

Recent Advances in Machine Learning for Business Process Optimization: A Systematic Review

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Abstract: Machine learning (ML) technology has been swiftly turning out to be the appropriate procedure of harmonizing the business activity in the cross-industrial environment. As people are getting more exposure to the big data and introducing new advancements in the possibilities of the internet, the use of ML has been solely undertaken with the aim of enabling organizations to do so in order to become more efficient and effective in their businesses by performing and making decisions. This systematic review touches on the given topic by discussing the emerging trends in the use of ML in optimization of business processes with specific mention of the importance that what it has in the operations management, supply chain management, marketing, human resource management as well as customer service. The key conclusions of the recent studies are generalized in the article and it was examined what ML-algorithms are most widespread and whether they are difficult to apply and what is beneficial in their activity. The review also predictive assumes that deep learning, reinforce learning and predictive learning would be more important in simplification of business processes as well as organisational competitiveness of the organisation. The results illustrate that ML would possess possibility to transform the likelihood of the business optimization on its way to the automation of the decision making procedure, and initiate the allocation of the resources, as well as increase the total endeavours of productivity. But the issue of privacy of the data, the lack of experts and the interface of ML systems with legacy are significant obstacles on the way to large-scale deployment. The future research directions in the field were outlined as the results of the paper in which the arguments about the necessity in the development of the extractable and understandable ML models in the business were indicated.

Keywords: Business Process Optimization, machine Learning, operations Management, Deep Learning, Predictive Analytics.

Introduction

The combination of machine learning with business processes is not even less important than a paradigm shift, since it will allow an enterprise to achieve a new level of the effectiveness and flexibility of its operations and the versatility of its strategies (Martins, 2024). Machine learning models, under the guidance of which the valuable intermediate information about the complex dataset can be obtained, will allow not only the businesses to make their decisions based on the information but also optimize numerous aspects of their activities (Abbasi et al., 2024). The competency also finds itself quite useful in the contemporary dynamic business world where organizations need to be able to process the movement of the market and the demands that customers have in a timely fashion (Helleckes et al., 2022). That machine learning can learn to realize the cognizance of pattern and relationship of large databases makes it easier to arrive at chains of decisions, get rid of errors on the part of people, pointed out opportunities, most of which become the efficient implement of various business processes (Pasupuleti et al., 2024). The majority of the leading software companies allow their customers to buy machine learning as software that can be easily used in their practices and businesses in the form of software ("Introduction to Machine Learning," 2019). Machine learning is transformational in a number of activities in running of businesses such as in operational management, supply chain enhancement, marketing strategy, human resources management and enhancement of customer services. The machine learning models can also predict the malfunction of the equipment and simplify the production schedule and improve quality control operations and save the company mind boggling investments and ensure the improvement of reliable operations in Ops (Sharma et al., 2022). The supply chain management will involve machine learning to forecast the demand, optimise the inventory and logistics in supply chain resulting in the low lead times, lower costs spent in holding the inventory and build resilient supply chain (Sharma et al., 2022).

Study background

The consequences of implementing the idea of Adding Machine Learning in a business company are rather high since groups can afford to be more automated and data-driven in their decisions than ever (Batz et al., 2025; Helleckes et al., 2022). The other vital branch of the artificial intelligence is called Machine Learning which enables the computer to complete its duties without any interference since it establishes algorithms and statistical structures and it is not necessary to enter a clear programming code (Helleckes et al., 2022; Pasupuleti et al., 2024). The ML methods allow the automation of other complex processes, improved predictive outcomes, and vulnerability of the higher order in the decision capacities of various business processes (Helleckes et al., 2022). Examples of the areas where ML algorithm is used include operation and management where the algorithm is used to optimise production schedule, identify maintenance requirement as well as streamlining resource distribution such that the most effective operations are attained. On the same note, some of these where the ML methods, such as predictive analytics and demand Forecasting can possibly apply in supply chain management would be the reduction of wastes and streamlining of inventories, which would help the business to improve customer satisfaction (Seyam et al., 2024). Second, the ML algorithms also play a role in marketing where a personalised marketing campaign can be done, customer segmentation can be performed, targeting the customers

and advertisement can be done that eventually results in revenue generation and customer interaction (Sinha & Dhanalakshmi, 2021).

Study Goals

- To step in and conduct a survey on such recent developments in the machine learning to make the activities of businesses manageable in a more organized manner.
- To be in a position to compare and contrast the different ML strategies that have been used in different business activities that include operation, marketing as well as human resource management.
- To discover the problems and obstacles in the path toward the optimization of the processes because of the integration of the ML-based solutions by the organizations.
- To determine the degree of effectiveness of ML algorithms, as regards to optimal profitability of businesses and decision making.
- To identify the trends and the research directions on ML in the enhancement of the business processes with the utilization of ML.

Literature Review

The machine learning has already become one of the most vital technologies in providing the business process optimization that is both dramatic and applied to the various functional spheres through the use of the algorithms to optimize the corporate processes and decision making process (Martins, 2024). One of the prominent trends observed in business process optimization according to the published literature is the application of the machine learning model such as decision tree, decision machine, neural network, and deep processing models (Helleckes et al., 2022). When it comes to predictive analytics, automation, and real-time decision support, these algorithms are relatively high in terms of performance and, therefore, result in high returns of operation efficiency and strategic responsiveness (Sindayigaya & Dey, 2022). In the scope of operations management, machine learning can be used in order to calculate the demand, streamline the production calendar, forecast adequate maintenance, and reduce the idle power capacity but increase the overall efficiency of the operations in progress (“ Introduction to Machine Learning,” 2019).

An example of predictive maintenance models is that the sensors data regarding the devices condition can be utilized in predicting the failure and prevent it because of making a proactive maintenance moves and minimizing the downtimes of the operations (Helleckes et al., 2022). The same way, the use of machine learning algorithms in optimization of the supply chain management is relevant because the demand forecasting models will be much more accurate, better requirement of the inventory management, and logistical processes optimization (Pasupuleti et al., 2024). The supply chain resiliency and responsiveness can be used to support the data-driven approach to decision making within the organization since the machine learning can operate with large volumes of information and spot the complex patterns therein. They are also attempting to handle most of the tasks with the help of machine learning in any way and it is usually done with the minimal interaction with the human being and thus more effective (Sinha & Dhanalakshmi, 2021).

Table 1: Summary of Common Machine Learning Algorithms Used for Business Process Optimization

Machine Learning Algorithm	Application Area	Description
Decision Trees	Marketing, Customer Segmentation	Used for classification and regression tasks to split data into branches based on feature values.
Random Forest	Supply Chain Optimization, Fraud Detection	An ensemble learning method that uses multiple decision trees to improve accuracy and prevent overfitting.
Support Vector Machines (SVM)	Fraud Detection, Anomaly Detection	Used for classification tasks by finding hyperplanes that separate different classes.
Neural Networks (ANN)	Image Recognition, Sales Forecasting	Models that simulate human brain functionality to solve complex problems by learning from data.
Deep Learning (CNN, LSTM)	Demand Forecasting, Predictive Maintenance	Advanced models that automatically learn features from data for tasks like forecasting and sequence modelling.

Material and Methodology

The systematic review approach is applied in the selected study in order to provide a definition of the existing knowledge base on the use of ML with the regard to optimization of the business processes. This process of

conducting the reviews is organized by trying to identify the concerted research that has been conducted in the past five years and published in peer reviewed journals, conferences and reports in the industries. The selection of the studies is achieved using its relevance in the problem of MB in optimization of business, methodological profundities, as well as the adequacy of significance of research findings.

Aspects that the review is centred on are reflected as follows:

- The ML algorithms, that can be applied to certain business functions.
- The success and the way ML on the business and decision making.
- The obstacles that organisations have to fill in order to think of implementing ML solutions.
- Advantages and disadvantages of the ML - based matrix of the business process optimization.

Results and Discussion

There are a number of spheres, to which application of ML in the sphere of business process optimization belongs, as per the review. Firstly, deep learning is also the fashionable method in the applications forecasting demand, fraud detection and image recognition just to name a few. Big, complicated data is of special worth to the models, and has the ability to update hierarchical trends which less conventional algorithms would overlook.

Second, optimization of the problems of route planning of the supply chain management has been used with reinforcement learning in the optimization of the chain management inventory. With this, the reinforcement-learning algorithms can create real-time-decisions based on the environmental-feedback and that is why, they adapt to new manipulations and enhance the quality of decision-making with the passage of time.

Although the results are encouraging, data quality, legacy systems integration, etc., remain a problem, as they require hiring specialized skills. Besides that fact, not all ML models are explainable and therefore lack any explainability that may also pose a problem to businesses in as far as they are unable to believe in and implement the systems.

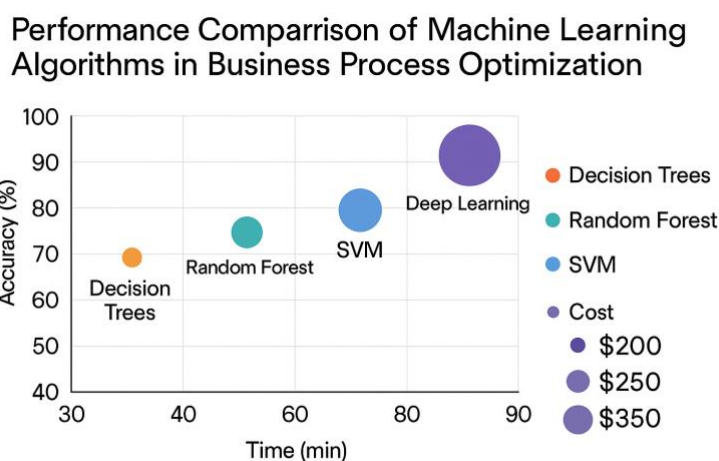


Figure 1: Performance Comparison of ML Algorithms in Business Process Optimization

Study limitations

The weaknesses of a certain research development should be admitted since it is a necessary condition to transform the work into one that is clear and give meaning to the findings (Abbasi et al., 2024). All the published results of the past five years are considered in the examination, as such, omitting the older works that modern research may have been founded upon that could have wider investigation on the history of machine learning application in business in optimisation of business processes (Schneider et al., 2020). Paying attention to the newest works we should not disregard the fact that the newer years literature accepts the latest technologies and the latest practices, but still in the few cases the older years articles devoted to invention of the modern methods can be so interesting and useful to understand how the modern methods appeared and how they were developed (Kibebe et al., 2024). Moreover, reviews focus on those papers that are already published in the journals in which an English language is applied though nobody mentions the chance that the audiences may overlook latent treasures of researches and the scope of other verses unintentionally (Ouanhlee, 2024). Research in the world has also become more multilingual and restricting the survey into English-speaking publications may cause the discovery of important novelty as well as other solutions and ways of solving problems that have been developed in another language and other regions of the world to be missed (Perifanis & Kitsios, 2023). The proper language

barrier may provide a closed-in image of the field at the cost of the most imperative regional and cross-cultural peculiarities of utilizing the machine learning in the optimization of business processes (Senivongse et al., 2017).

Future Scope

The issue of explainable and interpretable models of machine learning as an important direction of the future research aimed at such focus as the optimization of the business process and the gap that should be resolved in the area of algorithmic decision-making transparency and reliability will have to be further elaborated with more attention to the optimization of the business process and the space in which one should be filled to discuss the transparency and reliability of algorithmic decision-making (Bobadilla et al., 2024). This is what must be done to instil more confidence in the minds of the organizations and hence such systems are more widely used in a large number of areas of operation (Chen et al., 2023). This is because the contemporary ML models are excessively obscure and are frequently known to be a black box, which does not allow the user to understand and trust its outputs especially at the time of its application in somewhat serious business applications where the decision-making process has a lot of economic or functional ramifications (Rudin, 2019). The possibility of future research can be devoted to knowing how it is possible to circumvent this shortcoming by investigating the use of conceptual modelling as a medium that can take the clarity and transparency of the outputs of the machine learning algorithms to the maximum extent (Lukyanenko et al., 2019). Explainable AI is the potential direction of the research area that has many kinds of the approaches to the explanation of the conduct of the complicated model (Chen, 2023; Moraffah et al., 2020).

Conclusion

Business Machine learning is a transformative change in the role it occupies in optimizing businesses processes, improved decisions, distribution of the resources, and the enhancement of performance in various tasks. The use of predictive analytics in combination with deep learning and reinforcement learning can prove especially useful to control administration of the operations, the marketing, and the process of supply chain management. Nonetheless, issue of data quality, integration with the current systems, adequacy of human resources also constitute a piece stumbling block to the implementation process. But more advanced solutions will come to fore in the future of ML as far optimization of business process is concerned since latest trends will translate into more advanced solutions. Regardless of the industries where the Industry 4.0 technologies are implemented, ML will be facilitating a massive apparent impact to the operational excellence as well as the competitive advantage.

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