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A Novel Neuro-Optimization Techniques for Inventory Models in Manufacturing Sectors

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Abstract: Inventory modeling or policies are the necessity of every business or a new oil for any industry. In other words, inventory control and management are needed by businessmen or entrepreneurs to make effective strategies, i.e., for making their business profitable. It becomes a lot and a lot of vital for enterprises within the real-life things like producing sector like industry, food trade, etc. Inventory issues common in producing, remanufacturing, and lots of helpful applications like pharmaceutical. An associate improvement model for internal control of circulation enterprises was established to minimize the typical total price in the unit time of the inventory system. As we have seen, lot of researchers have made several attempts in the previous decade for improving inventory control/inventory policies, but due to the dynamic nature of human beings, it is difficult to make perfect and unique inventory for all business sectors. So, in this study, we will use collected data (from several research works done by the researchers, questionnaires, interviews) and then will apply an artificial neural network (ANN) concept to provide an optimized solution. Finally, our model shows economical, correct results, which can be additionally helpful for the inventory researchers to seek out the acceptable technique for determining the economic order quantity systems or creating AN assumption for making new inventory policies. Hence, this study provides helpful algorithms, economical inventory models for producing sectors, and future analysis direction toward our planned work.

Keywords: inventory management models, economic order quantity (EOQ), optimization algorithm, data cleaning, artificial neural network method

I. Introduction

In the current state of affairs of globalization, the organizations face the problem of a correct choice of producing processes, getting methods, merchandise style, appliances, machines, and facilities to satisfy the powerful challenges of world competition. With the focus on productivity improvement concepts and universal utilization of business technologies, administrators are seeking to break conventional cash and resource limits and continue attempting to discover the vast new future universe. Globalization is putting enormous pressure on the corporation to innovatively rethink the supply chain. In today's extremely competitive surroundings, the optimum choice of inventory policy or optimized inventory model is the necessity for any industry to progress and develop businessman or entrepreneur. Note that with better and more effective strategies, an entrepreneur can give tough competition to his/her competitors. To get a better understanding of inventory issues such as inventory location, manufacturing environment, inventory policies enforced, and inventory policy selection procedures in Indian automotive industries, food industry, etc., several nearby industries were visited.

In the previous decade, many attempts have been made for providing effective inventory solutions for the manufacturing sector, but all are man-made or based on previous experience, i.e., the role of technology in inventory modeling preparation is still very less. All practicable inventory policies and different procurement criteria/subcriteria are identified by comprehensive literature analysis of several publications, quest articles/reports, books, etc., and thorough consultations have been held with staff working in the automobile industry or some other sector specifically relevant to the purchasing of goods/materials and collection of product models. For example, a customer who wanted a product either made it or went to a skilled craftsman to deliver the requested product, in previous days. Manufacturers were searching for new manufacturing strategies to increase the quality and supply of goods and would like to satisfy the demand of other customers at a specific moment or within a minimum of time. Several manufacturers have been working on the concept of manufacturing more than one commodity at a time or mass production. The manufacturing sector like the automobile or food

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builds many products at a time. Producing products depend on demand in the market (always).

In most instances, mass production depends on the development of goods to meet a prediction. In certain cases, the presales procurement and manufacture of products involve the creation of goods based on a forecast versus actual orders. The unsold material creates inventory that includes (a) raw materials, (b) partially processed raw materials into semifinished goods, and (c) finished assembled goods. A company's financial report requires a working capital assessment, which gives a summary of the cash position of the firms and evaluates the profitability of the firm. This information is stored in inventory and several other policies are created for using these unsold materials by industries for the near future. Hence, in this section, we learn that inventory is a major component for many businesses or for many industries to meet the demand of customers. Our study tries to fulfill or complete the following objectives:

(a) To provide information on the physical and financial implications of manufacturing activities to other functions and
(b) In a dynamic environment, meeting customer requirements can be difficult to anticipate.

Today many optimized solutions based on neural networks or deep learning are being provided in many other applications. So, we think that the artificial neural network (ANN) can provide an optimal solution for our raised issues or problems. Hence, the article has been organized as follows: Section 2 reviews some previous literature. Section 3 explains our motivation behind this writing related to inventory models. Section 4 discusses the actual problem concerning or research. Section 5 discusses a proposed solution like an algorithm and process to make an effective inventory model for the manufacturing process. Section 6 discusses simulation parameters and results in brief. Finally, Section 6 concludes the article with some opportunities to investigate for future studies.

2. Literature Review

The product materials are a part of the working capital of manufacturing firms; effective usage of the product is essential for business performance. The reason for this analysis was the discovery of approaches to increase inventory performance and thereby boost competitiveness for companies. The particular business issue is that some managers lack techniques for efficient inventory management researching methods that managers use to maximize and monitor inventory levels in manufacturing processes. In today's era, we need to provide the following in our study (for the manufacturing sector or entrepreneur engaged with an industry).

(a) Significant incentives to boost operating efficiencies and thus productivity,
(b) Efficient management of the operations to support the solvency of companies,
(c) Offering work, preserving fair rates, and helping neighborhoods with education and taxes.

Many attempts for solving inventory problems have been made in the previous decade. These attempts can be summarized one by one and Park (1987) was the first one to develop the first Fuzzy Economic Order Quantity (FEOQ) model. Many fuzzy inventory mathematical models were studied and examined after this study (Jaggi et al., 2012; Jaggi et al., 2018; Shekarian et al., 2014). In the inventory literature, several research articles dedicated part of their study to the application of fuzzy set theory in inventory systems. The study of Jaber (2009), which evaluated and classified fuzzy inventory models covering studies up to 2008, is the most comprehensive study. Some papers were neglected in his review though, and it was not clear how the paper was collected. In addition, through the category of production and inventory planning, just four papers in stock lot-sizing models were reviewed by Guiffrida and Nagi (1998). Mula et al. (2006) supported some work based on fuzzy production planning inventories. Ko et al. (2010) published several papers on fuzzy logic, soft computing, neural network, and genetic algorithm applications in inventory management.

Aloulou et al. (2014), in a bibliography, presented several articles on complicated resource modeling along with those utilizing other approaches such as game theory, probabilistic and stochastic structure, and queue theory. Additionally, a survey conducted by Andriolo et al. (2014), which examined other deterministic and stochastic EOQ models, reviewed 17 papers containing fuzzy lot-size models. Additional studies (Bakker et al., 2012; Patro et al., 2018; Patro et al., 2019; Poswal et al., 2022; Rajput et al., 2022a; Rajput et al., 2022b) are included in the papers mentioned. They checked some fuzzy inventory models considering output and degradation, separating types of inventory models, respectively, into some classifications. Some important mathematical models based on EOQ models were developed (Dem et al., 2019; Dem et al., 2014; Malik et al., 2008; Mathur et al., 2019). Khan et al. (2011) researched papers that broadened Salameh and Jaber's inventory model (Salameh & Jaber, 2000) in a bubbling setting. The application of the fuzzy set theory in inventory management was surveyed by providing some concise data in Wong and Lai (2011). However, few important studies on fuzzy set theory were addressed by Garg (2016a), Garg (2016b), Kahraman and Yavuz (2010), Kahraman et al. (2006), Ünver et al. (2022), Zadeh (1965), and Barma and Modibbo (2022). A fuzzy inventory models using the signed distance method with triangular fuzzy numbers have been presented by Malik and Garg (2021). While some aspects of the implementation of the fuzzy set theory were analyzed by these researchers in the literature, none of them examined particular sections of the fuzzy set theory. An essential part of any paper that develops an FEOQ model is deciding a solution protocol to extract the correct policies. Do we intend to address the questions in this research on how to solve an FEOQ problem? Which are the correct optimization methods? And how have they implemented solution procedures categorized into FEOQ problems?

Notice that a single-site inventory includes incoming materials (such as raw materials), process materials-in-process, and location production (location finished goods). Defining the research boundaries using a value stream diagram identified the inventory location and the individuals who were responsible for managing inventory levels during the entire production process. Till now, many researchers and scientists have tried to develop and extend the first version (EOQ) to adapt to real-world situations, especially for manufacturing and supply chain management. These attempts made by researchers in the previous century can be used in inventory systems in imprecise business and industrial environments. Hence, this section discusses literature work related to inventory models and for producing efficient inventory or inventory policies for industries. Now, the next section will discuss our motivation behind writing this article related to this area.

3. Motivation

As product materials are a part of manufacturing companies' working capital, the effective use of the product is essential to business success. The basis for this study was to investigate methods to increase the productivity of the inventory and thereby improve liquidity for companies. The basic market concern is that some managers neglect techniques for effective inventory management researching methods that managers use in production systems to automate and track inventory levels. They ought to have substantial incentives to boost operational efficiencies and therefore productivity through programs. Efficient control of corporate processes improves the solvency of businesses, creates workers, and maintains competitive prices, which helps economies by jobs with taxation.

The principles and models of neural networks tend to have tremendous potential to address optimization issues that emerge as neuro-optimization in production planning activity. Many optimization techniques used for optimization shortest path determine as like traveling salesman problem (TSP) and nonlinear optimization and decision-making seem to perform effortlessly by human beings. There is no neural network architecture yet that could perform any optimization task with the same efficacy as humans do. Some of the other areas where the existing neural network architectures could not match human performance are optimization of control and decision-making in production planning. The neural network concepts are directly applicable in issues such as pattern classification, associative memory enhancement, vector quantization, and control applications.

4. Problem Definition

Since product materials are a part of manufacturing companies' working capital, the effective use of the product is essential to business success. The basis for this study was to investigate methods to increase the productivity of the inventory and thereby improve liquidity for companies. The basic market concern is that some managers neglect techniques for effective inventory management researching methods that managers use in production systems to automate and track inventory levels. They ought to have substantial incentives to boost operational efficiencies and therefore productivity through programs. Efficient control of corporate processes improves the solvency of businesses and creates workers, and maintains competitive prices, which helps economies by jobs which taxation.

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5. Proposed Solution

Because of the dynamic nature of demand, researchers need to develop inventory policies that can incorporate these dynamic realistic things accurately in today's age; products have a brief life. A variety of policies are developed to achieve this goal. The new policies are attempting to create higher predictions and mitigation of the problems arising from unreasonable assumptions made sooner. Different procurement programs are designed, and a few tend to be higher than others. Unfortunately, policies that unit area smart overall do not seem to be the most effective selection for a specific application forever, and it is troublesome to make your mind up the priorities of the inventory policy. Even once an acceptable inventory policy for associate degrees is employed, the predictions created by a policy should be less correct than desired. Choosing the correct inventory policy from a large array of possible inventory policies with additional requirement criteria or subcriteria may be a challenging requirement and needs a reasonable preference model for demand manufacturers; the subsequent systematic directions describe the analysis protocol for this study. The following algorithms will be worked for inventory control:

(1) Identify the value chain for the study;
(2) Obtain a letter of cooperation from the authority in the organization in the study;
(3) Create the value chain map;
(4) Identify the functions affecting the area of study;
(5) Identify reports, policies, and tools affecting the area of study;
(6) Identify employees with functions affecting the area of study (potential participants);
(7) Contact potential participants and arrange interviews;
(8) Have participants sign a consent form;
(9) Interviewees answering questions in Section 1 and documenting interviews (Audacity program in this study);
(10) Document journal interview (Microsoft Excel software);
(11) Gather inventory details (number of loads during the past 12 months and average usage) for commodity in the supply chain utilizing database reports for the manufacturing operations;
(12) Speech-for-word interviews (Automatically Communicating Dragon and Microsoft Word software);
(13) Study transcribed details with interviewee's checking consistency (member check);
(14) Compare records and quality management plans with evidence from inventories;
(15) Use Microsoft Word and Excel tools to evaluate interview records, inventory details, policies, and tool parameters;
(16) Code the job term and plan transcripts;
(17) Search for specific patterns, ideas, sentences, and vocabulary;
(18) Make conclusions;
(19) Document results;
(20) Save the data securely;
(21) Break down details after 5 years.

Step 1 to Step 21 discuss the procedure for creating inventory data and destroying it. These steps can be followed by a manufacturing company to increase the use of its inventory for a particular period for increasing productivity or meeting customer demands (at a dynamic time also). Further, the proposed study would deal with depth analysis of various techniques of intelligent systems to optimize production planning. More specifically, the research would concentrate on the implementation of techniques using soft computations for that system.

Some processes required in our study (for inventory models for manufacturing sectors) are data collection, data filtration or data cleaning and data transformation, data visualization for future demand, etc. Figure 1 discusses the procedure of data collection and analysis for inventory models.

Figure 2 shows the procedure of unmanned vehicles, i.e., the learning process for generating inventory models. Further, we have implemented use cases in Figure 3, predicting some useful output. In Figure 4, we have shown neural network-based models for processing and generating optimal inventory policies.

Figure 1
Data collection and analysis

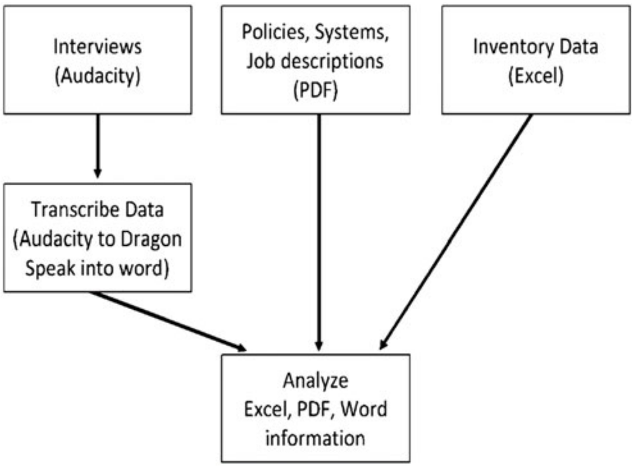
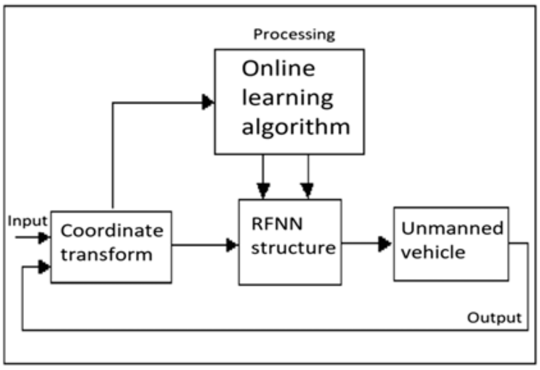


Figure 2
Neural network-based structure for manufacturing sector



Further, through ANN, the nature-inspired optimization algorithm is presented. The nature-inspired optimization algorithm is based on using some nature-inspired behaviors to resolve optimization issues. Such algorithms include particle swarm optimization, bat algorithm, optimization of the ant colony, bee colony, dolphin algorithm, wolf scan, flowers, and cat swarm (for producing sector, i.e., automobile sector, pharmaceutical sector). In this study, we all know a way to design efficient or economical algorithms and how to use these algorithms in control and artificial intelligence/robotics for real-world applications issues (or producing industries). Our rising neural model can solve inventory model issues and supply correct predictions. A common problem, i.e., "how to obtain an optimal structure of industry for producing more products, i.e., make profit/fulfill consumer's demand," is solved by our proposed nature-inspired optimization algorithms.

This section discusses our proposed study, algorithms, and process in detail. The next section will discuss simulation parameters and results for inventory models in brief.

6. Simulation Parameters and Results

Throughout this study, we proposed optimization of binary cat swarm to solve the question of product manufacturing. Its issues split up an industrial network into several fields. The growing area includes system knowledge of related process styles or

Figure 3
Procedure to optimized solution for inventory models (predicting demand)

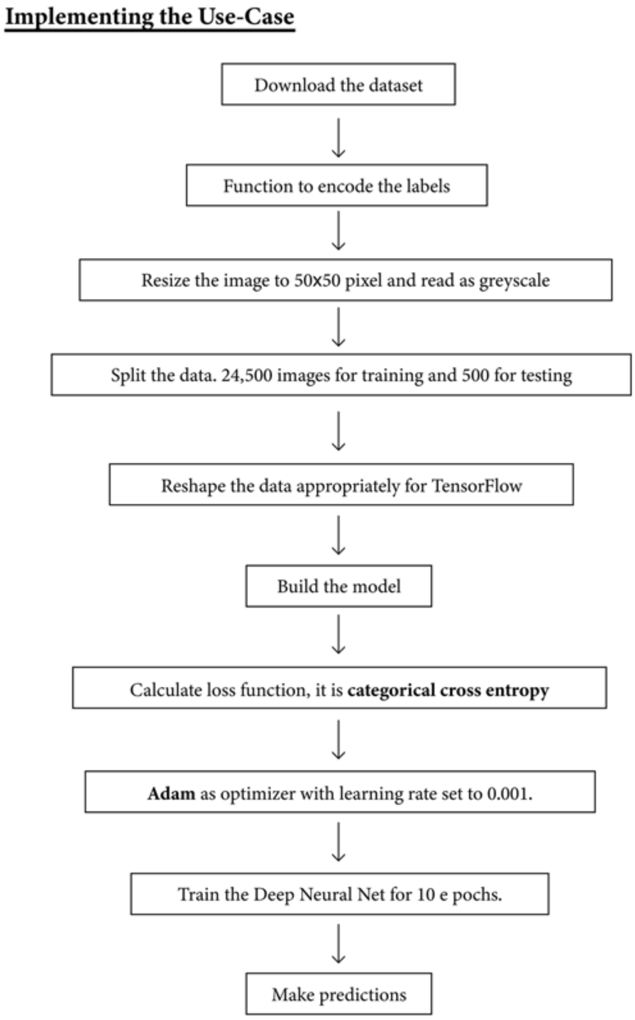


Figure 4
Neural network-based model for processing and generating optimal inventory policies

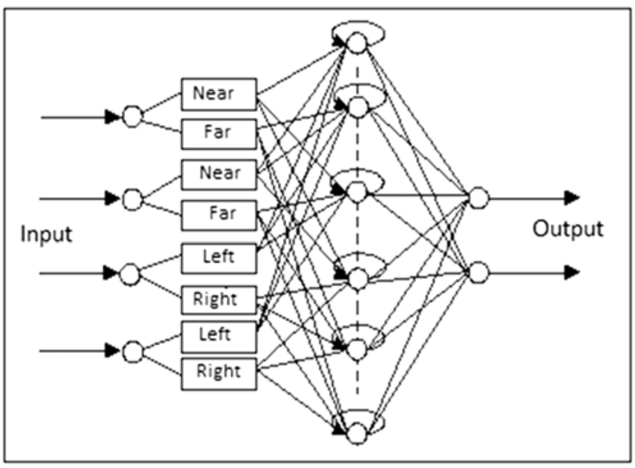
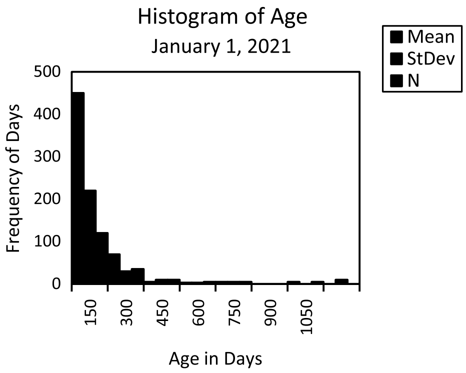


Figure 5
Results of inventory measurement by age in days



part-families. The objective is to identify a field structure in such a way that the transition of the various parts between fields is minimized. Cat swarm optimization is the way these fields are arranged, which is a new swarm metaheuristic strategy based on cats' behavior. Cats have two types of action in this methodology: search mode and trace mode, chosen from a mixture ratio. A variant of the autonomous search algorithm was also included here in our research (for experimentation) to enable easy access to some useful knowledge (in an emergency). The tests for both regular binary cat swarm optimization and the autonomous quest obtain global optimums, both for a collection of 90 with existing optima instances and for a collection of 35 new instances of 13 existing optima ones. Figure 5 shows the importance of inventory or inventory use or age based on days. We see that after 400, there is a huge decline in importance of inventory for a manufacturing sector or industry.

7. Conclusion and Future Enhancements

Today's inventory models and policies are in urgent need of manufacturing sectors. Today's all old inventory models need to be tested for generating a better inventory policy for the future by collecting data through well-designed questionnaires from their employees well conversant with the process. For better defective inventory models, methodologies with technology can be effective in decision-making for any sector or business. Through that, we can design and analyze a decision support system for industrial applications, for implementation and generating effective inventory policy. The developed software is user-friendly and can also be employed in any inventory policy selection system to evaluate and compare other new future policy and lot-sizing techniques based on both qualitative and quantitative criteria or subcriteria in manufacturing sectors like automotive and other industries (without any extensive or specialized knowledge).

This study proposed a model based on ANN for fulfilling customer demand at any time. AI-based simulation integrating the respective capabilities offers a strategic edge in a complex and stochastic setting. Within this research, there is some recent interest in the construction of neuro-fuzzy models, such as type 2 fuzzy neural networks, type 1 fuzzy neural models, and intuitive fuzzy neural networks. Notice that this is used mainly to address supply chain issues. We demonstrated with results that the integration of human and AI-based simulation also delivers satisfactory results in the supply chain, i.e., increases the inventory used for a long time. For further work, integration of various technologies like edge computing, deep learning with human intelligence, an extension of particle swarm optimization algorithm can be proceeding. Furthermore, big data may be combined with the proposed approach to enhance the supply chain participant's efficiency. Sentiment analysis can often be used directly to enhance market forecasting performance. However, the new approach may also be extended to other problems for potential research, such as the question of complex vehicle routing and the dual-channel supply chain.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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