Machine Learning and Supply Chain Management- A conceptual view

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Abstract— **Machine Learning algorithms forecast demand, improve logistics management and help us reduce paperwork, and automate the manual processes. It uses data, probabilistic models, and algorithms which includes problem identification, cleaning the data, implementing the model, training and testing, evaluating, deploying and updating the data files. In this paper a conceptual view of Machine learning and Supply Chain Management is taken. It also outlines Supervised methods to make predictions on future data such as predicts demand, classify images, detect fraud, or make medical diagnoses and Unsupervised Machine learning methods for customer segmentation and product recommendations works on unlabelled and uncategorized data. The paper is an attempt to outline Machine learning and its methods to make supply chain more effective.**

INTRODUCTION

Machine learning uses data, probabilistic models, and algorithms. The machine learning process requires problem identification, cleaning the data, implementing the model, training and testing, evaluating, deploying and updating the data files. Machine learning methods can be classified into three types supervised learning, unsupervised learning and reinforcement learning methods.

According to Gartner, supply chain organizations expect the level of machine automation in their supply chain processes to double in the next five years. At the same time, according to a recent study, annual Industrial IoT (IIOT) spending by growing companies is estimated to be a whopping $500 billion by the year 2020.

Machine learning is a subset of artificial intelligence that allows an algorithm, software or a system to learn and adjust without being specifically programmed to do so. It uses data or observations to train a computer wherein different patterns in the data are analysed and used to improve its functioning. Machine Learning (ML) models, based on algorithms, are great at analysing trends, spotting anomalies, and deriving predictive insights within massive data sets.

To manage a wide network of suppliers, warehouses, logistics service partners, supply chain management can become a daunting task and machine learning and AI can help us at all stages of the supply chain management. Machine Learning algorithms will correctly forecast demand, improve logistics management and help us reduce paperwork, and automate manual processes.

OBJECTIVES

1. To outline various Machine Learning Methods
2. To outline key challenges and benefits of Machine learning in supply chain.
3. How machine learning work for Supply Chain to make it more effective?

A. Machine Learning Methods
Supervised Learning method for Prediction and Classification
Supervised learning methods use labelled training data to make predictions on future data such as predicts demand, classify images, detect fraud, or make medical diagnoses. It is an algorithm that uses labelled training data to help you predict outcomes for unforeseen data. It can be compared to learning in the presence of a supervisor or a teacher. Building, scaling, and deploying accurate supervised machine learning models successfully takes time and technical expertise from a team of highly skilled data scientists. Moreover, Data scientist must rebuild models to make sure the insights given remains true until its data changes.
Suppose the input in the labelled data is weather conditions and output is time taken back home on that specific day. In this a set of labelled data inputs

includes weather conditions, time of the day, holidays, route chosen etc. You instinctively know that if it's raining outside, then it will take you longer to drive home. But the machine needs data and statistics. The first thing you required is to create a training set. This training set will contain the total commute time and corresponding factors like weather, time, etc. Based on this training set, your machine might see there's a direct relationship between the amount of rain and time you will take to get home. So, it ascertains that the more it rains, the longer you will be driving to get back to your home. It might also see the connection between the time you leave work and the time you'll be on the road. Your machine may find some of the relationships with your labelled data.

Unsupervised Learning method for Pattern Discovery
Unsupervised learning methods used for customer segmentation and product recommendations works on unlabelled and uncategorized data in which models are not supervised. So, models itself find the hidden patterns and insights from the given data. It can be compared to learning which takes place in the human brain while learning new things without supervision. For Example:- In learning algorithm in which there an input dataset containing images of different types of cats and dogs the unsupervised algorithm is never trained upon the given dataset. The task of the unsupervised learning algorithm is to identify the image features on their own. Unsupervised learning algorithm will perform this task by clustering the image dataset into the groups according is used ng to similarities between images.

It can be further be categorised to solve two types of problems:-
A.   Clustering: Clustering is a method of grouping the objects into clusters in which similar objects remains into a group and has less or no similarities with the objects of another group. It finds the commonalities between the data objects in a problem and it categories the data as per the presence and absence of those commonalities.
B.   Association: In large databases an association rule is used for finding the relationships between variables. It also determines the set of items that occurs together in the dataset. The Association rule used for large databases makes marketing strategy more effective. Such as people who buy X item (suppose a bread) are also tend to purchase Y (Butter/Jam) item. A typical example of Association rule is Market Basket Analysis.

Reinforcement Learning Method for neutral networks
Reinforcement learning methods use rewards to guide training and can also be used for skill acquisition. It is the process of taking suitable decisions through suitable machine learning models. It is a feedback-based machine learning technique, whereby an agent learns to behave in an environment by observing his mistakes and performing the actions. It is concerned with how software agents should take actions in an environment. Reinforcement learning applies the method of learning via Interaction and feedback.
For example:- Cats don't understand any form of language and therefore a different strategy has to be followed to communicate with the cat. A situation is created where the cat acts in various ways. It will be rewarded with fish if it is the desired way. Therefore the cat behaves in the same way whenever it faces that situation expecting more food as a reward. The scenario defines the process of do's from positive experiences and don'ts from negative experiences.

This leads to the following explanation
The cat acts as the agent as it is exposed to an environment i.e the house. The agent performs an action by transiting from one state to the other like moving from a sitting to a walking position. The action is the reaction of the agent. The policy includes the method of selecting an action in a particular state while expecting a better outcome in the future state. The transition of states might provide a reward or penalty.
In reinforcement learning an initial state of input should be provided from which the model will start and many possible outputs are generated through varied solutions to a particular problem. The Training of the RL method is based on the input. After the generation of output, the model will decide whether to reward the model. Therefore, the model keeps on getting trained. This model continuously keeps on learning and the best solution for a problem is decided on the maximum reward it receives.

B. Machine Learning in the Supply Chain

Machine learning can be used for many categories of supply chain applications. ML can be used for prediction or forecasting of demand, supply, on-time deliveries, and risks. ML can help automate many routine elements of supply chain operations and help detect or predict exceptions to routine operations. ML can be used for planning and design such as of networks, inventories, schedules, and routes. Finally, ML is a key component of autonomous supply chain vehicles such as trucks, ocean freighters, delivery drones, and forklifts.

Key Challenges In Supply Chain Management

The global supply chain market is full of uncertainties, fragilities, and lack of transparency and businesses can improve its supply chain management by using machine learning making it more resilient to any disruptions. According to the recent Supply Chain Complexity survey by Körber, only 1 in 10 businesses can stay ahead of their supply chain challenges. Companies are now faced with a unique set of challenges like customer expectations, lack of visibility, and operational complexity, transportation complications, remote work, shortages because of unexpected increased demand, etc. According to McKinsey, due to present pandemic there are five major sources of vulnerabilities in the supply chain and machine learning use cases in the supply chain to serve as a ready-made blueprint of activities regarding what supply chain professionals should begin with in order to solve major supply chain issues.

These are some of the challenges faced by Supply chain and logistics which can be solved through Machine learning and artificial intelligence powered solutions:-

Inventory management

Inventory management is for supply chain management allows enterprises to deal and adjust for any unexpected shortages. No supply chain firm would want to stop their company's production while they are find another supplier. Similarly, they don't want to overstock as it affects the company's profits. So, Inventory management in supply chain helps in striking a balance between timing the purchase orders to keep the operations going smoothly and not overstocking the items they don't need or use.

Quality and safety

Maintaining a dual check on quality as well as safety becomes a big challenge for supply chain firms with mounting pressures to deliver products on time to keep the supply chain assembly line moving. It could produce a big safety hazard to accept substandard parts not meeting the quality or safety standards. Further, issues and risks causing significant problems on the supply chain can be environmental changes, trade disputes and economic pressures.

Problems due to scarce resources

Issues faced in logistics and supply chain due to the scarcity of resources are algorithms predicting demand and supply needs early planning and stocking. Machine Learning has also made the management of the inventory and team members become super simple by offering new insights into various aspects of the supply chain.

Inefficient supplier relationship management

A steep scarcity of supply chain professionals is yet another challenge faced by logistics firms that can make the supplier relationship management cumbersome and ineffective. Machine learning and artificial intelligence can offer real insights into the supplier data and can help supply chain companies make real-time decisions.

Benefits that Machine learning delivers to supply chain are as follows:-

Following are several benefits that machine learning delivers to supply chain management including-

- Cost efficiency due to machine learning, which systematically drives waste reduction and quality improvement
- Optimisation of product flow in the supply chain without the supply chain firms needing to hold much inventory
- Seamless supplier relationship management due to simpler, faster and proven administrative practices
- Machine learning helps derive actionable insights, allowing for quick problem solving and continual improvement.

3. HOW TO MAKE MACHINE LEARNING WORK FOR SUPPLY CHAIN MANAGEMENT?

There are three significant steps you should take to adopt machine learning in supply chain management. They are:

a) Understand your supply chain's structure

Before implementing machine learning into your supply chain, you should evaluate your entire supply chain's structure:

- The first step is determining the critical components in company's operations.
- Next step is conducting a detailed analysis of the supplier network including Tier 1 suppliers and sub-tier suppliers.
- Thirst step is to Identify hidden relationships and nodes of interconnectivity.
- Then, Quantitatively diagnose the relative fragility of the supply chain.
- Next Step is to identify bottlenecks and risk factors in the supply chain.
- Sixth step is to draw meaningful comparisons with peers and industry benchmarks.
- Seventh is to assess the security of the supply chain.
- Finally, evaluate your functional maturity against the process, people, and technology.

b) Establishing transparent business KPIs and calculate ROI

Companies need to conduct a Discovery Phase and calculate ROI to understand under what circumstances machine learning use cases in your supply chain to be advantageous to your business. After calculating ROI estimate TCO and the profitability in the short run and the long run. It is also important to prepare a detailed plan for defining company goals and requirements needed to reach them. To eliminate inconsistencies, it is obligatory to align machine learning KPIs with business KPIs. In other words, you should define the business problem in Machine Learning terms.

c) Ensuring an effective ML engineering process

Machine learning use cases in the supply chain depending on the following aspects:

- Set up a multifunctional team of professionals with expertise in data science, DevOps, Python, Java, QA, business analysis, etc.
- Start with a business problem statement and establish the right success metrics.

- Choose the right tech stack to consider your data readiness by focusing on data quality and quantity.
- Develop, train, test, and optimize models.
- Deploy and retrain models where needed.
- Monitor the performance of model used in Machine Learning.

4. TOP COMPANIES USING SUPPLY CHAIN MANAGEMENT

Here are some of the top companies using machine learning to enhance the productivity of their supply chain management:

a) Amazon – eCommerce

Amazon, one of the renowned supply chain leaders in the ecommerce industry use technologically advanced and innovative systems like automated warehousing and drone delivery which is based on artificial intelligence and machine learning.

Amazon make heavy investments in intelligent software systems, transportation and warehousing to have a direct control over the main areas like packaging, order processing, delivery, customer support and reverse logistics.

b) Microsoft Corporation – Technology

The supply chain and logistics of Microsoft heavily relies on predictive insights driven by machine learning and business intelligence.

The company product portfolio generates a huge amount of data which needs to be integrated on a central level for predictive analysis and driving operational efficiencies. Machine Learning techniques have allowed the company to build a seamlessly integrated supply chain system which enables them to capture data in a real-time and analyse it. Further, the company's supply chain is also proactive and has a warning system to assist them in mitigating the risk and quick query resolution.

c) Alphabet Inc.– Internet Conglomerate

A well known technological giant and a highly innovative technological company, Alphabet relies on a flexible and responsive Supply Chain which can collaborate across regions in a seamless fashion.

Alphabet's Supply Chain is completely automated leveraging machine learning, AI and robotics.

d) Procter & Gamble – Consumer Goods

Procter and Gamble, the consumer goods leader, has one of the most complex supply chains with a massive product portfolio. The company leverages various machine learning techniques like advanced analytics and application of data for end-to-end product flow management.

e) Rolls Royce and Google – Automotive

Rolls Royce, in partnership with Google, creates autonomous ships where instead of just replacing one driver in a self-driving car, machine learning and artificial intelligence technology replaces the jobs of entire crew members.

ML and AI algorithms can also be used to track ship engine performance, monitor security and load and unload cargo and to accurately sense what is around them in the water and accordingly categorize items according to the danger they pose to the ship.

CONCLUSION

The COVID-19 pandemic has resulted in severely affecting thousands of supply chains globally affecting various companies. According to The Organisation for Economic Co-operation and Development (OECD), the Coronavirus could cut global economic growth in half, with several industries across the board facing a major fall off. China, the world's second-largest economy and several internal supply chains plunged as the Coronavirus spread from here to other countries in Asia, Australia, Europe, the Americas, and the Middle East. As a result, preventive actions that intended to block the further spread of the virus includes travel restrictions and large scale quarantine which resulted in further plunging disrupting global food, retails and medical supply chains, halting critical business operations, and freezing revenues.

A recent survey by the Institute for Supply Chain Management, nearly 75% of companies reported some sort of supply chain disruptions owing to coronavirus-related transportation restrictions, and the figure is expected to rise further over the next few weeks. This, in fact, is just one of the many facets of the global COVID-19 impact but a significant one.

An attempt has been made in the paper to outline various machine learning methods, key challenges and benefits of Machine learning in supply chain, how to make machine learning work for Supply Chain and view of top companies using supply chain management.

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