DOI: http://dx.doi.org/10.26483/ijarcs.v15i5.7130

Volume 15, No. 5, September-October 2024

ISSN No. 0976-5697

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

DEVELOPMENT OF A ROOM ALLOCATION SYSTEM USING GENETIC ALGORITHM

Akande Oyebola, Chukwuemeka Charles K., Adegbola Adesoji, Adewuyi Joseph Oluwaseyi, Oladipo Sunday O, Ayankoya Folasade, Adebanjo Samuel Adedoyin
Computer Science Department
School of Computing, Babcock University,
Ilishan Remo, Ogun State Nigeria

Abstract: The essence of managing educational institutions encompasses not only the delivery of academic content but also the efficient allocation of resources, notably student accommodations. This study delves into the development of an Artificial Intelligence based Automated Room Allocation System tailored for Babcock University, aimed at transforming the traditional manual room allocation process into an automated, digital platform. The objectives of this paper are: to gather and record students' room preferences, integrate genetic algorithm techniques that will work on the preferences to allocate room based on student's preferences and evaluate the system by conducting user testing to assess the system's usability and identify potential improvements, evaluate the accuracy and efficiency of the room allocation process and collect user feedback to ensure satisfaction. The transition to a digital and automated room allocation system is anticipated to overcome these drawbacks; laborious process of current manual allocation of rooms involving movement of files, waiting in line to receive administrative approval and a pass containing your room number.
.

Keywords: genetic algorithm, student's preferences, automated room allocation system

I. INTRODAUCTION

Modern room allocation systems have significantly impacted organizational efficiency, occupant satisfaction, and equitable resource distribution. Automation and machine learning (ML) algorithms have enhanced personalization, ensuring allocations are tailored to individual needs and preferences. This has led to improved satisfaction and productivity among users, with systems continuously adapting to dynamic factors like real-time availability and changing preferences. Room allocation is a frequently encountered problem in practice, e.g., allocating dorms among college students and allocating rooms among tenants [1].

Educational institutions face the challenge of efficiently managing resources, including the critical aspect of student room allocation. The current semi-automated accommodation system at Babcock University, which involves a manual and laborious process for room allocation, is plagued by inefficiencies and potential for fraudulent activities. The manual system, reliant on physical documentation and personal interaction, introduces delays, security risks, and inconvenience, underscoring the urgent need for an automated solution.

The journey from traditional allocation methods to ML-based systems has been marked by significant milestones. Initial efforts in the late 2000s, such as the work by [2], introduced genetic algorithms to optimize dormitory assignments based on student preferences.

Before ML's advent, traditional algorithms such as Linear Programming, Greedy Algorithms, and the First-Come, First-Served method were employed. These algorithms laid the groundwork for current systems by optimizing resource allocation based on linear equations or sequential choices, albeit often at the expense of personalization and optimal efficiency. Linear programming (LP) optimizes outcomes in mathematical models with linear relationships, making it ideal for room allocation by defining assignments through linear equations [3]. It focuses on maximizing or minimizing an objective function under linear constraints.

Greedy algorithms make sequential choices based on local optima, aiming to reach a global optimum in room allocation by assigning rooms sequentially [4] They prioritize simplicity and speed, offering quick solutions for real-time allocation challenges. However, their focus on immediate gains can lead to suboptimal solutions as they may overlook the broader problem context at each step.

The First-Come, First-Served (FCFS) algorithm is a straightforward scheduling method that prioritizes resource allocation based on the order of requests received. FCFS's simplicity and adherence to chronological order make it easy to implement but may not always lead to the most optimized or personalized room assignments [5].

Subsequent developments leveraged advanced ML techniques, including Support Vector Machines (SVM), Neural Networks, and Decision Trees, each offering unique strengths in handling the complexities of room allocation. SVM emerged as a powerful tool for classifying students into groups based on various accommodation preferences, utilizing the kernel trick for non-linear classifications and addressing scalability through methods like Stochastic Gradient Descent [6]. Neural Networks, especially deep learning models, revolutionized prediction capabilities, enabling the system to learn from complex data patterns and optimize student-room matches [7]. Decision Trees simplified the decision-making process by categorizing students based on preferences, offering scalability and interpretability but requiring measures to prevent overfitting.

Machine learning algorithms used in room allocation systems can consider a wide range of factors and preferences, promoting fairer and more equitable room allocations. These algorithms can identify and address potential biases, ensuring that individuals are not unfairly disadvantaged or marginalized in the room assignment process. This can lead to a more inclusive and equitable environment for all occupants.

This current research uses genetic algorithm which is a population-based metaheuristic algorithm which avoid solution to be stuck in local optimal [8]. Key elements of a GA are: chromosome representation, selection, crossover, mutation, and fitness function. GA is used in this current work because of its ability to provide adequate and balanced solutions [9].

II. REVIEW OF RELATED WORK

Several studies illustrate the application of genetic algorithms and ML techniques in room allocation:

[2] tackled the often-complicated task of assigning students to dormitory rooms while factoring in their preferences for roommates. It proposes a novel solution using a genetic algorithm, a computational technique inspired by the principles of natural selection. The primary objective is to develop an efficient system that matches students with compatible roommates based on their individual priorities. Genetic algorithm, which is actually a heuristic approach was used to handle student preferences. First, it identifies the most crucial factors students consider when choosing a roommate, factors such as: nationality, religion, or course of study. Then, each student assigns weights to these factors based on their individual priorities. With these weighted factors in place, the algorithm creates a ranking system for potential roommates for each student. The algorithm successfully finds stable roommate pairings and demonstrates improvement in efficiency over multiple iterations, suggesting its scalability for larger and more complex scenarios.

A multi-level genetic algorithm for a multi-stage space allocation problem was developed by [4,10]. The study aims to address the hostel space allocation problem (HSAP) in universities, focusing on optimal bed space distribution among students under various constraints. It seeks to demonstrate the effectiveness of a multi-level GA in solving this problem. The GA approach involves a detailed representation of the allocation problem, fitness evaluation to measure solution quality, and GA operators for selection, crossover, and mutation. The methodology includes simulating the algorithm using real-world data from a Nigerian university. The simulation experiments indicate that the GA can generate feasible and optimized allocations that satisfy the imposed constraints, including the specific needs of different student categories.

[5]. Automated Scheduling of Hostel Room Allocation Using Genetic Algorithm. The aim of the study was to address the critical issue of hostel room allocation in universities due to the rapid growth of the student population in developing countries. The objective was to propose a hierarchical heuristics approach for selecting eligible students and allocating them to the most suitable hostel rooms using a genetic algorithm (GA), thereby optimizing the hostel room allocation process. The study proposed a hierarchical heuristics approach involving two main stages: selection and allocation. In the selection stage, eligible students were selected using a rank-based selection method, considering both hard and soft constraints. In the allocation stage, selected students were assigned to hostel rooms through a GA, which was designed to handle specified constraints efficiently. The approach also examined the effects of different weights associated with constraints on the GA's performance. The GA included processes like solution encoding, crossover, mutation, and fitness evaluation to find the optimal room allocation. The results demonstrated the feasibility of the proposed approach for solving the hostel room allocation problem. The hierarchical heuristics approach successfully selected eligible students and allocated them to suitable rooms, taking into consideration various constraints. The study also found optimized weights for allocation constraints, which enhanced the GA's performance in satisfying both hard and soft constraints. The allocation results varied across different sets of weights, but an optimized distribution improved constraint satisfaction significantly. While the study showed promising results, it acknowledged potential areas for future improvement. It suggested that further enhancements could be achieved by tuning various components and parameters of the GA, such as the encoding method, crossover method, mutation rate, and population size, to increase the overall performance of the proposed approach.

[11] 2022 aimed at implementing a genetic algorithm (GA) for optimizing the assignment of dormitory rooms to students by considering various factors such as student preferences, dormitory capacities, and room compatibility. A Genetic Algorithm (GA) approach was adopted for this purpose, incorporating two main modifications: the locally exhaustive crossover method and the half-half selection strategy. The locally exhaustive crossover method aimed to mitigate divergence issues by exhaustively exploring all possible gene combinations between two rooms to obtain the best crossover result, thereby enhancing fitness values. The algorithm performance was compared its performance with two counterpart methods: simulated annealing and random assignment. Results indicated that the proposed algorithm exhibited significantly faster execution times compared to simulated annealing, while maintaining fitness values almost comparable to the latter. Furthermore, it outperformed the random assignment method in terms of fitness value, suggesting its superiority in optimizing room assignments.

[7], research aimed at tackling the issue of unsuitable room allocations in student hostels, which often lead to conflicts and dissatisfaction among students. The objective is to create an Android application that employs the Random Forest Classifier, a machine learning algorithm, to analyze various factors such as students' study habits, routines, and preferences to match them with compatible roommates. The hostel room allocation was done using the Random Forest algorithm that integrates data collection, preprocessing, feature extraction. Initially, an Android application serves as the interface for data collection, where users input relevant information such as personal preferences and habits. This data undergoes preprocessing to handle missing values and normalize numerical features, ensuring the dataset's suitability for analysis. Feature extraction then transforms categorical data into a machine-readable format through one-hot encoding, preparing it for input into the Random Forest Classifier. This machine learning model is trained on a dataset comprising historical allocations and student preferences, capable of handling both categorical and numerical data. The application successfully allocates hostel rooms based on the model's predictions, considering various student preferences and requirements. Test cases demonstrate the model's ability to make appropriate room assignments, reflecting on the importance of considering diverse factors such as gender, age, study habits, and personal preferences for a harmonious living situation..

III. METHODOLOGY

The objectives include gathering student room preferences, employing genetic algorithm techniques to allocate rooms based on these preferences, and conducting user testing to evaluate system usability and efficiency. This section details the strategic planning, organization, and development framework of the proposed solution, dividing the complex criteria into manageable components to define system specifications. The framework for the development is shown in figure 1.

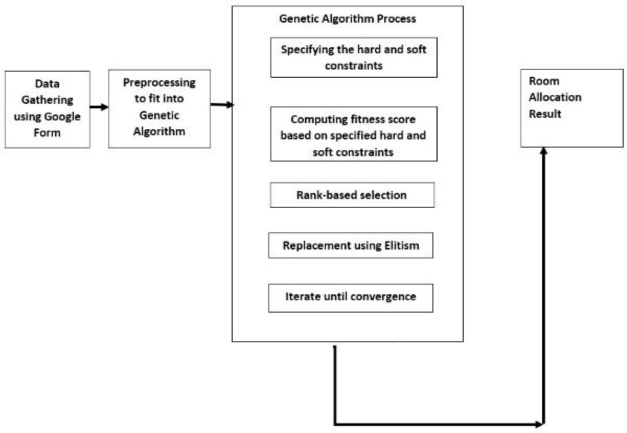

Figure 1: Framework for the Development of Room Allocation System

A. Data Collection

Data collection was pivotal in capturing students' preferences and requirements for room allocation. Utilizing Google Forms, surveys were designed to gather detailed information from students regarding their room preferences. Separate forms targeted male and female hostels, namely Bethel Splendor and Felicia Adebisi Dada, respectively, resulting in a combined total of 110 responses. The survey included questions on room retention preference, student age, department, preferred block and wing, proximity to the entrance, and bunk bed accommodation preference.

B. Preprocessing

To prepare the data for the genetic algorithm, several preprocessing steps were necessary: Merging data from male and female respondents, removing duplicates to ensure data uniqueness, adding columns for gender and hostel name to enrich the dataset. Following these steps, 109 valid entries remained for analysis.

C. Specifying hard and soft constraints

This research is a constraint-based optimization problem where there are hard and soft constraints. Hard constraints are the non-negotiable preferences which must be fulfilled such as “age constraint” which ensured students are grouped by age to maintain age-appropriate living environments and “retain current room” which allowed students to express their wish to keep their current room, influencing the allocation process if feasible.

The soft constraints are the preferences which are not compulsory, that is, they are negotiable. For example, soft constraints in this project they are: department preference, wing preference and proximity to entrance preference.

D. Computing Fitness score based on specified constraints

Evaluates how well a room allocation solution meets the set constraints and preferences, incorporating factors like adherence to age constraints, accommodation of department preferences, and balancing wing preferences. If a solution violates any hard constraint a penalty score in assigned. In this case the solution is not valid. But for a soft constraint, if it is violated penalty score is assigned based on the number of constraints violated but the solution can still remain valid.

E. Selection of Solutions using Rank Selection approach

From the solutions generated, each solution is ranked based on their respective fitness and solutions are chosen based on their ranks.

F. Crossover or Reproduction

During crossover, room assignments between two solutions are exchanged while ensuring that hard constraints like age groups are preserved. In this context, crossover might involve swapping rooms between students of similar age groups while accommodating soft constraints such as department preferences and wing preferences.

G. Mutation

Mutation introduces random changes to solutions to explore new possibilities and prevent premature convergence. In-room allocation, a mutation might involve randomly reassigning a student to a different room based on their preferences or randomly adjusting room assignments within constraints to improve the overall fitness of the solution. This function introduces genetic diversity by randomly swapping rooms in the chromosome with a certain probability, potentially leading to exploration of new solutions in the population. For each room, it checks if a randomly generated number is less than the mutation rate. If so, mutation is applied to that room. If mutation occurs for a room, it randomly selects another room in the chromosome and swaps their positions. This simulates the mutation process and the function returns the chromosome with potential mutations applied.

H. Replacement or Evolution using Elitism

Here the best performing new room allocations from mutation are guaranteed to be retained without modification, thus high-quality solutions are retained. This is done using elitism technique.

I. Iteration until Convergence

GA is an iterative algorithm, it goes back to the evaluation stage i.e., where fitness score is being computed. Fitness score is computed for the new population, then followed again by ranked selection, crossover, mutation and replacement using elitism. This process continues until population generated shows no improvement in fitness score over several generations. Thus, the algorithm has converged.

J. Development Tools are:

Visual Studio Code (IDE): Chosen for its cross-platform support and rich development features such as integrated debugging, syntax highlighting, and Git integration.

Python: Utilized for its versatility in tasks ranging from web development to data analysis. Specifically, the Pandas and Tabulate libraries were instrumental for data manipulation and presentation, aiding in the management of large datasets and the structured display of data.

Microsoft Excel: Utilized for organizing and analyzing survey data, Excel's powerful data analysis tools played a crucial role in the preliminary assessment of student preferences and requirements.

IV. RESULLTS AND SYTSEM IMPACTS

The implementation of this system demonstrates a significant optimization in room assignments, harmonizing hard constraints with individual preferences. By employing a sophisticated genetic algorithm, the system ensures that room allocations are both fair and efficient, significantly improving the room assignment process at Babcock University. This modern approach to room allocation stands as a testament to the university's commitment to leveraging technology for enhancing student services and administrative efficiency. The result is shown in the figure 2 below.

Allocated Rooms:

Email	HOSTEL	Retain current room	Current room	New Room
YIKESMAN50@GMAIL.COM	Bethel Splendor	NO	A6	C9
WUYEPRAYNAN@GMAIL.COM	Bethel Splendor	NO	A22	B23
NKEMNWABUISI17@GMAIL.COM	Bethel Splendor	NO	B14	B33
CHIKWELUGOKENECHUKWU@GMAIL.COM	Bethel Splendor	NO	B14	D20

dessyliam13@gmail.com	Felicia Adebisi Dada	YES	D31	D31
chimanwogwuwgwu3938@student.babcock.edu.ng	Felicia Adebisi Dada	YES	E5	E5
kejiasana15@gmail.com	Felicia Adebisi Dada	YES	E26	E26
demiladeteniii@gmail.com	Felicia Adebisi Dada	YES	F8	F8

Figure 2: Result of Room Allocation from Genetic Algorithm

V. SUMMARY AND CONCLUSION

The project undertaken for Babcock University involved designing an automated room allocation system aimed at optimizing the assignment process by harnessing a systematic approach to system analysis and design. Through meticulous planning and data gathering via surveys, the project sought to capture comprehensive student preferences for room allocation. This data underwent preprocessing to ensure its suitability for analysis via a genetic algorithm (GA), which stands as the backbone of the project, employing principles of natural selection to evolve room allocation solutions through iterative selection, crossover, and mutation processes.

In conclusion, room allocation systems have a profound impact on various aspects of organizations and institutions, leading to improved efficiency, enhanced occupant satisfaction, fairer room assignments, adaptive optimization, data-driven insights, enhanced security, seamless operations, and scalability. As technology advances and data availability increases, we can expect even more innovative applications of room allocation systems in the future.

VI. FUTURE WORK

Despite the project's successes, several limitations were identified, including the reliance on data quality, the rigidity of specified constraints, and the efficiency of the genetic algorithm, especially when handling large datasets. To overcome these challenges, recommendations include implementing robust data validation mechanisms, introducing dynamic constraint adjustment capabilities, continuously optimizing the algorithm for better performance, and integrating user feedback mechanisms to refine room allocations further. These steps are aimed at enhancing the overall effectiveness and flexibility of the room allocation process, ensuring it can adapt to changing preferences and requirements while maintaining efficiency and fairness.

VII. REFERENCES

[1] Pak Chan, Xin Huang, Zhengyang Liu, Chihao Zhang and Shengyu Zhang. (2016). Assignment and Pricing in Roommate Market. Proceedings of the AAAI Conference on Artificial Intelligence. doi:https://doi.org/10.1609/aaai.v30i1.10019

[2] Hossein Eslami & Maryam Afzali. (2007). Applying Genetic Algorithm for Allocating Students to the Dormitory Rooms. doi:https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=90cc2d37700a1071ffaecafb986a18646ac579e2

[3] Karl Gossen and Michel Truchon. (1986). Allocation of Classrooms by Linear programming. Journal of Operational Research Society (JORS), 37(6), 561-569.

[4] Ali, A. Y. (2021). Greedy Algorithm for Solving Student Allocation Problem in Internship Program: A Case Study. International Journal of Research in Industrial Engineering, 155-164.

[5] Olaa Hajjar, Escelle Mekhallalati, Nada Annwty, Faisal Alghayadh, Ismail Keshta and Mohammed Algabri. (2024). Performance Assessment of CPU Scheduling Algorithms: A Scenario-Based Approach with FCFS, RR, and SJF. Journal of Computer Science, 20(9), 972-985. doi:DOI: 10.3844/jcssp.2024.972.985

[6] Samiksha Mathur, Yogesh Chaba and Amandeep Noliya. (2023). Performance Analysis of Support Vector Machine Learning Based Carrier Aggregation Resource scheduling in 5G Mobile Commmunication. International Conference on Machine Learning and Data Engineering (pp. 2776-2785). Elsevier B.

[7] Walczak, S. (1998). Neural network models for a resource allocation problem. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 28(2), 276-284.

[8] Sourabh Katoc and Sumit Singh Chauhan and Vijay Kumar. (2021). A review on genetic algorithm: past, present and future. Multimedia Tools and Applications, 8091-8126. doi:https://doi.org/10.1007/s11042-020-10139-6

[9] Sofia Kaiafa and Athanasios P. Chassiakos. (2015). A Genetic Algorithm for Optimal Resource-driven Project Scheduling . Elsevier, 260-267.

[10] A.O. Adewumi and M.M Ali. (2010). A multi-level genetic algorithm for a multi-stage space allocation problem. Mathematical and Computer Modelling, 109-126.

[11] Chih-Ching Chang and Che-Chern Lin. (2022). Dormitory Assignment Using a Genetic Algorithm. Applied Artificial Intelligence An International Journal, 2276-2297.

