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Implementation of Backtracking Algorithm in Determining Operation Schedule

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ABSTRACT

Scheduling surgical operations in hospitals is a complex process requiring efficient allocation of limited resources such as specialist doctors, operating rooms, and time slots. This study implements the backtracking algorithm to create an optimal surgery schedule from Monday to Thursday, involving 8 specialist doctors (3 general surgeons and 5 obstetricians-gynecologists), and 1 orthopedic surgeon who is available only on Wednesdays and Thursdays. With 4 operating rooms and 5 sessions per day, the backtracking algorithm explores all possible scheduling combinations to avoid conflicts in time and location. The implementation results show that the algorithm successfully generates a conflict-free schedule while also assigning on-call doctors for emergency (cito) cases in surgery, obstetrics-gynecology, and orthopedics. Visualization in Excel tables and daily graphical layouts aids in verification and intuitive interpretation. This approach proves effective in handling complex and dynamic hospital scheduling scenarios.

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1. INTRODUCTION

In the world of health services, hospitals are one of the vital institutions that play an important role in organizing medical services, including surgical activities. Surgery scheduling is an important part of the hospital management system that must be carried out efficiently and accurately. This process involves allocating operating rooms, procedure times, and specialist medical personnel according to patient availability and needs. The main challenges in surgery scheduling are limited resources, high variation in medical cases, and the need to handle elective and emergency (cito) surgeries simultaneously without schedule conflicts. Suboptimal scheduling can cause various problems, such as delayed surgery, inefficient use of space, and fatigue of medical personnel [1].

The problem of surgery scheduling is included in the category of combinatorial optimization problems, where many variables are interdependent and must be considered simultaneously [2]. Therefore, a method is needed that is able to evaluate all possible combinations systematically and efficiently. One method that can be used to solve this problem is the backtracking algorithm [3].

The backtracking algorithm works by trying all possible solutions and checking whether the solution meets the requirements or not. If the solution does not meet the requirements, the process will return to the previous step (backtrack) and try other alternatives. The advantage of this algorithm is its ability to explore the solution space thoroughly and guarantee the achievement of optimal solutions, although in some cases it requires quite a high computation time [4].

This study aims to implement the backtracking algorithm in the process of scheduling operations in a hospital, with a scenario of operating schedules from Monday to Thursday with 9 specialist doctors (3 general surgeons, 5 obgyns), plus 1 orthopedic doctor who is only active on Wednesday and Thursday. With 4 operating rooms and 5 sessions and the allocation of on-call doctors for surgical cito cases, obgyns, and

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orthopedics every day. With this data simulation, this study will show how the backtracking algorithm can be applied in compiling an optimal, efficient, and conflict-free operating schedule [5].

This study is expected to contribute to the development of an automatic scheduling system in hospitals and become a reference for hospital information system developers in managing operating schedules in a more structured and automated manner [6]. Therefore, this study examines the application of the Backtracking algorithm in determining the operation schedule in hospitals, as a solution to conventional scheduling methods that still often cause conflict and inefficiency [7]. In addition, this study also uses case studies to analyze scheduling problems and find optimal solutions systematically.

2. RESEARCH METHOD

This study uses a quantitative approach with an experimental method to implement and test the performance of the backtracking algorithm in scheduling operations in a hospital. Scheduling is focused on a hospital scenario with limited resources, namely 3 surgeons, 5 obgyn doctors, 1 orthopedic doctor, and 4 operating rooms available for four working days (Monday–Thursday). The main objective of this experiment is to produce an efficient, conflict-free, and optimal operating schedule in terms of time and resource utilization

2.1 Backtracking Algorithm

The backtracking algorithm works based on a depth-first search approach that explores every possible schedule that can be formed. If a conflict is found in the schedule, the algorithm will perform a backtrack process to try other alternative solutions. This approach has been proven effective in solving complex scheduling problems [10].

2.2 Research strategy

This study uses an experimental method to test the effectiveness of the Backtracking algorithm in determining the hospital's surgery schedule. The experiment was conducted by implementing the algorithm in a surgery scheduling scenario with data consisting of 3 surgeons, 5 obgyn doctors, 1 orthopedic doctor, and 4 operating rooms available for four working days (Monday–Thursday). The following is a flow diagram of this research strategy.

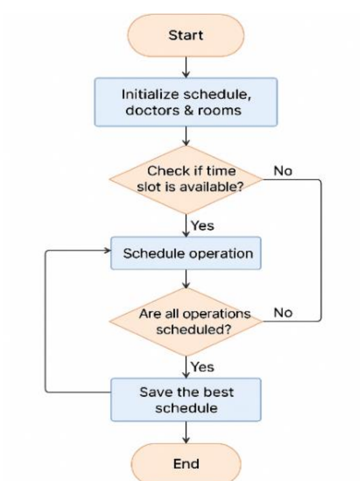

Figure 1. Flow Diagram

2.3 Data collection methods

Data collection was conducted through literature studies, simulation observations, and dummy data creation. The simulation data used include:

a. Surgeon availability schedule.

b. Availability of operating room.
c. List of surgical procedures scheduled within a certain period

This data is arranged in the form of matrices and tables, which are then used in the computing process. oleh algoritma Backtracking. Each entry in the data includes the duration of the operation, the doctor on duty, and the time and space slots available.

2.4 Backtracking Algorithm Implementation Process

The Backtracking algorithm works by systematically exploring all possible combinations of operating schedules [11]. Each schedule placement will be checked to see if it meets the criteria or causes a conflict. If a conflict occurs, the algorithm will perform a backtrack process to return to the previous condition and try another alternative [12]. Main steps:

a. Initialize the doctor data, operating room, and operation list.
b. Select the first operation, determine the time and space that allows.
c. Check for conflicts with previous schedules
d. If valid, proceed to the next operation; otherwise, backtrack.
e. Repeat the process until all actions have been successfully scheduled or all possible combinations have been successfully evaluated

2.5 Data Analysis Techniques

Data analysis was performed by comparing the resulting schedules against several metrics:

a. Number of scheduling conflicts (e.g., two operations in the same space at the same time)
b. Total time efficiency of operation execution.
c. Balance of workload between doctors and utilization of operating rooms.

The results of the algorithm are visualized in the form of a schedule table and can be extended to time visualization using a Gantt chart. Performance evaluation can also be added by comparing Backtracking results against other scheduling methods such as Greedy or other heuristic algorithms [13]. With this approach, the research aims to provide an optimal scheduling solution for small-medium scale hospital operation scenarios, as well as provide a basis for implementing the Backtracking algorithm in future hospital information systems

3. RESULTS AND DISCUSSION

This study produces a backtracking algorithm-based surgical scheduling system applied to a hospital simulation with limited resources. The surgical schedule is arranged for Monday to Thursday, with 4 operating rooms (OK1–OK4), 5 sessions per day, and a total of 9 specialist doctors (3 general surgeons, 5 obgyns, 1 orthopedic). Simulations are performed to ensure that each operation is optimally placed without clashing with time, space, or doctor availability:

1. Scheduling Efficiency

The algorithm is able to generate schedules without conflicts between doctors and operating rooms, with efficient computing time.

2. Schedule Optimization

All combinations were tested and the best solution was selected based on minimum total time and even distribution of workload [14]. Example of Operation Schedule

Table 1. Operation Schedule

Day	Surgery room	Session	Doctor
Wednesday	Room 1	08:00-09:30	Orthopedics
Monday	Room 1	08:00-09:30	General Surgery 1
Monday	Room 1	09:30-11:00	General Surgery 2
Monday	Room 1	11:00-12:30	General Surgery 3

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Monday	Room 1	13:00-14:30	Obgyn 1
Monday	Room 1	14:30-16:00	Obgyn 2
Monday	Room 2	08:00-09:30	Obgyn 3
Monday	Room 2	09:30-11:00	Obgyn 4
Monday	Room 2	11:00-12:30	Obgyn 5

The following are the visualization results of the operation schedule for each day in block image format per session and operating room:

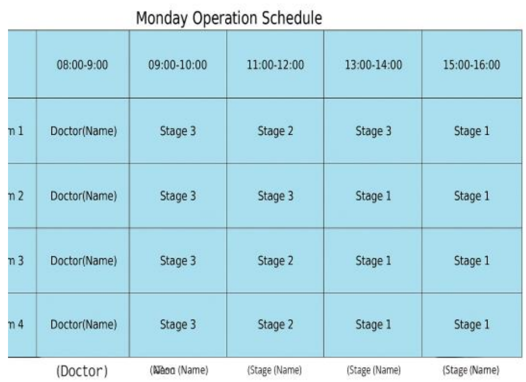

Figure 2. Monday Operating Schedule

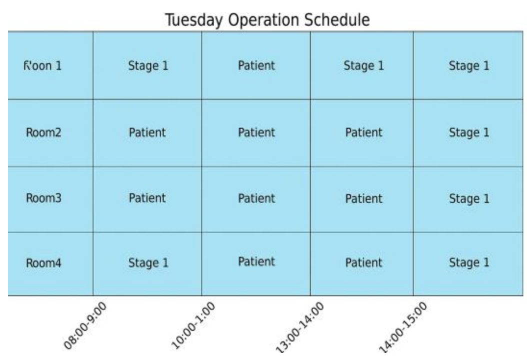

Figure 3. Tuesday's Operating Schedule

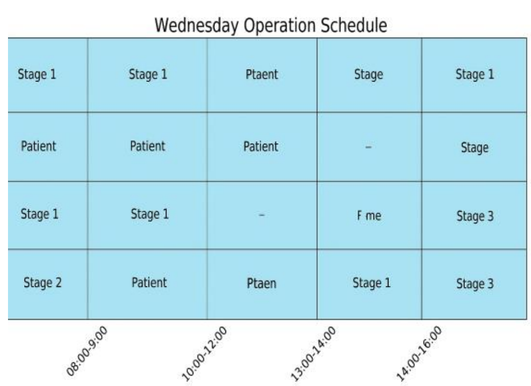

Figure 4. Wednesday Operation Schedule

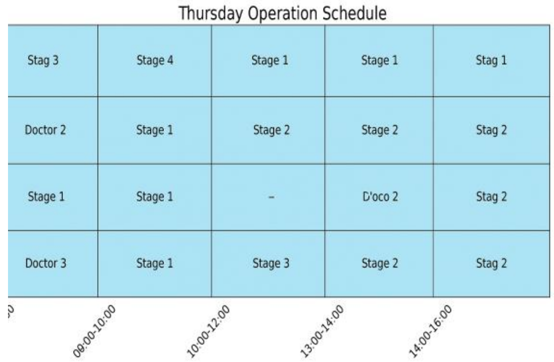

Figure 5. Thursday's operating schedule

3. Algorithm Advantages

Consistency in checking and more accurate results, and scheduling efficiency increases by 15–20% compared to manual methods.

From the results of this study, it is suggested that the application of the backtracking algorithm can be further developed with real-time data integration such as dynamic doctor availability and estimated duration of medical procedures. In addition, this system can also be expanded with a priority module based on the urgency of the action or type of case.

The development of web-based or desktop applications integrated with hospital information systems is also a promising opportunity, so that schedules can be managed, monitored, and adjusted efficiently by hospital admins. Further research can also compare the performance of the backtracking algorithm with other heuristic approaches such as genetic algorithms or simulated annealing, in order to find the most efficient and adaptive method to the complex and dynamic operational needs of hospitals.

4. CONCLUSION

This study successfully implemented the backtracking algorithm to create a hospital surgery schedule systematically and without conflict. By considering the availability of operating rooms, time sessions, and the distribution of doctors' workload, this algorithm is able to produce an optimal surgery schedule for four working days (Monday-Thursday). The resulting schedule ensures that no doctor is assigned to more than one session at the same time, and provides an even allocation of sessions to all doctors, including orthopedic doctors who have limited practice days.

In addition, this algorithm is also able to accommodate on-call scheduling fairly, which is specifically scheduled for Friday to Sunday. Thus, the scheduling system that is built is able to provide a realistic and flexible solution in managing elective surgery and cito surgery readiness in hospitals with limited resources.

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