• Received 6 April 2022; received in revised form 20 August 2022; accepted 18 October 2022.

Abstract

The sustainable supply chain, which emphasizes all three dimensions of economic, social, and environmental issues, is currently highly regarded by researchers and scholars in various industrial fields. This research has been done to present a sustainable supply chain model with lean and agile characteristics. The resulting model serves as a guide for companies. The model is designed with an economic perspective while paying attention to environmental and social concerns, aiming to achieve and maintain a competitive position. Using the subject literature and reviewing the conducted research as well as interviews with experts, the effective factors of sustainability, lean and agile supply chains were identified. The most important factors were selected by a survey of experts. The model was obtained by the using interpretive structural modeling. The model shows the relationships between the factors. MICMAC technique was used to determine the penetration power and dependence of factors. The research was conducted in the rotary equipment manufacturing industry, which is-used in oil and gas industries. From the thirty-one factors identified in three components of sustainability, lean and agile, as well as four dimensions of economic, social, environmental, and organizational, twenty-two factors were selected by experts to be used in the model. The model categorizes factors into four levels: driver, basic enabler, operational enabler, and achievements. As the main result of the research, it can be stated that in order to achieve the success of a sustainable supply chain and create a competitive advantage in it, managers should pay more attention to the two levels in the model, driver level (senior manager commitment and use of information technology in the sustainable supply chain) and also basic enabler level (job security and employee satisfaction, employee social welfare and the factor of transparency and cooperation between members of the supply chain).

Key Words: Sustainable supply chain, lean, agility, conceptual model.

constructive algorithm, while the original is a single-objective and improvement-based algorithm. The modified ICA has a variable self-tuned parameter and two assimilation process in strategic and operational level. The low-level heuristics refer to selecting courses for allocation that are pre-allocated, limited in time or location, most limited, most limited in remaining slots, most crowded, longest time, in the heaviest group, belong to a highly participated lecturer, or belong to faculty members.
The hyper-heuristic algorithm was programmed in MATLAB 2018b and ran on a PC with an Intel Core i5 3450 CPU and 8 GB of RAM. The algorithm was tested using real data from Shiraz University. The results revealed that the hyper-heuristic algorithm can generate 10 distinct timetables within a runtime of 17 hours, without the need for human intervention. The best-produced timetable can increase class utilization by up to 11% and reduce student average waiting time by one hour per week.

Key Words: Course timetable, hyper-heuristic, imperialist competitive algorithm, student waiting time, class utilization.

A BI-OBJECTIVE MATHEMATICAL MODEL TO DESIGN A HEALTH SERVICE NETWORK WITH CONSIDERING THE EFFICIENCY OF LOCATIONS

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 169-182, Original Article

- Received 8 March 2021; received in revised form 30 May 2022; accepted 28 June 2022.

Abstract
The healthcare system can be hierarchical in nature. There is a linkage between the different levels, which makes it hard to solve the location problems for each level of this system separately. This system may consist of primary health centers, regional health centers, and hospitals. A growing body of evidence reveals the importance of primary care to health of societies. Hence, all countries should provide efficient, effective, timely, and fair basic health services. This may consist of primary health centers, regional health centers, and hospitals. The aim of this research is designing a three-level health service network. To touch this purpose, we deem each candidate location as a decision-making unit and, then, calculate the efficiency score of this location based on the Non-Radial RAM method. In this paper, a bi-objective mixed-integer linear programming (MILP) model was introduced for a hierarchical three-level health service network design problem. The first objective function minimizes total transportation time from patient zones to each level. The second objective function seeks to maximize efficiency by selecting more efficient locations. We use the augmented e-constraint method (AUGMECON2) to solve the bi-objective mathematical model. To prove the applicability and validity of the proposed decision model, we provided a real case study in the city of Tehran. The results of the suggested model show that there is a conflict between objectives. Besides, the impact of the referral parameter on the flow of patients in the system is clear.

Key Words: Healthcare systems, three-level health service network, mixed-integer linear programming model, Non-Radial RAM method, augmented e-constraint method.

DEVELOPMENT OF A CONCEPTUAL MODEL OF A SUSTAINABLE SUPPLY CHAIN WITH LEAN AND AGILE CAPABILITIES (CASE STUDY: MANUFACTURERS OF ROTARY EQUIPMENT IN THE OIL AND GAS INDUSTRY)

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DOI:10.24200/J65.2022.59745.2279

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 183-192, Research Note

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 141-154, Original Article

- Received 2 February 2022; received in revised form 12 April 2022; accepted 27 April 2022.

Abstract

Setting a fixed price to a perishable product convinces customers to purchase fresher products and keep a portion of inventory unsold. However, pricing with respect to the time of expiring date can increase the demand rate of aged products and decrease the amount of waste. Having the price elasticity of demand and its impact on inventory management, especially for perishable products, makes investigating the pricing and inventory problems simultaneously an effective way for reducing costs and increasing the total profit. Pricing itself is considered as a mechanism to attract more customers and improve the retailer's total profit. Nowadays, the rise of health-conscious customers has led to increased demand for fresh products. The demand for these products depends on the selling price, freshness, and the displayed stock level. As the age of the perishable product increases, more attempts are needed to maintain the freshness of these products, increasing the holding cost over time, i.e., the older the product, the higher the holding cost. Due to dependence of demand rate on displayed stock level, the optimal value of ending inventory is not necessarily zero and another challenge is to decide on what is the optimal inventory level at the end of a replenishment cycle. This research investigates a pricing-inventory problem with a multiplicative demand function of price, freshness, and displayed stock level when the holding cost function is linearly time-increasing. A mathematical model is proposed to determine the replenishment cycle time, the ending inventory level, discounted selling price, the economic order quantity, and the time to apply the discount to maximize the retailer's total profit. It is shown that the objective function of type profit maximization is quasi-concave, and a search algorithm is presented based on this. Finally, an example is applied to show the well-defined structure of the model. The sensitivity of some important parameters is analyzed to illustrate theoretical and managerial aspects.

Key Words: Inventory management, pricing, linear holding cost, perishable products, multivariate demand function.

AUTOMATED UNIVERSITY COURSE TIMETABLING USING HYPER-HEURISTIC APPROACH

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 155-167, Original Article

- Received 6 March 2022; received in revised form 6 June 2022; accepted 14 June 2022.

Abstract

The university course timetabling problem (UCTP) is a crucial yet intricate task for academic departments. UCTP is classified as an NP-hard problem; therefore, a simple solution may not be applicable to it. However, recently, hyper-heuristic algorithms, as a new approach, can automatically generate solutions. A hyper-heuristic algorithm consists of one or two high-level heuristics and several low-level heuristics. The low-level heuristics are responsible for generating or improving the initial solution, while the high-level heuristics are used to select the best low-level heuristics for achieving better solutions.
This paper aims to produce timetables by mathematical modelling of real-world hard and soft constraints and developing a hyper-heuristic algorithm as an efficient solution. In formulating the mathematical model of UCTP, it is considered that certain classes are pre-allocated to departments. Additionally, some three- and four-unit courses are held in two sessions per week, following the traditional patterns of Saturday-Monday, Sunday-Tuesday, and Monday-Wednesday (assuming Saturday to Wednesday as the workweek). There is also the possibility of following new patterns, such as Saturday-Tuesday and Sunday-Wednesday.
The proposed hyper-heuristic is based on a customized Imperialist Competitive Algorithm (ICA) as a high-level heuristic. It utilizes nine low-level heuristics, five strategies for implementing them, and four heuristics for choosing time slots. The modified ICA is a bi-objective and

were classified into two levels of low-level hospitals (provision of public health services) and high-level hospitals (providing specialized health services). In high-level hospitals, patients require professional services, and in the low-level ones, hospitals do not have the power to respond to specialized health services demands. They refer the patients to high-level hospitals in the case of patient visits or in emergency situations by ambulance. In the present case, patients are divided into two categories including the high priority (the category in which immediate service delivery is needed) and low priority. Regarding this problem, a stochastic robust dynamic mathematical model for location and allocation of health network regarding limited capacity and disturbance is developed which tries to reduce the total costs including the real features of a real problem such as limited capacity. The limited capacity of hospitals revealed that the health network needed redefinition of different layers for the network in the disturbance situation. In this study, we try to reduce the total costs by reducing costs of hospitals and costs such as transportation and service to patients. To solve the model, two metaheuristic algorithms including Non-dominated Sorting Genetic Algorithm II (NSGAII) and Particle Swarm Optimization (PSO) are applied. Taguchi method design is applied to minimize the cost of parameter tuning including the level of factors related to the proposed. The results demonstrated the applicability of the model to large-sized problems. For example, the total cost is minimized in conditions that are considered in the genetic algorithm, the population parameter at the highest level (150) and the intersection parameters, and the probability of mutation at the lowest level (0.7 and 0.1).

Key Words: Hospital localization, stochastic robust dynamic model, limited capacity,NSGAII, particle swarm optimization.

A NEW CRV-BASED METHOD TO CALCULATE THE VALUE OF CUSTOMERS IN THE CINEMA AND THEATER INDUSTRIES

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 125-140, Original Article

- Received 29 January 2022; received in revised form 6 June 2022; accepted 28 June 2022.

Abstract

Identifying effective customers who have a positive or negative effect on other customers' purchasing decision behavior is a major concern of the businesses. The culture and art industry has the most dynamic and active customers. The cinema and theater industry customers are more sensitive to the product they receive and other customers who will buy it. In this study, based on complex network theory, social network analysis techniques, and using the concepts of verbal communication and customer referral value, a model for identifying effective users in customers' decision behavior is presented and customer value is measured based on different customer roles within the network. In this research, in the first step, the lifetime value of Tiwall (a social network of cultural and artistic products including cinema and theater) customers was calculated and then, by drawing the communication network, customers were divided into four optimal clusters based on the scope of communication with each other. Users' network parameters were extracted and the feature of life value of customers was added. In the next step, a model for identifying and measuring the verbal value of customers based on the definition of extractive relationships was presented. Using this model and with the decision tree algorithm, 10 different networks of influence and influence based on 6 defined roles of users (positive influencer, negative influencer, first-type client, type-two client, positive reversal, and negative reversal) were drawn and the lifetime value in the stream and the reference value in the flow of each network were calculated. By using the obtained results for the reference value and lifetime of each user, Characteristics of Lifetime Value and Reference Value were divided into four sections: Heroes, Wealthy, Propaganda, and Stingy. As a result, the comparison of referral value with lifetime value and network value indicates that the high share of neglected customer referrals in the profitability of a product, an organization and a dynamic industry, and customer valuation aspects in these types of businesses should be developed.

Key Words: Customer lifetime value, customer referral value, customer turning away, social network analysis, film and theater industries.

A PRICING-INVENTORY MODEL FOR PERISHABLE PRODUCTS WITH MULTIVARIATE-DEPENDENT DEMAND FUNCTION AND TIME-INCREASING-LINEAR HOLDING COST FUNCTION

Key Words: Scheduling, cellular manufacturing system, completion time, alternative processing routes, SA, GA.

COMPARISON OF NSGA-II AND SPEA2 ALGORITHMS IN A BI-OBJECTIVE ROBUST SCENARIO-BASED SUPPLY CHAIN CONSIDERING MATERIAL WASTE

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 99-109, Original Article

- Received 18 December 2021; received in revised form 13 April 2022; accepted 11 May 2022.

Abstract

Nowadays, increasing the quality level in production systems and reducing costs are two of the significant goals of manufacturers. More manufacturers pay for more qualitative raw materials, more skilled labor, and more advanced and accurate machines the more waste is reduced. Increasing quality levels and decreasing costs become more complex when some parameters are under uncertainty. One of the methods to encounter uncertainties is robust optimization, where uncertainty probability distribution is unknown. As a consequence, the robust scenario-based approach, which is presented by Mulvey, is applied. In this paper, we present a bi-objective scenario-based supply chain model. In this model, three echelons including suppliers, manufacturers, and customers are considered. Also, we consider uncertainty in backorder, demand, and cost values. The first objective function aims to minimize supply chain costs including production, raw material purchasing, production inventory holding, raw material inventory holding, transportation, and backorder. The second objective function aims to minimize the total amount of raw material wastes in the production line and supplier batch. The proposed model has been defined as a multi-product, multi-period, multiple suppliers, multiple customers, and multiple transportation modes mixed-integer linear programming model. Also, in this model, workforce efficiency, storage and transportation capacities, and inventory planning are considered. The model parameters are considered randomly distributed. The Epsilon constraint method, NSGA-II, and SPEA2 algorithms are applied to solving the proposed model. Also, the Taguchi method is applied to tune the parameters of the algorithms. Then, a comparison between the quality of results and the CPU time of these methods is provided. This comparison indicates that the use of evolutionary algorithms provides close results with the exact method in a shorter CPU time. Afterward, the Mean Ideal Distance (MID) and Analytic Hierarchy Process (AHP) methods are respectively employed to evaluate Pareto fronts performance and make a decision about selecting the best cost and quality level policy.

Key Words: Robust optimization, NSGA-II algorithm, SPEA2 algorithm, uncertainty, supply chain design.

STOCHASTIC ROBUST DYNAMIC MODEL DESIGN FOR LOCATION AND ALLOCATION OF HEALTH SERVICE NETWORK REGARDING RESTRICTED CAPACITY AND DISRUPTION

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DOI:10.24200/J65.2022.57263.2192

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 111-123, Original Article

- Received 18 December 2021; received in revised form 14 May 2022; accepted 24 May 2022.

Abstract

To locate hospitals, several points including the population of the area under the covering, transportation costs, and physical distance among the hospitals are very important. In the present study, health service networks

is one of the most important classic optimization problems that has been studied and developed by many researchers since its introduction. One developed form of VRPs is the Generalized Vehicle Routing Problem (GVRP). This problem is relatively new and is one of the novel areas for research. In the generalized vehicle routing problem, the customers are partitioned into clusters, each with a given demand. The objective is to construct a minimum-cost set of delivery routes serving one of the customers in each cluster in a way that the total demand of the customers served by a single vehicle does not exceed the vehicle capacity. In this article, we have considered generalized vehicle routing problem with time windows and sought to minimize the total traveling time of routes. This objective function is a comprehensive expression that includes both distances and waiting times. We have proposed two mathematical formulations for GVRPTW to minimize the total duration of routes. The first model is a three-dimensional model based on nodes, and the second model is based on flow and is presented by two indices. We have also designed a two-phase heuristic algorithm to solve the problem. In the first phase, an initial solution is created, and in the second phase, a heuristic algorithm is implemented to improve the constructed solutions. Three different approaches are considered to construct the initial solution, and based on these three approaches, four heuristic algorithms are designed. The first category is based on savings, including both sequential and parallel saving algorithms. The second category is insertion-based heuristics which is analyzed through 25 strategies, and the last category is a time-oriented nearest neighbor heuristic algorithm. Finally, the performances of the proposed algorithms are compared with each other. The results show the good performance of the insertion-based algorithm compared to other algorithms.

Key Words: Vehicle routing problem, selective vehicle routing problem, location-times of customers, time windows, heuristic algorithms.

SCHEDULING IN A DYNAMIC CELLULAR MANUFACTURING SYSTEM WITH CONNECTED PERIODS AND CONSIDERING THE POSSIBILITY OF MACHINES RELOCATION DURING THE PERIOD

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DOI:10.24200/J65.2022.59048.2255

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 85-98, Original Article

- Received 30 November 2021; received in revised form 7 May 2022; accepted 12 July 2022.

Abstract

Today, changes in the volume and type of customer demand are a serious and significant problem for manufacturing companies. To address this problem, new production systems, including the dynamic cellular manufacturing system, have provided some solutions. In this system, the layout of machines can be changed from one period to another according to changes in demand. On the other hand, in the problem of scheduling parts in the cellular manufacturing system, the relocation of machines is usually done between two periods. Still, no time is considered for this relocation, and it is necessary to consider this time to determine the completion time of parts exactly. This paper introduces an innovative mathematical model to address the scheduling challenges in a cellular manufacturing system with continuous periods. The proposed model allows for dynamic machine relocation and layout changes within each period while taking into account the associated time and cost factors involved in the movement process. The possibility of machine relocation during the period can increase the system's dynamics. In the proposed model, cell formation coincides with scheduling. Other features of the model include alternative processing routes and the existence of identical versions of a machine. The objective of the proposed model is to minimize the total costs of completion time, machine relocation, and intracellular and intercellular material handling. The objective of the proposed model is to minimize the total costs of completion time, machine relocation, and intracellular and intercellular material handling. Validation of the proposed model is performed in five steps. The results of examining the features of the proposed model show that the model can effectively reduce completion time and other costs. Finally, to solve the model in larger sizes, two meta-heuristic algorithms of simulated annealing (SA) and genetic algorithm (GA) have been designed, and the obtained results have been compared with the results of CPLEX solver.

ACCEPTANCE CONTROL CHARTS FOR MONITORING FIRST-ORDER AUTOREGRESSIVE PROCESS

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DOI:10.24200/J65.2022.58411.2228

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 63-72, Original Article

- Received 20 September 2021; received in revised form 6 June 2022; accepted 14 June 2022.

Abstract

The idea that any deviation should be recognized as soon as possible will often be impractical. Despite the existence of numerous assignable causes in the process, their effects may be so small and minor against the permissible tolerance. Identifying them seems uneconomical from practical sights. If the process reaches a high level of capability, the production may be acceptable even though assignable causes befall. Since customer expectation will not be affected in this case, it is not economical to stop the process. By considering the level of specifications, some changes in the average can be allowed. Dividing the conditions of the monitored process into just black and white can be simplistic. In such cases, traditional control charts with two zones are not applicable. By defining the zone of indifference, permissible deviations can be tolerated. For such a situation, Acceptance Control Chart (ACC) is developed based on three zones. Suppose that a statistically assignable cause is detected using the traditional control charts; however, no signal is observed by the ACC. Thus, this change does not result in a nonconforming output, and there is no need to stop production since no operational loss occurs. The most important assumptions of the ACC are the normality and independence of the monitored data. In some industrial/non-industrial processes (e.g., continuous production processes, financial processes, network monitoring, and environmental phenomena), serial correlation can be extracted among samples which violates the assumption of independence. Autocorrelation reduces the performance of traditional control charts by producing frequent false signals in the in-control state or makes them respond slowly to the detection of the out-of-control state. The main purpose of this study is to develop an ACC for monitoring the data of the most widely used autocorrelated process, namely the first-order autoregressive process AR(1). In this regard, two types of ACC are extended for the residuals of AR(1) processes. Upon evaluating the performance of monitoring methods using the average run length (ARL), it is found that the proposed EWMA chart has better results. Moreover, the economic-statistical design of the proposed chart is carried out at a lower cost.

Key Words: Acceptance control chart, autoregressive process, average run length, economic-statistical design.

TWO MATHEMATICAL MODELS AND FOUR HEURISTIC ALGORITHMS FOR VEHICLE ROUTING PROBLEM WITH SELECTING LOCATION-TIME OF CUSTOMERS

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 73-84, Original Article

- Received 15 November 2021; received in revised form 11 June 2022; accepted 3 August 2022.

Abstract

Transportation is one of the most significant issues in the field of logistics. The development and expansion of urban networks, the increase in population, and the consequent increase in the traffic of road networks have led to an increase in the importance and sensitivity of transportation compared to the past. On the other hand, transportation accounts for a significant part of any country's Gross National Product (GNP), and a lot of research has been done to improve the transportation situation. One of the most challenging problems in transportation is the Vehicle Routing Problem (VRP). VRP

Abstract

In this paper, the problem of simultaneous production planning, inventory control, transportation, and pricing of perishable goods (with limited lifetime) in a two-stage supply chain is investigated. Extensive research has examined each of the important supply chain sub-problems, including production and inventory planning, distribution and transportation planning, and pricing, separately. On the other hand, the global optimum solution can be achieved when these sub-problems are solved simultaneously and in the form of an integrated model. However, less research has focused on integrating these decisions. There are also many research papers that assuming inventory items can be stored indefinitely to meet future demands. While there are certain types of products that either decay or become obsolete over time and, as a result, become unused. Perishable goods include food, vegetables, human blood, photographic films, etc. which have a maximum shelf life to use. If the product is perishable, then there will be more need for integrated decision-making. Another important issue to consider is the uncertainty of the available data. In other words, the parameters influencing these decisions are not deterministic and this uncertainty must be controlled to minimize the possibility of losses associated with the decisions. A non-deterministic multi-period optimization model, in which demand uncertainty depends on the product price and the remaining periods, is proposed to solve the problem. In the proposed model, robust possibility planning is used to deal with uncertainty. To validate the proposed model and solution approach, data from a case study (taken from Patron Company, which produces green mortar and is used in the steel industry) were used. The results of computational experiments show that by applying the proposed approach while making integrated decision-making, supply chain costs can be reduced by an average of 16%. Also, by comparing the proposed robust possibility approach with the nominal approach in uncertainty control, it is observed that the maximum and average deviations from optimality are reduced by 46% and 11%, respectively.

Key Words: Two-stage supply chain, perishable goods, pricing, integrated decision-making, robust possibility planning.

A SCENARIO- BASED MULTI OBJECTIVE MODEL FOR BACKUP FACILITIES LOCATION-ALLOCATION CONSIDERING SUPPORTIVE STRATEGIES IN FLOOD DISASTER (A CASE STUDY: QOM CITY)

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 49-61, Original Article

- Received 20 September 2021; received in revised form 7 May 2022; accepted 24 May 2022.

Abstract

With ecological changes and population growth, demand for emergency services and relief items to protect people's lives, properties, and the environment has increased. Iran is at a high-risk level among the countries of the world in terms of the potential for natural disasters such as floods. According to the flood disaster, the occurrence of several crises in short time intervals and different places or long time and continuous in a special region is considered. Therefore, in this study, an integrated model of backup facilities in the field of accommodation and supply is presented to increase the reliability of the crisis chain. The presented mathematical model is a multi-objective, multi-period, and multi-scenario model that locates and allocates facilities at two phases of preparation and response and two sections of supply and accommodation. Then, after comparing the results of multi-objective solution methods, the model is solved by normalization and aggregation of objective functions. In flood situations, a combination of strategies such as construction, equipment, extra allocation, and safety stock is used. The results show that in events with long recovery periods and with the possibility of occurrence of various scenarios, the use of supportive strategies such as building backup facilities is critical. Thus, in this research, with this approach, we are able to greatly reduce the costs of the crisis chain. In this paper, we introduced the flood crisis in Qom City as a case study and recognized the characteristics and causes of this crisis and the challenges of crisis managers in this city. Finally, management solutions based on strategies are proposed that not only solve the problem of facilities location and land acquisition in densely populated areas of central Qom but also reduce the severity and amount of long-term risks to a significant level with the least cost.

Key Words: Location-allocation model, backup facilities, crises management, scenario-based model.

number of maintenance teams, 2) initial inventory, 3) assembly operations, 4) lot sizing, 5) sequence-dependent setup times, 6) safety stock levels, and 7) lots with unequal and variable sizes. The objective includes the costs of preventive and corrective repair activities as well as various production costs consisting of production and setup costs, tardiness penalty costs, and safety stock penalty costs. Due to the nonlinear nature of the failure rate of the production machines, techniques for solving linear mathematical models cannot be used. From this, a linear approximation of the model is presented. The validity and efficiency of the proposed model were analyzed by implementation in a numerical experiment.

Key Words: Opportunistic maintenance, dynamic grouping, production scheduling, lot sizing, mathematical programming.

DEVELOPMENT OF AN ALGORITHM FOR PERSIAN HANDWRITING DIGITS RECOGNITION BASED ON MLP AND PNN CLASSIFIERS AND USING CLUSTER CENTERS

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Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 23-34, Original Article

- Received 23 August 2021; received in revised form 3 July 2022; accepted 12 July 2022.

Abstract

Pattern recognition is a branch of machine learning that recognizes the patterns and regularities in a set of data, and digit recognition is considered one of the pattern recognition categories. Due to the similarities between some digits in each language, especially in Persian, different algorithms have been developed to recognize the handwriting digits with the least error and in the shortest time complexity. One of the most commonly used methods in data classification is the neural network algorithm. While neural networks have been used in the literature for handwriting digits recognition, the combination of clustering approaches and neural network classifiers has not been considered for this problem. Accordingly, this paper proposes an algorithm based on the combination of clustering approaches and neural network classifiers to recognize the Persian handwritten digits accurately. This algorithm performs pattern training and recognition based on Probabilistic Neural Networks (PNN) and multilayer perceptron (MLP) neural networks. In this regard, after extracting the characteristic loci feature and zoning from each image in the training database, the data of each of the ten classes has been clustered using linkage, Partition Around Medoids (PAM), and Fuzzy C-Means (FCM) methods based on the extracted features. Then, the new ten classes resulting from the clustering algorithm are taught by one of the two classifiers, including MLP and PNN. In order to determine the optimal number of clusters in each class, the Tabu search optimization algorithm, one of the most accurate meta-heuristic optimization algorithms, is used. The performance of the proposed algorithms is evaluated and compared with existing algorithms based on the HODA dataset. Based on the results, the proposed algorithm accurately recognizes the Persian handwritten digits. In addition, the proposed method performs more accurately and much faster than most competing algorithms.

Key Words: Clustering, MLP, PNN, digit recognition, tabu search.

DEVELOPING AN INTEGRATED MODEL FOR PRICING AND INVENTORY CONTROL OF PERISHABLE GOODS IN A TWO-STAGE SUPPLY CHAIN: A CASE STUDY OF GREEN MORTAR

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DOI:10.24200/J65.2022.57907.2218

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 35-48, Original Article

- Received 23 August 2021; received in revised form 16 January 2022; accepted 11 May 2022.

Abstracts of Papers in English

A MATHEMATICAL MODEL FOR DYNAMIC MAINTENANCE GROUPING CONSIDERING DISCRETE PERFORMANCE OF A MULTI-COMPONENT SYSTEM

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DOI:10.24200/J65.2022.56610.2163

Sharif Industrial Engineering and Management Journal
Volume 39, Issue 1, Page 3-21, Original Article

- Received 26 October 2020; received in revised form 10 April 2022; accepted 27 April 2022.

Abstract

The aim of this paper is to present a method to optimize maintenance planning for a flexible manufacturing system. Such a system can be considered as a multi-component system. Two types of methods may be used in the maintenance optimization of multi-component systems, i.e., static or dynamic methods. Static methods provide a fixed maintenance planning, whereas dynamic methods redefine the groups of maintenance operations at each decision time. Dynamic or opportunistic maintenance can incorporate up to date information such as 1) machines condition, 2) the number of maintenance teams, and 3) production-related constraints in redefining the groups of maintenance operations. As the literature review shows, the existing dynamic or opportunistic maintenance models are mainly developed to specify classes of multi-component systems that are expected to operate continuously without considering the production-related constraints and performance indicators. The objective of this paper is to develop the existing dynamic opportunistic maintenance approaches for flexible production systems that operate intermittently. To this end, a mixed-integer nonlinear mathematical model is developed to simultaneously decide on the maintenance grouping as well as lot sizing and production schedule. Moreover, the proposed model considers further underlying assumptions such as 1) the limited