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REVIEW OF EVOLUTION OF MACHINE LEARNING APPLICATIONS IN SUPPLY CHAIN MANAGEMENT AND LOGISTICS: BENEFITS AND CHALLENGES FOR A PAKISTAN-BASED DEFENSE ORGANIZATION

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Abstract

The swift evolution in the field of artificial intelligence and machine learning has impacted plenty of fields, including supply chain management, which encompasses logistics activities such as transportation, warehousing, and distribution. This study traverses through the progression of Machine Learning (ML) in Supply Chain Management (SCM) worldwide, with a particular focus on the landscape in Pakistan, including a defense organization. It extensively analyzes the existing literature to trace the current and future trends in ML technologies, which have a substantial impact on forecasting and decision-making processes. Moreover, it focuses on the specific context of ML adoption in Pakistan. Making use of qualitative methodology, this research delves into the current state of ML application in Pakistan, analyzing the existing framework in depth. Given the constraints of AI usage in military setups, the primary focus is to explore potential ways to integrate ML within the operational paradigm of defense organizations. Recommendations indicate the benefits of adopting such techniques to ensure operational readiness while also addressing potential challenges. By synthesizing insights from global trends and localized studies, this research proposes tailored ML applications that align with the specific logistics needs of defense organizations. This study serves as the initial step towards leveraging advanced ML technologies to foster innovation and operational excellence in Pakistan's SCM and logistics sector.

Keywords: Machine Learning (ML), Supply Chain Management (SCM), Logistics, Forecasting, Decision-Making and Defense Organizations.

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Introduction

The first idea of machine learning was given in a scientific publication in 1943 in the form of the first mathematical neural network model, marking the origin of machine learning. Donald Hebb's book “The Organization of Behavior” was released in 1949. The book states the relationship between brain activity and neural networks, and it would go on to become one of the major milestones in the development of machine learning. (Firican, 2022).

The discipline of supply chain management has been utilizing machine learning techniques since the mid-2000s when the first research and applications were developed. A 2019 literature study that examined 38 pertinent publications published between 2009 and 2019 showed how supply chain optimization with machine learning is becoming more and more popular. (Tymoshchenko, 2024). Numerous supply chain management functions, such as demand forecasting, inventory control, supplier selection, transportation optimization, quality assurance and supply chain risk management, have been addressed by machine learning. These applications are the result of the development of neural networks, the accessibility to massive amounts of live data, and advancements in computer power.

Major cloud platforms like Amazon Web Services (AWS) are the most feature-rich and widely used cloud in the world, offering 200 services from data centers all around the world. The machine-learning (ML) platform Sage Maker was introduced in 2017 and allows developers to build, train, and implement machine-learning models in the cloud. (Ashcroft, 2023). Watson Machine Learning is an IBM Cloud service that offers neural network and machine learning model deployment and training capabilities. Watson Machine Learning allows customers to create and train machine learning and deep learning models on a scalable, open-source platform built on Kubernetes and Docker components.

Machine Learning (ML) is a key concept in artificial intelligence (AI) that involves training machines to learn from data and make decisions based on that data without explicit programming. It is a subset of AI that focuses on developing algorithms that can learn from data and improve over time. ML is a technique to achieve AI using an algorithm trained with data. As a subpart of artificial intelligence, machine learning usually empowers the machine to learn from past data, generate output and predict results without interference from humans. There is no need for explicit programming. All you need are large datasets. Credit goes to machine learning. In today’s world, applications can adapt, grow and evolve according to scenarios and situations. (Kanade, 2022).

ML techniques and algorithms are utilized to handle massive amounts of data effectively. The more data is effectively used, the better the result. The increasing number of datasets, each passing day, created a demand for machine learning. They are widely used in a variety of industries, including education, healthcare, finance, and the military, to extract knowledge and information from data. Different projects and

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calculations of mathematicians and the hard work of programmers led to the innovation of its algorithms. (Tirkolaee, 2021)

As more data and samples are included in the learning and training process of ML models or algorithms, the contribution to the performance of machine learning-based applications or systems is greater. The latest mode of machine learning is deep learning, which uses multi-layered neural networks to mimic the complex decision-making power of the human brain. (Holdsworth, 2024)

With the growth of big data, robotics, automation, and IoT, it has become essential to address these uprisings in various industries:

- Image recognition, pattern recognition and object tracking. These technologies play a crucial role in fields like medical imaging, security surveillance, and self-driving cars.
- Predictive analysis and maintenance in the automotive industry. It helps optimize supply chains, anticipate demand, and enhance safety through predictive maintenance.
- Computational biology includes DNA sequencing and tumor recognition. Aids in the advancement of personalized medicine and drug discovery.
- Voice recognition. From speech-to-text services to speaker identification, it impacts communication and security.

Timeline Of Machine Learning Evolution

Table 01: Evolution of Machine Learning over the period

Year	Event	Reference
1950	Alan Turing proposes the Turing Test.	(Oppy & Dowe, 2021)
1952	Arthur Samuel develops a checkers-playing program.	(Srinivasan, 2020)
1967	Introduction of the Nearest Neighbor algorithm.	(Srivastava, 2024)
1970	Start of the Dendral project, a pioneer expert system.	(Lindsay et al., 1993)
1982	Introduction of the Hopfield network.	(Fernando Jean Dijkinga, 2023)
1986	Popularization of the backpropagation algorithm.	(Kyrlynn, 2024)
1995	Introduction of Support Vector Machines (SVM).	(Cortes & Vapnik)
1997	Defeat of world chess champion Gary Kasparov	(Campbell, Hoane & Hsu, 2002)
2006	Geoffrey Hinton et al. coined "deep learning."	(Kyrlynn, 2024)
2012	AlexNet wins the ImageNet competition by a large margin.	(Team, 2024)

Why Use ML in SCM?

The difficulties of existing techniques in tackling nonlinear problems and efficiently processing vast volumes of data are driving the replacement of old methods in supply chain management with machine learning applications. Additionally, improved visibility, forecasting, decision-making, logistics and transportation optimization, and the development of new business models and prospects are all made possible by the use of ML in SCM. (Stackpole,2020). Businesses may automate warehouse processes, speed up delivery, efficiently manage inventory, increase supplier connections, and improve customer experiences by utilizing machine learning algorithms. Finally, SCM is turning to machine learning to solve the problems brought on by the growing amount of data and to uncover insights that fuel operational enhancements and competitive advantages in the supply chain sector.

Machine learning in defense organization

The defense organization is a critical pillar of national security with the ambition to safeguard the territorial borders, maritime zones, and territorial seas. Robust logistics support is essential for fulfilling its core mission and objectives. “Behind every great leader, there is an even greater logistician,” said Mr. James M Cox in his famous quote. Therefore, ensuring operational preparedness requires maintaining a strong logistical system, which includes effective inventory management for the replacement of parts and the deployment of supplies and boats. The world has revolved through major technological shifts in almost every field. Vice versa in the supply chain, it has revolutionized the procedures and processes, resulting in effectiveness, efficiency and operational readiness. Traditionally, current processes have relied heavily on manual data analysis and human decision-making, leading to inefficiencies and challenges in responding to dynamic situations. The inability to address real-time issues, human-based errors, and ineffective decision-making are all problems that have convinced stakeholders to undergo a paradigm shift in the supply chain process.

Rational of the Study

The relevance of this research lies in the critical needs that defense organizations face in their supply chain networks in this modern world. They work in a complex and dynamic environment where quick decision-making and handling of situations in an appropriate way is paramount. The integration of advanced applications of machine learning creates a high probability of revolutionizing operations, making them more agile and responsive.

There is considerable interest in applications of ML worldwide, and they are currently being used in private companies at their best. However, the existing literature on ML applicability in the defense organization is very scarce. Therefore, digging out the potential key areas is very significant and necessary.

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Research Problem

Machine learning (ML) is gaining popularity in supply chain management globally, but its adoption within the logistics operations of Pakistan-based defense organizations remains limited. This study aims to investigate the development of ML applications in supply chains and assess the potential benefits and challenges of integrating these technologies into the logistics operations of Pakistan-based defense organizations.

Research Questions

The following are the research questions that assist this research:

1. How has the adoption and evolution of machine learning technologies impacted the efficiency, accuracy, and decision-making processes within both civilian supply chain management and military logistics?

2. What are the current capabilities, limitations, and future trends of machine learning technologies in optimizing supply chain management and logistics operations, and what strategies can be proposed for effectively leveraging these technologies to enhance operational effectiveness?

3. What are the primary challenges and opportunities associated with integrating machine learning applications into supply chain operations in Defense Organizations?

Research Objectives

These are the objectives that were supposed to be achieved through this research:

1. **Review the Development of Supply Chain Machine Learning Applications:**

    - Determine the key phases of ML development and implementation for supply chain management.

    - Analyze the impact of machine learning on various supply chain components, such as demand forecasting, inventory optimization, and transportation management.

    - Examine effective case studies of machine learning adoption across different supply chain sectors.

2. **Highlight Potential Key Areas for ML Integration in Defense Organization Logistics:**

    - Identify the possibilities for implementing ML applications within Pakistan's defense setup.

- Determine the critical models that can significantly enhance the efficiency of defense organization logistics.

3. **Identify Challenges in Integrating ML into Defense Organizations:**

- Examine the potential benefits of ML adoption, including cost reduction, faster delivery, and increased operational visibility.

- Identify potential obstacles to ML implementation in Pakistan-based defense organizations, including infrastructure requirements, cybersecurity concerns, and system integration challenges.

Significance of Study

The significance of this study is hidden in its ability to make a decent contribution to both academia and industry in several key areas:

Increasing Knowledge: This study adds to the expanding corpus of information about the nexus between technology and logistics by looking at the progress of ML applications in SCM and Defense Organization logistics. It offers a clearer picture of how machine learning has changed over time.

Practical Implications: This study's conclusions may have applications for companies, governmental bodies and armed forces, specifically in Pakistan. Decision-makers can optimize their supply chain and logistics operations by knowing the opportunities, risks and best practices related to integrating machine learning applications. This can result in cost savings, increased customer satisfaction, and improved operational performance.

Strategic Insights: This research can help firms make more informed strategic decisions by examining the potential, constraints, and future directions of ML technology. The study's insights can assist interested parties in prioritizing resource allocation, identifying investment opportunities, and creating winning plans to utilize machine learning to gain an edge in the civilian and military logistics sectors.

Academic Contribution: The present study can function as a basis for future investigations and scholarly discourse concerning the developing function of ML in logistics and supply chain management. It might serve as an inspiration for upcoming research projects that examine particular uses, approaches, or case studies in this area, encouraging ongoing innovation and learning in the industry.

Limitations of the study

After covering all the basic scope and areas of this study, it is also very pertinent to analyze the variables that would not be included in the study zone due to certain boundaries. This study explores the elements that are much less discussed in the current literature. The study focuses specifically on supply chain management and defense organizations. While these are critical areas, the findings may not be

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generalizable to other sectors where ML is also making significant impacts. The historical perspective relies on available literature and documented case studies, which may not cover all relevant developments, especially those in classified or proprietary contexts in the defense sector.

The quality and availability of data on ML applications can vary significantly. Some sources may provide detailed insights, while others may offer limited information, affecting the comprehensiveness of the review. In defense organizations, much of the information about ML applications may be classified or proprietary, limiting access to comprehensive data. ML is a rapidly evolving field, and new advancements occur frequently. The study may not be able to keep pace with the latest developments, making some findings potentially outdated shortly after publication.

Literature Review

The conceptual foundations of ML date back to the mid-20th century when the idea of "machines that learn" began to take shape. Innovators like Alan Turing and Arthur Samuel laid the foundation by discussing and creating early machine-learning programs. Turing proposed the concept of a machine that could learn from experience in his paper "Computing Machinery and Intelligence." (Turing, 1950)

Evolution into Supply Chain Management

A study by Tubal Kain and Griesser (1990) documented the adoption of expert systems at the Navy Finance Center, highlighting the use of such systems in managing financial aspects of supply chain operations. The paper evaluates the evolution of the expert system program at the Navy Finance Center from its initial conception to its successful implementation. The study by Eom and Karathanos (1996) explored the use of Expert Support Systems (ESS) in enhancing the processes within Total Quality Management organizations. Their work highlighted the potential of expert systems to streamline operations and improve decision-making in complex supply chain environments.

A notable early adoption of ML in SCM was by leading retailers like Walmart and Target in the early 2000s. They utilized ML algorithms to analyze past purchasing data and predict future buying trends. This analysis helped in optimizing stock levels and placements, which was crucial for maintaining high customer satisfaction and reducing carrying costs. The integration of ML in SCM not only improved efficiency but also led to significant advancements in areas like supply chain visibility, where ML algorithms began to predict and manage supply chain disruptions proactively. (*Making supply meet demand in an uncertain world* 2014)

Adaptive learning models were used to enhance decision-making processes in Supply Chain Management (SCM) by creating adaptive systems that absorb vast amounts of data, such as market trends and customer preferences, to develop powerful action plans that make supply chain companies more effective and resilient. (Ivanov & Sokolov) The integration of Big Data and Machine Learning (ML) in supply chain

management (SCM) has significantly transformed the landscape, especially from the mid-2010s onwards. A study by Aamer et al. (2020) explores how ML applications harness big data to improve demand forecasting accuracy in supply chain management. By analyzing historical data, ML models predict future demand more accurately, helping companies manage inventory more effectively. Conversational AI like chat GPT or Bard can handle routine customer inquiries 24/7, providing instant responses to questions regarding order status, inventory levels, and delivery schedules. This improves the customer experience by ensuring they receive timely information without delay, potentially reducing customer service costs by automating responses and freeing up human agents for more complex issues. (Belhadi et al., 2021) AI-based chatbots can facilitate smoother internal communication within supply chain operations. It can be used to automate and streamline communication between different departments, such as warehousing, logistics, and procurement.

Warehouse automation

Deep learning algorithms analyze data collected from IoT devices to make real-time decisions. For example, DL can predict equipment failures or maintenance needs based on real-time data from IoT sensors in warehouse equipment or vehicles. (Neog, 2023).

Amazon's use of robotics and AI to streamline operations. Their warehouses feature sophisticated robotic systems that facilitate rapid order processing and efficient inventory management. These robots are equipped with sensors to navigate safely around human workers and avoid obstacles, ensuring a seamless and safe working environment. (Automated warehouse: Examples, benefits, and Trends 2024).

Table 02: Evolution of Machine Learning in SCM

Year	Milestone	Description
1980s	Initial exploration	Early AI and machine learning techniques began being explored in simple inventory management and logistics planning.
1990s	Adoption of expert system	Deployment of expert systems in the supply chain for tasks like demand forecasting and distribution planning.
The early 2000s	Integration of Advanced ML	Introduction of more sophisticated ML techniques, such as neural networks and decision trees, to solve complex supply chain problems.
Mid-2000s	Rise of Predictive Analytics	Wider adoption of predictive analytics to enhance supply chain visibility and improve forecasting accuracy.
2010s	Big Data and Machine Learning	Leveraging big data with machine learning to optimize supply chain operations at a granular level.
2010s	AI-Driven Automation	Introduction of AI-driven robots and automated systems in warehouse and inventory management.
2020s	Deep learning and IoT	Integration of deep learning and IoT technologies to further enhance real-time data processing and decision-making in supply chains.

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Future and Potential of Machine Learning in Supply Chain Resilience

We discussed how machine learning has contributed to the efficiency of the supply chain, and there are also some potential future benefits of ML. Machine learning can forecast disruptions by analyzing patterns from vast datasets, including weather events, political changes, or market dynamics. (Camur et al, 2024).

Evolution of Machine Learning in Pakistan Landscape

Table 03: Evolution of Machine Learning in Pakistan

Year	Milestone	Details	Reference
The early 2000s	Initial Academic Research	Initial research in machine learning started in academia, particularly in leading universities such as NUST and LUMS.	(Vision and machine learning (VML) research group 2023)
2010	Formation of Research Groups	Establishment of dedicated research groups focusing on machine learning and AI at institutions like ITU and FAST-NU.	NCAI at NUST
2016	Major Company Adoption	Careem (now owned by Uber) started using machine learning for prediction services where most of the customer goes.	(Careem's destination prediction service uses Cat Boost 2019)
2018	Telecommunications Sector - Telenor	Telenor Pakistan employed machine learning to segment customers and develop personalized marketing strategies.	(Telenor, Analytics and AI)
2019	Banking Sector - HBL	HBL (Habib Bank Limited) implemented machine learning for fraud detection and risk management.	(Fatima., 2024)
2021	E-commerce - Daraz	Daraz incorporated machine learning to improve product recommendations and inventory management.	Daraz strengthening South Asian users' shopping experience with Microsoft Azure (OpenAI Service 2023)
2022	Agriculture Sector - Ricult	Ricult, an agritech startup, used machine learning to provide data-driven insights for farmers to optimize crop yields.	(Agri-fintech)
2023	Widespread Adoption and Innovation	An increasing number of startups and established companies across various sectors, including SCM, are adopting ML to enhance decision-making and operational efficiency.	Pakistan AI Startups

In 2020, a survey was conducted to know the current position of machine learning used cases in industries in Pakistan. The survey results indicate that machine learning in Pakistan is still in its development stage, but there is potential for significant growth in the coming years. The survey included over 300 enterprises from various sectors, such as education, financial/professional services, manufacturing, textiles, oil and gas production, insurance, and utilities. Following was the result of the case study. (Hussain & Mahmood, 2021)

Pakistan's Top 5 Machine Learning Use Cases:

- Increasing Customer Satisfaction (43.4%)
- Automating internal processes (39.6%)
- Forecasting Variations in Demand (34.0%).
- Producing Intelligence/Insights from Customers (32.1%)
- Engaging with Clients (32.1%)

NUST, one of the renowned educational institutions, shaped a research group called Vision and Machine Learning. The target of the Vision and Machine Learning (VML) Group is to carry out highly influential research on the frontiers of real-time hardware and software implementations, computer vision, and machine learning, as well as their application areas. Research is done in both fundamental and applied fields. Experts in object tracking, detection, recognition, and segmentation, stereo and multi-view vision, object tracking, structure from motion, shape from texture, unsupervised and supervised learning techniques, and augmented reality make up the group.

Telenor is focused on basic machine learning networks, considering how big data can help them automate their network operations and digitalize customer interaction. And create new growth areas. A Memorandum of Understanding (MoU) has been signed by Telenor and Ericsson (NASDAQ: ERIC) with the objective of investigating, developing, and testing state-of-the-art AI/ML solutions to improve energy efficiency without sacrificing the quality of connectivity in mobile networks. This is a step in the direction of developing machine learning (ML) and artificial intelligence (AI) technologies for the telecom sector.

According to the research conducted by a Pakistani researcher that mentions the dataset received from Habib Bank Limited (HBL) for analyzing credit card transactions. The dataset from HBL included 7500 legitimate transactions and 7500 fraudulent transactions, which were used for the analysis of credit card fraud detection methods. The study applied machine learning algorithms and deep learning models to this dataset to determine the most efficient method for fraud detection. (Fatima, 2024)

Daraz is one of the renowned e-commerce businesses running in South Asia. It announced the integration of Microsoft Azure, an AI chatbot named “askdaraz,” to customize the shopping experience of South Asian users. Allows customers to interact and streamline the entire shopping process.

Research Gap

Despite the growth and evolution of machine learning applications worldwide, along with significant and positive impacts on supply chain management. In Pakistan’s landscape, the existing literature is very limited. As far as defense organizations are concerned, there is a lack of existing literature on military organizations. The following

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are the few types of computer-based information systems currently used in defense organizations.

Inventory Management system is the software most used and is the backbone of procurement in defense organizations. It is used to raise the demand and manage the inventory level. It also shows the re-order signal whenever the inventory is near to stockout. There is no AI/ML intervention in this, and operations are being conducted on conventional software programs.

Some software is being installed on specific classes of ships that possess all the features and specifications of spare parts and equipment. From its time of origin to its maintenance schedule, this software has played a significant role. But this also works and has the functionality of a regular Computer-based Information system with very little automation and no involvement of artificial intelligence. This highlights the need for research into the integration of ML and AI technologies to enhance the efficiency and effectiveness of logistics operations.

Research Methodology

The purpose of this research is to explore the latest trends of ML in supply chain management and their evolution in logistics. Moreover, the findings of this study could help to search for future strategies for defense organizations and similar organizations that want to equip the power of machine learning in their operations. The approach adopted in this study was qualitative, which allows a comprehensive analysis of the existing literature on machine learning in the supply chain, open-ended interviews from the subject matter expert and analysis of supply chain operations within defense organization. By integrating these sources, this research provides a holistic view of the current state of machine learning application and their evolution. Qualitative research provides a deeper and more enriching understanding of complex topics by finding experiences, perceptions and ideas. The data was collected through the open-ended questions asked by the experts in structured interviews. These questions help in-depth analysis of machine learning and provide insight into challenges faced and success stories. Purposive sampling was done to identify the stakeholders that are directly involved. A purposive sampling approach is applied to intentionally and specifically select a crew that helps and benefits the research most finely. Different individuals are selected to get knowledge from different aspects. This contributes to the trustworthiness of the data.

Two interview sessions were conducted for this research study. The first session involved experts in machine learning and artificial intelligence who are actively working in the field, particularly in the Pakistan landscape. The second session included professionals from different industries where AI/ML is applied or currently being implemented and used, as well as students duly enrolled in graduate degree programs related to AI. The responses from these interviews were analyzed thematically to extract recommendations.

Data Analysis and Discussions

A. Revolutionizing of supply chain Successful AI/ML Projects

Implementing AI/ML in supply chains enhances efficiency through dynamic pricing, which helps predict the prices for retail stores; robots are being used for customer services, and humans empower decision-making.

Transforming the role of managers and the future of Machine learning

AI/ML is transforming supply chain roles by automating routine tasks and enabling strategic decision-making. Professionals will need skills in data analytics, AI tools and continuous learning. Training should emphasize leveraging AI capabilities alongside industry knowledge for optimal efficiency and resource management.

Key Strategies for the successful implementation

Key strategies for ML success include executive support, stakeholder engagement, iterative development, and scalable infrastructure. Provide thorough training, gather user feedback, encourage open communication and innovation, and implement changes carefully to address potential issues.

B. Challenges in implementing AI/ML

Challenges faced while implementing AI/ML in the supply chain

Key challenges in implementing machine learning in supply chain management include data quality and availability, resistance to change, system integration, scalability, model interpretability, and ethical considerations. Addressing these requires robust data preprocessing, stakeholder collaboration, and continuous model improvement.

Main Challenges in Adopting ML Technologies in Pakistan

The main challenges for ML adoption in Pakistan include underdeveloped IT infrastructure, skilled workforce shortage, data quality and privacy concerns, high costs, and the need for local adaptation.

C. AI/ML in Pakistan Landscape

Prevalent application used in Pakistan

Prevalent ML applications in Pakistan include fraud detection, risk assessment, personalized recommendations, crop health, personalized learning, facial and voice recognition, chatbots, image recognition, translation services, speech recognition, traffic management, crime prediction, and public safety. Additionally, Tim Tim is a friendly robot that deals with children with autism.

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Significant Impact of ML Technologies Across Sectors in Pakistan

ML significantly impacts agriculture (crop health), finance (fraud detection), healthcare (diagnosis), manufacturing (efficiency), and e-commerce (customer experience). It also benefits government services, education, and energy optimization.

Prospects for ML Applications in Pakistan.

Promising ML areas in Pakistan include precision agriculture, advanced finance, AI-powered healthcare, smart cities, natural language processing, and computer vision. Key growth sectors are agriculture, fintech, healthcare, and education, requiring investment, research, and collaboration.

Successful ML Implementations in Pakistani Organizations

Successful ML implementations in Pakistan include HBL's fraud detection, Koshish Foundation's crop health management, PITB's dengue prediction, Graana.com's property pricing, fraud detection by a local bank, customer behavior prediction by a startup, and traffic congestion prediction in major cities.

D. Historical Context and Milestones

Milestones in Evolution

Key milestones in Pakistan's ML evolution include early AI education at NUST, research at SPCAI, agricultural ML by the Koshish Foundation, growth of tech companies, the establishment of NCAI, and government policies. Notable applications span NLP, image recognition, e-commerce, advertising, census data analysis, and public safety.

Conclusion

Embedding Machine Learning (ML) into any field results in efficiency and productivity. The origin of machine learning dates back to the 1950s, and later on, it spread throughout the world into various departments. When it comes to supply chains, retailers like Walmart and Amazon use artificial intelligence in their operations and strategies. As the technology moves on, it also generates constraints and challenges related to data quality, system integration, and scalability, which is crucial for successful implementation. The future prospects of AI and ML in supply chains are promising, with advancements in robotics, predictive analytics, and autonomous operations. These technologies are expected to deliver unseen improvements. With the current market trends, managers have to mend their roles and invest their time in learning data analytics. Some successful metrics are forecast accuracy, cost savings, inventory turnover, stockout rates, order fulfillment times, on-time delivery, customer satisfaction, and return on investment (ROI).

The utility of ML applications is very limited in the Pakistani landscape, particularly in defense organizations. It was just confined to academic research;

initially, the latest on this technology was supported by the Government. Slowly and gradually, over time, ML made its way toward implications in various sectors such as medical, financial, and e-commerce. In defense organizations, the major constraint in implementing machine learning is data confidentiality. Therefore, this department has a very limited scope. However, there is still a probability of the areas where it is possible to overcome this challenge. Some of the successful ML implementations in Pakistan include fraud detection, crop health management, property pricing, and traffic congestion prediction. These examples demonstrate the tangible profit and potential of ML across various sectors in Pakistan, underscoring the importance of continued investment and development in this transformative technology.

Recommendations

Extracting out all the machine learning applications that are currently being used in this modern world, especially in the Pakistan landscape, has the potential to enhance the logistics and processes of Defense organizations by highlighting the potential and significant key areas. Following are a few applications that can be practically implicated:

Table 04: Recommendations

S. No	Current Usage	ML Applications	Potential Key Areas in Logistics of Defense Organization
1	XYZ Retailer optimized inventory levels by analyzing historical data on sales, weather patterns, and promotional events.	Demand forecasting	Leveraging ML models (e.g., LSTM, Random Forest) in procurement software will be productive for demand forecasting and automatic reordering. This will avoid stockout problems and increase efficiency.
2	By implementing ML techniques and data analytics, global defense organizations are predicting equipment failures, maintaining schedule maintenance and ensuring the operational readiness of their fleet.	Predictive analysis	Aligning the data of vessels/aircraft's previous maintenance record with the machine learning model, e.g., gradient boosting, predicts failure in any equipment and schedules its maintenance. It gathers historical maintenance data, sensor data from equipment, and operational logs.
3	Daraz launched an AI chatbot named “askdaraz,” enabling customers to naturally discuss personalized recommendations, streamlining the complete shopping process.	NLP-Natural language processing model (customer relationship management)	A chatbot utilizing Natural Language Processing (NLP) specifically designed for dialogue. It can sustain conversations, comprehend follow-up questions, offer detailed and informative responses about the induction process of any given organization, and is readily available on the organization's web portal. Specifically, defense organization
4	Orbit (AR/ML) supports the education system.	Training and simulation	An ML-based application that contains massive datasets covering visual ideas of nearly all the topics. That shows 3D images and videos of book content to make concepts easily understandable. AI models give real-time scenarios, especially for logistics purposes.
5	In the financial sector, a bank used the ML model to detect threats and identify fraudulent activities in real-time. This helps them avoid the occurrence of financial loss.	Fraud and anomaly detection	Further research is required to find out the payment method used by defense organizations in financial sectors like banks.

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Office Correspondence can also be powered and enhanced with AI/ML tools. It can be a Natural Language Processing NLP model that will automatically generate the letters or prepare the entire case in hand based on the complete historical data. It will save time and allow individuals to focus more on strategic tasks.

Moreover, the defense organization should continue to send officers to foreign countries for courses and degree programs in AI/ML. To further encourage this, the organization should announce more courses and create opportunities for officers from every branch and field. By studying and observing how advanced countries are integrating robotics, IoT, and deep learning, these officers can bring valuable insights back home. Applying these techniques will be a strategic way for the organization to initiate AI/ML projects within its system.

Possible Challenges

Although there are unlimited advantages of machine learning in any field, military setups have barriers. Here are a few challenges:

- **Lack of Quality Data:** Inadequate or poor-quality data can hinder AI algorithms' accuracy and effectiveness, impacting decision-making and performance
- **Data Silos:** Data fragmentation across different systems and departments makes it challenging to access and integrate relevant data for AI applications
- **Technical Expertise:** Implementing AI technologies requires specialized skills in data science, machine learning, and programming, which may be lacking within the organization
- **Integration Challenges:** Integrating AI solutions into existing systems and processes can be complex and time-consuming, requiring careful planning and coordination
- **High Initial Costs:** Developing and deploying AI solutions can be expensive, requiring investments in technology infrastructure, training, and talent acquisition

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