administrators and invigilators to manage students during examinations.

The generated seating plan improves transparency, reduces administrative effort, and ensures an organized examination environment.

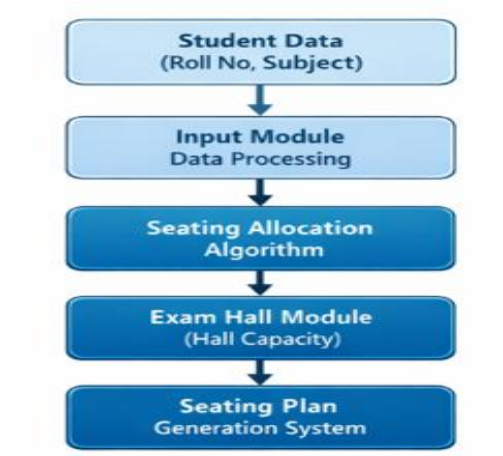

Fig. 1. System Architecture

IV. PROPOSED ALGORITHM

The proposed Intelligent Exam Seating Planner uses an automated allocation algorithm to distribute students across examination halls while maintaining fairness and minimizing opportunities for academic malpractice. The algorithm focuses on efficient seat utilization and proper subject distribution.

The system takes student records and examination hall details as input and processes them to generate a structured seating arrangement. The algorithm ensures that students belonging to the same subject are distributed across different rows or halls whenever possible. This reduces the likelihood of students sitting next to others writing the same examination.

The seating allocation process follows a sequential strategy in which students are assigned seats based on availability and predefined constraints such as hall capacity and subject grouping. The algorithm also verifies that no seat is assigned to more than one student and that the number of students does not exceed the available seats in a hall.

In addition, the algorithm automatically moves to the next examination hall once the current hall reaches its seating capacity. This ensures that all students are accommodated efficiently without manual intervention.

A. Pseudocode

```
Input: Student_Data, Hall_Data
Output: Seating_Chart
Begin
   Read Student_Data
   Read Hall_Data
   Sort students by subject
   For each hall
      For each seat
         Allocate student to seat
      EndFor
      If hall_capacity reached
         Generate seating chart
      Else
         Move to next hall
      EndIf
   EndFor
End
```

C. Algorithm Complexity

The algorithm processes each student only once during seat allocation. Therefore, the overall computational complexity of the system is approximately O(n), where n represents the number of students.

This linear time complexity makes the system suitable for large-scale examinations involving hundreds or thousands of students.

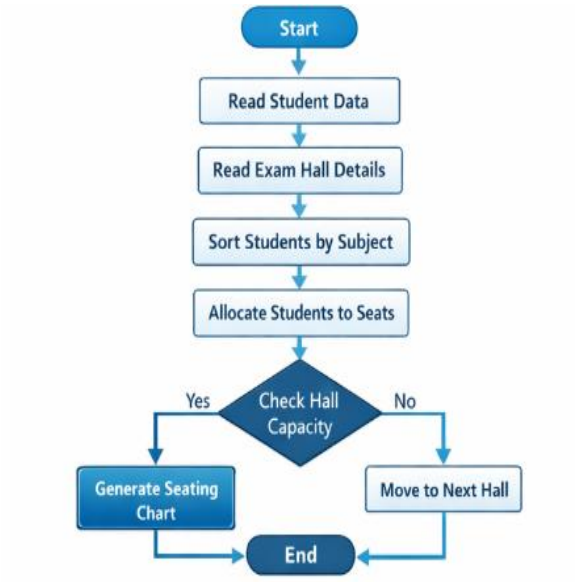

Fig. 2. Seating Allocation Flowchart

V. RESULTS AND DISCUSSION

The Intelligent Exam Seating Planner was tested using sample datasets containing student information and examination hall details. The objective of the evaluation was to measure the efficiency of the automated seating allocation system compared to traditional manual methods used by examination administrators.

The system successfully generated optimized seating arrangements by distributing students across examination halls while respecting hall capacity constraints. It ensured that students from the same subject were distributed evenly, reducing the possibility of academic malpractice.

Students	Rooms	Time (seconds)	Accuracy
60	2	1.2	100%
150	5	2.8	100%
300	10	4.5	100%
600	20	5.2	100%
1000	35	5.6	100%
1500	52	5.9	100%

Table I Performance evaluation of seating allocation algorithm

The automated system significantly reduced the time required to generate seating arrangements. Manual seating preparation often takes a considerable amount of time when dealing with a large number of students, whereas the proposed system can generate seating charts within a few seconds.

Additionally, the system improved hall utilization by efficiently filling available seats without exceeding hall capacity. The generated seating charts were clear and easy to interpret, allowing invigilators to manage examination halls more effectively.

VI. CONCLUSION AND FUTURE SCOPE

The Intelligent Exam Seating Planner presents an automated approach to managing seating arrangements for examinations in educational institutions. Traditional manual seating methods often require significant time and effort from administrative staff and are prone to human errors. The proposed system addresses these issues by implementing an algorithm-based seating allocation mechanism that distributes students efficiently across examination halls while considering hall capacity and subject distribution.

The results demonstrate that the automated system significantly reduces the time required to generate seating plans and improves overall hall utilization. By ensuring balanced student distribution, the system helps minimize opportunities for academic malpractice and creates a more organized examination environment. The generated seating charts also simplify the work of invigilators and examination administrators.

In the future, the system can be enhanced by integrating advanced technologies such as artificial intelligence and machine learning to further optimize seating arrangements. The planner can also be extended to support real-time integration with institutional databases, allowing automatic retrieval of student records. Additionally, a web-based or mobile interface could be developed to enable administrators to generate and monitor seating plans remotely. These improvements would make the system more scalable and adaptable for large educational institutions handling thousands of students during examinations.

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