E-ISSN : 2963-4946
Vol. 2 No. August 11, 2024

Asian Journal of
Social and Humanities
https://ajosh.org/

Drug Stock Optimization at Hospital Depot Using Shuffle Frog Leaping Algorithm (SFLA)

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KEYWORDS
machine learning; medicine stock; hospital; data warehouse

ABSTRACT
Optimal, efficient, and accurate drug stock management at hospital depots is crucial for ensuring the smooth operation of medical and operational services. Therefore, the use of machine learning is currently essential for managing drug stocks at hospital depots more optimally. This optimization process involves stages such as data collection, data pre-processing, attribute selection, data labeling, classification algorithm selection, model training, model evaluation, and result interpretation. The data used in this research includes information on drug stocks at hospital depots with details on drug items, quantities, prices, depot origins, demand trends, and types of transactions. The aim of using these algorithms is to classify drug stock items into categories such as "sufficient," "deficient," and "excess" based on historical data patterns and relevant attributes. Model evaluation is carried out by comparing classification results with actual data and measuring evaluation metrics such as accuracy, precision, recall, and F1-score. It is hoped that the classification results will indicate the need for optimization in the previously implemented algorithms and provide new solutions for managing drug stocks at hospital depots. The Shuffle Frog Leaping algorithm (SFLA) implemented will help drug stock management staff identify demand patterns more optimally, efficiently, and accurately. Thus, this research has the potential to make significant contributions to optimizing drug stock management and decision-making at hospital depots, which will also positively impact the progress of hospital services.

Introduction

Hospitals are important institutions in the provision of healthcare services that play a central role in patient care. The management of drug stock in hospitals is a crucial aspect in ensuring the availability of the necessary drugs to provide effective care to patients. Inefficient and poorly organized drug stocks can cause disruptions in the patient care process, increase operational costs, and hinder the productivity of medical and nursing personnel (Binsar & Mauritsius, 2020).

In this context, it is necessary to optimize the system that is already running in the management of hospital drug stocks. This optimization will be done by the process of extracting valuable information from a large amount of data by applying various techniques and algorithms (Liu, 2017). Optimization of drug stocks at hospital depots can help in identifying hidden patterns and relationships in the data, which can ultimately lead to better decision-making and more efficient stock management.

Hospitals generally collect data related to drug stock, such as the type of drug, the amount of inventory, the frequency of use, the reorder period, and so on. However, in many cases, this data is not optimally utilized for smarter decision-making (Nabizadeh et al., 2023). This optimization process can help in identifying demand patterns, usage trends, and relationships between specific items. This can provide better insight into planning stock needs, avoiding excess or understock, and improving hospital operational efficiency (Agada, 2024).

Some of the problems that may arise in the management of hospital drug stocks include:

1. **Demand Uncertainty:** The demand for different types of medical goods in hospital drug stocks tends to vary over time. The use of Machine Learning can help in optimally identifying seasonal patterns and long-term trends that can help in more accurate forecasting of demand.
2. **Priority Classification:** Not all items have the same priority in drug stocks at hospital depots. Some items may be very important and should always be available, while others may be used less frequently. With this machine larning optimization, it will help classify goods based on priority, so that stock management can focus more on more important items.
3. **Avoidance of Leaks, Losses and Runs Out of Supplies:** Loss, leakage and running out of medical supplies can lead to difficulties in providing care to patients. With this machine larning optimization, it will identify suspicious patterns in the use and movement of goods, so that preventive measures can be taken early.
4. **Reorder Optimization:** Reordering drug stocks requires efficient resource allocation. With this machine larning optimization, the hospital can identify the right reorder period based on the trend of goods use.
5. **Analysis of the Use of Certain Items:** Some items may have different usage tendencies by different units or departments in the hospital. By classifying data on the use of goods by unit or department, stock management can be further adjusted.

Through this optimization process, it is hoped that the Hospital can improve operational efficiency, optimize inventory management, and ultimately provide better care to patients (Figueiredo, 2021).

The purpose of the research is to analyze and understand the pattern of drug stocks at the hospital depot. Optimizing drug stocks at hospital depots so that they are always available and avoid leaks. Identify factors that affect stock classification, such as types of goods, seasons, and medical trends.

Benefits of the research to provide in-depth insight into drug stock patterns at hospital depots. Provides practical guidance for hospitals in selecting and implementing optimal methods and algorithms in drug stock management.

A study focusing on strategic management in logistics and supply chain operations within the healthcare sector highlighted various strategies and innovations that can enhance the performance of healthcare supply chains, which are crucial for improving the efficiency and effectiveness of healthcare services. The research underscores the importance of strategic planning and implementation in the management of healthcare logistics, which is pivotal in ensuring the smooth operation of healthcare systems (Syahrir et al., 2018).

Research exploring the optimal routing of complex transportation systems for biomedical waste management, considering multiple depots and disposal options, validated the effectiveness of the proposed routing approach by comparing it with benchmark solutions, using realistic data to illustrate the practical application of the methodology. This study contributes significantly to the field by providing insights into the optimization of waste management systems, essential for maintaining safety and compliance in healthcare operations (Deshpande & Tembhurkar, 2018).

An examination of the impact of inventory control techniques on organizational performance within the Kenya Medical Supplies Agencies employed a descriptive case study design, using stratified random sampling to determine the sample size and analyzing data through quantitative and qualitative techniques. The findings suggest that effective inventory management is crucial for the performance of healthcare supply chains, especially in resource-constrained environments where the efficient use of resources is critical (Sporta, 2018).

An investigation into the rotation of medical supplies for emergency response using a simulation-based approach evaluated the performance of rotation policies and analyzed the impact of various factors, such as emergency scenarios, hospital costs, perishability of supplies, and waiting times. The results provide valuable recommendations for optimizing the management of medical supplies in emergency situations, vital for ensuring the availability of essential resources during crises (Zhou & Olsen, 2018).

Research integrating statistical process optimization tools into inventory management for evaluating the quality of goods supplied to healthcare facilities utilized cloud computing technologies to demonstrate the effectiveness of combining material stock databases with statistical processing platforms. The study highlighted how dominant suppliers consistently delivered products that met target specifications, offering a significant contribution to the field by showing how modern technologies can enhance inventory management and supplier evaluation processes in healthcare settings (Eissa & Rashed, 2020).

Focusing on optimizing the medical resource supply chain during the COVID-19 pandemic in Baghdad hospitals, research presented strategies for the optimal utilization of medical resources despite inaccuracies and discrepancies in available data. The study, using the Fuzzy Inference System (FIS), is particularly relevant for managing medical resources during pandemics, where efficient resource allocation is critical (latif Ansseif & Dammak, 2022).

A cluster analysis-based approach to classifying healthcare warehouses according to their performance was proposed in a study that aimed to enhance the application of statistical analysis in healthcare supply chain management by identifying key logistics aspects that influence warehouse performance. This research is important for improving the efficiency of healthcare logistics by enabling better management and classification of healthcare warehouses (Cagliano et al., 2022).

The application of the Apriori algorithm to analyze and optimize medical device inventory management demonstrated how data mining techniques could build an intelligent business environment to address the increasing competition among medical stores. The study highlighted the role of advanced analytical techniques in optimizing inventory management, essential for maintaining the availability of critical medical devices (Avizenna, 2022).

Research on optimal stock and capital reserve policies for emergency medical supplies in the context of epidemic outbreaks revealed that increasing demand uncertainty often leads to low safety stock levels and suggested relying more on capital reserves to mitigate the risks associated with stockouts. This study contributes to the development of more resilient supply chains by providing strategies to manage uncertainties in demand during public health emergencies (Zhang et al., 2023).

Finally, a study presented on optimizing warehousing and transportation for a network of healthcare institutions focused on the Territorial Hospital Group in France. Mixed-integer linear programming was utilized to provide decision-makers with tools to select the best collection configurations and determine the flexibility of various problem parameters. This research is significant for healthcare supply chain management, offering solutions for reducing warehousing and transportation costs across a network of healthcare institutions (Saidi et al., 2023).

Research Methods

In this study, the research approach used is a quantitative approach. This approach is used to collect numerical data on drug stocks at hospital depots. This numerical data will be the basis for the application of data mining and mechine larning techniques to optimize drug stocks at the hospital depot.

This literature study will provide a theoretical basis for research with a focus on the Shuffled Frog-Leaping Algorithm (SFLA) and its application in drug stock optimization. The main focus is on the basic concepts of SFLA, including local and global search mechanisms that help it overcome multiobjective and combinatorial optimization problems. In addition, this study will discuss relevant data mining techniques, such as data pre-processing, feature selection, modeling, and model evaluation, to improve efficiency and accuracy in drug stock management. The study will also review optimization techniques that can be integrated with SFLA as well as real-world applications of these algorithms in the context of other optimization problems. The results of this literature study are expected to provide insights into how these techniques can be applied to improve the management of drug stocks in hospitals.

Results and Discussions

Research Results

In this study, an analysis was carried out on the management of drug stock in hospitals using data mining and machine learning methods. This study uses the Shuffle Frog Leaping Algorithm (SFLA) method and compares it with other drug stock optimization methods. The following are the results obtained from this study.

Drug Stock Data Analysis

The analyzed drug stock data includes the type of drug, the number of inventory, the frequency of use, and the reorder period. This data is then processed to find relevant patterns and trends in drug stock management.

a) Types of Medications and Quantity of Inventory: Data shows significant variations in the amount of inventory between different types of medications. Some types of drugs have a stable supply, while others experience high fluctuations.
b) Frequency of Use: The frequency of drug use varies based on the season and medical

trends. For example, cold and fever medicines tend to increase in demand during the rainy season.

c) Reorder Period: The reorder period for each drug is determined based on historical usage patterns. Data shows that timely reordering is essential to avoid understocking or overstocking.

Priority Classification of Drug Stocks

Using a data mining algorithm, priority classification of drug stocks is carried out based on the importance of drugs and the frequency of their use.

a) High Priority Drugs

Drugs that have a high frequency of use and are important for patient treatment are in the high priority category.

Examples are antibiotics and medicines for chronic diseases.

b) Low Priority Drugs

Drugs that are rarely used or have alternative alternatives are included in the low priority category.

Application of *Shuffle Frog Leaping Algorithm* (SFLA)

SFLA is implemented to optimize the management of drug stocks. The results of the application of this algorithm show an increase in efficiency in drug stock management.

a) Prediction of Stock Needs: SFLA has succeeded in predicting drug stock needs with higher accuracy than traditional methods. This helps in reducing excess and shortage of stock.

b) Reorder Optimization: This algorithm also helps in determining the optimal reorder period, thereby reducing operational costs and ensuring the availability of necessary medications.

Discussion

The results of this study show that the application of data mining and machine learning methods, especially SFLA, has a positive impact on the management of drug stocks in hospitals. The following is a discussion of the research findings:

Advantages of Using Data Mining and *Machine Learning*

a) Identify Patterns and Trends

The data mining method allows for the identification of patterns and trends in drug stock data, which are not visible with traditional analysis methods. These patterns help in predicting future stock needs and avoiding understocking or overstocking.

b) More Accurate Priority Classification

Machine learning *algorithms* help in classifying drug stock priorities more accurately, resulting in more efficient stock management. With this algorithm, the decision to reorder a drug can be made by taking into account various factors such as the frequency of use and expiration date.

Effectiveness of *Shuffle Frog Leaping Algorithm* (SFLA)

a) Higher Prediction Accuracy

SFLA shows higher accuracy in predicting drug stock needs compared to other methods. By providing "time attributes" and "optimal gaps" for each activity, the developed SFLA method allows decision-makers to quickly select effective solutions and expand the range of solutions. The algorithm is also capable of capturing complex patterns in the data, which contributes to improved prediction accuracy.

b) Reduced Operational Costs

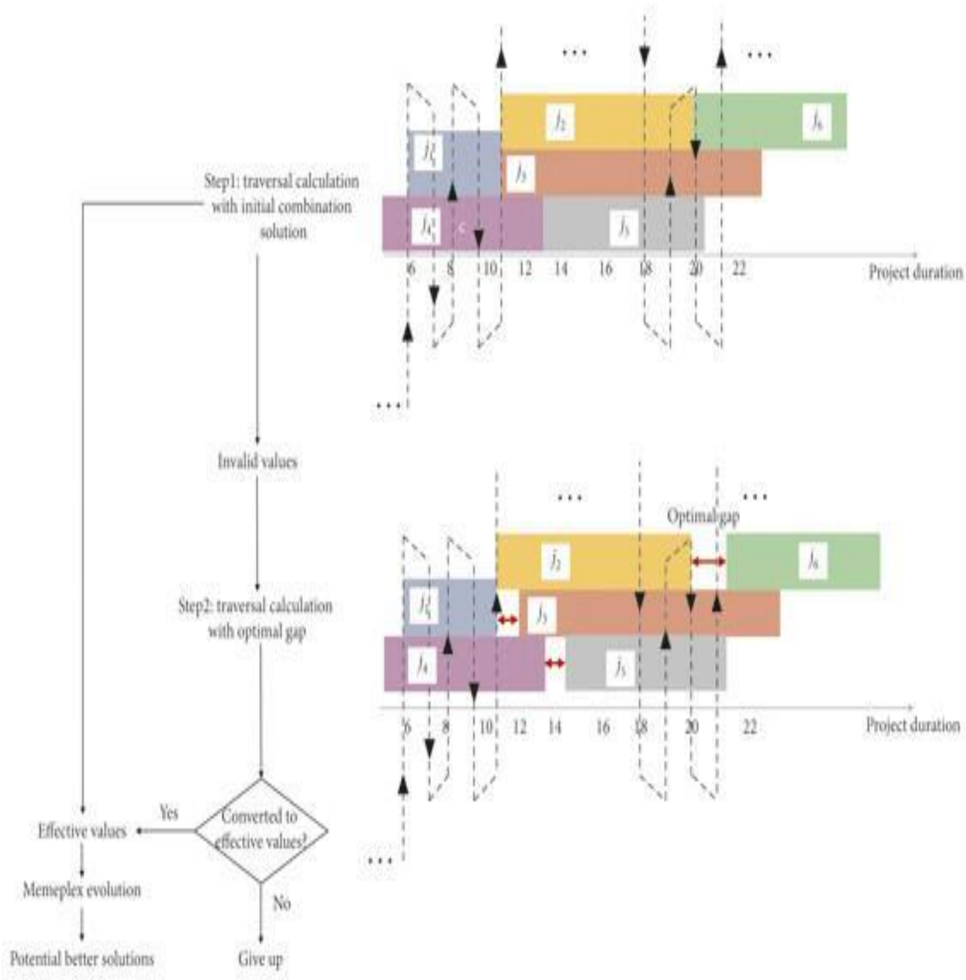
By optimizing the reorder period, SFLA helps reduce the operational costs associated with ordering and storing drug stock. The traversal process adopted in MATLAB coding allows the calculation of power load and resource usage at each time instance without the need for a new network diagram or resource usage histogram, thus accelerating the optimization process. In addition, by adjusting invalid values to be valid through "optimal gaps", SFLA is able to find more effective and efficient solutions, which in turn reduces operational costs.

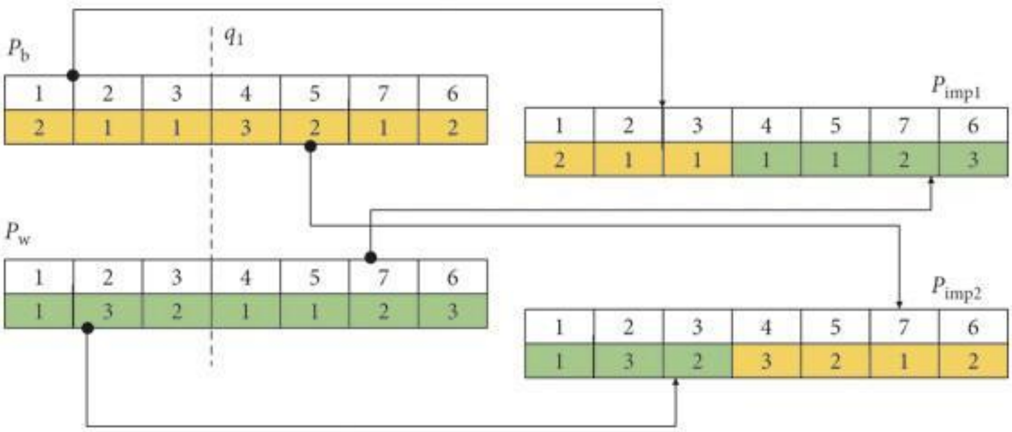
c) Efficiency in the Optimization Process

SFLA enables a more efficient optimization process by adopting a traversal approach to calculating power load and resource usage. By eliminating the need to generate new network diagrams, these algorithms speed up the optimization process. In addition, through rapid iteration, this algorithm is able to achieve convergence towards the optimal Pareto solution set. Figure 1 shows how this algorithm works to find the optimal solution by maintaining solution diversity through increasing iteration time.

SFLA Impretentization

By providing ***"time attribute" and "optimal gap"*** for each activity, the developed SFLA method allows decision-makers to quickly select effective solutions and expand the range of solutions. The " ***time attribute*** " defines the initial start time and duration of activity j in m mode. A traversal approach is adopted in the MATLAB coding process to calculate the power load and resource usage at each time instance without the requirement to generate a new network diagram or resource usage histogram, which speeds up the optimization process. The traversal approach only needs to check the activity assigned on each time instance and calculate the corresponding value. This process is presented in Figure 4.1, where the dotted line represents the order of the calculations. In certain solutions, j1 (from day 6 to 10), j2 (from day 10 to 20), j3 (from day 10 to 24), and j4 (from day 5 to 13) represent different activities with their "time attributes". When the traversal process arrives at t = 8, only the j1 and j4 activities should be considered. When t = 12, the resource requirement and power load values of j2 and j3 and j4 should be calculated. Furthermore, j2 and j3 should be calculated when t = 15. Instead of providing a solution that doesn't meet the constraints in the mathematical model (for example, exceeding the availability of a resource in a time instance) after the initial traversal calculation, SFLA converts these invalid values into valid values by automatically delaying the start time of some activities to balance the power load or resource usage. The "optimal gap" delay value is randomly generated by SFLA so that a more effective solution can be found. For this initial effective solution (combination), the " ***optimal gap*** " was also used to identify a better Pareto front. There are three advantages to finding an effective solution using SFLA: (a) a faster calculation process using a traversal approach, (b) a wider range of solutions by converting invalid values into valid values, and (c) a better optimization solution by using "optimal gaps" to facilitate trade-offs of time, cost, and resource fluctuations.


Step1: traversal calculation with initial combination solution
Invalid values
Step2: traversal calculation with optimal gap
Converted to effective values?
Yes
No
Effective values
Memeplex evolution
Potential better solutions
Give up
Optimal gap
Project duration
Project duration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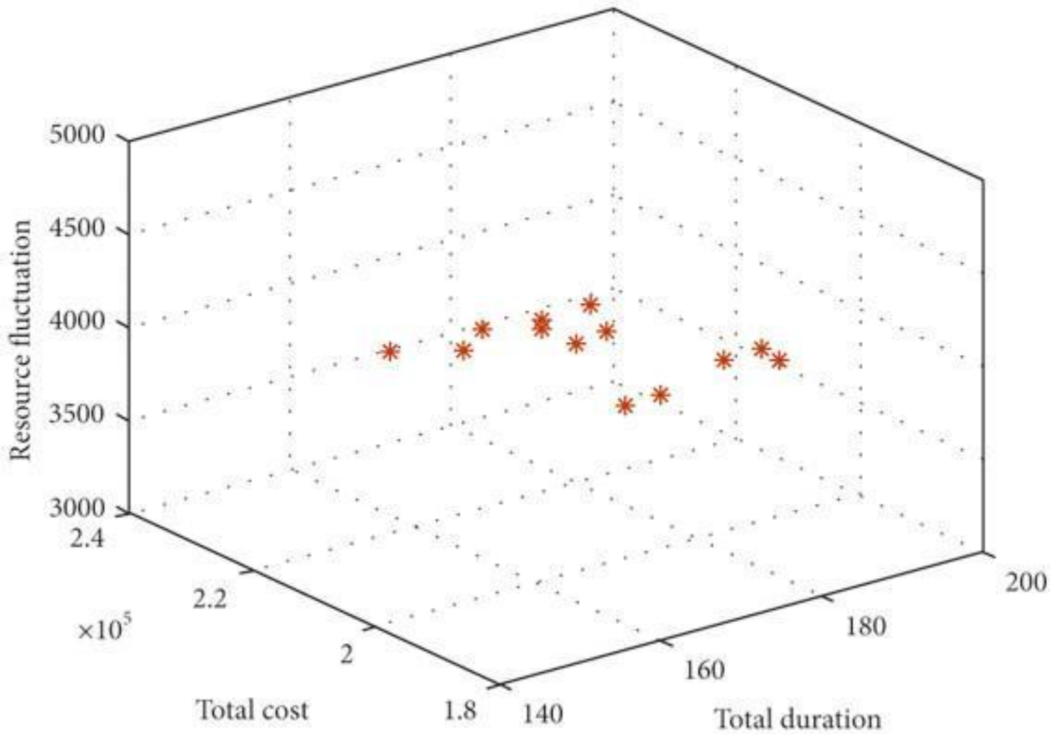
5000
4500
4000
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Resource fluctuation
2.4
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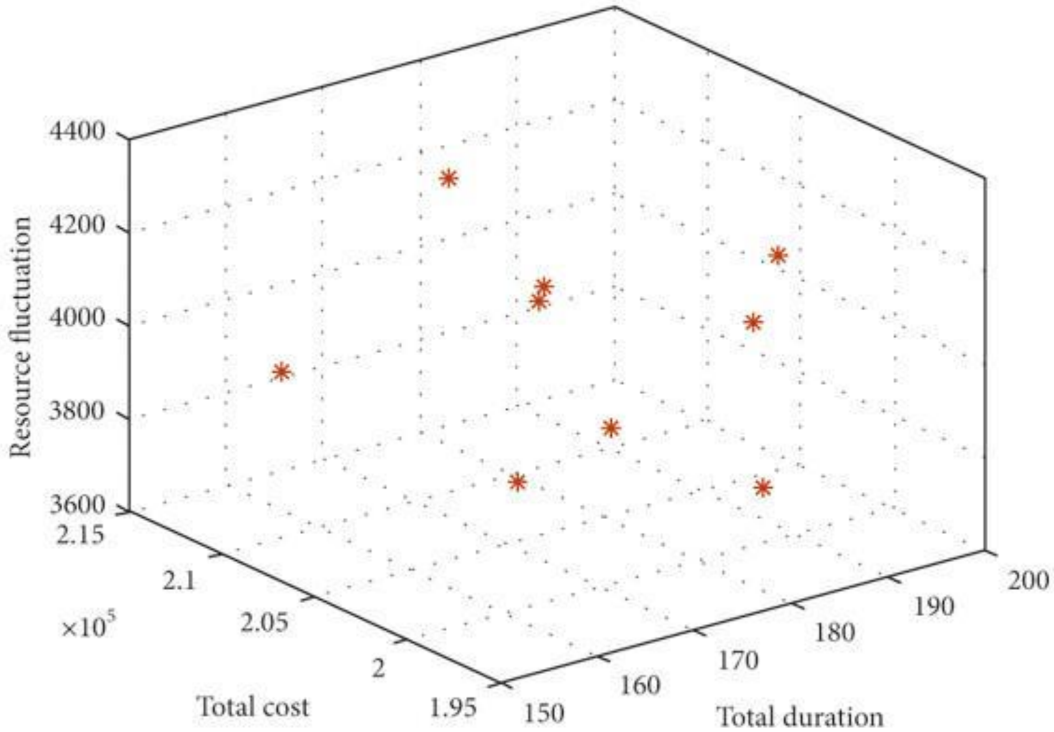
×10^5
2
Total cost
1.8
140
160
180
200
Total duration


4400
4200
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Resource fluctuation
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Total cost
1.95
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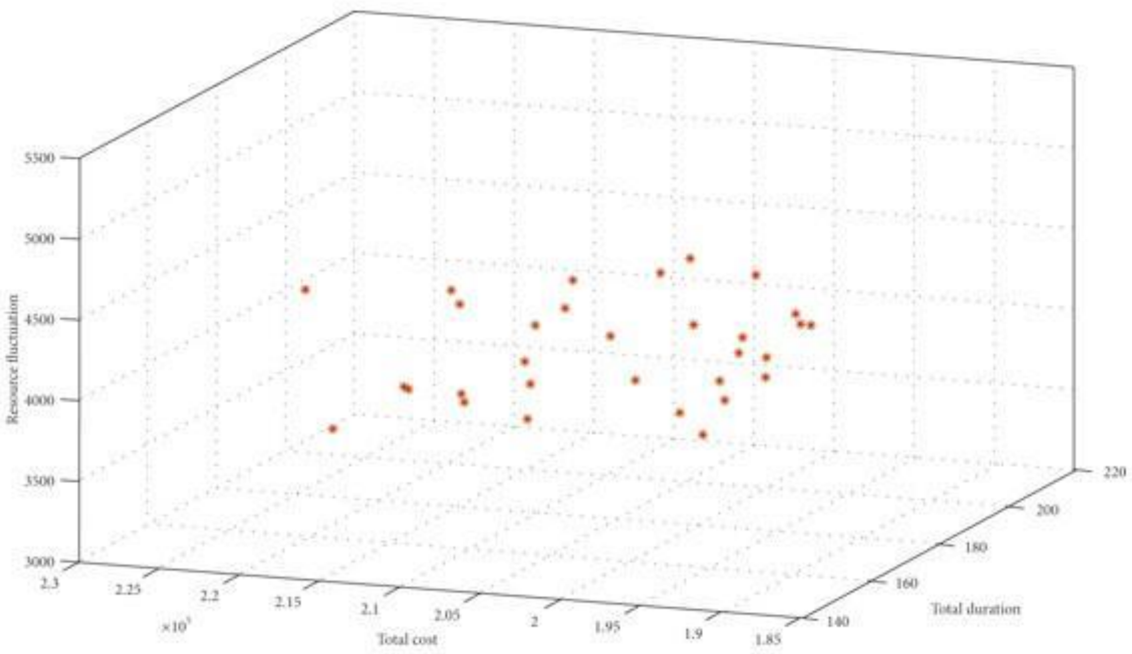
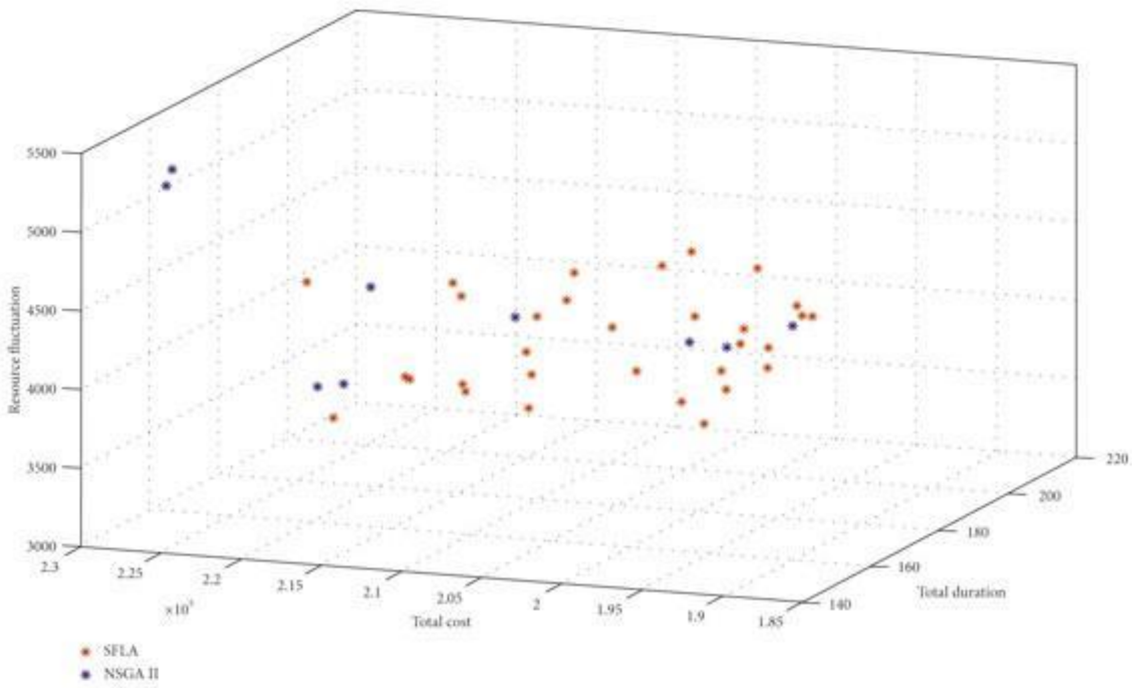
170
180
190
200
Total duration



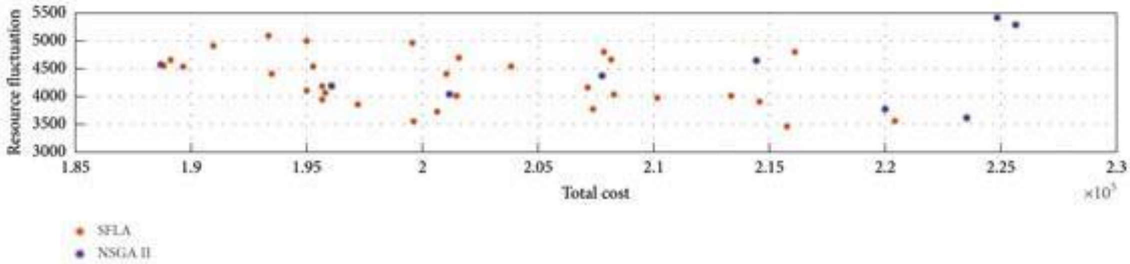


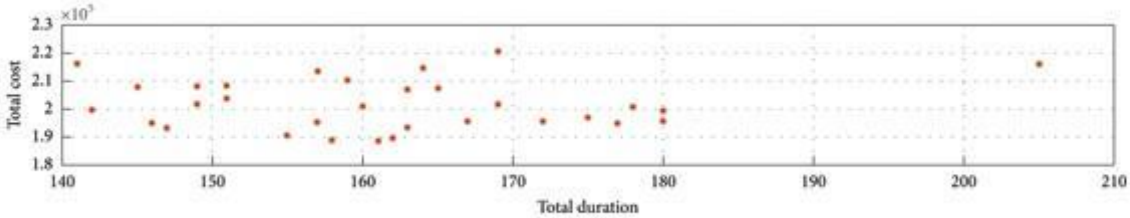
The schedules generated by the modified SFLA and the corresponding fluctuations in time, cost, and resource moments are presented in Table 4. An undominated distribution of 19 points, in three-dimensional space after the 100th iteration. The time deviation range is 141 seconds to 196 seconds. The cost deviation range is 151540 to 158618, and the resource moment deviation range is 3552.20 to 5156.86.

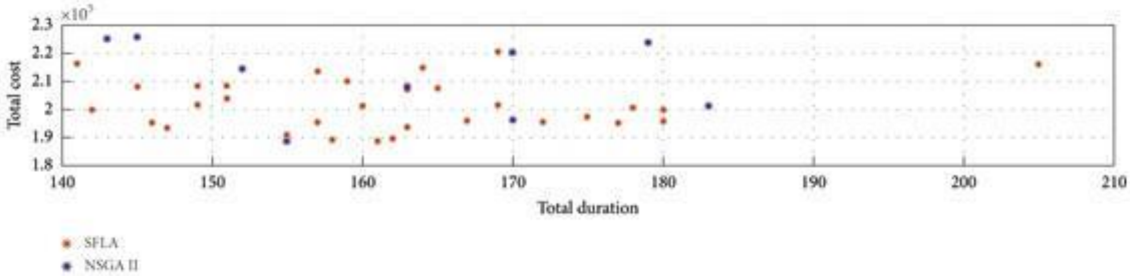
Solution	Total duration	Total cost	Resource fluctuation
Solutions of SFLA			
1	162	189665	4536.24
2	178	200640	3716.53
3	155	190965	5204.40
4	169	220420	3802.89
5	145	207850	4935.05
6	180	199640	3561.16
7	157	213350	4222.84
8	164	214605	4128.29
9	167	195800	4404.09
10	151	203850	4668.06

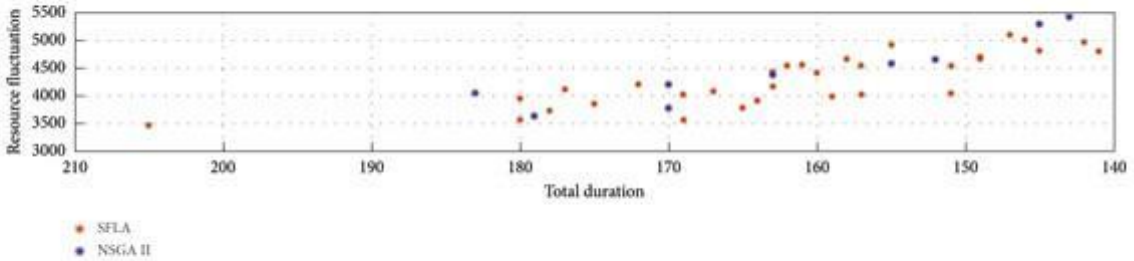
Activity number	Start time	Execution mode
1	23	1
2	9	2
3	14	2
4	8	1
5	39	3
6	45	2
7	75	2
8	69	2
9	76	1
10	74	1

The analysis of the data in two dimensions is presented on the Figure including the relationship between "TD-TC," "TD-RF," and "TC-RF." An interesting phenomenon occurs when the best solutions may be at odds with each other. For example, taking into account solution no. 2 (178 days, 200,640) and solution no. 3 (155 days, 190,965), solution no. 2, with its large duration (178 days) and greater cost (200,640), is still considered the optimal solution. This is because the results cannot be interpreted by considering only time and cost, while ignoring the variation of third-dimensional resources. Compared to no. 3 whose RF is 5,204.40, no. 2 remains in the optimal population because it has a smaller resource moment deviation (3,716.53) and thus has a finer resource use histogram. It is also the reason why there is no clear trend or regularity between any two goals.









Conclusion

This study examines the management of drug stocks in hospitals by applying data mining and machine learning methods, especially the Shuffle Frog Leaping Algorithm (SFLA). The results show that by using data mining, patterns and trends in drug use can be identified more accurately, so that hospitals can better understand the need for drug stocks and ensure the availability of the right drugs at the right time. The application of machine learning algorithms allows for more accurate classification of drug stock priorities, which helps hospitals in managing drug supplies more efficiently and effectively. In addition, the SFLA developed in this study has been proven to be able to improve the accuracy of predicting drug stock needs and optimize the reordering period. This algorithm not only contributes to the management of drug stocks, but also offers an optimal solution to the trade-off problem between time, cost, and resources under existing constraints, including peak electrical power load at hospital sites. The modified SFLA has successfully identified a larger number of optimal solutions and a wider range of solutions compared to other algorithms, thus positively impacting the reduction of operational costs and the prevention of drug shortages or overstocks. The results of this study provide strong theoretical and technical support for energy management in hospitals, and show that the successful application of data mining and machine learning methods is highly dependent on the quality of the data used, where accurate and complete data is indispensable to obtain optimal analysis results.

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