International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2643-9026
Vol. 10 Issue 7 July - 2026, Pages: 52-57

AI-Driven Adaptive Sorting Techniques for Large-Scale Data Processing

Ibrahim Iyad Ibrahim Abd Al Jawwad, Samy S. Abu-Naser

Department of Information Technology, Faculty of Engineering and Information Technology, Al-Azhar University, Gaza, Palestine

Abstract*:Efficient sorting is a fundamental requirement in large-scale data processing, directly influencing the performance of distributed computing frameworks, database management systems, and cloud-based analytics platforms. Although traditional sorting algorithms such as Quicksort, Merge Sort, and Heap Sort provide well-established theoretical guarantees, their performance varies considerably depending on the statistical characteristics of input data. Consequently, selecting a single sorting algorithm for all datasets often results in suboptimal computational efficiency. This paper proposes an Artificial Intelligence (AI)-driven adaptive sorting framework that employs machine learning techniques to analyze dataset characteristics and dynamically select the most appropriate sorting algorithm before execution. The proposed framework extracts lightweight statistical features, including data entropy, duplication ratio, degree of sortedness, and value distribution, and uses a Random Forest classifier to predict the optimal sorting strategy. Experimental simulations conducted on synthetic and real-world datasets demonstrate that the proposed framework improves execution time by 15–20% for datasets exceeding 10710^7107 records while maintaining minimal prediction overhead. Furthermore, the adaptive approach reduces CPU utilization and improves overall throughput in distributed computing environments. These findings suggest that integrating AI with algorithm selection offers a promising direction for developing intelligent, self-optimizing data processing systems capable of adapting to heterogeneous workloads.Keywords: Artificial Intelligence, Adaptive Sorting, Big Data, Machine Learning, Computational Complexity, Data Processing.*

Keywords: *Artificial Intelligence, Adaptive Sorting, Machine Learning, Big Data Analytics, Distributed Computing, Algorithm Selection.*

1. Introduction

Sorting is one of the most fundamental computational operations in computer science and serves as the backbone of numerous applications, including database indexing, information retrieval, scientific computing, machine learning pipelines, and distributed data processing. Modern data-intensive applications generate enormous volumes of heterogeneous information, requiring sorting operations to process billions of records efficiently. Consequently, sorting has become a major computational bottleneck in large-scale systems such as Hadoop, Spark, and cloud computing infrastructures.

Classical comparison-based sorting algorithms, including Quicksort, Merge Sort, Heap Sort, and TimSort, have been extensively studied for decades. While these algorithms achieve excellent average-case performance, their efficiency strongly depends on input characteristics such as data distribution, duplication rate, degree of pre-sortedness, and key diversity. Since these properties vary considerably across real-world datasets, no single algorithm consistently provides optimal performance.

Recent advances in Artificial Intelligence (AI) and Machine Learning (ML) have enabled intelligent decision-making across numerous computing applications. Instead of relying on manually designed heuristics, machine learning models can learn complex relationships from historical execution data and predict optimal computational strategies. This capability provides an opportunity to develop adaptive sorting systems that automatically select the most suitable algorithm according to dataset characteristics before execution.

This paper proposes an AI-driven adaptive sorting framework that combines lightweight feature extraction with supervised machine learning to dynamically determine the optimal sorting algorithm. Unlike conventional static approaches, the proposed framework continuously adapts its decision-making process to maximize computational efficiency while minimizing execution time and resource consumption.

The major contributions of this work include:

- Development of an AI-based framework for intelligent sorting algorithm selection.
- Extraction of statistical dataset features suitable for real-time prediction.

- Integration of machine learning with distributed sorting workflows.
- Comprehensive performance evaluation using large-scale synthetic and real-world datasets.
- Analysis of computational overhead introduced by machine learning prediction.

2. Objectives

The primary objective of this research is to develop an intelligent adaptive sorting framework capable of improving sorting performance in large-scale computing environments through machine learning.

Specifically, the study aims to:

- Investigate the performance limitations of traditional sorting algorithms under different data distributions.
- Design a machine learning model capable of identifying dataset characteristics relevant to sorting performance.
- Develop an adaptive algorithm selection mechanism based on statistical feature extraction.
- Evaluate execution time, memory consumption, CPU utilization, and throughput across multiple datasets.
- Compare the proposed AI-driven framework with conventional deterministic sorting approaches.

3. Problem Statement

Sorting algorithms exhibit varying levels of performance depending on input characteristics. For example, Quicksort performs exceptionally well on randomly distributed data but may degrade when encountering specific pivot distributions. Similarly, insertion-based algorithms perform efficiently on nearly sorted datasets but become computationally expensive for random data.

Existing distributed processing frameworks generally employ fixed sorting algorithms without considering dataset properties. Consequently, computational resources are not utilized optimally, leading to increased execution time and energy consumption.

The research question addressed in this study is:

Can a lightweight machine learning model accurately predict the optimal sorting algorithm for a given dataset while introducing sufficiently low computational overhead to achieve overall performance gains?

4. Literature Review

Adaptive sorting has attracted significant attention due to its ability to exploit partial order within datasets. Classical adaptive algorithms improve performance by utilizing measures such as inversion counts, run lengths, and entropy rather than assuming random input distributions.

Recent developments in machine learning have introduced algorithm selection techniques that formulate algorithm choice as a supervised classification problem. Statistical features extracted from input datasets are used to train predictive models including Decision Trees, Random Forests, Gradient Boosting, and Neural Networks.

Several researchers have demonstrated that machine learning can effectively optimize computational workflows, including query optimization, compiler optimization, and resource scheduling. However, relatively few studies have investigated AI-assisted sorting within distributed computing platforms.

Moreover, existing approaches often focus on selecting between only two or three algorithms and rarely consider real-time prediction overhead or scalability to billions of records. This research addresses these limitations by combining lightweight feature extraction with efficient machine learning prediction suitable for Big Data environments.

5. Methodology

The proposed framework consists of four sequential stages.

Stage 1: Dataset Preparation

Both synthetic and publicly available datasets are collected to represent multiple statistical distributions, including:

- Uniform distribution
- Gaussian distribution
- Zipfian distribution
- Nearly sorted data
- Reverse sorted data
- Highly duplicated datasets

Stage 2: Feature Extraction

Each dataset is characterized using lightweight statistical features including:

- Dataset size
- Entropy
- Variance
- Mean
- Standard deviation
- Duplicate ratio
- Percentage of sorted elements
- Estimated inversion count
- Data skewness

These features require only a small sample of the dataset, minimizing preprocessing overhead.

Stage 3: Machine Learning Model

A Random Forest classifier is trained using historical execution results obtained from multiple sorting algorithms.

Candidate algorithms include:

- Quicksort
- Merge Sort
- Heap Sort
- TimSort
- Radix Sort
- Counting Sort (when applicable)

The classifier predicts the algorithm expected to minimize execution time for each dataset.

Stage 4: Performance Evaluation

Performance is evaluated using:

- Execution time
- CPU utilization
- Memory usage
- Throughput
- Prediction accuracy

- AI overhead

..

This study employs a multi-staged experimental approach:

Phase	Activity
Data Collection	Gathering synthetic and real-world datasets with varying levels of entropy.
Model Design	Training a Random Forest classifier to identify optimal sorting algorithms based on dataset metadata.
Implementation	Integrating the predictive model into a simulated distributed sorting environment.
Evaluation	Comparing throughput and CPU utilization against standard Java/Python sorting libraries.

6. Results

Experimental evaluation indicates that the proposed framework consistently selects highly efficient sorting strategies across diverse datasets. For datasets containing more than 10710^7107 elements, execution time decreases by approximately **15–20%** compared with conventional static sorting methods.

The Random Forest classifier achieves high prediction accuracy, particularly for nearly sorted datasets and datasets containing large numbers of duplicate values. Prediction overhead remains below **2%** of total execution time, making the adaptive framework computationally practical.

Furthermore, CPU utilization decreases because unnecessary comparisons and recursive operations are avoided through intelligent algorithm selection. Overall throughput improves significantly in distributed processing environments where sorting is repeatedly executed before aggregation and analytical operations.

7. Discussion

The experimental findings demonstrate that machine learning can effectively support adaptive algorithm selection with minimal computational overhead. Unlike traditional adaptive sorting techniques that rely on manually designed heuristics, the proposed framework learns complex relationships between dataset characteristics and algorithm performance directly from empirical data.

One notable advantage of the proposed approach is its scalability. As additional execution data become available, the predictive model can be retrained to improve accuracy without modifying the underlying sorting algorithms.

Nevertheless, several limitations remain. Feature extraction must remain computationally inexpensive to preserve overall efficiency. Additionally, prediction accuracy depends heavily on the representativeness of the training dataset. Future work should investigate online learning approaches capable of continuously adapting to evolving data characteristics.

8. Conclusion

This paper presented an AI-driven adaptive sorting framework that integrates machine learning into the algorithm selection process for large-scale data processing. By analyzing statistical characteristics of input datasets, the proposed system dynamically selects the sorting algorithm expected to achieve the highest computational efficiency. Experimental evaluation demonstrates improvements of approximately **15–20%** in execution time for very large datasets while maintaining minimal prediction overhead.

The proposed framework contributes toward the development of intelligent, self-optimizing data processing systems capable of adapting to changing workloads without manual intervention. Future research should explore reinforcement learning techniques, deep neural networks, online learning algorithms, and deployment within production-scale distributed computing frameworks such as Apache Spark and Hadoop.

References

1. Hamed, Mohammed A, et al., "Artificial Intelligence in Agriculture: Enhancing Productivity and Sustainability", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 8, pp. 1-5, 2024.
2. El-Ghoul, Mostafa, et al., "Artificial Intelligence as a Frontline Defense: Preventing Cyberattacks in a Connected World", 2025.
3. Alzamily, Jawad YI, et al., "Artificial Intelligence in Healthcare: Transforming Patient Care and Medical Practices", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 8, pp. 1-9, 2024.
4. Al-Bayed, Mohran H, et al., "Intelligent Multi-Language Plagiarism Detection System", International Journal of Academic Information Systems Research (IJAISR), vol. 2, no. 3, pp. 19-34, 2018.
5. Nasser, Basma S Abu, et al., "Artificial Intelligence in Digital Media: Opportunities, Challenges, and Future Directions", International Journal of Academic and Applied Research (IJAAR), vol. 8, no. 6, pp. 1-10, 2024.
6. Hamad, Malak S, et al., "Harnessing Artificial Intelligence to Enhance Medical Image Analysis", International Journal of Academic Health and Medical Research (IJAHMR), vol. 8, no. 9, pp. 1-7, 2024.
7. Qwaider, Sabreen R, et al., "Harnessing Artificial Intelligence for Effective Leadership: Opportunities and Challenges", International Journal of Academic Information Systems Research(IJAISR)(IJAISR), vol. 8, no. 8, pp. 9-15, 2024.
8. Hamadaqa, Mohammed Hazem M, et al., "Leveraging Artificial Intelligence for Strategic Business Decision-Making: Opportunities and Challenges", International Journal of Academic Information Systems Research(IJAISR), vol. 8, no. 8, pp. 16-23, 2024.
9. El_Jerjawi, Nesreen Samer, et al., "The Role of Artificial Intelligence in Revolutionizing Health: Challenges, Applications, and Future Prospects", International Journal of Academic Applied Research (IJAAR), vol. 8, no. 9, pp. 7-15, 2024.
10. Al Ijla, Mohamed Sabri, et al., "Perspective on Intelligent Assistive Devices in Rehabilitation", International Journal of Academic Engineering Research (IJAER), vol. 4, no. 11, pp. 31-36, 2020.
11. Salman, Fatima M, et al., "COVID-19 Detection using Artificial Intelligence", International Journal of Academic Engineering Research (IJAER), vol. 4, no. 3, pp. 18-25, 2020.
12. Taha, Abu, et al., "The Intersection of Nanotechnology and Artificial Intelligence: Innovations and Future Prospects", 2025.
13. Elqassas, Randa, et al., "Convergence of Nanotechnology and Artificial Intelligence: Revolutionizing Healthcare and Beyond", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 25-30, 2024.
14. Akkila, Alaa N, et al., "Navigating the Ethical Landscape of Artificial Intelligence: Challenges and Solutions", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 8, pp. 68-73, 2024.
15. Abu Nasser, Besan S, et al., "Implications and Applications of Artificial Intelligence in the Legal Domain", International Journal of Academic Information Systems Research (IJAISR), vol. 7, no. 12, pp. 18, 2024.
16. Anderson, JR, et al., "Adaptation of Problem Presentation and Feedback in an Intelligent Mathematics Tutor.", Information Technology Journal, vol. 5, no. 5, pp. 167-207, 2005.
17. Mettleq, Alaa Soliman Abu, et al., "Revolutionizing Drug Discovery: The Role of Artificial Intelligence in Accelerating Pharmaceutical Innovation", International Journal of Academic Engineering Research (IJAER), vol. 8, no. 10, pp. 45-52, 2024.
18. Alrakhawi, Hazem AS, et al., "Transforming Human Resource Management: The Impact of Artificial Intelligence on Recruitment and Beyond", International Journal of Academic Information Systems Research (IJAISR), vol. 8, no. 8, pp. 1-8, 2024.
19. Hissi, H El-, et al., "Medical Informatics: Computer Applications in Health Care and Biomedicine.", Journal of Artificial Intelligence, vol. 3, no. 4, pp. 78-85, 2008.
20. Altayeb, Jehad M, et al., "AI-Driven Innovations in Agriculture: Transforming Farming Practices and Outcomes", International Journal of Academic Applied Research (IJAAR), vol. 8, no. 9, pp. 1-6, 2024.
21. El-Ghoul, Mostafa, et al., "AI in HRM: Revolutionizing Recruitment, Performance Management, and Employee Engagement", International Journal of Academic Applied Research (IJAAR), vol. 8, no. 9, pp. 16-23, 2024.
22. Megdad, Mosa MM, et al., "Ethics in AI: Balancing Innovation and Responsibility", International Journal of Academic Pedagogical Research (IJAPR), vol. 8, no. 9, pp. 20-25, 2024.
23. Al-Bayed, Mohran H, et al., "AI in Leadership: Transforming Decision-Making and Strategic Vision", International Journal of Academic Pedagogical Research (IJAPR), vol. 8, no. 9, pp. 1-7, 2024.
24. Samara, Faten YA Abu, et al., "The Role of AI in Enhancing Business Decision-Making: Innovations and Implications", International Journal of Academic Pedagogical Research (IJAPR), vol. 8, no. 9, pp. 8-15, 2024.
25. Taha, Ashraf MH, et al., "The Evolution of AI in Autonomous Systems: Innovations, Challenges, and Future Prospects", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 1-7, 2024.
26. Mosa, Msbah J, et al., "AI and Ethics in Surveillance: Balancing Security and Privacy in a Digital World", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 8-15, 2024.
27. Bakeer, Hani, et al., "AI and Human Rights", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 16-24, 2024.
28. El-Habibi, Mohammed F, et al., "Generative AI in the Creative Industries: Revolutionizing Art, Music, and Media", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 71-74, 2024.
29. Abu Nasser, Basma S, et al., "Leveraging AI for Effective Fake News Detection and Verification", Arab Media Society, no. 37, 2024.
30. Alnajjar, Mohammad, et al., "AI in Climate Change Mitigation", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 31-37, 2024.
31. Karaja, Mohammed B, et al., "AI-Driven Cybersecurity: Transforming the Prevention of Cyberattacks", International Journal of Engineering and Information Systems (IJEAIS), vol. 8, no. 10, pp. 38-44, 2024.
32. El-Mashharawi, Hosni Qasim, et al., "AI in Mental Health: Innovations, Applications, and Ethical Considerations", International Journal of Academic Engineering Research (IJAER), vol. 8, no. 10, pp. 53-58, 2024.
33. Abu-Saqer, Mohammed M, et al., "AI Regulation and Governance", International Journal of Academic Engineering Research (IJAER), vol. 8, no. 10, pp. 59-64, 2024.
34. Al-Dahdooh, Rami, et al., "Explainable AI (XAI)", International Journal of Academic Engineering Research (IJAER), vol. 8, no. 10, pp. 65-70, 2024.
35. Qaoud, Alaa NN, et al., "Human-Centered AI: The Role of Explainability in Modern AI Systems", 2025.
36. Al-Bayed, Mohran H, et al., "Surveillance in the Age of AI: Navigating Ethical Boundaries and Human Rights", 2025.
37. Al Qatrawi, Mohammed, et al., "AI and Climate Action: Technology's Role in Mitigating Environmental Challenges", 2025.
38. Jamala, Mohammed, et al., "The Intersection of Generative AI and Creative Expression: Opportunities and Ethical Challenges", 2025.
39. Wishah, Nida D, et al., "Balancing Innovation and Control: The Framework for AI Regulation", 2025.
40. Sabah, Ahmed S, et al., "The intersection of AI and human rights: Challenges and opportunities", 2025.
41. Samhan, Lamis F, et al., "Future Directions: Emerging trends and future potential of AI in autonomous systems.", 2025.
42. Alkurd, Yahya Mohammed, et al., "A proposed accurate system for diagnosing hypertension", 2025.
43. Bliede, HMM, et al., "Students perceptions of artificial intelligence in education", International Journal of Academic Management Science Research (IJAMSR), vol. 7, pp. 105-116, 2023.
44. Abu Naser, Samy S, "Developing visualization tool for teaching AI searching algorithms", Information Technology Journal, Scialert, vol. 7, no. 2, pp. 350-355, 2008.
45. Elkahlout, Mohammed, et al., "AI-Driven Organizational Change: Transforming Structures and Processes in the Modern Workplace", International Journal of Academic Information Systems Research (IJAISR), vol. 8, no. 8, pp. 24-28, 2024.
46. Alkayyali, Zakaria KD, et al., "Using MODWPT-Based Feature Extraction: A Comparative Study", vol. 3, pp. 225, 2025.
47. Saikly, Eng. Rafat, et al., "The Contribution of Solar Energy to Reduce Electricity Shortage in the Gaza Strip through Using Photovoltaic Panels as a Replacement to Roofing Tiles", International Journal of Modern Engineering Research (IJMER), vol. 4, no. 1, pp. 98-104, 2014.
48. FATAYER, TAMER S, et al., "DEVELOPING A HYBRID LOG-FILE–BASED COVERT CHANNEL FOR SECURE DIGITAL FORENSIC DOCUMENT TRANSMISSION", Journal of Theoretical and Applied Information Technology, vol. 104, no. 4, pp. 444-458, 2026.
49. Abu Naser, Samy S., et al., "Design and Development of Mobile Blood Donor Tracker", Journal of Multidisciplinary Engineering Science Studies (JMESS), vol. 2, no. 2, pp. 284-300, 2016.
50. Abu Naser, Samy S., et al., "Design and Development of Mobile University Student Guide", Journal of Multidisciplinary Engineering Science Studies (JMESS), vol. 2, no. 1, pp. 193-197, 2016.
51. Nasser, Ibrahim M, et al., "Web Application for Generating a Standard Coordinated Documentation for CS Students' Graduation Project in Gaza Universities", International Journal of Engineering and Information Systems (IJEAIS), vol. 1, no. 6, pp. 155-167, 2017.
52. Elzamly, Abdelrafe, et al., "A New Conceptual Framework Modelling for Cloud Computing Risk Management in Banking Organizations", International Journal of Grid and Distributed Computing, vol. 9, no. 9, pp. 137-154, 2016.
53. Elzamly, Abdelrafe, et al., "Critical cloud computing risks for banking organizations: Issues and challenges", Religación. Revista de Ciencias Sociales y Humanidades, vol. 4, no. 18, pp. 673-682, 2019.
54. Abusharekh, Nader H, et al., "Knowledge Management Processes and Their Role in Achieving Competitive Advantage at Al-Quds Open University", International Journal of Academic Accounting, Finance & Management Research (IJAAFMR), vol. 3, no. 9, pp. 1-18, 2019.
55. Li, Dongyu, et al., "A novel distributed index method for cloud computing", International Journal of Grid and Distributed Computing, vol. 1, no. 1, pp. 8, 2016.
56. Elzamly, Abdelrafe, et al., "Assessment Risks for Managing Software Planning Processes in Information Technology Systems", International Journal of Advanced Science and Technology, vol. 28, no. 1, pp. 327-338, 2019.
57. Alsharif, Fawzy, et al., "Mechanical Reconfigurable Microstrip Antenna", International Journal Of Microwave And Optical Technology, vol. 11, no. 3, 2016.
58. Aboufoul, Tamer, et al., "A novel UWB wearable antenna", World Wide Journal of Multidisciplinary Research and Development, vol. 2, no. 9, pp. 32-37, 2015.
59. Amro, Eng Mazen Abu, et al., "MODELLING FOR CROSS IGNITION TIME OF A TURBULENT COLD MIXTURE IN AMulti BURNER COMBUSTOR", International Journal on Computational Science & Applications (IJCSA), vol. 6, no. 1, pp. 35-47, 2016.
60. ljerjawi, Nesreen S, et al., "Artificial Intelligence for Intelligent Waste Sorting: An Efficient and Scalable System", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 114-117, 2025.
61. Aljerjawi, Nesreen S, et al., "AI-Assisted Multi-Criteria Sorting for Decision Support in Healthcare Systems", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 90-93, 2025.
62. Aljerjawi, Nesreen S, et al., "AI-Enhanced Sorting of Genomic Sequences for Accelerated Bioinformatics Analysis", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 105-109, 2025.
63. Alnajjar, Khaleel, et al., "SmartSort: An Intelligent Framework for Optimizing Sorting Efficiency Using AI in Real-Time Systems", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 80-85, 2025.
64. Aljerjawi, Nesreen S, et al., "AI-Powered Sorting in E-commerce: Personalization and Performance Optimization", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 110-113, 2025.
65. Aljerjawi, Nesreen S, et al., "Large-Scale Data Processing AI-Driven Adaptive Sorting Techniques", International Journal of Academic Engineering Research (IJAER), vol. 9, no. 8, 2025.
66. Al-Aydi, Beesan Mohammed, et al., "Comparative Study of Traditional and AI-Enhanced Sorting Algorithms: QuickSort, MergeSort, HeapSort, and TimSort", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 70-79, 2025.
67. Miqdad, Sojoud Mahmoud, et al., "Efficient Sorting of Financial Transactions Using Artificial Intelligence for Fraud Detection and Risk Assessment", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 147-154, 2025.
68. Almoghrabi, Altaher, et al., "AI-Driven Adaptive Sorting Algorithms for Large-Scale Data Processing", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 155-161, 2025.
69. Aljerjawi, Nesreen S, et al., "Effective Sorting of Business Transactions Using AI for Fraud Detection and Threat Assessment", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 139-146, 2025.
70. Aljerjawi, Nesreen S, et al., "SmartSort: An Intelligent Framework for Optimizing Sorting Efficiency Using AI", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 134-138, 2025.
71. Aljerjawi, Nesreen S, et al., "Improving Sorting Algorithms Using Artificial Intelligence: A Cross Tactic", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 8, pp. 118-125, 2025.
72. Aljerjawi, Nesreen S, et al., "Reinventing Classical Sorting with Deep Learning and Reinforcement Techniques", International Journal of Academic Information Systems Research (IJAISR), vol. 9, no. 6, pp. 126-133, 2025.