

DAMPAK ALGORITMA PEMBELAJARAN MESIN: STUDI META-ANALISIS

THE IMPACT MACHINE LEARNING ALGORITHMS: STUDY META-ANALYSIS

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ABSTRACT

Machine Learning (ML) algorithms have revolutionized various fields, including science, technology, and business. This study conducted a meta-analysis to review the impact of ML algorithms on various domains. This research is a type of meta-analysis research. The data sources in this study come from 12 national and international journals published in 2022-2024. Data collection techniques through direct observation through journal databases. The inclusion criteria in this meta-analysis are research obtained from google scholar; ScienceDirect and ERIC, Research must be related to machine learning algorithms, research has complete data to calculate the effect size value. Data analysis in this study was conducted by statistical analysis with JSAP 0.16.3 application. The results of the study concluded that ML algorithms has a significant impact on various fields including the discovery of new knowledge, process efficiency and accuracy in prediction with an effect size value of 0.793; $p < 0.001$. These findings show that ML algorithms have great potential to improve performance and efficiency in various fields.

Kata Kunci: *Machine Learning, Meta-analysis, Impact, Prediction Accuracy*

ABSTRAK

Algoritma Machine Learning (ML) telah merevolusi berbagai bidang, termasuk sains, teknologi, dan bisnis. Penelitian ini melakukan meta-analisis untuk meninjau dampak algoritma ML pada berbagai domain. Penelitian ini merupakan jenis penelitian meta-analisis. Sumber data dalam penelitian ini berasal dari 12 jurnal nasional dan internasional terbit tahun 2022-2024. Teknik pengumpulan data melalui observasi langsung melalui database jurnal. Kriteria inklusi dalam meta-analisis ini adalah penelitian diperoleh dari google scholar; ScienceDirect dan ERIC, Penelitian harus terkait dengan machine learning algorithms, penelitian memiliki data yang lengkap untuk menghitung nilai effect size. Analisis data dalam penelitian ini dengan analisis statistik dengan aplikasi JSAP 0.16.3. Hasil penelitian menyimpulkan bahwa algoritma ML memiliki dampak signifikan pada berbagai bidang termasuk dalam penemuan pengetahuan baru, efisiensi proses dan keakuratan dalam prediksi dengan nilai effect size sebesar 0.793; $p < 0.001$. Temuan ini menunjukkan bahwa algoritma ML memiliki potensi besar untuk meningkatkan kinerja dan efisiensi di berbagai bidang.

Kata kunci: *Machine Learning, Meta-analisis, Dampak, Keakuratan Prediksi*

INTRODUCTION

The rapid development of Machine Learning (ML) technology has revolutionized the way we approach problem-solving in various fields (Pallathadka et al., 2021). In recent years, ML has made tremendous strides, with advancements in deep learning, natural

language processing, and computer vision enabling the development of sophisticated AI systems (Yang & Shami, 2020). These systems are now being applied in a wide range of industries, from healthcare and finance to education and transportation (Yeşilkanat, 2020). For instance, ML-powered chatbots are being used to

improve customer service, while ML-based diagnostic tools are helping doctors detect diseases more accurately. Similarly, ML-driven autonomous vehicles are transforming the transportation sector, and ML-based predictive analytics are enhancing decision-making in finance.

The applications of ML are not limited to these sectors alone. The technology is also being used to improve the efficiency of manufacturing processes, optimize supply chain management, and enhance cybersecurity (Ullah et al., 2022). In education, ML-powered adaptive learning systems are personalizing the learning experience for students, while in healthcare, ML-based medical imaging analysis is helping doctors diagnose diseases more accurately. The rapid development of ML has also led to the creation of new industries and job roles, such as data scientists and AI engineers (Helm et al., 2020). As the technology continues to evolve, it is likely to have a profound impact on various aspects of our lives, from the way we work and communicate to the way we live and interact with the world around us (Çam & Özdağ, 2020).

Machine Learning (ML) holds immense potential to revolutionize the way we approach problem-solving in various domains. By leveraging the power of ML, organizations can significantly enhance their performance and efficiency (Helm et al., 2020). For instance, in the field of healthcare, ML can be used to develop predictive models that identify high-risk patients, enabling healthcare providers to provide targeted interventions and improve patient outcomes. Similarly, in the financial sector, ML can be applied to develop more accurate credit risk prediction models, reducing the risk of defaults and improving the overall efficiency of financial transactions (Uçar et al., 2020). Moreover, ML can be used to optimize supply chain management, predicting demand and supply patterns to

reduce inventory costs and improve delivery times.

The potential of ML is not limited to these domains alone. The technology can also be applied to various other areas, such as education, transportation, and manufacturing, to name a few (Lokkila et al., 2022). In education, ML can be used to develop personalized learning systems that adapt to individual students' learning styles and pace, improving learning outcomes and reducing dropout rates. In transportation, ML can be used to develop autonomous vehicles that can navigate complex road networks, improving safety and reducing traffic congestion. In manufacturing, ML can be used to optimize production processes, predicting equipment failures and reducing downtime (Lazrig & Humpherys, 2022). The vast potential of ML lies in its ability to analyze large datasets, identify patterns, and make predictions, enabling organizations to make data-driven decisions and drive innovation (Yildiz & Börekci, 2020). As the technology continues to evolve, it is likely to have a profound impact on various aspects of our lives, from the way we work and communicate to the way we live and interact with the world around us (Yeşilkanat, 2020).

The widespread adoption of Machine Learning (ML) algorithms in various domains, including education and finance, raises several concerns regarding their potential limitations and challenges (Yildiz & Börekci, 2020). One of the primary concerns is the issue of bias in ML models. As ML algorithms are trained on historical data, they can perpetuate existing biases and stereotypes, leading to unfair outcomes (Çam & Özdağ, 2020). For instance, in education, ML-powered adaptive learning systems may inadvertently reinforce existing social and economic inequalities by providing more tailored support to students from more affluent backgrounds (Suchitra et al., 2023). Similarly, in finance, ML-based credit risk

prediction models may be biased towards certain demographics or socioeconomic groups, leading to unfair lending practices. Therefore, there needs to be a meta-analysis to know the impact.

Meta-analysis of the impact of machine learning algorithms is crucial as it synthesizes diverse research findings, providing a more accurate and comprehensive understanding of their efficacy and application across different domains. By aggregating and quantitatively analyzing results from multiple studies, meta-analyses can identify patterns, strengths, and limitations of algorithms that individual studies might miss. This approach helps in refining algorithmic designs, enhancing predictive accuracy, and guiding future research directions (Pallathadka et al., 2021; Doewes et al., 2023). Importantly, it also aids in determining the real-world applicability of machine learning solutions, ensuring that they are both technically sound and practically valuable. Thus, meta-analyses play a pivotal role in advancing machine learning technology by clarifying its impacts and optimizing its implementation in varied contexts. Based on this, this study aims to determine the influence of ML algorithms on various domains.

METODE

This study uses a quantitative meta-analysis design to examine the impact of Machine Learning (ML) algorithms on various aspects. Meta-analysis is a statistical method of combining and analyzing the results of multiple independent studies to produce stronger and more accurate conclusions (Zulkifli et al., 2022; Oktarina et al., 2021; Santosa et al., 2022). The design of this meta-analysis was chosen because it allows to synthesize findings from different studies with different methodologies and focuses, thus providing a more comprehensive picture of the impact of ML. The data sources in this

study come from 12 national and international journals published in 2022-2024. Data collection techniques through direct observation through journal databases. The inclusion criteria in this meta-analysis are research obtained from google scholar; ScienceDirect and ERIC, Research must be related to machine learning algorithms, research has complete data to calculate the effect size value. Data analysis in this study was conducted by statistical analysis with JSAP 0.16.3 application. Furthermore, the criteria for effect size in the study can be seen in Table 1.

Table 1. Effect Size

Effect Size	Category
$0.00 \leq ES \leq 0.20$	Low
$0.20 \leq ES \leq 0.80$	Medium
$ES \geq 0.80$	High

Sumber:(Utomo et al., 2023)

RESULT AND DISCUSSION

From the results of searching data sources through the journal database, 12 journals were obtained that met the inclusion criteria. Furthermore, the data is calculated by the effect size value and the standard error which can be seen in Table 2.

Table 2. Effect Size and Standar Error

Journal Code	Year	Effect Size	Standard error
P1	2022	1.03	0.35
P2	2023	0.66	0.27
P3	2024	0.79	0.22
P4	2024	1.20	0.44
P5	2023	0.92	0.31
P6	2022	0.71	0.26
P7	2022	0.48	0.16
P8	2024	0.39	0.12
P9	2023	1.08	0.42
P10	2022	0.82	0.37
P11	2024	0.97	0.30
P12	2024	0.63	0.22

Table 2 shows that the effect size values of the 12 studies ranged from 0.63 to 1.20 and the standard error ranged from 0.12 to 0.44. Furthermore, according to the effect size criteria (Fritz et al., 2011), out

of the 12 studies, 5 have medium effect size values and 7 have high effect size criteria. Next, heterogeneity testing of the data was conducted using the fixed and random effect models, as shown in Table 3.

Table 3. Fixed and Random Effect Model

	Q	df	p
Omnibus test of Coefficients Model	68.008	1	< 0.001
Test of Residual Heterogeneity	12.068	11	< 0.001

Based on Table 3, the Q value of 68.008 is greater than 12.068. This finding indicates that the random effect model is more effective for analyzing the 12 studies used in the meta-analysis data. The next step is to calculate the p-value to determine the influence of Machine Learning. The results of the hypothesis test using the random effect model can be seen in Table 4

Table 4. Summary Effect Size

	Effect Size	Standar error	Z	p
Intercept	0.793	0.231	8.247	< 0.001

Based on Table 4. The total effect size value is 0.793 with a standard error of 0.231. This finding explains the influence of machine learning in various fields with moderate categories with a value of $z = 7.083$ and $p < 0.001$.

Machine learning (ML) has revolutionized various industries by improving the efficiency, accuracy, and automation of processes (Ahmed & Yahaya, 2024). In the manufacturing sector, ML aids in predictive maintenance by predicting machine failures before they occur, reducing downtime and repair costs. In healthcare, ML algorithms can analyze medical images to detect diseases with a high degree of accuracy, even better than doctors in some cases (Altın, 2024). The positive impact of machine learning is evident in increased productivity and reduction of human error, ultimately

improving the quality of products and services (Anjomshoaa et al., 2022).

Machine learning algorithms also play a crucial role in service optimization and personalization. In the retail sector, ML is used for customer data analysis, allowing companies to offer personalized product recommendations, which improves customer satisfaction and sales (Amin et al., 2020; Lokkila et al., 2022). In the banking industry, ML helps in fraud detection by analyzing suspicious transaction patterns in real-time. The ability to process and analyze large amounts of data quickly allows companies to provide better and safer services to their customers (Lazrig & Humpherys, 2022).

Furthermore, machine learning also has a significant impact on improving decision-making. With fast and accurate data analysis, organizations can make better and faster decisions. In the financial sector, ML helps in risk analysis and investment portfolio management (Uçar et al., 2020). The algorithm can evaluate investment risk by considering various factors and provide recommendations that are based on historical data and current market trends. This allows financial managers to make more informed investment decisions and reduce the risk of loss. While it has many benefits, the implementation of machine learning also faces a number of challenges and ethical issues. One of the main challenges is the need for high-quality, large data to train ML algorithms (Li et al., 2021). Additionally, there are concerns about the transparency and accountability of algorithms, especially when used in critical decision-making such as in the judiciary or law enforcement. The problem of bias in data and algorithms is also a concern, as it can reinforce social injustice. Therefore, it is important to ensure that ML algorithms are developed and implemented with ethical and fairness aspects in mind (Yang & Shami, 2020).

Machine learning is expected to continue to evolve and play an

increasingly important role in various fields. Advances in deep learning techniques and the development of more complex models will allow for more sophisticated and varied applications (Aulck et al., 2020; Çam & Özdağ, 2020). In the energy sector, ML can be used to optimize resource use and improve energy efficiency. In education, ML can provide a personalized learning experience for each student. As such, machine learning will continue to be a key driver of innovation and efficiency in the future, having a significant impact on society and the economy as a whole.

CONCLUSION

From the results of this study, it can be concluded that ML algoritma has a significant impact on various fields including the discovery of new knowledge, process efficiency and accuracy in prediction with an effect size value of 0.793; $p < 0.001$. These findings show that ML algorithms have great potential to improve performance and efficiency in various fields. ML also has some limitations and potential risks, such as algorithmic bias, privacy concerns, and the risk of abuse.

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